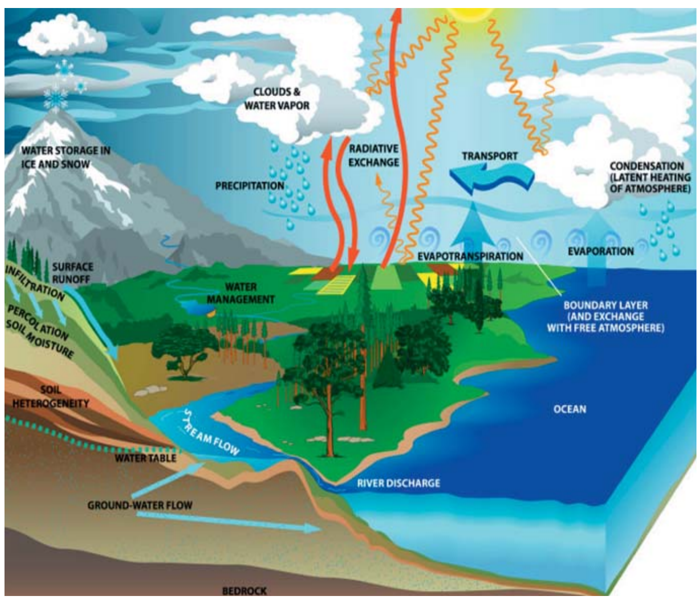
The Federal Plan for Meteorological Services and Supporting Research *Fiscal Year 2008*



Hydrometeorology

OFCM
OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY

FCM-P1-2007
U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

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Pictures displayed on the cover.
Top Left: Grady County, OK, August 20, 2007. Many roads were left impassable due to flooding caused by Tropical Storm Erin. [FEMA photo]
Bottom Left: La Conchita, Ventura County, CA, January 10, 2005. Although rainfall intensities were not extreme, moderate– to high–intensity rainfall persisted for more than 2 weeks, the landslide occurred at the culmination of this 15–day high–rainfall period. The landslide destroyed or damaged 36 houses and killed 10 people. [USGS photo]
Middle: Conceptualization of the Water Cycle (Schematic view). [U.S. Global Change Research photo]
Top Right: The amount of land suffering from severe drought has more than doubled in the past 30 years. [Photo by Evan Schneider, UN]
Bottom Right: The Toston Dam is located in southwestern Montana, on the Missouri River. Hydrometeorological products and services are vital for the management of water resources and the design of roads and dams. [Montana Department of Natural Resources & Conservation photo]

The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 2008

FEDERAL COORDINATOR
FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

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PREFACE

Since 1965, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) has developed a Federal Plan that articulates the provision of meteorological services and the support for meteorological and related research by agencies of the Federal government. The 2008 Federal Plan provides Congress and the Executive Branch with a comprehensive compilation of proposed programs for fiscal year (FY) 2008 and a review of agency programs in FY 2007. The Federal Plan's narratives, timelines, and schedules are current as of September 2007.

The Federal Plan consists of an Executive Summary, three sections, and Appendices. The Executive Summary, which is written as a concise, stand-alone report, provides a high-level view of the Federal resources dedicated to meteorological programs and the achievements of those programs.

This year's feature article (Section 1) focuses on hydrometeorology, which is the science that combines hydrology and meteorology, with its main emphasis on the atmospheric sector of the hydrological cycle. Hydrometeorological products and services are particularly important to managing water resources, including the growing risks to our water supply, water quality, healthy stream flows, agriculture, and ecosystems. They are also used to design roads, dams, and waterway systems; manage flood plains; plan and conduct emergency management operations when flooding threatens; and ensure the safety and preparedness of activities, ranging from recreation to aviation, construction, and surface transportation system use and management. Many Federal, state, and local agencies collaborate to provide accurate and updated hydrometeorological information which is needed by a broad spectrum of customers. The purpose of this article is to: (a) raise the awareness of hydrometeorological products, services, and supporting research; (b) highlight the hydrometeorological products and services available and the collaborating agencies responsible for the collection, maintenance and operation of the meteorological and hydrological data collection network; and (c) engage the users of this Federal information to ensure we understand their needs.

Section 2 of the Federal Plan summarizes the resources appropriated by Congress for FY 2007 and the resources requested in the President's FY 2008 Budget. Section 3 contains departmental and agency narratives on programs for providing meteorological services and supporting research and development. It also describes relevant research funded by the National Science Foundation.

Appendix A describes the OFCM's coordination, program, and planning activities. Appendix B addresses the World Meteorological Organization's World Weather Program. Appendix C lists the feature articles published in previous Federal Plans. The acronyms and abbreviations used throughout this year's Federal Plan are defined in Appendix D. The inside front cover lists the current members of the Federal and Interdepartmental Committees for Meteorological Services and Supporting Research, which provide guidance and support for OFCM activities. The inside back cover diagrams the infrastructure through which the OFCM performs its coordinating mission.

Samuel P. Williamson
Federal Coordinator for Meteorological
Services and Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH, FISCAL YEAR 2008

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THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

FISCAL YEAR 2008

EXECUTIVE SUMMARY

For Fiscal Year (FY) 2008, the President's budget requests over a total of $3.79 billion for meteorological services and supporting research. Of the requested total, over $3.05 billion is designated for operations and over $740.6 million for supporting research. Table ES-1 lists a breakout of the FY 2008 budget proposal.

For FY 2008, 94.5 percent of the total funds requested will go to the Departments of Commerce (DOC), Defense (DOD), and Transportation (DOT). The distribution among these three departments is DOC 52.1 percent, DOD 28.3 percent, and DOT 13.1 percent. The other Federal agencies will share the remaining 5.5 percent.

The FY 2008 request represents an increase of 1.2 percent above the over $3.74 billion appropriated in FY 2007. Within the three major departments, DOC's request is essentially flat; DOD an increase of 10.1 percent, and DOT a decrease of 9.4 percent. The overall DOD increase is mainly the result of increases in AF and DMSP requested funding. DOT's decrease is attributable to a decrease in FAA's operations requests.

The budget requests for the other departments are as follows:

- Department of Agriculture (USDA) a decrease of 11.5 percent,
- Department of the Interior (DOI) no change,
- Environmental Protection Agency (EPA) no change,
- National Aeronautics and Space Administration (NASA) an increase of 2.2 percent, and
- the Nuclear Regulatory Commission (NRC) no change.

Figure ES-1 depicts each agency's proportion of the requested FY 2008 Federal budget for meteorological operations and supporting research. Each agency's portion of the requested funding for meteorological operations is shown in Figure ES-2. Of the over $3.04 billion requested for meteorological operations, DOC, DOD, and DOT account for 98.6 percent of the funds. Overall, operational spending increased by 2.5 percent. Figure ES-3 depicts each agency's portion of the proposed Federal supporting research budget. Unlike operations, DOC, DOD, and NASA account for the major share (90.5 percent) of the supporting research budget. Overall, supporting research spending decreased by 3.5 percent.

All agencies project a personnel total of 12,260 full-time equivalent (FTE) to be employed in Federal meteorological operations in FY 2008. This figure represents a decrease of 2.7 percent from the 12,598 FTE employed in FY 2007, with the largest shares of the decrease attributed to reductions in DOD/Navy and DOT/FAA personnel.

Table ES-1. Federal Budget for Meteorological Operations and Supporting Research, FY 2008 (in thousands of dollars)

Agency	Operations	% of TOTAL	Supporting Research	% of TOTAL	TOTAL	% of TOTAL
Agriculture	$19,563	0.6	$29,216	3.9	$48,779	1.3
Commerce	1,871,181	61.5	99,298	13.4	1,970,479	52.1
Defense	665,728	21.9	404,187	54.6	1,069,915	28.3
Homeland Security	21,540	0.7	0	0.0	21,540	0.6
Interior	2,400	0.1	0	0.0	2,400	0.1
Transportation	462,117	15.2	32,514	4.4	494,631	13.1
EPA	0	0.0	9,000	0.6	9,000	0.2
NASA	2,389	0.1	166,400	22.5	168,789	4.5
NRC	120	0.0	0	0.0	120	0.0
TOTAL	$3,045,038	100.0	$740,615	100.0	$3,785,653	100.0

Total = $3.79 Billion

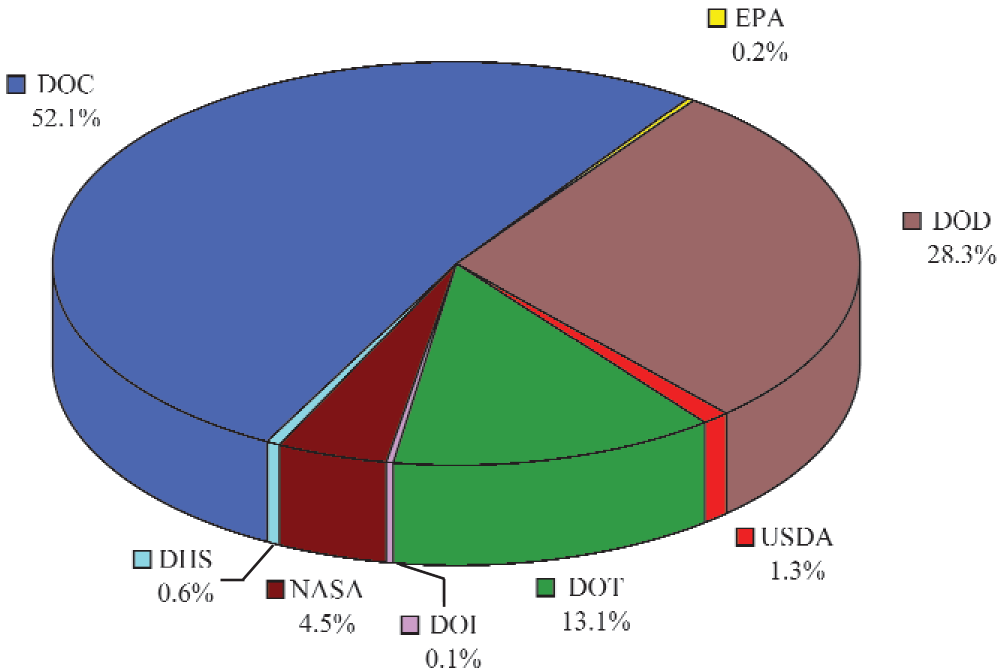


Figure ES-1. Agency Percent of Total Federal Budget for Meteorological Operations and Supporting Research, FY 2008.

Total = $3.05 Billion

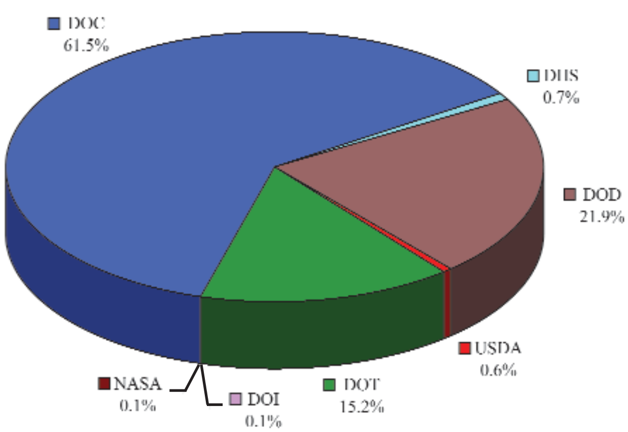


Figure ES-2. Agency Percent of Federal Budget for Meteorological Operations, FY 2008.

Total = $741 Million

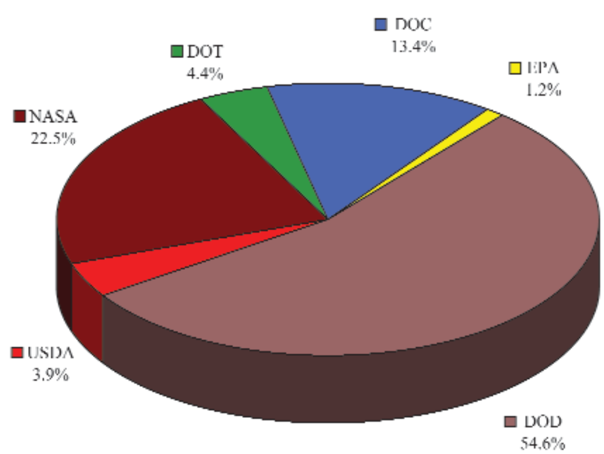


Figure ES-3. Agency Percent of Federal Budget for Supporting Research, FY 2008.

MAJOR PROGRAMS--DOC, DOD, and DOT

NEXT GENERATION WEATHER RADAR (NEXRAD)

The NEXRAD Program, which was initiated in FY 1981, was responsible for procurement, installation, and operation of the Weather Surveillance Radar-1988 Doppler (WSR-88D). The first limited production WSR-88D system was installed at Oklahoma City, Oklahoma in May 1990, and commissioned 4 years later in February 1994. The original program plan called for a total of 161 radars. In response to a National Research Council report, three additional radars were added and raised the total to 164 radar sites (158 operational sites and six support sites). By agency, as of June 2001, the DOC/National Weather Service had commissioned 120 operational sites, the DOD (USAF and Army) had commissioned 26 sites (within the states and overseas), and the DOT/FAA had commissioned 12 sites. DOD has three systems at Keesler AFB, Mississippi, for training; DOC/NWS has one each at the National Reconditioning Center and the NWS Training Center in Kansas City, Missouri, and one at the Radar Operations Center in Oklahoma City, Oklahoma. In 2004, an additional Doppler radar (installed by Enterprise Electronics) was commissioned in Evansville, IN, to augment coverage for southern Indiana and western Kentucky, bringing the count of operational radars to 159.

AUTOMATED SURFACE OBSERVING SYSTEM (ASOS)

The ASOS program began in 1983 as a joint development effort between the DOC, DOD, and DOT/FAA. Installation of ASOS units started in 1992. A total of 1,002 units have been purchased. The NWS has purchased, accepted, and commissioned 313 sites. The FAA has purchased 570 units, all of which have been accepted and commissioned by the NWS. The Navy has purchased and accepted 72 sites. The Air Force has purchased and accepted 47 sites. Collectively, a total of 1,002 ASOS sites have been commissioned.

The Air Force Observing System-21st Century (OS-21) program is providing a state-of-the-art life-cycle replacement for Air Force observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. Installation of 110 fixed systems, designated the FMQ-19, at Air Force bases and Army posts worldwide began in summer 2002, and is scheduled for completion in 2007. The manual version is intended for tactical operations and will continue upgrades begun under the Manual Observing System and Tactical Meteorological Observing System modification programs.

In support of operations, the Air Force purchased commercial off-the-shelf (COTS) remote miniature weather sensors to provide accurate real-time weather information from forward unmanned locations, and has since deployed remote miniature sensors to Afghanistan and Iraq.

AUTOMATED WEATHER INFORMATION SYSTEMS (AWlS)

The DOC, DOD, and DOT require AWIS to facilitate the collection, processing, and interpretation of meteorological data. AWIS are being procured to provide an automated, high-speed, user-friendly man/machine interface to access and process large volumes of sophisticated meteorological data. AWIS supports the timely production of accurate and geographically precise warnings, forecasts, and special tailored products. They also provide the communications capability for expeditious product dissemination. Major agency systems classified as AWISs are: NOAA's Advanced Weather Interactive Processing System (AWIPS), FAA's Weather and Radar Processor (WARP), Air Force's Joint Environmental Toolkit (JET), and the Navy's Naval Integrated Tactical Environmental Subsystem (NITES).

AWIPS

In February 1997, the Secretary of Commerce approved the limited deployment of AWIPS at over 40 sites. On April 9, 1998, the Secretary authorized full-scale production and deployment of AWIPS, through Build 4.2, for the remaining 95 systems. Installation of these 95 systems began in September 1998, and was completed in June 1999. An Operational Test and Evaluation of the commissioning software load (Release 4.2) was successfully conducted from mid-May through June 1999. AWIPS commissioning began in January 2000, was completed in November 2000, with 139 NWS systems commissioned at 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), the Spaceflight Meteorology Group (SMG), and 4 National Centers for Environmental Prediction (NCEP). The NWS successfully completed the final development phase release of AWIPS (Build 5) in early 2003, completed deployment of its first Operational Build (OB1) that summer, completed deployments of OB2 in December 2003, OB3 in August 2004, OB4 in February 2005, and OB5 in December 2005. Deployment of Operational Builds continued after that at a rate of about two per year. The Operational Builds deliver new functionalities and enhancements in the areas of warning product generation and warning support, hydrological product generation, data and imagery display, communications and infrastructure. Of note within the operational builds of AWIPS is an evolution of the architecture to the Linux open source operating environment which was started in 2001, and will continue through to its planned completion in 2007.

WARP

The FAA's WARP will greatly enhance the dissemination of aviation weather information throughout the National Airspace System (NAS). WARP will automatically create unique regional, WSR-88D-based mosaic products and send these products, along with other time-critical weather information, to controllers through the Advanced Automation System (AAS), as well as to pilots via the aeronautical data link.

JET

JET will replace several disparate legacy weather systems with a single, integrated means of supporting both garrison and deployed operations, including a "first-in" weather forecasting capability. Combining forecasting, product-tailoring, and mission-impact capabilities in an interactive, network-centric, standards-based package; JET accesses, processes, analyzes, tailors, and integrates terrestrial and space weather information into command and control systems to guide warfighter decision-making. This effort will eliminate Air Force weather weapon system redundancies and inefficiencies, reduce the burden on system administrators, and ultimately extend, consolidate, or replace the following systems: Operational Weather Squadron Production System Phase II, the New-Tactical Forecast System, the Joint Weather Impacts System, and the Army's Integrated Meteorological System Weather Toolkit.

NITES

The current series of NITES (I - IV) were reengineered from the Tactical Environmental Surveillance System and other legacy systems of the early 1990's. These NITES systems are fielded through fiscal year 2010 and have various capabilities to ingest, process, fuse, display, and disseminate metrological and oceanographic (METOC) information and its impact on tactical operations. In early 2000, the NITES II application software was redesigned to align with the Global Command and Control System (GCCS) Family of Systems 4.x, provide increased flexibility, enable operating system and/or hardware independence, and improve user operability with a new graphical-user interface for tactical decision aid applications. The NITES II redesign suite of software is integrated with both GCCS-Maritime (M) and GCCS-Joint (J) 4.x versions.

The Navy will field a follow-on system, called "*NITES - Next*," to increase the capabilities for ashore, afloat and mobile METOC support to naval tactical operations and be interoperable with the other services. NITES - Next will have four components including: tactical applications, a forecaster's toolkit, a data services package, and the ability to collect METOC information through organic sensors for rapid environment analyses. *NITES - Next* will interface with the data providers/users using Web services and take advantage of the future DOD Global Information Grid and Navy FORCEnet architectures. Navy is also analyzing how to efficiently and effectively leverage the Air Force's Joint Environmental Toolkit (JET) Program for meteorological and environmental impact support.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

On October 3, 1994, NOAA, DOD, and the National Aeronautics and Space Administration (NASA) combined the nation's military and civilian environmental satellite programs to create an Integrated Program Office (IPO) to develop, manage, acquire, and operate the national polar-orbiting meteorological satellite system, subsequently designated the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The IPO is organizationally located within NOAA and is headed by a System Program Director (SPD) responsible to the Program Executive Officer (PEO) for Environmental Satellites who in turn reports to the NPOESS Executive Committee (EXCOM). This committee, which consists of the Under Secretary of Commerce for Oceans and Atmosphere, the Under Secretary of the Air Force, and the NASA Administrator serves as a board of directors to ensure that overall program plans also meet the individual needs of the three participating agencies.

Pursuant to Section 2433 of Title 10, United States Code, Congress was notified on September 28, 2005, that NPOESS Program Acquisition Unit Cost (PAUC) would be exceeded by 15 percent. Since fall 2005, the fundamental structure of the management structure of the management chain at the IPO has been changed to improve lines of communication and reporting. The PEO and Staff were added to work interagency and external activities which allow the SPD to focus on the acquisition process. After further cost and alternatives were analyzed, a subsequent certification notification went to Congress on January 12, 2006, indicating cost growth of greater than 25 percent. This notification begins the Nunn-McCurdy certification process, which requires the Under Secretary of Defense (USD) for Acquisition, Technology and Logistics (AT&L) certify to Congress that 1) such acquisition program is essential to national security; 2) there are no alternatives that provide equal or greater military capability at less cost; 3) the new estimates of the program costs are reasonable; and 4) the management structure for the program is adequate to manage and control costs.

On June 5, 2006, the USD (AT&L) certified to Congress that the NPOESS program met the four Nunn-McCurdy criteria and sent an Acquisition Decision Memorandum (ADM) to the three agencies. The restructured NPOESS program, delineated in the ADM, includes two Engineering and Manufacturing Development (EMD) satellites, with the option, in FY 2010, of exercising a procurement option for two additional NPOESS satellites. The restructured program includes: the Visible/Infrared Imager/Radiometer Suite (VIIRS); Microwave Imager/Sounder; Search and Rescue Satellite Aided Tracking (SARSAT), Cross-track Infrared Sounder (CrIS), Advanced Technology Microwave Sounder (ATMS), Advanced Data Collection System (ADCS), Cloud and Earth Radiant Energy System (CERES) [to be flown on satellite C-1 only]; Ozone Mapping and Profile Suite (OMPS) Nadir and the Space Environment Monitor (SEM). The Conical Scanning Microwave Imager/Sounder (CMIS) is terminated while developing a competition for a new Microwave Imager/Sounder (MIS) starting with the second EMD satellite. The restructured program provides for continuity of existing programs, constellation management flexibility, and the most capability for the least costs, while maintaining growth potential to achieve the original capability envisioned for NPOESS.

Per the Nunn-McCurdy decision, the Aerosol Polarimetry Sensor (APS), Total Solar Irradiance Sensor (TSIS), OMPS Limb, Earth Radiation Budget Suite (ERBS), Altimeter (Alt), Survivability Sensor (SuS) and the Full Space Environment Sensors (SESS) were demanifested. The agencies are working with the Executive Office of the President to evaluate options for restoring the highest priority measurements. NASA and NOAA restored the de-manifested OMPS Limb instrument to the NPOESS Preparatory Project (NPP). NPP is the joint NASA/IPO instrument risk reduction project designed to function as a bridge between the NASA Earth Observing System (EOS) program and NPOESS for development of the ATMS, CrIS, OMPS, and VIIRS sensors. It will additionally serve as an initial checkout of the Command, Control, and Communications for the NPOESS program.

NPOESS was initially designed as a completely U.S. program in all three sun-synchronous orbits, distinguished by early-, mid-, and late-morning equatorial crossing times. NPOESS is now a two-orbit rather than three-orbit program that will use data from the European Meteorological Operational (MetOp) satellites provided by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) for the mid-morning orbit. Defense Meteorological Satellite Program (DMSP) satellites will provide flexibility depending on the health of the constellation in either early-morning or mid-morning orbits. The launch schedule for the restructured program is the NPOESS Preparatory Project (NPP) - January 2010; the two EMD satellites C-1 - January 2013 and C-2 January 2016; and an option in FY 2010 for block upgrade satellites C-3 - January 2018 and C-4 - January 2020. Table 3.1 summarizes the instruments originally and currently scheduled for the NPOESS orbits.

OTHER AGENCY PROGRAMS

For FY 2008, the Department of Agriculture (USDA) requested $48.8 million for meteorological operations and supporting research. Operationally, the USDA supports specialized weather observation networks and also conducts an active supporting research program to ensure an abundance of high-quality agricultural commodities, while minimizing the adverse effects of agriculture on the environment. Under supporting research, USDA focuses on the interactions of weather and climate with plant and animal production and water resources management.

The Department of the Interior's (DOI) FY 2008 request of $2.4 million is primarily to support the Bureau of Land Management's Remote Automatic Weather Station (RAWS) program.

The Environmental Protection Agency (EPA) budget request for FY 2008 is $9.0 million, the same amount as in FY 2007, to provide user-appropriate and scientifically credible air-quality and meteorological programs and models to support regulatory applications.

NASA's FY 2008 request is for just over a total of $168.7 million--over $2.3 million for operations and over $166.4 million for supporting research. These funding levels are composed of the estimated meteorology share of the supporting research and analysis programs as well as Earth Observing System (EOS) and Earth Probe instruments, EOS science, and the EOS Data Information System elements of the NASA Office of Earth Science budget.

The Nuclear Regulatory Commission's (NRC's) request for $120,000 in FY 2008 is for operations. The NRC will dedicate these funds to obtain and analyze meteorological data and information related to siting new nuclear power plants and safe operation of nuclear facilities, to the protection of public health and safety, and protection of the environment.

FEDERAL COORDINATION (See Appendix A for complete details.)

NATURAL DISASTER REDUCTION

INTERDEPARTMENTAL HURRICANE CONFERENCE

The OFCM annually hosts the Interdepartmental Hurricane Conference (IHC) to provide a forum for the responsible Federal agencies, together with representatives of the user communities such as emergency management, to review the nation's hurricane forecast and warning program and to make recommendations on how to improve the program. The OFCM hosted the 61st IHC in New Orleans, Louisiana, March 5-9, 2007. The theme of the 2007 conference was *The Nation's Hurricane Program: An Interagency Success Story*. The conference attendance was more than 190 for the eighth consecutive year. VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Under Secretary of Commerce for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA), set the tone for the meeting during his Monday afternoon keynote address-*The Nation's Hurricane Program: An Interagency Success Story*. He also paved the way for the rollout of the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*, one of the conference's principal objectives, by stating that the plan provides a comprehensive strategy to help meet the needs of the tropical cyclone warning and forecast centers and guide improvements in the nation's tropical cyclone forecast and warning program over the next decade. Objectives of the 2007 IHC included the following: (1) review the nation's tropical cyclone forecast and warning program from end-to-end, and update the *National Hurricane Operations Plan* for 2007; (2) evaluate the 2006 Joint Hurricane Testbed (JHT) results and successfully transition research results into operations, as well as potential candidates for 2007 and beyond; and (3) address and build upon the actions and results from the 60th IHC [rollout the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead* and begin addressing recommendations; and examine how hazard risk reduction improvements can be made through stronger partnerships and alliances]. The IHC proved to be an extremely valuable forum to bring the operational and research communities together to produce the best possible tropical cyclone forecast and warning program, to address the needs of the Federal agencies and user communities that have a stake in the nation's tropical cyclone program, and also to build interagency consensus for the new strategic research plan for tropical cyclones. Actions resulting from the conference are: (1) publish the *2007 National Hurricane Operations Plan* by May 15, 2007; (2) establish the Working Group for Tropical Cyclone Research to implement the recommendations of the new strategic research plan for tropical cyclones; (3) implement the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead* [develop a succinct 10-year implementation plan to address the strategic plan's research priorities and update annually; and establish a joint action group to develop a strategic/implementation plan for improved tropical cyclone reconnaissance and surveillance systems]; (4) work with diverse user groups to develop and test message format modifications (60th IHC action) [improved formats and products based on the latest communications technologies should be investigated (a related effort included a collaborative technical workshop, hosted by Texas A&M University in December 2006, to ensure that the new NWS storm-based (polygon) warnings meet the needs of both the public and private sector); two types of messages should be considered (technical and actionable); empirical research should be encouraged and supported to develop and test modifications to current terminology used to define levels of hurricane threat (e.g., watch, warning, CAT 1-5, etc.); current status (work ongoing)]; and (5) the OFCM will coordinate bringing together the appropriate Federal agencies to begin the process of reviewing and improving the national hurricane warning "system" (60th IHC action) [all elements of the full end-to-end "system" (e.g., protocols, responsibilities, NGOs, communications, etc.); current status (completed exploratory review at two locations-Charleston County, SC, and Mobile County, AL; final report is currently being drafted; the results of the 61st IHC workshop, *Hazard Risk Reduction through Stronger Partnerships and Alliances*, provided additional insights into ongoing efforts related to this action item)]. In May 2007, the 45th edition of the *National Hurricane Operations Plan (NHOP)*, which provides the basis for hurricane reconnaissance for the 2007 season and details Federal agency responsibilities, operations, and procedures; products; aircraft, satellite, radar, and buoy data collection; and marine weather broadcasts, was published based on the inputs and discussions from the 61st IHC. The comprehensive *NHOP* was critical to ensuring successful weather and reconnaissance operations for the 2007 hurricane season. The 2008 IHC is being planned for Charleston, South Carolina.

TROPICAL CYCLONE RESEARCH AND DEVELOPMENT PLAN

The tropical cyclone forecast and warning program is an interdepartmental collaboration to provide the United States and designated international recipients with forecasts, warnings, and assessments concerning tropical and subtropical weather systems. The three centers that cooperate to provide the operational forecast and warning services are the Tropical Prediction Center/National Hurricane Center (TPC/NHC), the Central Pacific Hurricane Center (CPHC), and the Joint Typhoon Warning Center (JTWC). The plan, *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*, was published in February 2007, and provides a strategy for continuing to improve the effectiveness of operational forecasts and warnings through strategic coordination and increased collaboration among the major players in the operational and research and development (R&D) communities. The plan represents extensive efforts by the Joint Action Group for Tropical Cyclone Research (JAG/TCR), established by the Federal Coordinator for Meteorological Services and Supporting Research in 2005, to respond to a principal action item, proposed at the 58th Interdepartmental Hurricane Conference in 2004, to develop a comprehensive strategy for tropical cyclone R&D to guide interagency efforts over the next decade. The action item was reviewed and supported by both the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) in November 2004, and the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) in December 2004. The plan notes that vast improvements in tropical cyclone prediction are attainable with focused research efforts; enhanced transition of research to operations capabilities; and strong interagency partnerships, coordination, and planning. The capability to gain skill in forecasting rapid intensity changes and to improve predictions of hurricane intensity and structure, sea state/storm surge, and precipitation is currently on the horizon, much as improving hurricane track was two decades or so ago. The ultimate goal is to prevent loss of life and injuries and to reduce the nation's vulnerability to these potentially devastating storms. This goal can and must be accomplished for the good of the nation.

EXPLORATORY REVIEW

During this period, the OFCM conducted an exploratory review, a first step in an end-to-end assessment of our national warning system for natural and technological hazards (with an initial focus on tropical cyclones). The exploratory review was responsive to an Interdepartmental Hurricane Conference action item as well as a recommendation of the *Interagency Strategic Research Plan for Tropical Cyclones-The Way Ahead*. It was performed in two locations prone to tropical cyclones-Mobile County, Alabama, and Charleston County, South Carolina. The emphasis of the review was on the tropical cyclone information flow from the emergency management community to the various organizations and entities and citizens of a community. The objectives of the exploratory review were to: (1) understand and document the information flow; (2) summarize information flow requirements and gaps; and (3) provide follow-on considerations to improve the flow that would ultimately aid in saving lives, reducing injuries, and protecting property. The review noted that the majority of citizens receive tropical cyclone information through one or more communications means: television, radio, newspaper media; computer internet and email; and NOAA Weather Radio. The review also noted the need to continue efforts to ensure the poor, elderly, disabled, non-English speaking, individuals with medical concerns, and those in outlying areas receive vital tropical cyclone information. The review also noted that NOAA Weather Radio should be used as much as possible to disseminate evacuation notices as well as tropical cyclone and other weather warnings; community-based organizations such as churches, civic groups, and neighborhood associations should be encouraged to form notification call trees to further disseminate information; and Mobile and Charleston Counties and the entire network of public and private entities involved in improving the public alert and warning system must continue to account for the entire demographics of the at-risk population. The OFCM is preparing the report for the exploratory review which the office has begun, with an initial focus on tropical cyclones, in an end-to-end assessment of our national warning system for natural and technological hazards. The report will include recommendations for future work and inclusion of information dissemination issues for other hazards such as tornadoes and human-caused hazards.

URBAN METEOROLOGY

NATIONAL WILDLAND FIRE WEATHER NEEDS ASSESSMENT

An important contribution to urban meteorology during the period of this report is related to the *National Wildland Fire Weather Needs Assessment* which is being conducted by OFCM. The formation of the Joint Action Group for National Wildland Fire Weather Needs Assessment (JAG/NWFWNA) and conduct of the assessment is responsive to ICMSSR Action Item 2005-1.1 where ICMSSR "concurred that OFCM should move forward to form a Joint Action Group (JAG) under the Committee for Environmental Services, Operations, and Research Needs (CESORN), to review the needs and requirements for wildland fire weather information, to include identifying organizational responsibilities and addressing the following issues: data collection, fire weather research, weather forecast services, data assimilation, air quality, information dissemination, education and outreach, and user response." An abundance of accumulated biomass in forests and rangelands, persistent drought conditions, and encroaching urbanization are contributing to larger, more costly wildland fires; and to effectively manage and suppress wildland fires, fire managers need timely, accurate, and detailed fire weather and climate information. 2005 and 2006 were record years for acres burned; acres burned have trended upwards more than 100 percent since the mid-1980's; and wildland fire suppression, preparedness, fuels management, and other activities receive approximately $2.7 billion in Federal annual funding.

An important benchmark is the June 2005 Western Governors' Association

(WGA) meeting where they approved Policy Resolution 05-04: National Wildland Fire Weather Program. Within the policy, the WGA urged NOAA to have the OFCM complete a *National Needs Assessment Report* of Federal, state, and local fire managers' needs for weather information in their wildfire and prescribed fire decision making processes and a framework to meet those needs by the National Weather Service and Predictive Services. The JAG/NWFWNA was established in December 2005, and has moved forward to conduct the assessment. The OFCM conducted a Special Session on wildland fire weather and climate use in decision making at the 3rd International Fire and Ecology Congress, November 14, 2006, in San Diego, California; briefed the Interdepartmental Committee for Meteorological Services and Supporting Research at its July 18, 2006, and May 31, 2007, meetings; presented a summary of user needs and issues at the June 10-12, 2007, Western Governors' Association meeting in Deadwood, South Dakota; and is completing a detailed report of user needs and issues, and a framework to meet the needs. In connection with this activity, the Chairman of the Western Governors' Association, Governor M. Michael Rounds, in a June 26, 2007 letter, thanked the Federal Coordinator and the OFCM team for the great work on the wildland fire needs assessment, and for the Federal Coordinator's presentation of the initial assessment to the governors at the WGA Annual Meeting in Deadwood, South Dakota.

CLIMATE

The OFCM supports the U.S. Climate Change Science Program (CCSP). The OFCM arranged for the former Director of the CCSP to brief the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) so that member agencies can stay abreast of the program and coordinate priorities for atmospheric requirements through the OFCM for inclusion in CCSP, and forwarded to the CCSP results of a Climate Services Survey to identify new climate products and services that have been developed and implemented since the Board on Atmospheric Sciences and Climate defined "climate services" in 2001, as "the timely production and delivery of useful climate data, information, and knowledge to decision makers." Also the Federal Coordinator, through his participation on the Committee on Environment and Natural Resources (CENR), reviewed and provided concurrence on a number of U.S. CCSP Synthesis and Assessment Products

Additionally, the OFCM is preparing for a meeting of the Committee for Climate Analysis, Monitoring, and Services which will be centered on extreme weather events. The goal is to be proactive in answering a number of questions, to include:

- Are the numbers and magnitude of extreme weather events on the increase?
- Can these extreme weather events be related to climate change?
- What is our capability to model and forecast these extreme events?
- Do our climate models have any skill in forecasting extreme events?
- What are the needs and requirements for climate services related to extreme weather events?
- What are the gaps in our capabilities to meet these needs?
- What will it take to fill these gaps-more research (basic and applied), more/better observations, improved models, etc.?

WEATHER INFORMATION FOR SURFACE TRANSPORTATION

Since 1998, the OFCM has made weather services and research and development (R&D) activities supporting the surface transportation community a priority for the Federal meteorological community. In December 2002, the OFCM published the comprehensive report, *Weather Information for Surface Transportation-National Needs Assessment Report*, which provides the first-ever compilation and analysis of weather support needs across six surface transportation sectors (roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations). In August 2004, OFCM established the Working Group for Weather Information for Surface Transportation (WG/WIST) to develop both a *WIST R&D Plan* and a *WIST Implementation Plan*. The OFCM also conducted two WIST workshops June 6-7 and June 13-14, 2006, with the objectives to: (1) help determine the priorities for the surface transportation weather information research needed to provide improved weather information and services to the surface transportation community; (2) gather and crossfeed information concerning ongoing or planned (next 3 years) surface transportation weather-related research and development; and (3) hear from workshop attendees on what they see as a vision (3-10+ years) on how weather information will be used to optimize surface transportation operations and safety, and what specific hurdles must be overcome to reach such a vision. Information from these workshops has been reviewed and organized to support continued progress in this important area, which will lead to the *WIST R&D Plan* and *WIST Implementation Plan* mentioned above. In addition, in August 2006, OFCM published the report, *Weather Information for Surface Transportation-Update on Weather Impacts and WIST Results*. This update focused on the status of transportation weather issues in the nation and the results achieved since the first WIST report in 2002. It also highlighted areas where further steps can be made in the near term. When statewide transportation incident reporting systems are implemented, we will be able to monitor, assess, and manage transportation weather risks, as well as evaluate the benefits of WIST-informed transportation decisions. R&D programs are in progress to improve warnings and decision support systems, implement weather-responsive traffic management in communities, and provide the observational support necessary for location-specific WIST

During the period of this report, OFCM attended and participated in the National Research Council Transportation Research Board (TRB) 86th Annual Meeting in Washington, D.C., January 21-25, 2007; the Intelligent Transportation Society of America (ITS-A) 2007 Annual Meeting and Exposition in Palm Springs, California, June 4-6, 2007; and the Mid-Continent Transportation Research Symposium in Ames, Iowa, August 16-17, 2007.

Very importantly, from July 25-27, 2007, OFCM and the Federal Highway Administration Road Weather Management Program cosponsored the Third National Symposium on Surface Transportation Weather in Vienna, Virginia. The symposium theme was *Improving Commerce and Reducing Deaths and Injuries through Innovative, Weather-related R&D and Applications for the Surface Transportation System*. The goal of the symposium was to advance the state of the surface transportation weather enterprise, including the use of weather and climate information to support decision making, safety, and productivity within the six surface transportation modes and related industries. Objectives were to: (1) Articulate a clear observation strategy for surface transportation weather that defines the types of data that are needed and the optimal mix of observing platforms required to meet those needs; (2) Identify the priorities, challenges, and opportunities for research and development that will contribute to saving lives, reducing injuries, and improving efficiency in the nation's surface transportation infrastructure; (3) Define the needs for advanced computing capacity required for surface transportation weather modeling and for the assimilation of data from multiple data sources; (4) Identify the needs for new products and services driven by current operations or concepts for future surface transportation systems; (5) Investigate opportunities to document and substantiate the socioeconomic impacts of improved surface transportation weather products and services; (6) Identify the potential and emerging information dissemination technologies available to get the "right message" to surface transportation weather stakeholders; and (7) Establish partnerships with the stakeholder community to ensure that customers and stakeholders understand how to effectively use surface transportation weather products and services in their decision-making processes.

Information stemming from the eight symposium sessions was summarized into categories that cut across many of the sessions. The categories are: current and emerging capabilities and transition of research to operations activities to improve products and services; getting the right message out-need for social science involvement; education and outreach; need for metrics to measure success and guide resource allocation; gaps and research priorities; and opportunity for a near-term intermodal initiative. Action items from the symposium are:

- The background work has been done and there is a need for more significant interagency coordination and support.
- Within the OFCM infrastructure, ICMSSR should consider raising the level of agency representation for WG/WIST to a level more appropriate for supervising work that falls within and under the WG/WIST's purview.
- The community should seriously consider requesting OFCM-sponsored Joint Action Group(s) be formed to accomplish actions outlined below. The JAG(s) would be aligned under the WG/WIST.
    - Develop an integrated observing strategy to include identification of critical new surface transportation weather and road condition sensor needs.
    - Establish several high-level R&D priorities for agencies to focus on and to collaborate with the academic community and the private sector.
    - Improve interagency coordination of products and services for common applications (joint use/cross-feed/new requirements).
    - Consider sponsoring a multi-mode surface transportation weather demonstration project (road/rail/maritime/pipeline/etc.).
    - Conduct socioeconomic surveys of impacts and needed format/semantic changes to improve understanding and usability of required products and services.
    - Consider fast tracking a Post-Doctoral position assigned to the National Centers for Environmental Prediction/Environmental Modeling Center, focused on surface transportation needs for modeling and prediction and products and services.

Subsequent to receiving a summary of the symposium, Mr. Jeffrey N. Shane, Undersecretary of Transportation for Policy, U.S. Department of Transportation, especially noting the research priorities detailed in the summary, stated that he is working hard to scope out some fresh approaches to financing and program organization for surface transportation weather. Mr. Shane also noted that this could be an important opportunity to "mainstream" our weather-related research and ensure a more predictable funding stream.

SPACE WEATHER

It was noted at the November 16, 2004, and December 1, 2004, meetings of the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) and Federal Committee for Meteorological Services and Supporting Research (FCMSSR), respectively, that the National Space Weather Program (NSWP) was nearing the end of its 10-year period to accomplish its overarching goal to achieve an active, synergistic, interagency system; providing timely, accurate, and reliable space weather warnings, observations, specifications, and forecasts by 2007. It was also noted that it was time to perform an interagency assessment to look at the progress toward meeting its goals. A National Space Weather Program Assessment Committee was formed by OFCM to perform the assessment, which was led by Dr. Louis J. Lanzerotti, Distinguished Research Professor, Center for Solar-Terrestrial Research, New Jersey Institute of Technology. The charge to the Assessment Committee was to review the NSWP to quantify and document the progress toward meeting the NSWP stated goals in observations, research, modeling, transition of research to operations, and education and outreach; to see if the program is still on target and moving in the direction pointed to by the *Strategic Plan*; to determine whether the strategic goals should be adjusted at this time based on emerging/evolving requirements; and to suggest a way ahead which will form a basis for a new strategic plan covering the next 10 years. The committee's activities in conducting the assessment included briefings at OFCM; visits to the National Security Space Office, National Reconnaissance Office, NOAA's Space Environment Center, U.S. Geological Survey, Air Force Space Command, Air Force Weather Agency, Air Force Space Weather Operations, STRATCOM, and Air Force Research Laboratory; community and user questionnaires; and issuance of a September 2005 interim report. Important reference sources were the *National Security Space Architecture 2000: Space Weather Architecture*; U.S. Department of Commerce Service Assessment, April 2004; and the *National Academies report, The Sun to the Earth-and Beyond: A Decadal Research Strategy in Solar and Space Physics, 2002*.

In its R*eport of the Assessment Committee for the National Space Weather Program* (June 2006), the Assessment Committee concluded that, since the program's inception in 1995, it has had a number of noteworthy achievements, most of which likely would not have been attained without the program's existence. The committee also found shortfalls in the program. The report identified the significant potential of the NSWP to enhance the nation's space weather mission through improved operational capabilities, which capitalize on the transition of innovative research. Moving NOAA's operational space weather prediction center (i.e., the Space Environment Center) from its research organization to the National Weather Service was a positive step to improve operational focus within the NSWP. The committee made a number of recommendations to further strengthen the NSWP in the areas of (1) centralized program management, national priorities, and increased effectiveness; (2) continuity of data sources; (3) strengthening the science-to-user chain; and (4) public and user awareness of space weather.

It was agreed that the *Report of the Assessment Committee for the National Space Weather Program* should proceed for consideration by the National Space Weather Program Council (NSWPC), and that the Program Council should be the executive agent for FCMSSR for continuing activities in this area. The NSWPC has accepted the report and has begun taking actions to address the report's recommendations.

Space weather activities include continuing to implement the recommendations of the *Report of the Assessment Committee for the National Space Weather Program*, and creating a Space Weather Implementation Plan (SWxIP) as requested by the Committee on Environment and Natural Resources (CENR) Subcommittee for Disaster Reduction (SDR). Space weather was identified as one of the SDR's Grand Challenges for Disaster Reduction and SDR requested that the OFCM spearhead an effort, through the NSWP, to develop the SWxIP.

The OFCM also sponsored the American Meteorological Society policy workshop on "Integrating Space Weather Observations and Forecasts into Aviation Operations" which was held November 29-30, 2006, in Washington, D.C., that led to recommendations on how to improve the safety and operations of the aviation system through better integration of space weather information. The workshop revealed that there are four main policy issues that need to be addressed to ensure the best use of current space weather information: communication, standardization of information and regulations, education and training, and cost benefit and risk analysis. The report of the policy workshop was issued in March 2007; it provided detailed recommendations for each of the main policy areas.

The OFCM also formed a Joint Action Group for Space Environment Sensors (JAG/SES) to address guidance from the Office of Science and Technology Policy (OSTP), requesting that the OFCM conduct, through its Federal coordinating infrastructure, an assessment of the impacts on the National Space Weather Program of Nunn-McCurdy certification of the National Polar-orbiting Operational Environmental Satellite System

(NPOESS) program, which resulted in a significant decrease in the capability of the space environment sensor (SES) suite previously manifested on NPOESS. The assessment will be completed in the fall of 2007.

On April 4-5, 2007, the OFCM participated in the first-ever Space Weather Enterprise Forum which was held in Washington, D.C. NOAA and NASA, in cooperation with partner agencies, sponsored the forum to address the economic, societal, and national security impacts of space weather with a principal focus on assessing the growing future needs of a rapidly growing technological world economy. Special focus was given to the impact of space weather on national security, aviation, communications, global positioning system applications, spacecraft operations, space exploration, and electric power grids. The OFCM also participated in Space Weather Workshop April 24-27, 2007, in Boulder, Colorado. The Space Weather Workshop, which was sponsored by NOAA's Space Environment Center and partners, is for users and researchers interested in space weather.

PHASED ARRAY RADAR

The OFCM Joint Action Group for Phased Array Radar Project (JAG/PARP) completed the report, *Federal Research and Development Needs and Priorities for Phased Array Radar* (June 2006). It is responsive to ICMSSR Action Item 2004-2.3 where ICMSSR supported the joint action group's "continued work to identify and document the potential needs and benefits that phased array radar and an adaptive radar sensing strategy would address, and to integrate those identified needs into a multiagency-coordinated R&D plan that would focus R&D efforts on meeting each agency's need." The report identified research and development for the next 9 years to capitalize on the replacement opportunity. This would include research to reduce risk, determine the capability of multifunction phased array radar (MPAR) to meet multiple user needs concurrently, develop a full MPAR prototype, and perform a cost analysis to determine system affordability. Delays in performing the necessary MPAR research, development, and testing could result in a missed opportunity to replace legacy radars. At its July 18, 2006, meeting, ICMSSR decided that an MPAR interagency working group should be established within the OFCM infrastructure with a defined charter to develop a strategy to address the key findings and recommended next steps in the MPAR report, and agency comments from the ICMSSR meeting. The Working Group for Multifunction Phased Array Radar (WG/MPAR) was established in September 2006. Cochairs for WG/MPAR are Dr. James F. Kimpel, Director of the NOAA National Severe Storms Laboratory (NSSL); Col Michael Babcock, USAF, Air Force Weather Deputy for Federal Programs; Mr. James H. Williams, Director of Systems Engineering for the Federal Aviation Administration; and Mr. Kevin "Spanky" Kirsch of the Science and Technology Directorate, Department of Homeland Security.

Benefits of an affordable MPAR include: potential replacement for the aging fleet of mechanically scanning radars over the next 20 years; allows consolidation of multiple single-mission radars into a single system, reducing the national radar fleet by more than 40 percent, saving nearly $5 billion over a 30-year lifecycle; provides both air and weather surveillance from a single radar site; no moving parts, lower maintenance costs; multiple transmit/receiver components, avoiding single point of failure; scalable design of prototype will provide proof of concept for future MPAR; better weather measurements; increased safety and capacity in severe weather conditions; terminal and en route surveillance; homeland security; and discrimination of non-meteorological hazards such as volcanic ash, airborne debris, smoke detection and tracking, and biological scatterers such as bird flocks.

Future efforts include: (1) Develop an affordable MPAR prototype for civilian use; (2) Refine radar requirements and lay the groundwork for MPAR cost/benefit analysis; (3) Implement the 9-year research and development plan proposed in the report, *Federal Research and Development Needs and Priorities for Phased Array Radar*; (4) Establish contacts and initiate partnerships with industry leaders in phased array technology; (5) Coordinate agency programming for the MPAR risk reduction effort; (6) The Board on Atmospheric Sciences and Climate evaluation of the MPAR planning process to date, *Evaluation of the Multifunction Phased Array Radar Planning Process*; (7) The MPAR Symposium, October 10-12, 2007, in Norman, Oklahoma, which will engage Federal stakeholders, academia, and industry; (8) Working Group for Multifunction Phased Array Radar (WG/MPAR) continue to refine user requirements; and (9) solidify technical requirements for the MPAR system, including engineering trade studies to balance user needs with lowest cost.

In a June 1, 2007 letter of commendation to the Federal Coordinator, Brig Gen Lawrence A. Stutzriem, USAF, Director of Weather, emphasized that MPAR will have a direct influence on the Air Force's capabilities. He also noted that other relevant, important projects in which OFCM is engaged include space weather, wildland fire, tropical cyclones, weather information for surface transportation, and volcanic ash. Also, in a January 31, 2007, Program Decision Memorandum issued by VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Undersecretary of

Commerce for Oceans and Atmosphere and NOAA Administrator, the Admiral emphasized evaluating the electronically steered MPAR as an alternative to mechanically steered conventional radar to meet severe and non-severe weather and aviation weather service requirements and to track the release of toxic agents as input into atmospheric dispersion forecasts; and, also, if the technical trade-off study and preliminary cost-benefit analysis support transitioning MPAR to operations, development of a transition plan for this purpose. The Program Decision Memorandum also included highlights for OFCM's hurricane, wildland fire, and weather information for surface transportation activities.

ATMOSPHERIC RESEARCH AND DATA ASSIMILATION/DATA MANAGEMENT

Advances in data assimilation are key to meeting virtually any forecast goal relating to model performance. It was stated in the *Strategic Plan for the U.S. Integrated Earth Observation System* (April 2005) that "In order to take the 'pulse of the planet,' we must establish a valid end-to-end process that will take us from observations to user-related products. Scientific needs for this end-to-end process require that we … assimilate the Earth observation data streams into models (eventually in real time) …" and "Data assimilation may be the most critical path through which advances in forecasting convective precipitation will be modulated." At its November 16, 2004, meeting, the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) supported action to examine gaps in data assimilation and data management capability, articulate challenges that lie ahead in meeting future requirements, and propose strategy to address gaps in capability and future challenges. And Action Item 2004-1.2 from the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) December 1, 2004, meeting, recommended that: FCMSSR agencies will support R&D needs and requirements based on agency priorities and will continue to identify issues and concerns that are necessary for the development of capabilities required to realize societal benefits; Federal requirements and capabilities in key areas like data assimilation need to be surveyed and further addressed; and FCMSSR agencies will support and facilitate opportunities for the transition of research into operational applications.

The data assimilation survey and follow-on strategy was briefed at the July 18, 2006, ICMSSR meeting. It was noted that the focus of the report which is being prepared is on data assimilation for the purpose of improving forecast skill of a numerical weather prediction (NWP) model; the scope of data assimilation is restricted to incorporation of observational data as a forcing factor in cycles of forward NWP models; and broader definition of data assimilation would be addressed through inclusion of related activities such as climate reanalysis, trace constituent monitoring, and air quality. Key data assimilation issues are:

- Data delivery and standard formatting.
- How best to evolve assimilation techniques over time to meet future application challenges.
- Early delivery of new instrument data.
- Testing and transitioning new data assimilation techniques and concepts into "hardened" data assimilation instruments for operational use.
- Availability of high performance computing and trained personnel.
- Data staging and delivery required for Global Earth Observation System of Systems (GEOSS)-level infrastructure capability.
- Education and public outreach: implications for data assimilation and modeling.

Data gathering and data assimilation activity analysis tasks are essentially complete; the report framework and key issues have been defined by the data assimilation group; and next steps are being defined. The draft report, *Federal Meteorological Data Assimilation Capabilities*, will be coordinated with ICMSSR at its November or December 2007 meeting.

CROSSCUTTING HYDROMETEOROLOGICAL ASSESSMENT

During this period the OFCM began a crosscutting assessment of Federal agency hydrometeorological products, services, and supporting research. The three primary objectives of the assessment are: (1) define the needs and requirements for hydrometeorological products, services, and supporting research for the Federal agencies and the customers they support; (2) investigate agency plans and alternatives for satisfying new requirements; and (3) create more efficient and effective partnerships among the agencies to better leverage subject-matter expertise and resources to meet the growing needs for better hydrometeorological products and services. Agencies which will be involved include: NOAA (National Weather Service and National Ocean Service-principal providers); Department of Interior (U.S. Geological Survey-stream flow, streamgaging, flood monitoring, ground-water climate response network; U.S. Bureau of Reclamation-dams, reservoirs, and *Agrimet* and *Hydromet* operations; U.S. Fish and Wildlife Service-coastal ecosystems; and National Park Service-tourism and natural resource monitoring and management); Department of Agriculture (USDA-drought monitor; National Resources Conservation Service-conservation and watershed planning); Department of Defense (U.S. Army

Corps of Engineers-flood plain management, Gulf Coast Hurricane Protection System); Department of Homeland Security (Federal Emergency Management Agency-National Flood Insurance Program, flood hazard mapping, post-storm data acquisition; U.S. Coast Guard-protect against degradation of natural resources associated with maritime transportation, fishing, and recreational boating); Environmental Protection Agency-water resource protection; and National Aeronautics and Space Administration-remote sensing. A key element of the assessment is to engage the users of this Federal information and the OFCM is ensuring that we understand the needs of user groups such as the National Emergency Management Association, International Association of Emergency Managers, Association of State Floodplain Managers, National Hydrologic Warning Council, American Meteorological Society, and the media (e.g., The Weather Channel and other TV broadcasters).

PUBLICATIONS

The following publications were prepared in hardcopy and/or have been placed on OFCM's Web site (www.ofcm.gov):

- *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2007*

- *National Hurricane Operations Plan*

- *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*

- *Federal Plan for Cooperative Support and Backup Among Operational Processing Centers*

- *The National Volcanic Ash Operations Plan for Aviation and Support of the International Civil Aviation Organization International Airways Volcano Watch*

- *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part A-System Concepts, Responsibilities and Procedures*

- *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part C-WSR-88D Products and Algorithms*

SECTION 1

HYDROMETEOROLOGY PRODUCTS AND SERVICES: A PARTNERSHIP IN PUBLIC SAFETY

INTRODUCTION

Hydrometeorology is the branch of meteorology that focuses on the "ups and downs" of water in the atmosphere, with particular interest in the where, when, how, and how much, regarding precipitating water. Hydrometeorology is the science of how atmospheric water in all its forms-water vapor, liquid, or solid-interacts with the land and with energy fluxes to deliver precipitation (or not deliver it) onto the land below. Whereas traditional hydrology studies what happens to water after it falls out of the sky, hydrometeorology wants to understand and predict the details of this initial "down side" in the global hydrologic cycle. The boundaries of hydrometeorology are not clear-cut, and the problems of the hydrometeorologist overlap with those of the climatologist, the hydrologist, the cloud physicist, and the operational meteorologist. But with its focus on atmospheric water becoming water on or in the ground, hydrometeorology and the products and services it provides are particularly important to managing water resources, including managing the growing risks to our water supply, water quality, healthy stream flows, agriculture, and ecosystems. These products and services are needed to design roads, dams, and waterway systems; manage flood plains; plan and conduct emergency management operations when flooding threatens; and ensure the safety and preparedness of activities ranging from recreation to aviation, construction, and surface transportation system use and management.

The purposes of this article are to: (a) explain what hydrometeorological products and services are and why they and the research that supports them are important; (b) highlight the hydrometeorological products and services available and the collaborating agencies responsible for the collection, maintenance, and operation of the meteorological and hydrological data collection network; and (c) engage the users of this information to ensure we understand their needs. Even though the Federal government is committed to improving the quality and accuracy of hydrometeorology warnings that the public receives, the Federal agencies implementing this commitment will have to work with many public and private organizations to expand existing capabilities and to develop new and innovative ways to further improve public safety.

THE VALUE OF HYDROMETEOROLOGY

The natural processes studied by hydrometeorology influence our economic and social lives in many ways. These processes and the "weather events" that result from them affect the revenues and profits of businesses, large and small. They can disrupt and disorganize communities. As our Nation's population grows and infrastructure costs increase, natural disasters stemming from precipitation patterns can undermine social and economic infrastructures at local and even regional levels.

Our ecosystems are subject to many pressures (e.g., land-use change, resource demands, and population changes); their extent and pattern of distribution is changing; and landscapes are becoming more fragmented. Climate change constitutes an additional factor reflected in hydrometeorological processes - a factor that could change ecosystems and endanger the many benefits they provide to populations and economic activities that depend on them.

Water quality is a critical environmental factor, partly due to the tremendous growth of the Nation's demand for clean water in the context of continuing urban expansion and development. Hydrometeorological processes affect the water resources of the Earth, which makes those processes of interest to both the meteorologist and the hydrologist. Measurements of rainfall, stream flow, and water loss as a result of evaporation-all of which are observations used by hydrometeorologists to issue precipitation rates, stream flow, flood predictions, and drought outlooks-are essential for various applications in connection with water resources planning, drainage design, water quality control, reservoir design and operation, and flood control.

The single hydrometeorological event that has resulted in the largest loss of life is storm surge: rapid rises of sea water and flooding associated with landfalling hurricanes. Storm-surge height can exceed 20 ft (6 m) when strong hurricanes strike a coastline with shallow water offshore. In recent decades, large losses of life due to storm surge have become less frequent. However, the rapid growth of U. S. coastal populations and related infrastructure and the increasing complexity of evacuation have increased the vulnerability of coastal communities. Improved building codes in hurricane-

Article prepared by Mr. Donell Woods, OFCM Senior Staff Meteorologist and Mr. Robert Dumont, OFCM Chief Scientist.

prone regions have greatly reduced fatalities from wind damage, but many fatalities continue to result from tropical cyclone-induced inland flooding. To provide reliable scientific information, the hydrometeorologist measures tide levels, wind direction and speed, barometric pressure, and rainfall rates to describe and forecast inland flooding events.

Figure 1-1. Landslide in La Conchita, California, 2005. (USGS photo)

Landslides (debris flows and debris avalanches) triggered by heavy rain occur in all 50 states and are widespread in the U.S. island territories of Puerto Rico and the U.S. Virgin Islands (Figure 1-1). In the conterminous United States, the areas most seriously affected are the Pacific Coast, the Rocky Mountains, and the Appalachian Mountains. Areas where wildfires or human modification of the land have destroyed vegetation on slopes are particularly vulnerable to landslides and debris flow during and after heavy rains. Flash flood-producing rains falling on steep terrain can weaken soil and trigger catastrophic mud slides that damage homes, roads, and property. Monitoring landslide-producing conditions typically requires extensive networks of ground-based rain gauges and hydrometeorological instruments.

Soil moisture has many possible applications in hydrometeorology, but the primary areas are in runoff and evaporation modeling. Moist ground can have an effect similar to open water in that it can easily absorb solar radiation, with some of the absorbed energy taken up in evaporating water. As a result, neither the ground nor the air above it heats up as much as it would if the ground were dry. However, the evaporated water now becomes part of the atmospheric water content that can feed into subsequent hydrometeorological processes. Runoff and evaporation modeling simulates water infiltration and movement in soils, evaluating precipitation and runoff, drainage, evaporation from the soil surface, and transpiration by vegetation.

Flash floods occur very quickly after the precipitation event that causes them (Figure 1-2). Flash-flood damage and most fatalities tend to occur in areas immediately adjacent to a stream or arroyo. Flash floods are very strong - they can roll boulders, tear out trees, destroy buildings and bridges, and scour out new channels. Rapidly rising water can reach heights of 30 feet or more.

Excessive rainfall that causes rivers and streams to swell rapidly and overflow their banks is frequently associated with hurricanes and tropical storms, large clusters of thunderstorms, supercells, or squall lines. Other types of flash floods can occur from dam or levee failures, or a sudden release of water held by an ice jam (Figure 1-3). Heavy rainfall in the mountains can cause downstream canyon flooding. A deep snowpack increases runoff produced by melting snow. Heavy spring rains falling on melting snowpack can produce disastrous flash flooding. Densely populated areas, in particular, are at a high risk for flash floods. The construction of buildings, highways, driveways, and parking lots increases runoff by reducing the amount of rain absorbed by the ground, increasing the flash-flood potential. *Flash Flood Guidance* is used to predict the occurrence of flash flooding in a specific area based on specified rainfall amounts within a given duration of time. *Flash Flood Warnings* are issued as needed and focus on specific communities, streams, or areas where flooding is imminent or already in progress.

Some examples of hydrometeorolog-

Figure 1-2. Flash flood in Las Vegas, NV, August 19, 2003. (Photo courtesy of Las Vegas Review Journal.)

Figure 1-3. Ice jam around Big Island in Richford, Vermont, March 15, 2007. (Photo courtesy of Richard Heurtley, http://www.richfordvt.net/icejam/index.html)

ical products and services that provide a vital foundation for numerous applications and users, including transportation, agriculture, water supply and flood control, are flood watches and warnings, drought outlook, water supply outlook, ice forecasts, and quantitative precipitation forecasts (QPF). Federal, state, and local agencies are working together to improve these products and services which help mitigate the socioeconomic impacts of hydrometeorological events. Understanding the importance of these products and services requires understanding of how the information is created, communicated, and used. The different perspectives of the hydrometeorological community and its stakeholders, regarding the use of these products and services, are a key consideration as well.

COLLABORATORS AND PARTNERS

Many Federal, state, and local agencies collaborate (in many ways) in providing accurate and updated information to produce these hydrometeorological products and services while avoiding duplication of efforts.

Collaboration enables the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS), an agency under the U.S. Department of Commerce, to fulfill its mission objectives of providing forecasts and warnings for the protection of life and property and of enhancing the national economy. The NWS data and products form a national information database and infrastructure that can be used by other governmental agencies, the private sector, the public, and the global community.

The United States Geological Survey (USGS) is an agency within the Department of the Interior. The USGS Water Resources Division collects and publishes stream flow data. It also provides other hydrologic information to enable better use and management of water resources. The USGS owns and maintains many of the river gages that provide the data needed for the NWS to accomplish its mission. The NWS often installs telemetry devices on USGS river gages to access data remotely which is then shared by the two agencies.

The United States Bureau of Reclamation (USBR) in the Department of the Interior primarily operates dams, power plants, and canals in the 17 western states of the country. The Bureau's mission is to assist in meeting the increasing demand for water in the West while protecting the environment and public investment. The USBR provides the NWS with rainfall and river data along with information about daily outflow from reservoirs. It uses NWS river forecasts and water supply forecasts in operating dams and plants.

The United States Army Corps of Engineers (USACE) provides engineering, management, and technical services to the Department of Defense and other Federal agencies. It is engaged in planning, designing, and operating water control structures (river and harbor navigation, flood control, water supply, hydroelectric power, etc.), and other civil works projects (environmental restoration, wildlife protection, recreation, disaster response, etc.). The USACE provides the NWS with current and forecast reservoir outflows. The NWS also exchanges river stage and precipitation data with the USACE.

The Natural Resources Conservation Service (NRCS), a Federal agency within the U.S. Department of Agriculture, works with local, state, and Federal agencies and with private groups to conserve, improve, and sustain natural resources and the environment. The NWS and the NRCS share and coordinate water-supply forecasting responsibility. The NWS provides hydrometeorological and snow cover data and receives data from the SNOTEL network operated by the NRCS. This network, consisting of 732 automated and 935 manual stations, provides valuable snow depth, snow-water equivalent, and temperature data for high-elevation sites. Many of these remote stations are inaccessible during winter time, but are essential to forecasting snow-melt runoff, which is the largest contributor to river flows in the western United States.

The National Park Service (NPS) of the U.S. Department of the Interior is entrusted to preserve the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout the Nation. The park system consists of 378 areas covering more than 83 million acres in 49 states. Many national parks are part of the Cooperative Observer Network. Cooperative Observer data includes 24-hour precipitation totals, snowfall, soil temperature, evaporation and other parameters important for hydrometeorological products and services. There are many gages located in the parks, and these data are exchanged with the NWS. The NPS use hydrometeorological forecasts for park safety and planning.

The mission of the Bureau of Indian Affairs (BIA) is to enhance the quality of life, to promote economic opportunity, and to carry out the responsibility to protect and improve the trust assets of American Indians, Indian tribes, and Alaska natives. BIA is part of the Department of the Interior. Native American lands are spread across the United States. Cooperation with various tribes is important when dealing with hydrometeorological issues such as flooding, rainfall, and water quality in areas under tribal jurisdiction. Often special consideration will be required to obtain data and disseminate hydrometeorological forecasts or products for these areas.

The Tennessee Valley Authority (TVA) operates the Tennessee River system to provide a wide range of public benefits that depend on accurate and timely hydrometeorological products and services. Among these benefits are year-round navigation, flood damage reduction, affordable electricity, improved water quality and water supply, recreation, and economic growth. TVA operates the dams, locks, and reservoirs of the Tennessee River and its tributaries as one integrated system in order to provide these multiple benefits to the region.

The Joint Agricultural Weather Facility (JAWF), which was created in 1978, is a cooperative effort between U.S. Department of Agriculture (USDA) World Agricultural Outlook Board and NOAA to collect, on an ongoing basis, global hydrometeorological data and agricultural information to determine the impact of atmospheric conditions on crop and livestock production. JAWF reports are followed closely not only by producers, but also by commodity traders.

The International Boundary & Water Commission (IBWC), established by a 1944 Treaty, is responsible for the distribution, regulation, and conservation of the Rio Grande between Mexico and the United States. As a bi-national commission, the commission is also responsible for the joint construction, maintenance, and operations of international storage dams, reservoirs, and hydroelectric plants on the Rio Grande. In addition, the IBWC uses hydrometeorological products and services to regulate the water allocated to Mexico from the Colorado River, protect the lands surrounded by the two rivers by maintaining river and levee projects, and strive to preserve the international boundary between the two countries in a sensitive, timely, and fiscally responsible manner.

The hydrometeorology community's strengths are derived from strong collaborative ties among its programs and with its partners and customers. By working together, the members of this community can reach more people more effectively and achieve the core results of their collective missions: *to save lives and protect property*.

HYDROMETEOROLOGICAL OBSERVATIONS

The NWS owns and operates important components of the Nation's environmental observing capability-radars, data buoys, upper air observing systems, surface observing systems, data collection and distribution systems - which provide real-time hydrometeorological data and contribute to the Nation's climate record. The NWS approach to observing systems explicitly recognizes the multiparty, multidisciplinary, multiplatform, and multipurpose nature of environmental observations and seeks to maximize the effectiveness of all participants through the Global Earth Observing System of Systems (GEOSS). GEOSS will help all involved produce and manage their hydrometeorological information in a way that benefits the environment as well as humanity by taking a pulse of the planet.

Historical stream flow data are essential for the NWS River Forecast Centers (RFC) to calibrate the rainfall-runoff models in the National Weather Service River Forecast System (NWS-RFS). Output from NWSRFS is the basis for NWS river forecasts and flood warnings. A long-term historical record that includes extreme wet and dry periods allows forecasters to define rate-dependent watershed parameters that govern the watershed response to the full range of possible hydrologic conditions. Hydrometeorological monitoring, communications, and computer technology used in stream flow forecast systems have advanced rapidly over the last few years. For operational forecasting, real-time stream flow data allows river forecasters to adjust model states or the projected hydrographs to match observed flows. Projected hydrographs at headwater points are routed downstream along with reservoir releases and intervening local flows. The routed flows must be converted to a stage at each forecast point. Stage-discharge relationships developed and maintained by the USGS and other partners are based on periodic on-site stream flow measurements and are essential to NWS hydrologic forecast and warning operations.

Figure 1-4. Stream gage at the Suwannee River above the Gopher River near Suwannee, Florida (7.6 miles upstream from the mouth of the Suwannee) (USGS photo)

The USGS operates and maintains a nationwide streamgaging network of about 7,000 gages (Figure 1-4). These gages help produce accurate and timely identification of floods and flash floods and their impacts on the ecosystem. The network is supported by funding through the USGS' Cooperative Water Program, the USGS National Streamflow Information Program, other Federal water and environmental agencies, and approximately 800 state and local funding partners. Data from this network are used by a large number of public and private users, including government agencies responsible for water management and emergency response, utilities, environmental agencies, universities, colleges, consulting firms, and recreational interests. Likewise, these users access the data for a wide variety of uses, including decision making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, environmental and watershed management, research, navigation, fishing, and water-based recreation.

Flood mapping studies are extremely important since the Federal Emergency Management Agency (FEMA) uses floodplain maps to establish flood risk zones and require flood insurance, through the National Flood Insurance Program (NFIP), for properties within the 100-year floodplain. Many areas subject to development in the near future are unmapped or have outdated maps. Preventing new development in floodplains, which reduces future flood damage, is the cornerstone of floodplain management.

The Global Precipitation Measurement (GPM) mission (Figure 1-5) is one of the next generations of satellite-based Earth science missions that will study global precipitation (rain, snow, and ice). The Tropical Rainfall Measuring Mission (TRMM) was the first satellite dedicated to rainfall measurement and is the only satellite that carries a weather radar. GPM can improve climate prediction through better understanding of surface water fluxes, soil moisture storage, cloud/precipitation microphysics, and latent heat

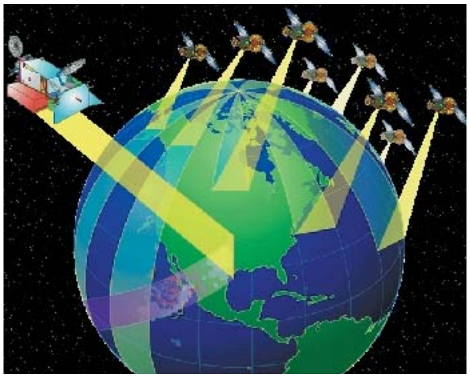


Figure 1-5. GPM is a cooperative mission between NASA, the National Space Development Agency (NASDA) of Japan, and other international partners. Building on the success of the Tropical Rainfall Measuring Mission (TRMM), GPM, via a constellation of small satellites, will continue measurement of global precipitation, a key climate factor. (NASA Goddard Earth Sciences Data and Information Services Center web site)

release in the Earth's atmosphere. It will advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques. These measurements will be used to calibrate dedicated and operational passive microwave sensors with the goal of achieving global sampling. GPM will advance numerical weather prediction (NWP) skills through more accurate and frequent measurements of instantaneous rain rates with better error characterizations and improved assimilation methods. It will advance knowledge about the global water/energy cycle and fresh water availability. Improved measurements of the space-time variability of global precipitation will close the water/energy budget and elucidate the interactions between precipitation and other climate parameters. GPM will improve flood-hazard and fresh-water-resource prediction capabilities through better temporal sampling and spatial coverage of high-resolution precipitation measurements and innovative designs in hydrometeorological modeling.

HYDROMETEOROLOGICAL MODELS AND PREDICTIONS

The National Weather Service River Forecast System (NWSRFS), designed for use in an operational environment, provides stream flow forecasts under a variety of hydrometeorological conditions in river basins, ranging from small systems to large and complex basins. The NWSRFS is used operationally at all thirteen NWS RFCs in the United States and has been implemented in many countries. Some of these implementations consist of more than a thousand data collection stations and hundreds of forecast points. Providing both deterministic and probabilistic forecast capabilities for short-term and long-term forecasting, the NWSRFS offers flexibility in the hydrologic and hydraulic models that can be used to model a basin.

Predicting the precise location, severity, and timing of flash-flooding events from predictions of precipitation or direct observation of rainfall rates is a key goal of hydrometeorology. The Flash Flood Monitoring and Prediction (FFMP) system is an integrated suite of multi-sensor applications which detects, analyzes, and monitors precipitation and generates short-term warning guidance for flash flooding automatically within Advanced Weather Interactive Information Processing System (AWIPS). FFMP will provide forecasters with accurate, timely, and consistent guidance and will supplement forecaster event monitoring with multi-sensor, automated event monitoring. The intended benefits are: longer lead times on warned events, fewer missed events, increased forecaster situational awareness, and reduced forecaster fatigue during warning situations. FFMP is a collaborative effort involving the NWS, the National Severe Storms Laboratory (NSSL), and the National Center for Atmospheric Research (NCAR). The focus of FFMP is on improving the accuracy and timeliness of warnings (severe thunderstorm, tornado, flash flood, etc) issued by NWS forecasters, through the development of automated warning guidance.

The Hydrometeorology Testbed (HMT) is a concept aimed at accelerating the infusion of new technologies, models, and scientific results from the research community into daily NWS and RFC hydrometeorological forecasting operations. Unlike typical research field projects, the HMT will operate as a demonstration with forecasters and researchers joining forces in an operational setting. An HMT plan now being formulated, under the auspices of NOAA's Weather and Water mission goal, targets California's flood-vulnerable American River Basin for the first full-scale deployment of this highly instrumented facility, (starting in the second half of this decade). Following the California demonstration, HMT facilities will be sequentially deployed to other regions of the Nation to address additional serious hydrometeorology problems that are unique to those locations. Hydrometeorological products and services are improving predictions of California's heavy winter rains, monitoring air, water and soil; to help water resource managers prevent catastrophic flooding in the Sacramento region.

INFORMATION DISSEMINATION

Hydrometeorological products, such as Quantitative Precipitation Forecasts (QPF), heavy snow forecast, soil moisture, and snow-water equivalent just to name a few, reach a broad spectrum of customers, including emergency and water resource managers. Emergency managers use this information for both strategic, long-term planning and tactical, short-term planning. RFCs also provide river forecasts to water resource managers, who make critical decisions that affect flood control, water supply, water quality, river and lake transportation, irrigation, hydropower, and recreation, as well as maintain the ecological health of the rivers.

The NWS' Advanced Hydrologic Prediction Services (AHPS) suite is a new and essential component of climate, water, and weather services. AHPS is a web-based suite of accurate and information-rich forecast products. They display the magnitude and uncertainty of occurrence of floods or droughts from hours, to days and months in advance. These new products will enable government agencies, private institutions, and individuals to make more informed decisions about risk-based policies and actions to mitigate the dangers posed by floods and droughts. AHPS provides better hydrometeorological information to water managers and city officials, helping them make water-allocation and economic-related decisions, such as when and where to evacuate, how to use reservoir storage capacity and releases, and when to reinforce levees and to what level.

The Hydrometeorological Automated Data System (HADS), is a real-time data acquisition and data distribution system operated by the NWS Office of Hydrologic Development. HADS exists in support of NWS activities of national scope, specifically the Flood and Flash Flood Warning programs administered by the weather service forecast offices and the operations performed at RFCs throughout the United States. The hydrometeorological data acquisition aspect of HADS involves the receipt of raw hydrological and meteorological observation messages from Geostationary Operational Environmental Satellites (GOES) Data Collection Platforms (DCPs). Raw DCP messages are received in a nearly continuous flow from Wallops Island. Every 3 minutes (beginning on the hour) the HADS processor program translates raw information into Standard Hydrometeorological Exchange Format (SHEF) products.

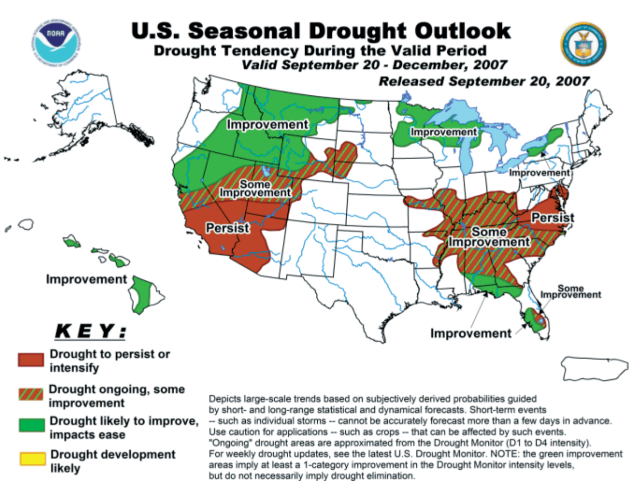
ALERT (Automated Local Evaluation in Real-Time) and IFLOWS (Integrated Flood Observing and Warning System) are automated flood warning systems which provide real-time precipitation data in many parts of the country. Basically, both systems use line-of-sight radio communications to transmit data via networks of transmitters, repeaters, and base stations. Both ALERT and IFLOWS use tipping-bucket gages which measure rainfall in 1 mm (about 0.04 inch) increments. The higher capacity tipping bucket performs better during heavy rainfall events than smaller mechanisms. The purpose of these systems are to reduce the annual loss of life from flash floods, reduce property damage, and reduce disruption of commerce and human activities.

The National Integrated Drought Information System (NIDIS) is a Drought Early Warning System. The system provides water users across the board - farmers, ranchers, utilities, tribes, land managers, business owners, recreationalists, wildlife managers, and decision-makers at all levels of government - with the ability to assess their drought risk in real time and before the onset of drought, in order to make informed decisions that may mitigate a drought's impacts. Recognition of droughts in a timely manner is dependent on our ability to monitor and forecast the diverse physical indicators of drought, as well as the relevant economic, social, and environmental impacts. NIDIS will coordinate and integrate a variety of observations, analysis techniques and forecasting methods in a system that supports drought assessment and decision-making at the lowest geopolitical level possible. The tools allow users to access, transform and display basic data and forecasts across a range of spatial and temporal scales most suited to their individual needs.

IMPROVING HYDROMETEOROLOGY: CURRENT AND PLANNED RESEARCH

The National Oceanic and Atmospheric Administration's National Severe Storms Laboratory (NSSL) continues to be a pioneer in the area of research and development. NSSL research serves society's needs for weather and water information by developing methods to monitor and predict floods and flash floods. For many years, the lab has researched the use of dual polarization radar to improve precipitation measurements. The more precise measurements of the spatial distribution of precipitation rates made possible by this technique will help forecasters provide more accurate and timely warnings for flash floods--the number one severe weather threat to human life. NSSL researchers are also adapting phased array radar, a state-of-the-art radar technology used by the military, to perform multiple observing tasks simultaneously and to detect the types of severe weather of interest to hydrometeorologist. For example, a phased array radar can do a full-volume scan in less than one minute, compared with 4-5 minutes for the current generation of weather radars. At the same time, this new radar can focus in on local storm conditions that may produce the heavy precipitation likely to cause a flash flood or landslide in a small part of the radar's search area. The next-generation quantitative precipitation estimates (QPE) (Q2) continues NSSL's departure from radar-centric precipitation estimation and moves toward a multi-sensor approach focused on high-resolution integration of radar, satellite, model, and surface observations to produce very high-resolution precipitation estimates. NSSL manages and maintains a national flash-flood-scale hydrologic geographic information system (GIS) dataset in support of the NWS AWIPS Flash Flood Monitoring and Prediction (FFMP) system for assisting forecasters in flash-flood warning decisions.

In support of the mission of the U.S. Geological Survey (USGS), its National Research Program (NRP) conducts basic and problem-oriented hydrologic research. The program has grown to encompass a broad spectrum of scientific investigations. The sciences of hydrology, mathematics, chemistry, physics, ecology, biology, geology, and engineering are used to gain a fundamental understanding of the processes that affect the availability, movement, and quality of the Nation's water resources. The NRP encompasses a broad spectrum of scientific investigations and focuses on long-term integrated studies related to water resource and environmental problems. The NRP provides an infrastructure within which the USGS can develop new information, theories, and techniques to understand, anticipate, and solve water-resource problems, facing managers of Federal lands and the Nation.



The Coastal and Inland Flooding Observation and Warning (CI-FLOW) Project consortium is focused on the Tar-Pamlico River Basin in North Carolina. CI-FLOW is working with North Carolina State University (NCSU) to couple its existing estuary model, a watershed water quality model, and an estuary water quality model to the NSSL multi-sensor precipitation estimation system and the NWS distributed hydrologic model. The resulting CI-FLOW demonstration program will facilitate the evaluation and testing of new technologies and techniques to produce accurate and timely identification of coastal, estuary and inland floods; flash floods; and their impacts on coastal ecosystems.

NOAA's Community Hydrologic Prediction System (CHPS) will enable NOAA's water research and development enterprise and operational service delivery infrastructure to be integrated and leveraged with other Federal water agency activities, academia, and the private sector. CHPS provides a new business model in which members of the hydrometeorological community operate more collaboratively through the sharing and infusion of advances in science and new data, without each member having to build or take ownership of the entire system.

EDUCATION AND OUTREACH

Hydrometeorological training at the University Corporation for Atmospheric Research (UCAR) Cooperative Program for Operational Meteorology, Education and Training (COMET®) covers a wide range of topics related to precipitation, atmospheric moisture, and watershed processes. COMET's mission is to serve as a premier resource that supports, enhances, and stimulates the communication and application of scientific knowledge of the atmospheric and related sciences for the operational and educational communities. The working professional in hydrometeorology can enter at a very basic level to learn about the hydrologic cycle and the rainfall runoff process. More advanced topics include hydrologic models, stream flow routing, flash flood processes, unit hydrograph theory, and more specialized topics, such as snow hydrology and river ice. To assist the learner in moving through the material in a logical and effective order, case scenarios are used to tie the various topics together. Case scenarios are structured around real events for long-term floods, short-term flash floods, warm and cool season concerns, and impacts in both urban and non-urban watersheds.

There is an opportunity to strengthen the connection between the weather enterprise and the larger science community through scientific education and outreach programs. To encourage the type of interdisciplinary interaction necessary for successful large-scale experiments, scientists entering into hydrometeorology from the universities and other institutions must grasp the complexity of the issues linked with regional water and energy cycles. Little of this knowledge is disseminated through traditional work/study approaches.

Public education and outreach programs can also play a role in strengthening the links between the providers and users of weather and hydrologic services so that individuals, communities, and organizations can make effective use of the available products and services. Education and outreach activities must be undertaken together with partners, such as educational institutions, emergency management agencies, and the media (Figure 1-6). An informed and educated public will have a better appreciation for the information provided as science and technology advance, and they will be better equipped to make decisions related to their life needs. A broad range of people use hydrometeorological products and services, and education and outreach programs must be carefully tailored to meet the needs of these various groups.

It's easy to underestimate the depth and force of floodwaters, especially at night and in unfamiliar areas.

Floodwaters often conceal damage to the roadbed.

Figure 1-6. NOAA weather hazard public awareness education on the web. Would you stop, or go on through this flooded roadway? **Turn Around...Don't Drown!** (NOAA web site)

SUMMARY

Integrated, improved, and an increased number of observations are key to improving our understanding, analysis, and prediction of the Earth's environment - from space to the atmosphere to water. Gaps in the observing architecture must be addressed to ensure continuity of observations and establish cost-effective approaches to establishing a truly integrated observing capability-the key to improving our hydrometeorological forecasting capability.

Clearly, the public is best served when the governmental, academic, and private sectors work together to take advantage of their different capabilities and to avoid duplication of effort. Together, the participating entities in all three sectors can reach more people, more effectively, and achieve the core results of our collective missions: to save lives and protect property. Internal and external partnerships allow these sectors to leverage resources to get the job done.

Public education is vital in preparing citizens to respond properly to hydrometeorological threats. Only an educated public will know how to respond to hydrometeorological warnings, how to recognize potentially threatening situations, and how to act appropriately. Through improved outreach and communications, the partners in providing hydrometeorological products and services can improve awareness and delivery of these services and develop products designed to best serve the needs of all users.

To that end, the OFCM plans to conduct, in coordination with the OFCM-sponsored Committee for Environmental Services, Operations, and Research Needs, a crosscut assessment of hydrometeorological products, services, and supporting research across the Federal meteorological community. While the approach focuses on the roles and contributions of Federal entities, effective coordination also requires attention to the roles of state and local governments, the private sector, the academic community, and public-private partnerships. The assessment, which will consider the end-to-end system from observations to modeling and data assimilation for analysis and prediction, to end-user education, has the following objectives:

- Define the needs and requirements for hydrometeorological products, services, and supporting research for the Federal agencies and the customers they support.
- Investigate agency plans and alternatives for satisfying new requirements.
- Create more efficient and effective partnerships among the agencies to better leverage subject-matter expertise and resources to meet the growing needs for better hydrometeorological products and services.

Decision makers need to receive hydrometeorological-related information any time, without delay. To better support stakeholders and decision makers, we must have a well-developed information system, allowing free exchange of data among the various agencies and avoiding duplication in data collection. We must increase the Nation's environmental observing capability and undertake joint activities with operational hydrometeorological services. We must collaborate at all levels (Federal, state, and local) and produce research of consistently high quality. Finally, we need to improve our products and services to help clarify the uncertainty of events such as floods and flash floods, resulting in short-term forecast and warning improvements and improved public response to the decisions of the emergency management and water resource communities.

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SECTION 2

RESOURCE INFORMATION AND AGENCY PROGRAM UPDATES

The tables in this section summarize budgetary information of the Federal government for Fiscal Years 2007 and 2008. The funds shown are those used to provide meteorological services and associated supporting research that has as its immediate objective the improvement of these services. Fiscal data are current as of the end of September 2007 and are subject to later changes. The data for FY 2008 do not have legislative approval and do not constitute a commitment by the United States Government. The budget data are prepared in compliance with Section 304 of Public Law 87-843, in which Congress directed that an annual horizontal budget be prepared for meteorological programs conducted by the Federal agencies.

AGENCY OBLIGATIONS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Table 2.1 contains fiscal information, by agency, for meteorological operations and supporting research. The table shows the funding level for Fiscal Year (FY) 2007 based on Congressional appropriations, the budget request for FY 2008, the percent change, and the individual agencies' percent of the total Federal funding for FY 2007 and FY 2008.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 2008 is $48.8 million for operations and supporting research, representing an 11.5 percent decrease from the FY 2007 funding level. A large portion of this decline was due to a reduction in funding for supporting research. USDA has requested $29.2 million for research and development programs, a $6.8 million decrease from 2007. The FY 2008 amount requested for meteorological operations is $19.6 million, up from $19.1 million in FY 2007.

Operational activities include specialized weather observing networks such as the SNOTEL (SNOw pack TELemetry) system operated by the Natural Resources Conservation Service (NRCS) and the remote automated weather stations (RAWS) network managed by the Forest Service. The SNOTEL and RAWS networks provide cooperative data for NOAA's river forecast activities, irrigation water supply estimates, and Bureau of Land Management operations. The Forest Service is also the world leader in developing emissions factors from fires and modeling its dispersion. The USDA and the Department of Commerce (DOC) jointly operate a global agricultural weather and information center located in Washington, D.C. This Joint Agricultural Weather Facility operationally monitors global weather conditions and assesses the impacts of growing season weather on crop and livestock production prospects. This information keeps crop and livestock producers, farm organizations, agribusinesses, state and national farm policy-makers, government agencies, and foreign buyers of agricultural products apprised of worldwide weather-related developments and their effects on crops and livestock. Furthermore, tracking weather and crop developments in countries that are either major exporters or importers of agricultural commodities keeps the agricultural sector informed on potential competitors. USDA is also actively involved in drought monitoring efforts in concert with the National Drought Mitigation Center.

For supporting research, USDA funds research projects through the Cooperative State Research, Education and Extension Service (CSREES) that study the impact of climate and weather on food and fiber production. The goal of supporting research is to develop and disseminate information and techniques to ensure an abundance of high-quality agricultural commodities and products while minimizing the adverse effects of agriculture on the environment. Furthermore, the Agricultural Research Service (ARS) conducts research on how annual variation in weather adversely effects crop and animal production, hydrologic processes, the availability of water from watersheds, and the environmental and economic sustainability of agricultural enterprises.

DEPARTMENT OF COMMERCE (DOC)

WEATHER SERVICES

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other government agencies, the private sector, the public, and the global community.

More and more sectors of the U.S. economy recognize the impacts of weather, water, and climate on their businesses, and are becoming more sophisticated at using weather, water, and climate information to make better

TABLE 2.1 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS*, BY AGENCY

(Thousands of Dollars)

AGENCY	Operations FY2007	Operations FY2008	Operations %CHG	% of FY2008 TOTAL	Supporting Research FY2007	Supporting Research FY2008	Supporting Research %CHG	% of FY2008 TOTAL	Total FY2007	Total FY2008	Total %CHG	% of FY2007 TOTAL	% of FY2008 TOTAL
Agriculture	19107	19563	2.4	0.6	35982	29216	-18.8	3.9	55089	48779	-11.5	1.5	1.3
Commerce/NOAA(Subtot)	1857125	1871181	0.8	61.5	112253	99298	-11.5	13.4	1969378	1970479	0.1	52.7	52.1
NWS	861887	880891	2.2	28.9	22505	22601	0.4	3.1	884392	903492	2.2	23.7	23.9
NESDIS***	953411	950437	-0.3	31.2	29854	27871	-6.6	3.8	983265	978308	-0.5	26.3	25.8
OAR	0	0	0	0.0	58238	47170	-19.0	6.4	58238	47170	-19.0	1.6	1.2
NOS	28337	26363	-7.0	0.9	500	500	0.0	0.1	28837	26863	-6.8	0.8	0.7
NMAO	13490	13490	0.0	0.4	1156	1156	0.0	0.2	14646	14646	0.0	0.4	0.4
Defense(Subtot)	552218	665728	20.6	21.9	419854	404187	-3.7	54.6	972072	1069915	10.1	26.0	28.3
Air Force***	312926	326868	4.5	10.7	383135	374618	-2.2	50.6	696061	701486	0.8	18.6	18.5
DMSP**	101289	145146	43.3	4.8	963	0	-100.0	0.0	102252	145146	41.9	2.7	3.8
Navy	72653	87370	20.3	2.9	24335	18910	-22.3	2.6	96988	106280	9.6	2.6	2.8
Army	65350	106344	62.7	3.5	11421	10659	-6.7	1.4	76771	117003	52.4	2.1	3.1
Homeland Security (Subtot)	20110	21540	7.1	0.7	0	0	0.0	0.0	20110	21540	7.1	0.5	0.6
USCG	20110	21540	7.1	0.7	0	0	0.0	0.0	20110	21540	7.1	0.5	0.6
Interior/BLM	2400	2400	0.0	0.1	0	0	0.0	0.0	2400	2400	0.0	0.1	0.1
Transportation(Subtot)	518335	462117	-10.8	15.2	27800	32514	17.0	4.4	546135	494631	-9.4	14.6	13.1
FAA	518335	462117	-10.8	15.2	23600	28314	20.0	3.8	541935	490431	-9.5	14.5	13.0
FRA	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0.0
FHWA	0	0	0.0	0.0	4200	4200	0.0	0.6	4200	4200	0.0	0.1	0.1
EPA	0	0	0.0	0.0	9000	9000	0.0	1.2	9000	9000	0.0	0.2	0.2
NASA	2423	2389	-1.4	0.1	162700	166400	2.3	22.5	165123	168789	2.2	4.4	4.5
NRC	120	120	0.0	0.0	0	0	0.0	0.0	120	120	0.0	0.0	0.0
TOTAL	2971838	3045038	2.5	100.0	767589	740615	-3.5	100.0	3739427	3785653	1.2	100.0	100.0
% of FY TOTAL	79.5%	80.4%			20.5%	19.6%			100.0%	100.0%			

*The FY 2007 funding reflects Congressionally appropriated funds; the FY 2008 funding reflects the amount requested in the President's FY 2008 budget submission to Congress.

**DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

***NESDIS and Air Force budget numbers include the DOC and DOD shares of the NPOESS budget, respectively.

decisions. To meet this growing demand for information and to improve the timeliness and accuracy of warnings for all weather related hazards, the NWS will continue to enhance observing capabilities, improve data assimilation to effectively use all the relevant data NWS and others collect, improve collaboration with the research community, make NWS information available quickly, efficiently, and in a useful form (e.g., the National Digital Forecast Database) and include information on forecast uncertainty to help customers make fully informed decisions.

With about 4,700 employees in 122 weather forecast offices (WFO), 13 river forecast centers, 9 national centers and other support offices around the country, NWS provides a national infrastructure to gather and process data worldwide from the land, sea, and air.

The FY 2008 President's Budget Request supports the funding and program requirements necessary to address established NOAA strategic goals and sets NWS on a path to achieve its vision: *Produce and deliver forecasts that can be trusted; use cutting-edge technologies; provide services in a cost-effective manner; strive to eliminate weather related fatalities; and improve the economic value of weather, water, and climate information.*

NOAA requests a total of $903,492,000 million and 4,658 FTE to support the continued and enhanced operations of the National Weather Service. The total includes $16,130,000 for Adjustments to Base, and net program changes of $2,329,000 for program increases.

ADJUSTMENTS TO BASE

NOAA requests a net increase of $18,297,000 and 0 FTE to fund adjustments to base across all accounts in the National Weather Service activities. With this increase, program totals will fund the estimated FY 2008 Federal pay raise of 3.0 percent and annualize the FY 2007 pay raise of 2.2 percent. Program totals will provide inflationary increases for non-labor activities, including service contracts, utilities, field office lease payments, and rent charges from the General Services Administration.

NWS also requests the following transfers between line offices or appropriations for a net change to NOAA of zero:

- $3,270,000 is transferred from the NOAA Profiler Network PPA of Operations, Research, and Facilities to the NOAA Profiler Conversion PPA of Procurement, Acquisition, and Construction. This transfer has no net effect on overall NWS or NOAA funding and was done to reflect the accurate activity of the funds within the program.
- $7,347,000 and 51 FTEs are transferred from the Space Weather Prediction Center (formally the Space Environment Center) to the Local Warnings and Forecast Base PPA within the Local Warning and Forecast line. This transfer has no net effect on overall NWS funding.

NWS - ORF PROGRAM CHANGE HIGHLIGHTS FOR FY 2008:

NOAA requests a net increase of $8,334,000 and 0 FTE over the FY 2008 base for a total request of $807,807,000 and 4,627 FTE. These changes are summarized at the subactivity level below and to be concise, do not include descriptions below $1,000,000. Descriptions of each request by line item are located in the NOAA FY 2008 Technical Budget.

<u>Operations and Research: $711,462,000</u>

A net increase of $8,334,000 and 0 FTE above the base is requested in the Operations and Research subactivity, for a total of $711,462,000 and 4,439 FTE.

<u>Local Warnings and Forecasts</u>. $7,294,000 and 0 FTE in net increases above the base, for a total of $658,214,000 and 4,133 FTE, requested under the Local Warnings and Forecasts line item of the Operations and Research subactivity.

<u>TAO Tropical Moored Buoy Technology Refresh</u>. NOAA requests an increase of 0 FTE and $1,100,000 to replace obsolete components of the Nation's foremost climate observing system. Total funding required to replace obsolete components for the 55 buoys in this array is $6.6M. This effort will be accomplished over a six year period beginning in FY 2008.

<u>Florida/Caribbean Hurricane Data Buoy (Operation and Maintenance)</u>. NOAA requests an increase of 0 FTEs and $3,000,000 for a total of $4,400,000 to operate and maintain 15 weather data buoys (eight buoys funded under the FY 2006 Hurricane Supplemental Appropriation and seven funded in by the FY 2005 Hurricane Supplemental Appropriation) for enhanced real time hurricane data observations and storm monitoring in the Caribbean, Gulf of Mexico, and the Atlantic Ocean to support the NOAA hurricane warning and forecast mission

<u>Ocean Sensor Operation and Maintenance</u>. NOAA requests an increase of 0 FTEs and $1,350,000 for ongoing operation and maintenance of the Congressionally mandated ocean instrumentation which was funded and installed by the National Ocean Service’s "Convert Weather Buoys Initiative." These sensors augment fixed and buoy observational sites. In keeping with NOAA's commitment of increased interoperability and cost effective approach to oceanographic observing, the NOS Convert Weather Buoy project augments existing National Weather Service buoys with oceanographic sensors. This national network of weather observing buoys

has been augmented with ocean sensors to measure directional waves and wave heights, and ocean current, temperature, and salinity profiles.

Ongoing Operations and Maintenance for Systems/equipment Purchased to Meet Requirements of Hurricane Supplemental. NOAA requests 0 FTE and $1,230,000 to pay ongoing operations and maintenance costs for Incident Meteorologist equipment, software support, and communications, ASOS and NWR backup power units, and backup communications for coastal Weather Forecast Offices and Next Generation Weather Radars.

Space Weather Prediction Center (SWPC) (formally the Space Environment Center). NOAA requests a reduction in SWPC funding of $1,300,000 to reflect funding of higher-priority NWS requirements. This $1,300,000 reduction will reduce SWPC model development and transition of models to operations; and eliminates outreach efforts. The $6,261,000 funding level supports SWPC real-time monitoring and forecasting of solar and geophysical events.

Strengthening the U.S. Tsunami Warning Program. NOAA requests an increase of 0 FTE and $1,700,000 for a total of $23,196,000 in FY 2008, to sustain the Administration's commitment to strengthen the U.S. Tsunami Warning Network. Funds are required to operate and maintain the expanded U.S. Tsunami Detection and Warning System put in place in FY 2004-2007 and complete deployment of the DART Buoy Network.

NOAA Profiler Network Operations and Maintenance. NOAA requests an increase of 0 FTE and $1,670,000. This $1,670,000 increase reflects the increased operations and maintenance costs for the NPN due to the need to continue operating all but three of the 37 sites for all of FY 2008, while needing to put in place the infrastructure for operations and maintenance of the frequency replacement.

US Weather Research Program (USWRP). NOAA requests a reduction in USWRP/THORPEX funding of $1,456,000 to reflect funding of higher-priority NWS requirements. This reduction will reduce support for THORPEX, including a multi-national experiment in the North Pacific targeted to improving high impact winter weather forecasts on the U.S. Pacific Coast. This field experiment will end a grants program between NOAA and the academic community focused on accelerating 1-14 day forecasts.

Central Forecast Guidance. NOAA is requesting $1,040,000 and 0 FTE in net increases above the base, under the Central Forecast Guidance line item of the Operations and Research subactivity.

Hurricane/Environmental Modeling Improvements. NOAA is requesting $1,040,000 and 0 FTE for operational support and maintenance of the next-generation hurricane and storm surge prediction system. As a result of the active 2005 hurricane season, NOAA was provided hurricane supplemental funding to accelerate the next-generation hurricane and storm surge prediction system. This request provides the necessary operations and maintenance funding to support these systems on a daily, routine basis leading to improved hurricane and storm surge prediction. This environmental modeling investment is necessary support operationally the next-generation hurricane prediction system and to integrate NOAA's several environmental prediction models into a single environmental modeling prediction system to meet demands for more accurate forecast products in weather, climate, ocean and coastal ocean and ecosystems. Operational hurricane intensity and storm surge predictions at landfall will be highlighted in this effort, which will capitalize on proven research, lay the groundwork for a national prediction system meeting civil, military, and homeland defense needs, and regain NOAA's position as a world leader in environmental prediction.

SYSTEMS OPERATION & MAINTENANCE (O&M)

NWS is requesting $96,345,000 and 188 FTE, which is an increase of $0 and 0 FTE to support the on going operations and maintenance of major NWS observation and processing systems. These systems include the Next Generation Weather Radar (NEXRAD), Automated Surface Observation System (ASOS), Advanced Weather Interactive Processing System (AWIPS)/NOAAPort, and the NWS Telecommunications Gateway System (NWSTG) and Backup. NWS currently operates 123 NEXRAD Systems that utilize Doppler technology and hydrometeorological processing to provide weather radar data for tornado and thunderstorm warnings, air safety, flash flood warnings, and water resource information. 315 NWS ASOS sites provide reliable 24-hour per day continuous surface weather observations. AWIPS provides an integrated system to display all hydrometeorological data at NWS field offices. The system acquires and processes data from modernized sensors and local sources, provides computational and display functions, provides interactive communication systems, and disseminates weather and flood warnings and forecasts in a rapid and highly reliable manner. NWSTG and Backup Systems are the Nation's hub for the collection and distribution of weather data and products. NWSTG and Backup provide national and global real-time exchange services using an automated communication system to collect and distribute a wide-range of environmental data such as observations, analysis, forecast, and warning products.

SYSTEMS ACQUISITION:

$69,081,000 and 31 FTE

Automated Surface Observing System (ASOS) ($1,635,000)

This acquisition is a tri-agency program involving NOAA, the Department of Defense, and the Federal Aviation Administration. ASOS provides reliable, 24-hour, continuous surface weather observations. Under the product improvement portion of this acquisition program, NOAA is developing new ASOS sensor capabilities in order to meet changing user requirements and decrease maintenance demands.

Advanced Weather Interactive Processing System (AWIPS)/NOAAPort ($12,764,000)

AWIPS is the cornerstone of the modernized NWS. This system integrates and displays all hydrometeorological data at NWS field offices. AWIPS acquires and processes data from modernized sensors and local sources, provides computational and display functions at operational sites, provides a robust communications system to interconnect NWS operational sites, and disseminates warnings and forecasts in a rapid, highly reliable manner. This system integrates satellite, NEXRAD Doppler weather radar data, and Numerical Weather Prediction (NWP) data enabling field forecasters to better visualize environmental processes to enable the creation of timely and accurate forecasts and warnings. AWIPS provides the only display for NEXRAD Doppler weather radar data at NWS Weather Forecast Offices (WFOs) and River Forecast Centers (RFCs). The AWIPS NOAAPort satellite broadcast network offers the communications capability to provide internal and external users with open access to much of NOAA's real-time environmental data.

Next Generation Weather Radar (NEXRAD) ($8,376,000)

NEXRAD is a Doppler weather radar system that provides automated signal processing, computerized data processing by sophisticated meteorological software algorithms, and a high-capacity, processor-driven communications capability. The system is modular in design, upgradeable, has a long life-cycle expectancy, and provides both governmental and commercial sector weather users with a wide array of automated weather information that will increase their capability to meet their respective operational requirements. For the NWS, the system uses Doppler technology and hydrometeorological processing to provide significant increases, both in the functional capability and in performance, compared with previous radars, including improved tornado and thunderstorm warnings, increased air safety, improved flash flood warnings, and improved water resources management.

Radiosonde Replacement Program ($4,014,000)

The NWS radiosonde network provides upper-air weather observations; the primary source of data required by NWS numerical weather prediction models, which form the basis of all NWS forecasts for day 2 and beyond. Observations of temperature, pressure, humidity, and wind speed/direction are taken twice a day at 102 locations nationwide and in the Caribbean using a balloon-borne instrument (radiosonde) which transmits the data via radio signal to a ground receiving station usually located at a Weather Forecast Office (WFO), where it is processed.

NOAA's Environmental Real Time Observation Network (NERON) ($4,234,000)

Funds are required to develop, & start deployment and installation of the Historical Climate Network in FY2008. NERON is a project to integrate a network of observing systems to sustain the Nation's climate record of land surface measurements essential to monitor and assess the surface climate. NERON will modernize 1,000 of the existing 1,221 HCN stations to collect temperature and precipitation data through automation and provide for expansion to collect other data sets (e.g., National Integrated Drought Information System (NIDIS). The Historical Climate Network (HCN-M) is a subset of the National Weather Service's (NWS) Cooperative Observer Program (COOP). This long-term data set furnishes valuable information for NOAA field offices and national centers in the production of operational products for various customers. Modernizing the HCN will reduce the uncertainty in the measure of regional climate change. HCN-M will sustain the regional climate record and improve the quality of climate observations directly contributing to NOAA's capability to monitor and analyze climate change and improve the accuracy of predictions in support of planning, mitigation, and informed decisions. As part of the NERON project, the Meteorological Assimilation Data Ingest System (MADIS), a research project run by OAR/GSD in Boulder, CO, will be transitioned into operations at NWS Headquarters in Silver Spring, MD. This central data collection and processing system will provide quality control of the NERON data and other mesonet data sets, and provide distribution of data to NWS offices, NOAA's National Climate Data Center (NCDC), other Federal and state agencies, and the public. MADIS currently collects, processes, and distributes data from over 20,000 mesonet stations.

NWS Telecommunications Gateway Legacy Replacement ($1,195,000)

The NWSTG is the NWS communications hub for collecting and distributing weather information to its field units and external users. Replacing the

NWSTG system with up-to-date technology will reduce the current delays in collecting and disseminating data by reducing transit time through the NWSTG. The replacement will ensure reliable delivery of NWS products to users and will fully capitalize on better observation data and prediction models to improve services. In FY 2008, NWS will conclude a three-year effort to replace the National Weather Service Telecommunications Gateway (NWSTG) switching system and repair and upgrade NWSTG facilities.

Weather and Climate Supercomputing ($19,092,000)

The cyclical upgrade of the NWS weather and climate supercomputing capability is intended to procure the computing and communications equipment needed to receive and process the increasing wealth of environmental data acquired by modernized observing systems, process improved and more sophisticated numerical weather prediction models, and stay current with the supercomputing technology the market has to offer. Execution of this program promotes public safety and the protection of property by providing the NCEP with the computer systems that are capable of producing more accurate NWS climate and numerical weather prediction (NWP) guidance products for hurricanes, severe thunderstorms, floods, and winter storms. Additionally, the supercomputing system more accurately forecasts large-scale weather patterns in the medium (3 to 10 days) and extended range (30 days), plus forecasts of major climate events such as El Niño and La Niña. In addition, the computer upgrades will improve the delivery of products to the field and provide system users with enhanced productivity. These products and services will lead to significant economic benefits for users, like the agriculture, construction, and transportation industries.

Weather Supercomputing Backup ($7,077,000)

The backup supercomputer system is a clone of the primary supercomputer system and located in an offsite facility. The backup system is used to thoroughly test pre-Production weather and climate forecasting applications when it is not being used to run the Production Suite during a backup system test or actual emergency. The backup supercomputer system is capable of handling 100 percent of the operational workload should the primary supercomputer system be disrupted. Implementation and maintenance of a redundant Weather and Climate Operational Supercomputer Systems architecture will ensure uninterrupted flow of essential weather and climate data and products, continuity of storm watch and warning services to the public, and compliance with NOAA Critical Infrastructure Protection (CIP) plans.

Complete and Sustain NOAA Weather Radio (NWR) ($5,594,000)

Continue refurbishment of four hundred (400) stations established in the 1970s, eliminating single points of failure and improving network reliability. NWR was designed to be and is used as a reliable, inexpensive means of communicating weather related warnings to the public. The existing infrastructure of NWR has tremendous potential for use communicating warnings and information about non-weather related hazards and emergencies. NOAA has had extensive meetings with the Department of Homeland Security, discussing the use of NWR as an all hazards warning system. National Weather Service received an appropriation of $5.4M in FY 2004 to make NWR an all hazard warning network. NWR infrastructure as a national warning network consists of over 900 existing broadcast stations; broadcast coverage that reaches 97 percent of the nation's population; and the ability to deliver the broadcasted message to individuals monitoring their own NWR receivers as well as the ability to reach millions of listeners and viewers since NWR signal enters the Emergency Alert System, which is monitored by television and radio license holders.

NOAA Profiler Conversation. ($5,100,000)

The conversion provides funding to modify the transmitting frequency and provide technology refresh the Wind Profilers system installed in 1988. The Wind Profiler is a vertical looking radar that provides input for numerical weather models that predict clouds, precipitation, and temperature. The data also provides important indicators of where severe weather such as tornadoes and winter storms may forms and is used for issuing aviation advisories and wildfire predictions. Currently, 32 of the 37 are using an experimental transmitter frequency of 404 mega hertz (MHz) issued by the National Telecommunications and Information Administration (NTIA). NTIA has permanently assigned this frequency to a series of search and rescue satellites and granted the Profilers a permanent frequency of 449 MHz. NWS must complete the conversion prior to the launch of the first satellites in FY 2008.

CONSTRUCTION: $26,604,000

NOAA requests a decrease of $5,205,000 and 0 FTE for a total of $14,100,000 to complete the NOAA Center for Weather and Climate Prediction (NCWCP) for FY 2008 occupancy and operations.

This FY 2008 decrease is consistent with the planned NCWCP investment profile to begin occupancy of the building by February 2008, and complete the move from the World Weather Building (WWB) to NCWCP by October 2008. This funding includes implementing mission critical systems overlap during the transition/move. NOAA must complete the purchase and installation and checkout of IT equipment, systems furniture, and other government furnished equipment, hire movers and pay rent on the new facility. The restored funds will allow the implementation of overlap operations of 24x7 mission critical systems. This overlap operation has been planned and will be closely coordinated to ensure that data and products critical to the protection of life and property in the U.S. are not interrupted during the move to NCWCP. This project is a key component of the NWS' effort to improve its weather and climate modeling performance, to accelerate the transfer of newly developed scientific information into operations, and to improve the use of global environmental satellite data. The NWS has demonstrated a direct linkage between establishing new facilities in the proximity of research organizations, and improved program performance. The expiration of the WWB lease dictates the timing of the NCWCP Project and affords an outstanding opportunity to enhance the NWS efforts to protect the continuity and flow of critical weather warning, forecasts and data products to the Public. The award of the lease by GSA in 2005, ensured occupancy of the new facility in October 2008.

FY 2005 funding provided project management for NOAA, and allowed NOAA to initiate the planning and engineering required to support the mission systems relocation. In FY 2007, construction of the NCWCP was completed. Simultaneously, NOAA implemented procurements to complete all tenant improvements and outfitting such as but not limited to: telecommunications cabling (systems acquisition and installation); interior design, system furniture acquisition and installation; and relocation costs. The FY 2007 effort also involved the one-time relocation of mission critical operational systems from the WWB to the NCWCP. This critical system relocation funding will ensure that NOAA will be able to operate its "mission critical" programs by providing an overlap in system functionality during the physical relocation from the WWB to the NCWCP. Funding for project management includes a project manager, space planner, a project engineer and technical support, to provide continued coordination and oversight among all involved parties including GSA, users, contractors, and consultants.

NOAA requests an increase of $0 and 0 FTE for a total of $12,504,000 for Weather Forecast Office (WFO) construction funding to NOAA facilities to support NOAA facility planning requirements. As part of the National Weather Service (NWS) modernization and associated restructuring, the Weather Forecast Office (WFO) Construction program was started in the late 1980s to meet NWS WFO facility requirements supporting the provision of public weather services and the nationwide NEXRAD radar network. The original scope of the project, completed in FY 1999, included the construction or lease of 117 WFOs (13 of which were co-located with River Forecast Centers) and cost approximately $250M. Since this time, the NWS has added five WFOs to address service coverage requirements in Guam, Northern Indiana, Caribou, ME, Huntsville, AL and Key West, FL. Other required construction elements currently ongoing include the upgrade and modernization of Alaska and Pacific Region Weather Service Offices, Tsunami Warning Centers, and associated employee housing units, upgrades of Heating, Ventilation, and Air Conditioning (HVAC) systems at approximately 60 WFOs, uninterruptible power supply (UPS) replacements, and mitigation of all building and fire code violations. This construction effort is essential to bring the NWS into full compliance with Federal law and national and local building codes.

ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICES

Proposed funding for FY 2008 includes a decrease in the Polar-Orbiting Satellite Program (POES) of $(11.8) million, a net increase in the Geostationary Satellite Program (GOES) of $112.4 million, and a request to fund the National Polar-orbiting Operational Environmental Satellite System (NPOESS) at the Nunn-McCurdy Certified program funding level. These changes allow for continuation of procurements to provide the spacecraft and instruments, launch services, and ground systems necessary to assure continuity of environmental satellite coverage. The budget request will maintain a system of polar-orbiting satellites that obtains global data and a system of geostationary satellites that provides near-continuous observations of the Earth's western hemisphere. Funding for the POES program is decreasing as it approaches the end of its production cycle with one remaining satellite, NOAA N prime, to be launched. The GOES request includes a decrease of $8.8 million for the GOES-N series of satellites, and an increase of $113.4 million for the next generation GOES-R series. The FY 2007 GOES-R funding will begin engineering for several key instruments and continue the imager production begun in FY 2005.

The converged NOAA and Department of Defense (DOD) polar orbiting system (NPOESS) will replace the current NOAA series and the DOD Defense Meteorological Satellite Program (DMSP). A total of $97.7 million is included in the budget request to maintain basic mission satellite services, including maintenance and operation of satellite ground facilities; provision of satellite derived products, including hazards support; and conduct of research to improve the use of satellite data.

Included in the above request is $3.8 million to continue the Ocean Remote Sensing Program, which began in FY 1995. During the next several years, NOAA will acquire data from foreign and other non-NOAA satellites that will provide measurement of ocean currents, surface winds and waves, subsurface temperature and salinity profiles, ice thickness and flows, and other marine factors. Included in the budget request is $51.9M for the NOAA Data Centers and Information Services sub-activity base operating funds.

NOAA OCEAN SERVICE (NOS).

NOS operational oceanographic observing systems are designed to measure both oceanographic and meteorological parameters in order to meet user and partner requirements. As a result, users of the data and information support a broad cross-cut of the marine transportation sector, the climate change research sector, weather and water programs, and ecosystems research community.

Funding provided through the FY 2008 budget will allow the continuation of the second generation of the NOS CO-OPS advanced data quality control program, the Continuous Operational Real-time Monitoring System (CORMS AI), as well as the continued implementation of the Ocean Systems Test and Evaluation Program (OSTEP), which is a development program for bringing new sensor technology into operations. The FY 2007 budget has allowed for sufficient support to operate the National Water Level Observation Network (NWLON) and for continued growth of the Physical Oceanographic Real-Time System (PORTS®). Both the NWLON and PORTS programs have subsets of operational water level stations with meteorological sensors installed for various partners and users, including the NWS.

In FY 2008, NOS has requested funding to upgrade and enhance as many as 45 NWLON with new meteorological sensors. The NWLON has traditionally been an oceanographic observing system; however, NWLON technology allows multiple other sensors to be added, including meteorological sensors such as wind speed/direction/gusts, air temperature, and barometric pressure. These observations provide a significant data source for improving and verifying marine weather forecasts and warnings. Actual verification data for special marine warnings (WFO Sterling) shows a 10 percent increase in the probability of detection and a ten-minute increase in warning lead-times, due in part to an increase in marine observations. Navigation data users require a complete picture of their operating environment to make the best safety and efficiency decisions, and local meteorological data is a part of that picture. Integration of existing observing infrastructure is a cost-effective alternative to establishing new platforms. The additional meteorological data will also improve the accuracy of NWS forecasts of storm surge, marine wind speed, and marine wave heights for use by both the marine navigation and coastal communities when extreme weather events occur. The real-time information can be used by emergency responders to make sound decisions based upon which coastal areas are flooding, which evacuation routes are still viable, and other situations requiring a good understanding of the current state of the physical environment.

In FY07, Hurricane Katrina supplemental funds were used to harden existing NWLON stations to withstand storm surge. In FY08, NOS has requested funds to construct additional new NWLON stations to fill critical observation gaps identified by NWS. Initial candidate sites are likely along the Gulf Coast. Also, NOS plans to harden additional existing Gulf Coast NWLON stations by constructing elevated strengthened platforms and relocating equipment to them.

NOS operational nowcast/forecast modeling activities are expanding and rely upon NWS Eta model data streams as hydrodynamic model drivers. NOS, in cooperation with NWS and OAR in have developed an operational nowcast/forecast capability for the Great Lakes.

OFFICE OF ATMOSPHERIC RESEARCH (OAR).

Requested funding for FY 2008 for Weather and Air Quality Research (W&AQR) is $47.1 million--a decrease of $11.7 million or more than 19 percent from the FY 2007 appropriation. Increases consist of upward base adjustments of $0.9 million to partially cover inflationary cost increases. Proposed decreases include $2.3 million from the Weather & Air Quality Research Laboratories and Cooperative Institutes line, the W&AQR share of NOAA's new Northern Gulf Institute as well as $1.0 million from Weather & Air Quality Research Programs (Phased-Array Radar or PAR). In addition, terminations totaling $25.3 million are proposed for: Atmospheric Investigation Regional Modeling Analysis and Prediction (AIRMAP) ($4.9 million); New England Air Quality Study ($3.0 million); Targeted Wind Sensing ($2.0 million); Risk Reduction in Water Forecasts at Mississippi State University ($2.0 million), New England Center for the Study of Atmospheric Sciences & Policy ($1.5 million); the "STORM" Program at the University of Northern Iowa ($0.6 million); Remote Sensing Research at the Idaho State University/Boise Center Aerospace Laboratory ($0.5 million); East Tennessee Ozone Study ($0.3 million); Central California Air Quality Study ($0.4 million), Urbanet ($5.9 million), Great Plains Center of Atmosphere and Human Health ($1.0 million), High-Altitude Air Study ($0.3 million), Reducing Wind-Induced Damages from Storms ($1.0 million), and Coordinate NASA-NOAA Severe Storm R&D ($2.0 million).

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS).

The FY 2008 DOC/DOD budget request for NPOESS is $666.2 million. FY 2008 funds will be used for the continued development of system architecture, technology development efforts, and critical sensor and algorithm development. NPOESS is planned to be launched in FY 2013. This system will exploit advanced hardware and software technologies to produce a more reliable, longer-lived spacecraft with greater mission capability. In addition to new products, NPOESS will also provide a significant reduction (90 minutes to 30 minutes) in the time required to move from sensed to processed data.

NOAA MARINE AND AVIATION OPERATIONS (NMAO).

NMAO supports meteorological activities by collection of related data from ships and aircraft. The FY 2008 President's Budget does not include any significant increases or decreases from the FY 2007 appropriation for NMAO that are related to meteorological data collection.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 2008, including NPOESS funding, is $1.07 billion which represents a funding increase of 10.1 percent from FY 2007. Specific highlights for each of the military departments are described below:

UNITED STATES AIR FORCE (USAF)

USAF resources for meteorological support fall into several categories: general operations, investment and research, Defense Meteorological Satellite Program (DMSP), and National Polar-orbiting Operational Environmental Satellite System (NPOESS) supporting research. The total Air Force operations and investment funding for fiscal year 2008, including DMSP and NPOESS, is $846 million.

General Operations

The operations portion of Air Force Weather's fiscal year 2008 budget is $326.8 million and funds day-to-day environmental support to the Department of Defense, including the Active and Reserve components of the Air Force and Army, nine unified commands, and other agencies as directed by the Chief of Staff of the Air Force. Just over 4,400 Active and Reserve Component military and civilian personnel conduct these activities at more than 275 locations worldwide. Approximately 85 percent of personnel specialize in weather; the remainder includes communications, computer, administrative, and logistics specialists.

General Supporting Research

Air Force Weather's fiscal year 2008 budget request for supporting research is $37.5 million. As part of AF Smart Operations 21st Century (AFSO 21), Air Force Weather is investing in modernized environmental prediction technologies and global information grid technologies that enhance automation and save manpower. Air Force Weather continues their extensive initiative to build-up the strategic center's information technology infrastructure for the expected 10-fold increase in satellite data. Also, Air Force Weather is investing in the following innovative software and/or systems development efforts in fiscal year 2008 and beyond: the Joint Environmental Toolkit (JET), Weather Data Analysis (WDA), and the Ensemble Prediction System (EPS). The goals of JET, WDA, and EPA are to simplify, standardize, minimize, and automate weather operations at the operational and tactical levels.

Specifically, JET will eliminate redundancies and/or inefficiencies and ultimately extend, consolidate and/or replace the Operational Weather Squadron (OWS) Production System-Phase II (OPS II), the Joint Weather Impacts System (JWIS), the New-Tactical Forecast System (N-TFS), and the weather effects decision aids portion of the Integrated Meteorological System (IMETS). WDA will provide many of the behind the scene tools at the weather production centers necessary for enabling JET to provide decision-quality products and information to warfighters. EPS will provide the foundation to fundamentally change legacy forecast processes to an AFSO 21 compatible process necessary for the rapidly changing, net-centric, machine-to-machine future environment.

While JET, WDA and EPS work synergistically to provide warfighters a quantum leap in capability, JET is the most visible piece to decision-makers. JET will exploit data contained in the Virtual Joint Meteorological Oceanographic (METOC) Database via common-user-communications, integrate with joint and coalition command and control and mission planning systems, and provide the machine-to-machine data exchange for assimilating METOC and C4ISR data to meet operational and tactical mission planning and execution requirements.

DMSP

DMSP operations are a critical source of space-borne meteorological data for the Military Services and other high-priority DOD programs. DMSP environmental data is also distributed to the National Weather Service, National Environmental Satellite, Data, and Information Service, the

Navy's Fleet Numerical Meteorology and Oceanography Center, the Naval Oceanographic Office, and Air Force Weather Agency according to interagency agreements.

The Air Force's total projected FY08 outlays for DMSP are $145.1 million. This funding provides for the operations and sustainment of the on-orbit constellation, as well as integration, test, and flight hardware modifications and replacement to maximize performance and longevity of the satellites that remain to be launched. DMSP satellites are acquired and launched by the Air Force and funding to operate the satellites on-orbit is transferred by the Air Force to National Oceanic and Atmospheric Administration each year.

NPOESS Supporting Research

The fiscal year 2008 DOD R&D budget for NPOESS is $334.9 million for the continued development of system architecture, technology, critical sensors, and algorithms. These dollars are applied to both the NPOESS Preparatory Project run by NASA and the NPOESS program being which is being acquired by a tri-agency Integrated Program Office.

US NAVY

The Department of the Navy's (DON) proposed $139.8 billion budget request for fiscal year 2008 (FY08) fully supports near and long-term warfighting requirements and will help win the Global War on Terrorism. The US Navy FY08 budget request for meteorological programs is $106.3 million. The request includes $87.4 million for operational programs and $18.9 million for supporting research.

Naval Oceanography Program (NOP)

NOP remains a unique, world-class program. Focusing support in the environmentally complex coastal/littoral regions around the globe, Naval METOC personnel (Navy and Marine Corps) are required to provide intelligence preparation of the environment (IPE) for operational decision makers by assessing the impact of atmospheric and ocean phenomena on platforms, sensors and weapon systems. Additionally, Navy and Marine Corp METOC personnel provide for safe flight and navigation in support o naval, joint, and combined forces operating throughout the world's oceans. This is done with a cadre of highly trained military and civilian personnel, educated in both sciences and warfighting applications. By teaming with, and leveraging the efforts of other agencies and activities, the NOP meets these challenges in a most cost effective manner, providing a full spectrum of products and services with only a small percentage of the Federal weather budget.

The NOP is required to provide comprehensive and integrated weather and ocean support worldwide. The Oceanographer/Navigator of the Navy sponsors programs in four closely related disciplines - meteorology, oceanography, geospatial information services, and precise time and astrometry. All are used to protect ships, aircraft, fighting personnel, and shore establishments from adverse ocean and weather conditions, and to provide a decisive tactical or strategic edge by exploiting the physical environment to optimize the performance and efficiency of platforms, sensors, and weapons.

Littoral Battlespace Sensing, Fusion, and Integration (LBSF&I)

LBSF&I is the Department of the Navy's principal Intelligence Preparation of the Environment approach for atmospheric and oceanographic data collection, processing, and data/product dissemination to users. LBSF&I will facilitate better tactical decision making by enabling a system of networked sensors to allow information sharing through interoperability with naval and joint networks and information systems. It addresses critical gaps with respect to environmental data fidelity (in time and space) shown to play a critical role in force disposition and force posture in current and future naval missions. LBSF&I is a critical persistent IPE technology, is considered a key component of the Naval Oceanography Battlespace on Demand framework, and supports the Battlespace Awareness Joint Capability Area through 2020 and beyond.

Operational Support

Naval METOC support starts with sensing the battlespace without being adversely affected by physical environmental and culminates with weapons arriving on target and enabling personnel to operate in the battlespace without being adversely affected by physical environmental phenomena. Operational support for the Navy and Marine Corps includes the day-to-day provision of METOC products and services. As naval operations in the littoral increase, Naval METOC support is directed towards providing on-scene capabilities to personnel that directly furnish environmental data for sensor, weapon system, and personnel planning and employment. These on-scene capabilities are key elements for enabling the warfighters to take advantage of the natural environment as part of battlespace management.

Owing to the crucial interrelationship of the ocean and the atmosphere, Naval METOC requires various oceanographic products to provide the requisite meteorological services. In addition to aviation and maritime METOC support, Navy and Marine Corps METOC teams provide a variety of unique services on demand, such as electro-optical, electro-magnetic, and acoustic propagation models and products, METOC-sensitive tactical decision aids, and global sea ice analyses and forecasts.

Systems Acquisition

Naval METOC systems acquisition is accomplished through the Program Executive Office for Command, Control, Communication, Computes and Intelligence and Space (C4I and Space) in San Diego, California.

Research and Development (R&D)

Naval METOC R&D are cooperatively sponsored by the Oceanographer/Navigator of the Navy and the Chief of Naval Research. Naval R&D efforts typically have applications to meteorological, oceanographic, and/or tactical systems. Navy's tabulation of budget data includes R&D funding for basic research, applied research, demonstration and validation, and engineering and manufacturing development.

Projects initiated by the Navy and Marine Corps, under sponsorship of the Oceanographer/Navigator of the Navy, transition from engineering development to operational naval systems. Such efforts include advances in Naval METOC forecasting capabilities, enhancements to communications and data compression techniques, further development and improvement of models to better predict METOC parameters in littoral regions, and an improved understanding of the impact these parameters have on sensors, weapons systems, and platform performance.

To realize the opportunities and navigate the challenges ahead, the Department of Navy must have a clear vision of how they will organize, integrate, and transform. "*Sea Power 21*" is that vision. It will align our efforts, accelerate our progress, and realize the potential of our people. Support to naval operations is provided under the direction of the Commander, Naval Meteorology and Oceanography Command (CNMOC) located at the Stennis Space Center, Mississippi and the Marine Corps advocate for METOC, the Deputy Commandant for Aviation, at Headquarters Marine Corps, Washington, D.C.

The CNMOC organization has recently transformed for efficiency and effectiveness to meet these future requirements. With the addition of the Naval Oceanography Operations Command the NOP optimizes warfighting recourses, supports safe operations and enhances dominance of the battlespace through superior understanding and exploitation of the environment. The Naval METOC community continues to work closely with research developers and operational forces to ensure that naval and joint force commanders will always have the most accurate, timely, and geo-referenced METOC information available for successful operations.

US ARMY

The US Army estimates a requirement for $106.3 million for operational support and $10.7 million in R&D in fiscal year 2008. The total amount of money budgeted for weather support is estimated because the costs to support USAF Battlefield Weather forces are normally part of the overall G-3 or G-2 operating budget at the Army Commands (ACOMs), Army Service Component Commands (ASCCs), corps, division, or brigade level and are not assigned their own program element or budget line. Additionally, programs or projects that are assigned a budget line are often part of a larger project's budget and the exact amount of monies spent on meteorological related activities cannot be verified. The budget numbers presented in this report represent the best estimate of the Army regarding meteorological related spending over the period of the report. Operational support is projected to increase approximately $40 million over the fiscal year 2007 expenditures and research is estimated to decrease about $0.7 million from the previous year. Staffing levels remain stable for fiscal year 2008. The large increase in operational funding is attributed to increases in the AN/TMQ-52 Meteorological Measuring Set - Profiler (MMS-P) program. The MMS-P received an increase of $16.2 million in fiscal year 2007 and is programmed to receive an increase of $64.8 million in fiscal year 2008 to procure additional AN/TMQ-52 MMS-P systems in support of Army combat operations.

Army monies for meteorology are spent in four main areas: support to US Army Artillery Met Sections (ARTYMET), support to USAF Battlefield Weather forces at Army locations, research and development related to the Army mission, and the development, production, and maintenance of Army meteorological systems.

ASCCs with staff weather officers and their associated battlefield weather forces provide the same support and services to Air Force Weather (AFW) personnel that they normally provide to Army personnel. This support includes the use of facilities to house weather operations, medical support, access to training facilities, office supplies, utilities and maintenance for weather facilities, vehicles and tactical equipment, and funding for official travel. Eighth US Army, US Army Europe, US Army Pacific, Forces Command, and Training and Doctrine Command (TRADOC) all provide this support to AFW personnel assigned at the ACOM level and below.

Major portions of ACOMs and ASCCs meteorological budgets go to support Artillery Meteorology Sections, also known as ARTYMET Teams, or Met Sections. Wind data are then passed to the US Army Artillery units for firing computations. Artillery Met Sections range in size from 6 personnel at a light division to 12 personnel at a heavy division. Eighth U. S. Army, US Army Europe, US Army

Pacific, Forces Command, and the Army National Guard all support Met Sections. Training and Doctrine Command supports 24 military and civilian personnel at the US Army Artillery School at Fort Sill, Oklahoma. These personnel train ARTYMET Teams on the use of the AN/TMQ-41 Meteorological Measuring Set. ARTYMET team structures will be changing over the next few years to support the Army's new modularity concept. No attempt has been made to convert the part-time Army National Guard ARTYMET Teams into full time equivalents.

Headquarters, Department of the Army, Deputy Chief of Staff, G-2 employs two full-time meteorologists for development of meteorological policy; coordination of meteorological support within the Department of the Army and with other Department of Defense and Federal agencies and organizations; Department of the Army Policy concerning weather; environmental services, and oceanographic support to the Army (less those environmental services functions assigned to the Corps of Engineers); and Department of the Army policy concerning peacetime weather support.

The Air Force provides one full time staff weather officer to serve as a liaison between AFW and the Army Staff. Forces Command (FORSCOM) will program approximately $13.2 million in fiscal year 2008 for meteorological operations support. This is a decrease of $0.9 million from the previous year.

The budgeted amount will be used in support of FORSCOM ARTYMET operations. An additional, undetermined amount of less than $1 million will be spent for supplies, travel, and other contracts for Air Force weather teams supporting FORSCOM units. FORSCOM and subordinate units do not budget directly for Air Force Weather teams, but provide some support for them on an as-needed basis from general operations and maintenance budgets.

TRADOC has programmed approximately $3.37M for FY07 for meteorological services. The majority of these TRADOC funds, a total of $3.15M, were programmed for operations support related to training development, instructor/support personnel, logistics (expendable supplies), and repair costs on artillery meteorological systems at the US Army Field Artillery School (USAFAS). Training development costs (~$1.06M) in FY07 are a result of initiatives to develop interactive multi-media instructional products and cost associated with rewrite of the artillery meteorology field manual. Because of the previous 2 years (FY06-07) of investment in creating training development products, training products will remain available without development costs in FY08. Instructor/support personnel costs (~$1.71M) in FY07 are the result of USAFAS at Fort Sill, OK employing 26 personnel to conduct training using the AN/TMQ-41 Meteorological Measuring Set (MMS) and the AN/TMQ-52 Meteorological Measuring Set-Profiler (MMS-P). Personnel funding is expected to increase by ~$283K in FY08 due to the addition of three instructors (two contractors and one enlisted soldier) to support the increased number of soldiers dictated by the Army's modular design. Logistics/supply costs (~$151K) in FY07 funds supplies for meteorological sounding equipment to support live fire and training at Fort Sill. In FY08 supply costs are expected to be ~$160K. Repair costs (~$230K) in FY07 on artillery meteorological systems is expected to increase by ~$30K in FY08 due to the costs associated with maintaining and operating a second MMS-Profiler system. TRADOC also programmed $69K in FY07 to fund a TRADOC Capabilities Manager (TCM) position for the Army's Integrated Meteorological System (IMETS). This position falls under the TRADOC Program Integration Office - All Source Analysis System (TPIO-ASAS) at the US Army Intelligence Center and School (USAICS) at Ft Huachuca, AZ. TPIO-ASAS has programmed $70K for this same position in FY08. TRADOC transferred $154K in FY07 to Air Combat Command for the maintenance and service of five Army Automated Surface Observing Sensor systems and two Army pole-mounted Tactical Meteorological Observing Systems at Fort Rucker, AL. Contract maintenance and service costs have been programmed to increase to ~$160K in FY08.

Army Materiel Command (AMC) will fund a variety of activities for FY 2008, most of which fall into research and development and systems acquisition. There has been no IMETS funding line for the last two fiscal years (FY06 and FY07). There have been 3 sources of funding available to the IMETS Project Office during this period - DA restored OPA funding via Program Manager Intelligence Fusion, Distributed Common Ground System - Army (DCGS-A) OPA, and DCGS-A R&D. Fiscal year 2007 OPA funds are being used for the continued production, fielding, and support of IMETS. Northrop Grumman Corporation (Tacoma/Lakewood, WA) is the primary contractor supporting the OPA effort. R&D funding supports the development of new capabilities, the testing and integration of IMETS capabilities into the DCGS-A, and to integrate the Air Force JET software into the IMETS/DCGS-A. The Army Research Laboratory and the New Mexico State University Physical Sciences Laboratory partner on IMETS development and technology insertion efforts. IMETS Project Office closes on 30 September 2007, to become DCGS-A Weather Services. Future funding for DCGS-A Weather Services (IMETS) will come from DCGS-A Program funding. To date, DCGS-A has not programmed fiscal year 2008

OPA funds to sustain and support the fielded IMETS. IMETS Project Office fiscal year 2008 R&D funding requirements are going through the DCGS-A process for approval and funding. IMETS fielded software support has transitioned to the CECOM Software Engineering Center, but it is unclear whether or not they will receive OMA funding for IMETS fielded software support in fiscal year 2008. Maintenance and support for the fielded IMETS, until the systems are replaced by DCGS-A, remains an issue to be resolved.

CECOM also oversees management of the AN/TMQ-52 Meteorological Measuring Set-Profiler program. This program received a supplemental increase in FY07 and has requested additional funds for FY08 to purchase additional systems in support of Army combat operations. Other activities within AMC include Army Research Laboratory, Battlefield Environment Division, which will continue to operate an integrated program of both basic and applied research.

The FY07 budget for weather support within Eighth US Army increased $1,350,000 (HQDA funded) for the acquisition and fielding of 15 additional automated weather sensor systems and upgrade to the 5 systems fielded in FY05. Budget activity of $762,000 was slightly lower and provided steady state operational support for meteorological services by Army ARTYMET ($730,000) and Air Force ($32,000) units. FY08 will see an increase of $183,000 to renew the warranty and maintenance contract supporting the 20 automated weather sensor system network. Budget activity will increase to $866,000 to support requirements from the fielding of the Army ARTYMET AN/TMQ-52 Profiler System ($825,000) and to restore Air Force funding ($41,000) from FY07 budget cuts.

The US Army Pacific (USARPAC) budget for Army Meteorological support will slightly increase for FY07/08. The 25ID(L), supported by the 25th Air Support Operations Squadron, received an increased estimate for FY07 IMETS-V and IMETS-L sustainment funds. In addition, a new Modified Table of Organization and Equipment for USARPAC's Operational Command Post authorizes an IMETS-L system for USARPAC, which will require sustainment funding in late FY07 and into FY08. ARTYMET personnel levels remain the same, but costs increased due to the annual cost of living increase for military personnel.

Because of changes in the US Army Research Institute of Environmental Medicine (USARIEM) research program for FY07, there was an increase in expenditures on weather-related research. It is anticipated that FY08 funding for weather-related research efforts at the USARIEM will be level relative to the FY07 level.

Space and Missile Defense Command (SMDC) supports several meteorological missions. SMDC has funding designated for the operational support at the High Energy Laser Systems Test Facility for contract services to operate and maintain the instrumentation, equipment, and facilities to support the atmospheric sciences/meteorological mission. SMDC also operates contract support services to operate the Ronald Reagan Missile Defense Test Site for operations support and special weather programs.

DEPARTMENT OF HOMELAND SECURITY (DHS)

U.S. COAST GUARD (USCG).

All of USCG's funding for meteorological programs is for operations support. For FY 2008, the requested funding level is $21.5 million. (The Coast Guard does not have a specific program and budget for meteorology--all meteorological activities are accomplished as part of general operations.)

The Coast Guard's activities include the collection and dissemination of meteorological and iceberg warning information for the benefit of the marine community. The Coast Guard also collects coastal and marine observations from its shore stations and cutters, and transmits these observations daily to the Navy's Fleet Numerical Meteorology and Oceanography Center and NOAA's National Weather Service. These observations are used by both the Navy and NOAA in generating weather forecasts.

The Coast Guard also disseminates a variety of weather forecast products and warnings to the marine community via radio transmissions. Coast Guard shore stations often serve as sites for NWS automated coastal weather stations, and the National Data Buoy Center provides logistics support in deploying and maintaining NOAA offshore weather buoys.

The International Ice Patrol conducts iceberg surveillance operations and provides warnings to mariners on the presence of icebergs in the North Atlantic shipping lanes. Coast Guard efforts in meteorological operations and services have not changed significantly during recent years.

DEPARTMENT OF THE INTERIOR (DOI)

The total DOI/BLM weather funding request for FY 2008 is $2.4 million. This amount is for meteorological operations and the support of the Bureau of Land Management (BLM) Remote Automatic Weather Station (RAWS) program. An additional $1.1 million is recovered each year through reimbursable accounts with participating agencies. Normal operations and maintenance of the RAWS program is approximately $900,000 yearly. (This includes travel, transportation, utilities, services, supplies, equipment and other non-labor costs.)

Support of the RAWS program by the BLM will continue in FY 2008, as part of the Wildland Fire Agencies' participation in Fire Weather activities and the National Fire Danger Rating System (NFDRS). In addition to upgrading and maintaining fixed-site RAWS, the BLM will address increasing demand for the use of mobile units for both fire and non-fire applications. Continued efforts will be made to achieve an optimum balance of fixed and mobile RAWS resources and support. Cooperation between DOI agencies and the USDA Forest Service regarding combined meteorological requirements for the National Wildland Fire support functions is ongoing. Interagency RAWS activity is coordinated at a working group level with representation by all participants, and will continue to implement NFDRS standards to ensure the protection of both life and property from wildland fires.

DEPARTMENT OF TRANSPORTATION (DOT)

The DOT total budget request for FY 2008 is $494.6 million which represents a funding decrease of 9.4 percent from FY 2007. The meteorological programs for the Federal Aviation Administration and the Federal Highway Administration, for FY 2008, are described below.

FEDERAL AVIATION ADMINISTRATION (FAA).

For 2008, FAA has requested a total $490.4 million for the Aviation Weather Programs including acquisition of new systems, operations and support, and supporting research. The actual funding for aviation weather in FY 2007 was $541.9 million. The $51.5 million decrease in FY 2008 constitutes a 9.5 percent decrease in total funding. The changes are comprised of:

• a decrease in acquisitions of $1.4 million (1.4 percent) to $92 million;

• a decrease in operations and support of $47 million (11 percent) to $362 million, reflecting salary increases throughout the agency, in associated logistics, and a decrease in Federal personnel in the automated flight service station operations as a result of the A-76 contract award; and

• an increase for aviation weather research of $4.7 million to a total of $28.3 million.

The funding changes reflect major initiatives in the aviation weather programs to bring much automation to the collection of weather observations from remote sensors, to the dissemination of weather products, graphics and decision making information available for use by the air traffic facilities, pilots, the aviation industry and general aviation users.

The AWRP will continue research into understanding the geophysical phenomena in the atmosphere and around airports that present hazardous conditions for aircraft operations. Among these are in-flight icing, turbulence, visibility, ceiling, convective activity, tornadoes, etc. Additional work will be done to improve models, develop better graphics for decision making information, and the impacts of space weather.

FEDERAL HIGHWAY ADMINISTRATION (FHWA).

The total FHWA request for surface transportation weather programs in FY 2008 is $4.2 million, all of which will be used for supporting research and special programs.

In 1999, the FHWA began documenting road weather data requirements, and this has served as the basis for the majority of work and research in this area. This work, some of which is described below, includes addressing the technical aspects of the road transportation system (including environmental data collection, processing and dissemination) as well as the institutional challenges associated with system implementation.

Addressing these institutional challenges has helped foster coordination within state and local Departments of Transportation (DOTs) as well as across the transportation and meteorological communities. With regard to technical areas of interest, data collection efforts have included increased coverage of atmospheric and road condition observations, as well as incorporation of road weather data (e.g., pavement and subsurface observations) into broader meteorological observation networks. Better processing includes the application of higher resolution weather models and the development of road condition prediction models (e.g., heat balance models) that are needed to develop the appropriate road weather information. This road weather information will enable more effective decision making, leading to a safer and more efficient surface transportation system.

A USDOT initiative entitled Clarus will develop, demonstrate and support deployment of a nationwide surface transportation weather observing and forecasting system, and ultimately foster nationwide data sharing capabilities. Clarus will allow agencies to share quality-checked environmental data, ultimately improving forecasts and value-added weather information products, as well as supporting anytime, anywhere road weather information for all road and transit users and operators.

A multi-year effort has been undertaken by the FHWA in cooperation with six national laboratories to prototype and field test advanced decision support tools for winter maintenance managers. The Maintenance Decision Support System (MDSS) prototype is a decision support tool that integrates relevant road weather forecasts, coded rules of practice for winter maintenance operations, and maintenance resource data to provide managers with customized road treatment recommendations. The first functional MDSS prototype was demonstrated in Iowa in early 2003 and during the winter season of 2003-2004. During the winter season of 2004-2005, the MDSS prototype was successfully deployed in a third demonstration in Colorado and in early 2006; this product was declared a "market ready technology." The current focus of the MDSS project is to continue to build on current outreach program activities such as sponsoring annual stakeholder meetings, conducting product "RoadShows," facilitating technology transfers to the private sector, providing assistance to public agencies in writing request for proposals, and participating in informational conferences. The project team also plans to conduct a series of cost/benefit analyses to produce "hard" financial data that can be used to support investing in such a system and exploring the potential of expanding the functionality of MDSS beyond winter maintenance to include such activities as non-winter road maintenance and traffic management.

The FHWA recently completed a study on how Traffic Management Centers (TMCs) around the country integrate road weather information into their operations. The FHWA documented the types of road weather information received by TMCs, the means of information delivery, how information needs change as the severity of a weather event increases, and how that information impacts traffic management decisions. The FHWA is also conducting analyses and developing models to quantify the impacts of various weather events on highway traffic, as well as investigating a variety of weather-responsive traffic management strategies such as changing traffic signal timing in response to weather and posting weather-related messages on variable message signs. These efforts will help FHWA advance the state-of-the-practice in weather-responsive traffic management.

The efforts described above, as well as future activities captured in the Road Weather Management program plan will be examined within the context of two key reports published in early 2004 and described below.

In 2002, the FHWA asked the National Research Council (NRC) Board of Atmospheric Sciences & Climate to examine what needs to be done from the research, development, and technology transfer perspectives to improve the production and delivery of weather-related information for the nation's roadways. In March 2004, the NRC released a report, *Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services*, which recommended the creation of a focused, national road weather research program led by FHWA that brings together the transportation and meteorological communities, identifies research priorities, and implements new scientific and technological advances. The NRC recommendations included making better use of existing road weather information and technologies to increase capabilities for transportation research, establishing a nationwide real-time road weather observing system, developing observing capabilities to assess the accuracy of road weather forecasts, improving environmental sensor technologies, and developing new means to effectively communicate road weather information to a wide range of users. Most, if not all of these recommendations, have been incorporated into the roadmap that is being used to guide the activities of the Road Weather Management Program.

To strengthen relationships between the meteorological and surface transportation communities, the FHWA Road Weather Management Program and the American Meteorological Society (AMS) co-sponsored a Policy Forum on Weather and Highways in November 2003. The objective was to discuss the provision of weather information to improve highway operations, the development of strategies to effectively respond to weather information, and the policy issues related to effective application of weather services to the management of the nation's highway system. The forum brought together nearly 100 representatives from public, private, and academic sectors at Federal, state, and local levels. The report resulting from the forum, *Weather and Highways: Report of a Policy Forum*, contained several recommendations including long-term congressional funding to develop a national road weather research, development, and applications program; close coordination of Federal and state DOTs to improve the safety and efficiency of highways during adverse weather; and establishing a national road weather data collection, processing, and dissemination system.

Based upon the recommendations that were made in the AMS and NRC reports, the FHWA and the National Oceanic and Atmospheric Administration (NOAA) signed a memorandum of understanding (MOU) in July of 2005, to enable the two agencies to work together to achieve shared goals for a safer and more efficient surface transportation system. By working together, these two agencies will be able to take advantage of each other's investments and expertise, as well as promote improved surface transportation weather training, products, and services. A near-term goal of this partnership will be the introduction of new products, services and training to improve the application of weather information to surface transportation operations.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of the EPA's funding of meteorological and air quality programs is for supporting research. The anticipated funding level in FY 2008 for directed meteorological research is $9.0 million which is the same funding level as in FY 2007.

Currently, increased attention is being paid to the effects of airborne toxins and fine particulate matter on human health, on the effect of climate change on air quality, and the impact on ecosystems. In addition, to promote excellence in environmental science and engineering, EPA established a national fellowship program and substantially increased its support for investigator-initiated research grants. The funding for grants (with reliance on quality science and peer review) and for graduate fellowships (to support the education and careers of future scientists) will provide for a more balanced, long-term capital investment in improved environmental research and development. The funding for the grants program will remain about the same in FY 2008 as in FY 2007.

This program will fund research in areas including ecological assessment, air quality, environmental fate and treatment of toxins and hazardous wastes, effects of global climate change on air quality, and exploratory research. The portion of these grants that will be awarded for meteorological research during FY 2008 cannot be foreseen, but it is probable that the grant awards will increase the base amount of $9.0 million listed above for directed meteorological research.

In collaboration with NOAA, EPA is continuing its development and evaluation of air quality models for air pollutants on all temporal and spatial scales as mandated by the Clean Air Act as amended in 1990. Research will focus on urban, mesoscale, regional, and multimedia models, which will be used to develop air pollution control strategies, human and ecosystem exposure assessments, and air quality forecasting. There will be increased emphasis placed on meteorological research into regional and urban formation and transport of air contaminants in support of the revisions to the National Ambient Air Quality Standards and homeland security. Increased efficiency of computation and interpretation of results are being made possible by means of supercomputing and scientific visualization techniques.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

For FY 2008, NASA requests a total of $168.7 million. The majority of this funding ($166.4 million) is for supporting research.

Nearly all of NASA funding in meteorology is for supporting research. The NASA Earth Science Division (ESD) budget consists of seven programs: Earth Systematic Missions, Earth Science Pathfinder, Research, Applied Sciences, Multi-Mission Operations, Technology and Education and Outreach. It is very difficult to extract the funding levels attributable to meteorology from the way the ESD budget is structured. The budget numbers presented here are obtained from the ESD budget by arbitrarily assigning approximately one ninth of the ESD budget to meteorology with the Earth Systematic Missions program contributing to the Systems Development line and the other six programs to the Research and Development line.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC planned expenditure of $120,000 in FY 2008, is for meteorological operations to continue technical assistance for the analysis of atmospheric dispersion for routine and postulated accidental releases from nuclear facilities, and the review of proposed sites for possible construction of new nuclear power plants.

The meteorological support program in the NRC is focused primarily on analyzing and utilizing meteorological data in atmospheric transport and dispersion models. These models provide insight on plume pathways in the near- and far-fields for building wake and dispersion characteristics to perform dose calculations on postulated releases to the environment. Meteorological information is used as input to the probabilistic safety assessment, the assessment of the radiological impacts of routine releases from normal operations, the assessment of other (non-radiological) hazards that may impact safe operation of the facility, and the assessment of design or operational changes proposed for the facility.

Additionally, after a hiatus of some 25 years, the nuclear power industry has expressed an interest in seeking site approvals for new nuclear power plants. Three early site permit applications have been received and are currently under review. These reviews will also consider regional climatology and local meteorology. In addition to its internal review activities, the NRC may seek assistance from other Federal agencies to support its safety reviews.

AGENCY FUNDING BY BUDGET CATEGORY

Table 2.2 depicts how the agencies plan to obligate their funds for meteorological operations broken down by "budget category." The two major categories are "Operations Support" and "Systems Acquisition." To a large degree, these categories correspond to non-hardware costs (Operations Support) and hardware costs (Systems Acquisition). For agency convenience in identifying small components that do not fit into these two major categories, a third category is added called "Special Programs." Programs that provide support to several government agencies such as the Air Force's DMSP are listed on a separate line.

In FY 2008, Operational Costs requested are $3.05 billion with a total of $1.78 billion (58.4 percent) for Operations Support, $1.23 billion (40.4 percent) for Systems Acquisition, and $36.5 million (1.2 percent) for Special Programs.

Table 2.3 describes how the agencies plan to obligate their funds for meteorological supporting research according to budget categories. The agencies' supporting research budgets are subdivided along similar lines--Research and Development (non-hardware), Systems Development (hardware), and Special Programs (for those items that do not easily fit into the two major categories).

For FY 2008, agencies will obligate a total of $740.6 million in Supporting Research funds in the following manner: $307.3 million (41.5 percent) to research and development and $433.3 million (58.5 percent) to Systems Development.

AGENCY FUNDING BY SERVICE CATEGORY

Table 2.4 summarizes how the agencies plan to obligate operational funds for basic and specialized meteorological services; Table 2.5 is a similar breakout for supporting research funds.

Table 2.4 reveals the distribution of FY 2008 operational funds: basic meteorology services receiving 59.4 percent; aviation 16.3 percent; marine 4.1 percent; agriculture/ forestry 0.7 percent; general military services 19.2 percent; and other specialized services accounting for 0.2 percent. Table 2.5 shows the distribution of supporting research funds among the services with basic meteorology receiving 14.9 percent, aviation 4.1 percent, marine 0.1 percent, agriculture and forestry 4.0 percent, general military 52.0 percent, and the remaining 24.9 percent dedicated to other meteorological services.

The definitions of specialized and basic services are described below:

Basic Services.

Basic services provide products that meet the common needs of all users and include the products needed by the general public in their everyday activities and for the protection of lives and property. "Basic" services include the programs and activities that do not fall under one of the specialized services.

Specialized Meteorological Services.

Aviation Services. Those services and facilities established to meet the requirements of general, commercial, and military aviation.

Marine Services. Those services and facilities established to meet the requirements of the DOC, DOD, and DOT on the high seas, on coastal and inland waters, and for boating activities in coastal and inland waters. The civil programs which are directly related to services solely for marine uses and military programs supporting fleet, amphibious, and sea-borne units (including carrier-based aviation and fleet missile systems) are included.

Agriculture and Forestry Services. Those services and facilities established to meet the requirements of the agricultural industries and Federal, state, and local agencies charged with the protection and maintenance of the nation's forests.

General Military Services. Those services and facilities established to meet the requirements of military user commands and their component elements. Programs and services which are part of basic, aviation, marine, or other specialized services are not included.

Other Specialized Services. Those services and facilities established to meet meteorological requirements that cannot be classified under one of the preceding categories; such as, space operations, urban air pollution, global climate change, and water management.

PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 2.6 depicts agency staff resources in meteorological operations. The total agency staff resources requested for FY 2008 is 12,260. This total represents a decrease of 2.7 percent from FY 2007, with the largest decreases occurring in the DOD/Navy and DOT/FAA personnel.

TABLE 2.2 AGENCY OPERATIONAL COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

AGENCY	Operations Support FY2007	Operations Support FY2008	Systems Acquisition FY2007	Systems Acquisition FY2008	Special Programs FY2007	Special Programs FY2008	Total FY2007	Total FY2008	Total %CHG	% of FY2008 TOTAL
Agriculture	19107	19563	0	0	0	0	19107	19563	2.4	0.6
Commerce/NOAA(Subtot)	942416	955784	880738	887637	33971	27760	1857125	1871181	0.8	61.5
NWS	754408	787156	74664	67131	32815	26604	861887	880891	2.2	28.9
NESDIS***	147337	129931	806074	820506	0	0	953411	950437	-0.3	31.2
OAR	0	0	0	0	0	0	0	0	0	0.0
NOS	28337	26363	0	0	0	0	28337	26363	-7.0	0.9
NMAO	12334	12334	0	0	1156	1156	13490	13490	0.0	0.4
Defense(Subtot)	379855	413076	171702	251991	661	661	552218	665728	20.6	21.9
Air Force***	258172	276460	54754	50408	0	0	312926	326868	4.5	10.7
DMSP*	14913	17796	86376	127350	0	0	101289	145146	43.3	4.8
Navy	71441	86122	1212	1248	0	0	72653	87370	20.3	2.9
Army	35329	32698	29360	72985	661	661	65350	106344	62.7	3.5
Homeland Security (Subtot)	20110	21540	0	0	0	0	20110	21540	7.1	0.7
USCG	20110	21540	0	0	0	0	20110	21540	7.1	0.7
Interior/BLM	2400	2400	0	0	0	0	2400	2400	0.0	0.1
Transportation(Subtot)	419090	362340	93110	91738	6135	8039	518335	462117	-10.8	15.2
FAA	419090	362340	93110	91738	6135	8039	518335	462117	-10.8	15.2
FRA	0	0	0	0	0	0	0	0	0.0	0.0
FHWA	0	0	0	0	0	0	0	0	0.0	0.0
EPA	0	0	0	0	0	0	0	0	0.0	0.0
NASA	2269	2220	154	169	0	0	2423	2389	-1.4	0.1
NRC	120	120	0	0	0	0	120	120	0.0	0.0
TOTAL	1785367	1777043	1145704	1231535	40767	36460	2971838	3045038	2.5	100.0
% of FY TOTAL	60.1%	58.4%	38.6%	40.4%	1.4%	1.2%	100.0%	100.0%		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

***NESDIS and Air Force budget numbers also include the DOC and DOD shares of the NPOESS budget, respectively.

TABLE 2.3 AGENCY SUPPORTING RESEARCH COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

AGENCY	Research & Development FY2007	Research & Development FY2008	Systems Development FY2007	Systems Development FY2008	Special Programs FY2007	Special Programs FY2008	Total FY2007	Total FY2008	Total %CHG	% of FY2008 TOTAL
Agriculture	35982	29216	0	0	0	0	35982	29216	-18.8	3.9
Commerce/NOAA(Subtot)	107933	94978	4320	4320	0	0	112253	99298	-11.5	13.4
NWS	20555	20651	1950	1950	0	0	22505	22601	0.4	3.1
NESDIS	29854	27871	0	0	0	0	29854	27871	-6.6	3.8
OAR	56368	45300	1870	1870	0	0	58238	47170	-19.0	6.4
NOS	0	0	500	500	0	0	500	500	0.0	0.1
NMAO	1156	1156	0	0	0	0	1156	1156	0.0	0.2
Defense(Subtot)	51195	42782	368659	361405	0	0	419854	404187	-3.7	54.6
Air Force***	15439	13213	367696	361405	0	0	383135	374618	-2.2	50.6
DMSP*	0	0	963	0	0	0	963	0	-100.0	0.0
Navy	24335	18910	0	0	0	0	24335	18910	-22.3	2.6
Army	11421	10659	0	0	0	0	11421	10659	-6.7	1.4
Homeland Security (Subtot)	0	0	0	0	0	0	0	0	0.0	0.0
USCG	0	0	0	0	0	0	0	0	0.0	0.0
Interior/BLM	0	0	0	0	0	0	0	0	0.0	0.0
Transportation(Subtot)	27800	32514	0	0	0	0	27800	32514	17.0	4.4
FAA	23600	28314	0	0	0	0	23600	28314	20.0	3.8
FRA	0	0	0	0	0	0	0	0	0.0	0.0
FHWA	4200	4200	0	0	0	0	4200	4200	0.0	0.6
EPA	9000	9000	0	0	0	0	9000	9000	0.0	1.2
NASA	104500	98800	58200	67600	0	0	162700	166400	2.3	22.5
NRC	0	0	0	0	0	0	0	0	0.0	0.0
TOTAL	336410	307290	431179	433325	0	0	767589	740615	-3.5	100.0
% of FY TOTAL	43.8%	41.5%	56.2%	58.5%	0.0%	0.0%	100.0%	100.0%		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

***Air Force budget numbers also include the DOD share of the NPOESS budget

TABLE 2.4 AGENCY OPERATIONAL COSTS, BY SERVICE

(Thousands of Dollars)

AGENCY	Basic Meteorology FY2007	Basic Meteorology FY2008	Aviation FY2007	Aviation FY2008	Marine FY2007	Marine FY2008	Agriculture & Forestry FY2007	Agriculture & Forestry FY2008	General Military FY2007	General Military FY2008	Other FY2007	Other FY2008	Total FY2007	Total FY2008
Agriculture	0	0	0	0	0	0	19107	19563	0	0	0	0	19107	19563
Commerce/NOAA(Subtot)	1756255	1773089	15328	16528	85542	81564	0	0	0	0	0	0	1857125	1871181
NWS	789354	809162	15328	16528	57205	55201	0	0	0	0	0	0	861887	880891
NESDIS***	953411	950437	0	0	0	0	0	0	0	0	0	0	953411	950437
OAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOS	0	0	0	0	28337	26363	0	0	0	0	0	0	28337	26363
NMAO	13490	13490	0	0	0	0	0	0	0	0	0	0	13490	13490
Defense(Subtot)	12351	14853	22936	26396	21069	25337	0	0	492229	594773	3633	4369	552218	665728
Air Force***	0	0	0	0	0	0	0	0	312926	326868	0	0	312926	326868
DMSP*	0	0	0	0	0	0	0	0	101289	145146	0	0	101289	145146
Navy	12351	14853	21796	26211	21069	25337	0	0	13804	16600	3633	4369	72653	87370
Army	0	0	1140	185	0	0	0	0	64210	106159	0	0	65350	106344
Homeland Security (Subtot)	0	0	0	0	20110	21540	0	0	0	0	0	0	20110	21540
USCG	0	0	0	0	20110	21540	0	0	0	0	0	0	20110	21540
Interior/BLM	0	0	0	0	0	0	2400	2400	0	0	0	0	2400	2400
Transportation(Subtot)	0	0	518335	462117	0	0	0	0	0	0	0	0	518335	462117
FAA	0	0	518335	462117	0	0	0	0	0	0	0	0	518335	462117
FRA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FHWA	0	0	0	0	0	0	0	0	0	0		0	0	0
EPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NASA	0	0	0	0	0	0	0	0	0	0	2423	2389	2423	2389
NRC	120	120	0	0	0	0	0	0	0	0	0	0	120	120
TOTAL	1768726	1788062	556599	505041	126721	128441	21507	21963	492229	594773	6056	6758	2971838	3045038
% of FY TOTAL	59.5%	58.7%	18.7%	16.6%	4.3%	4.2%	0.7%	0.7%	16.6%	19.5%	0.2%	0.2%	100.0%	100.0%

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

***NESDIS and Air Force budget numbers also include the DOC and DOD share of the NPOESS budget, respectively.

TABLE 2.5 AGENCY SUPPORTING RESEARCH COSTS, BY SERVICE

(Thousands of Dollars)

AGENCY	Basic Meteorology FY2007	Basic Meteorology FY2008	Aviation FY2007	Aviation FY2008	Marine FY2007	Marine FY2008	Agriculture & Forestry FY2007	Agriculture & Forestry FY2008	General Military FY2007	General Military FY2008	Other FY2007	Other FY2008	Total FY2007	Total FY2008
Agriculture	0	0	0	0	0	0	35982	29216	0	0	0	0	35982	29216
Commerce/NOAA(Subtot)	110128	97173	1625	1625	500	500	0	0	0	0	0	0	112253	99298
NWS	22505	22601	0	0	0	0	0	0	0	0	0	0	22505	22601
NESDIS	29854	27871	0	0	0	0	0	0	0	0	0	0	29854	27871
OAR	56613	45545	1625	1625	0	0	0	0	0	0	0	0	58238	47170
NOS	0	0	0	0	500	500	0	0	0	0	0	0	500	500
NMAO	1156	1156	0	0	0	0	0	0	0	0	0	0	1156	1156
Defense(Subtot)	11032	10259	0	0	24335	18910	0	0	384487	375018	0	0	419854	404187
Air Force***	0	0	0	0	0	0	0	0	383135	374618	0	0	383135	374618
DMSP*	0	0	0	0	0	0	0	0	963	0	0	0	963	0
Navy	0	0	0	0	24335	18910	0	0	0	0	0	0	24335	18910
Army	11032	10259	0	0	0	0	0	0	389	400	0	0	11421	10659
Homeland Security (Subtot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USCG	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interior/BLM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation(Subtot)	0	0	23600	28314	0	0	0	0	0	0	4200	4200	27800	32514
FAA	0	0	23600	28314	0	0	0	0	0	0	0	0	23600	28314
FRA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FHWA	0	0	0	0	0	0	0	0	0	0	4200	4200	4200	4200
EPA	0	0	0	0	0	0	0	0	0	0	9000	9000	9000	9000
NASA	0	0	0	0	0	0	0	0	0	0	162700	166400	162700	166400
NRC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	121160	107432	25225	29939	24835	19410	35982	29216	384487	375018	175900	179600	767589	740615
% of FY TOTAL	15.8%	14.5%	3.3%	4.0%	3.2%	2.6%	4.7%	3.9%	50.1%	50.6%	22.9%	24.3%	100.0%	100.0%

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

***Air Force budget numbers also include the DOD share of the NPOESS budget

TABLE 2.6 PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS
(Units are Full Time Equivalent Staff Years)*

AGENCY	FY 2007	FY 2008	% CHANGE	% of FY 2008 TOTAL
Agriculture	274	275	0.4	2.2
Commerce/NOAA (Subtotal)	5,741	5,753	0.2	46.9
NWS	4,660	4,658	0.0	38.0
NESDIS	876	890	1.6	7.3
OAR	32	32	0.0	0.3
NOS	119	119	0.0	1.0
NMAO	54	54	0.0	0.4
Defense	5,248	5,048	-3.8	41.2
Air Force (Subtotal)	4,313	4,266	-1.1	34.8
Air Force Weather	4,194	4,147	-1.1	33.8
DMSP	119	119	-0.0	1.0
Navy	571	413	-27.7	3.4
Army	364	369	1.4	3.0
Homeland Security (Subtotal)	108	108	0.0	0.9
USCG	108	108	0.0	0.9
Interior/BLM (Subtotal)	28	28	0.0	0.2
Interior	26	26	0.0	0.2
Reimbursed**	2	2	0.0	0.0
Transportation (Subtotal)	1,306	1,154	-11.6	9.4
FAA	1,302	1,150	-11.7	9.4
FHWA	4	4	0.0	0.0
EPA	0	0	0.0	0.0
NASA	0	0	0.0	0.0
NRC	1	2	100.0	0.0
TOTAL	12,598	12,260	-2.7	100.0*

* Column total may not exactly equal 100 percent due to rounding for several agencies.
** “Reimbursed" are personnel funded by other agencies.

INTERAGENCY FUND TRANSFERS

Table 2.7 summarizes the reimbursement of funds from one agency to another during FY 2007. Agencies routinely enter into reimbursable agreements when they determine that one agency can provide the service more efficiently and effectively than the other. While specific amounts may vary from year-to-year, the pattern shown is essentially stable and reflects a significant level of interagency cooperation.

DEPARTMENT OF COMMERCE

NESDIS will transfer a total of $310.2 million to NASA for procurement and launches of polar-orbiting ($64.5 million) and geostationary ($245.7 million) satellites.

DEPARTMENT OF DEFENSE

The Air Force will reimburse DOC a total of $20.7 million for operations [e.g., DMSP operations ($11,121 million), OFCM support ($405,000), Lightning Data ($225,000), NCEP operations ($140,000), WSR-88D support ($3,649,000), geomagnetic data ($2,926 million), and IPO support ($220,000)]. In addition, the Air Force will reimburse NASA $148,000 for a variety of data and USGS $247,000 for the purchase of magnetometer data support.

The Navy will reimburse DOC $230,000 for basic climatological analysis and forecasting, and interagency coordination.

The Army reimbursements to DOC/NOAA include $570,000 from COE to NWS for maintaining precipitation reporting stations The U.S. Geological Survey will also be reimbursed $547,000 by the Army's COE for operations and maintenance of hydrologic and precipitation reporting stations.

DEPARTMENT OF TRANSPORTATION

The FAA will reimburse NOAA $35.5 million for FY 2007. Included in those funds are development of enhancements and operational support associated with the WSR-88D, ASOS maintenance, the Center Weather Service Units at all Air Route Traffic Control Centers, the World Area Forecast System, meteorology instructors at the FAA, studies and OFCM support. The FAA will also reimburse the DOD a total of $3.4M for supporting research.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

The Air Force will be reimbursed a total of $1.625 million--$1.520 million for observations, forecasts, and operations/maintenance of weather infrastructure and replacement of upper air systems at Trans-Atlantic Abort Landing Sites and $105 million for operation and maintenance of weather towers at Edwards AFB, CA. The UCAR will receive $15,000 for data analysis to improve lightning launch commit criteria. The National Data Buoy Center will receive reimbursements of $116,000 for the operation of two data buoys.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

NOAA's Air Resources Laboratory (ARL) will receive $6.7 million for development, evaluation, and application of air quality dispersion models; and for provision of meteorological expertise and guidance for EPA policy development activities.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC enjoys a unique relationship with the DOE as a result of the Energy Reorganization Act of 1974. The act realigned the Atomic Energy Commission into a regulatory organization-NRC and a research and promotional organization-ERDA (which was subsequently absorbed into DOE). As a result, the NRC has access to the DOE national laboratories for technical assistance activities. This assistance, while not a reimbursable agreement, results in the transfer of funds from NRC for specific technical assistance by DOE laboratories. In FY 2007, the NRC expects to task DOE laboratories and the National Oceanic and Atmospheric Administration's National Climatic Data Center at a funding level of $120,000.

FACILITIES/LOCATIONS FOR TAKING METEOROLOGICAL OBSERVATIONS

Table 2.8 indicates the number of facilities/locations or platforms at which the Federal agencies carry out (or supervise) the taking of various types of meteorological observations.

TABLE 2.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 2007 Funds ($K) Estimated or Planned Operations	Supporting Research
Commerce/NOAA	NASA (Polar satellite acquisition)	64,512	
	NASA (Geo satellite acquisition)	245,731	
Defense/Air Force			
	NOAA(DMSP Satellite Operations)	11,121	
	DOC/NOAA/NWS (NEXRAD)		200
	DOC/NOAA/NWS (NEXRAD)	3,649	
	DOC/NOAA/NWS (ASOS)		138
	DOC/NOAA/NWS (ASOS)	431	
	DOC/NOAA (Shared Processing Network	710	
	DOC/NOAA/NWS/NCEP(NCEP Communication Circuit Support)	140	
	DOC/NOAA (COMET)		30
	DOC/NOAA/NWS (Lightning Detection System)	225	
	DOC/NOAAOFCM	405	
	DOC/NOAA/NESDIS/IPO (DMSP: Activation of DOMSAT)	220	
	USGS (Dept. of Interior) (USGS Magnetometer)	247	
	NASA (JPL Tech Data)	148	
	DOC/NOAA/SEC (ACE Radian / Data Geomagnetic)	2,926	
	DOC/NOAA/NWS (HAWCNET)	873	
	NSF (Universal Center for Atmos Research)		279
	NSF/UCAR/NCAR (WRF)		461
	NSF/UCAR (Data Assimilation)		445
	DOC/NOAA/ESRL (WRF)		15
	NASA (Land Information System)		125
Defense/Navy	DOC/NOAA/NCDC	45	
	DOC/NOAA/OFCM	185	
Defense/Army	DOD/USAF/ACC	160	
	NSF		46
	DOC/NOAA/NWS	570	
	DOI/USGS	547	
	DOC/NOAA/OFCM	65	

TABLE 2.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH (Continued)

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 2007 Funds ($K) Estimated or Planned	
		Operations	Supporting Research
Transportation/FAA	DOC/NOAA	35,500	
	DOD/USAF		3,400
	DOC/NOAA/OFCM	200	
Transportation/FRA	DOC/NOAA	289	
NASA	DOD/USAF/45th SW	1,520	
	DOD/USAF/Edwards AFB	105	
	DOC/NOAA/NDBC	116	
	UCAR		15
EPA	DOC/NOAA/OAR		6,700
NRC	DOE/PNNL	120	

TABLE 2.8 FACILITIES/LOCATIONS FOR TAKING METEOROLOGICAL OBSERVATIONS

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 2007)
Surface, land	
Commerce (all types)	841
Air Force (U.S. & Overseas)	162
Navy (U.S. & Overseas)	68
Marine Corps (U.S. & Overseas)	13
Army (U.S. & Overseas)	41
Transportation (Flight Service Stn)	8
Transportation (Lim Aviation Wx Rptg Stn)	114
Transportation (Contract Wx Obsg Stn)	189
Transportation (Auto Wx Obsg Stn)	198
Transportation (Road Wx Obsg Stn)	2,149
Transportation (Auto Sfc Obsg Sys, fielded)	569
Homeland Security (USCG Coastal)	50
Interior	470
Agriculture	2684
NASA (all types)	46
Surface, marine	
Commerce (SEAS-equipped ships)	640
Commerce (Coastal-Marine Autom Network)	56
Commerce (NOAA/NOS/PORTS)	13
Commerce (PORTS only meteorological stations	28
Commerce (Buoys--moored)	100
Commerce (Buoys--drifting)	21
Commerce (Buoys--large navigation)	10
Commerce (Water-level gauges)	222
Commerce (Water-level gauges with meteorology sensors	117
Navy (Ships with met personnel)	29
Navy (Ships without met personnel	247
Homeland Security (USCG Cutters)	248
NASA (Buoys - moored)	2
Upper air, balloon	
Commerce (U.S.)	86
Commerce (Foreign, Cooperative)	22
Air Force, Fixed (U.S. & Overseas)	12
Air Force, Mobile	15
Army, Fixed (U.S. & Overseas)	18
Army, Mobile (U.S. and Overseas)	85
Navy, Fixed (U.S. & Overseas)	0
Navy, Mobile(U.S. & Overseas)	10
Navy, Ships	29
Marine Corps, Mobile	10
NASA (U.S. and Overseas)	4
Atmospheric Profilers	
Air Force (Eastern Range) (915 MHz)	5
Air Force (Eastern Range) (SODARS)	5

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 2007)
Atmospheric Profilers (Cont.)	
Air Force (Western Range) (915 MHz)	5
Air Force (Western Range) (50 MHz)	1
Army	9
NASA (50 MHz)	1
Upper air, rocket	
Army (U.S. & Overseas)	1
Doppler weather radar (WSR-88D) sites	
Commerce (NWS)	123
Air Force (U.S. & Overseas)	26
Army (US and Overseas)	2
Transportation (Off CONUS)	12
Doppler weather radar (Not WSR-88D) sites	
NWS (Evansville)	1
Air Force (Fixed)	9
Army	2
Navy (Fixed)	9
Marine Corps (Mobile)	10
Marine Corps 9Fixed)	1
Off-site WSR-88D Processors (PUPs)	
Commerce (NWS) [Part of AWIPS]	0
Air Force (OPUPs only)	97
Navy (OPUP only)	1
Marine Corps (U.S. & Overseas)	9
Army	1
Transportation	25
NASA (KSC/AMU)	1
Airport Terminal Doppler weather radars	
Transportation (Commissioned)	45
Army (not airfield--Test Range/USAREUR)	2
Conventional radar (non-Doppler) sites	
Commerce (NWS)	31
Commerce (at FAA sites)	27
Air Force, Mobile Units	23
Army (U.S. and Overseas)	4
Transportation (FAA (WSP))	34
Weather reconnaissance (No. of aircraft)	
Commerce (NAMO)	3
Air Force Reserve Command (AFRC)	10
Geostationary meteorological satellites (No. operating)	
Commerce (2 primary, 2 standby, 1 post launch checkout)	5

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 2007)
Polar meteorological satellites (No. operating)	
Commerce (2 primary, 4 standby)	6
Air Force (2 primary, 3 standby)	5
Navy (WINDSAT and GFO)	2
Field Mills (Surface)	
NASA (KSC)	31
Stennis	2
Lightning Detection Systems	
Air Force (Eastern Range) (Cloud - Ground)	1
Air Force (Eastern Range) (National Lightning Detection Network Licensed Display)	1
Air Force (Western Range) (Cloud - Ground)	1
Kennedy Space Center (4D Total Lightning)	1

SECTION 3

DEPARTMENT OF COMMERCE WEATHER PROGRAMS
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) is the principal meteorological agency of the Federal government. By law, NOAA is responsible for reporting the weather of the United States, providing weather and flood warnings and forecasts to the general public, developing and furnishing applied weather services, and recording the climate of the United States. This mission is carried out within NOAA by the National Weather Service (NWS); the National Environmental Satellite, Data, and Information Service (NESDIS); the Office of Oceanic and Atmospheric Research (OAR); the National Ocean Service (NOS); and the NOAA Marine and Aviation Operations (NMAO).

NATIONAL WEATHER SERVICE

NOAA's National Weather Service (NWS) has the principal responsibility for planning and operating the basic climate, hydrologic, and weather services and certain specific applied services. The NWS provides climate, water, and weather warnings and forecasts for the U.S., its territories, adjacent waters, and ocean areas to help protect life and property and enhance the national economy. NWS data and products form a national information data base and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community. In support of this mission, NWS:

• Issues warnings and forecasts of weather, flood, Great Lakes, coastal and ocean conditions.

• Observes and reports the weather and the river and ocean conditions of the U.S. and its territories.

• Develops and operates national meteorological, hydrological, climate, space weather and oceanic service systems.

• Performs applied meteorological, hydrological, oceanic, space environmental and climate research.

• Assists in developing community awareness and educational materials and programs concerning weather-related natural disasters.

• Participates in international hydrometeorological and space weather activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of hydrometeorological equipment and systems overseas under the Voluntary Cooperation Program.

The basic enabling legislation and authority for weather services are summarized as follows:

• Organic Act of 1890 created the United States Weather Bureau in the Department of Agriculture.

• Enabling Act of 1919 allowed the United States Weather Bureau to enter into cooperative agreements for providing agriculture weather services.

• Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control; on July 1, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce.

• Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for providing weather observations and services to aviation.

• Reorganization Plan 2 of 1965 placed the "National Weather Service" in the newly created Environmental Science Services Administration (ESSA).

• Reorganization Plan 4 of 1970 made the NWS a part of the newly created National Oceanic and Atmospheric Administration (NOAA).

• International Convention for the Safety of Life at Sea (SOLAS) agreement to which the U.S. is signatory. This sets international policy for safer shipping and cleaner seas. The U.S implements the convention through Executive Order 12234 of Sept. 3, 1980 -- Enforcement of the Convention for SOLAS. Among the obligations of the agreement is to provide meteorological warnings and forecasts to ships at sea using charts and radio messages.

SERVICES

NWS provides climate, water, weather oceanic, and space weather prediction services; including watches, warnings, advisories, and forecasts 24 hours a day, seven days a week. These services are provided through a national network of 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), and the nine centers of the National Centers for Environmental Prediction (NCEP). These offices collect data, prepare local warnings and forecasts, and disseminate information to the public both nationally and internationally through NOAA Weather Radio, satellite-based telecommunication systems, radiofacsimile, the media and the internet. Forecast and warning services prepared at WFOs are derived in part from prediction guidance prepared by the 13 RFCs and the nine NCEP centers.

These centers are: Hydrometeorological Prediction Center, Storm Prediction Center, Aviation Weather Center, Environ-mental Modeling Center, Tropical Prediction Center, Climate Prediction Center, Space Environment Center, Ocean Prediction Center, and NCEP Central Operations.

Continually improving the accuracy, timeliness, and accessibility to prediction services is largely a result of research and development both within the NWS and externally from universities and private corporations.

PUBLIC WEATHER SERVICES

NOAA's NWS Public Weather Service Program provides forecast, warning, and response services to the public, private meteorological firms, broadcast meteorologists, and NWS partners who are responsible for public safety. These partners include Federal, state, and local emergency managers and planners. NWS forecasters issue short-duration watches and warnings for severe weather, such as tornadoes and severe thunderstorms, as well as long-duration watches, warnings, and advisories for hazardous winter weather conditions, high wind events, dense fog, and temperature extremes. NWS forecasters support several health related programs such as Air Quality, Heat Health, and the Ultraviolet Index (UVI). Ground based ozone concentration forecasts and an experimental smoke forecasting tool are now being produced for the CONUS. A nationwide air quality forecast capability including concentrations of ozone, particulate matter, and other pollutants is under development. Heat Health Watch Warning Systems (HHWWS) have been developed for select cities to provide advance notice of excessive heat events that produce the greatest number of weather-related deaths. These guidance systems will be expanded to other cities as resources are made available. Also, in partnership with the Environmental Protection Agency (EPA), a climatologically based UV alert is being produced for the entire nation. The Branch serves as the primary focal point for collaboration with Federal transportation agencies on weather issues related to surface transportation, with Federal, media, and private entities on the UVI, and with the World Meteorological Organization on the provision of public weather services to the international community. Additionally, NWS forecasters provide meteorological support both on-site and from WFOs for terrorist acts and other homeland security concerns, as well as accidental releases/spills of hazardous chemical, biological, or radioactive materials.

Since 2004, the National Weather Service has created, and made readily available, forecasts in digital formats. NWS forecasters use their expertise to maintain an up-to-date digital forecast database of sensible weather elements. This information is stored in the National Digital Forecast Database (NDFD). Output from NDFD is available in the form of web graphics available over the Internet, in gridded binary format (GRIB2) available via anonymous file transfer protocol, or in XML via an experimental web service. NDFD data can also be converted to a file format that can be used with Geographical Information Systems (GIS). NDFD includes the following operational forecast elements: Maximum Temperature, Minimum Temperature, 12-Hour Probability of Precipitation, Temperature, Dew Point, Weather, Wind Speed and Direction, Relative Humidity, Apparent Temperature, Significant Wave Height, and Probabilistic Tropical Cyclone Surface Wind Speeds. Experimental forecast elements include Quantitative Precipitation Forecast (QPF), Snow Amount, Sky Cover, Wind Gust, and Convective Outlook Hazard Probabilities. For more detailed information on NDFD, please see http://www.nws.noaa.gov/ndfd/.

AVIATION WEATHER SERVICES

NWS' Aviation Weather Services Branch funds a broad range of initiatives designed to improve the delivery of aviation weather information to National Airspace System (NAS) users. These initiatives include the acquisition of aircraft mounted water vapor sensors, development of software, tools and training programs to enhance forecaster effectiveness, and products to improve weather information availability to the aviation community. The Aviation Weather Program also serves as NOAA's focal point in the development of the Next Generation Air Transportation System (NextGen). In order to accommodate the projected tripling of demand for air transportation, Congress established the Joint Planning and Development Office (JPDO) to develop and implement NextGen. The NextGen plan will increase NAS capacity by relying on 4D aircraft trajectories for air traffic management. It will rely on highly automated systems to route air traffic around areas of hazardous weather. These systems, and related decision support tools, will require a 4 Dimensional (4D) digital database of aviation relevant weather elements that will serve as a single authoritative source of aviation weather data. This 4D Database must be continuously updated, internally consistent, and utilize Network Enabled Operations to provide for common situational awareness. The 4D Database will give NOAA the ability to provide airspace users with the current and forecast weather conditions for any point in space, thereby providing for the safe and efficient movement of air traffic. This capability is required to have an initial operational capability by 2012, in order to support the planned automated air traffic management systems.

In order to operationally support the needs of aviation users, the NWS WFOs prepare Terminal Aerodrome Forecasts (TAFs) four times a day,

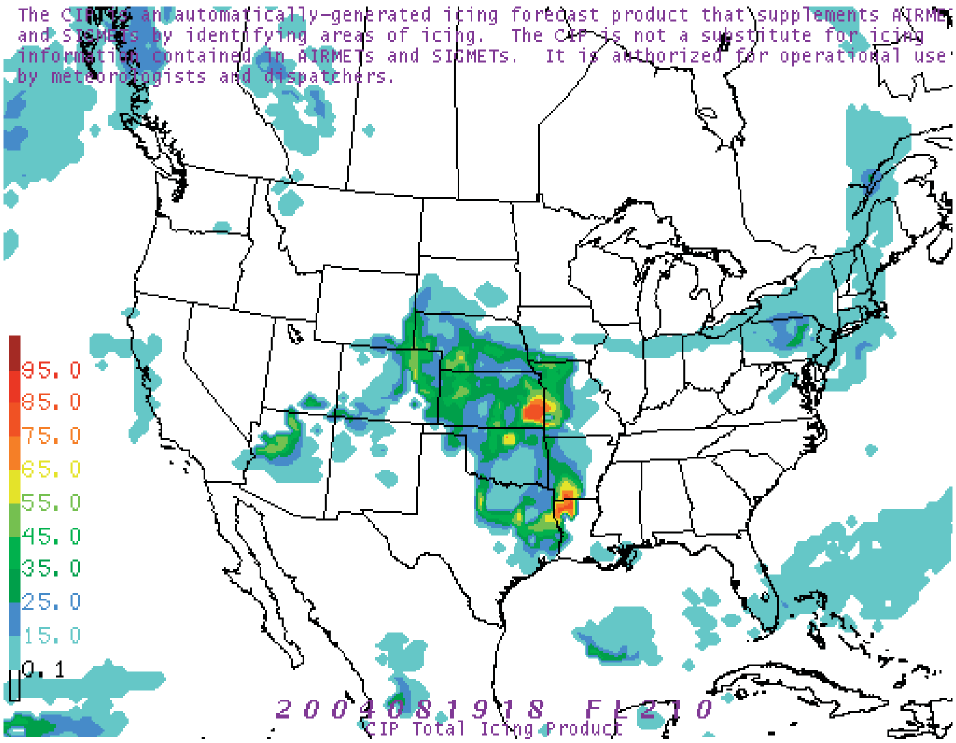

Figure 3-DOC-1. Current Icing Potential (CIP) Product. The FAA's Aviation Weather Research Program and the NWS developed this graphical icing product, updated every 3 hours, and available for user selected altitudes across the contiguous U.S.

with amendments as needed, for more than 625 public-use airports in the U.S. and its territories in the Caribbean and Pacific. These offices also produce about 241 individual route-oriented forecasts three times a day for the 48 contiguous states and over the Pacific Ocean.

NCEP's Aviation Weather Center (AWC) and the Alaska Region's Alaska Aviation Weather Unit (AAWU), and WFO Honolulu, HI prepare area forecasts three or four times daily describing general aviation weather conditions over the lower 48 states, the Gulf of Mexico, Caribbean, Alaska, Hawaii and coastal waters respectively. These three specialized offices also issue in-flight advisories and warnings of hazardous weather conditions associated with thunderstorms, icing, turbulence, and strong, low level winds. The AWC also prepares forecasts of significant aviation weather over the continental U.S. four times a day (Figure 3-DOC-1).

NWS Center Weather Service Units located in each of the 21 FAA Air Route Traffic Control Centers provide direct meteorological support to en route centers, Terminal Radar Approach Controls, airport towers, and Automated Flight Service Stations. These units are operated by NWS, but funded through an Interagency Agreement with the FAA.

The NWS provides weather warnings, advisories and forecasts to international aviation as one of the International Civil Aviation Organization's (ICAO's) two World Area Forecast Centers. NCEP's Environmental Modeling Center supplies global gridded model data of temperature, winds, and humidity twice a day for flight levels from 5,000 to 45,000 feet. The AWC prepares forecasts four times a day of globally significant thunderstorms, tropical cyclones, severe squall lines, moderate or severe turbulence and icing, and cumulonimbus cloud associated with the above. The forecast charts also include information on volcanoes, radiological releases, jet streams and tropopause heights. This information is transmitted by the International Satellite Communications System with coverage in the Americas, Caribbean, Atlantic, western portions of Europe, the Pacific, and eastern Asia.

The United States, in agreement with the International Civil Aviation Organization (ICAO), operates two Volcanic Ash Advisory Centers (VAACs). NESDIS's Satellite Analysis Branch and NWS's NCEP share management responsibility for operating the Volcanic Ash Advisory Center in Washington, D.C. Alaska's Volcanic Ash Advisory Center is run by NWS's Alaska Aviation Weather Unit. The Washington VAAC area of responsibility includes the continental United States and southward through Central America, the Caribbean to 10 degrees South in South America, and the United States controlled oceanic Flight Information Regions (FIR). The Anchorage, Alaska, VAAC is responsible for the Alaska and Anchorage FIRs.

MARINE WEATHER SERVICES

The NWS Marine Weather Program is the lead for the nation's marine and coastal weather services. Programs include warnings, forecasts, and advisories for coastal waters, offshore, high seas, and near-shore and open waters of the Great Lakes. It leads programs for tropical cyclone, coastal flood, severe convective coastal weather, and coastal hazards such as high surf, rip currents, and tsunamis. NWS forecasters at 46 coastal and marine WFOs, in collaboration with NCEP's Ocean Prediction Center and Tropical Prediction Center, provide a range of weather services focused on the expanding and weather-sensitive U.S. coastal population and those responsible for its safety.

The program develops plans, policy

and procedures for the delivery of marine and coastal weather products and services from the coastal WFOs, the Ocean Prediction Center, the Tropical Prediction Center, and the Central Pacific Hurricane Center. It ensures marine and coastal forecast training needs are met. The program works with the Office of Science and Technology to prioritize tropical, marine and coastal science and technology development and approve new or improved product designs, and with the Office of Operational Systems to ensure the collection of marine and coastal observations and the delivery of marine and coastal products to users. The program creates internal and external partnerships, collects and validates marine and coastal service and mission needs, solicits feedback on products and services and validates whether these needs are met.

The program works with NOAA's NESDIS, the U.S. Navy and the U.S. Coast Guard (USCG) to provide ice warning and advisory services through the joint National Ice Center; with the Navy, the USCG, the U.S. Maritime Administration, and the Corps of Engineers to safely operate the nation's Marine Transportation System; with the Department of Defense, Federal Emergency Management Agency, and Corps of Engineers to provide tropical cyclone services; with the USCG, Navy, Air Force, and private entities to disseminate weather to mariners; with NOAA's National Ocean Service (NOS) on the PORTS and TIDES programs; and with the World Meteorological Organization to provide services to the international community. It also works in cooperation with NOAA's Office of Response and Restoration, the Department of Defense, and the Department of Homeland Security for forecasting services for hazardous material spills, marine area search, rescue, and recovery operations, and security needs.

FIRE/ALL HAZARD WEATHER SERVICES

NOAA's NWS offices provide routine pre-suppression and wildfire weather support to Federal and state land management agencies. NWS forecasters provide routine fire weather forecasts, forecast support for the National Fire Danger Rating System, and site specific forecasts during the local fire season over roughly three-quarters of the nation. The NWS deploys a national cadre of specially-trained Incident Meteorologists (IMET) to provide on-site support for large wildfires and other homeland security concerns, as well as accidental releases/spills of hazardous chemical, biological, or radioactive materials. IMETs use weather instrumentation, telecommunications, and display equipment to aid in on-site forecast preparation and briefings. In the early morning, NOAA's National Centers for Environmental Prediction's Storm Prediction Center issues outlooks for days 1, 2 and 3 to 8 that highlight areas with critical and extremely critical fire potential based on the state of the fuels (trees, brush, grasses), and critical weather parameters. Areas where significant lightning activity accompanied by less than 0.1 inch of precipitation (dry lightning) is forecast are also highlighted. Additionally, NWS forecasters provide forecasts in response to hazardous material incidents or Incidents of National Significance (such as the Columbia Recovery effort).

TSUNAMI WARNINGS

Tsunami watches, warnings, and information bulletins for the Pacific Ocean and Hawaii are prepared by the Richard H. Hagemeyer Pacific Tsunami Warning Center in Ewa Beach, Hawaii, and for the west coast of the continental U.S. and Alaska by the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska. NWS collects and analyzes observational data from an international network of seismological observatories, sea-level observing stations, and deep-ocean tsunami detection buoys which operate on a cooperative basis. The centers use these data to prepare and disseminate watches, warnings, and information bulletins to international customers, WFOs, Federal and state disaster agencies, military organizations, private broadcast media, and other agencies involved with warning the public.

CLIMATE SERVICES

Climate prediction products and other services relate to the period of week two out to one year, including seasonal forecasts and hazard assessments. The NWS's Climate Prediction Center produces a suite of products covering these periods. The climate services program provides the strategic vision for climate services at NWS, oversees the program including the expanded regional and local climate services programs, and serves as steward of the climate observing system. It maintains strong ties with other countries; across NOAA lines, specifically through the NOAA Climate Office; with Federal agencies; the university community; and the private sector and encourages collaborative arrangements among the Regional Climate Centers (managed by NOAA/NESDIS), the State Climatologists, and NWS WFOs and regional headquarters to tailor climate forecasts for local users.

HYDROLOGIC SERVICES

The 122 WFOs, 13 River Forecast Centers (RFCs), and NCEP's Hydrometeorological Prediction Center (HPC) work as a team to provide hydrologic forecast and warning services which minimize loss of life and property damage from flooding and to meet the water service needs of our Nation. RFC hydrologists use a modeling system called the NWS River Forecast System (NWSRFS) to produce forecast time series of discharges or river stages at approximately 4,000 locations along the nation's rivers. HPC provides the quantitative precipitation forecasts serving as the primary forecast input for NWSRFS. RFCs also provide long-term water supply forecasts used by water managers in the western U.S., where decisions about water allocation and use are particularly critical now, with much of the West still feeling the effects of a long-term drought.

WFOs work cooperatively with the RFCs to monitor the major river systems around the clock. Using RFC guidance, advanced Doppler radar (NEXRAD) and telemetered rain gauge observations, WFOs continuously monitor the threat of flash flooding and urban flooding to provide timely flood watches and warnings to protect life and property.

Partnerships with a variety of Federal, state and local agencies are critical to NOAA's NWS Hydrologic Services Program. For example, the NWS works very closely with the United States Geological Service (USGS), the United States Army Corps of Engineers, the Natural Resources Conservation Service (NRCS), the Bureau of Reclamation, and the Bureau of Land Management on a variety of water related issues including stream gauging, support of flood fighting activities, river and water supply forecasting, and water management. River stage observations and stage-discharge relationships provided by the USGS are critical to warning and forecast operations for the Nation's rivers. The NRCS furnishes snow measurements that are combined with advanced snow modeling and analysis provided by NOAA's National Operational Hydrologic Remote Sensing Center to support joint NWS-NRCS water supply forecasting in the western U.S.

The NWS is implementing the Advanced Hydrologic Prediction Service (AHPS) to provide hydrologic forecasts with lead times ranging from minutes to months (Figure 3-DOC-2). AHPS builds on the existing NWS infrastructure, including AWIPS, NEXRAD, and NWSRFS. AHPS also provides Ensemble Streamflow Prediction, a feature that allows the NWS to quantify forecast uncertainty. This lets decision makers apply risk-based analyses as they respond to flooding, and as they try to balance competing demands on water supply, especially during periods of drought.

Flash floods, typically caused by intense, small-scale convection, are the leading cause of flood fatalities. Another AHPS capability, known as Flash Flood Monitoring and Prediction (FFMP), combines high-resolution radar rainfall observations with Geographic Information System (GIS) technology to provide more accurate and much more precise flash flood forecasts. The added precision provided by FFMP greatly reduces the false alarm rate of flash flood forecasts, making them more credible and leading to better public response, which will ultimately save lives.

AHPS services are provided as a suite of Web-based products (weather.gov/ahps), that feature user-friendly menus and maps which allow users to zoom in to areas of interest.

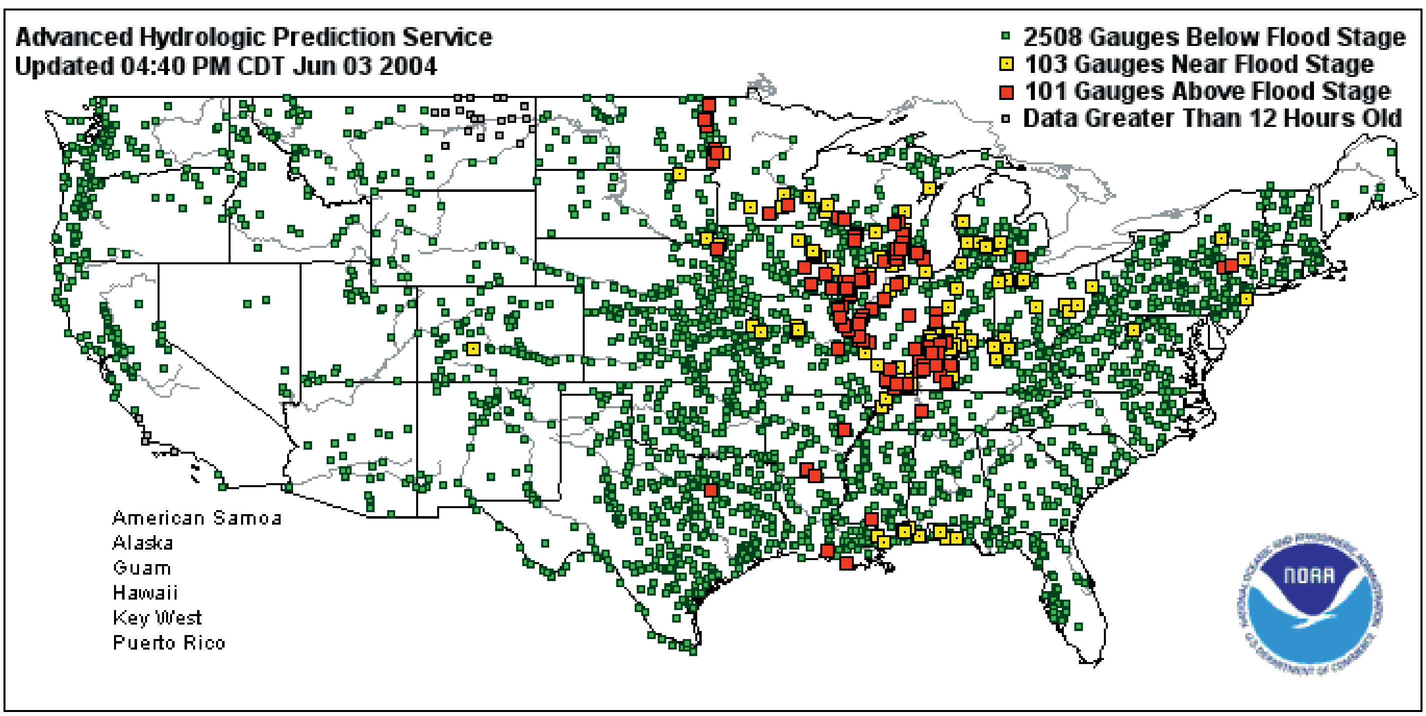

Figure 3-DOC-2. Map showing status of river conditions throughout the Nation. This map is included on the primary AHPS Web page and it provides access to more detailed local information on river conditions, including observations and forecasts at specific locations along rivers, as well as expected impacts that could result from flooding.

Clicking on an area of interest on the national map brings the user to a map of the NWS WFO serving that area which provides more detailed information on river conditions. AHPS also opens opportunities to improve NOAA's analysis and forecast capabilities related to coastal water conditions, through joint efforts with other components of NOAA (e.g., National Ocean Service, Office of Oceanic and Atmospheric Research).

The Water Resources Forecasting Activity is being implemented to build on AHPS and other NOAA services to deliver new services at a higher resolution (down to the neighborhood scale) with more information; such as soil moisture, soil temperature, snow pack, and surface runoff volume. It enables NOAA to provide nationally consistent water quantity and quality condition forecasts via: 1) a national digital database which assimilates hydrometeorological data and observations, and 2) a community hydrologic modeling system which brings the current state of science to NWS hydrology.

The national digital database will integrate fresh water resource observations and analysis components such as precipitation estimates, snowpack analysis, and soil moisture data. The goal of this database is to increase the amount, type, and accuracy of water resources information for use within the NOAA and by partners and other users.

The Community Hydrologic Prediction System (CHPS), facilitates the sharing of data and models between NOAA, other Government agencies, universities, and private sector research groups to advance water prediction science. CHPS will allow a new suite of high-resolution forecasts (including estimates of uncertainty) to be produced for streamflow, soil moisture, soil temperature, water quality, and many other variables directly related to watershed conditions.

OBSERVATIONS

Observations form the basis for forecasts and the monitoring and evaluation of the environment. Differing applications and requirements are associated with each of these functions. Forecast applications associated with watch and warning functions must be served immediately, while real-time availability is not a significant factor for climate monitoring. The range of differing applications will dictate how future instrument deployments will be conducted. This poses a constant challenge to the optimization of resources placed into in situ and remotely sensed observation platforms.

The fundamental application of observations is to deliver better products and improve services. This demands the link between improved services and observing systems be well defined. We need to determine the gaps in observations to meet varied requirements, emphasizing the importance of metadata and sensor calibration continuity. Coordinated efforts within the Federal community throughout all aspects of observations development, dissemination and use are needed for efficient utilization of resources.

The NWS approach for improving observations consists of several efforts:

• Make better use of data from observing systems that currently exist;
" Extend the system life of current observing systems to postpone technical obsolescence;

• Replace obsolete observing systems;

• Implement new observing technologies and communication systems that better meet the data needs of our customers; and

• Strengthen the link between user requirements and technology research and development.

The NWS manages programs that produce observations in support of a wide range of customers, such as the aviation, climate monitoring and research communities. As part of its responsibility, the NWS inspects all surface weather observing stations and certifies equipment and observers. NWS Headquarters establishes policy for observations and standards and coordinates with other Government agencies and international organizations.

NOAA'S COOPERATIVE WEATHER OBSERVER NETWORK (COOP)

COOP is the Nation's largest and oldest weather network (see Figure 3-DOC-3). Modernization of the COOP under NERON is consistent with the President's Climate Change Research Initiative, providing a richer source of data to improve weather, water and climate forecasting and to contribute to climate change research. The COOP is the primary source for monitoring U.S. climate variability over weekly to interannual time frames. These data are also the primary basis for assessments of century-scale climate change. The modernized network will add to NOAA's vision of an-end-to-end monitoring program that "takes the temperature" of the earth's systems.

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION

NCEP delivers analyses, guidance, forecasts and warnings for weather, ocean, climate, water, land surface and space weather to the nation and world. NCEP provides science-based products and services through collaboration with partners and users to protect life and property, enhance the Nation's economy and support the Nation's growing need for environmental information. Each service center depends on the observational infrastructure, the data assimilation systems, the numeric modeling function, and the application of model output statistics to produce value added forecast guidance prod-

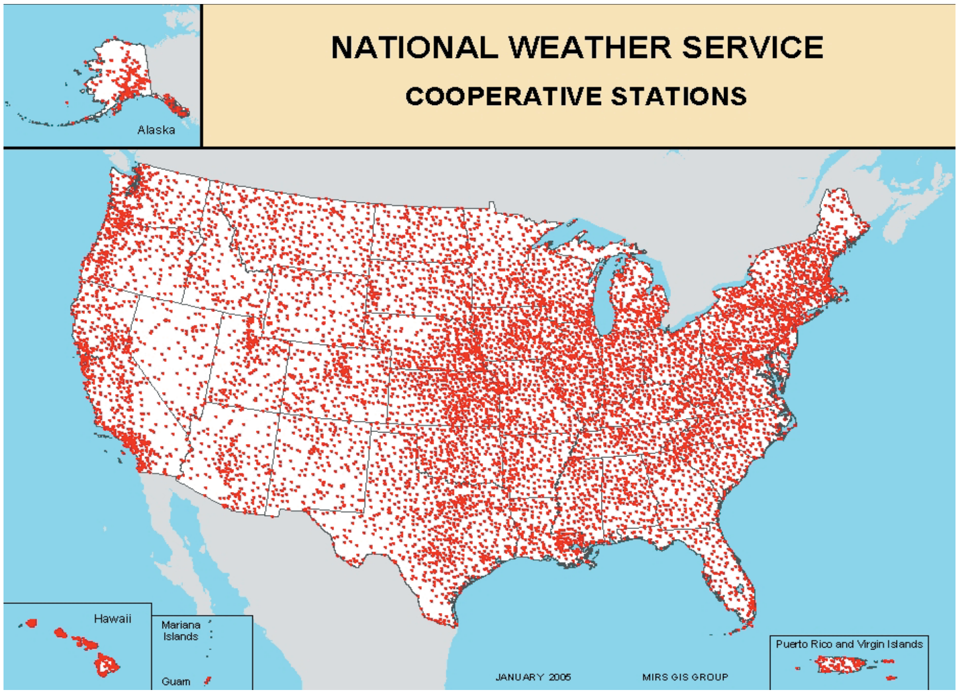

Figure 3-DOC-3. Map showing locations of Cooperative Weather Observer Network (COOP). Interactive web site can be found at *http://www.nws.noaa.gov/om/coop/wfo-rfcmap.htm*

ucts for NWS field offices and other users.

NCEP is organized into seven science-based, service-oriented centers that generate environmental prediction products and two central support centers that develop and operate numerical models -- the basis for NWS predictions.

STORM PREDICTION CENTER

The Storm Prediction Center (SPC) focuses on hazardous weather events, such as severe thunderstorms, tornadoes, extreme winter weather, fire weather, and excessive precipitation with emphasis on the forecast period that ranges from 2-8 hours to the next 6 to 72 hours. All Tornado and Severe Thunderstorm Watches issued anywhere in the contiguous United States come from the SPC in collaboration with local NWS Forecast Offices. Also, the SPC prepares Mesoscale Convective Discussions which are technical explanations of developing mesoscale features and their impact on hazardous weather. For longer time periods, the SPC produces the Convective Outlook which is the one, two or three day forecasts of the probability and intensity of both non-severe and severe thunderstorms (including tornadoes). A product depicting the day 4-8 forecast for organized severe thunderstorms over the contiguous United States has recently become operational. In addition, the SPC produces probabilistic Convective Outlooks in conjunction with the traditional categorical Convective Outlooks. These outlooks are issued for all Day 1, Day 2, and Day 3 periods. The SPC also issues one and two day Fire Weather Outlooks for the contiguous United States, defining areas with critical, extremely critical and dry thunderstorm fire conditions and potential for defined areas. An experimental 3-8 day Fire Weather Outlook is also available.

HYDROMETEOROLOGICAL PREDICTION CENTER

The Hydrometeorological Prediction Center (HPC) provides forecast, guidance, and analysis products and services (1) to support the daily public forecasting activities of the NWS and its customers, and (2) to provide tailored support to other government agencies in emergency and special situations. As part of this mission, HPC prepares Quantitative Precipitation Forecasts (QPF) used by the RFCs to develop local river and flood forecasts and by WFOs to develop local rainfall, snow and ice forecasts. The HPC provides special QPFs and coordinates with other Federal agencies, such as the Federal Emergency Management Agency (FEMA), during major flood events. The HPC also provides an array of analyses and forecasts out to seven days of frontal systems, pressure patterns, temperature, and precipitation for use by WFOs and the private weather community. Additionally, HPC serves as the backup to the National Hurricane Center. From September 15 through May 15 of each year, HPC staffs a Winter Weather Desk for two shifts per day, issuing probability graphics for snow and freezing rain as well as a graphic depicting the position of lows impacting the 48 contiguous United States in 12 hour increments out to 72 hours into the future. HPC also operates International Desks with the mission of providing visiting scientists meteorological training with an emphasis on the operational use and application of numerical model products.

AVIATION WEATHER CENTER

The NCEP experts for aviation meteorology are concentrated at the Aviation Weather Center (AWC). The AWC provides weather warnings, advisories and forecasts to the aviation community under an international agreement through the International Civil Aviation Organization. The AWC provides wind, and flight hazards (e.g., convection, icing, turbulence) forecasts for flight planning and en route aircraft operations for the U.S., the Gulf of Mexico, the Caribbean Sea, the Atlantic and Pacific routes in the Northern Hemisphere and some routes in the Southern Hemisphere. In addition, every two hours, the AWC issues the Collaborative Convective Forecast Product (CCFP), a graphical representation of expected convective occurrence at 2-, 4-, and 6-hours after issuance time. Its purpose is to aid in the reduction of air traffic delays, reroutes, and cancellations influenced by significant convective events. It is produced March through October by a collaborative process involving AWC forecasters along with aviation forecasters from commercial airlines, Center Weather Service Units, and Meteorological Services Canada.

ENVIRONMENTAL MODELING CENTER

The Environmental Modeling Center (EMC) improves NCEP's numerical climate, water, and weather predictions through data assimilation and computer modeling. To provide mesoscale predictions (thunderstorms, hurricanes, tornadoes, blizzards, etc.), ocean predictions and global weather and climate predictions, EMC develops, adapts, improves, and monitors data assimilation systems and global, regional and mesoscale models of the atmosphere, land surface, ocean, and atmosphere/ocean/land systems. The EMC uses advanced modeling methods developed internally and cooperatively with universities, the international scientific community, NESDIS, NOAA laboratories, and other government agencies. As an example, EMC is a partner in the NASA/NOAA Joint Center for Satellite Data Assimilation (JCSDA) designed to accelerate the use of research and operational satellite data in NCEP operational models.

The EMC integrates research and technology through collaborative model development projects. These interactions serve as an efficient and effective interface between NCEP and the scientific community that develop ideas, numerical models, and forecast techniques to implement model improvements and improve NWS products. The EMC conducts applied research and technology transfers and publishes research results in various media for dissemination to the world meteorological, oceanographic, and climate community. EMC also participates in ongoing interactive research programs such as the USWRP Hurricane at Landfall project and the community Weather Research and Forecast (WRF) model. Furthermore, EMC is participating in the Winter Storm Reconnaissance Program in the Pacific through targeted observations aimed at improving forecasts across the country. In addition, at NCEP, led by the EMC, the ensemble approach has been applied operationally at the short- medium- and extended range. EMC efforts with collaborative development have resulted in improvements to mesoscale and global models, as well as advancements in hurricane track forecasts, climate forecasts and air quality forecasts.

CLIMATE PREDICTION CENTER

The Climate Prediction Center (CPC) provides operational monitoring and prediction of global and regional climate variability, with emphasis on applied research and partnerships, to improve understanding of the global climate system, weather and climate links, extremes and trends. CPC develops and maintains databases for determining current and historical climate anomalies and trends, and provides analyses and assessments of their origins and linkages to the global climate system. CPC products and services cover time scales ranging from next week (days 6-10) to seasons and out to a year in advance, and cover land, ocean, and atmosphere extending into the stratosphere. CPC's products include probabilistic monthly and three monthly outlooks (out to one year) for temperature and precipitation, a U.S. Hazards Assessment, the multi-agency U.S. Drought Monitor, a drought outlook, and El Niño Southern Oscillation (ENSO) discussions and outlooks, among many others. WFOs, as well as the public, private industry, and the national and international research community use CPC products and climate services. CPC also houses the Climate Test Bed (CTB) to accelerate the transfer of research and development into improved NOAA operational climate forecasts, products, and applications. CTB personnel include scientists from NCEP and other NOAA and non-NOAA organizations.

SPACE ENVIRONMENT CENTER

The Space Weather Prediction Center (SWPC) provides national and international forecasts, alerts, and warnings of extraordinary conditions in the space environment, solar radio noise, solar energetic particles, solar X-ray radiation, geomagnetic activity, and conditions of stratospheric warming. The SWPC observes, assesses, and predicts activity in the space environment to promote public safety and to mitigate economic loss that could result from disruption of satellite operations, communications and navigation systems, and electric power distribution grids. The SWPC issues to the public, its U.S. Air Force partners, and vendors of value-added services specific predictions of the space weather activity level for the next three days and more general predictions up to several weeks in advance, as well as weekly summaries of observed solar terrestrial conditions. SWPC serves as the international World Warning Agency for the International Space Environment Service (ISES). It exchanges international data- solar wind, X-ray, sunspot, corona, magnetic, and ionospheric measurements- in real-time and, from these data, provides and meets additional specific needs of other government agencies. The SWPC also distributes (receives) data to (from) other countries and issues a consensus set of daily forecasts for international use.

OCEAN PREDICTION CENTER

The Ocean Prediction Center (OPC) provides atmospheric and oceanographic warning, forecast, and analysis products and services out to five days for the North Atlantic and North Pacific (north of 30 degrees) (see Figure 3-DOC-4) as part of the NWS mission of protecting life and property and enhancing economic opportunity. As part of this responsibility, OPC handles U.S. international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). The OPC provides weather and sea state warnings and forecasts for the offshore waters of the U.S. and the high seas of the Northern Hemisphere north of 30 degrees for planning and operational purposes. OPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The OPC also coordinates forecasts with and provides forecast guidance to WFOs with coastal responsibilities. The OPC, the Tropical Prediction Center (TPC), HPC, and WFO Honolulu, HI collaborate daily to produce unified and seamless surface weather analyses covering from 30 degrees South to the North Pole, and from East Asia across the Pacific and Atlantic to Western Europe and Africa.

TROPICAL PREDICTION CENTER/NATIONAL HURRICANE CENTER

The NCEP experts in the area of tropical meteorology are concentrated in the Tropical Prediction Center (TPC)/National Hurricane Center (NHC). TPC/NHC services include public and marine advisories, watches, and warnings for tropical cyclones in the North Atlantic and eastern North Pacific hurricane basins including the portions of the coastline threatened by such storms. In addition, TPC forecasters provide marine analyses and forecast products for the same areas of responsibility, south of 30 degrees north latitude and a portion of the southeast Pacific. TPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The TPC/NHC provides guidance, coordination, and tropical weather expertise to WFO forecasters, the media, and private industry.

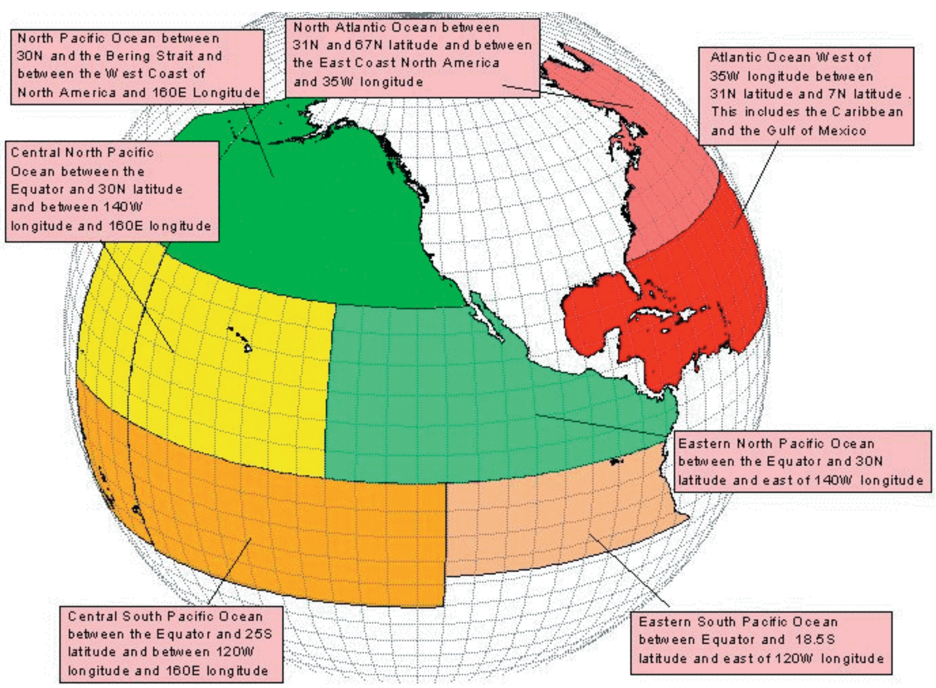

Figure 3-DOC-4. United States High Seas Forecast Areas of Responsibility.

NCEP CENTRAL OPERATIONS

The NCEP Central Operations (NCO) is responsible for NCEP operations, including access to real time data, and its quality control and use in numerical weather prediction systems, as well as the workstations used by NCEP forecasters to access model output and other data necessary for producing guidance products. The NCO provides management, procurement, development, installation, maintenance, and operation of all computing and communications related services that link individual NCEP activities together. The NCO is the focal point for establishing and executing policies, standards, procedures, and documentation for computing and communications within the entire NCEP organization. The NCO maintains and manages the supercomputer and runs the computer applications that generate all NCEP model products. The NCO leads the technical transition between the research and development of numerical weather and climate prediction models and their operational use on the NCEP computer systems. In addition, NCO provides 24-hour information services and operational support for NCEP computing systems, including the network which ties together internal NCEP communications, NWS high performance computer systems, forecaster workstations, personal computers and a user service that support all NCEP centers. Since an upgrade to NCEP's main computer systems and facilities in 1999, and throughout subsequent upgrades, NCO has delivered NCEP model forecasts and products to its users with a high degree of reliability and timeliness. NCO manages two supercomputers located in Gaitherburg, MD and Fairmont WV, representing an operational machine and backup, each of which operates with a sustained speed of 14 teraflops, has 2094 processors running at 1.9 gighertz speed, using 4608 gigabytes of shared memory, 150 terabytes of disk space and 75 terabytes of tape archive. Each day, the operational machine processes over 239 million meteorological observations (99.9 percent of which are from satellites), and generates more than 14.8 million model fields.

OTHER NWS OFFICES WITH NATIONAL RESPONSIBILITIES

In addition to the NCEP centers, there are two other offices that provide National products. They are the Alaska Aviation Weather Unit, the Anchorage WFO, and the WFO Honolulu/Central Pacific Hurricane Center.

Alaska Aviation Weather Unit

The Alaska Aviation Unit (AAWU) provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for Alaska and surrounding areas.

WFO Anchorage Marine and Ice Programs

The Anchorage WFO prepares offshore marine forecasts and warnings for interstate and international marine commerce traversing the Gulf of Alaska and the Bering Sea. They also prepare ice analyses and forecasts for the Arctic Ocean, Bering and Chukchi Seas, and the Cook Inlet.

WFO Honolulu/Central Pacific Hurricane Center

WFO Honolulu/Central Pacific Hurricane Center (CPHC) provides products in aviation, marine, and tropical cyclone areas. In aviation, WFO Honolulu provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for the central north Pacific from 140 degrees W to 160 degrees E longitude and in the Oakland Flight Information Region south of 30 degrees N latitude through ICAO international agreement. The office handles international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). WFO Honolulu provides weather and sea state warnings and forecasts for the high seas of the central north and south Pacific south of 30° N latitude. CPHC issues tropical cyclone advisories, forecasts, watches, and warnings for the central north Pacific including Hawaii.

SUPPORTING RESEARCH

The NWS conducts applied research, building upon the more basic research conducted by NOAA laboratories and the academic community. Applied meteorological and hydrological research is integral to providing more timely and accurate weather, water, and climate services to the public.

METEOROLOGICAL RESEARCH

The NWS conducts meteorological research to develop, test, evaluate, and improve numerical models and analysis/forecast techniques for weather and climate prediction including:

- Techniques for predicting mesoscale phenomena (e.g., heavy precipitation, tornadoes, and severe thunderstorms).
- Models to improve hurricane tracking, hurricane probability estimates, and tropical analyses.
- Storm surge models to assist in developing hurricane evacuation plans for additional coastal basins.
- Techniques to improve prediction of seasonal to interannual climate variability and their impacts on weather variability.
- Techniques to improve incident data retrieval and display (with NOAA's Environmental Systems Research Laboratory's (ESRL) Global Systems Division).

Hydrologic Research

The NWS develops, implements and operationally supports improved hydrologic, hydraulic and hydrometeorological models and manages hydrologic data and enhanced quality control procedure to support national flood and water resources forecasting. Research encompasses the following areas:

- Improvements to the Ensemble Streamflow Prediction (ESP) system and its complementary models in the NWS River Forecasting System. Research, development and implementation of improved ESP procedures which improve forecast accuracy and quantify uncertainty at all time scales.
- Specialized flood and flash flood forecasting procedures using linked hydrologic, hydraulic and meteorological models. Major research areas include developing distributed hydrologic models that use high resolution precipitation data from the NWS radar network, improvement of cold region processes in watershed models, and assimilation of data to improve model initialization. Highly specialized hydraulic models for routing river flows will also provide information for generating maps of inundated areas.
- Development of improved multi-sensor precipitation estimates for input estimates for input into operational hydrologic and atmospheric models. Radar, rain gauge and satellite rainfall estimates are merged to produce optimum rainfall analyses.
- Development of verification methods to assess the added-value of new science and technology to the customer.
- Development of the Community Hydrologic Prediction System (CHPS) to facilitate the sharing of data and models and allow for production of a new suite of high-resolution forecasts.

Space Weather Research

Research and development at SEC

emphasizes understanding of the fundamental physical processes governing the regime from the solar surface, through the interplanetary medium, into the magnetospheric-ionospheric regions, and ending in Earth's upper atmosphere. These processes are manifest in the climatology and disturbances of Earth's magnetic field, the ionosphere, the charged particle populations at satellite orbits, and the atmospheric density at high altitudes (including low-Earth orbit). This applied research is focused on areas where advanced applications can be devised and prototyped to improve the specification and forecast of conditions in the space environment by developing and implementing models and indices, as well as by obtaining and processing new observations.

• Developing of the first dynamic, global ionospheric model to use ensemble Kalman filter techniques to assimilate data every 15 minutes. Disparate data from widely dispersed sources will enable the model output to be useful to radio-communicators and Global Positioning System (GPS) and Loran users.

• Developing of models to characterize and predict geomagnetic storm intensity development, spatially and temporally.

<u>Support for Collaborative Research with the Academic Community and Other Partners</u>

The Collaborative Science, Technology, and Applied Research (CSTAR) program was established to bring NWS-supported collaborative activities with the academic community into a structured program and to create a cost-effective transition from basic and applied research to operations and services. The CSTAR Program issues requests for proposals through which colleges and universities compete for 1-3 years of research funding. CSTAR supports shorter-term research activities with colleges and universities through the NWS/Cooperative Program for Operational Meteorology, Education, and Training (COMET) Outreach Program. The NWS also funds specific applied research grants and cooperative agreements directly in support of hydrology and meteorology research needs.

TRAINING

NOAA's NWS provides training to its workforce to enhance the professional and scientific development of its staff in support of NOAA's NWS mission and strategic goals. Training deficiencies and requirements are identified and addressed via the National Strategic Training and Education Plan (NSTEP) process, described in NWS Instruction 20-102 and available at http://www.nws.noaa.gov/directives/020/pd02001002a.pdf

Training is provided through residence classes and workshops, distance learning methods, Internet modules, teletraining sessions, webcasts and CD-ROM based training. The NWS Training Center (NWSTC) in Kansas City, Missouri, provides technical, meteorological and hydrologic, and management/leadership training. The Warning Decision Training Branch (WDTB) in Norman, Oklahoma, conducts situational awareness and remote sensing training with modules that integrate data for improving the warning decision process. The Forecast Decision Training Branch (FDTB) in Boulder, Colorado, provides scientific and forecast-decision training. NWS employees also have direct access to scientific and managerial training materials through the Department of Commerce's Learning Center. NOAA's NWS training is also supported by a partnership with the Cooperative Program for Operational Meteorology, Education and Training (COMET) located in Boulder, Colorado.

The NWSTC, in addition to providing scientific and technical training, is working to expand its leadership training and development skills through NOAA's NWS Leadership Academy. The goal of the Leadership Academy is to enable NWS and NOAA employees to become world-class leaders. The Academy is founded on a sequential and progressive approach designed to develop professional skills and capabilities to improve employee performance. From entry into the agency to senior career status, employees can take advantage of courses and processes that are part of a powerful management and leadership learning environment. Finally, NOAA's NWS is working to develop an organized curriculum to supply the necessary knowledge, skills, and abilities for all

INTRODUCTION

The National Oceanic and Atmospheric Administration's (NOAA's) National Environmental Satellite, Data, and Information Service (NESDIS) oversees the daily operations of the United States civil operational environmental satellite systems, as well as NOAA's National Data Centers (NNDCs) that develop global, national, and regional databases to support meteorology, oceanography, geophysics, and the space environment. NESDIS was established as a NOAA line office on December 1, 1982. The merger of the former National Environmental Satellite Service (NESS) and the Environmental Data and Information Service (EDIS) formed NESDIS. NESDIS develops and distributes environmental data and information products and services critical to the protection of life and property, the national economy, energy development and distribution, global food supplies, and the development and management of environmental resources.

NESDIS procures, launches, and operates two types of satellites to provide worldwide environmental data and information products and services to Federal agencies, state and local governments, and private users. These satellite types are the Polar-orbiting Operational Environmental Satellites (POES) and Geostationary Operational Environmental Satellites (GOES).

POES

The POES spacecraft circles the Earth in an almost north-south orbit, passing close to both poles. These orbits have an altitude between 830 km (morning orbit) and 870 km (afternoon orbit), and are sun synchronous. One satellite crosses the equator at 10:00 a.m. local time, the other at 2:00 p.m. local time. Operating as a pair, these satellites ensure that data for any region of the Earth are no more than six hours old. Each satellite orbits the Earth 14 times per day, collecting global data for atmospheric and surface measurements in support of short-term weather forecasting and long-term global climate change research.

NOAA also manages the command, control, and communications function of the Department of Defense's (DOD's) Defense Meteorological Satellite Program (DMSP) constellations. Currently NESDIS is operating six polar orbiters. The NOAA-12, NOAA-14, NOAA-15, and NOAA-16 satellites continue to transmit data as stand-by satellites. NOAA-17 serves as the primary morning satellite and NOAA-18 the primary afternoon satellite.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS), the next generation of polar-orbiting satellites, will provide standard meteorological, oceanographic, environmental, and climatic information as well as space environmental remote sensing information. NPOESS will also continue to provide surface data collection and search and rescue capability. The Integrated Program Office (IPO), in consultation with the POES and DMSP program offices, is also studying additional potential cost effective approaches to maximize user satisfaction during the transition to NPOESS while guaranteeing continued non-interrupted data services. The first NPOESS launch is planned for 2013.

GOES

The GOES spacecraft, in contrast to the POES spacecraft, circles the Earth in a geosynchronous orbit, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. There are three types of GOES spacecraft; two geostationary satellites, referred to as GOES-East and GOES-West, plus an on-orbit spare satellite. Each satellite continuously views nearly one third of the Earth's surface. The GOES-12 (East) satellite is positioned at 75 degrees W longitude at the equator and monitors North and South America and most of the Atlantic Ocean. GOES-11 (West) is positioned at 135 degrees W longitude at the equator and monitors North America and the Pacific Ocean basin. GOES-13 was launched in 2006, and is the on-orbit backup for NOAA's geostationary satellite constellation. These two satellites (and the on-orbit backup satellite) operate together to provide continuous monitoring necessary for effective and extensive weather forecasting, prediction, and environmental monitoring. The geosynchronous orbit is about 35,800 km (22,300 miles) above the Earth's equator.

ENVIRONMENTAL SATELLITE SERVICES

NATIONAL ICE CENTER

The U.S. National Ice Center (NIC), under the sponsorship of the U.S. Navy, NOAA, and the U.S. Coast Guard, is tasked with providing the highest quality operational global, regional, and tactical scale sea ice analyses and forecasts tailored to meet the requirements of U.S. national interests. NIC uses data from polar-orbiting satellites to create guidance products and maps.

Routine NIC ice guidance products include regional-scale ice maps, annotated satellite imagery, short- and long-term ice forecasts, and legacy ice information and ice climatology. Specific sea ice features analyzed include ice edge position, ice concentration, ice thickness, form or floe size, ice motion, areas of compression and heavy surface deformation, and the location/orientation of open water or thin ice-covered leads.

Ice products are disseminated via the Internet in formats consistent with the World Meteorological Organization (WMO) digital standard for Sea Ice in GRIDDED (SIGRID-3) format (see www.natice.noaa.gov). The date and time of data acquisition as well as the percentage of each data type used in all ice analyses are documented in a metadata narrative.

Another NIC responsibility is oversight of the United States Interagency Arctic Buoy Program (USIABP). USIABP is a collaborative program that draws operating funds and services from the collective contributions of government agencies and/or programs. These organizations include: the Naval Oceanographic Office, Office of Naval Research (ONR), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), and NESDIS, Office of Oceanic and Atmospheric Research (OAR), and the Office of Global Programs (OGP). USIABP was established in 1992, to provide the management structure and coordination necessary to maintain a baseline network of drifting buoys. Buoys within the array provide sufficient spatial resolution to define surface synoptic scale atmospheric pressure, air temperature, and sea-ice drift fields. Data are used in real-time for operational weather and ice forecasting and for research in the Global Climate Change Program.

CENTER FOR SATELLITE APPLICATIONS AND RESEARCH (STAR)

STAR's mission is to transfer satellite observations of the land, atmosphere, ocean, and climate from scientific research and development into routine operations and offer state-of-the-art data, products, and services to decision makers. STAR is an operations-driven research and development center, tuned to the needs of the Nation's users of satellite data products. STAR conducts diverse research on satellite remote sensing, including the study of atmospheric, oceanic, and land processes. STAR participates in the life cycle of all operational NOAA satellites-from defining the initial requirements for a satellite mission, through calibration and application of the data after the satellite is in orbit, to development of products from the data, to final archiving, and even reprocessing of data. STAR also works with data from non-NOAA satellites as well, for research, to transfer capabilities to NOAA, and to obtain even more observations of the Earth than what is available from NOAA satellites.

STAR is a leader in planning future satellite observing systems to enhance the Nation's ability to remotely monitor the environment. STAR also calibrates the Earth-observing instruments of all NOAA satellites to provide reliable measurements. STAR investigates how to develop satellite data sets that can be used in the following ways:

- Assess the current conditions on the Earth in a timely manner,
- Predict changes in the current conditions, and
- Study long-term trends in the environment.

STAR will create new products for monitoring atmospheric, oceanic, and environmental hazards; enhance NOAA's infrastructure for remote sensing; reduce the risk of launching new, untested, and very expensive satellites and sensors; expand its support to users (for example, expanding the NOAA CoastWatch Program into a global OceanWatch); and train users of STAR products and applications.

JOINT CENTER FOR SATELLITE DATA ASSIMILATION (JCSDA)

JCSDA is a geographically distributed center operated as a partnership between NOAA, NASA, the U.S. Navy, and the U.S. Air Force. This cooperative arrangement allows NOAA, NASA, and DOD to take advantage of their combined science and technology resources in order to accelerate and optimize the use of existing and new satellite data for numerical weather prediction (NWP). JCSDA provides a focal point for cooperative research and development of common modeling and data assimilation infrastructure among its partners. JCSDA will enable NOAA to improve NWP and climate prediction through the optimal use of data from existing satellites. In addition, JCSDA will prepare for a large volume of new data from advanced satellite instruments (such as those on NPOESS) that will be launched during the next five to six years. These efforts will also help guide the selection and specification of future satellite instruments to ensure that the most effective observing system possible is created. JCSDA is tasked with developing new and powerful techniques to assimilate data into NWP and ocean, climate, and air quality analyses and models. This center is also tasked with reducing the time elapsed from satellite launch to operational data use from two years to one year. The JCSDA activities directly support the missions of NASA, NOAA, and DOD as well as those of organizations who contribute to or rely on NOAA's environmental assessment, prediction, and stewardship missions. In addition, through its partnership and coordination with DOD and other agencies, JCSDA will enhance efforts to facilitate the transition from research into operations. Current projects focus on speeding available satellite data into operations and developing tools to support future assimilation projects. Six scientific priorities are being emphasized toward these ends.

- Development of a community-based radiative transfer model (CRTM). In the next few years, the accuracy and capability of the JCSDA CRTM will be significantly improved by including additional physical processes (e.g., atmospheric scattering), more efficient numerical techniques, and better surface emissivity models to allow more satellite data which is affected by surface to be properly assimilated.
- Development of data thinning and configuration technology and methodology: This allows faster and efficient delivery of advanced satellite data to major NWP centers globally.
- Advanced techniques to assimilate satellite data in cloudy and precipitation regions: Improving radiative transfer models and NWP cloud prediction schemes will significantly increase the fraction of satellite data being ingested into the assimilation systems and increase their impact.
- Improvement of the use of satellite land products in NWP models: For example, green vegetation fraction, snow cover, snow pack parameters, surface albedo, land, and sea surface temperature.
- Improvement of the use of satellite data in ocean data assimilation: This provides assimilated ocean data sets to the community for research purposes and providing access to and support of an operational ocean data assimilation system.
- Assimilate satellite derived aerosol, ozone, and trace gas product: This will improve forecasts of visibility and health index with state-of-the-art air quality forecast models, including chemical and biological process.

JCSDA has additional long-term strategic goals. One is to accelerate the transfer of data assimilation research into operations by fostering common data assimilation code components, including techniques for specifying observation errors, background error co-variances, and data selection and reduction. Another is to foster development of a workforce capable of meeting the data assimilation challenges of future. The JCSDA approach is bearing fruit. Recent accomplishments include:

- Improved radiative transfer techniques. CRTM was implemented operationally in the Global Data Assimilation System (GDAS); improved microwave surface emissivity models leads to more Advanced Microwave Sounding Unit-A (AMSU-A) data used over land, snow, and ice; and vetted CRTM components are made available to partners and stakeholders via internet.
- Improved uses of current satellite data. More AMSU-A data are used over land, snow, and sea ice due to an improved surface emissivity model; advanced data selection and assimilation techniques for infrared sounders increase use of the Atmospheric Infrared Sounder (AIRS) data; NOAA-18 AMSU data is used operationally in the National Centers for Environmental Prediction (NCEP) GDAS; OMI Ozone data from TERRA satellite result in improved global ozone analysis; and AIRS data used to predict NWP effectiveness of proposed designs for a future Geostationary Operational Environmental Satellite Series R (GOES-R) sounder.
- More new satellite data tested for use in NCEP operational GDAS and forecast models. Techniques to assimilate GPS Radio Occultation data is developed, has been tested, and will improve NWP: WindSat ocean surface wind data was tested in the Global Forecast System with positive impact; and JASON sea surface altimetry data was tested in the Global Ocean Data Assimilation System.

POLAR SATELLITE PROGRAM

The primary mission of the Polar-orbiting Operational Environmental Satellite (POES) system is to provide daily global observations of weather patterns and environmental measurements of the Earth's atmosphere and the proton and electron flux at satellite altitude. Since the beginning of the POES program, environmental data and products acquired by its satellites have been provided to users around the globe. These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. Currently, the two primary operational spacecraft are NOAA-17 and NOAA-18.

NOAA polar satellites carry instruments that provide atmospheric temperature and moisture profiles. They also provide multichannel images and carry a data collection and platform location system. In addition, the satellites are equipped with a Search and Rescue Satellite Aided Tracking (SARSAT) subsystem, which is used to detect and locate distress alerts from maritime, aviation, and land-based users of emergency beacons operating at 121.5, 243 or 406 MHz. In addition to taking thermal images of the Earth's surface and atmosphere, NOAA polar-orbiting satellites carry sounder instruments to provide vertical profiles of atmospheric temperature and moisture.

The POES spacecraft carries four primary instrument systems: the Advanced Very High Resolution Radiometer (AVHRR); the Television and Infrared Observation Satellite (TIROS) Operational Vertical Sounder (TOVS); the Space Environment Monitor (SEM); and the Solar Backscatter Ultraviolet Spectral Radiometer, MOD 2 (SBUV/2).

• AVHRR provides data for real-time transmission to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. The AVHRR/3 series of instruments measure six spectral channels (0.63, 0.86, 1.6, 3.75, 10.8, and 12 µm) with a nominal spatial resolution of 1.1 km and global resolution of roughly 4 km. The AVHRR/3 provides stored and direct-readout radiometer data for day and night cloud cover, sea surface temperatures, vegetation indices, fire detection, and snow and ice mapping.

• TOVS is comprised of the High-Resolution Infrared Radiation Sounder (HIRS) and the Advanced Microwave Sounding Unit (AMSU). The HIRS/4 is a discrete-stepping, line scan instrument designed to measure scene radiance in 20 spectral bands to permit the calculation of the vertical temperature profile from the Earth's surface to about 40 km. The Advanced Microwave Sounding Unit-B (AMSU-B), provided by the United Kingdom Meteorological Office, produces soundings of humidity from the surface to 200 millibars (mb). The specialized 89 GHz channel is used to determine the position and structure of tropical cyclones on a global scale.

• SEM measures solar proton flux, alpha particle and electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitudes. The two sensors included within this instrument are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED), in addition to a common data processing unit. This instrument augments the measurements made by NOAA's geostationary satellites.

• The SBUV/2 instrument is a non-scanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 nanometers to 400 nanometers. Data obtained from the instrument are used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth.

GEOSTATIONARY SATELLITE PROGRAM

The GOES spacecraft host an imager capable of detecting atmospheric, sea surface, and land properties in five spectral bands including the 3.9 µm and 13.35 µm wavelengths. The geostationary satellites transmit all five spectral bands simultaneously, providing the user community with continuous views of atmospheric measurements in various wavelengths, each with its own atmospheric, land, and ocean application. GOES spacecraft were designed for flexible scanning of the Earth; a variety of scans or sector coverage can be scheduled. For example, the full-Earth disk is normally scanned once every 3 hours and requires about 30 minutes to complete the entire scan. Depending on requirements to monitor environmental hazards on the Earth's surface or in the atmosphere, 30-minute periods in between the full-disk scans may be scheduled as a mixture of 15-minute intervals (routine operations) or 7½-minute interval (severe storm operations) rapid scans over the contiguous U.S. To further support mesoscale and microscale analyses, 1000 km x 1000 km areas can also be scanned at 1-minute intervals, to capture rapidly developing and dynamic environmental phenomena. The 13.35 µm channel provides more accurate cloud height assignments for mid- and upper-level atmospheric satellite wind-velocity estimates. This trade-off notably impacts the sea surface temperature retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. Also, the spatial resolution of the water vapor channel is improved to 4 km from 8 km.

The GOES Space Environment Monitor (SEM) collects data for warnings of solar activity. The GOES SEM instruments include X-ray monitors that detect solar flares, energetic particle sensors, and three-component vector magnetometers to measure changes in the ambient magnetic field. Real-time SEM data are used to support operational NOAA and DOD space environment forecasts and alerts. Data from GOES SEM sensors are archived by the National Geophysical Data Center (NGDC) and provided to retrospective users online via Internet and on a variety of computer media.

Starting with GOES-12, a Solar X-Ray Imager (SXI) is being flown that provides near-real-time X-ray images of the sun for ionospheric changes that affect radio communications and mangetospheric variations that induce currents in electrical power grids and long distance pipelines. Also, these conditions can cause navigational errors in magnetic guidance systems, introduce changes in spacecraft charging, produce high energy particles that can cause single event upsets in satellite circuitry, and expose astronauts to increased radiation. SXI will observe solar flares, solar active regions, and coronal structures. Images from SXI will be used by NOAA and U.S. Air Force forecasters to monitor solar conditions that affect space weather conditions, including the dynamic environment of energetic particles, solar wind streams, and coronal mass ejections emanating from the sun.

GOES also carries a Data Collection System (DCS), which is used to collect and relay environmental data observed by a variety of remotely located platforms, such as river and tide gauges, seismometers, buoys, ships, and automatic weather stations. In support of NOAA missions, GOES DCS data are used in weather forecasts and warnings, reservoir control, and flood monitoring. While the GOES DCS is a critical element for national and international meteorological and hydrological programs, the National Weather Service (NWS) NEXt Generation Weather RADar (NEXRAD) program relies on the DCS data as a vital input for calibration and validation. Tsunami watches and warnings for the Pacific Ocean are prepared using the Data Collection Platform data transmitted via GOES DCS.

SEARCH AND RESCUE SATELLITE AIDED TRACKING (SARSAT)

The GOES SARSAT System is capable of providing an immediate distress alert, unlike the POES spacecraft SARSAT transponders, which must come within line of site of a Local User Terminal in order to relay the distress beacon back to the U.S. SARSAT Mission Control Center (USMCC). Newer state-of-the-art COSPAS-SARSAT distress beacons, utilizing the Global Positioning System (GPS), now have the capability to provide location information in the distress message relayed by GOES to USMCC. NOAA satellites helped save 272 people from potentially life-jeopardizing emergencies throughout the United States and its surrounding waters in 2006 - up from 222 the previous year. This is the highest number of rescues since 1999, when 294 people were rescued. Since its creation in 1982, COSPAS-SARSAT has been credited with more than 20,300 rescues worldwide, and 5,396 within the United States and its surrounding waters. Most of the rescues each year happen at sea.

COMPREHENSIVE LARGE ARRAY-DATA STEWARDSHIP SYSTEM (CLASS).

NESDIS continues to improve user access to its operational satellite products and services using new communications technologies including the Internet. One important online access system, managed and operated by the Office of Systems Development (OSD), is the CLASS (see www.class.noaa.gov). CLASS provides satellite data access, display, and electronic transfer. Available data types include AVHRR, the Advanced TIROS Operational Vertical Sounder (ATOVS), DMSP (special sensor), and RADARSAT (authorized subscription users). While developed as an independent system, the Satellite Active Archive (SAA) serves as NOAA's initial interoperable interface to NASA's Earth Observing System Data and Information System (EOSDIS). After the phase-out of the GOES-TAP system in 1998, many users now rely on GOES sectorized images, mapped to standard Advanced Weather Interactive Processing System (AWIPS) grids, available in near-real-time at www.goes.noaa.gov. Near-real-time images and interpretive analyses of tropical storms and hurricanes worldwide, ash from volcanic eruptions within the western hemisphere, heavy precipitation in the United States that cause flash flooding or blizzards, wild fires and smoke within the U.S., and northern hemisphere snow boundaries are located at www.ssd.noaa.gov. Specially enhanced and annotated imagery and image loops of environmental events, such as flooding, hurricanes, and other severe storms, volcanic eruptions, fires, and dust storms are available at www.osei.noaa.gov. This website was set up for use by the news media and general public, and to provide once or twice per day satellite views of an environmental event for Federal, state, and international governments and agencies. Also supporting the media, scientific organizations, and Federal and state agencies is a specially designed website featuring visualizations of satellite data, found at www.nnvl.noaa.gov.

CLASS is the NOAA implementation program for an improved architecture for archiving and servicing large-volume data. Advances in technology, including faster network access, web-based interfaces, and emerging discovery and analysis tools, will provide a one-stop capability to access the NOAA large array data sets. The CLASS objective is to establish a web-enabled browse, order, and retrieval delivery system that will enhance and increase the availability and accessibility of satellite, radar, and other data and derived products to customers worldwide. The CLASS integrated storage and web-based access and servicing system design incorporates many of the features and capabilities of the current Satellite Active Archive system built for the POES data stored on a robotic system located in Suitland, MD. The CLASS program has established dual sites, one in Asheville, NC, and another in Suitland, MD. There are plans to move the Suitland site to Boulder, CO. A third CLASS site is also slated for Fairmont, WV. NOAA POES and GOES data are currently available via the CLASS interface. CLASS data and product enhancements will be implemented in phases called campaigns. New major campaigns planned include NEXRAD, NPOESS, NPOESS Preparatory Project (NPP), Earth Observing System Long Term Archive, and the European Meteorological Operational Satellite Program.

ENVIRONMENTAL SATELLITE SERVICES - SUPPORTING RESEARCH PROGRAMS

WIND ESTIMATION

Recent advances in numerical weather prediction (NWP) models, both at NOAA's NCEP and other major International NWP Centers, require higher quality satellite-derived winds, particularly over the traditionally data void oceanic regions of the globe. The NESDIS GOES-East and GOES-West wind processing suites are totally automated and use a series of geostationary satellite images to derive wind estimates. The automated winds algorithm uses an objective pattern matching technique to estimate velocity, and satellite water vapor and infrared brightness temperature data to assign heights to these derived wind estimates. The automated quality control of image registration is also an important component of the NESDIS GOES-East and GOES-West winds processing suite. Approximately 20,000 cloud-drift and water vapor motion wind vectors are derived from both satellites for each cycle and distributed to electromagnetic compatibility (EMC) and to the Global Telecommunications System (GTS). EMC uses these operational NESDIS wind products in their global and regional data assimilation/numerical forecast systems. NESDIS recently completed the effort to reformat the winds in WMO-sanctioned binary universal format for records (BUFR). Current work involves the investigation of a slow bias seen in water vapor winds.

The newest satellite wind products include the low-level high-density visible satellite winds. During the daylight hours, visible channel data can be used to track cloud motions. The GOES visible imagery offers high horizontal resolution (1 km) and frequent image sampling (15-30 minutes nominally; higher in special rapid scan modes). The visible channel can depict lower tropospheric cumuliform tracers in areas not covered by opaque cirrus. In terms of tropical cyclones, visible winds can depict the low-level flow in the outer storm vortex region, which is an important area in assessing storm motion. The GOES spacecraft have an atmospheric sounder that includes two water vapor channels centered at 7.0 μm and 7.3 μm. These sounder channels can be employed as surrogate imagers to track water vapor features radiating from the lower layers of the troposphere. The weighting function of the 7.0 μm channel peaks around 450 mb and the weighting function of the 7.3 μm channel peaks around 550 mb. Water vapor winds generated from these two channels will compliment the imager-based cloud-drift and water vapor winds, resulting in an improved three-dimensional depiction of the wind field. The implementation of these new algorithms and the visible wind products into the operational environment at NESDIS began in 1999.

AVIATION

Aviation applications research focuses on detection and mitigation of hazards such as volcanic ash, in-flight icing, and fog and low ceilings. Remote sensing is the primary means of identifying and tracking volcanic ash clouds. An encounter with an airborne volcanic ash cloud can result in millions of dollars in damage to jet engines and the airframe, as well as the risk of engine stalls. Therefore avoiding these hazards is critical. In-flight icing causes significant aerodynamic drag and 5-10 percent of all fatal air crashes for smaller, general aviation and commuter class aircraft. Fog and low ceilings are a major reason for aviation delays, resulting in more than 2 billion in annual economic loss and account for about 25 percent of fatal aviation and maritime accidents.

ATMOSPHERIC MOISTURE AND STABILITY PRODUCTS

Research continues to improve the atmospheric moisture and stability products from the GOES-East and GOES-West sounder instruments. Precipitable water for three layers of the atmosphere (surface to 900 hPa, 900-700 hPa, and 700-300 hPa) are computed from the soundings. Total precipitable water (TPW) for the entire atmospheric column, from the Earth's surface to the top of the atmosphere, is also computed. These precipitable water products are particularly valuable for the short-term forecasting of precipitation, locating those environments favorable for heavy precipitation and flash floods, thunderstorms, and fog. Hourly updates of this data provide useful information for the EMC regional data assimilation systems and for weather forecasters in the field. EMC currently uses the GOES precipitable water retrievals as input to Eta Data Assimilation System (EDAS), which provides the initialization for the Eta forecast model. NESDIS is currently aiding EMC with running global and regional model impact analyses to improve and optimize the use of the GOES derived products in numerical weather prediction schemes. As of July 8, 2003, the hourly cloud top information from the GOES sounder data is being assimilated into the operational NCEP EDAS.

The regional Eta model and the Rapid Update Cycle (RUC) model both assimilate GOES sounder cloud information to help improve the initial moisture and cloud field. In addition to the moisture products, numerous atmospheric stability indices can be computed from measurements made by the GOES sounder instrument. Two stability indices, the lifted index (LI) and CAPE index, are computed on a routine basis. Since these indices are produced hourly, sequential images of these derived quantities clearly show the diurnal and dynamic changes associated with weather events. So, in addition to providing these data to EMC for use in numerical weather prediction models, the graphical representation of these products allows for the looping of the products in time. This capability aids NWS forecasters in the field, for example, to understand the time evolution of severe storms. For example, several of these derived images (lifted index, total precipitable water, and cloud-top information, etc.) are operational and then sent to the NWS AWIPS.

Because channel noise has improved with each successive sounder instrument, the GOES sounder moisture and stability products moved from a horizontal resolution of approximately 50 km to be approximately 10 km (see Figure 3-DOC-5). The increased horizontal resolution offers exciting possibilities for enhanced use of these products in mesoscale forecasting. For example, the finer resolution improves the depiction of gradients in the retrieved products, such as moisture and atmospheric stability, which focuses attention to a local area of interest. These products can be viewed at www.orbit.nesdis.noaa.gov/smcd/opdb/goes/soundings/index.html#products and http://cimss.ssec.wisc.edu/goes/realtime. In addition, these products are available from GOES computer servers within OSDPD or at www.ssd.noaa.gov/PS/PCPN/pcpn-na.html#SNDR.

TROPICAL CYCLONE FORMATION

The Tropical Cyclone Formation Probability Product indicates the probability of formation of a tropical cyclone. This product uses GOES imagery and global model analyses to provide an estimate of the probability that a tropical cyclone will form in the next 24 hours. The current operational product (www.ssd.noaa.gov/PS/TROP/genesis.html) covers the area of responsibility of the National Hurricane Center (NHC), but a general version is being developed that also covers the central and western North Pacific Ocean for use by the Central Pacific Hurricane Center (of NWS) and the Joint Typhoon Warning Center (JTWC) (of the Defense Department).

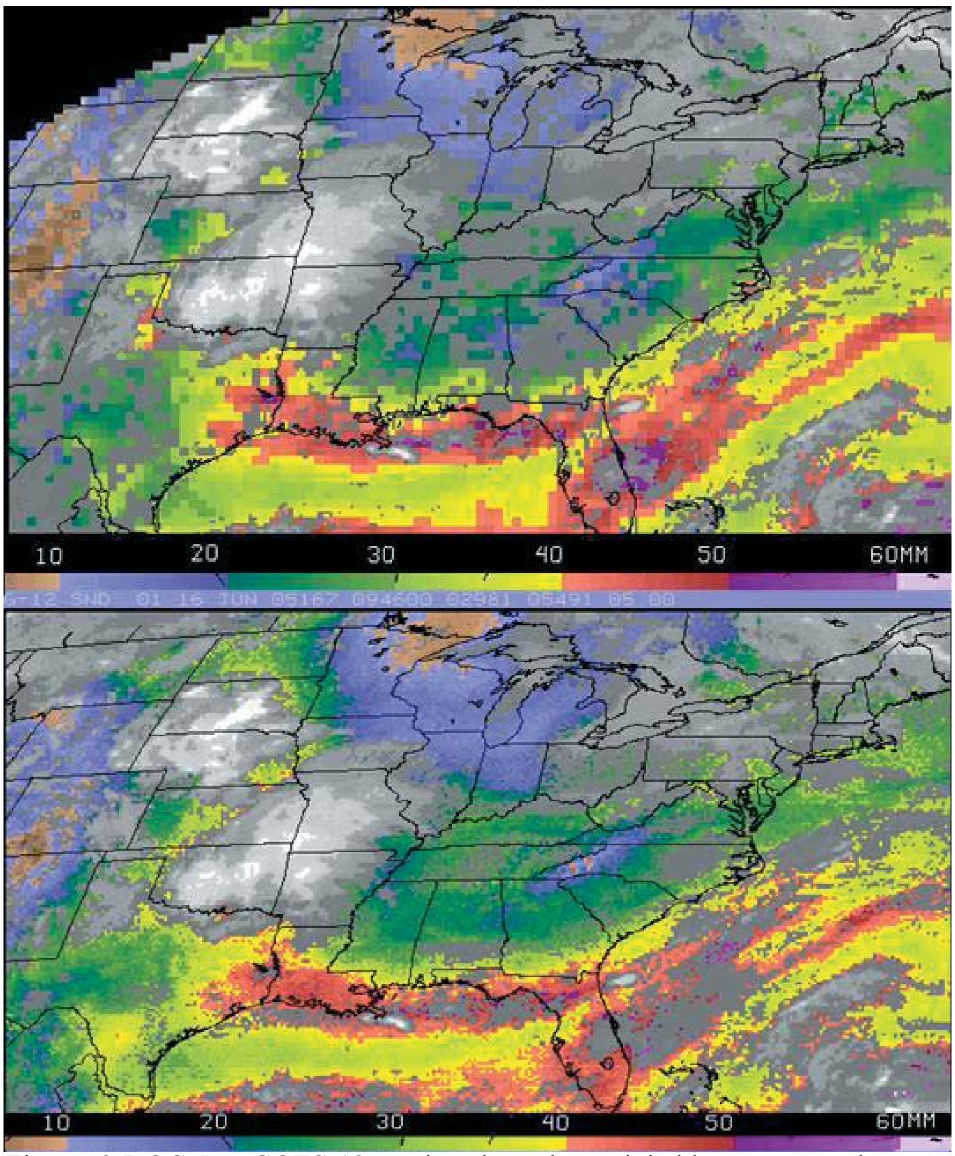

Figure 3-DOC-5. GOES-12 retrieved total precipitable water products at approximately 50 km resolution (top) and approximately 10 km resolution (bottom).

NESDIS has improved upon satellite-based techniques for estimating tropical cyclone positions and intensities and for describing the internal structure of these storms. Data from new sensors, such as AMSU and Tropical Rainfall Measuring Mission (TRMM), are incorporated into the NESDIS operational tropical program, which supports hurricane forecasting programs of the NWS and DOD. Real-time satellite images and text messages on tropical storms can be viewed at www.ssd.noaa.gov. NESDIS is also investigating how to use satellite observations to improve forecasts of formation of tropical cyclones, and even more important, changes in their intensity.

NESDIS works closely with the Hurricane Center to upgrade the operational Statistical Hurricane Intensity Prediction Scheme (SHIPS), which relies upon GOES imagery, satellite measurements of sea surface height (via "altimetry") and global model forecasts. A companion model for typhoons (the Statistical Typhoon Intensity Prediction Scheme) is also being upgraded for use by JTWC in the Pacific.

PRECIPITATION ESTIMATES

Estimates of precipitation from satellites provide a valuable supplement to

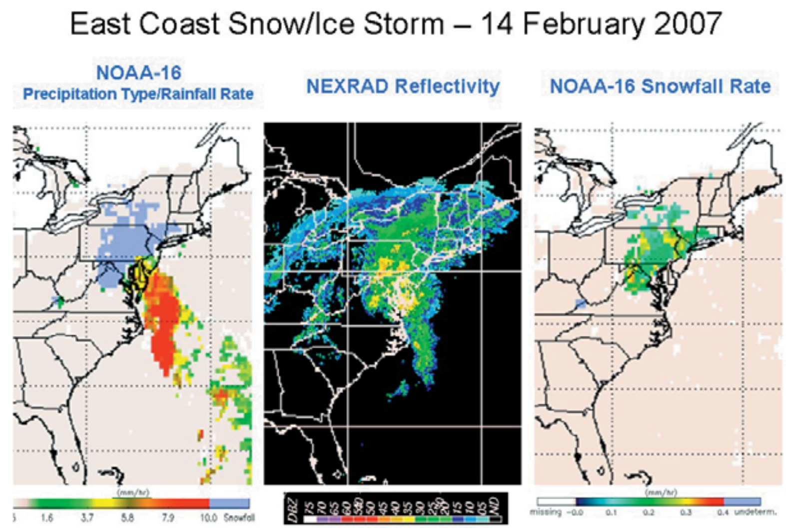

Figure 3-DOC-6. Left: Derived precipitation rates (in mm/hr) and falling snow, from the AMSU instrument on the NOAA-16 satellite; Center: radar reflectivity; and Right: experimental snowfall rate (in mm/hr) from AMSU, all for a high-impact East coast snow and ice event on February 14, 2007.

information from radar and rain gauges (see Figure 3-DOC-6). This information is particularly useful for such phenomena as tropical systems that are beyond the reach of the radar umbrella. For monitoring short-term rainfall events, the primary operational algorithm is the Hydro-Estimator (H-E), which estimates the instantaneous rain rate from GOES infrared images every 15 minutes over the continental United States and produces experimental estimates worldwide. H-E adjusts its computed rain rates for moisture availability, sub-cloud evaporation, uplift by mountains, and other factors using data from operational weather prediction models. Another algorithm approaching operational status is the GOES Multi-Spectral Rainfall Algorithm (GMSRA), which uses four of the five GOES Imager channels for more precise identification of raining areas. An experimental algorithm, called the Self-Calibrating Multivariate Precipitation Retrieval, attempts to combine the relative strengths of infrared-based and microwave-based precipitation algorithms to produce a more accurate result than could be achieved using GOES data alone. Real-time graphics of these and other algorithms plus real-time validation statistics are available at www.orbit.nesdis.noaa.gov/smcd/emb/ff. In addition, H-E is available to NWS field forecasters once per hour via AWIPS. In the future, both H-E and GMSRA will be available on AWIPS every 15 minutes and coverage will expand to Hawaii and Puerto Rico.

In addition to short-term rainfall monitoring, longer-term precipitation analyses are created using microwave data from an improved AMSU-B/Microwave Humidity Sounder (MHS) and the Advanced Microwave Scanning Radiometer (AMSR)-E. The AMSU-B/MHS products, which also include cloud properties and other related information, can be obtained at www.osdpd.noaa.gov/PSB/IMAGES/MSPPS_day2.html. These include estimates of equivalent snow water content, the discrimination of falling rain from falling snow, and snowfall rates (which are experimental).

NESDIS cooperates with the U.S. Air Force and Navy to generate rainfall estimates from another satellite, DMSP, which carries the Special Sensor Microwave Imager (SSM/I) and Sounder (SSMIS) instruments. The rainfall products can be accessed at www.osdpd.noaa.gov/PSB/SHARED_PROCESSING/SHARED_PROCESSING.html.

These rainfall products are also used in direct forecasting applications. The Hydro-Nowcaster extrapolates H-E estimates forward in time up to 3 hours based on storm cell movement. The resulting nowcasts are available at www.orbit.nesdis.noaa.gov/smcd/emb/ff/hn.html. Meanwhile, forecasts for 24-hour rainfall from tropical systems that are about to make landfall are produced operationally for the entire globe by extrapolating microwave-based estimates of rainfall along the predicted storm track. These Tropical Rainfall Potential (TRaP) estimates are available at www.ssd.noaa.gov/PS/TROP/trap-img.html. The next efforts will produce an ensemble version of TRaP to enhance its accuracy and utility to forecasters (see Figure 3-DOC-7).

MICROBURST PRODUCTS

Convective storms can pose serious threats to life and property. Of great concern are those storms that produce downbursts, defined as strong convective downdrafts that result in an outburst of damaging winds on or near the Earth's surface. In addition, downbursts are a hazard to aircraft in flight, especially during takeoff and landing phases. In order to assist the operational forecaster in the prediction of this type of hazardous weather event, GOES sounder-derived microburst products have been developed and implemented. These sounder-derived products include the Wind Index (WINDEX) for estimating the magnitude of convective wind gusts, a Dry Microburst Index (DMI) for dry microburst potential, and Wet Microburst Severity Index (WMSI) for wet microburst potential.

The newest product of the suite, the Hybrid Microburst Index (HMI), indicates the potential for convective

TABLE 3.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM		GEOSTATIONARY SYSTEM	
Satellite Designator	Planned Launch Date*	Satellite Designator	Planned Launch Date*
NOAA-N	CY 2005	GOES N	CY 2006
METOP-2	CY 2010	GOES O	CY 2008
NPP	CY 2010	GOES P	CY 2009
NOAA-N’	CY 2007	GOES Q	Cancelled
NPOESS-C1	CY 2013	GOES R	CY 2012
METOP-1	CY 2006	GOES S	CY 2014
NPOESS-C2	CY 2016	MTSAT-1R	CY 2005
NPOESS-C3	CY 2018		
METOP-3	CY 2015		
NPOESS-C4	CY 2020		

*Launch date depends on performance of prior spacecraft and is subject to change.

<u>NOAA Instruments for NOAA Polar-Orbiter and METOP Series</u>

AVHRR - Advanced Very High Resolution Radiometer
SEM - Space Environment Monitor
SBUV - Solar Backscatter Ultraviolet Instrument (NOAA PM mission only)
HIRS - High Resolution Infrared Sounder
DCS ARGOS - Data Collection System
AMSU-A - Advanced Microwave Sounding Unit-A
AMSU-B - Advanced Microwave Sounding Unit-B
SARP - Search and Rescue Processor
SARR - Search and Rescue Repeater
MHS - Microwave Humidity Sounder (NOAA-N/N' and METOP)

<u>Instruments for NPOESS Series</u>

VIIRS - Visible/Infrared Imager/Radiometer Suite
Microwave Imager/Sounder (to be determined by new competition for C2, C3, and C4)
CrIS - Cross-track Infrared Sounder
ATMS - Advanced Technology Microwave Sounder
ADCS - Advanced Data Collection System
SARSAT - Search and Rescue Satellite-Aided Tracking System
OMPS - Ozone Mapping and Profiler Suite - (Nadir & Limb for NPP, Nadir for C1 and C3, Limb demanifested from C1 and C3) **
CERES - Clouds and the Earth's Radiant Energy System (to be flown on C1 only)
ERBS - Earth Radiation Budget Satellite (follow-on to CERES, demanifested from C3)**
SEM - Space Environment Monitor
Alt - Altimeter (demanifested from C2 and C4)**
TSIS - Total Solar Irradiance Sensor (demanifested from C2 and C4)**

** Can be remanifested if funded by sponsor agencies.

<u>Instruments for GOES-R+ Series</u>

ABI - Advanced baseline Imager
HES - Hyperspectral Environmental Suite
SEI - Solar Instrument Suite
SEISS - Space Environment In-Situ Suite
GLM - Geostationary Lightning Mapper

<u>EUMETSAT Unique Instruments for METOP Series Satellites</u>

ASCAT - Advanced Scatterometer
GOME - Global Ozone Monitoring Experiment
GRAS - GPS Receiver for Atmospheric Sounding
IASI - Infrared Atmospheric Sounding Interferometer

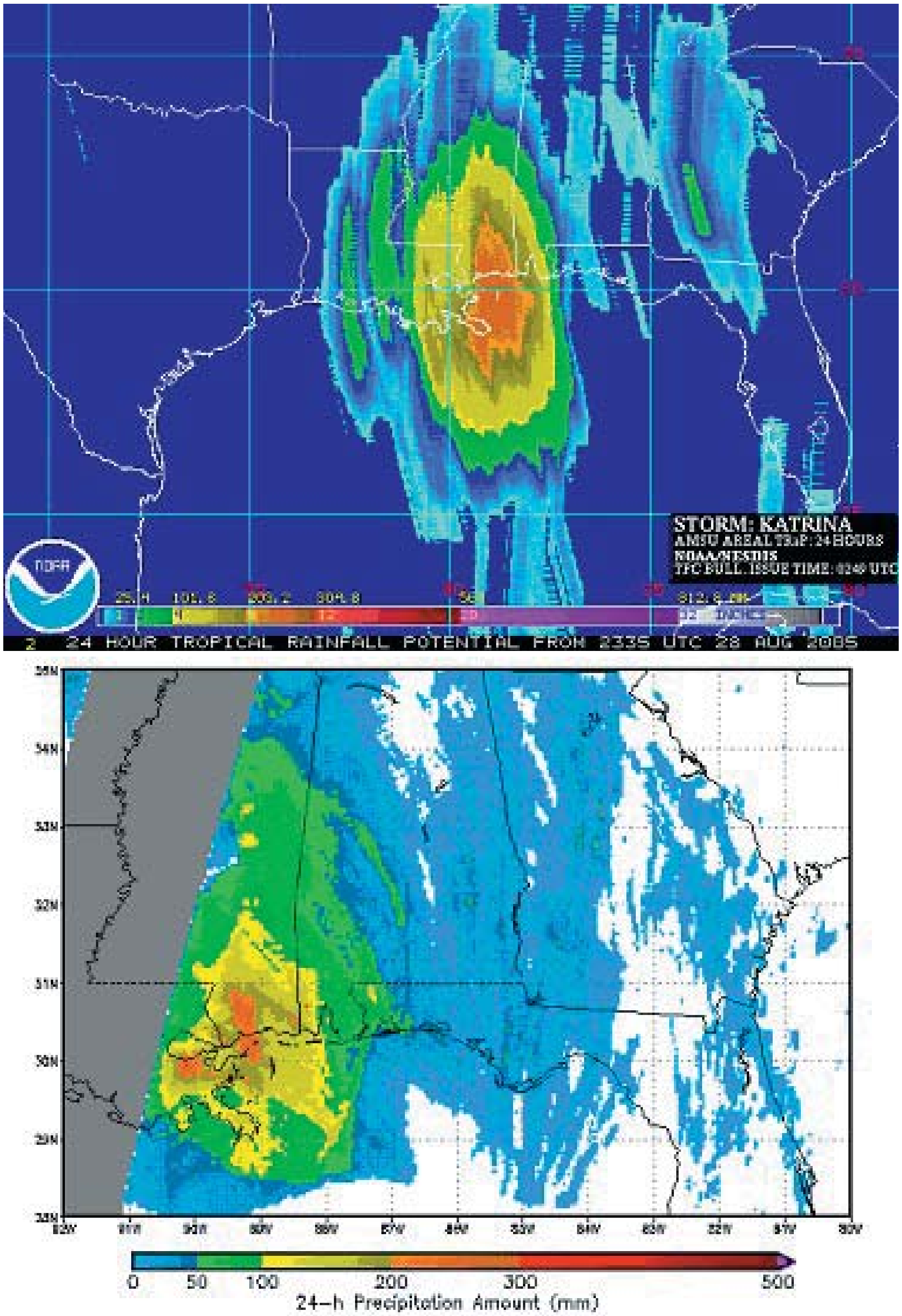

Figure 3-DOC-7. (Top) TRaP forecast map for Hurricane Katrina; expected rainfall amounts in 24 hours are shown as numbers in inches on the color bar, and as numbers in mm above the color bar; and (Bottom) corresponding ground truth from Stage IV radar+rain gauge measurements for 24 hours on August 29, 2005. (Data over the western portion image are missing due to storm-related communication failures.)

downbursts that develop in an intermediate environment between a wet type, associated with heavy precipitation, and a dry type associated with convection in which very little to no precipitation is observed at the surface (see Figure 3-DOC-8). For more information, visit www.orbit.nesdis.noaa.gov /star/Pryor_K.php.

AIRCRAFT ICING

Several upgrades to the GOES aircraft icing product have been implemented. New thresholds for the Band 2-4 (3.9-10.7 micrometer) brightness temperature difference versus visible brightness count corrected for solar zenith angle were employed in September 2003, followed by inclusion of cloud top heights from the GOES Sounder Cloud Top Product in February 2004. The latter combination, referred to as ICing Enhanced Cloud-top Altitude Product (ICECAP), was made available on the Web in February 2004. Finally, a correction to reduce the over-detection of icing caused by thin cirrus was employed in September 2004, based on a technique that uses Bands 4-6 (10.7-13.3 micrometers). Probability of detection (determined from the NOAA Forecast Systems Laboratory's Real-Time Verification System) is now consistently in the 55-70 percent range for the Continental U.S.

FOG AND LOW CLOUDS

GOES-12 visible and infrared (IR) data for a case of sea fog over the northeast United States in June 2003, was analyzed to determine if the fog could be discriminated objectively from other cloud types. The results were provided to the NWS Meteorological Development Laboratory, which is developing objective sea fog forecasting techniques using surface, model, and satellite data.

Figures 3-DOC-9a and 3-DOC-9b feature selected legacy products. The first image is ICECAP that indicates the vertical extent of possible icing conditions. The GOES Sounder is used to estimate the maximum height of the clouds (in color) where icing is possible. The last image is a fog product that displays regions of fog or low cloud (in yellow), and distinguishes fog from cirrus clouds (in blue).

GEOSTATIONARY SEA SURFACE TEMPERATURES

GOES-12 and GOES-11 are capable of measuring sea surface temperatures

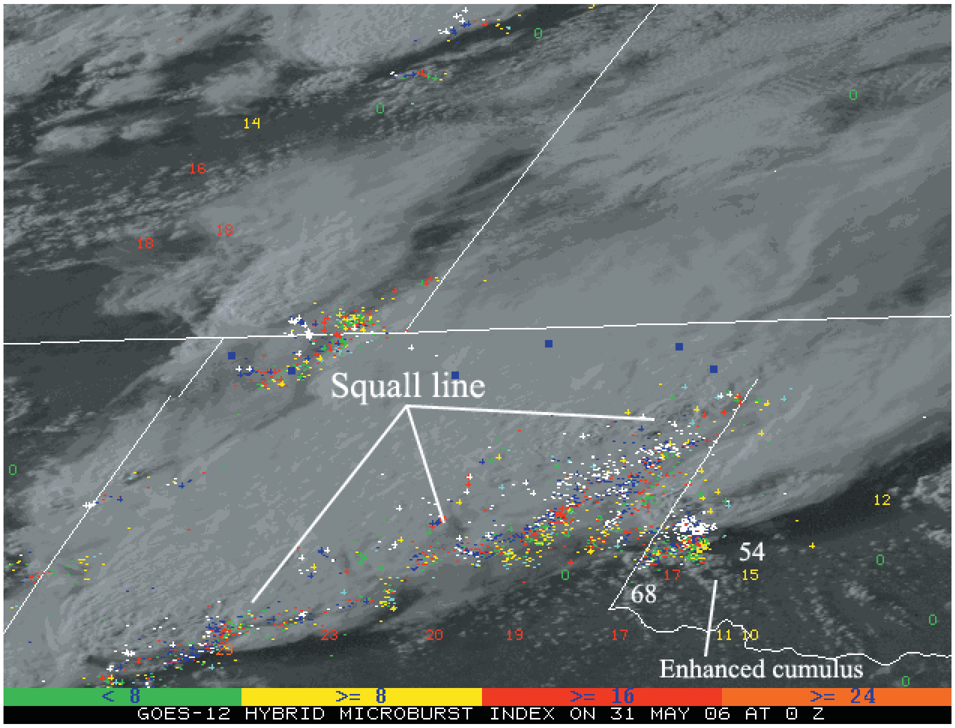

Figure 3-DOC-8. An Example of the GOES HMI Product

(SSTs) over most of the Western Hemisphere nearly continuously. The accuracy and spatial resolution achieved with the GOES measurements are close to that achieved from the polar-orbiting platforms, and GOES has a unique advantage of high temporal sampling frequency. Unfortunately, the trade-off of replacing the 12.0 µm channel with a 13.3 µm channel notably impacts the SST retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. For the SST determination, the frequent sampling by GOES makes a more complete map of SST possible after clouds have moved on. Additionally, a change in scene temperature over a short period of time may indicate the presence of clouds, thereby enhancing cloud detection.

The abundance of GOES observations helps to maintain a balance between high-quality, cloud-free observations, and good geographical coverage of SST estimates. GOES is enabling quantification of the diurnal variation of a radiometrically determined SST over large areas and long time periods. This quantification may have important implications in both numerical weather prediction and climate monitoring. NESDIS has been producing the GOES SST hourly in an experimental configuration since December 1998, from both GOES-East and GOES-West. A global SST product is produced every three hours; regional SST products are generated every hour. These products were recently implemented operationally and can be accessed as digital files from the GOES computer servers within OSDPD.

VOLCANIC ASH

A new technique has been developed to mitigate the loss of the 12 µm IR band on GOES-12 to help track hazardous volcanic ash clouds (see Figure 3-DOC-10). The technique uses IR channels centered at 10.7, 13.3, and 3.9 µm. Several recent eruptions of Soufriere Hill's volcano on Montserrat Island in the eastern Caribbean have shown that this new product is helpful in monitoring ash cloud emissions even at night. GOES-12 ash product can be viewed for several volcanically active regions at www.ssd.noaa.gov/VAAC. The analysis of Moderate Resolution Imaging Spectroradiometer (MODIS) data from the NASA Terra and Aqua spacecraft has also yielded valuable information about optimum detection of volcanic ash using several spectral bands. A

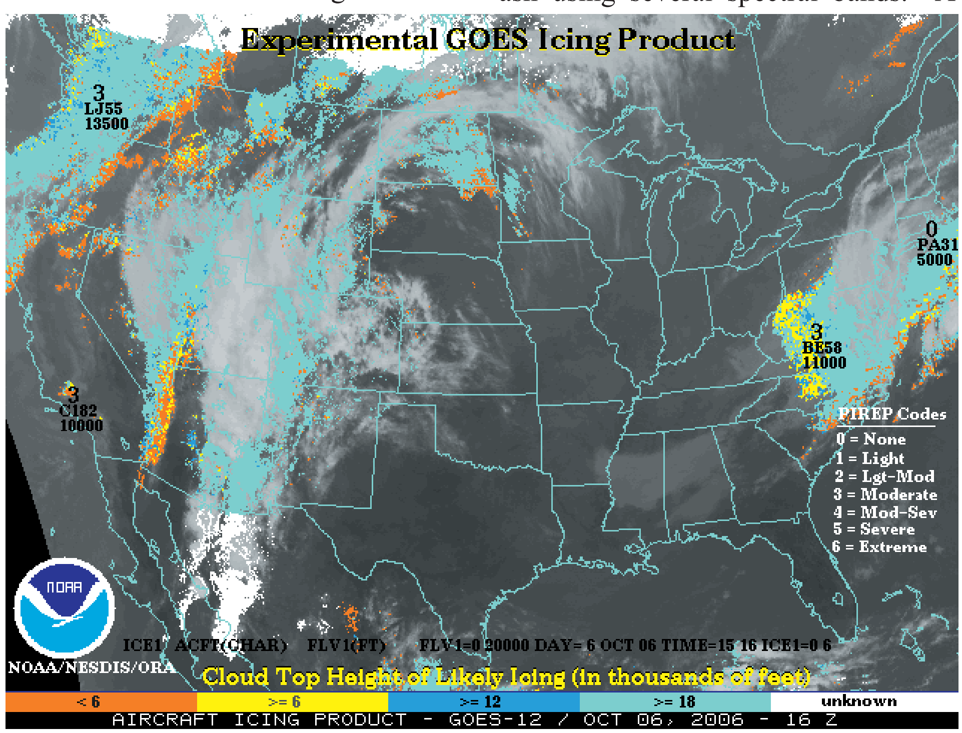

Figure 3-DOC-9a. Products depicting hazards to aviation. ICECAP indicates possible icing conditions and the vertical layer where icing would occur.

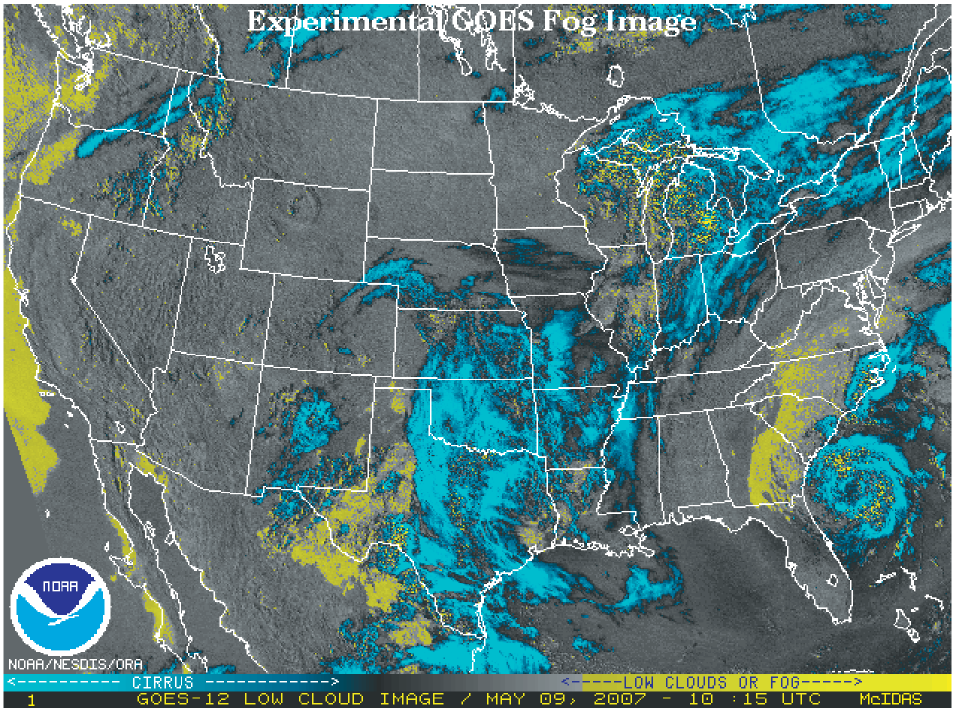

Figure 3-DOC-9b. A Fog product indicates where fog or low cloud (yellow) is present and distinguishes fog (yellow) from cirrus clouds (blue).

three-channel combination product based on the 8.6, 11, and 12 µm bands has been developed that provides effective discrimination of ash or sulfur dioxide gas with minimal false alarms. This algorithm could be applied to future products from NPOESS and GOES-R, which will have similar spectral bands. Volcanic Ash Advisories (VAA) with associated Volcanic Ash Graphics (VAG) and ash forecasts are provided by NESDIS to the aviation community. The region of coverage is the continental United States, Central America, northern South America to 10 degrees S, the Caribbean region, the Pacific Ocean south of Alaska and the Aleutians Islands, and, to the east of Japan, the Marianas Islands. The Volcanic Ash Advisory Center (VAAC) is located in Camp Spring, Maryland. GOES infrared and visible images, aerosol and sulfur dioxide products from NASA's Total Ozone Mapping Spectrometer (when applicable), and operational volcanic ash products for the Washington VAAC area of responsibility can be found at www.ssd.noaa.gov/VAAC/washington.html.

In addition to current operational products for volcanic ash, research into new and improved ways to detect volcanic ash continues. Relevant bands from experimental multi-spectral and hyper-spectral satellite instruments, especially those spectral bands scheduled to be on future operational satellites, are being probed in the development of new products for the detection of volcanic ash. That is in addition to the improved spatial, temporal, and radiometric resolution offered by next-generation satellites.

FIRE MONITORING

Geostationary and polar-orbiting meteorological satellites have been used to detect large active wildfires for over 20 years. NOAA, NASA, and the STAR Cooperative Institutes have developed the algorithms to utilize NOAA operational satellites, research satellites, and Defense Department satellites (DMSP) to monitor fires in real time. In the mid-latitudes, polar-orbiting instruments (MODIS and AVHRR) observe a given region several times each day, and more frequently near the poles. In its routine mode, the GOES Imager allows fire monitoring every 15 minutes over the United States and every 30 minutes over the rest of North, Central, and South America.

Automated algorithms include the MODIS Fire and Thermal Anomalies algorithm and the GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA).

Current research includes the development of a near-real-time, operational global network for fire monitoring, to monitor fires as they occur and capture

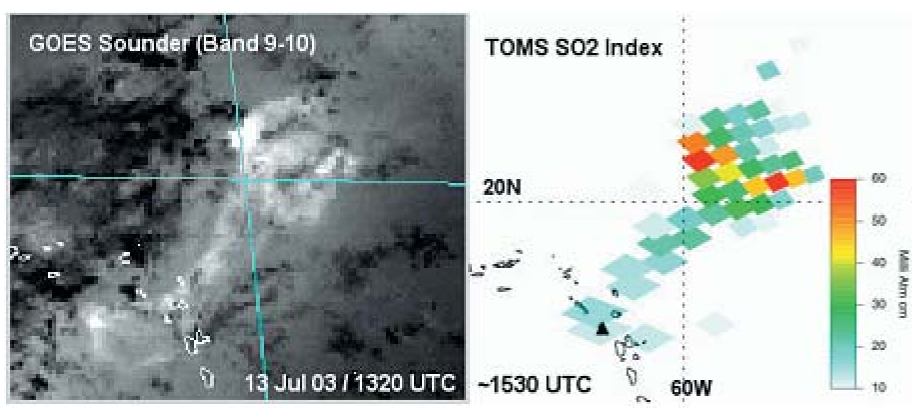

Figure 3-DOC-10. Comparison of GOES Sounder Band 9 minus Band 10 (left) versus the SO2 Index from the Total Ozone Mapping Spectrometer (TOMS) instrument (right) on July 13, 2003, are shown for the indicated times. The SO2 cloud was emitted from an eruption of Soufriere Hills Volcano, Montserrat (located shown in bottom of right hand image) that began around 0600 UTC, July 13, 2003.

the day-to-night signal around the globe. The GOES WF_ABBA product is being adapted to the European METEOSAT-8 and MTSAT-1R satellites. Plans are underway to adapt the WF_ABBA product to satellites of three other countries: China (FY-2C SVISSR satellite), India (INSAT-3D), and Russia (GOMS Electro N2). This suite of sensors in geostationary orbit will enable nearly global fire monitoring with significant overlaps in Asia. STAR has plans to derive similar but enhanced fire products with next generation polar-orbiting (NPOESS and MetOp) and geostationary (GOES-R) satellites.

Since 2002, the NOAA NESDIS Satellite Service Division has provided fire products online via the Hazard Mapping System (HMS) (www.firedetect.noaa.gov). The HMS is an operational interactive processing system that integrates fire products from seven different sensors on NOAA (POES AVHRR, GOES Imager, DMSP Operational Line Scanner [OLS]) and NASA (Earth Observing System [EOS] MODIS) satellites to produce fire and smoke product analyses for the United States and parts of Canada and Mexico. Automated algorithms including the MODIS Fire and Thermal Anomalies team algorithm, the GOES WF_ABBA, the AVHRR Fire Identification Mapping and Monitoring Algorithm (FIMMA), and the DMSP OLS algorithm are used to generate the fire products while smoke is delineated by an image analyst. Analyses are quality controlled by an analyst who inspects all available imagery and automated fire detects, deleting suspected false detects and adding fires that the automated routines miss. Graphical, text, and the Geographic Information Systems (GIS) compatible analyses are posted to the HMS website. All products are archived at NOAA's NGDC, which can be found at http://map.ngdc.noaa.gov /website/firedetects.

Over the past 10 years, the use of these satellite derived fire products has grown appreciably with applications in hazards monitoring, fire weather forecasting, climate change, emissions monitoring, aerosol and trace gas transport modeling, air quality, and land-use and land-cover change detection. The user community includes government agencies (such as NOAA, NASA, Environmental Protection Agency [EPA], and United States Forest Service [USFS]), resource and emergency managers, fire managers, international policy and decision makers, educational institutions, and the general public. At NOAA's National Severe Storms Laboratory (NSSL) Storm Prediction Center (SPC) GOES WF_ABBA fire products provided by University of Wisconsin-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) are used in fire weather forecasting. The SPC Fire Weather Analysis Page integrates the GOES WF_ABBA fire product with other meteorological data and fire weather and danger indices to provide an overview of existing fires and fire danger in the continental United States (see www.spc.noaa.gov/exper/firecomp). Since 2000, the Naval Research Laboratory (NRL) in Monterey has been assimilating the GOES WF_ABBA and MODIS fire products (as of 2003) into the NRL Aerosol Analysis and Prediction System (NAAPS) in near-real-time to both monitor and predict aerosol loading and subsequent transport around the world (see www.nrlmry.navy.mil /flambe/index.html). In Brazil, the National Institute of Space Research (INPE)/Center for Weather Forecasts and Climate Studies (CPTEC) has been assimilating the data into their air quality/transport models in real-time for several years (see http://tucupi.cptec.inpe.br/meio_ambiente).

Current research includes the development and implementation of a near-real-time operational global geostationary fire monitoring network to monitor fires as they occur and capture the diurnal signature around the globe. Initially the GOES WF_ABBA is being adapted to METEOSAT-8 and MTSAT-1R. Plans are underway to eventually adapt the WF_ABBA to FY-2C SVISSR (China), INSAT-3D (India), and the GOMS Electro N2 (Russia). This suite of geostationary sensors will enable nearly global geostationary fire monitoring with significant regions of overlap in Asia. Future activities include better utilization of current systems and long-term plans that ensure the capability to derive similar or improved and enhanced fire products with next generation operational polar-orbiting (NPOESS, MetOp) and geostationary (GOES-R, METEOSAT Third Generation [MTG]) series.

AEROSOL OPTICAL DEPTH

Satellite-measured aerosol optical depth has been shown to be a good proxy for the presence of pollution, especially where long-range transport is involved. STAR has provided the optical depth product in nearly real time since 2003. It is available at 30-minute intervals at a spatial resolution of 4 km by 4 km during the sunlit portion of the day. EPA and NWS have been using the product for monitoring and forecasting applications.

SMOKE CONCENTRATION PRODUCT

STAR developed an Automatic Smoke Detection Algorithm that uses the GOES fire product and the Aerosol Optical Depth product in a pattern recognition algorithm that identifies smoke from biomass burning. This algorithm tracks smoke plumes in the vicinity of fires and their transport. This hourly product is currently operational and is used by the NWS to verify its HYSPLIT smoke forecasts over the United States.

EMISSIONS

Emissions from both natural and anthropogenic sources of burning contribute to poor air quality. Biomass burning (prescribed fires and wildfires) releases huge amounts of smoke (mainly primary particulates dominated by black carbon) and trace gases into the atmosphere. Power plants, oil refineries, and other industrial sources release nitrogen dioxide (NO2), formaldehyde (H2CO), sulfur dioxide (SO2), and other organic compounds, which degrade air quality as well. EPA compiles a National Emissions Inventory every year for a number of critical environmental management activities, such as tracking the Clean Air Act and Clean Air Interstate Rule. Emissions data are used to determine trends over time as well as to initialize air quality forecast models. One of the primary sources of uncertainty in air quality forecasts comes from the uncertainties in these emissions. STAR developed algorithms to derive emissions of aerosols (PM2.5) and trace gases from biomass burning. These products (example in Figure 3-DOC-11) will be provided to NWS in nearly real time for assimilation into models that forecast air quality.

THREE-DIMENSIONAL MAPPING OF AIR QUALITY

Satellite data have been useful in diagnosing long-range transport of pollutants because the transport occurs well above the ground where it is more easily detected by satellites. NOAA is interested in the arrival of pollutants transported over long distances into local surface air where it impacts local air quality. NASA launched the CALIPSO satellite in 2006, with a Lidar that can measure vertical profiles of aerosol backscatter ratio. When combined with measurements of the optical depth of aerosols in the whole column, these measurements provide a valuable three-dimensional look at pollution plumes. Additionally, combining data from multiple sensors will optimize the information on type of aerosol and location in space and time. Scientists of STAR's Satellite Meteorology and Climatology Division are co-investigators with NASA on the 3D Air Quality System, which will combine information from various sensors into 3-dimensional measures of air quality. The intention is to study the linkages between air quality and human health.

MODEL FORECASTS

The NWS now issues ozone forecasts and experimental aerosol (PM2.5) forecasts for the northeast. They will soon migrate to the Weather Research and Forecasting (WRF) model with integrated chemistry and meteorology. Satellite data have the potential to improve forecasts by providing initial and boundary conditions and constraining the emissions, where the largest uncertainties lie. In situ data collected during field campaigns will be very useful in verifying the forecasts. Assimilation of chemical data is in its infancy; only ozone data have been successfully assimilated and demonstrated to have an effect on forecasts of surface ozone. STAR is developing a methodology for assimilating aerosol data to improve forecasts of particulate pollution (PM2.5).

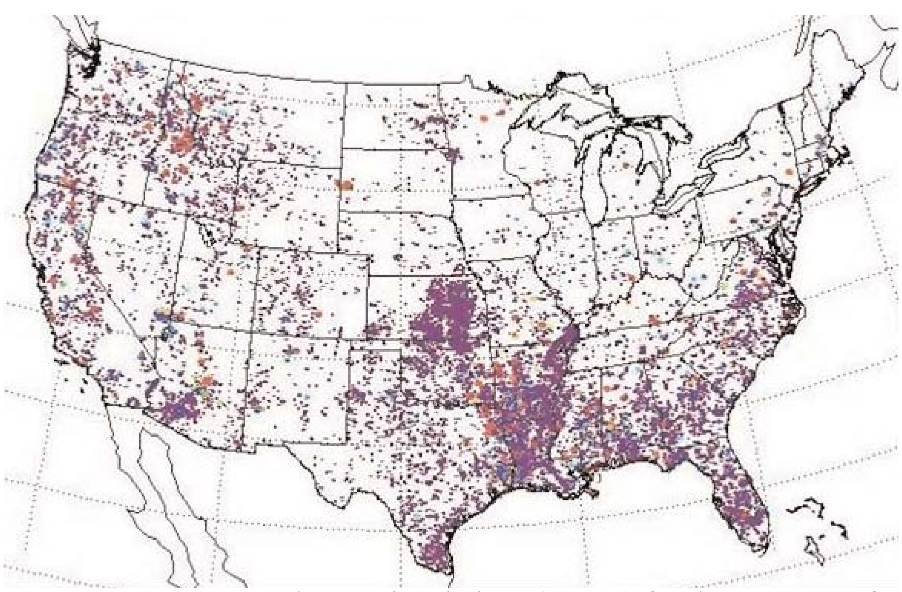

Figure 3-DOC-11. Annual aerosol emissions (PM2.5) for the year 2005 from biomass burning, observed by the GOES-12 Imager.

OBSERVATION OF AIR QUALITY WITH GEOSTATIONARY DATA

Measuring trace gases and aerosols from a geostationary satellite permit much higher sampling in time (see Table 3-2 and Table 3-3). For example, the Federal Aviation Administration (FAA) would like to have a total ozone product every hour from GOES-R to monitor clear air turbulence. Similarly, an ability to monitor concentration, type, and vertical location of dust would provide unprecedented information for air quality and climate applications. The ability to distinguish between different types of aerosols is extremely important for monitoring and forecasting air quality. It is hoped that GOES-R will provide profiles of at least four trace gases (O3, CO, CH4, and CO2).

While the current ozone data come from polar-orbiting satellites, the capability of geostationary satellites to provide measurements of ozone on the same time and space scales that existing air quality models and observation networks are using, will be a tremendous advantage. Hourly ozone measurements from geostationary satellites will have many benefits, including:

• providing more cloud-free observations, essential for a number of reasons; and

• monitoring diurnal changes of air quality.

ATMOSPHERIC WINDS FROM CLOUD MOTIONS

Atmospheric motion vectors (AMV) or wind vectors derived from a sequence of satellite images are an important source of global wind information, particularly over the world's oceans and more remote continental areas where conventional weather observations are lacking in time and space. These data are routinely used by the major NWP centers in the world and assimilated into regional and global prediction models. These data are also made available to NWS forecasters responsible for providing the public with day-to-day weather forecasts. In addition, these products are distributed to other countries.

Wind vectors are typically derived from the GOES imagery, providing coverage from approximately 60 degrees S to 60 degrees N latitude. The currently operational GOES wind products include IR cloud-drift winds, water vapor (WV) motion winds, and visible (VIS) cloud-drift winds.

Recent advances in models for NWP, at NCEP and other international centers, require higher quality satellite-derived winds, particularly over the data void oceans. A series of geostationary satellite images from GOES-East and GOES-West are used to calculate estimates of the wind, in a totally automated wind processing suite. The automated winds algorithm uses an objective pattern matching technique to estimate wind velocity and it assigns heights to these wind estimates by using brightness and temperature data from the water vapor and infrared channels of the satellite.

The winds processing suite now delivers approximately 20,000 wind vectors from both satellites at least twice a day to NCEP and to the Global Telecommunications System. NCEP uses these NESDIS wind products in their global and regional weather forecast systems.

The newest satellite wind products include low-level, high-density satellite winds from visible images. During the daylight hours, visible channel data can be used to see cloud motions. The GOES visible imagery offers high horizontal resolution (1 km) and frequent images (15 to 30 minutes). The visible channel can show low-level cumulus clouds in most areas having partly cloudy skies. In tropical cyclones, visible winds can depict the low-level airflow in the outer storm region, which is an important area in assessing storm motion. Implementation of new algorithms and the visible wind products in the operational environment at NESDIS began in 1999.

The capability to derive winds from measurements made by the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments aboard the polar-orbiting Terra and Aqua satellites was first developed at CIMSS and is based upon established methodologies and algorithms used to derive wind observations from the GOES series of satellites. MODIS cloud-drift and water vapor wind observations from Terra and Aqua provide unprecedented coverage in the polar regions of the globe, areas where wind observations are sorely lacking.

The MODIS wind products have a significant positive beneficial impact on forecast accuracy in the Arctic and Antarctic, as well as in the extra-tropical latitudes of both the Northern and Southern Hemispheres. Given the positive results, the MODIS winds capability was transferred to the OSDPD/Satellite Services Division (SSD), which now routinely provides MODIS wind vectors to the user community. Ten NWP centers around the world now use the MODIS winds operationally.

In the United States, GOES has been used in operational forecasting for quite some time. Forecasters recognize the additional detail that can be captured from more frequent imaging in weather associated with rapidly changing cloud structures. The value of more frequent imaging is demonstrated by the inclusion of a 15-minute update cycle over the Continental United States sector in the current GOES schedule and by the multitude of special NWS operational requests for more frequent sampling at 7.5-minute intervals (Rapid-Scan Operations). On occasion, special periods of Super-Rapid-Scan Operations have been requested by the research community. That mode allows one-minute sampling in a limited-area over meteorological events of interest.

Recently, special GOES rapid-scan periods have been collected during several field programs and research initiatives designed to maximize observations in regions of high-impact weather events. Some examples include the NASA Tropical Cloud Systems Program, the Atlantic Thorpex Regional Campaign, and the TROpical Predictability EXperiment (TROPEX). In the first two campaigns, the data sets were used in real time in mission planning and in directing aircraft to targets of opportunity. In TROPEX, the data sets will be used to target "observing strategy experiments" run by modelers at the Naval Research Laboratory. In all three cases, the enhanced data sets are expected to be employed in case study analyses and numerical model impact studies.

INTEGRATED CAL/VAL ENTERPRISE SYSTEM

The users of numerical weather predictions require accurate calibration of satellite measurements. For satellite measurements having anomalies in radiances and/or large systematic biases, the data will be rejected during the data assimilation stage. It is also very difficult to use the satellite observations that are not quantified for their measurement precision. For climate studies, satellite instruments must be capable of measuring Earth system variables at high accuracy and stability over decadal (and ultimately, centennial) time scales. During a calibration workshop organized by the National Institute of Standards and Technology (NIST), NOAA, NPOESS-IPO, and NASA in November 2002, accuracy and long-term stability objectives for satellite measurement were established. The final report of the workshop defines the required absolute accuracies and long-term stabilities of global climate data sets, and it translates the data set accuracies and stabilities into the required satellite instrument accuracies and stabilities (e.g., for troposphere atmospheric temperatures, the measurement accuracy is 0.5 degrees K and stability is 0.04 degrees K/decade; for surface albedo measurement, the accuracy is 0.01 and stability is 0.002 degrees K/decade). Those requirements pose tremendous challenges to the post launch calibration of satellite sensors.

NESDIS/STAR has an excellent track-record in supporting the operational calibration of radiometers on polar-orbiting environmental satellites, transferring research results to operations and performing advanced research in satellite instrument calibration. In addition to our heritage in onboard and vicarious calibration, in recent years we have developed many additional components such as intersatellite calibration, on-orbit and prelaunch instrument characterization, and the incorporation of radiative transfer model calculations.

STAR also plays an important role in re-calibrating historical data to support climate studies, through the scientific data stewardship program. In recent years, STAR has developed comprehensive calibration/validation capabilities which are being incorporated into the Integrated Instrument Calibration/Validation System (ICVS). The vital components of the ICVS include pre-launch and on-orbit quantification of satellite instrument noise and online performance monitoring; linear and nonlinear thermal calibration; onboard ultraviolet (UV), vicarious visible and near-infrared calibration; independent verification of radiances through inter- and intra-satellite calibration; and radiative transfer calculations to isolate biases and anomalous contributors to the biases. Today, we can quantify the on-orbit instrument noise and biases with little ambiguity, significantly reducing the uncertainties for the data users in direct radiance assimilation in numerical weather prediction, physical retrievals, and climate monitoring and reanalysis.

With the ICVS framework, STAR is now in an excellent position for leading and coordinating the WMO Global Space-Based Inter-Satellite Calibration System (GSICS). GSICS integrates observations and products from different satellite systems through intercalibration. The intercalibration can quantitatively relate the radiances from different sensors viewing the same target and allow consistent measurements to be taken over the globe by all elements of the space-based observing system. Without intercalibration of the space-based component of the World Weather Watch (WWW) Global Observing System and of the Global Earth Observation System of Systems (GEOSS), the full benefit of the observations will not be realized for the environmental data stewardship.

During the 2005 hurricane season, ICVS was first applied for NOAA-18 on-orbit verification and led to an early delivery (45 days after the NOAA-18 launch) of high quality satellite observations for uses in NOAA computerized models that significantly improve the accuracy and extend the range of weather prediction for severe storms such as hurricane track, wind damage, and surface flooding. With ICVS, STAR scientists are able to provide an accurate analysis of the root cause of the NOAA-18 HIRS/4 anomaly and provide mitigation strategies for containing the noise and reducing the risk for future launches.

ICVS is also providing a root-cause analysis and diagnostics for DMSP Special Sensor Microwave Imager Sounder (SSMIS) radiance anomalies. SSMIS is the first conically-scanning microwave instrument that measures the Earth's radiation from 19 to 183 GHz and presumably provides improved atmospheric temperature and water vapor sounding under all weather conditions. It is a key sensor for NPOESS risk reduction studies. Unfortunately, the main reflector from the SSMIS antenna subsystem emits some radiation and contaminates the Earth scene signals. In addition, the warm calibration target is intruded by direct solar radiation and other stray lights, producing anomalous calibration counts in several latitudinal zones. These contamination sources cause anomalies in SSMIS radiances in Temperature Data Records (TDR) and Sensor Data Records (SDR), which change with latitude and season. As part of ICVS, SSMIS anomaly distributions (locations and magnitudes) are detected and corrected during the calibration process. Therefore, SSMIS data after the NOAA recalibration and processing is of improved quality for operational applications in weather and climate models.

NPP/NPOESS SENSOR CALIBRATION, PRODUCT DEVELOPMENTS, ENHANCEMENT, AND VALIDATION

STAR scientists continue to play an important role in the evaluation of NPOESS contractor sensor design and retrieval methods. This group provides the end-to-end support to the NPOESS program from instrument calibration to product validation and applications.

TABLE 3.2 TRACE GAS AND AEROSOL PRODUCTS FROM OPERATIONAL POLAR-ORBITING SATELLITES

Pollutant	Location	Satellite (Sensor)	User/Application
NO_2	Troposphere	IJPS (GOME-2)	NWS – Assimilation NWS – Forecast model evaluation EPA – Assessment work (emissions) Model evaluation NOAA – Model evaluation
SO_2	Troposphere Stratosphere (volcanic)	IJPS (GOME-2) NPP/NPOESS (OMPS) IJPS (IASI) NPP/NPOESS (CrIS)	NWS – Forecast model evaluation EPA – Model evaluation NOAA – Model evaluation
H_2CO	Troposphere	IJPS (GOME-2) NPP/NPOESS (OMPS)	NWS – Forecast model evaluation EPA – Assessment work (emissions) Model evaluation NOAA – Model evaluation
CHOCHO	Troposphere	IJPS (GOME-2)	EPA – Assessment work (emissions)
O_3	Column	IJPS (GOME-2) IJPS (IASI) NPP/NPOESS (OMPS) NPP/NPOESS (CrIS)	NWS – Assimilation

TABLE 3.2 (CONTINUED) TRACE GAS AND AEROSOL PRODUCTS FROM OPERATIONAL POLAR-ORBITING SATELLITES

Pollutant	**Location**	**Satellite (Sensor)**	**User/Application**
O_3	Profile (stratosphere)	IJPS (GOME-2) NPP/NPOESS (OMPS)	NWS – Assimilation
CO	Troposphere	IJPS (IASI) NPP/NPOESS (CrIS)	EPA – Assessment work (emissions) NWS – Forecast model evaluation
CH_4	Column	IJPS (IASI) NPP/NPOESS (CrIS)	EPA – Assessment work (emissions)
CO_2	Column	IJPS (IASI) NPP/NPOESS (CrIS)	NOAA – Climate monitoring
BrO	Stratosphere	IJPS (GOME-2)	NOAA – Climate monitoring NASA – Climate monitoring
OclO	Stratosphere	IJPS (GOME-2)	NOAA – Climate monitoring NASA – Climate monitoring
Aerosols	Troposphere	IJPS (GOME-2) IJPS (IASI) NPOESS (OMPS) NPOESS (CrIS) NPOESS (VIIRS)	NWS – Assimilation NWS – Forecast model evaluation EPA – PM2.5 monitoring

TABLE 3.3 GOES-R BANDS AND PRODUCTS

Sensor	Bands	Product	Applications
ABI	0.47 µm, 0.86 µm, 2.1 µm	Aerosol optical depth, type (dust vs. non dust), particle size (effective radius), and fraction of fine mode vs. coarse mode	EPA – PM2.5 monitoring NWS – PM2.5 forecasting NIEHS – Health impacts CDC – Health impacts
ABI	9.6 µm	Total column ozone	FAA – Clear-air turbulence NWS – Ozone forecasting
ABI	3.9 µm, 11 µm	Fire location, size, intensity and carbon consumption Aerosol and trace gas emissions	EPA – Assessments NWS – Forecasting
ABI	11 µm, 12 µm	Dust detection	EPA – Monitoring
HES	800 – 1000 cm^{-1}	Dust loading and height Volcanic ash detection, amount and height Smoke plume height	VAAC – Advisories EPA – Monitoring NWS – Forecasting
HES	1650 – 2250 cm^{-1}	Carbon monoxide Methane	EPA – Assessments NWS – Forecasting NOAA – Climate
HES	950 – 1050 cm^{-1}	Ozone profile	NWS – Forecasting
HES	600 – 800 cm^{-1}	Ash cloud height Smoke plume height	VAAC – Advisories NWS – Forecasting
HES	1100 – 1200 cm^{-1}	Sulfur dioxide	VAAC – Advisories

STAR scientists have also been participating in NPOESS operational algorithm teams (OAT) and all phases of the NPOESS sensor calibration process to assure that radiometric performance of NPP/NPOESS instruments will meet the scientific needs of NOAA and other agencies.

STAR scientists have also been providing significant technical support to the prelaunch calibration of major NPOESS instruments in the last few years. As early as 2001, STAR scientists contributed to the technical design of the several major NPOESS instruments and supported the investigation of prelaunch calibration issues using comparisons with current POES instruments and evaluating how they affect the calibration traceability between POES and NPOESS. Currently, STAR is providing technical examination of the calibration accuracy, NE T, and nonlinearity for several instruments such as the Advanced Technology Microwave Sounder (ATMS).

In the NPOESS post-launch calibration, STAR will focus on the characterization of on-orbit instrument noise and biases of all NPOESS instruments using the STAR integrated cal/val enterprise system and develop an online instrument performance trending system that monitors a selected number of key parameters.

It is critical to the NPOESS program and to the scientific community at large that the contractor scientific algorithms are assessed independently during the pre-launch phase so that potential corrective measures are taken early, avoiding sub-optimal results later in the process and/or delays in delivering the real-time data to weather centers and other customers after launch has occurred. STAR scientists have proposed a vigorous assessment of radiometric and geophysical performances of NPP/NPOESS instruments, in both pre-launch and post-launch stages. Further assessments will be made to check the robustness and the timing requirements for an operational use.

The contractor algorithms are being extensively compared in simulation and with real data, with operational products developed by STAR from EOS, POES, and DMSP platforms. STAR is a center with various proxy data sets and testbeds through simulations and real measurements for NPOESS instruments. NPOESS contractor algorithms are now being run at the STAR systems and assessed with the proxy data. Since the STAR team has dual experience with both the contractor algorithms and in the operational algorithms running at NOAA, there have been rapid advances in the assessment of the contractor's algorithms performances.

LAND SURFACE PARAMETERS FOR USE IN WEATHER FORECAST MODELS

Satellite-derived fields of land surface characteristics are being produced operationally for use in NWP models. These include radiation products delivered in near-real-time as forcing variables; surface characteristics, such as fractional green vegetation and albedo, that specify model lower boundary conditions; and validation quantities, such as surface temperature. These products are meant to help the NWP models maintain better soil moisture fields which in turn results in better near surface temperature and humidity forecasts and better precipitation forecasts. These fields now include POES-based (SSM/I and AMSU) estimates of surface emissivity, snow cover, sea-ice extent and concentration, land surface skin temperature, and soil wetness. Development of snow depth is underway. Plans are in the making to develop the AMSU-A Snow Water Equivalent (SWE) product for operational use. Forward models for surface emissivity at various microwave frequencies have been developed and are being tested in the forecast models. Algorithms to determine clear sky ice surface temperatures have been developed and delivered to Atmospheric Environment Service, Canada for evaluation. New techniques such as automatic edge detection and incorporation of new sensors such as AMSU and NASA's MODIS are in development to improve operational production of daily snow and ice extent products. These products are delivered as digital files to NWP models and to the NWS Climate Prediction Center and other users. Graphical imagery of operational northern hemispheric snow cover can be found at www.ssd.noaa.gov.

LONG-TERM MONITORING OF NOAA-15 ADVANCED MICROWAVE SOUNDING UNIT-A (AMSU-A) PERFORMANCE

Since the launch of the NOAA-15 satellite, the AMSU-A level 1B data have been captured from the Central Environmental Satellite Computer System (CEMSCS) and stored on optical disks. These data are used for off-line characterization of the instrument radiometric performance on orbit. Over 20 important radiometric parameters are extracted or calculated from the AMSU-A 1B data. NESDIS has already demonstrated that the noise in the observations in all channels is lower (better) than that required by the specifications and, in some channels, it is lower than estimates based on pre-launch test results. NOAA will continue compiling long-term trends of all the parameters to provide a better understanding of the instrument performance. The PC-based software developed for evaluating these data will be improved for better efficiency in processing the data.

CALIBRATION OF THE VISIBLE AND NEAR-INFRARED CHANNELS OF THE AVHRR

It is very important to characterize and document the in-orbit performance of the AVHRR flown on the polar orbiters. Toward this end, a very comprehensive program of post-launch calibration and characterization of AVHRR has been implemented to ensure the accuracy, continuity, and viability of the various AVHRR-derived geophysical products, with particular attention paid to the visible and near-infrared channels which do not have any onboard calibration devices. The major program elements are:

- development of an optimal vicarious post-launch calibration technique, utilizing radiometrically stable calibration sites, model simulations of the radiation measured by the sensors, and simultaneous radiation measurements by AVHRR and by calibrated spectrometers onboard aircraft;
- enhancement of available vicarious calibration techniques to improve attainable radiometric calibration accuracies beyond ±5 percent;
- evaluation of the feasibility of using the International Space Station (ISS) as a platform to calibrate satellite sensors, in general, using radiometers on the ISS traceable to NIST;
- establishment of AVHRR as a traveling calibration standard to monitor the performance of sensors, such as the imager on GOES, the visible channel of HIRS, MODIS, and various sensors to be flown on the Environmental Satellite (Envisat); and
- design of optimal onboard and vicarious calibration techniques for the visible and near-infrared sensors planned under NPOESS. The relevance and importance of these activities has been recognized by the national and international user community, as evidenced by the appreciation and endorsement of the Working Group on Calibration and Validation (WGCV) and the Global Observing Systems Space Panel (GOSSP).

To ensure global access to the results of the AVHRR calibration program, and recognizing the importance of the AVHRR-derived products to national and international programs, such as the International Satellite Cloud Climatology Project (ISCCP), the International Geosphere Biosphere Programme (IGBP), the Global Climate, Ocean, and Terrestrial Observing Systems, and to benefit from sensor calibration research elsewhere, active liaison, and collaboration in some instances, has been established with researchers in NASA, NIST, EUMETSAT, China Meteorological Administration, Beijing, China; Rutherford Appleton Laboratory, United Kingdom; National Space Development Agency, Japan; the NOAA/NASA Pathfinder Program; several space agencies and remote sensing laboratories outside the U.S., and academia both in the United States and abroad.

CALIBRATION OF GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE INSTRUMENTS

The GOES ground-system calibration processing was modified to accommodate the changes in spectral locations and field-of-view sizes of the Imager channels that became effective with GOES-12. Additional processing changes are being developed to accommodate the further changes that will be made to the Imager on GOES-N. The most notable of these is a tenfold increase in the time the Imager spends viewing its blackbody for calibrating its infrared channels. The increase is intended to improve calibration precision.

On November 24, 2003, the operational calibration processing in the GOES Imager's infrared channels was modified to deal with artificial depressions in measured brightness temperatures that occurred in the hours near local midnight. These depressions, reaching a maximum of approximately 1degree K (for a scene at 300 degrees K), were most pronounced in the infrared channels at the shortest wavelengths. We believe they were caused by effects of solar heating in the calibration measurements. The processing modification, which invokes a statistical technique to calculate the calibration coefficients near midnight, succeeded in minimizing the artificial brightness-temperature depressions. In addition to calibration, the product processing algorithms for several products will have been modified to accommodate the new channel configuration. FY 2004 saw considerable progress in the on-orbit calibration of the Imager's visible channel. This channel, lacking an on-board calibration device, can only be calibrated vicariously, i.e., with targets external to the satellite. Here we report results from two such targets. From eight years of observations of a stable Earth target (the Grand Desert in Sonora, Mexico), we estimated that the responsivity of the GOES-8 Imager's visible channel degraded an average of 5.8 percent per year. From routine observations of approximately 60 stars, we estimated visible-channel responsivity degradations of 4.86plus or minus 0.08 percent for the GOES-8 Imager (from 10/19/95 to 4/1/03) and 5.56 plus or minus 0.18 percent for the GOES-10 Imager (from 1/4/01 to 11/6/03). The difference between the GOES-8 degradation rates from the two methods is a topic of current research.

More information on GOES calibration topics, including the GOES-12 Imager channel changes, the correction for the midnight infrared-channel calibration errors, and the star- and desert-based vicarious calibrations of the visible channel, can be viewed at www.oso.noaa.gov/goes/goes-calibration/index.htm

OCEAN SURFACE WINDS

Calibration and validation studies are performed by STAR for all new operational ocean surface wind data streams. Product refinement and development activities are currently underway to improve ocean wind vector retrievals in the high wind speed regime, as well as precipitation regimes, where current retrieval algorithms underestimate the wind speeds. There are several satellite-based active and passive microwave sensors planned for launch in the near future from which NOAA would have the opportunity to obtain near-real-time data streams. One of these sensors will be the first demonstration of the passive polarimetric technique, which is being relied on in the NPOESS design to meet the Nation's ocean surface wind vector requirements.

HIGH-RESOLUTION COASTAL WINDS AND STORM SIGNATURES FROM SYNTHETIC APERTURE RADAR

STAR scientists have developed techniques for deriving high resolution (1 km or less) winds from synthetic aperture radar (SAR) imagery and are using these derived winds to study ocean surface wind signatures of coastal wind phenomena of atmospheric fronts, hurricanes, and other storms. By sensing variations in ocean surface roughness on the centimeter scale, SAR sensors can image storms, atmospheric waves (such as mountain lee waves), island and mountain wakes and vortex streets, gap flows, atmospheric fronts, and barrier jets. Application demonstrations are currently underway to provide high-resolution winds, imagery, and other SAR-derived products to operational agencies for evaluation. Demonstrations included near-real-time winds for Alaska coastal waters and SAR-derived hurricane winds. By the year 2007, there will be as many as four wide-swath SAR satellites. If data acquisition and sharing arrangements can be established to obtain access to SAR imagery from these new sources, frequent routine SAR coverage of U.S. coastal areas will be possible. This increased coverage will allow use of SAR-derived marine and atmospheric products for operational purposes.

NOAA NATIONAL DATA CENTERS (NNDC)

NESDIS is responsible for the management of the NOAA National Data Centers (NNDCs). NNDCs consist of three data centers: the National Climatic Data Center (NCDC), located in Asheville, North Carolina; the National Geophysical Data Center (NGDC), located in Boulder, Colorado; and the National Oceanographic Data Center (NODC), located in Silver Spring, Maryland.

NNDC was established to be the Nation's primary repository for NOAA data. Since their inception, the role of the data centers has expanded in response to the introduction of new technologies useful to the centers and available to the users. Originally designed to archive only NOAA data, these centers now hold environmental data from a variety of sources, to include other U.S. government agencies, such as DOD and NASA, foreign governments, universities and cooperatives, and numerous commercial research programs.

The three NNDCs are responsible for the scientific stewardship of the Nation's environmental data and the development and operation of the associated ingest, monitoring, quality control processing, access, archive, analysis and assessment, creation of climate data records (CDRs), and other product generation systems in support of their national and international commitments and users. The NNDCs archive and provide access to numerous types of data. Each type of data provides a unique perspective for use in climate, oceanographic, space weather, and other geophysical research. It is often the combination of many of these data sets that lead to new discoveries and products that support activities, such as weather forecasting, risk (hazards-public safety and economic) mitigation, weather impact assessments, and climate assessments and predictions.

Data sets are typically divided into the method of collection: Remote (Satellites), Airborne, and in situ (surface: land and ocean). In situ includes radar, radiosonde, manual and automated surface observing systems, fixed and drifting buoys, etc. Observational data must be accompanied by comprehensive and complete station history data, referred to as metadata, as well as other ancillary and auxiliary documentation describing the data processing procedures (quality control and assurance) used prior to and after archiving the data.

Climate monitoring, evaluation, and prediction are critical to economic sustainability and environmental stewardship. The challenge facing the NNDCs is not only ingesting and processing very large volumes of new data, but also the convenient and timely access to the data and information. Millions of paper pages and thousands of feet of microfilm/microfiche of recorded instrument measurements and other information dating back hundreds of years are currently under the stewardship of the NNDCs. Over the past 50 plus years, many observations have been stored in digital form. There is now in place a program to convert analog records to digital form. The process will take many years to complete.

The development of a new generation of satellites over the next ten years (NASA's EOS, the next generation GOES, and NPOESS), the Initial Joint Polar-orbiting Operational Satellite System (IJPS)/MetOp, and the enhancement of the operational NEXt Generation Weather RADar (NEXRAD) (dual polarization) present major data management (stewardship and customer access) challenges to the NNDCs.

To meet these challenges, NESDIS has developed the CLASS program that will provide a significant portion, but not all, of the funding resources required to improve and maintain the information technology (IT) infrastructure required to support the mandated scientific data stewardship responsibilities for these incredibly large volumes of data.

NATIONAL CLIMATIC DATA CENTER (NCDC)

The National Climatic Data Center (NCDC), a designated Federal Records Center, is the officially designated national archive for weather and climate data and information. NCDC is the world's largest archive of climate data. This center also produces and maintains numerous data sets, products, and assessments in order to service many thousands of customers worldwide. In addition, NCDC operates the World Data Center (WDC) for meteorology and WDC for paleoclimatology.

The NCDC mission is to provide stewardship and access to the Nation's resource of global climate and weather related information, and to assess and monitor climate variation and change. In support of that mission, the vision of NCDC is to be the most comprehensive and accessible source of high-quality meteorological data and information and to be a leading center of climate science expertise.

NCDC produces national and global data sets and assessments that support economic, national security, emergency and environmental planning and decisions, which are affected by climate variations and change. This center monitors the climate of the United States through monthly and annual State of the Climate reports. NCDC is co-located with the U.S. Air Force Combat Climatology Center and the U.S. Navy Fleet Numerical Oceanography and Meteorology Detachment. These three organizations make up the Federal Climate Complex, fulfilling much of the Nation's climatological needs.

This center conducts activities in four primary areas necessary to achieve its mission.

- Acquisition - receipt and quality assurance processing of weather and climate data.
- Archiving - long-term security, storage, and stewardship of these climate products.
- Access - efficient identification and delivery of appropriate weather and climate products to scientists, planners, policy makers, and the public.
- Assessments - monitoring current climate behavior and activity, and placing current climate conditions into relevant historical context.

As the Nation's climate scorekeeper and center of climate expertise, NCDC is frequently called upon to provide summaries, information, and historical comparisons of extreme climate events, as well as of the present state and long-term behavior of National and global climate. As part of its responsibility for monitoring and assessing the climate, NCDC tracks and evaluates climate events that have significant economic, security or societal impacts to the Nation and to the globe. Events include drought, hurricanes, tornadoes, blizzards, floods, and wildfires (see Figures 3-DOC-12 and 3-DOC-13). Such reports are accessible at several websites (see www.ncdc.noaa.gov /extremes.html and www.ncdc.noaa. gov/oa

Figure 3-DOC-12. Remnants of a supermarket in Dumas, Arkansas, after a February 24, 2007, F3 tornado ripped through the town.

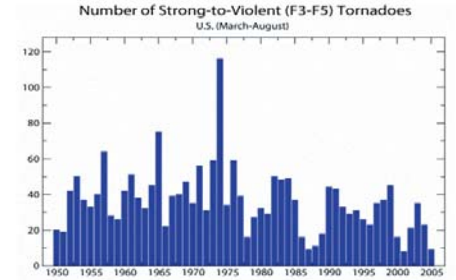

Figure 3-DOC-13. Number of strong-to-violent (F3-F5) tornadoes in the U.S. between March and August.

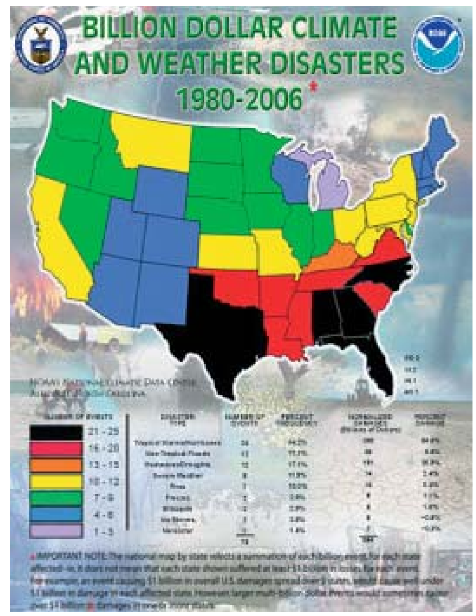

Figure 3-DOC-14. Billion-dollar Climate and Weather Disasters 1980-2006.

/climate/research /monitoring.html).

The importance of these monitoring activities is underscored by NCDC's assessment of billion-dollar weather disasters. From 1980 through 2006, the United States sustained 70 weather-related disasters in which overall economic costs reached or exceeded $1 billion (unadjusted) at the time of the event (see Figure 3-DOC-14). Twenty-two of these events occurred since 2000-an average of over three events per year, with an average cost to the Nation of $11.4 billion and 116 deaths per event.

In addition, NCDC utilizes its resources and expertise to provide applied climate guidance to decision makers in the form of assessments relating climate behavior to impacts on agriculture, transportation, energy, manufacturing, and other socioeconomic sectors. Examples of such guidance include the Residential Energy Demand Temperature Index (REDTI) and the assessment of climate change impacts on transportation (see Figures 3-DOC-15 and 3-DOC-16). The REDTI was recently developed to provide energy suppliers with a population weighted measure of trends in residential energy use, relative to air temperature.

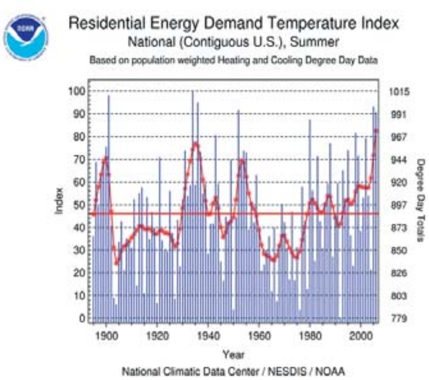

Figure 3-DOC-15. January Residential Energy Demand Temperature Index for the contiguous U.S. for the period 1895 - 2007.

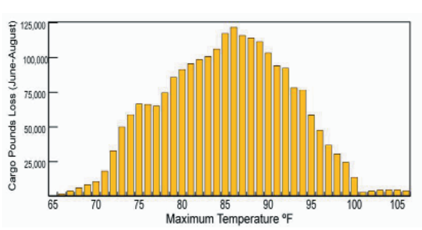

Figure 3-DOC-16. Potential loss in cargo/passenger weight from a commercial aircraft (Boeing 747) departing Denver International Airport (DIA) in 2030 based upon a projected warmer climate scenario.

NCDC plays a key role in the newly developed National Integrated Drought Information System (NIDIS). NCDC produces weekly drought ranking maps. In addition, NCDC participates in the North American Drought Monitor, an important multi-national and multi-institution cooperative effort to assist decision makers by identify regions of developing, ongoing, and recovering drought conditions in near-real-time (see Figure 3-DOC-17). NCDC is partnering with several agencies to develop the U.S. Drought Portal (USDP), which will provide user communities with a critical link to information, products, and service providers, and will support the United States Group on Earth Observations (USGEO) concept "to provide seamless, timely access to integrated Earth observations data, information, and products within the next decade." The interagency nature of USDP necessitates common data and metadata standards to assure optimal interoperability. To this end, USGEO linkage to Federal Enterprise Architecture (FEA) for both governance and operational guidelines will need to be fully leveraged by USDP.

NCDC continually develops innovative visualization tools to improve data accessibility, interpretation, and understanding. For example, the NCDC NEXRAD Interactive Viewer and Data Exporter tool uses Java to provide a client-side interface to NEXRAD level II and III products residing at NCDC. Through the tool, a visitor may browse radar images, select custom overlays and animations, and export images and movies in a variety of formats. The NEXRAD Data Exporter allows for data export in both vector polygon (Shapefile, GML, Well-Known Text) and raster (GeoTIFF, ESRI Grid, HDF, NetCDF, GrADS) formats. This and other NCDC visualization tools are part of university course curricula, have assisted in Space Shuttle upper atmospheric electron distribution studies, used by the National Transportation Safety Board for accident investigations, and routinely used by government and university researchers, both nationally and internationally.

<u>Operational programs</u>

Operational programs are those at the core of the NCDC mission. These

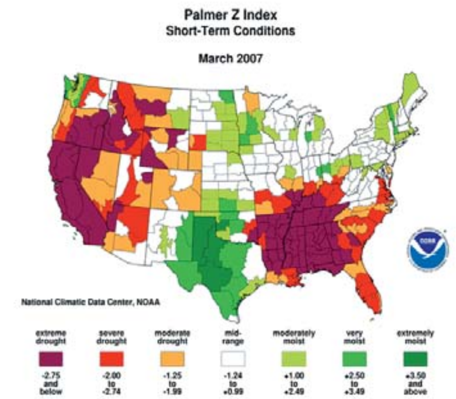

Figure 3-DOC-17. U.S. Drought Monitor Palmer Z Index for March 2007.

programs support ingest, quality assurance, archival, and access to environmental data, as well as the monitoring and assessment of the national and global climate.

<u>Long-term stewardship</u> (archive and access) of the Nation's weather and climate data, as part of the Federal Records Retention System. NCDC is an approved Agency Records Center and operates under the National Archives and Records Administration Federal Records Center guidelines and policies for managing weather and climate data records and information.

<u>Scientific data stewardship</u> functions inherent to the mission of the legislatively designated NCDC. These include developing and operating the associated ingest, monitoring, quality assessment processing, access, archive, analysis and assessment, creation of climate data records, and other product generation systems in support of national and international commitments.

<u>National partnerships</u> with Federal agencies (such as NASA, DOD, EPA, Department of Agriculture, Department of Energy, Department of State, National Science Foundation, U.S. Geological Survey, and the U.S. Global Climate Research Panel), many state agencies, all NOAA Line Offices, Regional Climate Centers, State Climatologists, universities, and many others. These partnerships aid in the

collection and rescue, quality assurance processing, and access of data from regional and national environmental observing networks. In addition, they contribute to climate monitoring, national climate assessments, and a National Climate Services program.

International partnerships with the World Meteorological Organization, International Council of Scientific Unions, World Data Centers, Intergovernmental Panel on Climate Change, United Nations Educational, Scientific and Cultural Organisation (UNESCO), and other nations through bilateral and multilateral agreements. Examples are the World Data Center for Meteorology (archiving the data collected by internationally sponsored research programs and actively exchanging climate data with foreign countries to support research and other activities) and the World Data Center for Paleoclimatology (assembling, archiving, and providing access to global paleoclimatic data derived from worldwide collection of tree-rings, stalactites and stalagmites, coral samples, pollen and macro-fossils, lake and bog sediments, marine sediments, ice cores, and other geological and biological sources).

Maintaining and updating national and global baseline data sets and climate data records that are used for monitoring, evaluation, analyses, and assessments of climate variation and change on global and regional scales. Examples of these data sets include the Global Historical Climatology Network, the U.S. Historical Climatology Network, the U.S. Climate Reference Network, the Comprehensive Ocean-Atmosphere Data Set, the Comprehensive Aerological Reference Data Set, and the Monthly Climate Data of the World.

Customer Service. Customers can access data, information, and products through a variety of means, such as real-time and near-real-time digital access and retrieval of new and archived historical observations through E-Commerce web-enabled capabilities (i.e., Internet), as well as through traditional methods (i.e., telephone, e-mail, facsimile, and traditional post). Digital access, retrieval, and delivery of data online and in a robotic storage system via the Internet is the primary and preferred customer service capability. Data and information can also be delivered on magnetic media (tape and disk), hard copy (paper and microfilm), electronic downloads, and staged for file transfer protocol (FTP) transfers. Many of the NCDC assessments, peer reviewed journal articles, published papers, and conference reports are also available online.

Climate Data Online (CDO) System. The CDO system is NOAA's primary means for distributing and providing access to in situ climate data. CDO includes both recent and historical data, useful for studies of particular weather events and for historical analysis of data for statistical and other research purposes. The general types of data currently included in the system, which continues to be populated, are surface hourly, daily, and monthly data, hourly precipitation data, and 15-minute precipitation data. As data integration efforts continue, the system will be greatly expanded to include numerous additional stations and data types. There are two methods to access climate data within CDO:

- The CDO homepage (see http://cdo.ncdc.noaa.gov): This provides numerous search and retrieval mechanisms, such as by region, country, state, climate division, county, and station, for any required times series.
- The GIS interface (see www.ncdc.noaa.gov): Click on "search by map" on the left hand side bar. The GIS tool set provides an array of methods to select regions and locations of interest, to overlay various layers of information, etc.

Supporting Activities

NCDC engages in an active research and development program to support the operational programs. Research activities and the development of new applications and technologies improve NCDC's ability to conduct its mission.

Scientific Data Stewardship Program. This program provides an approach to maximizing the performance, quality, and utility of climate observing systems, data, and information so that the scientific integrity and long-term utility of climate records for a broad range of users will be ensured. Five fundamental principles provide the framework for this program:

- ensure Observing System quality during the design phase and real-time monitoring of performance;
- develop an end-to-end Climate Processing System that includes the timely ingest, quality assurance processing, immediate access to new and long-term access to historical records, and the long-term safeguarding of the climate records for future generations;
- provide basic IT support;
- document Earth System Variability through monitoring and evaluation of present, future, and past observations; and
- enable and facilitate future research through periodic analysis and assessment of new and historical records.

Digital Health of the Network (HoN) Monitoring (Observing System Performance Indicators). The purpose of the HoN monitoring process is to improve the quality of new observations and the fidelity of the historical archives by providing real-time information on the health and status of NOAA's observing networks. The fully developed system will continually monitor and assess the state of these networks with the intent of providing feedback that could either lead to improvements in the network or changes in analysis techniques to account for problems in the network. Anomalies and systematic performance problems are evaluated and reported to the network manager. The outcome will be improved observing system performance and higher quality data records. As a result of HoN monitoring, many data quality issues can be identified and corrected before the data are incorporated into the historical archives and associated databases. The Cooperative Observer Program (COOP) Observing Network, the U.S. Climate Reference Network (USCRN), the Automated Surface Observing System (ASOS), the Global Climate Observing System Surface Network (GSN), and the Global Climate Observing System Upper Air Network (GUAN) are currently regularly monitored and the addition of other networks is planned. The USCRN program has a more rigorous operational daily monitoring system of hourly performance (see www.ncdc.noaa.gov/oa/hofn/global-insitu.html).

Assessments and Reports. A series of regular reports are released regarding several key climate issues of concern to the Nation. For example, NCDC releases a monthly and annual State of the Climate for the United States and the North American Drought Monitoring Report, which is a collaborative effort between Canada, Mexico, and the United States (see www.ncdc.noaa.gov/oa/climate/research/monitoring.html). Continuing study of the identification and blending of key parameters from satellite, radar, and in situ observing systems will lead to a new generation of quality climate data records. Understanding and knowledge, as well as new products and services for research and practical economic and environmental uses, will be derived from this progressive approach to maximizing the true value of observations.

U.S. Climate Reference Network (USCRN). The Ten Climate Monitoring Principles, described in the National Research Council Report, Adequacy of Climate Observing Systems (1999), are being used to guide the design, deployment, and life cycle management of USCRN (see Figure 3-DOC-18). USCRN is the first U.S. observing system built with the primary purpose of providing climate-quality measurements. Data from the fully deployed network of approximately 114 stations will quantify the variance in surface air temperature and precipitation on a national scale.

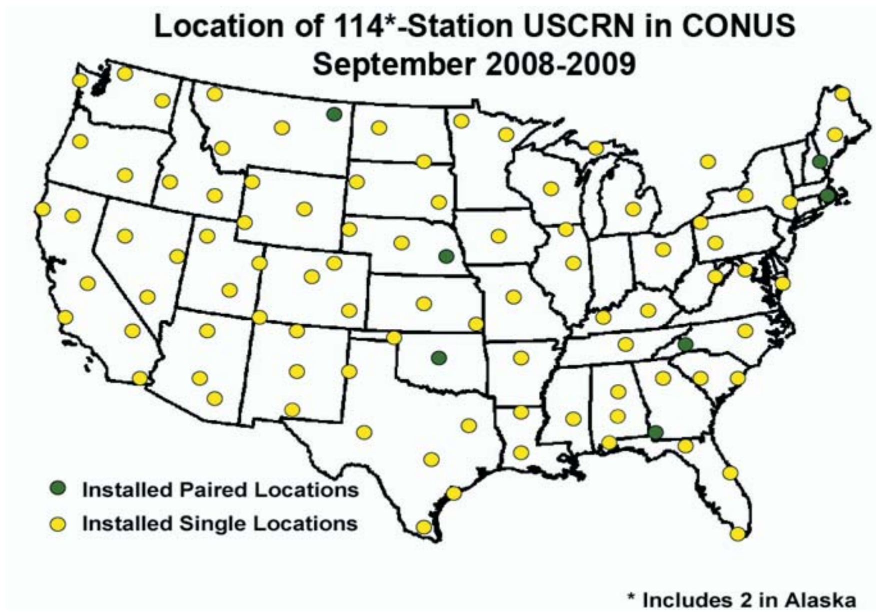

Figure 3-DOC-18. Current Climate Reference Network Site Locations.

The USCRN climate-quality observations avoid many of the time-dependent biases typically experienced with other surface observing networks. USCRN is quickly becoming the Nation's benchmark network, by providing a standard to which satellite, weather radar, and other surface systems (e.g., ASOS, COOP, Mesonet) observations can be validated and verified. In essence, the USCRN is providing the means to enhance the quality of and confidence in other observations, as well as contributing to the rehabilitation of existing historical databases and data sets. The results of these efforts will be a significant increase in the volume of climate quality data and information that can be used in assessing past climate trends and change, as well as contribute to the present and future climate monitoring, evaluation, and forecast tasks (see www.ncdc.noaa.gov/crn.html).

As of early 2007, 89 of the USCRN stations have been deployed (12 in the past year) and 25 more are currently funded, including two that are currently being installed. Of the 89, 84 stations have been commissioned. In addition, USCRN has attracted international attention, and in addition to one station that is currently operating in Canada, a second Canadian Climate Reference Network (CRN) station will be installed in the summer of 2007. Based on the success of USCRN, Canada intends to deploy an identical network of between 200 and 300 such stations. Also, under an agreement reached with the Russian Federation, a CRN station will be deployed at the research facility in Tiksi, Siberia, in the late summer of 2007. The station will be geographically equivalent to one deployed at Barrow, Alaska, and will vastly improve our understanding of the manifestations of climate change in the high latitudes.

NOAA Operational Model Archive and Distribution System (NOMADS). NOMADS is a collaborative approach to provide access and data analysis capabilities for model and other data (see Figure 3-DOC-19). NCDC, in partnership with NCEP and the Geophysical Fluid Dynamics Laboratory, initiated this project to address a growing need for remote access to high volume Global Climate Model and Numerical Weather Prediction model data. The NOMADS team has partnered with existing and development activities, including CLASS, National Oceanographic Partnership Program's, National Virtual Ocean Data System, the Department of Energy's Earth System Grid, and the Thematic Realtime Environmental Data Distributed Services developed through the National Science Foundation. NOMADS uses a distributed client-server framework of data servers together with emerging technologies to access data stored in heterogeneous formats at geographically distributed repositories. NOMADS provides, for the first time, long-term stewardship of numerical and climate model runs and provides the regional modeling community with the data necessary to initialize local models. In addition, NOMADS provides the tools necessary to inter-compare model and observational data sets from around the world (see http://nomads.ncdc.noaa.gov).

<u>Climate Database Modernization Program (CDMP)</u>. Climate data, such as wind speed and direction, precipitation, temperature, and pressure, are of critical importance to many disciplines and enterprises, including economic research, engineering, risk management, energy, and agriculture. Decision making in these and other sectors requires the ease of access and use that only digital databases of these data can provide. CDMP is a concerted effort to ensure the conservation of and improve access to environmental data by identifying and transcribing these data from historical analog sources (i.e., paper, film, or other non-digital media) to digital formats that can be more safely, securely, and easily stored, accessed, retrieved, and handled. Under CDMP, new digital databases of historical environmental data and information are created. Many existing digital data sets are being extended back in time, in many cases by a century or more.

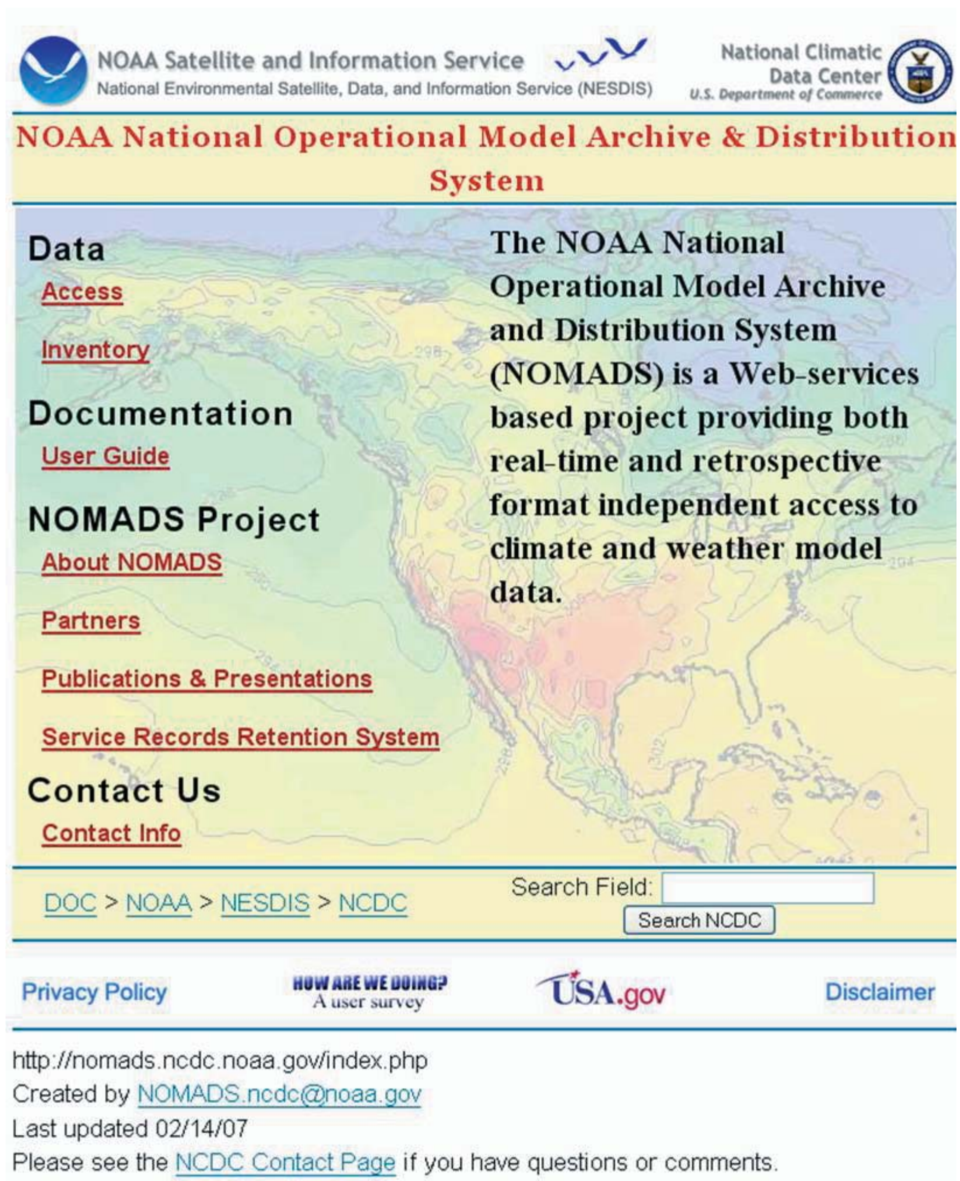

Figure 3-DOC-19. NOAA Operational Model Archive and Distribution System provides visualization and access to model data.

CDMP transcribes data from analog to digital formats by digitally scanning the original documents or images, by manually transcribing data and information from the original sources into a digital format, or both. These digital copies and manually-keyed digital data sets are made available to researchers via interactive Web-based interface tools, such as the Web Search, Store, Retrieve Display (WSSRD) located at http://noaa.imcwv.com (see Figure 3-DOC-20).

Additionally, the conversion of analog data sources to digital databases and data sets ensures the efficient and inexpensive long-term preservation of data that exist on non-digital media that may be deteriorating and excessively expensive to continue preserving.

Over fifty million documents have been imaged and many thousands of observations manually keyed or digitized from the merchant and military ship records, America's military forts,

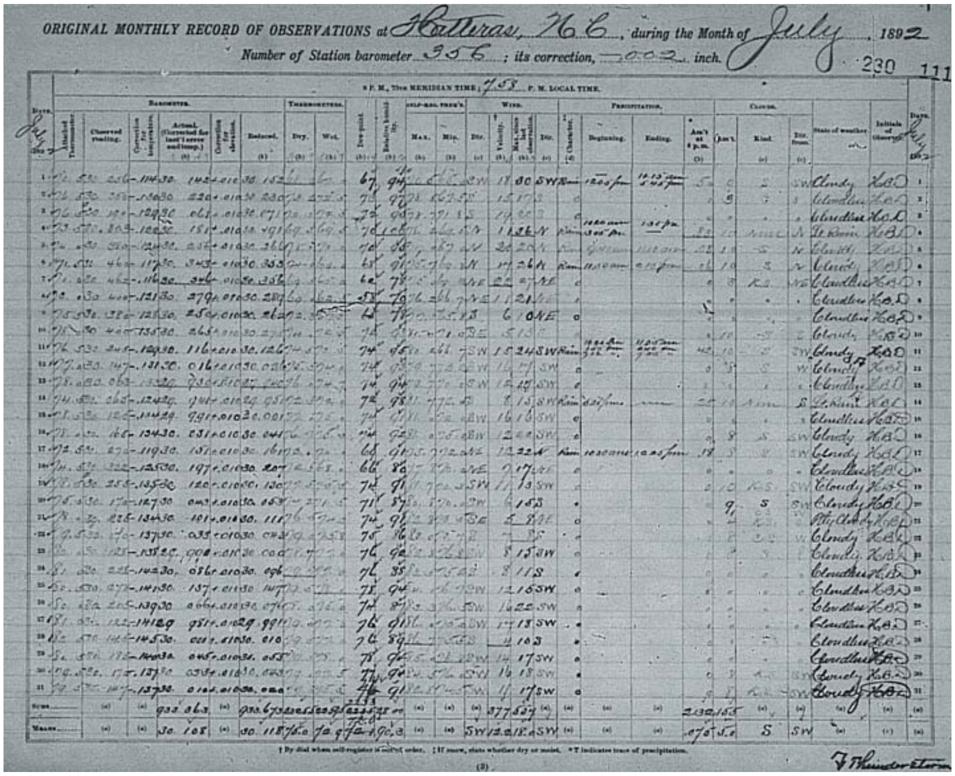

Figure 3-DOC-20. Scanned image of an original weather observation form from Hatteras, NC, for the month of July 1892, as scanned by CDMP and stored in the WSSRD system.

U.S. cities, lighthouses, weather ships, and other sources. The CDMP services currently extend into all NOAA operational line offices (see Figure 3-DOC-21). CDMP provides an unprecedented and unique opportunity to rescue valuable climate and environmental data dating back into the 1700s that are in jeopardy of permanent loss due to the deterioration of the paper and microfilm media (see www.ncdc.noaa.gov/oa/climate/cdmp/cdmp.html).

NOAA Paleoclimatology Program. Paleoclimatic data is an important segment of documenting and reconstructing annual to century scale records leading to climate records dating back 10s and 100s of millennia. The incorporation of this program into the functions and activities of NCDC enhances the identification and understanding of climate change and variation. The NCDC Paleoclimatology Branch cooperates with many countries in research projects that combine the global paleoclimate database with the instrumental record to extend the climate record back in time for climate model verification and climate change studies. Objectives of the program are to cooperate with researchers in academia, NOAA, and other agencies to: conduct original research to describe the global patterns of annual-to-millennial scale climate change; understand the causes of climate change; separate man-induced climate change from natural variability; and validate the models that are used to predict future climates (see www.ncdc.noaa.gov/paleo/paleo.html).

Air Quality Forecasts. NCDC archives NOAA's Air Quality Forecasts. The Air Quality Forecasts are forecast guidance of one-hour and eight-hour averaged ground-level (surface) ozone concentration. The guidance is produced twice a day, for hourly intervals through midnight on the following day (48 model hours), seven days a week for the northeastern United States initially, and then gradually will include the entire United States by 2009. NWS provides the data. These data provide ground-level ozone forecast guidance for state and local air quality forecasters and help the public limit adverse effects from poor air quality. This forecast guidance helps meet a congressionally directed national air quality forecast capability. These data will have received a high measure of quality control through computer and manual edits.

Global Observing System Information Center (GOSIC). GOSIC is now fully operational and online at NCDC. GOSIC began in 1997, as a research effort at the University of Delaware to aid the major global observing systems in providing more efficient access to data and information. GOSIC provides unique tools for searching and accessing data, such as matrices and

Figure 3-DOC-21. NOAA tasks supported by the CDMP.

portals. This allows users to search for specific data, such as data located at NCDC and other global data centers. GOSIC serves the global observing system community and has provided a great tool for coordinating the various Global Climate Observing System (GCOS) Lead Data Center activities across NCDC (see http://gosic.org).

NATIONAL OCEANOGRAPHIC DATA CENTER

The National Oceanographic Data Center (NODC) is an enterprise organization that provides scientific and public stewardship for national and international marine environmental and ecosystem data and information. NODC, the National Coastal Data Development Center (NCDDC), and the NOAA Central Library, with its regional branch assets, are integrated to provide access to the world's most comprehensive sources of marine environmental data and information. NODC maintains and updates a national ocean archive with environmental data acquired from domestic and foreign activities and produces products and research from these data that help monitor global environmental changes. These data include physical, biological, and chemical measurements derived from in situ oceanographic observations, satellite remote sensing of the oceans, and ocean model simulations. NODC manages and operates the World Data Center (WDC) for Oceanography, in Silver Spring, Maryland. Its personnel directly interact with Federal, state, academic, and industrial oceanographic activities; represent NESDIS on various interagency domestic panels, committees and councils; and represent the United States in various international organizations, such as the International Oceanographic Data Exchange. NODC represents NESDIS and NOAA to the general public, government agencies, private institutions, foreign governments, and the private sector on matters involving oceanographic data.

<u>NODC Data Holdings</u>

NODC manages the world's largest collection of publicly available oceanographic data. NODC holdings include in situ and remotely sensed physical, chemical, and biological oceanographic data from coastal and deep ocean areas. These were originally collected for a variety of operational and research missions by U.S. Federal agencies, including DOD (primarily the U.S. Navy); by State and local government agencies; by universities and research institutions; and private industry. NODC data holdings extend back over one hundred years and the volume is expected to grow exponentially as new ocean observing systems are deployed.

Through NODC archive and access services these ocean data are being reused to answer questions about climate change, ocean phenomena, and management of coastal and marine resources, marine transportation, recreation, national security, and natural disasters. Another significant user community is education, where these data and information products help teach each new generation of students about the oceans. Requests for oceanographic data and information have increased each year since NODC was established in 1961.

<u>User Services</u>

Each year NODC responds to thousands of requests for oceanographic data and information. Copies of specified data sets or data selected from NODC's archive databases can be provided to users on various media types or online. NODC data products are provided at prices that cover the cost of data selection and retrieval. Most data provided on the NODC website is free of charge.

NODC supports ecosystem stewardship through NCDDC, in Stennis, Mississippi, by providing access to the Nation's coastal data resources. NCDDC achieves this capability through the integration of diverse coastal data distributed in multiple repositories and provides data to users via the Internet using established and emerging technologies. They provide a searchable metadata catalog of coastal data, developing gateways to data repositories and using middleware technology that provides data in user specified formats.

Specifically, NODC data archive and access responsibilities support climate research and operational ocean observing system activities. NODC performs ocean profile data management for internationally coordinated global ocean observing systems, such as the Argo Ocean Profiling Network and the Global Temperature Salinity Profile Program (GTSPP) in cooperation with applicable Joint WMO/IOC Commission for Oceanography and Marine Meteorology (JCOMM) committees. NODC's objectives are: (1) to safeguard versions of the Argo and GTSPP near-real-time and retrospective data and information; and (2) to provide high quality data to a wide variety of users in a timely and useful manner. The Argo and GTSPP data system present an excellent opportunity to improve ocean and climate forecasting, with consequent benefits for the protection of life and property and effective planning for the effects of seasonal to interannual climate variability.

NODC produces regular updates of the *World Ocean Database and World Ocean Atlas*. The most recent version, 2005, includes over eight million profiles of scientifically quality controlled ocean temperature, salinity, oxygen, plankton, pigment, and nutrient data. The atlas presents statistics and objectively analyzed fields for one-degree and five-degree squares generated from the World Ocean Database 2005, observed and standard level flagged data. The ocean variables included in the atlas are: in situ temperature, salinity, dissolved oxygen, apparent oxygen utilization, percent oxygen saturation, dissolved inorganic nutrients (phosphate, nitrate, and silicate), chlorophyll at standard depth levels, and plankton biomass sampled from 0 - 200 meters depth. For more information on both products, go to www.nodc.noaa.gov /OC5/indprod.html.

The NOAA Marine Environmental Buoy Database is one of the largest and most frequently used data archives maintained by NODC (see www.nodc.noaa.gov/BUOY/buoy.html). This database holds wind, wave, and other marine data collected by the NOAA's National Data Buoy Center (NDBC) from moored buoys and the Coastal Marine Automated Networks (C-MAN) stations. Parameters reported by both buoys and C-MAN stations include air temperature and pressure, wind speed and direction, wind gust, and sea surface temperature.

NODC is developing a capability to provide public access to consistently-processed, climate-capable satellite data sets and applying them to various scientific problems. The first products provided in 2003 were Pathfinder reprocessed 9 km and 4 km sea surface temperatures. For further information, visit www.nodc.noaa.gov/sog.

NCDDC manages the Coastal Data Development (CDD) program. NCDDC's focus is to improve the quality of web-based search and access tools and implement web-based access to priority data sets from Federal, state, and local repositories. Geospatial display capabilities have been added that allow the user to link the data to coastal imagery, charts, and bathymetry to obtain a complete data picture of the ecosystem of interest.

To identify priority data sets, NCDDC coordinates with Federal, state, and local agencies, academic institutions, nonprofit organizations, and the private sector to create a unified, long-term database of coastal data sets available from a variety of sources. NCDDC develops and maintains a catalog of available coastal data; builds gateways to these sources; ensures the equality of the metadata; populates and updates the databases; and provides online search and access and geospatial display for the coastal user community.

The CDD program supports NOAA's ecosystem strategic goal that aims to build the capacity of Federal, state, local, and international managers to make decisions that protect, restore, and use coastal ecosystem services. The Earth's coastal ecosystems are home to a wealth of natural resources; the lives and livelihoods of people are linked to these national treasures. Sustainable growth of our coastal regions is critical to our economy by supporting commercial and recreational fishing, waterborne commerce, home construction, and tourism. Base activities aim to advance understanding and predict changes in the Earth's environment to meet the economic, social, and environmental needs of the United States. This supports the strategic goal of the Department of Commerce to "Observe, protect, and manage the Earth's resources to promote environmental needs."

International Cooperation and Data Exchange

A significant percentage of the oceanographic data held by NODC is foreign. NODC acquires foreign data through direct bilateral exchanges with other countries and through the facilities of the World Data Center for Oceanography, Silver Spring, which is collocated with and operated by NODC. This is part of the World Data Center System initiated in 1957 to provide a mechanism for data exchange, and they operate under guidelines issued by the International Council of Scientific Unions (ICSU).

Under NODC leadership, the Global Oceanographic Data Archaeology and Rescue (GODAR) project has grown into a major international program sponsored by the Inter-governmental Oceanographic Commission. GODAR is a comprehensive effort to locate, rescue, quality control, and disseminate historical global ocean profile data for use by the climate and global change research community.

Data Management for Global Change Studies

NODC provides data management support for major ocean science projects such as the Tropical Ocean Global Atmosphere (TOGA) program, the World Ocean Circulation Experiment (WOCE), and the Joint Global Ocean Flux Study (JGOFS). To promote improved working relations with the academic ocean research community, NODC established the following three joint centers with university research groups:

- Joint Environmental Data Analysis Center (with Scripps Institution of Oceanography, University of California at San Diego)
- Joint Archive for Sea Level (with the University of Hawaii)
- Joint Center for Research in the Management of Ocean Data (with the University of Delaware)

NOAA Library and Information Network

NODC also manages the NOAA Library and Information Network, which includes the NOAA Central Library in Silver Spring, MD; regional libraries in Miami, FL, and Seattle, WA; and field libraries or information centers at about 30 NOAA sites throughout the United States. The combined libraries contain millions of volumes, including books, journals, CD-ROMs, DVDs, audio, and videotapes.

The NOAA Central Library (see www.lib.noaa.gov) supports weather and climate research programs by providing a variety of information services, including:

- Access to print and electronic versions of American Meteorological Society journals
- Access to Meteorological and Geoastrophysical Abstracts (desktop access at the Silver Spring campus)
- Desktop access to Web of Science at several NOAA sites
- Assistance in obtaining site licenses for 169 National Weather Service field sites for electronic access to Monthly Weather Review and Weather and Forecasting
- Archival of historic collections of the Weather Bureau
- Rescuing hundreds of volumes of meteorological data publications

NATIONAL GEOPHYSICAL DATA CENTER

The National Geophysical Data Center (NGDC) staff archive, assess, and provide access to satellite and ground-based observatory data from national and international programs supporting research in meteorology, climatology, and space weather as well as solar-terrestrial physics, snow and ice, marine geology and geophysics, and solid Earth geophysics (see www.ngdc.noaa.gov). The National Snow and Ice Data Center (NSIDC), at the University of Colorado, is an affiliated partner with NGDC. The two national centers house and operate the World Data Centers for Solar-Terrestrial Physics, Marine Geology and Geophysics, Glaciology, and Solid Earth Geophysics under the auspices of the International Council for Science. Research activities focus on satellite remote sensing to assess the long-term changes of the land surface, the space environment, snow cover, and sea ice.

NGDC's vision is to be the world's leading provider of geophysical and environmental data, information, and products. NGDC's mission is to provide long-term scientific data stewardship for the Nation's geophysical data, ensuring quality, integrity, and accessibility. NGDC's vision and mission statements are consistent with the assigned responsibilities of the NOAA National Data Centers for scientific stewardship of the Nation's environmental data and the development and operation of the associated systems for ingest, monitoring, quality control, access, archive, analysis, and assessment of environmental data and other product generation systems in support of national and international commitments and users.

Long-term archive responsibilities for the Nation are provided by NGDC activities. NGDC maintains the Nation's archive for global tsunami and related hazard events, including tsunami events, triggers, run-up locations and heights, damage descriptions, and photographs. This information is essential for researchers focusing activity on at-risk areas. As part of NOAA's effort to improve tsunami research and warning, NGDC established a long-term archive for ocean bottom pressure and Deep-ocean Assessment and Reporting of Tsunamis (DART) data. NGDC also manages the sole archive of space weather data from GOES, POES, and DMSP satellites. NGDC maintains the only archive of raw data records and visible and near-infrared imagery collected on DMSP satellites for meteorological, oceanographic, and Earth surface studies. The space weather ground-based archives focus on data used in NOAA's space weather forecasts, warnings, and alerts. NSIDC manages cryospheric data from both ground-based and satellite instruments. These data stewardship and scientific stewardship activities for satellite and ground-based data include processing, management, analysis, and quality assessments.

Online WWW-based access services to these large databases continue to evolve at NGDC. Data discovery, browsing, and delivery are fairly mature functions. Data directories are managed by relational database management systems available to most search engines. Almost all of the data sets reside in robotic libraries and are accessible online, however, some data sets are easier to browse, display, and use than others. NGDC uses Web map-based access to the integrated hazards databases. Users can select events either through a geo-referenced map interface or via traditional search and retrieve engine. NGDC has several projects as part of the NESDIS program to digitize and make accessible the most important records in the huge historical archive. Interactive displays of multidisciplinary data sets and data mining are under development. NGDC has embarked on an environmental scenario generator project to mine information from the archives and to use the mined information to launch numerical simulations of the atmospheric and space environments.

The DMSP activity prepares calibrated and geo-referenced records from the raw data records recorded by the scientific instruments on DMSP satellites. Data sets include visible, infrared, and microwave imagery, microwave soundings, and in situ measurements of the space environment. User services are provided through the Space Physics Interactive Data Resource (see http://spidr.ngdc.noaa.gov/spidr). Research activities focus on the use of the nighttime visible and infrared imagery from the DMSP OLS. The nighttime lights product has been used to assess changes in power consumption both regionally and globally from 1992 to present. Nighttime lights have been used to support humanitarian relief services after natural disasters such as Hurricanes Wilma and Katrina.

GOES, POES, and DMSP satellite data of solar activity and the near Earth space environment managed by NGDC provide the long-term monitoring of space weather conditions. These data record the Earth's magnetic field, the electrically charged environment, and Solar X-rays from geosynchronous and polar sun-synchronous altitudes. Data from ground-based observatories recording solar activity, ionospheric characteristics, and geomagnetic variations complement, enhance, and provide ground truth for the satellite measurements. The Solar Geophysical Data bulletin containing solar and space weather data is published monthly. The space weather program at NGDC archives measurements of total solar and solar spectral irradiance for use in climate studies. Tabular listing of ionospheric parameters and ancient solar images are part of the digitizing and access program.

Supporting Research

Natural Hazards Classification and Risk Assessments. Tsunamis are infrequent high impact events that can cause a considerable number of fatalities, inflict major damage, and cause significant economic loss to large sections of the Nation's coastline. Since 1900, over 200 tsunami events have affected the coasts of the U.S. and its territories, causing more than 500 deaths. NGDC maintains the national archive for tsunami data and the global tsunami event database. As part of the national program and as required under Public Law 109-424, NGDC provides open access to the observational and event data, supporting NOAA's mission to provide reliable forecast and warning and to promote community resiliency. One of the newer data streams now managed by NGDC is from the DART network (see http://ngdc.noaa.gov/seg/hazard/DARTData.shtml). NGDC, working with the United States Geological Survey (USGS), just released the first complete assessment of the tsunami hazard for all U.S. coasts based on historic event data and seismic sources. NGDC is working with the Tsunami Warning Centers to provide nightly replication of the event database for tsunami warnings and with the NOAA Tsunami Research Center to improve the tsunami forecast models.

Environmental Remote Sensing. Operational meteorological satellite systems provide a unique opportunity to monitor features on or near the Earth's surface, sometimes on a nightly basis. DMSP nighttime imagery are used to locate sources of visible and infrared light emissions, including city lights, wildfires, gas flaring, and fishing boats. Research projects use the city lights to infer such diverse parameters as population density changes, regional economic vitalities, and global carbon dioxide emissions. More information is available at www.ngdc.noaa.gov/stp/stp.html.

Space Weather Climatology. The Space Weather program at NGDC provides scientific data stewardship for the Nation's operational space environmental data in accordance with Data Quality Act, Public Law 106-554, Section 515 (2001), NOA 212-15 (Dec. 22, 2003), 33 U.S.C. § 883e. NGDC scientists use long-term data records to develop space weather climatologies of the ionosphere, thermosphere, and magnetosphere. NGDC is also involved in the development of virtual observatories for space environmental data allowing the scientific research community seamless access to data sets residing at NGDC and other locations. Space weather climatologies are used to monitor changes in the near-Earth space environment and to determine probabilities for significant environmental events. Access to the NGDC space weather data and climatologies is provided at www.ngdc.noaa.gov/stp/stp.html.

Geomagnetic Field Modeling. The NGDC geomagnetism group develops and produces magnetic field models for navigation and pointing, which are used in a multitude of defense and

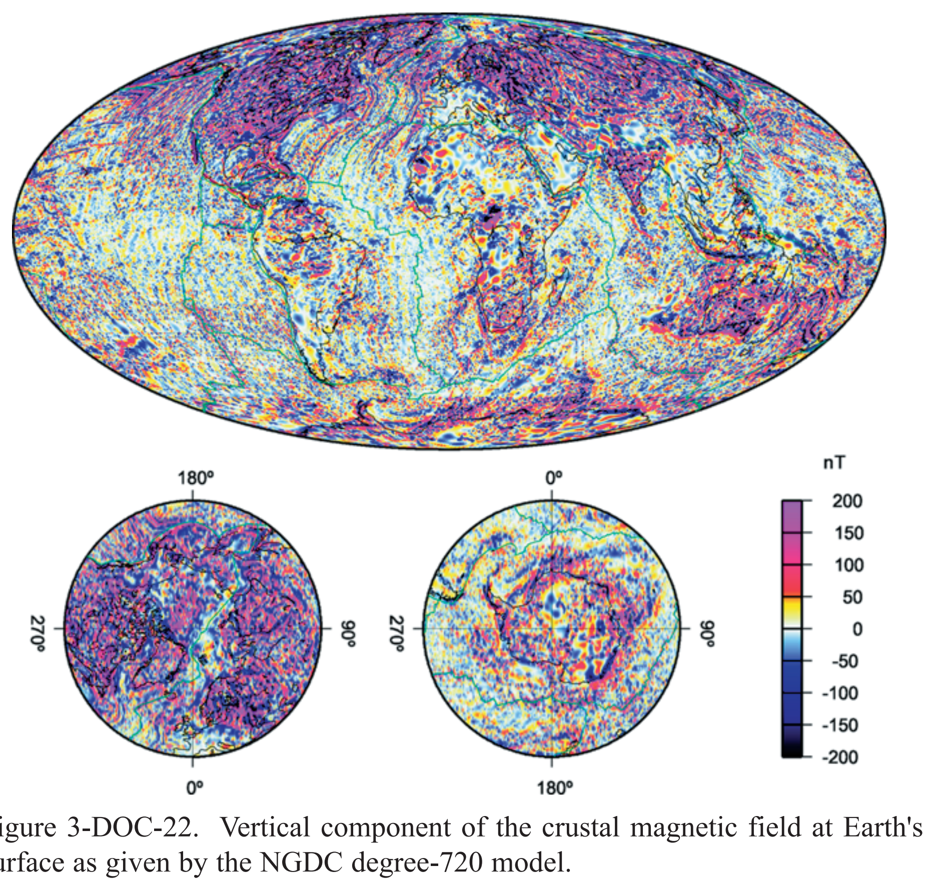

Figure 3-DOC-22. Vertical component of the crustal magnetic field at Earth's surface as given by the NGDC degree-720 model.

civilian applications. Production of the World Magnetic Model, the standard magnetic model for DOD and the North Atlantic Treaty Organization (NATO), is sponsored by the National Geospatial-Intelligence Agency. The geomagnetism group also heads the production and distribution of the International Geomagnetic Reference Field. Making use of its extensive holdings of satellite, airborne, and marine magnetic data, NGDC is developing new high-resolution magnetic field models. Recent products include a 3-arc-minute World Digital Magnetic Anomaly Map and the extended magnetic reference model to spherical harmonic degree 720 as shown in Figure 3-DOC-22. Additional information can be found at www.ngdc.noaa.gov/seg/geomag/geomag.shtml.

Cryospheric Research. NSIDC's research interests cover a broad spectrum of climate-cryosphere interactions using a variety of observing techniques with special emphasis on arctic regions and satellite-borne measurements. Research projects within NSIDC examine the long-term record of snow and ice in polar and mountainous regions, as well as the hydrology of the southwestern U.S. Algorithms to detect snow, frozen ground, and sea ice in passive microwave images from DMSP and NASA satellites have been developed at NSIDC. With the International Polar Year providing the incentive, NSIDC made its popular Sea Ice Index data set available through Google Earth as shown in Figure 3-DOC-23. The Sea Ice Index allows users to see how current Arctic and Antarctic ice conditions compare with long-term trends. Other research includes developing models of the physical and mechanical properties of snow and ice in glaciers and the freeze-thaw cycles of soils in polar regions- the latter is an important component of hydrological modeling. Other areas of special interest and study are the interactions between sea ice and the ocean and the atmosphere. More information is available at http://nsidc.org.

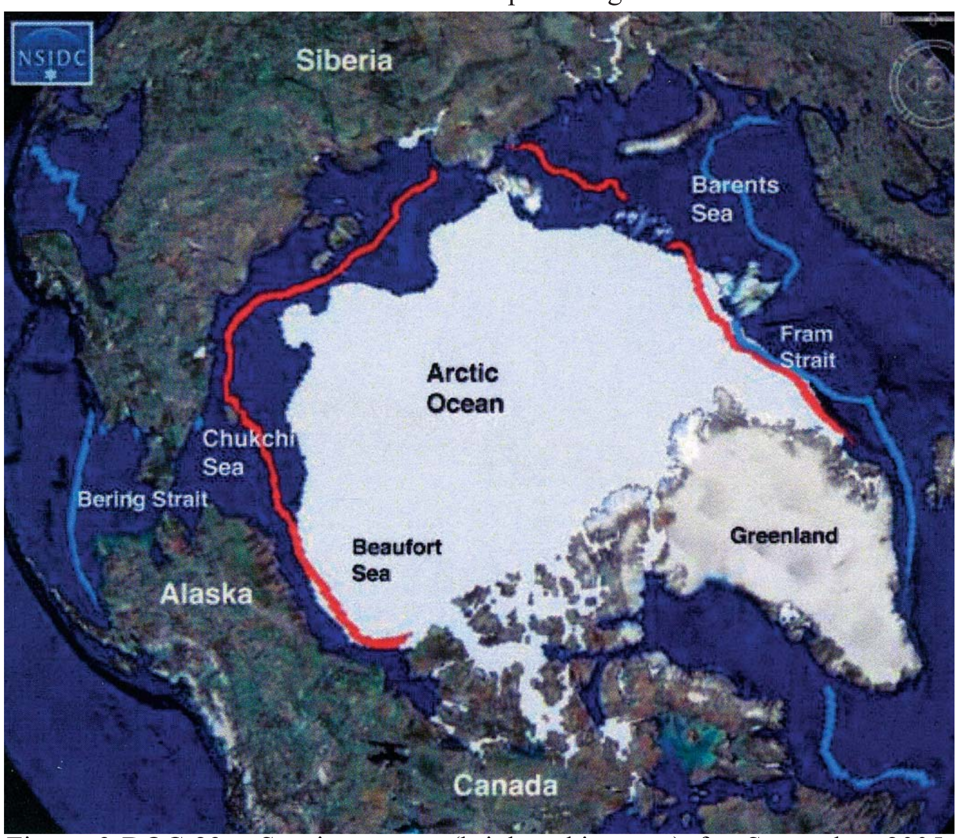

Figure 3-DOC-23. Sea ice extent (bright white area) for September 2005. Median ice extents based on the period 1979 to 2000 for September (red line) and March (blue line) illustrate the typical seasonal range.

OCEANIC AND ATMOSPHERIC RESEARCH LABORATORIES

Programs within the Oceanic and Atmospheric Research (OAR) Laboratories support various National Oceanic and Atmospheric Administration (NOAA) meteorological and oceanographic missions. The activities of OAR laboratories provide the innovative ideas needed to improve our understanding of atmospheric, oceanic, and climate science and develop the practical solutions, tools, and techniques that form the basis of improved ocean, weather, water, and climate services.

In an effort to improve national resiliency and better protect lives and property, OAR places special emphasis on improving severe weather, flood, and hurricane warnings and forecasts and on improving the utilization and dissemination of data and information. Severe weather events include flash floods, strong winds, thunderstorms (including tornadoes, lightning, and hail), heavy snowstorms, extreme cold and heat, drought, and geomagnetic storms. OAR also places emphasis on enhancing our understanding of the global climate system and improving regional decision support tools for climate and weather.

OFFICE OF WEATHER AND AIR QUALITY (OWAQ)

OWAQ, located at OAR Headquarters, is an important focal point for facilitating and coordinating weather research in OAR and throughout NOAA. OWAQ implements the NOAA's component of the United States Weather Research Program (USWRP, http://www.esrl.noaa.gov/research/uswrp/) and the NOAA component of THORPEX: A Global Atmospheric Research Program (http://www.mmm.ucar.edu/uswrp/programs/nathorpex.html, from which one can link to the international THORPEX website). Also within OWAQ is the Special Program Initiative which is an internal OAR competition that provides awards to the OAR weather and air quality laboratories for innovative proposals. OWAQ also does budget planning for and assists in prioritization of NOAA's weather and air quality research.

United States Weather Research Program (USWRP)

The USWRP has been an interagency weather research and transition of research to application program. The member agencies have been NOAA (lead), NASA, NSF, the Navy, and the Air Force. The NOAA component of USWRP has been quite active although the funding levels have been flat. The USWRP funds reside in the National Weather Service (NWS) Office of Science and Technology (OST). OWAQ helps plan NOAA USWRP priorities, implements the program, and monitors progress. During the Fiscal Year (FY) 2007-2008 period, NOAA USWRP has provided the sole NOAA support for the Developmental Test Center (DTC, http://www.dtcenter.org/index.php) at the National Center for Atmospheric Research in Boulder, CO. The DTC is a test bed for the Weather Research and Forecasting (WRF) community model (http://wrf-model.org/index.php) and is a cooperative venture among NOAA, NSF, the Air Force, and the Navy. The USWRP provides most of the support for the Collaborative Program on the Societal Impacts and Economic Benefits of Weather Information or Societal Impacts Program (SIP) for short (http://www.sip.ucar.edu/). Its mission is to be a clearing house for socioeconomic information on weather, to increase knowledge among the weather community concerning the human and economic impacts of weather, to better determine the value of weather information, and to improve our ability to communicate weather information to all public and private sectors. Recent highlights of the SIP activities are the Weather and Society*Integrated Studies (WAS*IS) workshops and training sessions that bring social science to the metereological community and vice versa. The SIP also provides the bulk of the U.S. support for the societal and economic research and applications component of THORPEX (see below).

The NOAA USWRP also provides total support for the Joint Hurricane Testbed (JHT), (http://www.nhc.noaa.gov /jht/index.shtml) which transitions mature research products from the hurricane research community into operations through improvements in hurricane landfall decision support systems. Recently, the JHT has been emphasizing improving forecasts of hurricane intensity at landfall. Most recently, NOAA USWRP has invested in research and transition of research to applications to improve quantitative precipitation forecasts through NOAA's Hydrometeorological Testbed (HMT, http://hmt.noaa.gov/). The HMT seeks to improve regional precipitation forecasts, particularly heavy, flooding rains.

THORPEX: A Global Atmospheric Research Program

THORPEX is a 10-year international research program under the World

Meteorological Organization that focuses on accelerating improvements in 1- to 14-day global numerical prediction of high impact weather. THORPEX began in 2004. THORPEX is the weather component of the Global Earth Observing Systems of Systems (GEOSS) and provides the regional and global weather support for the International Polar Year (IPY, 2007-2008). The U.S. representative to the THORPEX international management committee resides in NOAA and NOAA is the lead agency in THORPEX, providing the U.S. funding contribution to the THORPEX international management. Key U.S. agencies that are participating in THORPEX, in addition to NOAA, are NSF, NASA, and the Navy. The main thrusts of U.S. THORPEX are:

- Understanding global scale atmospheric processes and phenomena
- Improving the science of prediction
- Providing socioeconomic research and applications

NSF, the Navy and NASA provide the bulk of support for the first bullet. All agencies support the second bullet and NOAA USWRP and NCAR support activities within the third bullet. NOAA/National Centers for Environmental Prediction (NCEP) has developed a North American Ensemble Forecasting system (NAEFS, http://www.emc.ncep.noaa.gov/gmb/ens/NAEFS.html) which has become operational in Fiscal Year 2007 and includes the U.S., Canada, and Mexico (as a user). NAEFS will be an important component of the THORPEX Interactive Forecast System (GIFS) to be available by the end of the THORPEX program period. NCEP is one of the ten operational centers contributing to the THORPEX Integrated Grand Global Ensemble (TIGGE) that provides global ensembles to the weather community. The NOAA USWRP-funded SIP (discussed above) provides U.S. support for the socioeconomic component of THORPEX. In essence, THORPEX underpins all ensemble, probabilistic atmospheric modeling in NOAA. It is the program in which key advances are made in ensemble techniques and atmospheric data assimilation with a significant portion of the applied research being done at OAR's Earth Systems Research Laboratory (ESRL). It is also provides the connection on the weather side to climate prediction at the intraseasonal scales that will eventually lead to a seamless weather-climate prediction system.

A major near-term field activity in which the NSF, the Navy, and NOAA are significantly involved is the THORPEX Pacific Asian Regional Campaign (T-PARC), (http://www.ucar.edu/na-thorpex/PARC.html). It has three phases: summer, extratropical transition (ET), and winter - most of the activity takes place in 2008. It takes place in the Southeast, East, and North Pacific and will involve an intensive observing campaign. Most of the Pacific Rim countries are participating, including the U.S. and Canada. In addition, there will be participation by Germany. The summer phase will study the formation, propagation and intensity modulation of East Pacific tropical cyclones. The ET phase will study the transition of tropical cyclones into mid-latitude storms that strike the Northeast Asian and U.S./Canadian West Coast. The winter phase will study the optimum use of targeted observations to improve the forecasts of high impact winter storms on the U.S., Canada, and the Arctic. This phase links to IPY.

<u>OAR/OWAQ Special Projects Initiative</u>

The Special Projects Initiative (SPI) began in Fiscal Year 2004 to provide funds, based on internal competition, among OAR laboratories with expertise in weather and air quality research, for innovative research. The competition emphasized inter-laboratory collaboration. Three proposals are being funded with a partial new competition planned for Fiscal Year 2008. The three proposals include:

1. Use of the NOAA-GIV High Altitude Jet to Investigate the Saharan Air Layer and Assimilation of Moisture Observations in the Tropical Cyclone Development": Atlantic Oceanographic and Meteorological Laboratory and the Cooperative Institute for Marine and Atmospheric Science
2. Improving Particulate Matter (PM) Forecasts and Evaluating Its Interaction with Atmospheric Radiation": Earth Systems Research Laboratory
3. Improving the Ability to Forecast Floods: A Proposal to Accelerate and Strengthen the Development of a Hyrdometeorological Testbed": Earth Systems Research Laboratory, National Severe Storms Laboratory

OBSERVING TECHNOLOGY

Meteorological, oceanographic, and climate research requires a strong network of observing systems providing data and information and consistent advancements to our observational capabilities. In support of NOAA's mission, OAR supports the advancement of our observing technology through the development and testing of new observing systems, observation techniques, and data ingest and dissemination systems. All OAR observing technology research supports the Global Earth Observing System of Systems (GEOSS) and further establishes OAR as a preeminent leader in meteorological, oceanographic, and climate research.

Numerous OAR laboratories and their related academic and private sector partners are heavily involved in developing new environmental observing system technologies. The Global Systems Division (GSD) of the Earth System Research Laboratory (ESRL) in Boulder, Colorado, takes promising new scientific and engineering technologies from the research arena, helps develop them into mature engineering systems, and transfers these technologies to NOAA operations and the private sector. The Physical Sciences Division (PSD) of ESRL evaluates new remote-sensing concepts and systems as they apply to specific problems of interest such as the impact of atmospheric rivers on severe west coast flood events. The transition of new forecast products into NOAA operations is accomplished through regional testbeds such as the Hydrometeorlogical Testbed (HMT) situated in the American River Basin near Sacramento California (http://hmt.noaa.gov/) and the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma, which develops both new remote sensing systems and assists in the transfer of these technologies to the NWS. The Atlantic Oceanographic and Meteorological Laboratory (AOML) in Key Biscayne, Florida, develops, deploys, and manages in situ oceanographic observing systems across the global oceans. The Air Resources Laboratory (ARL) manages the deployment and operation of the Climate Reference Network for NESDIS and operates state-of-the-art chemical deposition measurements in support of model development. This environmental research, development and associated transition of products and services directly support the Nation's forecasting and warning services.

GSD is taking a leadership role in implementing the International Earth Observation System including the development and testing of Unmanned Aircraft Systems (UAS, formerly referred to as UAVs) for providing global weather and climate observations (Figure 3-DOC-24). ESRL/GSD is one of several NOAA Research organizations collaborating with NASA in support of this project. The goal of these missions is to evaluate the utilization of UASs for improved U.S. and global observing in areas too remote or dangerous for lengthy manned flights, e.g. the polar regions and hurricanes. High and medium altitude, long-endurance UASs (HALE and MALE-class) can fly in remote locations in dangerous flying conditions for long periods. This technology provides many scientific benefits such as sustained global high quality all-weather profiles of atmospheric composition (water vapor, aerosol, cloud water and trace gases), and high altitude vertical resolution and profiling. It also offers a rapid response platform for improved high impact weather forecasts at 1-day to 2-week lead times, and better climate change detection, attribution, and prediction in support of policy decisions. For testing purposes, the HALE-class UAS's integrated sensor package consists of such components as an ocean color sensor and passive microwave sounder developed by the NOAA's PSD, a gas chromatograph and ozone sensor developed by GMD, a digital camera system provided by NASA, and an electro optical infrared sensor provided by GA-ASI. GSD is also developing ultra-lightweight sondes to include in the UAS sensor package.

GSD has developed GPS-Meteorology, a ground-based research system (GPS-Met) that uses the Global Positioning System (GPS) to measure atmospheric water vapor in real-time, increasing the accuracy of precipitation forecasts in the hourly-updated numerical weather prediction model used by the National Weather Service for high impact weather events. This

Figure 3-DOC-24. Altair UAS.

system collects and processes observations from 400 GPS-Met stations, owned and operated by NOAA and other government agencies across the U.S., and the data is distributed using a web interface. In collaboration with the NWS, this research system functionality currently in the Office of Oceanic and Atmospheric Research will transition to NWS operations so that system reliability and maintainability can be ensured and sites expanded for use by NWS forecasters, the research community, and the private sector, as well as incorporated into the weather prediction models. In addition, the GPS-Met observations for water vapor, an important greenhouse gas, are sensor and model independent providing the consistency necessary to support long term monitoring of water vapor for climate applications and a reproducible climate quality data record. The near real-time water vapor measurements from GPS-Met are distributed to forecasters by the Meteorological Assimilation Data Ingest System (MADIS) which ingests, integrates, quality controls and distributes surface and supper-air observational datasets to the meteorological community. Among these datasets are an integrated surface mesonet database containing high-frequency, real-time observations from over 21,000 surface stations operated by over 150 different organizations, and an integrated profiler database with observations from 100 wind and temperature profilers operated by dozens of different agencies. MADIS is now ready to be transitioned to the NWS operations to provide reliable 24/7 data availability.

GSD also continues to move ahead in GOES R3 work in the areas of assisting in the transfer of product improvements to AWIPS, namely looking at current GOES moisture bias and seeing how this compares to GOES R synthetic data using MODIS. In addition, GSD is working with the Cooperative Institute for Research in the Atmosphere (CIRA) in the application of CloudSat data to verify GOES derived vertical cloud structure. GSD also conducts Observing Systems Simulation Experiments (OSSEs).

PSD and GSD will continue development of new sensors and innovative techniques for combining observing systems synergistically and economically. Efforts include developing tools and techniques to integrate the data from surface-based and satellite-borne profiling systems for more effective use of these data in forecasts. In support of this effort, PSD has an active satellite remote sensing group that uses data from various environmental satellites to study air-sea interaction processes, the global hydrological cycle including water vapor and precipitation, and the Earth's radiation budget.

Icing is a weather hazard that occasionally causes aviation disasters, especially in winter. In-flight icing forms on wings and other exposed surfaces as an aircraft flies through clouds that contain super-cooled liquid water droplets. Leveraging earlier work with polarization-sensitive cloud radars, PSD designed a new ground-based cloud radar and radiometer system to monitor clouds in the vicinity of airports and to provide automated warnings of icing conditions aloft. This instrument is the Ground-based Remote Icing Detection System (GRIDS). In addition, GSD continues to perform research and analysis to improve aviation forecasts.

PSD, in association with the Center for Environmental Technology (CET) at the University of Colorado is developing an airborne Polarimetric Scanning Radiometer (PSR) designed to provide higher resolution measurements of sea state quantities, including surface winds. PSD/CET is also investigating the possibility of measuring soil moisture by L-band radiometers.

Starting in 2003, PSD and GMD have been working together with the Canadian Meteorological Service and Canadian Network for the Detection of Climate Change (CANDAC) to re-establish a new Arctic Atmospheric Observatory at Eureka, Ellesmere Island, Canada, in North East Canada as a part of the U.S. SEARCH (Studies of Environmental Arctic Change) Program (SEARCH). The Canadian Observatory is being designed to mirror many of the cloud, aerosol and radiation measurements that are already made at the GMD Baseline Observatory at Barrow, Alaska, that has been in continuous operation for 33 years. Since North East Canada and Barrow, Alaska, are in markedly different Arctic regimes the long-term measurements from these sites will be complementary in providing information to monitor Arctic atmospheric changes. Long-term data from these sites will be used to improve short-term and long-term forecast models, and improve satellite measurement of meteorological phenomena in the Arctic regions. Along with the National Science Foundation, PSD and GMD are helping to refurbish a historic meteorological station and establish an Atmospheric Baseline Observatory at Tiksi, in the Russian Arctic. This would be the first station of this type in a region that spans 75 percent of the Arctic littoral. Meteorological data from this newly re-instrumented site will continue a century of data collection that had deteriorated since the collapse of the Soviet Union, and expand measurements to complement those collected at Barrow, Alaska, and Eureka, Canada. The high quality of the data to be forthcoming from the Tiksi station should considerably enhance Arctic weather prediction and Arctic climate models.

PSD is engaging in a comprehensive observation program to improve operational weather forecast and planned climate model treatments of boundary layer forcing processes. This work centers on development and application of observing technologies for surface fluxes and key boundary-layer variables (profiles of temperature, humidity, wind, and cloud properties). Ship-based measurement systems have been developed and are now used routinely on NOAA research vessels to investigate model accuracies in the marine boundary layer. Recently, land-based systems have been developed and deployed. One point of emphasis is linking observed cloud properties (obtained with mm-wavelength cloud radars and microwave radiometers) to cloud effects on surface turbulent and radiative fluxes (this approach is termed cloud forcing). Ship-based and satellite retrievals of cloud and flux properties are being used. PSD is compiling a large data base to allow climatologically-oriented studies of model parameterizations. Future plans include expanding the observational capabilities to add scanning mm-radar capabilities for investigation of precipitation initiation (a critical issue in triggering deep convection in model domains).

The PSD satellite applications group has developed new techniques for monitoring atmospheric properties over the ocean surface including air temperature and specific humidity. Retrievals of these quantities were improved through novel use of satellite atmospheric sounders in combination with passive microwave imaging radiometers. The products are being applied to improved global estimates of the flux of heat between the ocean and atmosphere. PSD is also producing a new satellite-derived sea surface temperature product through the blending of infrared and passive microwave data. The technique takes advantage of the complementary strengths of the two sensor types. The product has significant meteorological applications through its use as an input to numerical weather forecast and climate models.

The NSSL is known for its development of observational capability, both remote and in situ, and in particular for its role in the development of the WSR-88D NEXRAD radar. NSSL continues to improve the WSR-88D software algorithms used by the NWS forecasters and is exploring ways to enhance the WSR-88D hardware using dual polarization techniques under the NEXRAD Product Improvement (NPI) activity. NPI planning, guidance, and funding involves NOAA, DOT/FAA, and DOD/Air Force.

Most weather radars, including the WSR-88D NEXRAD radar, transmit radio wave pulses that have a horizontal orientation. Polarimetric radars (also referred to as dual-polarization radars), however, transmit radio wave pulses that have both horizontal and vertical orientations. The horizontal pulses essentially give a measure of the horizontal dimension of cloud (cloud water and cloud ice) and precipitation (snow, ice pellets, hail, rain) particles while the vertical pulses essentially give a measure of the vertical dimension. Since the power returned to the radar is a complicated function of each particle size, shape, and ice density, this additional information results in improved estimates of rain and snow rates, better detection of large hail location in summer storms, and improved identification of rain/snow transition regions in winter storms. The signal processing requirements for dual polarization required an initial step of deploying a new Radar Data Acquisition (RDA) unit for the WSR-88D capable of processing the polarimetric signals. The new RDA deployment was completed in 2006.

In 2020, the WSR-88D radars forming this NEXRAD network will be over 23 years old. In about the same time frame, most of the Nation's aircraft surveillance radars will be nearing the end of their design life. Decisions on replacing or repairing and upgrading these National radar assets must be made over the next 10 to 15 years. We are now on the threshold of a revolution in civilian radar capability, enabled by the adaptation of established military radar technology to existing civilian applications, plus new capabilities beyond what current systems can provide. Historically, civilian radars with large rotating antennas like the NEXRAD weather surveillance network and the aircraft surveillance radars used by the Federal Aviation Administration (FAA) evolved from military radar applications. During the past several decades, a new generation of military radars has matured. These electronically scanning phased array radars with no moving parts (rotating antennas) were originally developed to track multiple airborne objects such as aircraft and missiles simultaneously. The unique beam agility, increased resolution, and faster full-volume scan rate of phased array radar can enable a single radar unit to perform multiple weather and atmospheric surveillance tasks and, at the same time, track multiple airborne craft.

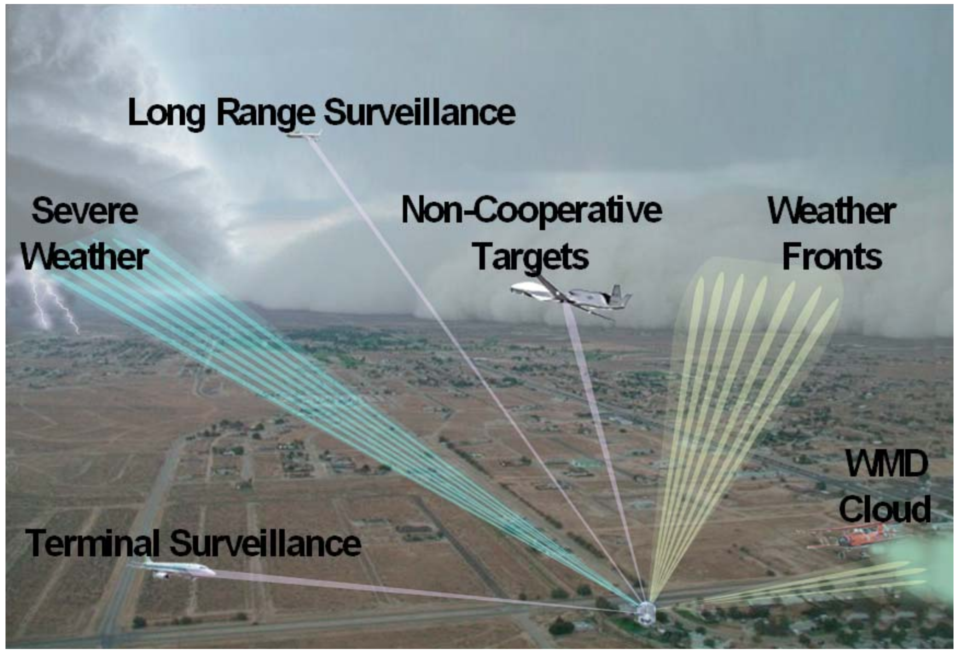

Figure 3-DOC-25. Electronically scanning phased array radars with no moving parts enable a single radar unit to perform multiple weather and atmospheric surveillance tasks and, at the same time, track multiple airborne craft.

Thus, a single network of multifunction phased array radar (MPAR) units could provide next-generation expansion of our current weather surveillance network, replace the Nation's aging air traffic surveillance radars, and meet homeland security and defense requirements for identifying and tracking non-cooperative craft operating over the U.S. homeland (Figure 3-DOC-25). MPAR will enable continued improvement of the Nation's severe weather warning system. It can provide adaptive sensing for warnings and nowcasts related to severe convective storms and the locally destructive effects of hurricanes (tropical cyclones) after they make landfall. Among the storm phenomena that could be tracked are tornadoes, strong wind gusts, hail, and locally heavy rains responsible for flash floods and mudslides. The enhanced weather surveillance provided by an MPAR network will provide economic benefits to domestic aviation and surface transportation systems. The agility and specificity of its multitasking beams will provide more detailed weather and atmospheric observations for urban meteorology, air quality nowcasts and forecasts, climate variability monitoring and forecasting, wildland fire monitoring and prediction, and atmospheric transport and diffusion modeling. The non-cooperative aircraft surveillance capability of an MPAR network would complement the cooperative surveillance strategy planned for the Next Generation Air Traffic System (NGATS), while also addressing new craft tracking requirements of the Departments of Defense and Homeland Security. While research at NSSL is establishing the proof-of-principle for new applications of weather radar in these and other areas, the adaptive flexibility of MPAR will be essential in transferring these promising radar techniques to operations.

Because an MPAR network would replace multiple existing networks, it offers an affordable option to the alternative strategy of continuing with the existing civilian radar capability by repairing and eventually replacing aging units. Due to technology breakthroughs in radio frequency components, fueled by the wireless telephony and digital communications industries, the cost of a key MPAR component-the transmit-receive elements in an MPAR antenna-has dropped by orders of magnitude over the past 5 years, and this trend should continue. For a number of reasons, the operations and maintenance costs for MPAR units appear to be a third area of substantial savings relative to continuing to repair and replace current radar units as they age.

Thus, with respect to both capabilities and cost, MPAR is a promising option for meeting the Nation's future domestic radar surveillance needs. Using multiple beams and frequencies that are controlled electronically, NSSL has demonstrated phased array radar reduces the scan time of severe weather from six minutes for NEXRAD radar to less than one minute, producing quicker updates of data and thereby potentially increasing the lead time for tornado warnings well beyond the current average of 13 minutes.

In support of improved understanding of the changing chemical composition of the atmosphere, the Field Research Division of the Air Resources Laboratory (ARL) has continued to refine its constant-level "smart" balloon. The smart balloon is intended to serve as a marker of parcels of air moving across the countryside and permitting samples to be made of the changes occurring in its composition. These balloons are being used both for air quality studies, such as the 2006 Texas study, and for hurricane research. The Field Research Division has also developed an Extreme Turbulence (ET) probe for measuring turbulence and surface fluxes in hurricanes. ET probes were successfully deployed into landfalling hurricanes in 2004, and plans are in place to eventually deploy them on moored NOAA buoys. The Oak Ridge Division of ARL continues to lead in the development of specialized sensors for measuring atmospheric turbulence. Their systems are now widely used for measuring the efficiency of coupling between the air and the surface, and have recently been selected for instrumenting the latest generation of research aircraft, manufactured in Italy. Future efforts will likely focus on instrumention of UAVs.

In addition to the many weather related observing systems, OAR also dedicates significant time to improving the development, deployment, and monitoring of oceanographic related observing technologies and related data. As part of this effort, AOML manages the deployment of drifting buoys around the world, deploying some 900 new drifters annually and tracking approximately 1250 as part of the Global Drifter Program. Using research ships, ships of the Ship of Opportunity Program (SOOP), and United States Navy aircraft, Global Lagrangian Drifters (GLD) are placed in areas of interest. Once verified as operational, they are reported to AOML's Data Assembly Center (DAC). Incoming data from the drifter are then placed on the Global Telecommunications System (GTS) for distribution in real time to meteorological services everywhere. The primary goal of this project is to assemble and provide uniform quality control of SST and surface velocity measurements. These measurements are obtained as part of an international program designed to make this data available in an effort to improve climate prediction. Climate prediction models require accurate estimates of SST to initialize their ocean component. Drifting buoys provide essential ground truth SST data for this purpose. The models also require validation by comparison with independent data sets. Surface velocity measurements are used for this validation.

In support of Global Climate Observing System (GCOS) requirements, OAR, in cooperation with NWS, the Climate Program Office (CPO; housed within OAR), AOML, and the Scripps Institution of Oceanography, maintains a network of approximately 100 meteorological drifting buoys in the Southern Hemisphere as part of the Southern Hemisphere Drifting Buoy Program. The buoys measure atmospheric pressure at sea-level, air temperature, surface sea water temperature, and surface currents. Observations are obtained through the ARGOS data collection and platform location system on-board the NOAA polar-orbiting satellites. The buoys are a subset of the Global Drifter Program (see above).

NOAA supports measurements from thermosalinographs (TSGs) that are instruments mounted close to the water intake of research and cargo ships and that continuously measure the sea surface salinity and temperature along the track of the ship. AOML currently operates several TSG transects from three ships of the SOOP in support of the CO2 Observing System funded by the NOAA Climate Program Office. These TSG data will be used to calibrate and validate observations of the upcoming Aquarius NASA sea surface salinity satellite mission.

NOAA operates and maintains AMVER SEAS 2K, a Windows based real-time ship and environmental data acquisition and transmission system. The AMVER software creates a series of reports that describe point of departure, route, and arrival of a ship. The meteorological reports are transmitted using Standard-C and include ships in a real-time search and rescue database used by the U.S. Coast Guard. The SEAS 2K software acquires atmospheric and oceanographic data and transmits the data in real-time to the GTS and to operational databases to be used by scientists. SEAS 2K is employed on ships of the Volunteer Observing System (VOS), SOOP, and on NOAA, UNOLS, and U.S. Coast Guard vessels. SEAS 2K is now installed on more than 400 ships of the VOS and SOOP, and over 200,000 AMVER SEAS meteorological messages are transmitted per year and inserted into the GTS.

AOML operates a global XBT Program that utilizes approximately 30 ships of the SOOP and collaborates with international institutions that operate another 30 ships to monitor the global upper ocean thermal structure. This includes low and high density deployment modes. TSG and XBT data are placed in real-time onto the GTS and are being used to initialize weather and climate forecast models.

Together with NOAA/PMEL, Brazil, and France, AOML contributes to the Pilot Research Moored Array in the Tropical Atlantic (PIRATA), a project designed as an extension of the TAO array into the Atlantic. The purpose of PIRATA is to study ocean-atmosphere interactions in the tropical Atlantic that are relevant to regional climate variability on seasonal, inter-annual and longer time scales. We recently deployed four ATLAS moorings as the eastern extension of the PIRATA array. The moorings were built by PMEL and are similar to those deployed in the Pacific. Planned expansion of the PIRATA array into the hurricane genesis region of the Atlantic will allow for a better understanding of ocean-atmosphere interactions on hurricane development and enhanced predictions of hurricane formation.

In an effort to better understand and forecast climate, OAR has been deploying a global array of profiling floats since 2000. The broad-scale global array of temperature/salinity profiling floats, known as Argo, has already grown to be a major component of the ocean observing system with an intended deployment of 3000 floats. Argo floats are free-drifting profiling floats that spend most of their life "parked" at 1,000 or 2,000 meters depth in the ocean, regularly surfacing to make temperature and salinity profile measurements and providing those observations in real-time. As of June 2007, 2856 Argo floats have been deployed (95% complete). AOML is the U.S. Argo Data Assembly Center and the South Atlantic Argo Regional Center, in charge of all U.S. Argo deployments in the Atlantic. The Argo array is part of the Global Climate Observing System/Global Ocean Observing System GCOS/ GOOS) and is a major contributor to the WCRP's Climate Variability and Predictability Experiment (CLIVAR) and the Global Ocean Data Assimilation Experiment (GODAE). Along with satellites, Argo provides a quantitative description of the changing state of the upper ocean and the patterns of ocean climate variability from months to decades, including heat and freshwater storage and transport.

The Tropical Atmosphere Ocean/TRIangle Trans-Ocean buoy Network (TAO/TRITON) array consists of approximately 70 Autonomous Temperature Line Acquisition System (ATLAS) and TRITON moorings in the tropical Pacific Ocean, telemetering oceanographic and meteorological data to shore in real-time via the ARGOS satellite system (Figure 3-DOC-26). Designed to improve detection, understanding, and prediction of El Niño, TAO/TRITON is a major component of the El Niño/Southern Oscillation (ENSO) Observing System, the Global Climate Observing System (GCOS), and the Global Ocean Observing System (GOOS). The array is supported by the United States (NOAA) and Japan (JAMSTEC), with JAMSTEC responsible for the TRITON moorings west of 165 degrees E longitude and NOAA responsible for the 59 moorings along and east of 165 degrees E. Responsibility for maintaining the TAO Array has been transferred to the NWS/National Data Buoy Center, and the Pacific Marine Environmental Laboratory (PMEL) continues to be involved by providing the instrumentation for the TAO surface moorings. These buoys provide climate researchers, weather prediction centers, and scientists around the world with real-time data from the tropical Pacific. El Niño (the warm phase of the ENSO cycle) is associated with a disruption of the ocean-atmosphere system in the tropical Pacific and has important consequences for weather around the globe.

The Pilot Research Moored Array in the Tropical Atlantic (PIRATA) is a project designed as an extension of the TAO array into the Atlantic. The purpose of PIRATA is to study ocean-

Figure 3-DOC-26. One of approximately 70 Autonomous Temperature Line Acquisition System (ATLAS) and TRITON moorings in the tropical Pacific Ocean.

atmosphere interactions in the tropical Atlantic that are relevant to regional climate variability on seasonal, inter-annual and longer time scales. The PIRATA Array consists of 20 ATLAS moorings similar to those deployed in the Pacific, including moorings established within the hurricane genesis region of the Atlantic, which will allow for a better understanding of ocean-atmosphere interactions on hurricane development and enhanced predictions of hurricane formation.

A third research array, the Indian Ocean Moored Buoy Array, was initially established in 2000 by Japan, and later joined by India, the United States, Indonesia, and France. The U.S. contribution to this array utilizes PMEL's ATLAS moorings, similar to those in the Pacific TAO and PIRATA Arrays. The Array continues to expand toward its eventual goal of 47 sites and is designed to conduct research on the seasonal monsoonal variability in the Indian Ocean, its interactions with ENSO, and the Indian Ocean Dipole, an El Niño-like phenomenon in the Indian Ocean.

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As part of the backbone for the Integrated Ocean Observing System (IOOS), OAR supports the national ocean observation backbone through 29 deployed or planned operational ocean moorings as part of the Ocean Reference Station network. The operational ocean moorings provide measurements of high quality air-sea fluxes of heat, moisture, and momentum that will be used to make regional assessments of flux components from numerical weather prediction models and satellites. A partnership with the National Science Foundation's ORION program will greatly enhance the capacity of the network.

HIGH IMPACT WEATHER RESEARCH

In addition to research and development of observing systems and related technology, OAR also focuses on ways to improve our understanding and the predictability of severe weather systems and their associated hazards. Providing significant national leadership in this area, the National Severe Storms Laboratory (NSSL) focuses on research to better understand such hazards as tornadoes, hail, high winds, heavy rain and snow, lightning, and ice storms with the goal of helping the National Weather Service (NWS) improve forecasts and warnings. The parameters of storm development and intensification are identified and studied by incorporating observations from Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning-location networks. NSSL's research includes assessment and improvement of numerical models to forecast severe weather systems.

NSSL provides significant technical and scientific support, with a focus on research and development, for the NWS WSR-88D radar program. In 2007, NSSL continued to develop techniques, in cooperation with the NWS, to forecast and warn of weather hazards to aviation and the general public.

NSSL's vision for the warning decision process continues to evolve as scientists and engineers work toward integrating the next generation radar (MPAR) and storm-scale numerical models to create a storm-scale prediction capability for the National Weather Service. While it is not possible today, within the next decade NSSL envisions operational units using a "Warn on Forecast" methodology, e.g., a forecaster will use thunderstorm-resolving computer models for severe weather warnings in the same way as he/she does today with the current Doppler radar systems. NSSL believes that these enhancements to the operational weather capability will lead to a more accurate warning system which increases lead time and provides probabilistic information that enables the public to take the best reasonable action during a severe weather event.

During the spring and summer of 2006, NSSL conducted the Severe Hail Verification Experiment (SHAVE) with the goal of testing new technologies that will vastly improve the verification of severe weather events, as well as the climate record of those events (Figure 3-DOC-27). SHAVE researchers documented hail swaths from severe thunderstorms at a high spatial and temporal resolution by integrating real-time meteorological data into Geographic Information Systems (GIS). This integration permitted the SHAVE team (NSSL/CIMMS scientists and U. of Oklahoma students) to make verification phone calls to very

Figure 3-DOC-27. Photo taken May 11, 1982, by NSSL storm intercept team in the hail core of a supercell thunderstorm that later produced an F2 tornado.

specific locations. Rather than an average of 1-2 hail reports collected from each storm, SHAVE collected anywhere from 10-100 reports along the storm's paths at a much higher spatial resolution and with fewer time and space errors than in the official storm climate record (the Storm Data publication). Better verification data such as these are vital to future improvements to the warning process. These high-resolution data sets enable:

1. validation of new probabilistic warning techniques that would not otherwise be possible given the typically coarse spatial resolution of the severe event reports in Storm Data,
2. enhanced, independent verification of warnings issued by the National Weather Service, and
3. validation of high-spatial and temporal resolution hail detection tools.

NSSL works with the Federal Aviation Administration's (FAA) Aviation Weather Research Program (AWRP) to develop weather radar applications that enhance the safety and efficiency of the aviation community and the National Airspace System. Work is focused on both convective weather and winter weather, with special attention to treating all WSR-88D radars within the continental United States as a single network. Such treatment allows NSSL to produce a single, authoritative 3-dimensional grid of radar data. Intensive research is also directed to polarimetric radar applications unique to aviation needs. Examples include winter time quantitative precipitation estimation, detection of icing conditions, and data quality issues unique to FAA users.

Leveraging the technology developed for the SHAVE project, NSSL invited the public to assist in collecting data for a winter field project called the Winter Hydrometeor Classification Ground Truth Program. The response was overwhelming. Volunteers were asked to report their exact location and time, and what kind of winter precipitation they were observing (rain, freezing rain, snow, sleet/ice pellets, drizzle, freezing drizzle, graupel or snow grains) through a link on NSSL's Website. Over 2500 observations of winter precipitation around central Oklahoma were reported since the project began with the first winter storm of the year at the end of November.

The information collected from the public will be compared with winter precipitation data measured by dual-polarized Doppler radar. The project will help NSSL researchers refine and develop winter precipitation radar techniques and products. The call for volunteers first went out to schools, and was expanded to include the entire public. Local broadcast meteorologists and newspapers spread information about the need for volunteers, and the Norman National Weather Service Forecast Office provided announcements on NOAA weather radio and a link to the project Web site from their home page.

Researchers estimate they have data from 300 to 400 different locations, with more than half of the reports coming from the Oklahoma City metro area. These observations closer to the radar are especially valuable because the radar beam is still low enough to the ground to capture the characteristics of what the observers report. Volunteers were asked to check NSSL's home page for the "Project Status." When the project was "Active," they could spend as little or as much time as they wanted making observations. Not only did involving the public in data collection provide additional observations for NSSL researchers, it also was an effective way to increase awareness of winter weather hazards, winter weather safety and NSSL's efforts to improve techniques that identify these hazards.

The NSSL is collaborating with the NWS Office of Hydrologic Development (OHD) and the Office of Climate Weather and Water Services in the development, testing, and research-to-operations of a 'state of the science' approach to quantitative precipitation estimation (QPE) and short-term precipitation forecasts (QPF). The goal of this cross agency collaboration is to increase warning lead times for the detection and prediction of flash floods and river flooding. This effort is part of the Advanced Hydrologic Prediction Services (AHPS), which is an essential component of the NWS Climate, Water, and Weather Services. The research and development into QPE and QPF is being afforded by a Federal Aviation Administration and National Centers for Environmental Prediction collaboration towards the integration of radar networks into seamless high-resolution three-dimensional mosaics for use in aviation safety and atmospheric model data assimilation. NSSL has established the infrastructure and techniques for ingesting domestic and international weather surveillance radars, along with integrating satellite and surface observations, to facilitate research and development toward advance monitoring of the Nation's fresh water resources. The vision and objectives of the research is to improve the capability to effectively manage the Nation's fresh water resources and to mitigate the social and economic impacts of flooding through timely and accurate detection and prediction of precipitation.

NSSL continues to lead a project called CI-FLOW (Coastal-Inland Flood Observation and Warning) that uses NSSL's multi-sensor rainfall estimates to drive an NWS distributed hydrologic model that predicts streamflow to help NWS improve flash flood warnings. CI-FLOW is the primary component of NOAA's new Integrated Water Resource Services project called Coastal, Estuary Resource Information System (CERIS). In addition to the streamflow prediction, streamflow data from predictive models are used to drive three models run by academic collaborators at N.C. State University, a water quality model, estuarine model, and storm surge model. This system of coupled models, when fully integrated, can be used for land-use studies, algal bloom studies, pollution studies, inundation studies of land-falling tropical systems, for example.

NSSL is participating in NOAA's Hydrometeorological Testbed or HMT. The HMT is a NOAA-led research activity with several external partners (e.g., universities, water management groups, etc.). The objective of the overall HMT program, of which HMT-West is the first full-scale deployment, is to accelerate the infusion of new technologies, models, and scientific results from the research community into daily forecasting operations of the National Weather Service and its River Forecast Centers. The research activities in HMT-West this year focused on deployment of NSSL's SMART-R radar system to observe heavy rainfall events over the American River Basin near Sacramento, California. Several storm systems were observed and unprecedented data sets were collected in FY2006 and FY2007.

NSSL has been working with U.S. Geological Survey (USGS) and NWS scientists to improve the debris flow warnings for Southern California. Recent fires in the foothills can lead to devastating debris flows (mudslides) when subsequent storms deposit relatively modest rains on those foothills. The USGS instrumented a burn area in 2006 (the Harvard fire region near Burbank California) and one in 2007 ("Day Fire") for high resolution studies in order to refine the warnings thresholds. NSSL contributed a mobile radar to make high-resolution radar estimates of precipitation over the Harvard burn area in 2006 and Day Fire area last winter. Five rainstorms were observed in 2006, of which 2 produced moderate debris flows. In 2007, unfortunately, La Nina conditions resulting in the driest winter on record resulting in very little useful data.

Improvement of short-range (1-12 hour) forecasting will be accomplished by the development and evaluation of new local data system technologies and techniques, many of which can be incorporated into operational weather forecasting in the near term. GSD develops and evaluates decision tools for forecast office environments, including commercial and civil aviation. Specifically, GSD has and will continue to develop capabilities to allow the forecaster to integrate, view, and manipulate observations from current and planned meteorological sensing systems using computer-assisted data display and synthesis techniques. GSD has developed an AWIPS thin client capability, FX-Net, which is used extensively by the NWS Incident Meteorologists in the field and agencies responsible for wildland fire fighting.

FX-Collaborate is an AWIPS capability developed by GSD that allows forecasters in different geographical locations to interact in real-time to develop a forecast. FX-Collaborate is being used to support decision aids for aviation weather (Volcanic Ash Coordination Tool, FAA traffic management units coordination) and for weather effects and early warnings in response to homeland security events (Geo-Targeted Alerting System and UrbaNet). NSSL is collaborating with NWS and GSD to integrate some of NSSL's advanced single and multi-radar display capabilities into AWIPS.

GSD will continue efforts toward effective assimilation of diverse observational data into numerical prediction models. Data from the Aeronautical Radio Incorporated (ARINC) Aircraft Communications, Addressing, and Reporting System (ACARS); Tropospheric Aircraft Meteorological Data Relay (TAMDAR), WSR-88D Doppler radars; and weather satellites, especially Geostationary Operational Environ-mental Satellite (GOES), are frequent and provide unprecedented resolution, either in the vertical or the horizontal, or both. These data are being more fully exploited in the Local Analysis and Prediction System (LAPS) which employs conventional analysis methods and 3-D variational methods (GSI and STMAS) to provide highly detailed analyses and coupled numerical models (WRF-NMM and WRF ARW) to provide forecasts over areas hundreds of kilometers on a side. Efforts include methods for surface boundary detection and tracking, convective initiation, and heavy rain forecasting with a hydrologic emphasis. LAPS has been installed for use in the U.S. Space Centers and in a number of DOD programs. GSD is working with the Department of Homeland Security to implement a high resolution forecast and dispersion system for major urban areas. LAPS is an integral part of an emerging wild fire forecasting system that assimilates airborne and ground sensor data and make short range predictions of the atmosphere in the vicinity of the fire.

GSD has been a collaborator in the NOAA HMT conducted in the American River Basin in Central California from 2005 to the present. This has involved configuring high resolution ensembles, probabilistic quantitative precipitation forecasts, evaluation, and de-biasing and calibration to better frame the uncertainty in heavy rain events. This has applications in warning on forecast and integrating into decision aids. Over the last two years 18 intensive observing periods have been supported and forecasts verified. The program has demonstrated the ability to produce high resolution probabilities in operationally critical thresholds of 1-2 inches in 6 hours for the west slope of the Sierras.

OAR will continue to transfer knowledge of Doppler radar applications, severe weather systems, forecast and warning improvements, and heavy rainfall events; much of the transfer is through courses at the NWS training center and through the Hazardous Weather Testbed at the new National Weather Center in Norman, OK. Visits and interactions with NWS centers, regional headquarters, and forecast offices continue and NSSL is participating directly in training programs, such as COMET in Boulder, Colorado, and the WSR-88D Operational Support Facility in Norman, Oklahoma.

Coastal meteorology research continues at the Pacific Marine Environmental Laboratory (PMEL). Emphasis has shifted from the study of terrain effects on West Coast weather to coastal wind and air-sea interaction research in the Gulf of Alaska. Research partners include the NWS Forecast Office in Juneau, AK, with financial support for the research being provided by NSF and NOAA/NOS through the GLOBEC program.

MESOMETEOROLOGY AND PRECIPITATION FORECASTING AND WARNING RESEARCH

In support of NOAA's goal of protecting lives and property, OAR contributes to the development of techniques to improve short term forecasters of significant weather events. Through detailed case studies and regional climatologies, National Severe Storms Laboratory (NSSL) scientists have developed diagnostic tools and aids for operationally forecasting thunderstorms, lightning, flash floods, and large mesoscale convective storm complexes. Field programs were carried out and followed by extensive analyses were conducted to improve the science behind technology advances. Example programs whose data have been and continue to be analyzed include:

- the Severe Thunderstorm Electrification and Precipitation Study (STEPS) in 2000,
- the International H2O Project (IHOP),
- the Thunderstorm Electrification and Lightning Experiment (TELEX) 2003 and 2004, and
- the annual collaborative severe storm research by NSSL, the NWS/SPC, the Norman Weather Forecast Office, and collaborators through the Hazardous Weather Testbed Spring experiments.

Other NSSL studies underway are focused on the precipitation structure of large storm systems (mesoscale convective systems), the interactions between meso-convective systems and the larger environment, the use of satellites to infer storm development and rainfall, short-range ensemble forecasting techniques, and winter storm forecasting procedures. Findings from these research activities lead

National Weather Center (NWC)

- 244,099 sq.ft
  - (~50% NOAA, 50% OU)
- $69M Jointly Funded
  - ($36M NOAA, $33M OU)
- 12 units occupy space
  - (5 NOAA, 7 State/OU)

to supporting the forecasting of a variety of high impact weather events.

NSSL will continue to investigate various model convective parameterization schemes, along with techniques to improve model initialization through four-dimensional data assimilation. Advances continue in numerical simulation and forecasting at mesoscale and stormscale resolutions. Current research is using data assimilation by ensemble Kalman Filter method, as well as lightning data assimilation, to improve forecasting of convection. At stormscale, pure simulation is also employed for improving understanding of dynamics, microphysics, and lightning. Toward the goal of improving operational mesoscale model and human forecasts of storms and their environments, NSSL researchers investigate the convection initiation (CI) process and the types of observations required to represent CI and storms in both research and operational mesoscale analysis and forecast model systems.

In 2002, NSSL contributed expertise and ground-based mobile radar, mobile mesonets, and mobile sounding observations during the International H2O Project (IHOP) conducted on the U.S. Southern Great Plains (SGP). The chief aim of the 2002 IHOP campaign is improved characterization of the four-dimensional (4-D) evolution of water vapor and boundary layer (BL) structure with application toward improving the prediction of convective storms. The SGP region is an optimal location due to existing experimental and operational facilities, strong variability in moisture, and active storms and convective systems providing most of the warm season precipitation east of the Rocky Mountains. Recent studies report a new method for objectively combining diverse radar and in-situ measurements to obtain internally consistent analyses of BL evolution and cloud formation with application to cases that illustrate the impact of drylines and cold fronts on the CI process. Given sound conceptual models of the CI process, forecasters in turn can interpret available observations more precisely to improve specificity and accuracy of storm forecasts. Another recent study reports the potential improvement of mesoscale model initialization via the assimilation of all types of real-time total and cloud-to-ground lightning observations to improve representation of ongoing convection and its integrated effects on model initial conditions.

NSSL has also made advances in interpreting lightning data in forecasting. This information will point to new ways for the National Weather Service to use lightning observations to improve forecasts and warnings of hazardous weather. NSSL operates state-of-the-science facilities that include the KOUN radar in Norman, which is a WSR-88D radar modified with polarimetric parameters to provide information about the particle size and water phase of precipitation and the Oklahoma Lightning Mapping Array (LMA). The OK-LMA is a network of 11 stations in central Oklahoma that continuously maps in high space and time resolution the structure of all types of lightning in three-dimensions out to a range of 75 km and in two-dimensions out to a range of 200 km. All the technology advances and research findings are aimed at NSSL's contribution to advances in forecasting high-impact weather events.

NSSL is working with the NWS Storm Prediction Center (SPC) to improve the nation's ability to forecast severe weather and to enhance severe winter weather guidance products. Data collected during the IPEX campaign held in 2001 should help. The data are being analyzed by NSSL, SPC and University of Utah scientists. The IPEX field and research program was designed to improve the understanding, analysis, and prediction of precipitation and precipitation processes in complex terrain. In addition, the SPC/NSSL collaboration has led to improvements in the way we understand convection initiated near the dryline and tornadoes spawned by hurricanes. A major forecast challenge for SPC forecasters is severe weather from elevated convection. Recent collaborative research shows the spatial and temporal distribution of such severe weather reports and begins to provide insight into processes that would improve our ability to forecast these events.

NSSL has developed a unique and vibrant collaboration with the operational forecasting community, which has recently been formalized with the establishment of the NOAA Hazardous Weather Testbed (HWT). The mutual interests of forecasters from the NOAA Storm Prediction Center, researchers from NSSL, and collocated joint research partners from the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) inspired the formation of the HWT. The testbed's activities have been varied, including activities such as daily map discussions involving imminent severe weather, loosely-related research projects involving 2-3 collaborators, and periodic intensive collaboration periods with larger groups. But the cornerstone of the testbed has been the SPC/NSSL Spring Program, a series of annual experiments that attracts 50-60 researchers and forecasters to Norman each year.

The premise of each Spring Experiment is to provide forecasters with a first-hand look at the latest research concepts and products, while immersing research scientists in the challenges, needs, and constraints of front-line forecasters. In practice, this program gives forecasters direct access to the latest research developments while imparting scientists with the knowledge to formulate research strategies that will have practical benefits. The end result is not only better severe-weather forecasts, but important contributions to the scientific literature as well. Science partners in recent Spring Experiments have included NCAR, NCEP/EMC, OU/CAPS, and numerous academic centers.

The Norman meteorological community consolidated its diverse workforce into a common building in 2006. Numerous groups are adopting the collaborative spirit and innovative approach of the HWT. At the same time, the HWT is expanding to embrace these groups and provide the framework for development and implementation of new technologies in different areas, particularly those focusing on shorter-timescale forecasting challenges. For example, NSSL's Severe Weather Warning Applications and Technology Transfer (SWAT) team and the NWS Norman WFO are stepping into important leadership roles within the HWT.

NSSL anticipates that the proof of concept established through the annual NSSL/SPC Spring Experiment and the early years of the HWT will play an important role in bringing together the diverse elements of the Norman meteorological community and like-minded meteorologists from across the country. In fact, Congress recently provided seed funding to help foster a collaboration between the HWT, the University of Alabama at Huntsville, and NASA's Short-term Prediction Research and Transition Center (SPoRT), a joint center staffed by NASA research meteorologists also located in Huntsville, and the Huntsville WFO. The group in Oklahoma is being referred to as HWT/Norman and the groups in Alabama are being referred to as HWT/Huntsville. The HWT/Norman has decades of experience on severe weather and tornadoes characteristic of the central plains (long-lived supercell thunderstorms, for example), while the HWT/Huntsville has experience with the severe weather and tornadoes that are characteristic of the southeast U.S. (especially those spawned by land-falling tropical systems). Working together, we believe these groups will strengthen the nation's collective knowledge and understanding of these hazardous convective events, leading to significant contributions to the science and improved severe-thunderstorm and tornado watches and warnings for the public.

NSSL has been on the forefront of short-range ensemble forecasting and exploring the use of ensembles for forecasts of severe weather. During the summers of 2002 through 2004, NSSL was a partner in the New England High-Resolution Temperature Program. The role of NSSL was to provide several model forecasts and collect forecast data from NCEP and FSL and develop post-processing techniques to improve upon Model Output Statistics. A simple yet powerful bias correction approach was developed in which the past 12 days of model data and observations are used to bias correct today's forecasts. Results indicate that the bias-corrected ensemble forecasts improve upon MOS and also provide reliable probabilistic forecast information. In addition, a novel approach to providing reliable probabilistic quantitative precipitation forecasts was developed and tested. In 2003, NSSL in partnership with the SPC embarked on an experiment to test the value of human forecasters in creating ensemble initial condition perturbations. Results indicate that human-generated ensemble perturbations can contribute positively to ensemble skill for severe weather events, indicating that the knowledge and experience of forecasters needs to be put to better use as we learn how to design ensembles for a variety of end users. With ensembles a regular part of the NCEP operational suite, approaches such as bias correction and human- generated ensemble perturbations as crucial to making best use of the model forecast data for both routine and severe weather forecasts.

Mesoscale dynamics research at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey, develops and utilizes atmospheric models with limited spatial domains to understand mesoscale phenomena and the interaction of these regional scale features with the atmosphere's larger-scale synoptic processes. As part of these research activities, GFDL scientists investigate the practical limits of forecast models to predict the behavior of these mesoscale features through model sensitivity studies. Current research focuses on extending these activities to the global domain through state-of-the-art global atmospheric models. High resolution mesoscale and regional models provide a key scientific tool to explore, verify, and validate parameterizations of unresolved processes such as convective and stratiform precipitation in the global models.

In 1994, the Global Systems Division (GSD) of ESRL implemented a Rapid Update Cycle (RUC) model at the NWS National Centers for Environmental Prediction (NCEP) and continues to provide periodic follow up upgrades. The RUC provides a new analysis of surface and atmospheric conditions every hour as well as short-range predictions for the next 12 hours. This information is useful to forecasters at local NWS offices around the country and also supports commercial and general aviation.

A higher-resolution, higher-frequency version of the RUC was implemented at NCEP in 2005. The 13-km version of NOAA's Rapid Update Cycle (RUC13) model became operational at 1200 UTC Tuesday, 28 June 2005, at the National Centers for Environmental Prediction (NCEP). This is a major milestone for improving the RUC high-frequency short-range forecasts for NOAA and external users, especially for aviation and severe weather forecasting. The main changes include higher horizontal resolution (from 20km to 13km), improved data assimilation especially for moisture/cloud fields, and improved cloud/precipitation physics. Most notable improvements are in surface and cloud/precipitation forecasts, resulting in part from assimilation of new observation types in the RUC13. GSD conducted assessments with new observation types to consider potential operational assessment at NCEP including wind profilers, GPS-Meteorology precipitable water, TAMDAR data, and METAR ceiling/visibility. The model updates every hour, incorporating information from virtually all high frequency data sources:

- hourly wind profiles;
- WSR-88D (Doppler radar) velocity azimuth displays;
- ACARS reports (up to 65,000 per day);
- cloud-drift winds and estimates of total precipitable water vapor from the GOES satellites; and
- surface observations

Along with NCAR, NCEP, and the university community, GSD has collaborated on the development of the Weather Research and Forecast (WRF) model. The WRF model has become a community model and a tool both for experimental and operational prediction, thus paving the way for quick realization of research advances in forecast dissemination to the public and industry. GSD will replace the RUC with the WRF Rapid Refresh model by 2009, updated hourly and extended to Alaska, Puerto Rico, and the Caribbean Sea.

GSD scientists lead work with other scientists from NOAA/ESRL toward development of a new global model including use of the adaptive isentropic-sigma hybrid vertical coordinate successful with the RUC model, accurate finite-volume horizontal advection, and use of an icosahedral horizontal grid. ESRL is collaborating with NCEP/EMC and GFDL on development of the FIM model (Flow-following Finite-volume Icosahedral Model).

The Air Resources Laboratory (ARL) is also involved in the development of new models for operational use by NCEP. The main focus is on mesoscale models and in the development of new capabilities for data assimilation. In particular, the new generation of mesoscale models (such as the WRF model referred to above) will require advanced descriptions of the coupling between the air and the surface, a matter that is being studied intensively in ARL programs involving closely interacting measurement and modeling activities. To this end, ARL continues to work closely with the Chemical Sciences Division (CSD) of ESRL to maintain the nation's surface radiation network (SURFRAD), data from which are now routinely employed to test both forecast mesoscale models (such as the Eta model) and satellite outputs. ARL conducts research on the surface energy balance and on the spatial variability of surface fluxes using aircraft. In addition, ARL serves as the provider of the NCEP modeling capability to address situations of atmospheric dispersion, such as of emissions from sources like volcanos, industrial enterprises, and nuclear accidents. In recent work, ARL is adapting a new system developed to forecast dispersion of smoke from forest fires, in a study performed in collaboration with the Association of South East Asian Nations, the U.S. Forest Service, and The Mediterranean Centre for Environmental Studies Foundation. The present program will provide interim products to the joint NOAA-EPA Air Quality Forecasting Program to improve smoke dispersion estimates in the particulate forecast model.

TROPICAL ATMOSPHERIC RESEARCH

The Tropical Dynamics and Climate Program of the ESRL Physical Sciences Division (PSD) is using precipitation profilers to study the structure, evolution and variability of precipitating cloud systems in the tropics and elsewhere. Precipitation measurements can be made with sufficient vertical resolution to categorize precipitation in deep and shallow convective systems and in stratiform conditions. A recent focus of research with profilers has been to provide ground validation research in support of satellite precipitation measurement missions such as the NASA Tropical Rainfall Measuring Mission (TRMM). These observations have provided important information on the vertical structure and temporal evolution of precipitating cloud systems during TRMM Ground Validation field campaigns. The observations made during the field campaigns are the subject of collaborative research with other TRMM researchers with an emphasis on the use of profilers to calibrate scanning radars used for TRMM ground validation research and the use of profilers to retrieve drop-size distributions and related precipitation parameters of interest to the TRMM Science Team. Validation of drop-size distributions used in algorithms is key to improving the retrieval of rainfall estimates from the TRMM satellite data. The profiler-based precipitation research described above also can be used to provide calibration of NEXRAD scanning radars as has recently been demonstrated for Melbourne, Florida. In related activities PSD is carrying out hydrometeorological studies in collaboration with the NWS in demonstrating the value of hydrometeorological testbeds as a means of improving the transition of scientific advances to operations.

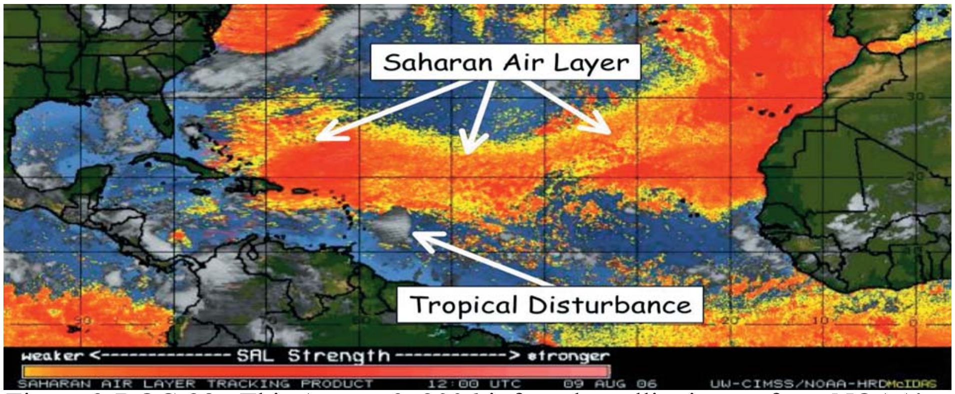


Figure 3-DOC-28. This August 9, 2006 infrared satellite image from NOAA's GOES satellite shows a Saharan Air Layer (SAL) outbreak (yellow to red shading) spanning nearly 4,000 miles across the North Atlantic. A tropical disturbance is indicated along the southern periphery of the SAL and was likely being suppressed by the SAL's dry dusty air and strong mid-level winds.

HURRICANE ANALYSIS AND PREDICTION RESEARCH

The Atlantic Oceanographic and Meteorological Laboratory's Hurricane Research Division (HRD) mission is to advance the understanding and prediction of hurricanes and other tropical weather. HRD's research is based on a combination of models, theories, and observations, with particular emphasis on the utility of the data obtained with research aircraft. The goals of this research are to:

1. Advance the prediction of tropical cyclone intensity change by improving understanding of the processes that modulate internal storm dynamics and storm interactions with the atmosphere and ocean;
2. Improve the prediction of tropical cyclone tracks by enhancing understanding of the interactions between a tropical cyclone and its environment through an optimal analysis of field observations;
3. Improve the understanding of and ability to predict tropical cyclone frequency and intensity on intraseasonal, interannual, decadal and longer time scales; and
4. Enhance the ability to diagnose and predict the impact of tropical cyclones on life and property through wind, rain, waves, and storm surge.

These goals are accomplished by:

1. designing and conducting research experiments in the hurricane to collect and provide data for research, and operational applications;
2. analyzing these data sets and publishing the research in the refereed literature;
3. developing new technology and applications based on this research to improve NOAA's products;
4. developing and testing hurricane models to improve models' ability to simulate nature, improve forecasts, and to optimize hurricane observing through the use of observing system simulation experiments (OSSEs), and
5. providing outreach to the public through the WWW, conferences, presentations, and other means.

Much of HRD's research is based on the in situ and remotely-sensed observations in the inner core of tropical cyclones and their surrounding environment9Figure 3-DOC-28). These observations are primarily collected in NOAA's annual field program using the two NOAA turboprop aircraft and jet operated by the NOAA Aircraft Operations Center (AOC). The field program is used to carry out scientific experiments designed to address the goals stated above. Data sets gathered by these experiments, combined with dynamical and statistical models and theoretical development, range from global to microscale, forming the cornerstone of research in HRD. Because of this extensive field experience, HRD scientists are recognized internationally for their knowledge of tropical cyclones as well as their expertise in technological areas such as airborne Doppler radar, dropsondes, cloud microphysics, and air-sea interaction, to name a few. These assets make HRD unique worldwide, and provide NOAA a unique capability.

HRD coordinates its programs with other NOAA organizations, e.g., NOAA's Aircraft Operations Center (AOC), NESDIS, and NCEP, in particular with EMC and NHC. HRD maintains active research programs with, and receives funding from other governmental agencies, in particular, the Department of the Navy's Office of Naval Research (ONR) and the National Aeronautics and Space Agency (NASA).

In program areas where it is beneficial to NOAA, HRD arranges cooperative programs with scientists at the National Center for Atmospheric Research, and at a number of universities.

Under the USWRP and its participating agencies, OAR, NWS, and NESDIS established a Joint Hurricane Testbed (JHT) at the Tropical Prediction Center in Miami, Florida, in 1999 (http://www.nhc.noaa.gov/jht/index.shtml). This testbed is where the hurricane research is evaluated for operational use and those research products passing the test will be handed off to operations.

NUMERICAL ANALYSIS AND PREDICTION MODELING

As part of its weather research activities, GFDL conducts long lead-time research to understand the predictability of weather on both large and small scales and to translate this understanding into improved numerical weather prediction models. Three groups at GFDL are engaged in weather research activities: Climate Dynamics and Prediction, Weather and Atmospheric Dynamics, and Atmospheric Physics and Chemistry.

The Goal of the Climate Dynamics and Prediction Group is to develop and use computer models of the atmosphere-ocean- ice-land system in order to:

• identify and elucidate the physical and dynamical mechanisms which maintain climate and cause its variations on seasonal to centennial time scales

• assess and understand the predictability of the climate system on seasonal and longer time scales, including the El Niño phenomenon

• evaluate the impact of human activity on the Earth's climate system

This group is charged with studying and modeling climate phenomena on seasonal to multi-century time scales. The group's work is highly relevant to key elements of the NOAA Strategic Vision, especially Mission Goal 2 to "Understand climate variability and change to enhance society's ability to respond". In addition to examining a wide range of climate time scales, various members of the group have expertise spanning the expansive set of complex and interconnected parts that together constitute the Earth's physical climate system (this includes the atmosphere, ocean, land surface and sea ice). Group members participate in the development, testing, application, and analysis of numerical models of the climate system. Running on supercomputers, these models are the research tools used by group members to both advance our understanding of the Earth's climate system and to generate products relevant to assessment and policy decision support.

The Weather and Atmospheric Dynamics Group at GFDL improves our understanding of atmospheric circulations ranging in scale from hurricanes to extratropical storms and the general circulation, with an emphasis on extreme weather events and the interplay between weather phenomena and climate variability and change, using high resolution atmospheric modeling as the central tool. This effort is augmented by the Atmospheric Physics and Chemistry group, which performs research to improve our understanding of the interactive three-dimensional radiative-dynamical-chemical-hydrological structure of the climate system from the surface and troposphere to the upper stratosphere and mesosphere on various time and space scales. This is achieved by employing meteorological observations in conjunction with models for diagnostic analyses of atmospheric processes, and evaluating and improving parameterizations employed in weather and climate models; modeling the interactions between clouds, convection, radiation and large-scale dynamics to understand their roles in climate and climate change; and modeling the physics, chemistry and transport of atmospheric trace gases and aerosols to investigate the impact of future emissions on regional and global air quality, and to investigate the regional and global climatic effects due to changes in natural and anthropogenic radiatively-active species.

Together, these groups use the models to address problems of critical interest to the Nation. For example, there is now a very high degree of confidence that anthropogenic effects have already altered the climate system and that this forcing will increase in the coming decades. At the same time, insurers are abandoning hurricane insurance markets, and infrastructure is being built or rebuilt in areas vulnerable to sea-level rise and hurricanes at the same time sea-level rise seems to be accelerating and hurricane activity is high. Water resource management, urban planning, and agricultural decisions are being made even as observations and models suggest the potential for persistently drier conditions. The trend towards an ice-free Arctic has major social, economic, and policy implications, as well as the potential to accelerate global warming. Energy technologies that might affect global change need to be examined. The Nation must plan for the geopolitical challenges of global warming, because many of its most severe effects are expected in regions where fragile governments are least capable of responding to them.

To prepare for and confront these effects, an understanding of the regional impacts, the role of extreme events and abrupt change, and their interactions with natural variability are being developed so that decisions can be made with the best possible scientific information. Over the last half century in general and the last few years in particular, NOAA's Geophysical Fluid Dynamics Laboratory has demonstrated world leadership in pushing the boundaries of climate prediction. Through direct participation in producing the Intergovernmental Panel on Climate Change 2007 Assessment and the Administration's Climate Change Science Program Synthesis and Assessment Reports, GFDL's premier climate science capacity and recent investment in computer model infrastructure allow NOAA deliver essential climate forecast information at the regional and local level and provide an invaluable and unique opportunity for the Nation to make critical progress in global change science.

AIR QUALITY RESEARCH

The principal mission of the Air Resources Laboratory (ARL) is to

improve the capability to forecast changes in air quality and atmospheric deposition. Deposition is the factor that links the pollutant characteristics of the air with the terrestrial and aquatic environments. ARL's research focuses on the lower atmosphere, where the atmosphere is in direct contact with other media-- aquatic, terrestrial, and biospheric. The core of ARL research relates to studies of the atmosphere as a component of the total environment. Much of this work is in collaboration with other parts of NOAA (principally NCEP) and with other agencies, such as EPA, DOE, and the DoD.

The ARL Headquarters Division in Silver Spring, Maryland, develops models for air quality prediction, for use in special forecasting (both weather and air quality) programs, and in emergency response. The Atmospheric Sciences Modeling Division, in Research Triangle Park, North Carolina, develops predictive models on local, regional, and global scales for assessing changes in air quality and air pollution exposure as affected by ecosystem management and regulations. This work is primarily to provide technical guidance to the EPA on air pollution control strategies for attainment and maintenance of ambient air quality standards, and for the provision of ozone and particulate matter forecasts in support of the joint NOAA-EPA Air Quality Forecasting program.

The ARL Atmospheric Turbulence and Diffusion Division, in Oak Ridge, Tennessee, conducts studies to improve understanding of atmospheric transport, diffusion, and air-surface exchange processes, and to develop new predictive models. Recent efforts have focused on the air-surface exchange of mercury in polar and coastal environments and of nitrogen (both oxidized and reduced) over agricultural soils.

The ARL Field Research Division, in Idaho Falls, Idaho, designs and conducts field studies to evaluate the performance of transport and dispersion models, over local, regional, and continental scales. The ARL Special Operations and Research Division (SORD) in Las Vegas, Nevada, conducts research on problems of mutual interest to NOAA and DOE that relate to the Nevada Test Site, its atmospheric environment, and its emergency prepared-ness and emergency response activities. ARL participates in two national networks that direct research attention on the needs of the next generation of predictive models. The Atmospheric Integrated Research Monitoring Network (AIRMoN) is a nested-network with sites of varying complexity addressing evolving scientific issues of wet and dry deposition from the atmosphere. A major current item for scientific attention is the atmospheric deposition of nitrogen compounds and its role in promoting eutrophication of ecosystems, primarily coastal. The ARL-developed Integrated Surface Irradiance Study (ISIS) serves as the national array of monitoring stations for solar radiation (and ultraviolet-B) with a subset of more advanced stations (the SURFRAD array) where both incoming and outgoing radiation components are monitored. Many of the SURFRAD stations are augmented with instrumentation to measure fluxes of sensible heat, latent heat, momentum, and carbon dioxide. Thus, the SURFRAD program is evolving into one of complete energy balance with supporting data on carbon dioxide exchange. ISIS and SURFRAD are presently operated by Global Monitoring Division (GMD) of ESRL. This work forms an intersection with the new flux measurement networks in the United States and overseas, referred to as "Ameriflux" and "Fluxnet." All of this work is coupled with ARL research on atmospheric aerosols and with the development of new automatic methods for measuring cloud cover.

Much of ARL's research focus is on expressing air surface exchange processes in numerical models. To this end, ARL scientists have been instrumental in developing methods for describing an air surface exchange appropriate for use with model grid cells of several tens of kilometers on a side. ARL also provides forecast support to NOAA's emergency response systems with emphasis on chemical, nuclear, and volcanic events. For this application, ARL develops and couples advanced dispersion models with the forecast products of the NWS to provide a basis for trajectory and dispersion calculations. The models in question are now widely accepted. The Hazardous Atmospheric Release Model (HARM) is operationally employed at a number of DOE locations. The ARL Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model is now operational in many countries, including China and Australia, as the national dispersion forecasting capability. It also serves the NWS in this role. Registered users can also access HYSPLIT products via the Internet. HYSPLIT is the major product employed in the operations of the Regional Specialized Meteorology Center (RSMC) set up as a joint undertaking of ARL and NCEP under the auspices of the World Meteorological Organization (WMO). The WMO/ RSMC is the source of dispersion products in the event that a pollution plume (in this case, radioactive) crosses international boundaries.

The provision of dispersion forecasts by ARL scientists extends to two specific areas of special relevance - the Nevada Test Site and the Idaho National Laboratory. ARL maintains staffs of dedicated dispersion meteorologists at each location, where site-specific models are developed and run using data generated by dedicated regional networks of meteorological sensors. These sites also serve as research testbeds for improving ARL's dispersion models, such as the HYSPLIT model.

Each of ARL's divisions also participates in a cooperative agreement designed to explore the synergy that can be accomplished by collaboration between the government and private industry. The focus is the use of private sector data to address homeland security threats and potential local accidental events, as well as protection of the general population through the provision of better data in response to weather and climate related events. The intent of the program is to address threats where most of the population lives - in cities - exploring the use of the large non-government database that is available to most cities for use in the next generation of computer models.

The Chemical Sciences Division (CSD) of ESRL coordinates the Health of the Atmosphere air quality research effort. NOAA's Health of the Atmosphere research is focused on the atmospheric science that underlies regional and continental air quality, with the goal of improving our ability to predict and monitor future changes, leading to improved scientific input to decision-making. CSD, ARL, GMD, GSD, PMEL, and PSD participate in the research. The Health of the Atmosphere research goals are to:

- characterize regional ozone and particulate matter (PM) episodes;
- characterize the factors that cause poor air quality in regions of the U.S. where excessive levels of ground-level ozone and fine particle pollution are occurring.

In the summer of 2006 a, major field study was carried out to characterize air quality in New East Texas. Ground-based measurements, ship and aircraft measurements, forecasting, and modeling analyses were applied in the research. Among the processes investigated were the role of nighttime chemistry in the formation of ozone and PM pollution, the role of the sea-breeze/land-breeze circuit in influencing Houston's air quality, and the role of the marine boundary layer as a conduit for the movement of pollutants throughout the region.

- Document trends in air quality: Help evaluate predicted atmospheric responses to changes in emissions (i.e., the ongoing measurements provided by the Atmospheric Investigation, Regional Modeling, Analysis and Prediction (AIRMoN) and the ozone profiling networks).
- Develop a better understanding of the fundamental science underlying the processes responsible for the formation and distribution of fine particles in the atmosphere to improve the atmospheric predictive capability that links sources of fine particles and their precursors to human exposure and visibility impairment.

Under the future Health of the Atmosphere research umbrella, the OAR Laboratories integrate their meteorological, chemical, and forecasting expertise to support an assessment and prediction capability for regional air quality that incorporates the influence of multiple-timescale meteorology/climatology. While the ambient levels of pollutants like ozone and fine particles are clearly dependent on pollutant emissions, the variation in those levels is also influenced by meteorology, both in the short term and longer term. Therefore, assessing both the intended long-term improvements in air quality and the more-episodic variations requires an understanding, of pollutant transport, transformation, and loss. Research efforts will also focus on an evaluation and improvement of the tools used to forecast future air quality and the observing systems needed to evaluate their skill.

CSD and GMD, working with collaborators throughout North America and Europe, are using ozonesonde releases to characterize the vertical distribution of ozone over North America. Coordinated ozonesonde releases have been conducted in conjunction with field intensives in New England (2004) and Texas (2006). The data collected has provided new insights into the import of ozone from Asia, transport aloft and the role of lightning in ozone formation in the upper free troposphere.

CSD conducts laboratory studies of the chemical processes that are responsible for ozone and fine particle formation and transformation in the atmosphere. These studies are designed to elucidate the chemical mechanisms and quantify the kinetic and thermodynamic parameters needed to properly represent these processes in predictive models.

CSD develops and deploys lidars that are capable of characterizing the vertical structure of ozone and aerosols in the atmosphere. These instruments are deployed on NOAA research aircraft, ships (Figure 3-DOC-29), and at surface sites to characterize the regional distribution of ozone and PM in three dimensions. The data collected provides detailed information on the regional and inter-regional horizontal transport and vertical mixing of ozone and PM pollution.

CSD develops fast response instrumentation for use on mobile platforms (ships and airplanes) that are capable of characterizing the atmospheric pollutant mix. These instruments are designed to characterize the chemical composition of the atmosphere, as well as the optical (scattering and absorption) and physical (e.g. size distribution) properties of ambient PM.

PSD and CSD use their suite of remote sensors, including a mobile profiler network, airborne and ground-based ozone Lidars, Doppler Lidar, and supporting turbulence instrumentation to understand and better model the transport, transformation, and fate of primary and secondary pollutants in both rural and urban environments as well as in complex orography. These

Figure 3-DOC-29. The research vessel, Ronald H. Brown.

instruments are deployed at surface sites and on NOAA research ships during the regional air quality intensives such as the Texas air quality study.

CSD works with GSD and PSD to develop and evaluate air quality models. These models are used to aid in the interpretation of data collected during regional fields studies and to produce prototype air quality forecasts. The detailed physical and chemical data collected during intensive field studies are used to diagnostically evaluate these models and their components.

The Air Quality Research Subcommittee (AQRS) of the Committee on Environment and Natural Resources (CENR) provides interagency collaboration at the United States Federal level. NOAA co-leads the AQRS. On the broader international arena, the coordinating body is the North American Research Strategy for Tropospheric Ozone (NARSTO), a tri-lateral public/private partnership focused on ozone and particulate matter research in the United States, Canada, and Mexico.

The National Ocean Service (NOS) monitors, assesses, and forecasts conditions in the coastal and oceanic environment to maintain a healthy, safe, and economically productive coastal and oceanic environment for present and future generations. NOS is the primary civil agency within the Federal government responsible for the health and safety of our nation's coastal and oceanic environment. Largely through the Tides and Current Program budget line, NOS acquires water levels, currents, winds, and other physical oceanographic and meteorological data, and distributes these data and circulation predictions as elements of an integrated NOS program to provide a comprehensive science-based suite of information products required by the marine transportation community to ensure safe and efficient marine transportation, including the transport of oil and other hazardous materials. NOS also provides coastal oceanographic and meteorological products required by the National Weather Service (NWS) to meet its short-term weather and forecasting responsibilities, including tsunami and storm surge warnings. NOS manages several observing systems and programs, however four in particular are heavily linked to the capability of NOAA to meet weather and water needs of the nation.

NATIONAL WATER LEVEL OBSERVATION NETWORK (NWLON)

NOS manages the NWLON, 200 stations located along the coasts of the United States and the Great Lakes, from which water level data, as well as other oceanographic and meteorological data, are collected and disseminated. NWLON provides a number of NOAA and other Federal programs with data and supporting information, such as the NOAA Nautical Charting Program, NWS Tsunami Warning System, NWS storm surge warning/forecast activities, and the Climate and Global Change Program. An DCP NWLON modification is now operational that allows emergency "Tsunami Warning" GOES transmissions to NWS at 6-minute intervals and imbedded in those data streams are high-rate 1-minute averages for tsunami use. The 6-minute interval GOES transmission capability also supports the NWS storm surge warning program when expected elevations are predicted or observed during coastal storms and hurricanes. This capability for high-rate data has recently been implemented at almost all NWLON by the introduction of 6-minute interval GOES transmissions. Although not all NWLON stations are presently equipped with meteorological sensors, an increasing number of stations are each year. Water level and meteorological data are automatically formatted into bulletin format for inclusion into the NOAA AWIPS pipeline.

PHYSICAL OCEANOGRAPHIC REAL-TIME SYSTEM (PORTS®)

PORTS® is a decision support tool which improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, bridge air gap and many meteorological parameters, e.g. winds, air temperature and barometric pressure, needed and requested by the mariner to navigate safely.

The 13 existing PORTS® systems come in a variety of sizes and configurations, each specifically designed to meet local user requirements (Figure 3-DOC-30). PORTS® are partnership programs in which local operating partners fund the installation and operation of the measurement systems. The largest of NOS's existing installations is comprised of over 100 separate instruments. The smallest consists of a single water level gauge and associated oceanographic and meteorological instruments, i.e. winds, barometric pressure, etc. Regardless of its size, each PORTS® installation provides information that allows shippers and port operators to maximize port throughput while maintaining an adequate margin of safety for the increasingly large vessels visiting United States ports. In addition, prevention of maritime accidents is the most cost effective measure that can be taken to protect fragile coastal ecosystems. One major oil spill, e.g. EXXON VALDEZ, can cost billions of dollars and destroy sensitive marine habitats critical to supporting coastal marine ecosystems. PORTS® provides information to make navigation safer, thus reducing the likelihood of a maritime accident, and also provides the information necessary to mitigate the damages from a spill, should one occur. An extensible PORTS® can be integrated with other marine transportation technologies such as Electronic Chart Display Information Systems (ECDIS) and Vessel Traffic Systems (VTS).

NATIONAL OPERATIONAL COASTAL MODELING PROGRAM (NOCMP)

NOCMP serves a variety of users with oceanographic nowcast forecast products for ports, estuaries and the Great lakes. The integration of PORTS® technology and numerical circulation models allows nowcasts and predictions of parameters within the boundaries of the models even at locations where physical measurements are not available. The Chesapeake Bay Oceanographic Forecasting System (CBOFS) is an NOS project that provides forecasts of total water level within the Bay in addition to the astronomical tidal prediction. The New York/New Jersey Harbor nowcast/forecast model came on line in 2003, fol-

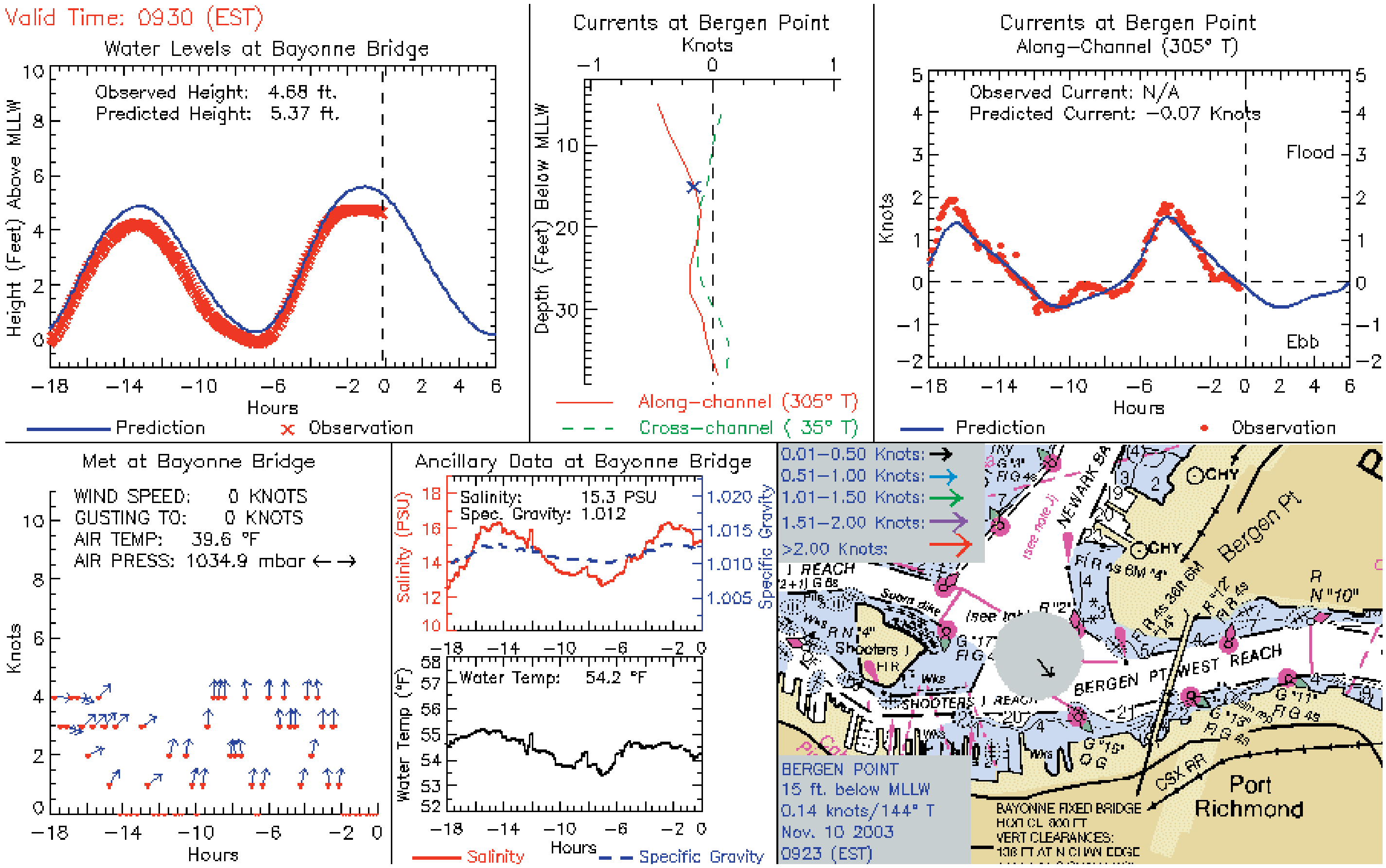


Figure 3-DOC-30. New York/New Jersey PORTS: Bergen Point Composite.

lowed by a Houston/Galveston Bay nowcast/forecast model in 2004. Newer models include the St. Johns River, FL and the Great Lakes. In cooperation with OAR and NWWS, the NOS CO-OPS now runs 5 models as part of the Great Lakes Operational Forecast System (GLOFS) providing forecast guidance for water level , wind, currents and water temperature. Also, ongoing research will enable PORTS® or similar systems to incorporate biological and chemical sensor systems and forecast models as required and integrate the information with circulation measurements to provide information on transports of materials in the ecosystem essential for effective marine resource management and homeland security.

THE NOS CONTINUOUS REAL-TIME MONITORING SYSTEM (CORMS)

CORMS was designed to operate on a 24-hour/7-days a week basis to ensure the accuracy and working status of tide and current observations acquired via the NWLON and PORTS® programs. CORMS improves the overall data quality assurance of real-time measurements, reduces NOAA's potential liability from disseminating inadequate data, and makes the observations more useful for all applications (Figure 3-DOC-31). CORMS ingests real-time data from all field sensors and systems, including the operational nowcast/forecast models, determines data quality, and identifies and communicates the presence of invalid or suspect data to real-time users/customers who rely on the data. CORMS is especially vigilant during storm and tsunami events to ensure the full set of products and services is being disseminated in a timely fashion. An advanced version of this system, CORMS AI, is presently in developmental stages.

Figure 3-DOC-31. PORTS sites in the New York and New Jersey linked by CORMS.

NOAA Marine and Aviation Operations (NMAO) operates a wide variety of specialized ships and aircraft to support NOAA mission goals. NOAA's ship fleet includes oceanographic and atmospheric research vessels. NOAA's aircraft fleet includes aircraft that collect environmental and geographic data essential to NOAA hurricane and other severe weather and atmospheric research; and aircraft that conduct aerial surveys for hydrologic research for forecasting flooding potential from snow melt.

Figure 3-DOC-33. NOAA Ship KA'IMIMOANA

NOAA SHIPS SUPPORTING METEOROLOGICAL ACTIVITIES

NOAA Ship RONALD H. BROWN, an oceanographic and atmospheric research platform (Figure 3-DOC-32), is the largest vessel in the NOAA fleet (274 feet). With its instruments and sensors, RONALD H. BROWN travels worldwide supporting scientific studies to increase our understanding of the world's oceans and climate. An advanced meteorological scientific Doppler radar makes the ship a unique attribute to the research fleet.

Figure 3-DOC-32. NOAA Ship RONALD H. BROWN

NOAA Ship KA'IMIMOANA (Figure 3-DOC-33) primarily supports the research programs of NOAA's Tropical Atmosphere-Ocean (TAO) Project (real-time data from moored ocean buoys for improved detection, understanding and prediction of El Niño and La Niña). These research programs are designed to improve our understanding of the role of the tropical ocean in the world's climate. The ship deploys, recovers, and services deep sea moorings that measure ocean currents, ocean temperatures, and atmospheric variables, throughout the equatorial Pacific Ocean. In addition to data from these moorings, the ship measures upper ocean currents, surface salinity, carbon dioxide content, and takes upper air atmospheric soundings while underway.

RONALD H. BROWN and KA'IMIMOANA annually support the Tropical Atmospheric Ocean (TAO) Array by servicing approximately 60 ATLAS and current meter moorings in the central and eastern equatorial Pacific.

In FY 08, the RONALD H. BROWN will work in cooperation with the Woods Hole Oceanographic Institute to conduct mooring recovery and deployment operations of the Stratus Ocean Reference Station (the sixth setting) under the stratocumulus clouds off Chile and Peru. The ship will conduct meteorological and air-sea flux observations to document and establish the accuracy of the moored metrological observations, and to observe the oceanic and atmospheric variability. This region is of critical importance to climate predictability. Additionally, during the Stratus project the BROWN will support in the deployment of a Deep-ocean Assessment and Reporting of Tsunami (DART) mooring off the coast of Central America.

The RONALD H. BROWN will also conduct the Pirata Northeast Extension

(PNE) study to improve understanding of the West African monsoon and its influence both on the regional environment as well as its role in Atlantic Tropical cyclone development. Following the PNE cruise the BROWN will conduct a CLIVAR/CO2 project that will determine the changes in anthropogenic CO2 distributions and fluxes in the Pacific. After the CLIVAR/CO2 work the vessel will begin a GasEx study to quantify air-sea CO2 fluxes in the Southern Ocean carbon sink region utilizing newly developed direct flux measurement techniques.

NMAO when able supports NDBC in recovery of buoys that have been disabled or become adrift.

NOAA AIRCRAFT SUPPORTING METEOROLOGICAL ACTIVITIES

NOAA aircraft support a broad range of meteorological activities and projects with its fleet of aircraft based at MacDill Air Force Base in Tampa, Florida. Three of its twelve aircraft are dedicated to this purpose throughout the year, providing valuable information to NOAA and the nation.

Operations of the G-IV and two WP-3D during the hurricane season of 2006 were strikingly different from 2005. Whereas these three NOAA aircraft flew 123 missions logging 897 flight hours in 2005, they only flew 36 missions totaling 123 flight hours in 2006. Interestingly enough, there were no surveillance or reconnaissance missions flown on hurricanes that year. Ten missions were flown in and around Hurricane Helene, but all of these were for research purposes. During 2006, the second AOC P-3 participated in an air quality study in the Houston and Dallas, Texas areas from the NASA site at Ellington Air Base, TX.

The NOAA Gulfstream, G-IV (SP) (N49RF), provides scientists with a platform for the investigation of processes in the upper troposphere and lower stratosphere (Figure 3-DOC-34). With an operating ceiling of 45,000 ft, the G-IV is a critical tool for obtaining the data necessary to improve hurricane and winter storm track forecasts and for research leading to improvements in hurricane intensity forecasts. The G-IV is also being used for air chemistry studies where a high altitude capability is required. In 2006, researchers also studied the role of Saharan dust on tropical storm development and intensity.

Figure 3-DOC-34. NOAA Gulfstream G-IV (SP)

The NOAA G-IV annually supports Hurricane Synoptic Surveillance missions where the aircraft flies in the environment surrounding the storm at a high altitude releasing GPS dropsondes at pre-selected locations (Figure 3-DOC-35). The data from these vertical atmospheric soundings are transmitted from the aircraft to the NCEP computer site where they are incorporated into the hurricane computer models to improve hurricane track forecasts. The dropsonde directly measures temperature, pressure, and humidity as it falls through the atmosphere to the surface, and computes wind speed and wind direction using a full-up GPS receiver. Recent estimates of the improvement in hurricane track predictions utilizing this aircraft and dropsonde are between 20 and 30 percent, resulting in a savings of $10 million or more per hurricane in warning and preparedness costs.

The NOAA G-IV also annually supports the Winter Storms Reconnaissance Program in an effort to improve forecasts released 24 to 96 hours before winter storms in the United States. This aircraft, in conjunction with the Air Force Reserve's WC-130s, utilize the GPS dropsondes to collect data on developing severe winter storms over the Pacific Ocean that will seriously impact the continental U.S. and Alaska. During one month of the two-month season, both aircraft operate in tandem, one from Alaska and the other from Hawaii, to collect data both north and south of the jet stream simultaneously. General improvement in forecast accuracy of up to 20 percent has already been seen, and even higher percentage improvements on individually targeted events have been realized from this program. Typically, during the final month of the program, the NOAA G-IV operates independently from either the base in Alaska or Hawaii as the case may dictate.

A recent additional mission for the G-IV was the support of the Saharan Air Layer Experiment (SALEX). The outbreaks of dry Saharan dust have been shown to have a dampening effect on the development of tropical cyclones in the Atlantic, and the G-IV, with its high altitude and dropsonde capabilities, is the ideal tool to study this phenomenon. Operating from Barbados, the most easterly island in the western Atlantic, this aircraft flew

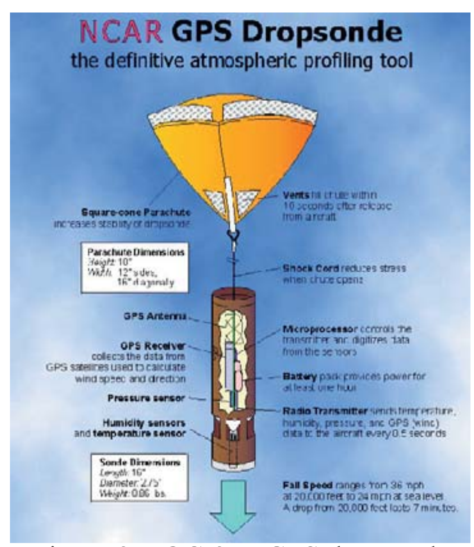


Figure 3-DOC-35. GPS dropsonde

six missions in 2006 on an a continuing study of the dust outbreaks.

NOAA's Chemical Science Division (CSD) of the Earth System Research Laboratory, located in Boulder, CO, is presently expanding its air chemistry capabilities on the G-IV beyond just ozone measurements with the addition of a proton transfer reaction mass spectrometer (PTR_MS). The PTR_MS provides in-situ measurements of volatile organic compounds (VOCs). A second instrument, which measure carbon monoxide (CO), is also being tested aboard the aircraft.

NOAA's atmospheric and oceanographic research, as well as its reconnaissance operations, is supported by two WP-3D Lockheed Orion aircraft (N42RF and N43RF) which carry a full array of state-of-the-art environmental research instrumentation (Figure 3-DOC-36). The aircraft research and navigation systems provide detailed spatial and temporal observations of a wide range of atmospheric and oceanic parameters. NOAA's Aircraft Operations Center (AOC) develops and calibrates specialized instruments, integrates user-supplied instrumentation into its automated data recording systems, and processes and analyzes data sets collected during various field programs.

Figure 3-DOC-36. NOAA WP-3 Orion

The AOC WP-3D aircraft, while executing the complex patterns for hurricane research, also provided storm data to the National Hurricane Center (NHC) in near real-time, transmitting flight level data, GPS dropsonde messages, as well as radar images via its multiple aircraft-satellite data links. With the Stepped Frequency Microwave Radiometers (SFMR) now on-line, increasing emphasis was placed on utilizing the NOAAWP-3D to map the surface wind fields in and around hurricanes and tropical storms in 2006. Real-time surface wind speed maps are critical to providing more accurate forecasts of the extent of hurricane and storm force winds.

The AOC aircraft also augment the Air Force Reserve reconnaissance aircraft during particularly active storm periods when tasking requirements exceed their available resources.

Each year, one of the NOAA WP-3Ds participates in a Hurricane Awareness Tour targeting, alternately, the Gulf and East coast regions of the U.S., those areas that are most vulnerable to land-falling storms. This educational outreach effort is directed at both middle-grade school children, the age group most likely to see, learn and convey a message home, as well as the general public. These tours are operated in concert with the participation of officials from NHC, the Red Cross, FEMA and other local and state emergency management personnel. This is becoming an increasingly popular and successful venture as coastal populations grow and the threat of an increasing number of storms place more people in harm's way.

During 2006, the two NOAA WP-3Ds supported three major research experiments. In support of NOAA's Hurricane Research Division, one of these aircraft participated in the Saharan Air Layer Experiment (SALEX), along with the Center's Gulfstream G-IV, flying missions into Hurricane Helene from a base in Barbados.

The NOAA WP-3Ds annually support both a summer and winter operation in support of a NESDIS satellite validation program. Operating in regions of high winds and heavy precipitation, one of the WP-3Ds, equipped with microwave scatterometers and radiometers, provide underflight validation of NOAA satellite-mounted QuickScat and WindSat sensed ocean surface wind vectors. Traditional venues for these operations are Alaska or Newfoundland in the winter and the Atlantic and Caribbean regions during the summer hurricane season.

During the summer of 2006, N43RF joined several other aircraft, operating in the Houston, TX area, and in the vicinity of the NOAA Ship Ronald H. Brown, operating in the Gulf of Mexico in the Texas Air Quality Study. Packed completely with an impressive array of in-situ chemical samplers and carrying three instrument pods mounted beneath its wings, the aircraft took measurements of a wide range of chemical constituents at low altitudes over the urban and rural landmass as well as the marine boundary layer. Additionally, atmospheric profiles were made from the surface to the maximum altitude capability of the aircraft (~25,000 ft). A number of flights at a wide range of altitudes were made over and around the metropolitan areas of Houston and Dallas. This research was in support of the Chemical Science Division of the NOAA Earth System Research Laboratory (ESRL).

In FY2006, AOC received a supplemental budget (Hurricane Katrina Supplemental)of approximately $13.5M to acquire a third P-3 aircraft, to buy dropsondes and to make major improvements to the WP-3D instrumentation. The upgrades to be made on the existing WP-3Ds include improvements to the radar data system, new tail Doppler radar antennae, upgrades to avionics and navigation systems including replacement inertial navigation units with GPS, new cloud particle measuring systems, a new generation GPS dropsonde and a new research data system. The 3rd P-3 has been acquired to provide an additional platform to support non-hurricane related research missions that are scheduled to occur during the hurricane season in future years. An additional $4.6M in capital acquisition funds were received in FY2007 to further modify and ready this aircraft to carryout these specialized NOAA research missions.

A NOAA AC-695A Commander 1000 (N45RF) and a NOAA AC-500 Shrike (N51RF) are used annually to conduct important snow pack surveys in the northern and western continental U.S., Alaska, and southern Canada (Figure 3-DOC-37). During these survey flights, the gamma radiation sensors aboard these aircraft measure the naturally occurring terrestrial radiation emitted from the ground to obtain snow water-equivalent estimates. This data is transmitted to the National Operational Hydrologic Remote Sensing Center (NOHRSC) up to three-times a day from each aircraft, and after further processing the data is distributed to NWS field offices within five minutes of receipt from each aircraft. These data are used by the NWS to forecast river levels and potential flood events resulting from snowmelt water runoff. Hydroelectric power interests and other water supply managers also use the data to regulate water storage and delivery.

An important component of the 2006 Texas Air Quality Study was a differential absorption lidar (DIAL) deployed on a NOAA DeHavilland Twin Otter (DHC-6) aircraft for remote sensing of local and regional ozone and aerosol distribution. Airborne remote sensing enables tracking of plumes from urban areas and point sources, identification of isolated regions and layers of high ozone concentration, observations of atmospheric layering as characterized by aerosol structure, and investigation of local meteorological effects such as sea breezes and urban heat islands on pollution transport and mixing. Inclusion of a remote sensing aircraft also provided information on the three-dimensional representativeness of in situ observations made on the NOAA WP-3D and other aircraft during those periods when the flight tracks of the two aircraft sample the same region.

Figure 3-DOC-37. NOAA JetProp Commander - N45RF.

SECTION 3

DEPARTMENT OF DEFENSE WEATHER PROGRAMS

The Department of Defense (DOD) operates military environmental services to provide specialized worldwide meteorological, space environmental and oceanographic analysis, and prediction services in support of military forces and joint operations. Military environmental services directly support all phases of military operations from strategic planning to tactical operations. While the Army and Marine Corps each have a small weather operations capability, the Navy and Air Force are the primary sources of military weather products and services. The military weather services contribute to the national and international weather observing capability by taking conventional observations on land and at sea where there are no other conventional weather observing capabilities and where the observations are most needed to meet military requirements. In addition, DOD maintains specialized observing capabilities, such as the Defense Meteorological Satellite Program to meet unique military requirements. Observational data are sent through military communications systems to military and civil facilities in the United States and overseas.

UNITED STATES AIR FORCE

METEOROLOGICAL AND SPACE ENVIRONMENTAL SERVICES

Air Force weather forces provide high-quality, mission-tailored terrestrial and space environment observations, forecasts, and services to the United States Air Force (USAF), United States Army (USA), and a variety of United States Government (USG) departments and agencies. See Section 3, United States Army, for details of Air Force Weather (AFW) support to the Army.

AFW ORGANIZATION

AFW is functionally organized under the Director of Weather (AF/A3O-W), Directorate of Current Operations and Training (AF/A3O), Deputy Chief of Staff for Air, Space, and Information Operations, Plans and Requirements (AF/A3/A5), Headquarters Air Force.

The Director of Weather oversees Air Force-wide training, organizing, and equipping of AF weather organizations to include the following functions:

- Development of doctrine, policies, requirements, and standards for weather support
- Evaluation of weather support effectiveness
- Management of weather officer, enlisted, and civilian career fields
- Development and implementation of mid- to long-range plans for the organization, equipment, manpower, and technology necessary to meet future Air Force and Army weather requirements
- Advising Air Staff and subordinate headquarters weather functional managers regarding manpower, career field management, personnel utilization, training, operations policy and procedures, and technology acquisition
- Advocating and fielding standardized weather equipment

AF weather operations provide a Total Force capability employing over 4,200 Active Duty (AD) and Reserve Component (RC) military and civilian personnel supporting Air Force and Army conventional and SOF worldwide. The majority of AF weather personnel are focused on two distinct, yet related functions: characterizing the past, current, and future state of the natural environment and exploiting environmental information to provide actionable environmental impacts information directly to decision-makers.

Environmental characterization is typically accomplished in large, centralized units focused primarily on global and regional scales of weather, whereas support to decision-makers is primarily the realm of personnel embedded in operational units. Normally, these personnel are assigned to weather flights under the operations support squadron of a flying wing, a weather squadron collocated with a supported Army unit, or a weather squadron providing a unique capability such as space launch support. These weather squadrons may include geographically separated detachments and operating locations.

The centerpiece of global-scale collection and production is the Air Force Weather Agency (AFWA), Offutt AFB, NE, a field operating agency reporting directly to the Air Force Director of Weather. AFWA provides timely, accurate, relevant, and consistent terrestrial and space weather products necessary to effectively plan and conduct military operations at all levels of war. AFWA also provides dedicated support to SOF and the Intelligence Community (IC). The agency consists of a functional management headquarters, the 1st Weather Group (1 WXG) with four subordinate CONUS operational weather squadrons (OWS), the 2nd Weather Group (2 WXG) which operates AFWA's global processing center, two subordinate centers (the Air Force Combat Climatology Center (AFCCC) and the Air Force Combat Weather Center (AFCWC)), and 11 detachments and operating locations.

The 1 WXG commands four operational weather squadrons performing CONUS missions: 15 OWS at Scott AFB, IL, 26 OWS at Barksdale AFB, LA, 25 OWS at Davis-Monthan AFB, AZ, and 9 OWS at Shaw AFB, SC. The 2 WXG, collocated with HQ AFWA at Offutt AFB, NE, consists of the 2nd System Operations Squadron (2 SOS) which provides automated weather characterization on a global scale, and the 2nd Weather Squadron (2 WS) which provides global coverage of forecaster-in-the-loop products to exploit the weather as well a providing backup for five national weather centers. AFCCC, Asheville, NC, provides centralized climatological database services, produces specialized weather-impact information for the Department of Defense and allied nations, and warehouses and distributes atmospheric science-related technical information. From Hurlburt Field, FL, AFCWC transitions technology to support tactical-level weather operations while developing operational concepts, tactics, techniques, and procedures.

Eight operational weather squadrons form the backbone of regionally focused weather operations, providing a variety of weather forecast products and support to units assigned and/or deployed into their AOR. These AORs are depicted in Figure 3-DOD-1. OWSs produce and disseminate terminal aerodrome forecasts, weather watches, warnings, and advisories, planning and execution area forecasts, and other products using the OWS Production System Phase II (OPS II). OWSs also provide theater-scale, tailored environmental information to guide development of mission execution forecasts by AC and RC weather personnel embedded in operational units. Moreover, OWSs provide flight weather briefings to aircrews operating within their AOR without home station support or as requested by base or post-level weather forces.

At base and post level, weather forces take and disseminate local observations and develop tailored mission execution forecasts based on centrally produced guidance. These personnel also act as "eyes forward" for OWS. Weather personnel supporting conventional AF operations typically deploy with a New Tactical Forecast System (N-TFS), hand-held Kestrel observing kits, and the TMQ-53 semi-automated observing system for semi-permanent sites. This equipment, coupled with adequate communications to receive weather data, including satellite imagery, provide the essential capability required for deployed weather forces to meet operational requirements.

The RC is composed of the Air Force Reserve Command (AFRC) and the Air National Guard (ANG). AFW continues to integrate these forces to more closely align with AD weather force operations. Air Force reservists augment the AD at all levels. To augment OWS, AFRC recently organized two operational weather flights (OWF),

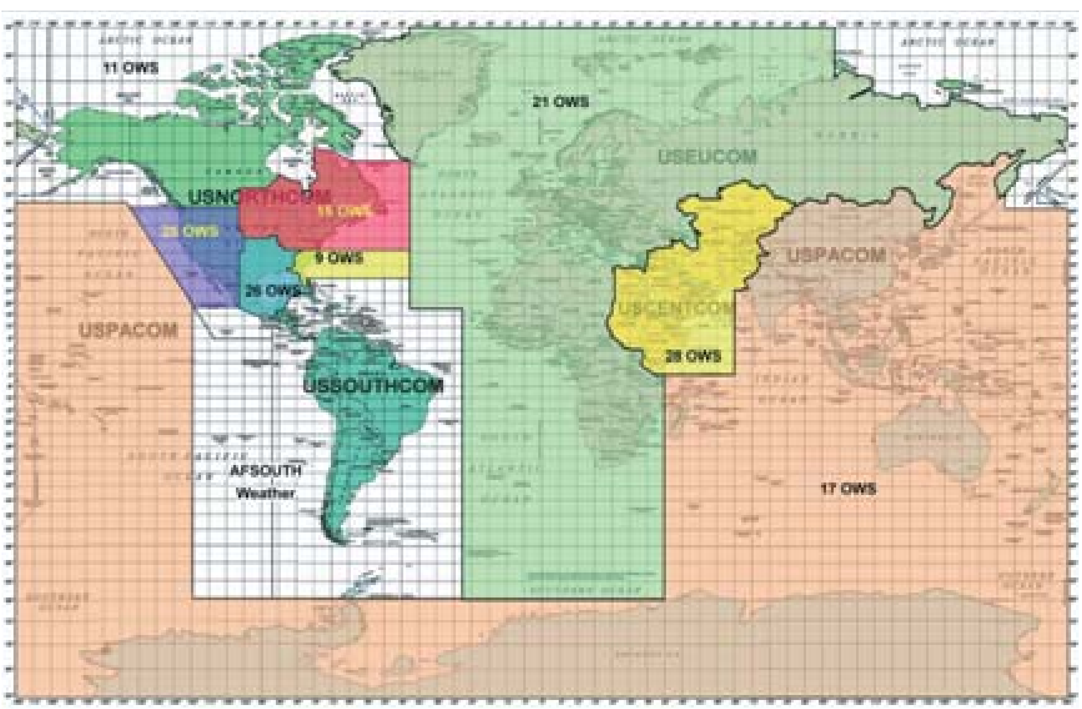


Figure 3-DOD-1. Air Force Operational Weather Squadron (OWS) areas of responsibility (AORs) overlaid on geographic combatant commander AORs.

each with over 20 traditional reserve positions. The OWF traditional reservists perform at least one weekend of drill monthly and 2 weeks of duty each year unless mobilized to the active force. Approximately 50 additional weather personnel serve as AFR individual mobilization augmentees (IMAs) assigned to various active AFW organizations at all echelons, typically in staff or scientific roles. IMAs normally train one day each month and for an additional two weeks each year.

The ANG traditional program consists of 27 weather flights, ranging in size from 13 to 25 personnel, who meet monthly to train for their wartime mission. These flights provide weather information to ANG and United States Army Reserve units. Many ANG flying wings also have up to five personnel to provide weather operations for each wing's flying mission. The ANG also provides peacetime weather operations at locations where the ANG is responsible for airfield operations. The Weather Readiness Training Center at Camp Blanding, near Starke, FL, is also operated by the ANG to provide weather force operations training.

CHARACTERIZE THE ENVIRONMENT

To characterize the environment across the globe, AF weather forces continually improve the core processes of collection, analysis, and prediction.

Collection

AF weather forces collect terrestrial and space environmental measurements from ground-, sea-, air-, and space-based sensors across the globe. While openly shared foreign data greatly improves the coverage of measurements across the globe, the Department of Defense retains an assured global weather collection capability. In regions where air, space, and land operations are occurring, environmental data may be insufficient; consequently, the AF maintains a capability to deploy and establish an in-theater environmental data collection network.

AF weather personnel take observations essential for effective military operations. Weather personnel at both Air Force and Army locations (garrison and deployed) make observations available to local users and transmit them to military and civil locations throughout the world for subsequent weather analysis and forecasting. United States and foreign rawinsonde reports are primary sources of upper air observations. These observations are supplemented with military and civilian pilot reports. The Army's Forward Area Limited Observing Program (FALOP) and the Army artillery meteorology (ARTYMET) program augment Air Force observations in the tactical environment. Weather data is also received from DOD-operated HF radio receiver sites strategically positioned around the globe to intercept weather broadcasts. These broadcasts originate from nations that do not routinely make data available through World Meteorological Organization channels.

The Observing System 21st Century (OS-21) program will provide a much-needed, state-of-the-art life-cycle replacement for Air Force observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. The manual configuration is intended for tactical operations. It continues the improvements begun under the Manual Observing System and Tactical Meteorological Observing System Modification programs. AFW began fielding the fixed-base automated observing system -- and will continue to do so through 2008. The remaining configurations will be upgraded or replaced after fielding of fixed-base automated systems nears completion.

Weather radar data is vital to the production of timely severe weather warnings. DOD, the FAA, and Department of Commerce (DOC)/National Weather Service (NWS) operate and maintain WSR-88Ds within CONUS, and the Air Force operates and maintains WSR-88Ds overseas. The Air Force transitioned to the open architecture Open Principal User Processors (PUPs) at installations with stand-alone legacy PUPs and at all CONUS and Pacific Air Forces OWS, allowing these regional forecasting centers real-time access to WSR-88D radar data at locations for which they have remote forecasting responsibility. Tactical weather radars provide fixed Doppler radar coverage for major overseas installations not covered by the WSR-88D. Ellason weather radars provide a deployable weather radar capability for worldwide military contingency operations. Weather radar data extracted from air surveillance radars and displayed using the Digital Weather Intelligence Data system supplement primary weather radar data, and provide data from areas without primary weather radar coverage.

The AFRC's 53d Weather Reconnaissance Squadron (53 WRS), also known as the "Hurricane Hunters," provides another means of collecting vital meteorological data, especially in and around tropical cyclones. Their specially equipped WC-130J aircraft collect temperature, moisture, wind, pressure, and visually observed information at the aircraft location as well as vertical profiles of the atmosphere collected by dropsondes. Hurricane Hunter aircraft penetrate the eyes of tropical cyclones to provide the National Hurricane Center a very accurate center fix location as well as other meteorological parameters, including sea level pressure (Figure 3-DOD-2). In addition to the tropical cyclone reconnaissance, the 53 WRS collects meteorological information to improve wintertime West Coast forecasts and to support scientific field programs when possible.

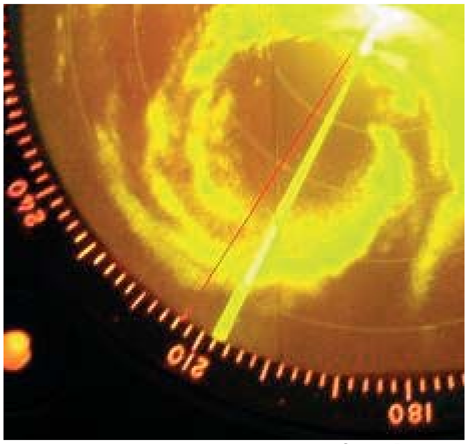


Figure 3-DOD-2. Aircraft radar shows the eye of Hurricane Claudette is 25 nautical miles wide and the wall cloud is weakest in the northeast quadrant (53 WRS website)

The Defense Meteorological Satellite Program (DMSP), which provides cloud, upper air, and space environmental data, is a vital source of global weather data used to support combat operations. On-board sensors provide AFWA and the Navy's Fleet Numerical Meteorology and Oceanography Center with visible, infrared, and microwave imagery, temperature and moisture sounding data, electrically charged particle fluxes, and other specialized space environment data. The DMSP also supplies direct, real-time readout of regional imagery and mission-sensor data to DOD land-based and shipboard terminals located worldwide (Figure 3-DOD-3).

The DMSP satellite constellation uses the Operational Linescan System to provide visible and infrared imagery to distinguish between clouds, ground, snow, and water. The Block 5D-2 series spacecraft flies the Special Sensor Microwave Temperature SSM/T-1) and water vapor (SSM/T-2) sounders. Processing algorithms convert the sensed data into vertical temperature, moisture, and height profiles of the atmosphere, providing key data for numerical analysis and forecasting. The Special Sensor Microwave Imager (SSM/I) collects data from which rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data can be determined. The Special Sensor for Ions and Electrons (SSIES), Special Sensor Magnetometer (SSM), and the Precipitating Electron and Ion Spectrometer (SSJ), measure the space environment on the topside of the ionosphere in situ. The Block 5D-3 series spacecraft and sensor suite began service in 2004 with the launch of DMSP Flight 16. These spacecraft add several new capabilities: enhanced microwave imaging and atmospheric temperature/moisture sounding through the Special Sensor Microwave Imager/Sounder (SSMIS); new auroral boundary and electron density measuring capability through the Special Sensor Ultraviolet Spectrographic Imager (SSUSI); and profiles of upper-atmospheric temperature, electron content, and species densities through the Special Sensor Ultraviolet Limb Imager (SSULI). These are in addition to SSIES, SSM, and SSJ sensors.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will replace the existing DMSP and NOAA polar-orbiting satellite programs beginning in 2013, and is a joint DOD, DOC, and National Aeronautics and Space Administration (NASA) program. The AF also expects to gain operational experience as well as benefit from the risk reduction planned with the NPOESS Preparatory Program planned for launch in 2009. In January 2006, the program was expected to exceed its approved program baseline by 25 percent. This required the Department of Defense to recertify the program to Congress in accordance with the Nunn-McCurdy Amendment of the 1982 Defense Authorization Act. AFWA hosted and provided information on operations and requirements to Integrated Product Team 2 (IPT-2). IPT-2 was charged with assessing alternatives for the program. The certification resulted in a reduced configuration. One of three orbits was eliminated and will be augmented by the polar-orbiting constellation of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). The number of satellites was reduced from six to four. Some non-Key Performance Parameter sensors were removed and the Conical Microwave Imager/Sounder was terminated and will be reworked.

In addition to DMSP polar-orbiting data, AFWA receives stored data from the DOC's Polar-orbiting Operational Environmental Satellite constellation and real-time high-resolution data from the DOC's Geostationary Operational Environmental Satellite (GOES) East and West; EUMETSAT's Meteosat-5, -7, -8, and -9 geostationary satellites; and the Japanese Multi-functional Transport Satellite (MTSAT). AFWA currently receives data from NASA's Tropical Rainfall Measuring Mission (TRMM), Quick Scatterometer (QuikSCAT), and AQUA Advanced Microwave Scanning Radiometer-E (AMSR-E) via Direct Asynchronous Transfer Mode (ATM) System-Unclass (DATMS-U).

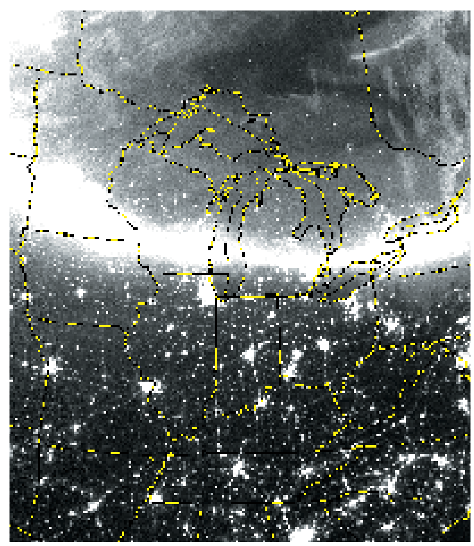


Figure 3-DOD-3. DMSP captures Aurora Borealis, over the Midwest; the aurora was pushed toward the equator by a November 4, 2003, geomagnetic storm. (AF Weather website)

Moderate Resolution Imaging Spectroradiometer (MODIS) data is currently received via the Defense Research Engineering Network (DREN).

Next generation satellite programs, in particular NPOESS and GOES-R, require that AFWA reengineer the way it receives, stores, and processes meteorological satellite (METSAT) data, as well as how it exposes and delivers that data to internal and external users. AFWA is partnering with Electronic Systems Center (ESC) on the METSAT Data Exploitation Capability program. Over the coming several years, METSAT Data Exploitation Capability (MDEC) will engineer and implement state-of-the-science solutions for these capabilities and define the "to be" enterprise software and system architecture for optimal exploitation of METSAT data from current and future programmed satellites.

Space environmental information is obtained through a combination of ground- and space-based systems. For the near-Earth environment, ground-based systems provide highly accurate point source verification and specification, whereas space-based systems enable global coverage and theater-wide situational awareness.

AFWA operates the Solar Electro-optical Observing Network (SEON), a system of ground-based telescopes at Sagamore Hill, MA; Holloman AFB, NM; Palehua, HI; San Vito, Italy; and Learmonth, Australia (Figure 3-DOD-4). This network provides 24-hour observations of solar phenomena at optical and radio wavelengths. A worldwide (primarily Northern Hemisphere) network of ground-based ionosondes and other sensors provide ionospheric data. The AF manages 16 automated Digital Ionospheric Sounding Systems (DISS) to measure electron density profiles in the ionosphere. NASA's Jet Propulsion Laboratory operates a complementary global network of over 125 sensors deriving ionospheric line-of-sight total electron content from global positioning system (GPS) signals and provides these data to AFWA's Space Weather Branch. In addition, the United States Geological Survey operates a network of ground-based magnetometers, primarily in the northern hemisphere, which provides the Space Weather Branch with critical measurements of the geomagnetic field and its variances. Air Force Research Laboratory at Wright-Patterson AFB, OH, provides ionospheric scintillation data from a global network of 15 UHF and L-Band receivers, supporting AF C2 satellite systems and strategic long-range radar systems.

From space, the GOES satellites provide real-time solar X-ray, charged energetic particle, and geomagnetic data through the Space Environment Center (SEC). The Solar X-Ray Imager, which became operational 30 January 2003, aboard GOES-12, monitors solar emissions in the X-ray portions of the solar spectrum and provides near real-time display at AFWA and the SEC. The DMSP, NOAA, and other DOD geostationary satellites provide charged energetic particle data in low-Earth and geosynchronous orbits. Additionally, the AF leverages space-based data from NASA and other agencies. For example, NASA's advanced composition explorer satellite provides real-time solar wind data critical for forecasting geomagnetic disturbances and their impact to warfighter communications.

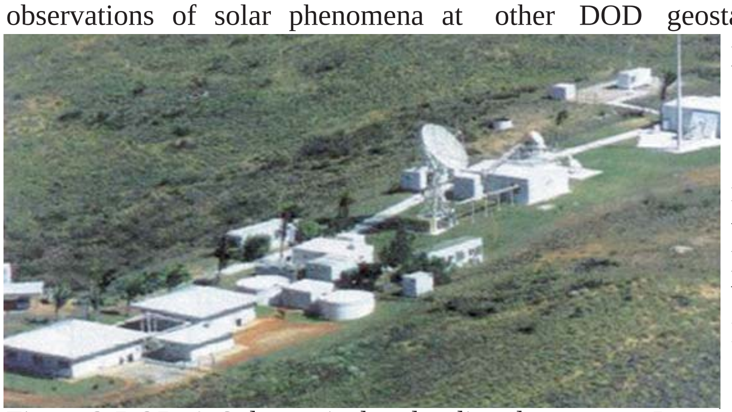


Figure 3-DOD-4. Solar optical and radio telescopes at Learmonth, Australia. (US Air Force Released)

Analysis and Prediction

Effective analysis of collected terrestrial and space weather data enables identification of environmental features and conditions that may affect air, space, and land operations and thus require subsequent monitoring. From that analysis, detailed forecasts are developed through a combination of computer models and skilled human intervention.

AFWA's 2 SOS is the AF's main automated production capability for global space and terrestrial weather analyses and forecasts. Worldwide conventional weather data are relayed to 2 SOS and combined with civil and military meteorological satellite data to construct a real-time, integrated environmental database. Computer programs further process the data to construct models of the atmosphere and forecast its future behavior.

The Global Theater Weather Analysis and Prediction System (GTWAPS) is the AFWA hardware enclave (IBM Scalable Parallel Computing and pSeries® servers) used to run most meteorological models at AFWA. The key software component of GTWAPS is a theater analysis and forecast model which provides fine-scale forecasts (Figure 3-DOD-5). During Operations ENDURING FREEDOM and IRAQI FREEDOM, AFWA initiated various model window locations and resolutions as mission requirements dictated. The highly responsive nature of the MM5, and the way AFWA employs it, permitted new contingency windows to be operational within hours. Advancements in cloud modeling have enabled GTWAPS to produce high-resolution products that became a mainstay of weather data during the continuing GWOT. AFWA is transitioning

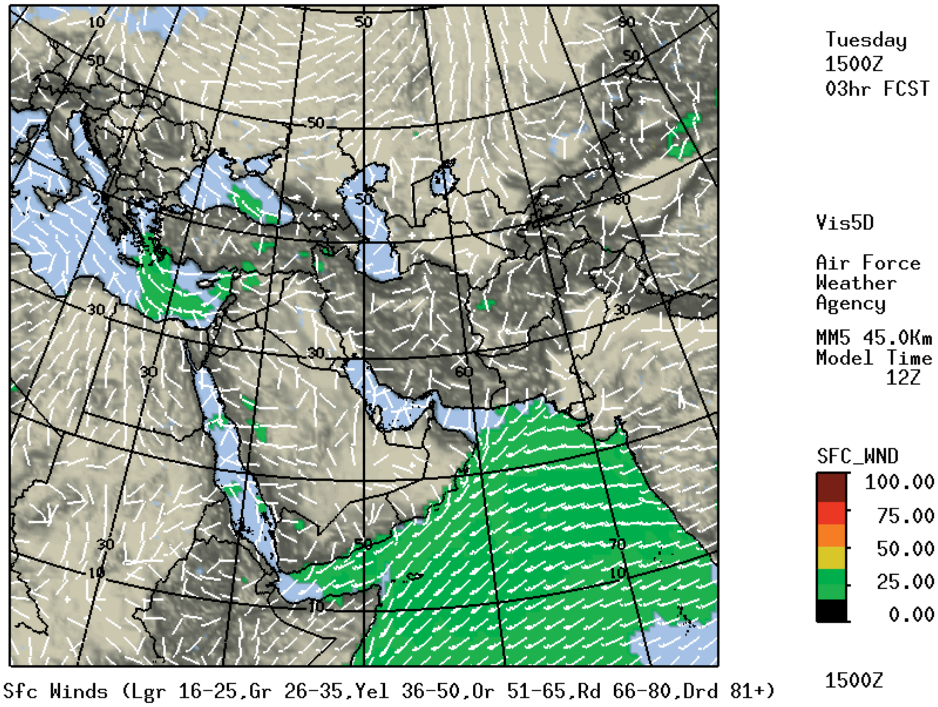


Figure 3-DOD-5. Joint Air Force and Army Weather Information Network (JAAWIN) provide reachback capability for deployed weather forces. This 3-hour forecast of surface winds over Southwest Asia was generated from AFWA's 45-km MM5 (AFWA Website)

from Mesoscale Model version 5 (MM5) to the Weather Research and Forecasting (WRF) model as its operational theater scale model.

AFWA's replacement of MM5 with the WRF model is underway. WRF will possess the responsiveness of MM5 but also has the ability to interchange different microphysics modules within the model. AFWA will leverage this capability to tailor model output for different theaters. AFWA will decommission MM5 windows and replace them with WRF model output. Additionally, AFWA will leverage NCEP's WRF model output for North American regions and run WRF over other areas of the world.

On-going modernization initiatives at AFWA include the Space Weather Analysis and Forecasting System (SWAFS) and the Weather Data Analysis Capabilities (WDAC) program. SWAFS will integrate additional space weather data sources and execute next-generation space weather models for DOD and IC operations. WDAC will continue the modernization of AFWA as a key component of the Air Force Weather Weapon System (AFWWS). The transformed AFWA will provide standards-compliant hardware and software tools, a central 4-D database, and a classified processing environment to modernize the AFWWS communications and data processing infrastructure. WDAC provides a significant increase in the database capability by standing up Joint DOD-approved metrological and oceanographic (METOC) database segments, promoting interoperability among data sharers. WDAC, using the Joint METOC segments and the Joint METOC Broker Language (JMBL) for Web services, will improve the interoperability with DOD C2 and command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) systems by providing a common interface to request the wide range of weather information. In addition, WDAC-developed components, including the Consolidated Dissemination Capability (subscription services), are reusable within the OWS. This reusability will allow OWS-unique data to become part of the overall AFWWS 4-D database.

AFWA's 2 WS METSAT flight analyzes imagery, and produces rapid response, tailored METSAT imagery for DOD contingency operations and generates automated METSAT imagery products for Web-based distribution to DOD users. The flight also tracks and classifies tropical cyclones for the DOD Joint Typhoon Warning Center (JTWC) and the DOC National Hurricane Center; and serves as the DOD focal point for volcanic ash plume detection, advisories, and trajectory forecasts; and provides backup for both JTWC satellite operations and the DOC's Washington Volcanic Ash Advisory Center. In addition, the METSAT Flight produces worldwide snow and ice cover analyses to update and refine the snow depth database and generates customized snow depth and dust event analyses for contingency areas. During Operation IRAQI FREEDOM, flight imagery specialists provided high-resolution analyses of oil fire initiation points for smoke plume dispersion forecast model products. These smoke plumes impacted both air and land operations. Advance notice allowed mission planners to modify operations to maximize mission effectiveness. The flight also develops new capabilities to display and visualize satellite imagery on workstations and infuses state-of-the-art techniques into improved imagery analysis.

The 2 WS space flight employs a suite of state-of-the-art space weather models to specify current solar and global characteristics, extrapolate space weather phenomenon to areas of the globe where observations are not currently available, and to forecast future conditions. These models use available observations and include both climatology-based and physics-based algorithms. Some of the more significant models employed include the following. A Kp analysis and prediction algorithm provides realtime analysis of Kp and a 1- and 4-hour prediction. A Dust prediction algorithm provides a 1-hour Dust forecast. The newly implemented Global Assimilation of Ionospheric Measurements (GAIM) model provides large scale, global ionospheric specification every 15 minutes and a 24-hour forecast capability every hour. The climatology-based WIDEBAND model provides scintillation forecasts. The branch uses the Magnetospheric Specification and Forecast Model to specify and predict (for 3 hours) the lower energy particle environment. The newly implemented Radiation Belt Environments model provides specification of the higher energy particle environment. The relativistic Electron Prediction model provides a 27-day prediction of relativistic electron behavior at geostationary altitude. For the solar wind, the branch uses the Hakamada-Akasofu-Fry solar wind model, capable of producing a 96-hour forecast of solar wind parameters, including the tracking of Coronal Mass Ejections. Several other applications are also employed to calculate other important space weather related parameters.

As the sole source of DOD space environmental information, AFWA's Space Flight partners with NOAA's Space Environment Center to meet the Nation's military and civilian space weather needs and provides a suite of automated and manually tailored analyses and forecasts (including advisories and warnings) of space weather phenomena that affect military operations and IC activities. Similarly, signal fades due to space weather effects on UHF satellite communications links provide valuable planning information to improve C2 capabilities. Further examples of model output informational products include Single-Frequency GPS Receiver Error maps (Figure 3-DOD-6, UHF Satellite Communication Scintillation maps (Figure 3-DOD-7), HF Illumination maps (Figure 3-DOD-8)), and Radar Auroral Clutter maps. These products assist warfighters in determining and mitigating space weather impacts to their systems as well as in exploiting enemy space weather susceptibilities for possible asymmetric advantage.

The Air Force Combat Climatology Center (AFCCC) is collocated with the National Climatic Data Center to facilitate cooperation and data exchange. AFCCC collects, quality assures, and assesses worldwide surface and upper air observations, satellite-derived soundings, numerical model output such as global gridded surface and upper air model data, a global 3-dimensional cloud analysis (worldwide merged cloud analysis), a global analysis of snow cover, and other specialized environmental data sets. AFCCC exploits these data to generate standard climatic summaries of meteorological phenomena for points around the globe, such as Operational Climatic Data Summaries and Wind Stratified Conditional Climatologies. Modeled climatologies are produced using the Advanced Climate Modeling and Environmental Simulations (ACMES) model. Analyses are available to develop tailored products to meet new requirements. AFCCC employs the Point Analysis Intelligence System to produce vertical profiles for any point on earth for any time from 1985 to the present.

The Air Force Director of Weather carries out the DOD Air and Space Natural Environment Modeling and Simulation Executive Agent (ASNE MSEA) responsibilities. The DOD ASNE MSEA ensures DOD communities who use simulations for their training, acquisition, testing, planning, experimentation, and analysis have the right tools, infrastructure, and databases necessary to represent the air and space natural environment and its effects. To do this, the DOD ASNE MSEA works closely with government and industry meteorology and space environment tools and data providers like the Air Force Weather Agency, National Geophysical Data Center, and

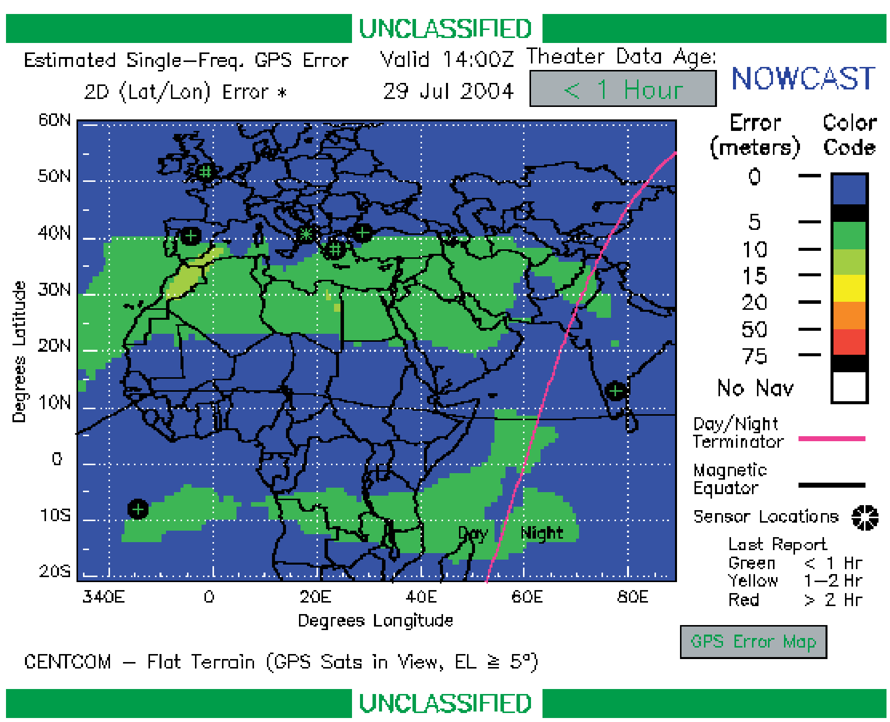


Figure 3-DOD-6. Single-Frequency GPS Receiver Error Map (visualization by HQ AFWA)

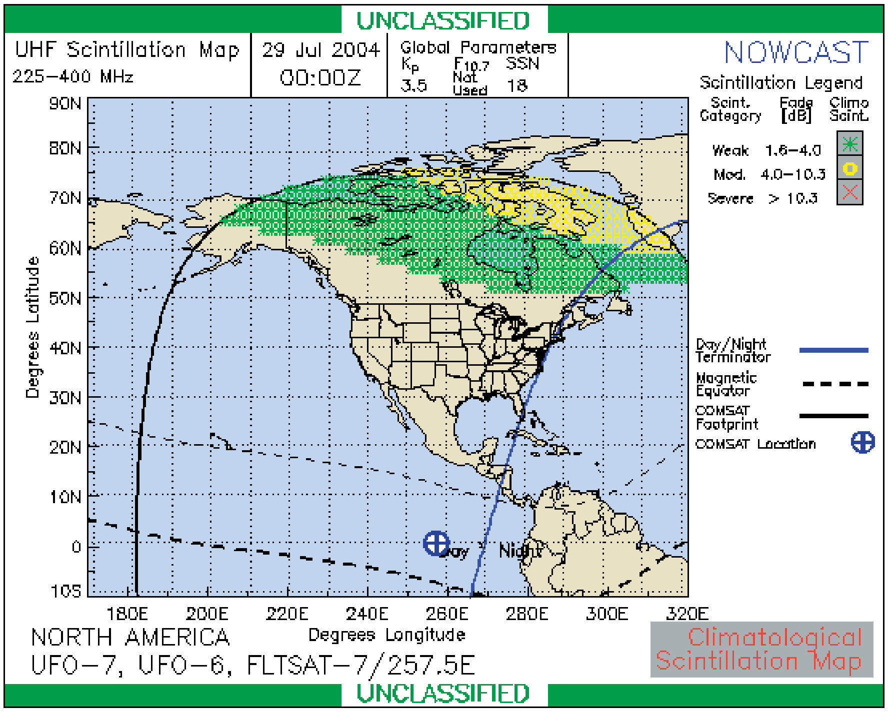


Figure 3-DOD-7. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

others. The executive agent keeps abreast of both current and emerging capabilities within the field of meteorology and the space environment enabling identification of gaps in these capabilities to meet DOD environmental requirements for live, virtual, and constructive simulations. Often, the MSEA is required to champion development and transition of new technologies at government resource centers like those mentioned above. The DOD ASNE MSEA also works closely with the Ocean MSEA (Navy, CNMOC) and the Terrain MSEA (NGA) to ensure a consistent, integrated natural environment is represented in the synthetic environment of a simulation. In 2007, the ASNE MSEA successfully transitioned a new technology, the Environmental Scenario Generator (ESG), which will help facilitate assembling a consistent, integrated natural environment from distributed centers nationwide. The core ESG system was transitioned to the Air Force's Combat Climatology Center for long-term operational support of the DOD with future capabilities being integrated from the National Geophysical Data Center (Boulder, CO), the Naval Oceanographic Center (Stennis, LA), and future NGA centers of excellence.

OWSs are AFW's regional/theater analysis and forecast centers for Air Force and Army operations. OWS generate a variety of products: hazard charts; drop zone, range, and aerial refueling track forecasts; fine-scale target forecasts; airfield forecasts; and weather warnings, watches, and advisories for Air Force and Army installations within their AOR. OPS II, a component of the Forecasting System 21st Century (FS-21) program to provide necessary computer hardware and software throughout the AFWWS, is the OWS's primary production tool. A hybrid of software, databases, servers, and workstations, OPS II facilitates production and dissemination of weather information to supported forces.

<u>Provide Actionable Environmental Impacts Information to Decision Makers</u>

To provide actionable environmental impacts, AF weather forces continually improve the core processes of tailoring and integration.

<u>Tailoring.</u> Once centralized weather units create a depiction of the past, current, and future state of the natural

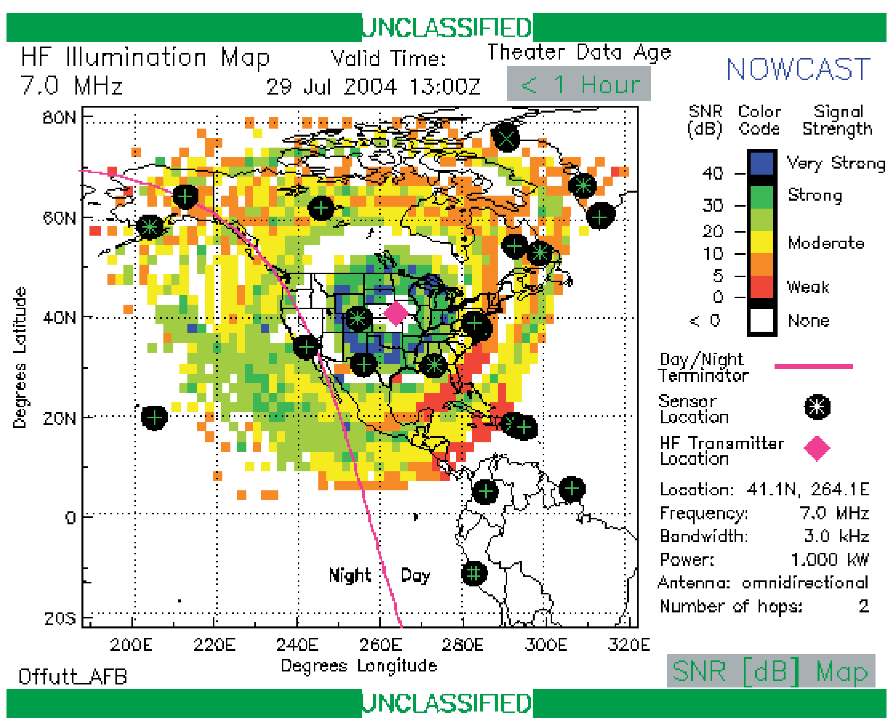


Figure 3-DOD-8. HF Illumination Map (visualization by HQ AFWA).

environment, AF weather forces directly supporting decision-makers tailor the information to identify impacts to operations, personnel, weapons and weapons systems, and tactics. These weather forces then help decision makers mitigate these effects through appropriate actions such as routing a flight to a new target, selecting a different weapons load, or adjusting the time of attack.

N-TFS, another component of FS-21, provides garrison and deployed weather forces with the meteorological tools to manipulate and disseminate graphical and alphanumeric products (satellite imagery, graphical forecast products, weather forecasts, advisories, briefings, observations, etc.) to Army and AF operations, C2, and support forces worldwide. Additionally, N-TFS ingests data from AF and indigenous observing sources, which then are forwarded to OWS/AFWA for further dissemination and incorporation into centrally produced models.

AFW is currently working toward a single workstation that will eliminate redundancies and/or inefficiencies and ultimately extend, consolidate and/or replace the OPS II, Joint Weather Impact System (JWIS), N-TFS, and the weather effects decision-aids portion of the Integrated Meteorological System (IMETS). The Joint Environmental Toolkit (JET) is expected to enhance warfighter awareness of the natural battlespace environment by ensuring accurate, timely, relevant, and consistent terrestrial and space weather and weather impacts information is available and accessible by appropriate personnel and processes. JET will perform its functions by interfacing with information contained in the Virtual Joint Meteorological Oceanographic Database via common-user-communications. Additionally, JET will integrate with joint and coalition C2 and mission planning systems by enabling machine-to-machine exchange of METOC and C4ISR data and information to meet operational, planning, and execution requirements. Furthermore, JET enhances the accuracy and utility of terrestrial/space weather and oceanographic information and operational impacts by enabling the forecaster and/or forecast process to incorporate Geographic Information System (GIS) capabilities (to include a standard high-resolution topographic database), forecasting rules of thumb, and operational thresholds into weather and weather impact products. In July 2004, two contractors were selected for a fly-off. After a 20-month source-selection process, Raytheon was awarded the JET contract on 28 March 2006. Fielding of the first increment is expected to begin in early 2008, with and expected delivery of all JET capabilities by FY 2013.

Tactical Decision Aids (TDAs) provide warfighters an automated way to "visualize" environmental impacts on operations. These tools, which continue to be integrated into C2 systems (e.g., mission planning systems), include Target Acquisition Weapons Software (TAWS) (Figure 3-DOD-9), Infrared Target Scene Simulation (IRTSS), and Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA). The Air Force Research Laboratory (AFRL), the Navy's Space and Naval Warfare Systems Command, the Navy Research Laboratory (NRL), and the Army Research Laboratory (ARL) are developing these modular programs. TAWS provides a joint mission-planning tool to combine platform, weapon, target, background, and weather impacts to depict three-dimensional target acquisition and lock-on range and recognition range versus time. This includes prediction of environmental impacts on night vision goggles and low light-level systems used by air, naval, and ground forces to execute nighttime operations. IRTSS uses detailed terrain information and multispectral imagery with TAWS weather inputs to generate forecast target scene images for mission rehearsal. The T-IWEDA uses envi-

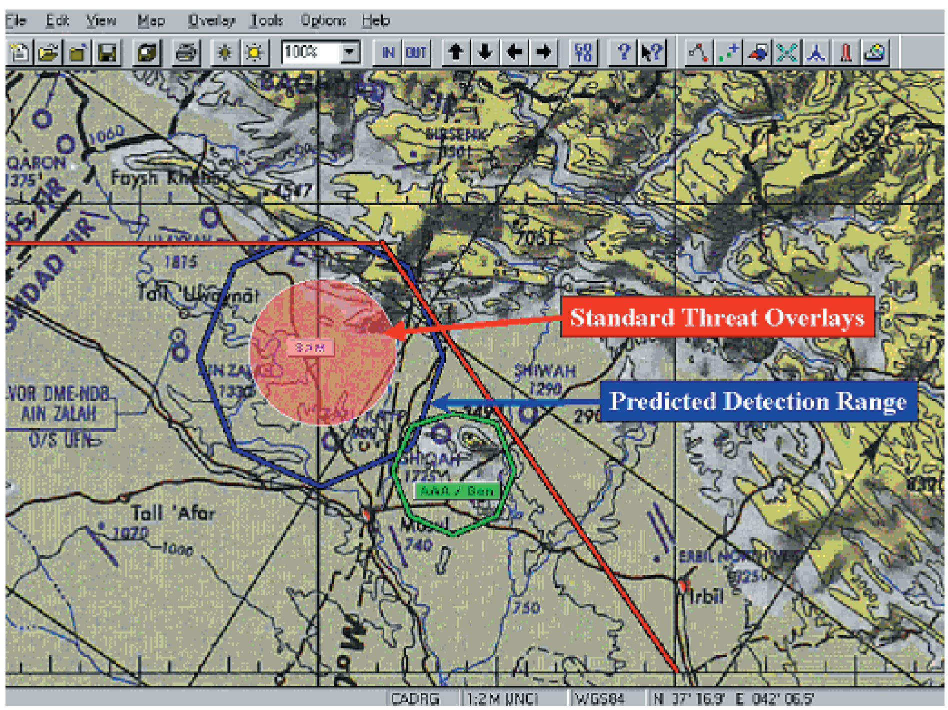


Figure 3-DOD-9. Target Acquisition Weapon Software (TAWS) integrates meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution. (US Air Force Released)

ronmental data with force, mission, and/or individual weapons rules of engagement or performance parameters to automatically generate mission-impact forecasts for large-scale planning efforts such as air tasking order preparation. TAWS, IRTSS, and T-IWEDA integrate environmental impacts into the mission execution forecasts for C2 and mission planning (MP) systems throughout the military planning and execution cycle. The TDA program continues adding weapons systems and targets at the request of users from the Services. Additional decision aids in development or in coordination include the airborne laser (ABL) atmospheric decision aid to support ABL development and operations and a common radio frequency (RF) system performance prediction capability based on US Navy software.

AFWA's 2 WS Special support operations flight generates a myriad of products ranging from air refueling forecasts, to detailed mission control forecasts, to weather impacts for SOF operations, and distributes this information via secure media to support worldwide Joint SOF operations. The branch also provides tailored meteorological information for end-to-end planning at US Special Operations Command (USSOCOM), Service component special operations commands, and theater special operations commands. The Special Operations Weather Flight (SOWF) is continually involved in global military operations, including Operations ENDURING FREEDOM and IRAQI FREEDOM. Additionally, the SOWF includes the American Forces Network Weather Center, which provides worldwide, broadcast-quality public weather services and planning forecasts through the American Forces Radio and Television Service to over 1,000,000 Department of Defense and Department of State (DOS) personnel and family members stationed overseas.

The 2 WS Intel flight provides detailed global cloud analyses and forecasts to the IC. The branch provides worldwide mission-tailored planning and execution forecasts for IC agencies at security levels up to Top Secret/Sensitive Compartmented Information (TS/SCI). The branch also serves as the focal point for AFWA Special Access Program (SAP) requirements; ensures the IC and other SCI and SAP meteorological requirements are integrated into AFWA programs; monitors and evaluates accuracy and timeliness of centralized weather services to the IC, and interfaces with the Department of Defense and IC regarding weather services and the exploitation of weather information.

The Air Force provides meteorological and space weather products to the Nation's space and missile programs, including a wide range of weather observing services at the Air Force Eastern Range and the Kennedy Space Center (KSC). The Air Force also provides tailored forecasting for NASA's manned and unmanned launches and for commercial launches from KSC. In addition, the Air Force provides specialized meteorological information for the Air Force Western Range at Vandenberg AFB, California; the Pacific Missile Range, which includes Point Mugu and San Nicholas Island, CA, and Barking Sands, HI; White Sands Missile Range, NM; Kwajalein Missile Range, Republic of the Marshall Islands; and other DOD research and test facilities as directed.

The Air Force also provides agrometeorological support to the United States Department of Agriculture's Foreign Agricultural Service and other similar users. The output includes diagnostic soil hydrology and other meteorological information pertinent to crop growth and yield estimation as well as to trafficability and rudimentary flooding estimations.

<u>Integration</u>. Tailored environmental information and operational impacts are of little use to decision-makers if the information and/or impacts are not integrated into the shaping, planning, execution, and sustainment of air, space, and land operations. The AF employs a blend of information technology (IT), including automated machine-to-machine (M2M) interfaces, and personnel embedded at the right echelons with decision-makers, to integrate timely, accurate, relevant, and consistent weather and weather impacts information into decision-making processes. Since timeliness is critical to effective integration; AF weather operations rely on robust, assured communications for dissemination.

AFWA receives alphanumeric weather data, parses it according to data type, eliminates duplicate reports from different sources, and creates specially tailored bulletins. Some of these bulletins are sent to the large processing centers to provide the input data for global, regional, and fine-scale forecast models. Other bulletins are redistributed to end-users over dedicated circuits, NIPRNET, and satellite broadcast facilities.

High-speed communications between large DOD and civilian processing centers facilitate sharing of data, high-resolution satellite imagery, and output from numerical weather prediction models. Additional circuits provide a subset of these data to OWS.

Forecaster-developed products and gridded data sets are distributed from AFWA via the Weather Product Management and Distribution System to base/post-level weather forces around the globe using the DOD's NIPRNET and SIPRNET.

AFWA’s 2 SOS operates a website on the NIPRNET known as the Joint Air Force-Army Weather Information Network (JAAWIN). JAAWIN provides worldwide access to numerical model forecasts, satellite imagery, forecaster-in-the-loop products, and text bulletins, and includes links to all OWS Web sites. Additional products are available to classified users via JAAWIN-Secret (JAAWIN-S) and JAAWIN-Sensitive Compartmented Information (JAAWIN-SCI).

JWIS offers another means of making tailored weather information available to DOD users. JWIS provides a link to weather information from both Air Force and Navy sources for exploitation by C2 systems and applications. AFW successfully demonstrated a JWIS-based M2M weather information transfer to C2 applications during Joint Expeditionary Force Experiment 2004.

Although information technology continues to enhance the integration of weather and weather impact information into decision-making processes, well-trained weather professionals are still essential. Designated AF weather personnel serve on the staffs of operational Air Force, Army, and Joint force units worldwide. In this capacity, they identify weather-sensitive areas of the operation and provide expert advice to help mitigate weather impacts on personnel, platforms. weapons and weapons systems, and tactics. The ultimate goal is to identify opportunities for an asymmetric advantage over our foes, i.e., when enemy force capabilities are more severely degraded by weather than those of friendly forces.

For AF operations, these weather professionals are normally assigned to a flight under an operations support squadron in a flying wing; however, individuals from the weather flight are integrated into flying squadron mission planning and execution processes. In this capacity, they infuse critical weather information at key points in the decision cycle to help aircrews maximize wartime capabilities, enhance flight safety, and optimize training effectiveness. Weather experts are also assigned to weather specialty teams in air and space operations centers. This cross-cutting team integrates all-source actionable environmental information at key decision points of air and space operations planning, execution, and assessment. Armed with this information, decision-makers can balance operational risks against mission need to optimize timing, tactics, target and weapons selection, and other factors affecting air and space operations. Finally, AF weather experts are integrated into a variety of other unique mission areas, such as space launch support and RDT&E activities. In each capacity, these specialists enable the supported organization to minimize or alleviate weather impacts to the mission. For instance, to avoid potentially devastating storms, space launch weather personnel may advise decision-makers to adjust launch timing, while RDT&E weather personnel may identify potential weather sensitivities to system developers to ensure a safe, effective design.

Likewise, Army weather requirements are incorporated into the AF's overall weather operations concept. AF weather forces are integrated with Army intelligence staffs, and the Army trains and educates Air Force personnel on Army organizations, concepts of operations, and the weather sensitivities. AF weather forces are currently habitually aligned with echelons above corps, corps, divisions, separate brigades, aviation brigades, armored cavalry regiments, ranger regiments, and special forces groups (as well as subordinate battalions deployed at forward operating bases). However, over the next few years, AFW support to the Army will undergo significant transformation as the Army transitions from a division-centric force based on large standing organizations to a brigade-centric force based on smaller, modular organizations.

The operational environment (post-Cold War, 9-1l, and GWOT) is characterized by less predictability stemming from decentralized, well-networked threats. The AF is transforming the way it delivers environmental information to the warfighter to meet these challenges. Key to this transformation is creating an information advantage through the robust networking of well-informed, geographically dispersed forces, which will help create a decisive warfighting advantage. In this fast-paced, net-centric environment, the AF will rely more heavily on M2M information exchanges. The challenge to AF weather forces is to deliver timely and actionable information via M2M exchanges, thereby supporting more efficient and faster application of force on shorter decision timescales.

In 2001, AFWA initiated the WDAC program to begin the migration to the DOD Joint METOC Data Architecture to support dynamic, fast-paced M2M operations. This architecture provides for authoritative, timely, relevant accurate, and consistent environmental information, accessible via a common Web-services interface from anywhere on the Global Information Grid. The WDAC program modernizes the AFWA production center and AFCCC infrastructure, providing a centralized net-centric reach-back source for worldwide space and atmospheric weather information, to include environmental intelligence data to C2, C4ISR, MP, and mission support systems such as the Joint Mission Planning System. This vision is accomplished through implementation of the Joint METOC Data Base (JMDB), which is a virtual collection of worldwide METOC databases. JMBL is the common mechanism for users to access the JMDB for M2M operations.

Increments one and two of WDAC delivered JMGRID (gridded analysis and forecast data), JMOBS (conventional observation data), JMAN (alphanumeric messages and bulletins), and JMPLAT (fixed and mobile weather station platform data). In 2007, increment three will deliver CDC (subscription capability for data from JMGRID). Work is underway to develop JMSESS (space environment and solar data), JMIM Lite (imagery and visualized products), and a CDC capability for alphanumeric data. Later increments will deliver JMSAT (METSAT data), JMCLIM (climatology products), and JMR-SOB (remote-sensed observations).

RESEARCH INITIATIVES

The overarching objective of the Air Force meteorological and space environmental R&D program is to provide capability designers, operational weather personnel, and weather information users with the technology and tools to gain and maintain the advantage over a potential adversary. Documented R&D requirements in the atmospheric sciences are articulated in the AFW Mission Support Plan and in the Mission Area Plans of the Air Force major commands. Space environment R&D is targeted to meet the DOD's space weather requirements as documented in the AFW and AFWA Strategic Plans, the AFW Characterize the Environment Enabling Concept, and the AFW Space Weather Modeling Implementation Plan. AFW also strives toward improvements through cooperative research and development agreements with for-profit companies. AFW has recently fielded an IOC version of the Utah State University (USU) developed GAIM model. AFW continues to work with USU toward the fielding of a FOC full physics version of the GAIM model sometime in FY 2009-2010. In addition, AFW will be working during FY 2008 to fully integrate ultraviolet sensing instruments (SSUSI, SSULI, and GUVI) into space weather operations. This effort will include model integration, visualization, and validation efforts.

In meteorological R&D, the AF is improving cloud depiction and forecasting system (CDFS) techniques by doubling the resolution, integrating geosynchronous METSATs into the cloud analysis, using a new cloud interpretation scheme, and blending numerical weather prediction with forecast cloud advection techniques. The AF has transitioned key advances in tactical decision aids into operations, permitting improved forecasting of electro-optical system performance and generation of cloud and target scene visualizations for training, system development, and mission rehearsal. In addition to internal efforts, AFW will continue to rely on collaboration and leveraging of efforts with other Federal meteorological agencies, research labs, and universities to further improve CDFS system performance and meet other research needs.

MESOSCALE MODELING FOR AIR FORCE AND ARMY OPERATIONS

The Weather Research and Forecasting (WRF) model is the next generation community model replacing MM5. It is another area of AFWA participation in research. AFWA is closely collaborating with the National Center for Atmospheric Research (NCAR), NOAA's NCEP, NOAA' s Earth Systems Research Laboratory (ESRL), the University of Oklahoma's Center for the Analysis and Prediction of Storms, and others in WRF development. AFWA initially implemented WRF operationally in 2006, and will continue with sponsorship and funding of development at NCAR and ESRL, test and evaluation of real-time runs of the WRF prototype, and will lead the Land Surface Model (LSM) Working Group while participating in others. The LSM analyzes the current state of the land surface to provide information to DOD and civilian agencies, and through coupling with WRF, will improve forecasting performance in the low levels of the atmosphere. This allows AF weather forces to provide better forecasts for low-level aircraft operations, the dispersion of aerosol contaminants, and the employment of precision-guided munitions. It also allows for assessment of trafficability for ground forces.

Over the next several years, AFWA will transform its modeling approach from a traditional deterministic (single forecast) process to a stochastic (multiple forecast) process with the use of ensemble forecasting (EF). The purpose of this change is to add forecast uncertainty information into weather support, thus enabling optimal decision making for warfighter Operational Risk Management (ORM). AFWA is currently exploring how to best design and apply EF to weather operations with a prototype project called the Joint Ensemble Forecast System (JEFS). Dependent on the success of JEFS, AFWA will begin operational transition of EF in about 2010.

ATMOSPHERIC OPTICAL TURBULENCE

Electro-optical (EO) systems are adversely affected by optical distortions caused by thermal or refractive turbulence. As the sophistication of current and next-generation military systems grows, the requirement for more detailed knowledge of fine-scale (meters or less) atmospheric behavior also grows. The Airborne Laser (ABL) program is one such capability whose performance is highly dependent on the variations of the meteorological conditions that produce optical turbulence. The Air Force program in atmospheric optical turbulence measurements and modeling seeks to address these needs. Researchers used a balloon-borne turbulence sensor mated to a standard radiosonde to obtain measurements, producing data and empirical models that are the basis for ABL system specification. Balloon-borne measurements were made in conjunction with airborne stellar scintillometer measurements to understand the relation between atmospheric structure and path-integrated optical effects. The turbulent scalar spectrum was also sampled using balloon-borne high-bandwidth sensors. As part of an international program, aircraft measurements of temperature and velocity turbulence have been made in different locales worldwide. Horizontal measurements by the aircraft augment the vertical profiling by balloons to assist in the development of the detailed knowledge required to support new EO systems.

UNITED STATES WEATHER RESEARCH PROGRAM (USWRP)

USWRP's mission is to accelerate forecast improvements for high-impact weather phenomena and to facilitate full use of advanced weather information. AFW first entered into discussions with USWRP in 2001, to explore expanded participation in the program. The program currently focuses on land-falling hurricanes, heavy precipitation, and socio-economic impacts. The AF is eager to leverage future efforts in the areas of observing, assimilation strategies for data-sparse regions, and urban forecasting to increase warfighters' abilities to anticipate and exploit the weather. AFW is already committed to the USWRP-affiliated community development of the WRF model and will continue its USWRP involvement during the coming fiscal year.

AIR FORCE RESEARCH LABORATORY (AFRL)

AFRL supports AFWA by executing research conducted by external agencies and by conducting in-house research on both terrestrial and space weather. AFRL works with AFWA to execute the research portion of AFWA's forecasting and modeling program. AFRL coordinates with government agencies (e.g., NASA), Federally Funded Research and Development Centers (e.g., NCAR), and private corporations to fund research in support of weather model development. AFRL's in-house terrestrial weather program concentrates on optical turbulence. This research attempts to determine the impact of optical turbulence on laser propagation. Basic mechanisms of turbulence genesis, energy transfer, and dissipation are explored. Methods are explored for predicting the impact of turbulence on laser propagation with an emphasis on developing forecasting methods. Research is also being performed on determining the impact of cloud layers on directed energy transfer. Emphasis is on detecting and predicting cloud layers that interfere with lasers. In space weather research, AFRL programs focus on ionospheric impacts to radio frequency systems, space particle specification and forecasts, solar disturbance prediction, and neutral density effects on Low-Earth Orbit spacecraft. Working closely with the DMSP System Program Office at the Space and Missile Systems Center under a Memorandum of Agreement, AFRL supports the development and upgrading of operational space weather sensors, models, and software products to include: space environment sensors on the DMSP spacecraft; state-of-the-art ground-based scintillation detectors; total electron content sensors; DISS; SEON; and the Operationalized Space Environment Network Display suite of Web-based products. In addition to the AFRL research portfolio, AFW collaborates with others in the space weather community to develop new techniques, models, and systems for transition to operational applications. These include the Community Coordinated Modeling Center, John Hopkins Applied Physics Laboratory, the Naval Research Laboratory, NASA, NOAA's Space Environment Center, and the Constellation Observing System for Meteorology, Ionosphere, and Climate.

In conclusion, through a continuous process of review and definition, the Air Force documents its requirements for research aimed ultimately at providing timely, accurate, relevant, and consistent weather information to the warfighter today and in the future. In meteorological R&D, AFW is committed to continued development of the WRF model and collaboration with others to the benefit of the warfighter and the nation. Space weather research will continue with a strong program at the AFRL to facilitate the transition of required capabilities to operational use at minimum expense.

OVERVIEW

The US Naval Oceanography Program (NOP) provides global meteorology, oceanography, Maritime Geospatial-Environmental Information & Services, and ocean surveillance critical for safe and effective operations of the Navy and Marine Corps and the Department of Defense. Its mission is to protect the Fleet, shape the battlespace and maximize warfighting capability. The program includes meteorology, oceanography, bathymetry, hydrography, ocean surveillance and acoustics, geophysics, and astrometry and precise time.

Naval METOC underpins every aspect of naval operations and warfare. It provides an affordable and sustainable competitive advantage to the Nation and protects the substantial national investment in both afloat force structure.

The NOP, which is supported by ocean engineering, operational supercomputing, and operations research, in recent years reinvented itself to meet the warfighting needs of the operators and the fiscal needs of today's Navy.

Increasingly, costs are leveraged in the joint, interagency, and international arenas to deliver capabilities at a shared cost. The NOP is the Department of Defense's numerical weather forecasting capability and it partners with the Air Force Weather Agency in the areas of flight weather forecasting, joint operations, information management and acquisition programs. It also has strong relationships with all five directorates in NOAA.

The NOP backs up NOAA's National Centers for Environmental Prediction (NOAA/National Weather Service's numerical prediction capability for all national weather including Atlantic, East, and Central Pacific hurricanes). It also shares both scientific and technical and research and development discoveries across the National community to ensure cost-wise technical excellence.

ORGANIZATION

The Commander Naval Meteorology and Oceanography Command is an Echelon III command reporting to the United States Fleet Forces Command (USFFC). Its resource sponsors are OPNAV N4 for Operations and Maintenance, Navy (OMN) funding; the Oceanographer of the Navy, N84, for Research and Development (R&D) and Other Procurement, Navy (OPN) funding; and N87 for Commander Undersea Surveillance (now an Echelon 4 command under CNMOC). Military Personnel Navy (MPN and Reserve Personnel Navy (RPN) are resourced under OPNAV N1.

The Naval Oceanography Program's operational concept is "knowledge-centric" - production is centralized, service delivery is distributed in Naval C2 centers and the total capabilities are brought to bear directly on Naval strategic, warfighting, and safe operating challenges.

Naval Oceanography focuses its services on five warfighting capabilities --antisubmarine warfare, naval special warfare, mine warfare and countermeasures, fleet operations, and intelligence, surveillance, and reconnaissance--and four strategic and enabling capabilities: maritime weather forecasting, aviation weather

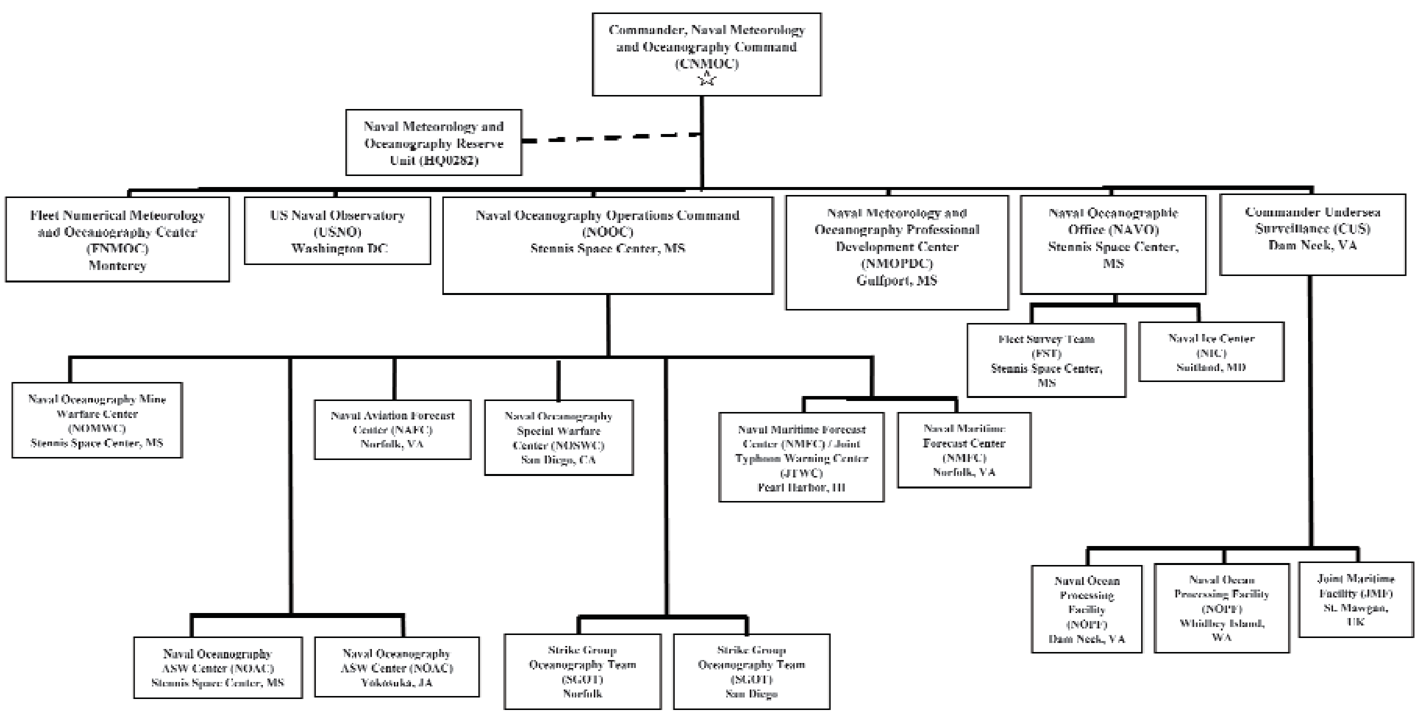


Figure 3-DOD-10. Naval Meteorology and Oceanography Command Organizational Chart (US Navy Released)

forecasting, navigation and charting and precise time and astrometry.

Major activities within the command currently include:

• Naval Oceanography Operations Command, Stennis Space Center, MS

• Naval Oceanographic Office, Stennis Space Center, MS

• Fleet Numerical Meteorology and Oceanography Center, Monterey, CA

• US Naval Observatory, Washington, D.C.

• Naval Meteorology and Oceanography Professional Development Center, Gulfport, MS

• Commander Undersea Surveillance (CUS), Dam Neck, VA

Additional subordinate commands include:

• Naval Aviation Forecast Center, Norfolk, VA and components

• Naval Maritime Forecast Center, Pearl Harbor, HI (with an activity in Norfolk)

• Strike Group Oceanography Teams in Norfolk VA, San Diego, CA and Fallon, NV (with subordinate mobile environmental teams)

• Naval Special Warfare Oceanography Center in San Diego (with components and detachments in Stuttgart, GE, Norfolk and Pearl Harbor)

• Naval Oceanography ASW Centers in Yokosuka, Japan, and Stennis Space Center, MS (with subordinate detachments)

• Fleet Survey Team, Stennis Space Center, MS

• Naval Ice Center, Suitland, MD

• Naval Ocean Processing Facilities in Dam Neck, VA, and Whidbey Island, WA (with detachments)

• Joint Maritime Facility St. Mawgan, UK

NAVAL OCEANOGRAPHY OPERATIONS COMMAND (NAVOCEANOPSCOM)

The NAVOCEANOPSCOM, headed by the Commander, Oceanographic Operations, serves as the principal operational organization of CNMOC and coordinates and manages efforts among field activities under the Operational Oceanography Program to optimize warfighting resources, support safe operations and enhance dominance of the battlespace through superior understanding and exploitation of the environment. The Command encompasses the nine warfighting and enabling directorates. Each directorate normally is headed by a Navy Captain who determines how that directorate's services are delivered globally. The directorate heads report to a Captain who functions as Naval Oceanography's Chief Operating Officer.

The Commander, Oceanographic Operations, supports the combatant commanders and national missions, US interagency and international partners. The other NAVMETOCCOM production centers (NAVOCEANO, FLENUMETOCCEN, NAVOBSY) support the Commander, Oceanographic Operations.

The command's operational model is based on standardizing services for each directorate, automating everything that can be automated and coupling situational awareness and a small on-scene presence, supported by a significant 24/7 reachback production capability at the major production centers.

Dangerous weather and safe navigation are the top two fleet concerns. Recently, aviation and maritime operations were de-regionalized and organized under NAVOCEANOPSCOM.

Aviation Forecasting

Many environmental conditions severely impact flight operations and mission accomplishment. These include wind speed and direction, cloud ceiling, precipitation, turbulence, visibility, icing and severe weather such as thunderstorms. An accurate forecast is often the deciding factor in mission success and for the safety of the pilot and their aircraft.

Navy meteorologists and forecasters analyze current environmental conditions and use state of the art computer models to forecast atmospheric and oceanographic phenomena impacting naval flight operations.

Meteorologists are assigned to Aviation Forecasting hubs in the United States and overseas locations.

Figure 3-DOD-11. Aerographer's Mate 3rd Class Bryan Murray, and Aerographer's Mate 3rd Class Timothy Fleming take and record wind readings that will be added to a meteorological aviation observation report. The report is completed hourly and then sent to the Joint Air Force and Army Weather Information Network (JAAWIN). (US Navy Released)

Figure 3-DOD-12. Early morning fog sets across the flight deck of the aircraft carrier USS CARL VINSON. (US Navy Released)

Core aviation weather services include flight route weather briefings (DD 175-1) via internet-based flight weather briefer, severe weather warnings and advisories for Navy airfields and terminal aerodrome forecasts for Navy airfields.

Fleet Operations:

The Naval Meteorology and Oceanography Command is actively engaged with fleet forces to provide valuable environmental knowledge to aid warfighting decision making. Personnel are integrated with the fleet, where they provide in situ observations, run tactical decision aids, and interpret environmental data to provide decision support to fleet commanders.

The onboard personnel work with reachback cells to analyze and forecast environmental conditions from launch point to target; and to determine optimum fleet maneuvers, ingress and egress routes, amphibious landing points and times, flight operations, weapons load outs, and target selection.

Deploying personnel are highly trained meteorology and oceanography specialists for support planning and operations. Reachback teams work with onboard personnel to refine data, develop models, conduct forecast analyses and deliver high-quality information to fleet commands.

Tailored Strike Group Oceanography Team (SGOT) detachments train, work-up, and deploy with carrier and expeditionary strike groups through each phase of the Fleet Readiness Training Plan and deployment. Each SGOT detachment includes a team who forecast for the CVNs/LHDs/LHAs. In addition to flight deck weather, they forecast the target area METOC which varies greatly considering the tremendous reach of Naval Aviation along the world's dynamic coastlines.

Maritime Weather Operations

Navy meteorologists and forecasters are assigned to Maritime Forecasting Centers in Pearl Harbor, HI, and Norfolk, VA.

Core maritime weather services include Optimum Track Ship Routing (OTSR), a weather forecasting service to support transoceanic voyages and coastal operations. OTSR services:

- Provide hazardous weather advisories and divert recommendations to ship commanding officers and masters at sea.
- Include sortie recommendations for potentially damaging weather conditions in port.
- Provide preliminary climatologic outlooks for transit and mission planning.
- Routine ship weather forecasts and aviation weather forecasts for ship-based helicopters include high wind and seas warnings and local area warnings for fleet concentration areas.

The Joint Typhoon Warning Center (JTWC), established by USPACOM, is jointly manned with US Air Force personnel. JTWC services include tropical cyclone forecasts, warnings and other products for Department of Defense warfighters operating in the Pacific and Indian oceans. JTWC, located in Pearl Harbor, HI, is an internationally recognized tropical cyclone forecasting center.

FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER

The Fleet Numerical Meteorology and Oceanography Center (FLENUMETOCCEN) Monterey, CA, an Echelon IV activity reporting to the Com-

Figure 3-DOD-13. Aerographer's Mate 2nd Class Ryan Sorge, left, updates Office of the Deck, LCDR Joseph Baxter, on current weather conditions for flight operations aboard the nuclear-powered aircraft carrier USS NIMITZ (CVN 68). (US Navy Released)

Figure 3-DOD-14. A Landing Craft Air Cushion (LCAC) Vehicle from Assault Craft Unit Four (ACU-4) transports Marine Assault Vehicles to the USS KEARSARGE (LHD 3). (US Navy Released)

mander, Naval Meteorology and Oceanography Command, is the command's production center for meteorology. The center plays a significant role in the national capability for operational weather and ocean prediction through its operation of sophisticated global and regional meteorological and oceanographic models, extending from the top of the atmosphere to the bottom of the ocean. Through close collaboration with the Naval Oceanographic Office (NAVOCEANO), FLENUMETOCCEN is a key component in the Navy's operational weather and ocean prediction program. This program provides information that helps give Naval forces an asymmetric advantage in speed, access and persistence in any combat operation for which they may be called upon.

FLENUMETOCCEN is well known for its long and productive history of implementing, evaluating, operating, maintaining and improving complex Numerical Weather Prediction (NWP) models specifically to meet the requirements of the US Navy. These requirements include the need for a particularly accurate representation of coastal meteorology and the air-sea heat fluxes and wind stresses required to drive the Navy's ocean models. In support of this need, FLENUMETOCCEN acquires and processes over six million observations per day -- creating one of the world's most comprehensive real-time databases of meteorological and oceanographic observations -- for real-time fusion and assimilation into its models. In addition, FLENUMETOCCEN is designated as the DOD center for global Numerical Weather Prediction. FLENUMETOCCEN uniquely satisfies the military's requirement for an operational global NWP capability based on software certified to DOD information assurance standards and operated in a secure classified environment protected from outside intrusion by DOD-certified firewalls. This requirement is driven by the importance of weather and ocean conditions on modern military operations, the need to utilize classified weather observations to guarantee the very best weather and ocean predictions in theaters of conflict, and the imperative to produce and disseminate weather and ocean products to military decision makers without fear of interruption or compromise as a result of cyber terrorists or cyber warfare.

FLENUMETOCCEN employs four primary models, the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), the Geophysical Fluid Dynamics - Navy (GFDN) model, and the WaveWatch III model (WW3), along with a number of specialized models and related applications. NOGAPS is a hydrostatic, global spectral model that drives nearly all other FLENUMETOCCEN models and applications in some fashion, and forms the basis for the FLENUMETOCCEN global Ensemble Forecast System. COAMPS is a high-resolution, non-hydrostatic regional model, multiply nested within NOGAPS, that has proven to be particularly valuable for forecasting weather and ocean conditions in highly complex coastal areas. GFDN is a moving-nest tropical cyclone (TC) model, nested within NOGAPS, that is used to forecast TC tracks globally. WW3 is a spectral ocean wave model that is employed both globally (driven by NOGAPS) and regionally (driven by COAMPS) in support of a wide variety of naval operations. Other models support and supplement the main models with predictions of ocean thermal structure, ocean currents and other data. All of the models are configured, scheduled, and operated under the central control of FLENUMETOCCEN operations. COAMPS, however, can also be configured, scheduled, and operated remotely by users in the field as an on-demand modeling service. This is done over the Web via the FLENUMETOCCEN Centralized Atmospheric Analysis and Prediction System (CAAPS). In general, FLENUMETOCCEN strives to treat the air-ocean environment as a fully integrated system, from the top of the atmosphere to the bottom of the ocean, placing special emphasis on the air-ocean interface.

FLENUMETOCCEN's complex and robust operational prediction capability is designed to deliver, in conjunction with NAVOCEANO, 7x24x365 support organized along the warfare areas. For example, some FLENUMETOCCEN products consist of detailed forecasts of wind stresses and heat fluxes to drive very high-resolution ocean models at NAVOCEANO that provide ocean thermal structure and currents in support of antisubmarine and mine warfare operations, or near-shore wind, sea and surf forecasts that directly support fleet operations through ship-to-objective maneuver. In many cases, the outputs of the FLENUMETOCCEN models feed directly into applications models, tactical decision aids and other products that provide direct support to various weather-sensitive activities associated with the wafighting directorates identified above. These include optimum path aircraft routing, optimum track ship routing, issuance of high-winds and high-seas warnings, hurricane/typhoon sortie decisions, covert ingress/egress of SOF, ballistic missile targeting, cruise missile launch and targeting, radar performance prediction in support of ship self defense, naval gunfire operations, understanding the threats posed by airborne nuclear/biological/chemical agents, search-and-rescue at sea, and many other activities.

FLENUMETOCCEN also provides a wide-range of meteorological and oceanographic observations and satellite imagery to complement its models and applications products. These include on-demand extracts from its global observational database, a full range of Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager products, ERS and QuikScat scatterometer wind products, a comprehensive view of tropical cyclones via the FLENUMETOCCEN TC Web page, and various experimental satellite products fielded for evaluation in conjunction with the Naval Research Lab (e.g., satellite imagery that enhances the visualization of airborne sand and dust). FLENUMETOCCEN also hosts the USGODAE Monterey Data Server in support of the Global Ocean Data Assimilation Experiment. This system serves as a one-stop shop for meteorological and oceanographic data and model products required to support global ocean modeling R&D. It also functions as one of two Argo Global Data Assembly Centers, hosting the complete collection of quality-controlled Argo temperature/salinity profiling float data.

Many of FLENUMETOCCEN's products are distributed to users over the Web via the PC-based METCAST system, and subsequently displayed and manipulated on the user's PC with the Joint METOC Viewer (JMV) software. This includes all standard meteorological and oceanographic fields, synoptic observations, and satellite imagery. For those who require only graphical display of model-predicted meteorological or oceanographic fields, FLENUMETOCCEN provides a Web-based capability called WxMap (i.e., "Weather Map"). WxMap, requiring only a Web browser for access, allows the user to select and quickly display predicted meteorological and oceanographic fields for any user-defined geographical area.

All of FLENUMETOCCEN's production capabilities are fielded on a collection of computer hardware and software designated as the Primary Oceanographic Prediction System (POPS). POPS is organized into two subsystems: the Analysis and Modeling Subsystem (AMS) and the Applications, Transactions, and Observations Subsystem (ATOS). AMS is a cluster of SGI and IBM supercomputers on which the major NWP models run. ATOS is a large suite of IBM Linux clusters that ingests, decodes, and quality-controls data; does satellite data processing; hosts many of the applications models and products mentioned above; and supports data distribution via a services oriented architecture and Web portal. Note that FLENUMETOCCEN also hosts a DOD High Performance Computing Modernization Program Distributed Center, which are integrated closely with POPS.

In addition to its primary role of focused support to the warfighter, FLENUMETOCCEN also plays a key role in the US national program for weather prediction. In this regard, FLENUMETOCCEN's tropical cyclone track predictions, widely recognized as among the best in the world, have proven to be especially valuable, with the National Hurricane Center (NHC) relying on them heavily. FLENUMETOCCEN also provides an important and physically separate backup for some of the models run at the National Weather Service's National Centers for Environmental Prediction (NCEP).

FLENUMETOCCEN benefits greatly from collocation with its supporting R&D activity, the Marine Meteorology Division of the Naval Research Laboratory (NRL/MRY). NRL/MRY is a world-class research organization, with focus on weather-related support to warfighting. FLENUMETOCCEN and NRL/MRY share space, data, software and computer systems, and together with the nearby Naval Postgraduate School represent one of the largest concentrations of weather-related intellectual capital in the Nation. Collocation and close cooperation between research and operations, such as exists between NRL/MRY and FLENUMETOCCEN, is the optimum arrangement for transitioning R&D quickly and cost-effectively into new and improved operational weather prediction capabilities.

NAVAL OCEANOGRAPHIC OFFICE

The Naval Oceanographic Office, Stennis Space Center, MS, is the command's production center for oceanography.

Since atmospheric conditions are inherently coupled to oceanographic conditions, the Navy's program in meteorology is closely linked with oceanography, which is the focus of the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi. NAVOCEANO is an Echelon IV activity reporting to the Commander, Naval Meteorology and Oceanography Command NAVOCEANO's primary responsibilities include the collection, processing, and distribution of oceanographic, hydrographic, and other geophysical data and products. NAVOCEANO runs and disseminates products from the world's first operational global ocean model--NRL Layered Ocean Model (NLOM), as well as a number of regional and coastal circulation and wave models. NAVOCEANO also runs the Polar Ice Prediction System (PIPS) ice model and provides the output to the National Ice Center for product generation. A key ingredient to ocean model performance is real-time data for assimilation and evaluation. NAVOCEANO is the Navy's primary processing facility for NOAA polar-orbiting satellite data and is nationally recognized for satellite-derived sea-surface temperature and satellite altimeter-derived sea-surface topography and wave height. NAVOCEANO's global sea surface temperature data are critically important to successfully running NOGAPS and COAMPS. Additionally, NAVOCEANO houses a DOD Major Shared Resource Center, enabling transition of the latest research and development models on the most modern scalable, supercomputing architecture, and facilitating transition from R&D to operational use.

US NAVAL OBSERVATORY

The US Naval Observatory, in Washington, D.C., is the production center for precise time and time interval as well as astrometry. It is one of the oldest scientific agencies in the country. Established in 1830, as the Depot of Charts and Instruments, the US Naval Observatory today is the preeminent authority in the areas of Precise Time and Astrometry and distributes Earth Orientation parameters and other astronomical data required for accurate navigation and fundamental astronomy.

The US Naval Observatory serves as the official source of time for the Department of Defense and the standard of time for the United States. The atomic clock timescale of the Observatory is based on an ensemble of cesium-beam frequency standards and hydrogen masers.

The US Naval Observatory performs an essential scientific role for the United States, the Navy and the Department of Defense. Its mission includes determining the positions and motions of the Earth, Sun, Moon, planets, stars, and other celestial objects, providing astronomical data; determining precise time; measuring the earth's rotation; and maintaining the Master Clock for the United States. Observatory astronomers formulate the theories and conduct the relevant research necessary to improve these mission goals. This astronomical and timing data, essential for accurate navigation and the support of communication on earth and in space, is vital to the Navy and Department of Defense. It is also used extensively by other government agencies and the public at large.

COMMANDER, UNDERSEA SURVEILLANCE/INTEGRATED UNDERSEA SURVEILLANCE SYSTEM

In March 2007, the Commander, Undersea Surveillance, merged with Naval Oceanography becoming an Echelon IV command under Commander, Naval Meteorology and Oceanography Command. Previously, CUS was aligned under the Naval Submarine Force.

CUS uses and monitors sensors in the Navy's antisubmarine warfare (ASW) effort; the Oceanography Community analyzes and predicts acoustic ranges for the Navy's ASW effort.

CUS/IUSS is comprised of over 800 active duty, civilian, and NATO personnel whose mission is to provide world-wide maritime surveillance and cueing from undersea sensors to warfare commanders and intelligence partners in support of ASW and Homeland Security/Defense (HLS/D). CUS executes its mission via two shore facilities in the US, one in the UK, and five forward deployed surveillance towed array sensor system ships.

EDUCATION/TRAINING

Navy officer (meteorologists/oceanographers) are all university graduates in meteorology, oceanography, or other earth sciences with most attaining dual meteorology and oceanography advanced graduate degrees.

Enlisted forecasters and/or briefers are trained in meteorological analysis and forecasting at military schools. Enlisted observers receive training at military schools.

The enlisted Aerographer's "A" (observer) and "C" (forecaster) schools are located at the Naval Technical Training Unit collocated with Air Force and Marine weather training at Keesler Air Force Base, MS.

Ongoing professional development for both officer and enlisted personnel is offered through the Naval Meteorology and Oceanography Professional Development Center in Gulfport, MS (with Pacific and Atlantic detachments). The center offers directorate training as well as training on oceanographic knowledge continuum.

Figure 3-DOD-15. Airman Jaime Minor inflates a weather balloon on the fantail aboard Nimitz-class aircraft carrier USS JOHN C. STENNIS (CVN 74). Weather balloons gather atmospheric information used to help plot and direct ships movements for the best conditions to conduct flight operations. (US Navy Released)

THE FUTURE

The central objective for the Naval Oceanography Program's future capability is a three-tiered construct designed to bring the forecast battlespace into operational decision making. It hinges on high resolution modeling and will require extensive sampling and continuous validation. All three tiers, each encompassing a separate knowledge set, will be developed simultaneously.

Tier 1, the "environment layer" will consist of developing and using the sampling methods given the observed and forecast ocean/atmosphere system and the desired knowledge to be gained. Littoral Battlespace Sensing Fusion & Integration is the baseline Program of Record for acquiring Navy-unique data and sensors critical to model initialization, verification, validation, skill improvement, and confidence. In this tier, focus will also be placed on improving modeling capability in an air/ocean environment at all scales, aligned with a National approach in areas where leverage is possible.

Tier 2, the "performance layer" revolves around transforming understanding of the air-ocean environment into knowledge of that environment will impact sensors, platforms and people and communicating inherent opportunities and constraints.

Tier 3, "the decision layer," applications will quantify strategic and operational risks, provide asset allocation recommendations at the operational level and sensor settings and predictions at the tactical level. As much of this information as possible will be provided via the Web and tailored "push" products.

Together the three "tiers" will deliver time-responsive, "on demand" sensing and modeling and prediction of critical ocean parameters on strategic, operational, and tactical timelines with tightly coupled warfighting applications.

PROGRAM ALIGNMENT

The NOP is changing focus from an acquisition-based program to "in stride" technology transition that rapidly transitions R&D and influences the Navy's S&T investments. Emerging R&D technologies will be tested in computational and operational environments and transitioned after an appropriate collaborative period.

CONCLUSION

The NOP has reinvented itself into a program that emphasizes the Navy's interests - and will evolve as the Navy's future challenges evolve. Ultimately, it delivers an operational NOP (aligned vertically with the S&T and R&D communities) that protects the fleet, helps the Nation shape the battlespace and maximizes warfighting capability.

UNITED STATES MARINE CORPS (USMC)

The mission of the Marine Corps METOC Service is to provide meteorological, oceanographic, and space environmental information, products, and services required to support Marine Corps and other military operations. The Marine Corps METOC

Figure 3-DOD-16. A boat crew from the amphibious transport dock ship USS SAN ANTONIO (LPD 17) returns to the ship after rescuing the crew of the fishing vessel Miss Melissa. (US Navy Released)

support infrastructure is designed to readily deploy and operate in austere expeditionary environments. It is capable of providing sustained, comprehensive, and relevant METOC support to all elements of a Marine Air Ground Task Force (MAGTF), as well as bases and stations of the supporting establishment.

ORGANIZATION

The Deputy Commandant for Aviation, Headquarters United States Marine Corps (Code ASL-37), is the responsible office for Marine Corps METOC requirements and support. The Marine Corps METOC organization consists of two operational chains

Figure 3-DOD-17. Aerographer's Mate 2nd Class Jeremy Richards from Gravois Mills, MO, prepares weather reports for the ship's Commanding Officer as well as pilots preparing for missions in support of Operation ENDURING FREEDOM. (US Navy Released)

Figure 3-DOD-18. Marines assigned to Weapons Company, 3rd Battalion, 3rd Marine Regiment, conduct a mounted patrol in the cold and snowy weather of the Khowst-Gardez Pass, Afghanistan in order to disrupt any enemy activity. (U.S. Marine Corps Released)

of command, one for supporting establishment METOC units, and the other for the Fleet Marine Force (FMF).

Supporting establishment METOC units are located worldwide at Marine Corp Air Stations (MCAS) and Facilities (MCAF). These activities are manned and equipped to provide direct aviation METOC support and services to host and tenant units at seven major air stations in the continental United States, one in Hawaii, and two in Japan.

Within the FMF, Marines deploy and employ as scalable, tailored, combined-arms teams known as MAGTFs. There are three sizes of MAGTFs. They are the Marine expeditionary unit (MEU), Marine expeditionary brigade, and Marine expeditionary force (MEF) with the latter being the largest. Additionally, Special Purpose MAGTFs may be formed to support operationally unique situations and/or requirements. All MAGTFs, regardless of size, share four organizational elements that vary in size and composition according to the mission: command element (CE), ground combat element (GCE), aviation combat element (ACE), and combat service support element (CSSE).

FMF METOC activities are organized, trained, and equipped to provide tailored support products and services to all combat elements of the MAGTF. METOC support is focused towards impacts on expeditionary maneuver warfare operations, particularly operational maneuver from the Sea. FMF METOC activities are fully interoperable within joint force operations as part of a Service or functional component command. When directed to stand-up as part of a joint task force headquarters, they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from pre-crisis state to full operational capability in a distant theater to provide on-scene support to MAGTF, combined, joint, allied, and coalition operations and other military operations as may be directed.

FMF METOC assets are permanently assigned to MEF headquarters, intelligence battalions, Marine wing support groups, and Marine wing support squadrons (MWSSs). There are three MEFs strategically positioned for global response. I MEF, based in southern California and III MEF, forward based in Okinawa, Mainland Japan, and Hawaii fall under the control of the Commander, Marine Forces Pacific. II MEF, located at bases in North and South Carolina, falls under the Commander Marine Forces Command. MEF METOC personnel serve as special staff to the commanding general and are under the direction and cognizance of the G-2 (Intelligence) division.

The three intelligence battalions in the Marine Corps are co-located with respective MEF headquarters. These battalions directly support the MEF G-2 and serve as MAGTF intelligence centers during operations. METOC is a vital part of the intelligence estimate and is an essential element that supports the Marine Corps Rapid Response Planning Process. METOC personnel assigned to these commands provide expertise, products, and services that directly support the intelligence preparation of the battle-space (IPB) process by helping intelligence analysts to effectively evaluate, integrate, and synchronize METOC effects for both enemy and friendly courses of action.

Marine aircraft wings (MAWs) conduct the complete range of air operations in support of the MEF, to include anti-air warfare, offensive air support, assault support, aerial reconnaissance, electronic warfare, and control of aircraft and missiles. The MAW serves as the principle headquarters for the ACE. Most of the MAGTF's METOC support assets reside within the MAW, specifically at the MWSG and its subordinate MWSSs. These assets are organized, structured, and capable of supporting a variety of MAGTF and ACE-specific operations as defined by the size, scope, and mission requirements. Dedicated METOC support is available for all MAGTF elements from within the MAW/ACE.

Figure 3-DOD-l9. Marines, supporting Operation IRAQI FREEDOM with Marine Medium Helicopter Squadron 764, tie down the rotor blades of a CH-46E SEA KNIGHT helicopter as a massive dust storm approaches the squadron's work area in AL ASAD, Iraq. (U.S. Marine Corps Released)

METOC SUPPORT CAPABILITIES

Meteorological Mobile Facility-Replacement (MetMF(R))

The highest level of METOC support to the MAGTF and ACE-specific operations is the deployment of the MetMF(R). The MetMF(R) provides a METOC support capability similar to that found in garrison METOC facilities. The MetMF(R) is normally employed as part of MWSS to a forward operating base and is the only realistic option for large-scale MAGTF operations. Once established ashore, the MWSS may detach small METOC support teams with portable ancillary equipment to a forward base in support of ACE units that are separated from the main airbase. This redeployment also provides the MetMF(R) with a forward data collection capability that significantly enhances METOC situational awareness and overall support efforts to the entire MAGTF. With appropriate Service personnel augmentation, the MetMF(R) is also capable of serving as host for an in theater Joint METOC Forecasting Unit (JMFU) during joint operations and exercises.

METOC Support Team (MST)

MSTs are task organized and equipped to provide a limited level of METOC support to combat elements other than the ACE (e.g., CE, GCE, and CSSE) and are assigned in support of MEU operations. It is capable of rapidly deploying as part of a first-in level of METOC support response to a crisis and can be easily integrated into an Air Contingency MAGTF. Additionally, the MST can be assigned to augment a JMFU during joint operations.

Each MWSS within the MAW is structured and organized to provide one MST that consist of one METOC officer, two forecasters, and two observers. When deployed, the MST will normally be assigned to the G/S-2 (Intelligence) division/section of the supported combat element or MEU. The MST deploys with rugged, ancillary environmental collection and data processing equipment. During operations they organically collect METOC products, data, and information from the nearest deployed MetMF(R), Navy METOC OA Division afloat, host nation, or other METOC support organizations and agencies to satisfy METOC information requirements.

SPECIALIZED METOC SUPPORT

The Marine Corps' Chemical Biological Incident Response Force was established in 1996, as a result of Presidential Decision Directive 39 to manage the consequences of NBC materials or weapons used by terrorists. This national-level asset is part of the reactivated 4th Marine Expeditionary Brigade - Anti-Terrorism located at Indian Head, MD. It is comprised of specially trained and equipped Navy, Marine, and civilian personnel who can rapidly be forward deployed and/or respond to a credible threat of a CBRNE incident in order to assist local, state, or Federal agencies and designated unified combatant commanders in the conduct of consequence management operations. Within the S-2 (Intelligence) section, permanently assigned METOC forecasters provide specialized NBC dispersion forecast products and services that aid mission accomplishment of this organization.

METOC SUPPORT DOCTRINE

Marine Corps War Fighting Publication 3-35.7, MAGTF Meteorological and Oceanographic Support, provides more detailed information about the Marine Corps METOC Service. An electronic copy is available for viewing and downloading from the Marine Corps Combat Development Command, Doctrine Division Web site at https://www.doctrine.quantico.usmc.mil/.

The United States Army is undergoing a historical transformation from a division-centered Army, to a smaller, brigade-based Army. This transformation will require an adjustment on how weather support will be provided to the new modular Army. Weather forces will be pooled at designated Army locations to provide a force pool of personnel ready to accompany deploying Army forces. These force pools will rely more on "reach back" capabilities to obtain pertinent meteorological data. The Army and Air Force are working together to determine the optimal weather team sizing, equipment, and communications capabilities required to support the new modular Army forces.

OPERATIONAL EQUIPMENT AND SUPPORT MISSIONS

Although it is transforming to a modular force, the existing weather support structure within the US Army is a mix of Army and USAF personnel and equipment according to Army-Air Force agreement (Army Regulation (AR) 115-10/Air Force Joint Instruction (AFJI) 15-157, Weather Support for the US Army, 30 June 1996). This joint regulation describes the Service responsibilities and those of Army commands and Army Service Component Commands (ASCC) within the Army for providing weather support. The US Army provides direct weather support to two Army missions: upper air observations for field artillery fire support, and limited surface weather observations to support Army weapon systems forward of division tactical operations centers. Air Force major commands provide operational weather services to war fighting ASCCs in combat, contingencies, and peacetime training. US Army Forces Command (FORSCOM), US Army Europe (USAREUR), US Army Pacific (USARPAC), US Army Special Operations Command (USASOC), Eighth US Army, and US Army Training and Doctrine Command (TRADOC) have AF Weather personnel providing daily installation and tactical weather support. ARTYMET crews provide direct upper air observation support to artillery units in the same ASCC. During peacetime training and activation, the ANG provides AF operational weather support to the US Army Reserve (USAR) and Army National Guard (ARNG), collectively designated the RC. In addition, during exercises and contingencies, the ANG may augment the active Army (AA) Battlefield Weather forces.

The Army also provides the operational weather support to Army RDT&E ranges, centers, and other research facilities using the Developmental Test Command's (DTC) Meteorological Teams (MET Teams) and US Army Space and Missile Defense Command (SMDC) contractors. DTC operational support is established under Army Test and Evaluation Command. SMDC provides weather support to the Ronald Reagan Ballistic Missile Defense Test Site at Kwajalein Atoll through a meteorological environmental test support contractor.

The Army provides the tactical field and communications equipment to USAF weather forces for tactical operations. The Integrated Meteorological System (IMETS) is the US Army's tactical weather communication, intelligence, and information system providing digital weather support to the commanders and staffs of tactical units, from Echelons Above Corps to aviation battalions. In FY 2008, the IMETS program will transition to the Distributed Common Ground System - Army program. The Communications and Electronics Command (CECOM) and ARL provide fielding and technical support to Program Director (PD), IMETS and to field artillery meteorology programs.

ARTYMET crews are assigned to artillery units at division level, to field artillery brigades, and to separate brigades with a direct support artillery battalion. Army Soldiers regularly take tactical upper air observations to support field artillery units during tactical training exercises, at permanent Army artillery ranges, or during the full range of combat missions. ARTYMET crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

ARTYMET crews in the AA and RC sections currently use the Meteorological Measuring Set (MMS), AN/TMQ-41, to take upper air observations during tactical operations. It is a mobile, upper air sounding system mounted on a high mobility multipurpose wheeled vehicle (HMMWV). The MMS provides upper-air data to the Field Artillery Tactical Data System for use in adjusting artillery fire (see Figure 3-DOC-20), to USAF BWTs, and to the chemical officer for use in smoke and in NBC defense operations. The US Army Field Artillery School (USAFAS), Fort Sill, OK, develops requirement documents and is the combat and training developer for meteorological equipment used for field artillery support.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff, G-2, is responsible for Army weather support policy. The Office of the Deputy Chief of Staff, G-3, is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements.

ARMY OPERATIONAL SUPPORT PROVIDED BY THE AIR FORCE

Under AR 115-10/AFJI 15-157, the AF provides the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical and garrison AA and RC support requirements. Army support manpower requirements are sourced from

Figure 3-DOD-20. Accurate wind profiles are essential for the Artillery to engage their targets. (US Army Released)

AF active, reserve, and ANG weather forces. While direct support of the field artillery remains an Army responsibility, and is supported by Army ARTYMET teams, AF Battlefield Weather forces provide supplemental information to artillery crews in contingencies for areas beyond direct ARTYMET observation capabilities. The AF assigns AF weather personnel to the war fighting Army commands and ASCCs at theater, corps, division, armored cavalry regiments, and separate brigades to provide direct, on-site weather support. Air Force Special Operations Command (AFSOC) Special Operations Weather Teams (SOWTs) conduct weather operations for USASOC and are primarily funded by USSOCOM. AF OWS and post-level weather organizations provide garrison and tactical weather warning, observing, forecasting, special support, and staff weather officer (SWO) services to combat, combat support, and combat service support units throughout the peacetime/war continuum. Peacetime garrison activities include supporting flying operations at Army Airfields and severe weather watch, warning, and advisory services for aircraft and post resource protection. Per Army-AF agreement, the AF is responsible for installation, operation, and maintenance of standard AF meteorological and observing equipment at Army airfields. Tactically, the Army is responsible for vehicles, tactical communications, and weather effects criteria. The Army's IMETS is fielded for these purposes and is operated by AFW personnel. The Army also maintains IMETS hardware and software, with the AF maintaining AF software that performs meteorological functions within IMETS. IMETS uses AF meteorological software, but IMETS is hosted on an Army vehicle, uses Army tactical communications and Army weather effects software. IMETS baseline software is hosted on Army Common Hardware and is Defense Information Infrastructure Common Operating Environment and Joint Technical Architecture - Army compliant. The Army provides other tactical equipment to AF BWTs through an Army Table of Organizations and Equipment (TOE). The following paragraphs describe weather activities within Army Commands and Army Service Component Commands.

Eighth US Army

The Eighth United States Army (Eighth Army) requires and uses Army resources to collect upper air data for artillery support. Two ARTYMET crews with the Second Infantry Division (2 ID) are programmed to field the AN/TMQ-52 Profiler Systems to replace the AN/TMQ-41 Meteorological Measuring Sets to collect upper air data for direct use by field artillery units. Air Force weather personnel assigned to the 607th Weather Squadron (607 WS) provide operational weather support to Eighth Army units. The 607 WS provides garrison and tactical weather observing, advisories, mission execution forecasts and staff weather support during armistice operations, exercises, and contingencies. These personnel use knowledge of Army missions to prepare theater-scale and site-specific weather forecasts essential to resource protection, operational planning and execution of combat operations. The 607 WS has units at four installations to provide direct support to HQ Eighth Army, HQ 2 ID and the 2nd Combat Aviation Brigade. In FY07, the 607 WS had 64 assigned weather personnel to support the Army mission. IAW AR 115-10/AFJI 15-157, the Eighth Army provided garrison facilities, tactical equipment (MTOE and CTA), and an operating budget.

United States Army Europe

USAREUR and 7th Army require and use Army resources to provide meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations.

The Air Force's 7th Weather Squadron (7WS) provides USAREUR/7th Army in-garrison and tactical weather intelligence and sup-

Figure 3-DOD-21. Reliable wind forecasts are necessary to ensure safety during flight operations. (US Army Released)

port. This includes observing services for in-garrison operations, contingency and exercise operations, staff weather officer (SWO) services, and specialized support. The United States Air Forces in Europe (USAFE) OWS at Sembach AB, Germany, provides operational-level forecast products for the USEUCOM AOR, to include all USAREUR units. Combat weather teams located at V Corps and its aviation assets, 1st Infantry Division and its aviation brigade, 1st Armored Division and its aviation brigade, Southern European Task Force, and 7th Army Training Command, as well as 7WS supporting 7th Army, evaluate and tailor these forecast products to produce mission execution forecasts.

The 7WS mission, with its 7 detachments and operating locations, is to provide weather operations packages to conform to the Army's garrison and war operations. Additionally, 7WS conducts weather operations and planning to meet future Army transformation and modularity initiatives. 7WS will match the deploying weather force structure to the mission that USAREUR is called upon to execute. 7WS will tailor the permanently assigned weather force to meet requirements of the new USAREUR structure and utilize "reachback" capabilities to the maximum extent possible to minimize the fielded footprint without compromising weather operations.

Three Integrated Meteorological Systems (IMETS) and five IMETS Lights are fielded within USAREUR (V Corps, two divisions and their aviation brigades, and two separate brigades). IMETS is geared to interface as a module of the Army Battlespace Control System (ABCS) to inject weather decision products into the common battle picture for Army commanders.

USAREUR provides supporting USAF weather teams with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four ARTYMET sections collect upper air observations for direct use by field artillery units. The FALOP consists of Army personnel taking limited observations at forward areas in the battlespace. USAREUR G2 funded purchases of handheld weather sensors for use in FALOP training and equipping Army teams to provide limited weather data at forward operating bases and forward arming and refueling points. These additional "eyes forward" provide critical information that benefits flight safety as well as the theater weather sensing strategy without having to forward deploy more people to austere locations.

US Army Special Operations Command

Routinely deployed in over three dozen countries, USASOC's forces have demanding missions spanning the globe and all levels of warfare. SOF missions are often carefully managed, high-risk scenarios operating at the edge of equipment capabilities, frequently at night and in adverse weather; these mission profiles routinely create great demands for precise weather information. SOF METOC operations with USASOC forces enable commanders to improve efficiency, effectiveness and safety of operations. Air Force Special Operations Command (AFSOC) Special Operations Weather Teams (SOWTs) and ANG weather personnel provide direct support to USASOC units and are assigned to AFSOC's 10th Combat Weather Squadron (CWS); 320th Special Tactics Squadron (STS); and 321st STS. ANG personnel providing direct support to USASOC when activated are assigned to the 107th Weather Flight (MIANG), 146th Weather Flight (PAANG), and the 181st Weather Flight (TXANG). These SOWTs employ specialized AFSOC-provided tactical METOC kits to conduct environmental reconnaissance and provide METOC observations from data-sparse areas in permissive and uncertain environments for planning and executing US military operations. At the deployed team level, 10th CWS

SOWTs collect weather data that are used by SOF commanders and staffs and forwarded to strategic METOC centers to improve meteorological models and forecasts. Additionally, SOWTs operate with the US Army Special Forces Command's seven Special Forces Groups (SFG); the 75th Ranger Regiment; the 160th Special Operations Aviation Regiment; all SFG and regimental subordinate battalions, and Psychological Operations Groups. AFSOC SOWTs provide the DOD's sole source for high-fidelity METOC environmental data collection from austere, denied, hostile, or semi-permissive areas of the battlespace. In addition, full-spectrum METOC operations include: climatology, solar/lunar illumination and geometry analyses and atmospheric effects studies; feasibility analyses, courses of action and mission impact assessments; surface, upper-air and tactical radar observations; weather watch/warnings; highly-resolved mission execution forecasts that demand fully-integrated and highly-qualified SOF METOC forces, including flight weather briefings and drop/landing zone forecasts; training ARSOF and host nation and indigenous forces on conducting limited METOC observations; and foreign internal defense analyses, surveys, and training.

USASOC plans and expends resources for some operational and administrative support to SOWTs operating with USASOC components. USASOC provides funding for office and deployable automation systems and connectivity to local networks; operations and maintenance/sustainment to support USASOC requirements. Additionally, USASOC provides for some tactical items such as NBC and some communications equipment; electrical power, vehicles, life support equipment necessary for accomplishing AFSOC's USASOC weather operations; and maintenance and supplies for USASOC-provided equipment. USASOC also provides funding for facilities, telephones, office space, and real property to house supporting special operations weather units, as well as secure storage of required equipment.

USASOC and AFSOC are cooperating to integrate the JET into the DCGS-A and suite of SOF operational capabilities. Two AFSOC meteorological liaison staff from the HQ AFSOC/A3W (Operations Weather Division) are located at HQ USASOC to coordinate AFSOC-USASOC METOC operations, logistics, and related requirements.

United States Army Pacific

USARPAC uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating surface weather observations to support tactical units and operations. USARPAC provides supporting USAF units with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operations and maintenance funds.

The Integrated Meteorological System (IMETS) and New Tactical Forecast System (NTFS) have been fielded within USARPAC as the primary meteorological equipment for deployed operations. The IMETS and NTFS receive data via Army-provided reachback NIPRNET and SIPRNET conduits.

There are three subordinate commands within USARPAC: United States Army, Hawaii (USARHAW), United States Army, Alaska (USARAK), and United States Army, Japan (USARJ).

The 17th Operational Weather Squadron (17 OWS) at Hickam AFB, HI, provides HQ USARPAC ASCC with garrison and tactical weather warnings, forecasts, special support, and Dedicated Support (DS) Staff Weather Office (SWO) services. Additional Battlefield Weather Teams (BWTs) provide DS to the 25th ID (L), 25th CAB, and the 1-25 SBCT. USAF also provides weather support, though not in a DS role, to USARJ, USARHAW, 4-25 IBCT, USARPAC's Early Entry Command Post (EECP), and USARAK. DS BWTs deploy with their supported operational organizations, providing tailored battlefield observations and forecasts. Weather reengineering has reduced the requirement for forward-deployed weather personnel, instead leveraging IMETS and other recently fielded technology for reachback capability. 17 OWS provides regional weather support, allowing forward-deployed BWT forces to focus on specific area and target forecasts. The 17 OWS also provides tactical- and operational-level forecast products for the USFJ and USFK AORs, to include all USFJ and USFK Air Force and Army units. This includes specific resource protection support (i.e., weather advisories, warnings, and watches), as well as Terminal Aerodrome Forecasts for selected units.

The 5th Air Force (5 AF) Liaison serves as USFJ's SWO, and also serves as the USARJ SWO. Day-to-day support for Camp Zama, Japan, is provided by an operating location (OL) under the AF CWT assigned to the 374th Operational Support Squadron at Yokota, AB. The OL on-site at Camp Zama provides weather observation services and produces mission execution forecasts ISO support aviation operations.

The 11th Operational Weather Squadron (11 OWS) at Elmendorf AFB, AK, provides operational-level forecast products for the Alaskan Command AOR, to include all USARAK units. The Commander, 11 OWS, provides as-needed staff weather support and services to USARAK. Additionally, 11 OWS is responsible for providing Terminal Aerodrome Forecasts for

Fort Wainwright, along with resource protection weather support (i.e., weather advisories, warnings, and watches) for Forts Wainwright, Greely, and Richardson. 11 OWS provides flight weather briefing support, as required, to Army, Army Reserve, and Army National Guard aviation assets in theater. An AF reengineering and consolidation effort will close the 11 OWS, and move all forecast production, weather watch/warning, and remote aviation briefing responsibilities currently performed at the 11 OWS to the 17 OWS, in Hawaii. Tactical-level BWT support will remain unchanged. 3 ASOS/WE is collocated with the 1-25 SCBT at Fort Wainwright, AK. They provide weather support for both tactical and garrison operations, observe the atmosphere and evaluate and tailor forecast products to produce mission execution forecasts and staff briefings. 3 ASOS/WE also supports 1-25 SCBT tactical unmanned aerial vehicle (T-UAV) operations. The Alaska Army National Guard operates the Fort Richardson Army Airfield.

US Army Forces Command

Weather support to the US Army Forces Command is diverse and demanding. FORSCOM, the Army's largest major command, requires and uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations. FORSCOM consists of more than 750,000 AA, US Army Reserve, and ARNG Soldiers. These Soldiers account for more than 80 percent of the Army's combat power. FORSCOM trains, mobilizes, deploys, and sustains combat ready forces capable of responding rapidly to crises worldwide. The AA component of FORSCOM has nearly 200,000 Soldiers. Third US Army is the Army component of US Central Command (USCENTCOM), which is the Joint command responsible for Southwest Asia (SWA), the Persian Gulf, and the Horn of Africa. U.S. Army South (USARSO) serves as the Army component to US Southern Command (USSOUTHCOM). USARSO relocated from Fort Buchanan, Puerto Rico, to Fort Sam Houston, TX, in 2003, and became a FORSCOM major subordinate command October 1st, 2003. FORSCOM also commands three Army Corps: I Corps at Fort Lewis, WA, III Corps at Fort Hood, TX, and XVIII Airborne Corps at Fort Bragg, NC. Together they include six divisions, two armored cavalry regiments, five separate brigades and a range of other corps combat, combat support, and combat service support units. Two Continental US Armies (CONUSAs), First US Army, and Fifth US Army, are responsible for training, mobilization, and deployment support to Reserve Component units in FORSCOM. Another major subordinate command to FORSCOM, the US Army Reserve Command (USARC), commands all US Army Reserve units in the continental United States except those assigned to Special Operations Command. FORSCOM's Army Reserve strength stands at approximately 196,000 Soldiers. USARC units are part of the Federal force and make their primary contribution to FORSCOM combat power in combat support and combat service support specialties such as medical, civil affairs, transportation, maintenance, and supply.

The ARNG provides FORSCOM a balanced force of eight National Guard combat divisions, 15 enhanced separate brigades, extensive combat support, and combat service support units. The current FORSCOM ARNG strength is approximately 367,000 Soldiers.

Weather support to FORSCOM's AA units comes from dedicated AFW forces aligned under three Air Support Operations Groups (ASOGs) within Air Combat Command (ACC): 1 ASOG at Fort Lewis, WA; 3 ASOG at Fort Hood, TX; and 18 ASOG at Pope AFB, NC. A weather squadron under each ASOG supports the Corps. Each Army division normally has dedicated

Figure 3-DOD-22. Soldiers and equipment are constantly exposed to the elements, as evidenced by this dust covered HMMWV. US Army photo by Sgt. Igor Paustovski. (US Army Released)

AFW forces aligned under an Air Support Operations Squadron (ASOS) or one of the weather squadrons, at their respective installations. Corps and division weather forces are authorized personnel and equipment to support a variety of missions at the various Army echelons. Weather support at each Army echelon is provided according to Army Field Manual 34-81. Currently, there are nearly 350 AFW authorizations supporting various echelons across FORSCOM. These personnel, enabled by an operational weather squadron, provide garrison and tactical weather warning, observing, mission execution forecast, special support, and SWO-services during peacetime, combat, contingency, exercise, or armistice operations.

ACC weather organizations provide direct, on-site support at 11 major Army installations, including the National Training Center at Fort Irwin, CA, and the Joint Readiness Training Center at Fort Polk, LA and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions.

FORSCOM provides supporting AFW forces with a Modified Table of Organization and Equipment (MTOE) and operating funds (expendables, maintenance, etc.).

ARTYMET requirements in FORSCOM increased from 17 to 20 sections in FY 2005, due to modularity. These 6-person sections, comprised of Army weather personnel, collect upper air observations for direct use by field artillery units.

The N-TFS is the primary in-garrison and tactical weather equipment for receiving graphics and alphanumeric data. Data is received via the Very Small Aperture Terminal (VSAT), Tactical VSAT (T-VSAT), Non-Secure Internet Protocol Router Network, and Secure Internet Protocol Router Network. Nineteen IMETS and 15 IMETS-Lights, developed by the Army Research Laboratory, have been fielded within FORSCOM. FORSCOM has also fielded commercial Automated Weather Observing Systems at Yakima Training Center WA, Fort Campbell, KY, and Georgetown Bahamas.

<u>Training and Doctrine Command Programs</u>

Headquarters, TRADOC, is responsible for development and management of Army weather training programs, weather support doctrine (concepts and field manuals), and the establishment of Army requirement documents for tactical weather support. Key mission areas for the next few years will be to assist the AF to develop and implement a new weather support concept to meet the needs of the Army's Modular Force including brigade combat teams; to update weather support doctrine, policy, organization, concepts, and tactics, techniques, and procedures; to ensure weather effects to Army operations are documented and communicated to Soldiers and AF weather support personnel, and to ensure Army weather support processes and procedures are trained across the TRADOC schoolhouses.

The Integrated Meteorological System (IMETS) is one of the Army's weather programs of record. Over the next few years some of its capabilities will be consolidated into the Air Force's JET program. The Army will (1) retain research and development efforts related to Army-specific weather support challenges, (2) be responsible for integrating JET into DCGS-A weather services and interfacing JET with Army C2 systems, and (3) will be responsible for fielding IMETS/JET software capabilities on common Army hardware systems. In FY 2008, the IMETS Program Office will move under the Program Executive Office - Intelligence, Electronic Warfare & Sensors (PEO-IEW&S) as part of the Distributed Common Ground System-Army (DCGS-A) program. Initial JET fielding is programmed to begin in FY 2010.

The US Army Intelligence Center and Fort Huachuca (USAIC&FH) is the functional proponent for Army tactical weather support. USAIC&FH represents the Army warfighter by collecting weather support requirements and developing solutions to satisfy those requirements when they are the responsibility of the Army. The key system that provides weather support to the Army is IMETS, which is fielded by the Army and operated by AF Battlefield Weather personnel. The USAIC&FH Weather Team assists the IMETS program by advising the Army Research Lab, USAIC&FH, DAMI-OPS, and AFW on Army weather support shortfalls and issues. The USAIC&FH Weather Team provides instruction on weather support techniques and weather effects to Army operations to Army Military Intelligence personnel as well as AFW personnel supporting the Army. The USAIC&FH Weather Team consists of two active duty AFW personnel, one civilian contractor that manages the Battlefield Weather Course, and one Department of the Army Civilian that serves as the assistant TRADOC Capabilities Manager (TCM) for IMETS. The USAIC&FH Weather Team recently drafted an Army Weather Functional Area Analysis for Battlespace Weather Sensing and will continue associated work on weather inputs to the Intelligence, Surveillance, and Reconnaissance Concept Capabilities Plan. The TCM for IMETS coordinates with DCGS-A to ensure the highest level of integration of IMETS into the DCGS-A family of systems. The TCM recently participated in the DCGS-A Fusion Working Group and provided DCGS-A an evaluation of IMETS ability to satisfy the DCGS-A requirements.

The AF SWO at the Army's Combined Arms Center (CAC) is the primary overseer of the TOE for AF weather teams supporting Army operations. The CAC SWO is the AFW point of contact for implementing TOE structure changes for support to Modular Forces in the Transformed Army. The CAC SWO also arranges for or provides environmental data, concepts of operation, and weather subject matter expertise for programs, projects, documents, and studies conducted by (1) the TRADOC System Manager - Army Battle Command (BC) System, (2) the BC Battle Lab-Leavenworth, (3) the Center for Army Lessons Learned, (4) the Combined Arms Doctrine Directorate, (5) the TRADOC Assistant Deputy Chief of Staff for Intelligence -Threats, the Foreign Military Studies Office, and (6) the TRADOC Analysis Center-Leavenworth. Other key CAC SWO tasks are to develop weather/weather effects scripts and climatology packages to support modeling and simulation efforts of the BC Training Program (BCTP) and the National Simulation Center, to make available Army weather support instruction at the Command and General Staff College (CGSC), and to provide climate expertise to all units assigned or attached to Fort Leavenworth.

The US Army Field Artillery School (USAFAS), Fort Sill, OK, is the proponent for upper air meteorological support to the Army. The AN/TMQ-41 Meteorological Measuring Set (MMS) and AN/TMQ-52 Meteorological Measuring Set-Profiler (MMS-P) are utilized to conduct surface and upper air observations. The MMS and MMS-P provides weather data to the Field Artillery Tactical Data System for ballistic calculations; to USAF weather forces for weather forecasting; and to the Chemical Officer for obscurant deployment, and NBC defense operations. Efforts are ongoing to ensure these surface and upper air observations are sent back to military weather centrals where they can be ingested in to the newest numerical meteorological analysis and forecasting models. Active unit's MMSs will eventually be replaced by the AN/TMQ-52 MMS-P. The MMS-P is a suite of meteorological sensors and associated software/models which will provide the Field Artillery with current and/or expected weather conditions at a point where the weapon munitions is expected to engage a target (Target Area Met). Currently, both the MMS and MMS-P are trained to all Advanced Individual Training Soldiers attending the Field Artillery Meteorology Course.

The US Army Aviation Warfighting Center (USAAWC) at Fort Rucker, AL, incorporates weather instruction and procedures into rotary-wing training programs in their mission areas. The center is the proponent for all Army Aviation including Unmanned Aerial Vehicle Systems (UAVS). The Center has requirements for weather observations and USAF forecast support at Cairns Army Airfield, Troy Municipal Airport (MAP), AL, and Andalusia MAP, AL. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites.

Air Combat Command (ACC) contracts day-to-day operational weather support to aviation operations at Fort Rucker (Cairns Army Airfield, Troy Municipal Airport, and Andalusia Municipal Airport) to 3D Research Corporation (3DRC). ACC, through the same contract with 3DRC, also provides garrison airfield weather services (observing and/or forecasting) at Fort Belvoir, Fort Benning, Fort Knox, Fort Leonard Wood, Fort Huachuca, and Fort Sill. The current 3DRC contract ends in August 2008, and will then be re-bid to ensure there is no lapse in services.

Army National Guard Artillery

In the ARNG Modular Force, there is one 6-soldiers team per fires battalion in the brigade combat team (BCT), providing 34 teams with 6 Soldiers each, for 204 Soldiers. In the fires BDE there are 3 MET teams required per BDE providing 21 teams with 6

Figure 3-DOD-23. Meteorological Measuring Set- Profiler (MMS-P) obtains upper level wind data for artillery fires. (U.S. Army Released)

Soldiers each, for a total of 126 Soldiers; however, all fires BDE TABs are authorized only one MET team for a total of 48 Soldiers. The ARNG is authorized 252 Soldiers in the Artillery Meteorological Teams.

The ARTY MET sections provide upper air observations at least 39 training days each year supporting artillery live fire during Annual Training and monthly Inactive Duty Training. The ARTY MET sections support an average of 20 live fire training days and annually expend in excess of 100 balloons per section. The ARNG's ARTY MET Teams use the Meteorological Measuring Set (MMS), AN/TMQ-41A.

Army Corps of Engineers

In its civil operational activities, the Corps of Engineers (COE) uses a network of about 10,850 land-based gages. About 55 percent of the sites collect meteorological data, 35 percent a combination of hydrologic and meteorological data, and 10 percent hydrologic or water quality data. The COE funds or partially funds 58 percent (6350) of all the gages it uses. Meteorological gages commonly measure precipitation and temperature as a minimum. Most sites also measure hydrological data. All data are used in the regulation of COE dams and other water projects used for flood control, navigation, hydroelectric power, irrigation, water supply, water quality, and recreation.

The COE transfers funds to NOAA/NWS to collect and maintain precipitation information from 877 of meteorological sites. Similarly, COE transfers funds to the US Geological Survey to maintain precipitation data collection from about 2400 sites, while the COE maintains the rest. Seventy-five percent of all COE sites provide real-time data via satellite, microwaves, meter bursts, landlines, or radio. Data from COE gauging sites are available to other Federal, state, and local agencies. All COE data are made available to the National Weather Service. Most of the data are also used by other agencies.

Figure 3-DOD-24. Army Corps of Engineers Working to Protect New Orleans from the Next Hurricane. Pumps at the 17th Street Outfall Canal operate at full capacity during a test on 24 March 2007. Photo by Task Force Hope. (US Army Released)

United States Army Space and Missile Defense Command (USASMDC)

The High Energy Laser Systems Test Facility (HELSTF), an USASMDC directorate located on White Sands Missile Range, is an Army element of the DOD Major Range and Test Facility Base with the mission of high-energy laser (HEL) test and evaluation for future Army and sister Service HEL weapons. In addition to HEL systems test and evaluation, extensive use has been made of on-site laser systems to perform damage and vulnerability testing on laser-hardened materials, missile, and aircraft components, and assorted battlefield equipment. The atmospheric sciences/meteorological mission is to support HEL testing by providing measurements of atmospheric conditions that are extremely important to propagation of any HEL beam thru the atmosphere. Many unique meteorological instruments are maintained to support this critical data collection for HEL testing. The HELSTF meteorological team also supports critical safety analysis of atmospheric dispersion for the very toxic laser fuels used. Efforts for FY 2007 include work required to modernize the atmospheric measurements and data collection/analysis capabilities needed to support new laser testing activities.

United States Army Kwajalein Atoll (USAKA) is a subcommand of USASMDC, which provides operational support for the Ronald Reagan Ballistic Missile Defense Test Site (RTS). The RTS (Figure 3-DOD-25) meteorological services support contractor provides meteorological support for range activities including missile operations within the atoll, intra-atoll transportation (marine and aircraft), remote island missile launches including Wake Island, and emergency operations support.

A full suite of surface and upper air

observing equipment is available to support of these operations. Three, fixed upper air sounding systems are located on Kwajalein and Roi-Namur. Two portable upper air systems can be deployed to remote locations to provide upper air soundings. Additionally, one dual-polarized -Doppler S-band weather radar and one Doppler C-band weather radar, two DMSP/NOAA satellite receivers (one mobile) both having McIDAS display and management systems, one geostationary satellite receiver, and an intra-atoll mesonet and lightning detection network round out the sensors available to RTS forecasters. RTS, in cooperation with NASA/GSFC, continues to support global climate studies through the Tropical Rainfall Measurements Mission and the follow-on program of Global Precipitation Measurement and a smaller program of monitoring the solar-earth radiation flux for NOAA/ERL.

Figure 3-DOD-25. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll. (U.S. Army Released)

WEATHER SUPPORT FOR RDT&E

Under Army-AF agreement, the Army has responsibility for weather support for RDT&E to support Army ground combat missions as specified in AR 115-10/AFJI 15-157. The Corps of Engineers (COE), and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to Soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations. The Army Test and Evaluation Command (ATEC) is responsible for operational meteorological support to Army RDT&E.

Army Corps of Engineers

The COE is responsible for reviewing all emerging Army systems for environmental effects, as stated in Army Regulation 70-1. The Topographic Engineering Center (TEC) and the Cold Regions Research and Engineering Laboratory (CRREL) of COE's Engineer Research and Development Center (ERDC), develop Tactical Decision Aids (TDAs) to interpret the impact of weather on terrain to enhance Army operations. TDAs are transitioned to the Digital Topographic Support System (DTSS) and the Commercial Joint Mapping Tool Kit (CJMTK). Under its military mission, CRREL, Hanover, NH, provides support to Army weapon systems RDT&E with all season solutions for mitigating adverse environmental effects on Army operations. CRREL conducts basic and applied research to investigate energy and mass transfer process at and near the terrain surface. Energy propagation and interaction across the electromagnetic, acoustic, and seismic spectral regions sees special emphasis, particularly with regard to dynamics in propagation caused by properties and processes of materials near the terrestrial surface. CRREL develops databases and models for predicting the state of the terrain including surface temperature, and tactical decision aids supporting mobility analysis and sensor performance. In partnership with TEC, Alexandria, VA, these products transition to various research and engineering programs including advanced technology demonstrations and specific programs of record such as DTSS and CJMTK.

Army Materiel Command (AMC)

The Army Materiel Command (AMC) is responsible for the research, design, development, test, and evaluation of equipment to satisfy the Army's requirements for meteorological support. AMC provides climatological and meteorological support to RDT&E projects involving electro-optical sensors, atmospheric and obscurant effects on systems and their performance. It is also responsible for determining weather impact critical threshold values and the environmental sensitivities of battlefield systems, including soldiers. AMC has several Major Subordinate Commands (MSCs) and elements carrying out weather research and development responsibilities including the Research Development and Engineering Command (RDECOM), which has responsibility for the Army's Research Development and Engineering Centers (RDECs) and the ARL.

The Army Research Laboratory Battlefield Environment (BE) Division has a robust program in developing very high spatial and time resolution characterizations of the lower atmosphere using both measurements and numerical models. This research is particularly focused on characterizing and predicting higher resolution effects caused by complex and urban terrain. The focus of RDT&E is in the near-surface boundary layer domain that is most critical to Army applications. RDT&E includes characterizing aerosols and CBRN contaminants in the atmosphere and on predicting more general impacts of weather on Army systems, sensors, personnel and operations. Research addresses how to assimilate battlefield meteorological observations into diagnostic and prognostic numerical weather models and how to fuse forward area observations into these short term forecasts or "nowcasts" to correct for actual local conditions and improve actionable weather information.

The BE Division within the ARL Computational and Information Sciences Directorate (CISD), consists of three branches shared between Adelphi, MD, and White Sands Missile Range, NM. The three branches combine basic and applied research programs in the areas of: meteorological, modeling, and modeling applications at high space and time resolution and the effects of complex terrain; atmospheric sensing of aerosols, and contaminants using laser scattering, spectral analysis, multi-wavelength imagers, and lidars; atmospheric and aerosol propagation including electromagnetic and acoustic signal and target effects modeling; meteorological measurements as part of the "develop-verify-improve-verify" modeling and measurement cycle; and advanced weather impact decision aids for C2 and for intelligence, surveillance, reconnaissance, and target acquisition. The division also provides liaison personnel between Army weather R&D and the coupled programs at the Air Force Weather Agency and the National Polar Orbiting Environmental Satellite System (NPOESS) IPO. These positions focuses on coordinating technology transitioned from the BE Division into Army and Air Force fielded systems.

BE Division and the Army Project Director (PD)- IMETS office are partnering with AFW in new programs such as the development of a common JET. The Army IMETS BC 6.4 software and several Air Force weather system software baselines are to converge as a single weather forecasting software tool. The Army will add C2 interfaces and weather effects tactical decision aid products such as the Tri-Service Weather Effects Decision Aid (TS-IWEDA). The combined JET-IMETS software will transition to the Distributed Common Ground Station-Army (DCGS-A) and Army software Block 2 to enhance weather capabilities for net-centric Army support. POR IMETS weather products can be accessed through a Web-browser, client server applications, or overlaid on the user's Common Operational Picture (COP) through Web services such as publish and subscribe (PASS). Current client applications will be Web-enabled over time. IMETS technologies will continue to provide net-centric weather support to Army BC and Future Combat Systems (FCS) as DCGS-A Weather Services.

The Meteorological Modeling Branch conducts a research program in the micrometeorological and mesoscale-gamma (small end of mesoscale) processes and structure of the atmospheric boundary layer at scales generally smaller than a few kilometers. This program focuses on the complex interactions of the land-air interface with wind fields, turbulence, and fluxes in terrains that range from open rolling grasslands to mountains and from forest canopies to urban canyons. Detailed modeling of aerosol and chemical-biological transport and dispersion in this wide variety of tactical environments are addressed. A range of numerical weather models are addressed, including non-hydrostatic predictive and diagnostic gridded meteorological models. Diagnostic models are fed with near-real-time observations from lidar, sonic anemometers, and other battlefield sensors to produce rapid refresh analyses for urban domains and complex terrain. Short term 2-3 hour local "nowcasting" and "Weather Running Estimate" products are being developed to improve the confidence in actionable weather intelligence for future Army systems. The integration of next generation ensemble forecasts and development of measures of confidence to improve decision making are performed under SBIR.

The Atmospheric Dynamics Branch performs research to measure and model the basic characteristics and structure of the dynamic atmospheric boundary layer, especially for its effects on sensing, soldier and weapons systems performance in urban and complex domains. The branch designs and executes experiments to verify new diagnostic models and improve numerical weather prediction model accuracy. Technology is developed to more easily capture forward area environmental data and information in near real-time in a networked environment. The branch is responsible for producing and verifying tactical decision aids and models for atmospheric effects and impacts on weapon systems, sensors, and personnel. Weather knowledge management tools are developed for Army C2 and ISR systems including automation of IPB and automatic optimization of routes for unmanned ground and aerial vehicles. Controlled field measurements are performed to develop or verify theoretical models for atmospheric and optical turbulence, acoustic propagation, radar propagation, wind flow in small scale urban domains and desert aerosol production.

The Atmospheric Sensing Branch is working to enhance warfighter situational awareness through the utilization of advanced atmospheric instrumentation and novel characterization techniques. They are developing, testing, evaluating, and implementing novel polarimetric imaging techniques to analyze effects from surface contaminants for target recognition and identification. Research on real time four dimensional monitoring of the atmosphere using remote sensing techniques will provide war fighters and homeland defense with a realistic understanding of the atmosphere for its effects on CBRNE. This research also includes modeling the effects of forest canopies on acoustic propagation and investigating the use of beam-forming techniques for the mitigation of the effects of the atmosphere on sensors, systems, and Soldiers.

The Army Research Office,

Research Triangle Park, NC, manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with understanding the dynamical and physical processes of the atmospheric boundary layer at scales of interest to the Army (millimeters to 10"s of kilometers) through measurements, simulations, and theoretical considerations. The basic research program is conducted through the peer-reviewed, individual investigator program and occasional special initiatives. The focus of the research is on the atmospheric processes and effects of the atmospheric boundary layer over land, where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding, modeling, and quantifying of atmospheric effects on Soldiers, materials, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on airflow, and the development of natural obscurations throughout the diurnal cycle. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture of the boundary layer at turbulence time scales.

Special funding areas are also managed. The Defense University Research and Instrumentation Program provide funds for instrumentation needed to support ongoing research activities. The Defense Experimental Program to Stimulate Competitive Research participation is a competition restricted to universities in certain states that compete for additional basic research funds. Also basic research under the Small Business Innovative Research Program (SBIR) is managed for selected topics. The primary research focus continues on the analysis and understanding of the stable boundary layer, which is augmented by external funding as a special program. New initiatives include development of a plan for a Soldier Scale Atmospheric Test Bed to examine the diurnal boundary layer processes and studies of stable boundary layers in complex terrains.

CECOM, a major subordinate command of AMC, provides support to developing and fielding weather programs through the following organizations: Logistics Readiness Center (LRC), Research, Development, and Engineering Center (RDEC), Software Engineering Center (SEC), and Safety office. The CECOM LRC is the level II manager of the Meteorological Measuring Set (MMS) program.

RDEC's Communications-Electronics Research Development Engineering Center, Intelligence and Information Warfare Directorate provides technical management and support to the Program Manager, Intelligence and Effects and Program Manager, Night Vision/Reconnaissance, Surveillance and Target Acquisition for the IMETS and the MMS-Profiler. A brief description of each of these programs shows CECOM's involvement.

Meteorological Measuring Set (MMS), AN/TMQ-41. The MMS is an upper air meteorological data collection, processing and dissemination system that provides data to the field artillery and target acquisition users. The system is a non-developmental item (NDI). All AA units and National Guard Bureau are equipped with the MMS.

The MMS-P AN/TMQ-52 and AN/TMQ-52A systems. The MMS-P is a major improvement over the MMS. The Profiler design will support the new generation of artillery weapons. Profiler provides highly accurate MET data to adjust artillery fire and achieve first round hits and fires for effect. The system provides MET data on demand with data staleness of less than 30 minutes. The system will include frequent and update meteorological messages that enhances the meteorological validity over a larger battle space than the current equipment. The MMS-P uses the MM5 mesoscale meteorological model to assimilate data from a variety of sources to provide the best meteorological messages to the user in a timely fashion. The system receives data from ground-based sources, radiosondes, and satellite-based sources, (such as boundary data from communications satellites and, in a future program block improvement, polar orbiting meteorological satellites) through onboard satellite receiving capability. The data affects the operation of the mesoscale meteorological model and for post-processing of the data in order to generate meteorological messages. Finally, an operator interface, in conjunction with the message generation and formatting software, facilitates communication between the MMS-P and all other systems that require interoperability with the MMS-P. Full Rate Production (FRP) was approved at a FRP Decision in FY 2005.

The Integrated Meteorological System. The IMETS will be fully fielded (46 Vehicle Mounted and 81 Light Configuration) by the end of FY 2007. There will be no IMETS Project Office in FY 2008. IMETS capabilities will transition, as Weather Services, to the DCGS-A Program Office, but all of the fielded systems will not be replaced by DCGS-A Weather Services until 2012 or beyond. The latest version of IMETS software (V6.2.8) is currently under Intra Army Interoperability Certification testing at the Fort Hood Central Technical Support Facility and should be available for fielding in FY 2008. This version introduces T-IWEDA and the Weather Running Estimate (WRE) applications. Key development and integration efforts for FY 2008 include the integration of IMETS capabilities into the DCGS-A, integration of the AF JET, and an

Figure 3-DOD-26. IMETS Vehicle Mounted Configuration. (U.S. Army Released)

upgrade (from Windows 2000 Server) to Windows 2003 Server. Additional FY 2008 development/integration efforts include application Web-enabling, evolving the WRE (Nowcast) application, adding/enhancing weather based tactical decision aids, and enhancing the IMETS weather satellite and tactical (send/receive) communication architecture.

Army Test and Evaluation Command (ATEC)

The Developmental Test Command (DTC), a subordinate command of United States Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to Army RDT&E. Under responsibilities established in AR 115-10/ AFJI 15-157, the DTC meteorological units provide meteorological data collection and analysis, consultation, and weather forecast and warning services to support Army and other DOD RDT&E activities at eight Army installations. Because much of the operational meteorological support workforce at the Army ranges is or soon will be eligible to retire, the Program has implemented an intern program to recruit and train entry-level scientists to ensure continuity in specialized meteorological support services as senior employees retire.

The Army RDT&E Meteorology Program is continuing to collaborate with NCAR on enhancements to the ATEC Four-Dimensional Weather (4DWX) System, which is the backbone of the meteorological support infrastructure at the Army test ranges. Major system components include a central data archival/retrieval system for all range and external meteorological and model data, a high-resolution mesoscale meteorological model, and a variety of user-configurable displays. System enhancements planned during FY 2008 include completion of an improved meteorological data archival/retrieval system with automated data quality control checks. During FY 2008, the 4DWX program also will complete its transition from Mesoscale Model Version 5 (MM5) to the next-generation Weather Research and Forecast (WRF) model. The MM5 and WRF mesoscale models are used operationally in both predictive and analytic modes to provide detailed information about the past, current, and future structure of the atmosphere over the Army's test ranges. ATEC 4DWX modeling capabilities include MM5- or WRF-based real-time four-dimensional data assimilation (RT-FDDA) at seven Army test ranges and Global Meteorology on Demand (GMOD), a globally-relocatable mesoscale modeling system to support Army RDT&E (including DTC distributed and virtual testing) at locations other than the Army ranges. In FY 2007 the 4DWX program took delivery of a DOD high performance computer which will enable operational mesoscale ensemble forecasts to support major DTC test operations. Output from the 4DWX mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results.

The Chief of the Meteorology Division at Dugway Proving Ground's West Desert Test Center serves as the DTC Program Manager for Meteorological Support to Army RDT&E. Specialized services provided by the Division include: (1) technical assistance to the DTC operational meteorological teams/branches; (2) atmospheric model verification and validation, including algorithm evaluation and the generation of validation data sets; and (3) technical assistance to the DOD CB defense modeling community in the development of new CB hazard assessment models. Division employees also serve on various national and international committees addressing issues related to meteorological measurements, atmospheric dispersion modeling, and CB hazard assessment.

Army Medical Research and Materiel Command

The US Army Research Institute of Environmental Medicine (USARIEM) conducts basic and applied research on the effects of heat, cold, high terrestrial altitude, and nutritional status on the health and performance of individual Soldiers and combat crews operating Army systems.

Applied research in thermal physiology and biophysical modeling is directed towards improving Soldier performance and minimizing health risks in climatic extremes. The sensitivity of the Soldier to local weather parameters (primarily ambient temperature, dew point, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The overall goals of USARIEM weather-related research programs are to develop methods to effectively monitor and, where possible, extend the operational envelope for both training and operational scenarios.

Weather-related research efforts include the development and validation of automated methods to integrate thermal strain prediction models with real-time weather information resources relevant to dismounted infantry operations. Temporal and spatial scales of interest are meters to kilometers and minutes to several days. USARIEM is working through an MOA with the Army Research Laboratory Battlefield Environment Division to implement thermal models on Personal Digital Assistant (PDA) devices and the Integrated Weather Effects Decision Aid (IWEDA).

The availability of ground-level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. As part of the Warfighter Physiological Status-Monitoring (WPSM) program, USARIEM is investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with predictive model processes. The effective fusion of these two real-time data streams will enable near-term environmental strain and performance status predictions for individual warfighters.

DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

The Federal Aviation Administration (FAA) has the responsibility to provide national and international leadership in the optimization of aviation weather systems and services. This leadership is manifested through the management of a safe and efficient National Airspace System (NAS) and the encouragement of consensus and cooperation between government agencies, private weather services, research organizations, and user groups involved in aviation weather. The Federal Highway Administration (FHWA) manages programs that provide Federal financial and technical assistance to the states, promotes safe commercial motor vehicle operations, and provides access to and within national forests and parks, Native American reservations, and other public lands. Safety, efficiency, and mobility in these programs require the incorporation and use of timely weather and road condition information. The Federal Railroad Administration promotes and regulates railroad safety. It also sponsors research to enhance railroad safety and efficiency, including support for improved collection, dissemination, and application of weather information to reduce hazards to train operations and to railroad employees. The Federal Transit Administration's mission is to ensure personal mobility and America's economic and community vitality by supporting high quality public transportation through leadership, technical assistance and financial resources.

FEDERAL AVIATION ADMINISTRATION

THE NATIONAL AIRSPACE SYSTEM OF THE FUTURE

In a proactive stroke to broaden the capabilities of the National Airspace System for the future, the 108th Congress and President Bush took the first critical step toward transforming our air transportation system by passing and signing into law *VISION 100 - Century of Aviation Reauthorization Act (P.L. 108-176)*. The Act calls for an integrated, multi-agency plan to transform the nation's air transportation system to meet the needs of the year 2025, while providing substantial near-term benefits. This Next Generation Air Transportation System (NGATS) Initiative will address critical safety and economic needs in civil aviation while fully integrating national defense and homeland security improvements into this future system.

Along with the private sector and academic community, the Federal Aviation Administration, NASA, the Departments of Commerce, Defense, Homeland Security, Transportation, and the White House Office of Science and Technology Policy are working together to design and build the NGATS.

The first product of this landmark effort was an *Integrated National Plan* delivered to Congress in December 2004. This strategic business plan lays out a common vision for the NGATS, establishes benchmarks for our success, and establishes a structure by which we can design and implement the changes we need to make. *VISION 100* also created the Joint Planning and Development Office (JPDO). Jointly managed by the FAA and NASA and supported by staff from all the agencies involved, the JPDO serves as a focal point for coordinating the research related to air transportation for all of the participating agencies.

Overseeing the work of the JPDO is a Senior Policy Committee chaired by the Secretary of Transportation that includes senior representatives from the participating departments and agencies and the Director of the Office of Science and Technology Policy. Among its key responsibilities, the Senior Policy Committee provides policy guidance and review; makes legislative recommendations; and identifies and aligns resources that will be necessary to develop and implement the *Integrated National Plan*. Secretary Norman Mineta chaired the first meeting of the Senior Policy Committee on September 26, 2003.

The JPDO has defined eight strategies that are the first steps towards creating the roadmap for NGATS. While the strategies deal with transforming specific areas of the air transportation system, they make up a larger whole and will integrate the sum of the efforts into building the NGATS system as a whole. The transformation strategies are:

1. Develop Airport Infrastructure to Meet Future Demand
2. Establish an Effective Security System without Limiting Mobility or Civil Liberties
3. Establish an Agile Air Traffic System
4. Establish User-specific Situational Awareness
5. Establish a Comprehensive Proactive Safety Management Approach
6. Environmental Protection that Allows Sustained Economic Growth
7. Develop a System-wide Capability to Reduce Weather Impacts
8. Harmonize Equipage and Operations Globally

For each of the eight *Integrated National Plan* strategies is an integrated product team (IPT). The IPTs will be made up of government and private sector experts with extensive aviation experience. The IPTs will be responsible for applying best private and public sector practices to achieve that particular strategy's mission and objectives. The primary responsibility for assembling and leading each IPT belongs to one Federal agency.

The IPTs will establish detailed action plans that will break the project down into manageable tasks. Specific IPT activities include:

- Managing the planning and orchestrating the execution of all relevant work to complete the assigned strategy;
- Conducting analyses and trade studies to select and validate implementation alternatives;
- Analyzing changes currently underway, identifying gaps, and establishing the required Government and/or industry research and development activities to close necessary gaps;
- Coordinating with Government and private industry on research and development resources;
- Collaborating with industry on research and implementation for the initiative;
- Identifying non-technical approaches such as policy, regulation, and operational procedures;
- Establishing detailed requirements for individual mission areas;
- Conducting advanced concept and technology demonstrations;
- Creating a transition plan for implementation of products; and
- Creating public/private partnerships that include multi-agency, industry, and Government participation.

The JPDO is responsible for approving broad strategies of the IPTs as part of the *Integrated National Plan* and ensuring IPT plans and schedules are consistent with the roadmap and architecture.

In addition, the NGATS Institute will support the NGATS mission by recruiting, selecting, and assigning private sector experts and technical resources to participate on IPTs and perform technical work for the IPTs and JPDO. These efforts will guarantee the establishment of a collective enterprise among key stakeholders to achieve the transformation, as well as to ensure that we fulfill our critical obligation to create a process that is transparent and fully open to public scrutiny.

The Joint Planning and Development Office (JPDO) have developed a set of operational improvements (OI) that define specific, weather-related enhancements needed in order to realize the goals of the NextGen Integrated Plan. The OIs are grouped into four key areas:

1. providing weather information for integrating into air traffic and flight deck decision support tools,
2. improving observations of weather information,
3. improving forecast of weather information, and
4. providing improved access to weather information by all users.

The FAA NextGen Network Enabled Weather (NNEW) portfolio provides the solution sets necessary to achieve the JPDO OIs. The NNEW solution sets will provide ready access to accurate weather information by all air traffic managers, airline operations centers, and flight deck operational decision makers. It will improve the comprehensiveness and accuracy of weather observations and forecasts and support the integration of weather information into decision support tools for those decision makers.

AVIATION WEATHER MANAGEMENT

Although the Department of Commerce National Weather Service has the Weather IPT lead within the JPDO, the Federal Aviation Administration (FAA) continues to have the leadership role for the national aviation weather program requirements. As the leader, FAA must conduct continual coordination for identifying needs for aviation weather products and services among the Air Traffic Control organization, the aviation industry components and among service providers. The coordination process leads to opportunities to leverage efforts and resources to form partnerships in finding solutions in response to the needs. The *National Aviation Weather Program Strategic Plan* and the *National Aviation Weather Initiatives* are two documents that formalize the coordination and partnerships.

The FAA focus for Aviation Weather has been to promote safety first; then improve NAS efficiency to reduce delays and re-routing due to weather. The Administrator has launched *The Safer Skies, A Focused Safety Agenda* which includes a government/industry Commercial Aviation Safety Team (CAST) and Joint Safety Analysis Teams (JSAT) to evaluate accident investigation reports to analyze the series of events leading to the accidents, and get a sense of what and how decisions were made in the course of the flight. Other teams, Joint Safety Implementation Teams (JSIT), using the findings of the JSAT, develop and recommend intervention actions to eliminate or reduce the causes or improve the actions in the decision making process. Training about the decision making process has been identified by these teams as a major part of the solution.

Aviation weather information is complex and highly perishable, is most useful when customers can successfully plan, act, and respond in ways that avoid accidents and delays. FAA will improve the ability of the aviation community to use weather information through a review and upgrade of airmen training and certification programs. FAA will also develop multimedia training tools to support aviation safety and training initiatives. Funding has been requested to further this effort.

Weather has been made a standard consideration in all aspects of the operation and architecture of the NAS. Aviation weather needs from the field, Federal agencies, and industry are entered into the FAA Acquisition Management System (AMS) through which all new programs and changes to the NAS are processed, evaluated, validated, engineered to a requirement, and acquired. The new Air Traffic Organization (ATO) Service components have the responsibility to guide all initiatives through the AMS process and organization, including the Integrated Requirements Team, the Integrated Product Team, and the Decision Boards; to assure the development continues to meet the original need; and to guide the activity should the need evolve. Improvements to the AMS process facilitate non-system or non-hardware (e.g., service improvement or rule changes) solutions receiving the same rigorous evaluation and validation.

FAA has established an Aviation Weather Technology Transfer (AWTT) Board which addresses the key issues involved in bringing new weather capabilities in to the operational system. At key decision points, the board evaluates the maturity of the capability, its integration into the existing system, its supportability in the field, and the training program to prepare the users.

FAA relies on other Federal agencies for weather services and support, especially NOAA's National Weather Service (NWS) and its Aviation Weather Center. Requirements validated by FAA for domestic and International Civil Aviation Organization (ICAO) users are coordinated annually and supported through the agencies and contractual arrangements. All agencies' efforts in the area of aviation weather services are coordinated for use by everyone, as appropriate. Aviation weather technology includes the ways in which aviation weather information is gathered, assimilated, analyzed, forecast, disseminated, and displayed. The development of this technology also demands that consideration be given to human factors and the application of decision-making tools. FAA will support the use of technology to improve aviation weather information through integration of Federal and non-Federal resources. Automation, improved product and graphics generation, and dissemination to the cockpit are being developed as early opportunities to achieve these goals.

AVIATION WEATHER ACQUISITION AND SERVICES

One of the primary functions of the FAA ATO organization is the development and management of requirements for the FAA *Capital Investment Plan*. The ATO Operations Planning Service component manages the NAS Requirements Development program to align requirements, priorities, programs, resources and develop metrics to understand the impacts of weather on the NAS. The program develops strategic plans and defines weather requirements, policy and standards.

Recent projects in the AMS have focused on weather detection and display systems for pilots and air traffic controllers to ensure that aircraft avoid hazardous weather. The following paragraphs describe many of those projects.

The Integrated Terminal Weather System (ITWS) will integrate weather data from sensors in the terminal area to provide and display compatible, consistent, real-time products that require no additional interpretation by controllers or pilots--the primary users. ITWS will use data from automated surface observing systems, Doppler weather radars, and low-level windshear alert systems, together with NWS data and products, to forecast aviation impact parameters, such as convection, visibility, icing, and wind shear, including down bursts.

ITWS has been installed at 15 locations. Installations are planned at 7 additional locations by FY 2009. The current long range program has been limited to 22 ITWSs, which will cover about 30 high-activity airports that are supported by terminal doppler weather radars (Figure 3-DOT-1).

The Corridor Integrated Weather System (CIWS) is a demonstration program which will take some of the capabilities of the integration software of the ITWS and expand it to cover larger areas beyond the terminals (Figure 3-DOT-2). 'Corridor' in the name

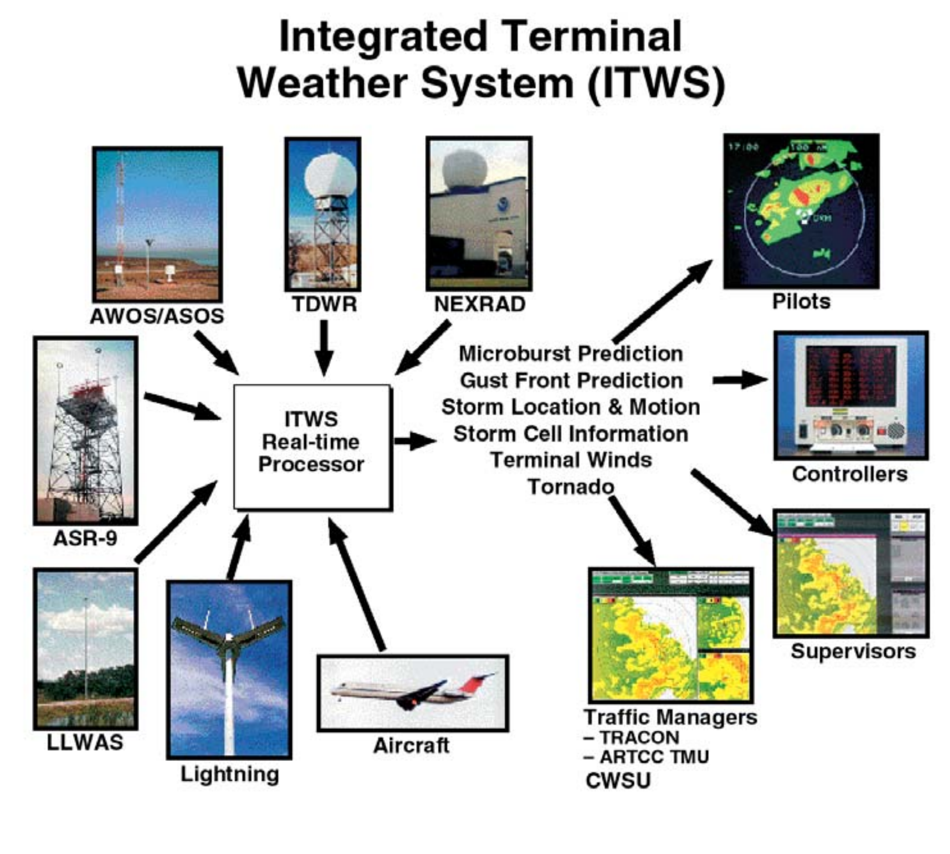


Figure 3-DOT-1. The ITWS integrates data from FAA and NWS sensors and systems to provide a suite of weather informational products.

implies the area covered will be an elongated zone which may include a number of terminal areas. The demonstration area extends from Boston southward over New York as far as Washington and westward over Pittsburgh and Cleveland connecting to Chicago. The CIWS is expected to integrate information from the WSR-88D and ASR-9 radars and other observing sensors in the corridor to produce weather information products focused on current conditions affecting en route traffic in the corridor. It will provide automated graphic high resolution forecasts of convective and winter weather as well as echo tops in the 0-2 hour timeframe. CIWS provides the opportunity for improved collaboration among specialists such as traffic managers, area supervisors and meteorologists in 8 ARTCCs, 6 TRACONs and the ATCSCC, as well as airlines. The comprehensive plan calls for implementation by 2009; however the funding stream was interrupted in 2006 which may delay implementation to a later year.

The Terminal Doppler Weather Radar (TDWR) program consisted of the development, procurement, and installation of a new terminal weather radar based on Doppler techniques. TDWR units have been located to optimize the detection of microbursts and wind shear at selected airports with high operations and frequent weather impacts. In addition, TDWR has the capability to identify areas of precipitation and the locations of thunderstorms (Figure 3-DOT-3).

Microbursts are weather phenomenon that consists of an intense down draft with strong surface wind outflows. They are particularly dangerous to aircraft that are landing or departing. TDWR scanning strategy is optimized for microburst/wind shear detection. The radars are located near the airport operating areas in a way to best scan the runways as well as the approach and departure corridors. The displays are located in the tower cab and Terminal Radar Approach Control (TRACON).

The FAA has 45 TDWR systems. A software upgrade that integrates TDWR and low level wind shear alert system data has been integrated at 9 high traffic/high weather threat airports.

The Low Level Wind Shear Alert System (LLWAS) provides information on hazardous wind shear events that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The 101 basic systems, LLWAS-2, consists of a wind sensor located at center field and 5 to 32 sensors near the periphery of the airport (Figure 3-DOT-4). A computer processes the sensor information and displays wind shear conditions on a ribbon display to air traffic controllers for relay to pilots. The improvement phase, referred to as LLWAS-Relocation/Sustainment (LLWAS-RS), will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new informa-

Figure 3-DOT-2. Corridor Integrated Weather System (CIWS) Display

Figure 3-DOT-3. FAA Terminal Doppler Weather Radars provide supplementary wind and precipitation conditions for airport approach and departure.

tion/alert displays. The new information/alert displays will enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. LLWAS-RS deployment was completed this year.

The Weather Systems Processor (WSP) program provides an additional radar channel for processing weather returns and de-alias returns from the other weather channel in the ASR-9. The displays of convective weather, microburst, and other wind shear events will provide information for controllers and pilots to help aircraft avoid those hazards. All 34 units are in place and operating. Also, there is one mobile system in operation.

The Terminal Weather Information for Pilots (TWIP) program provides text message descriptions and character graphic depiction of potentially hazardous weather conditions in the terminal area of airports with installed TDWR systems. TWIP provides pilots with information on regions of moderate to heavy precipitation, gust fronts, and microburst conditions. The TWIP capability is incorporated in the TDWR software application. Text messages or character graphic depiction are received in the cockpit through the Aeronautical Radio Incorporated (ARINC) Communication Addressing and Reporting System (ACARS) data link system. A total of 45 TDWR systems are deployed, installed and commissioned. The TWIP capability is operational at most of the TDWR sites. Activation of TWIP at the remaining sites is dependent on availability of National Airspace Data Interchange Network (NADIN) II connectivity and program funding.

The FAA has installed Aviation Closed Circuit Television (CCTV) Weather Cameras as an aid to Visual Flight Rules (VFR) pilots operating in Alaska. Through the cameras and the Internet, pilots get a current picture of the weather conditions to assist them in making weather related decisions. There are 62 weather camera sites.

The Juneau Airport Wind System (JAWS) is specific to the Juneau, Alaska airport, which endures severe turbulence conditions. It is a prototype with a long development history. When operational, it will enable air traffic controllers to pass turbulence alerts to airline pilots and other users via the Automatic Terminal Information System (ATIS) and radio transmissions. It is also intended to enable Automated Flight Service (AFSS) specialist to provide pertinent JAWS wind information to general aviation pilots on request during pre-flight and in-flight weather briefings and radio contacts.

The Flight Information System (FIS) Policy was implemented during FY 2001, through Government-Industry Project Performance Agreements (G-IPPAs) with two industry FIS data link service providers (ARNAV Systems, Inc. and Honeywell International, Inc.). Through the government-industry agreements, the FAA provides access to four VHF channels (136.425-136.500) in the aeronautical spectrum while industry provides the ground infrastructure for data link broadcasts

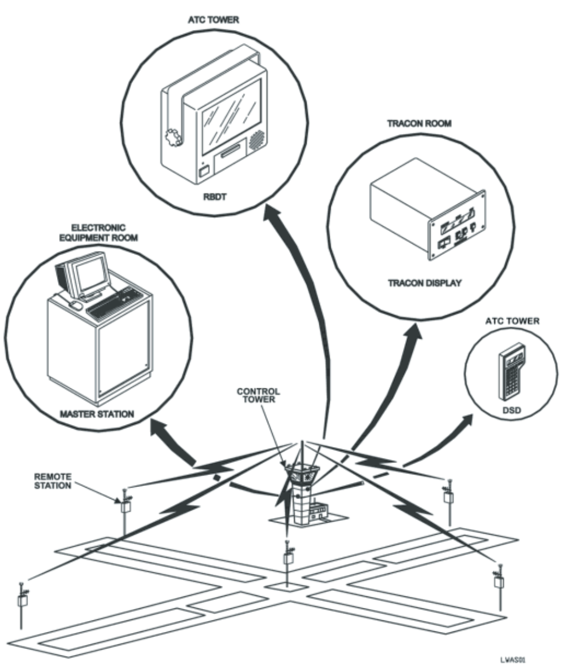


Figure 3-DOT-4. LLWAS equipment on an airfield.

of text and graphic FIS products at no cost to the FAA. Under the agreements, a basic set of text products are provided at no cost to the pilot users while industry may charge subscription fees for other value-added text and graphic products.

The FAA FIS data link program will continue development of necessary standards and guidelines supporting inter-operability and operational use. In addition, the need and feasibility for establishing a national capability for collecting and distributing electronic pilot reports (E-PIREPs) from low-altitude general aviation operations is being evaluated. A concept analysis has been initiated to define the need for transition and evolution of FIS data link services supporting the future NAS architecture including Free Flight operations.

SURFACE WEATHER OBSERVING PROGRAM

Aviation Weather Observations. The FAA has taken responsibility for aviation weather observations at many airports across the country. To provide the appropriate observational service, FAA is using automated systems, human observers, or a mix of the two. It has been necessary to place airports into four categories according to the number of operations per year, any special designation for the airport, and the frequency at which the airport is impacted by weather.

• Level D service is provided by a stand-alone Automated Weather Observing System (AWOS) or an Automated Surface Observing System (ASOS). In the future, Level D service may be available at as many as 441 airports.

• Level C service includes the ASOS/AWOS plus augmentation by tower personnel. Tower personnel will add to the report observations of thunderstorms, tornadoes, hail, tower visibility, volcanic ash, and virga when the tower is in operation. Level C service includes about 301 airports.

• Level B service includes all of the weather parameters in Level C service plus Runway Visual Range (RVR) and the following parameters when observed: freezing drizzle versus freezing rain, ice pellets, snow depth, snow increasing rapidly remarks, thunderstorm/lightning location remarks, and remarks for observed significant weather not at the station. Level B service includes about 58 airports.

• Level A service includes all of the weather parameters in Level B service plus 10-minute averaged RVR for long-line transmission or additional visibility increments of 1/8, 1/16, and 0 miles. Level A service includes about 70 airports.

Automated surface aviation weather observing systems will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, and precipitation type, occurrence, and accumulation) through the use of automated sensors. These systems will process data and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

AUTOMATED WEATHER OBSERVING SYSTEMS (AWOS)

AWSOS was deployed at over 200 airports to provide the basic aviation weather observation information directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that previously did not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations and are available off-the-shelf as a commercial product. There remain 228 AWOSs.

AUTOMATED SURFACE OBSERVING SYSTEMS (ASOS)

In a joint program with NOAA NWS, the FAA has procured, installed, and operates ASOS at the remaining airports where the FAA provides observations and at additional non-towered airports without weather reporting capabilities in accord with the levels of service listed above. Production is complete and the FAA has 572 systems installed and commissioned.

AVIATION WEATHER SENSOR SYSTEMS (AWSS)

AWSS, a new program, will have capability similar to ASOS (Figure 3-DOT-5). However, the AWSS is a direct acquisition of the FAA - not from the joint ASOS program. Production was completed in CY 2005.

Figure 3-DOT-5. Aviation Weather Sensor Systems (AWSS) an ASOS like supplement for observations.

AWOS/ASOS DATA ACQUISITION SYSTEM (ADAS)

ADAS functions primarily as a message concentrator and will collect weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each ARTCC's area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to the Weather and Radar Processor (WARP) within the air route traffic control center in which it is installed. ADAS will also distribute AWOS data to the NADIN which will in-turn forward the data to the Weather Message Switching

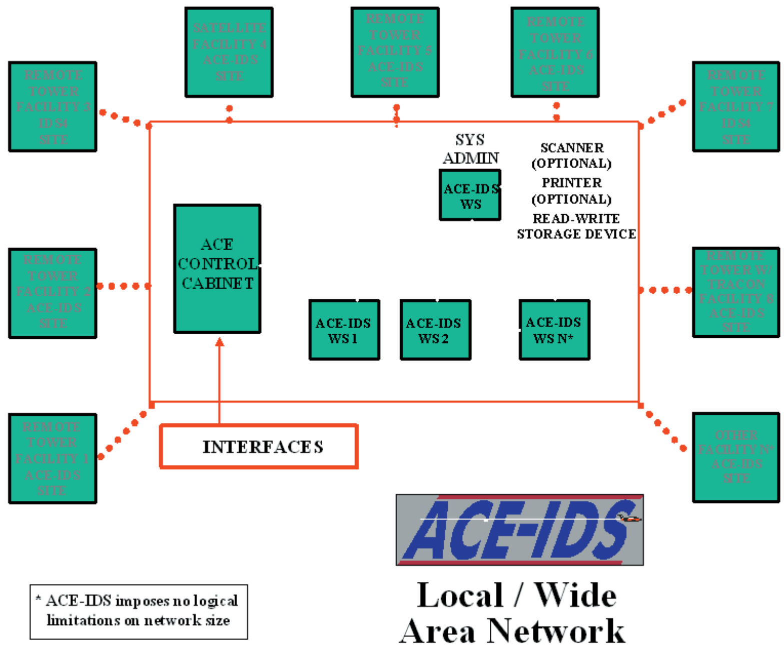


Figure 3-DOT-6. ASOS Controller Equipment- Information Display System (ACE-IDS)

Center Replacement (WMSCR) for further distribution. Field implementation of ADAS is complete.

AUTOMATED LIGHTNING DETECTION AND REPORTING SYSTEM (ALDARS)

ALDARS is a system adjunct to the ADAS. ALDARS collects lightning stroke information from the National Lightning Detection Network (NLDN) and disseminates this data to AWOS/ASOS for the reporting of thunderstorms in METAR or SPECI observations, when appropriate. The use of ALDARS eliminates the need for manual reporting of thunderstorms and increases the number of airports where thunderstorms will be reported. ALDARS is completely operational.

STAND ALONE WEATHER SENSORS (SAWS)

SWAS are back-up systems for some AWOS/ASOS sensors at locations where no other back-up capability is available. SAWS have been demonstrated and full delivery is nearly completed. The full deployment will comprise up to 307 units.

ASOS CONTROLLER EQUIPMENT- INFORMATION DISPLAY SYSTEM (ACE-IDS)

ACE-IDS is an electronic cabinet of displays available to the controller at his work station. It provides graphics of information which comes from many sources that originate at many nodes of an LAN which includes, but is not limited to, weather related parameters, observations, and other automated weather products. This system is designed specifically to support operations in high-volume, high-tempo Terminal Radar Approach Control (TRACON) facilities. They are installed at the following TRACONs: Atlanta, Boston, Dallas-Fort Worth, Honolulu, Northern California (San Francisco), Oklahoma City, Potomac (Wash. D.C.), Saint Louis, and Seattle (Figure 3-DOT-6).

AWOS FOR NON-FEDERAL APPLICATIONS

Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement, as well as the funding for the regular maintenance. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on Non-Federal Automated Weather Observing Systems. There are more than 275 non-Federal AWOS locations. Some of these are capable of reporting through a geostationary communications satellite. These observations will be entered into the national network for use in support of the NAS and the national weather network.

NEW GENERATION RUNWAY VISUAL RANGE (NRVR)

The NRVR program provides for a new generation RVR sub-element of the NAS. The NRVR provides runway visual range information to controllers and users in support of precision landing and take-off operations. The NRVR incorporates state-of-the-art sensor technology and embedded remote maintenance monitoring. The FAA plans to procure and install these NRVR systems at all new qualifying locations. FAA plans also call for the replacement of many existing RVRs in the NAS inventory.

The NRVR provides for near real-time measurement of visibility conditions along a runway (up to three points along the runway can be measured-- touchdown, midpoint, and rollout) and reports these visibility conditions to air traffic controllers and other users. The system automatically collects and formats data from three sensors: forward scatter meters will replace the transmissometers currently in use; a runway light intensity monitor for both runway edges and center-line lights; and an ambient light sensor which controls computer calculations using a day or night algorithm. The data processing unit calculates runway visibility products and distributes the products to controllers and other users.

NRVR visibility sensors will be deployed at 359 airports. Delivery of the NRVR sensors began in November 1998. To date, 230 units have been delivered and 185 have been commissioned. At the current levels of annual funding, the program will be completed the deployment by the end of CY 2009.

OPERATIONAL AND SUPPORTABILITY IMPLEMENTATION SYSTEM (OASIS)

The FAA procured OASIS to improve weather products, flight information, aeronautical data collection, analysis, and timeliness of dissemination, thereby enhancing the safety and efficiency of the NAS. OASIS will replace the Model-1 Full Capacity Flight Service Automation System, which includes the Aviation Weather Processor. OASIS will also integrate the Interim Graphic Weather Display System functions and include several automated flight service data handling capabilities. This configuration will be an initial deployment capability. Operational testing began in 1999; 16 systems have been deployed from the original plan of 61. Future enhancements leading to the full capability deployment will include: interactive alphanumeric and graphic weather briefings; direct user access terminal (DUAT) service functionality; automated special use airspace; and training support. OASIS will support flight planning, weather briefings, NOTAM service, search and rescue, and pilot access terminal services. Note: This program will be suspended in FY 2008.

NEXT GENERATION WEATHER RADAR (NEXRAD)

NEXRAD, known operationally as the Weather Surveillance Radar-1988 Doppler (WSR-88D), is a multi-agency program that defined, developed, and implemented the new weather radar. Field implementation began in 1990 and was completed in 1996. There are a total of 161 WSR-88D systems deployed. The FAA sponsored 12 systems in Alaska, Hawaii, and the Caribbean. DOC and DOD WSR-88Ds provide coverage over the continental United States.

The FAA emphasized the development of WSR-88D algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms. The FAA also stressed that these algorithms provide new or improved aviation-oriented products. These improvements in detection of hazardous weather will reduce flight delays and improve flight planning services through aviation weather products related to wind, wind shear, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones and tornadoes. WSR-88D data provided to ATC through the WARP will increase aviation safety and fuel efficiency.

In addition, the three funding agencies support the field sites through the WSR-88D Radar Operations Center (ROC) at Norman, Oklahoma. The ROC provides software maintenance, operational troubleshooting, configuration control, and training. Planned product improvements include a shift to an open architecture, new antenna design, dual polarization, and the development of more algorithms associated with specific weather events, such as hurricanes.

AIR ROUTE SURVEILLANCE RADAR (ARSR-4)

The ARSR-4 provides the ARTCCs with accurate multiple weather levels out to 200 nautical miles. The ARSR-4 is the first enroute radar with the ability to accurately report targets in weather. The ARSR-4 can provide weather information to supplement other sources. The ARSR-4 is a joint FAA/USAF funded project. Forty joint radar sites were installed during the 1992-1995 period.

WEATHER AND RADAR PROCESSOR (WARP)

WARP has replaced the Meteorologists Weather Processor to provide aviation weather information to the Center Weather Service Units. WARP automatically creates unique, regional, WSR-88D-based, mosaic products, and sends these products, along with other time-critical weather information, to controllers through the Display System Replacement and to pilots via the FIS. WARP greatly enhances the dissemination of aviation weather information throughout the NAS. WARP underwent operational testing and evaluation in early FY 2003 and is operationally fielded at the 21 ARTCCs and the command center. Others systems used for enhancements, testing, and software support bring the total to 25 systems.

DIRECT USER ACCESS TERMINAL (DUAT)

The DUAT system has been operational since February 1990. Through DUAT, pilots are able to access weather and NOTAMs and also file their IFR and/or VFR flight plans from their home or office personal computer.

AVIATION WEATHER COMMUNICATIONS

It should be noted that FAA communications systems are multi-purpose. Weather data, products, and information constitute a large percentage of the traffic, as do NOTAMS, flight plans, and other aeronautical data.

The National Airspace Data Interchange Network (NADIN II) packet-switched network was implemented to serve as the primary inter-facility data communications resource for a large community of NAS computer subsystems. The network design incorporates packet-switching technology into a highly connected backbone network which provides extremely high data flow capacity and efficiency to the network users. NADIN II consists of operational switching nodes at two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City, Utah, and Atlanta, Georgia. It will interface directly to Weather Message Switching Center Replacement (WMSCR), WARP, ADAS, TMS, and the Consolidated NOTAM System. NADIN II also may be used as the intra-facility communications system between these (collocated) users during transition to end state.

The Weather Message Switching Center Replacement (WMSCR) replaced the Weather Message Switching Center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, Missouri, with state-of-the-art technology. WMSCR performs all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of NOTAMs. WMSCR will rely on NADIN for a majority of its communications support. The system will accommodate graphic data and function as the primary FAA gateway to the NWS' National Centers for Environmental Prediction (NCEP)--the principal source of NWS products for the NAS.

To provide for geographic redundancy, the system has nodes in the NADIN buildings in Atlanta, Georgia, and Salt Lake City, Utah. Each node supports approximately one-half of the United States and will continuously exchange information with the other to ensure that both nodes have identical national databases. In the event of a nodal failure, the surviving node will assume responsibility for dissemination to the entire network.

Currently, specifications for an upgrade or replacement for the WMSCR are being formulated. The needs, when developed, will be entered into the AMS process for validation and acceptance into the NAS architecture.

The Flight Information Service (FIS) is a new communication system to provide weather information to pilots in the cockpit. FIS is a partnership program among the government and private industry with the government providing the base information and the bandwidth while the private companies provide the broadcast and value-added products. New products are screened for technical suitability and value to the pilots. Two companies have demonstrated preliminary products and capability.

The Worldwide Aeronautical Forecast System (WAFS) is a three geosynchronous satellite-based system for collecting and disseminating aviation weather information and products to/from domestic or international aviation offices as well as in-flight aircraft. The information and products are prepared at designated offices in Washington, District of Columbia, and Bracknell, United Kingdom. The United States portion of WAFS is a joint project of the FAA and NWS to meet requirements of the ICAO member states. FAA funds the satellite communications link and the NWS provides the information/product stream.

Two of the three satellites are funded by the United States. The first is located over the western Atlantic with a footprint covering western Africa and Europe, the Atlantic Ocean, South America, and North America (except for the West Coast and Alaska). The second United States-funded satellite is positioned over the Pacific and covers the United States West Coast and Alaska, the Pacific Ocean, and the Pacific rim of Asia. The third satellite, operated by the United Kingdom, is stationed over the western Indian Ocean and covers the remaining areas of Europe, Asia, and Africa. The data available via WAFS include flight winds, observations, forecasts, SIGMETs, AIRMETs, and hazards to aviation including volcanic ash clouds.

The System Wide Information Manager (SWIM) is a new concept developed in conjunction with NGATS to support NAS operations in the 2025 timeframe. For all facets of the NAS operations, all data will be resident on a 'data cube' which will be accessible to all users; thus assuring that all users will have the same data. This will assure that collaborative decision making will benefit from the same situational awareness, weather and traffic programs.

AVIATION WEATHER RESEARCH PROGRAM

Working closely with the Integrated Product Team for Weather/Flight Services Systems, ATO sponsors research on specific aviation weather phenomena which are hazardous and/or limiting to aircraft operations. This research is performed through collaborative efforts with the National Science Foundation (NSF), NOAA, NASA, and the Massachusetts Institute of Technology's Lincoln Laboratory. A primary concern is the effective management of limited research, engineering, and development resources and their direct application to known deficiencies and technical enhancements.

IMPROVED AIRCRAFT ICING FORECASTS

The purpose of this initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as described in the FAA Aircraft Icing Plan. The objectives of this plan are to develop:

1. an icing severity index,
2. icing guidance models, and
3. a better comprehension of synoptic and mesoscale conditions leading to in-flight icing.

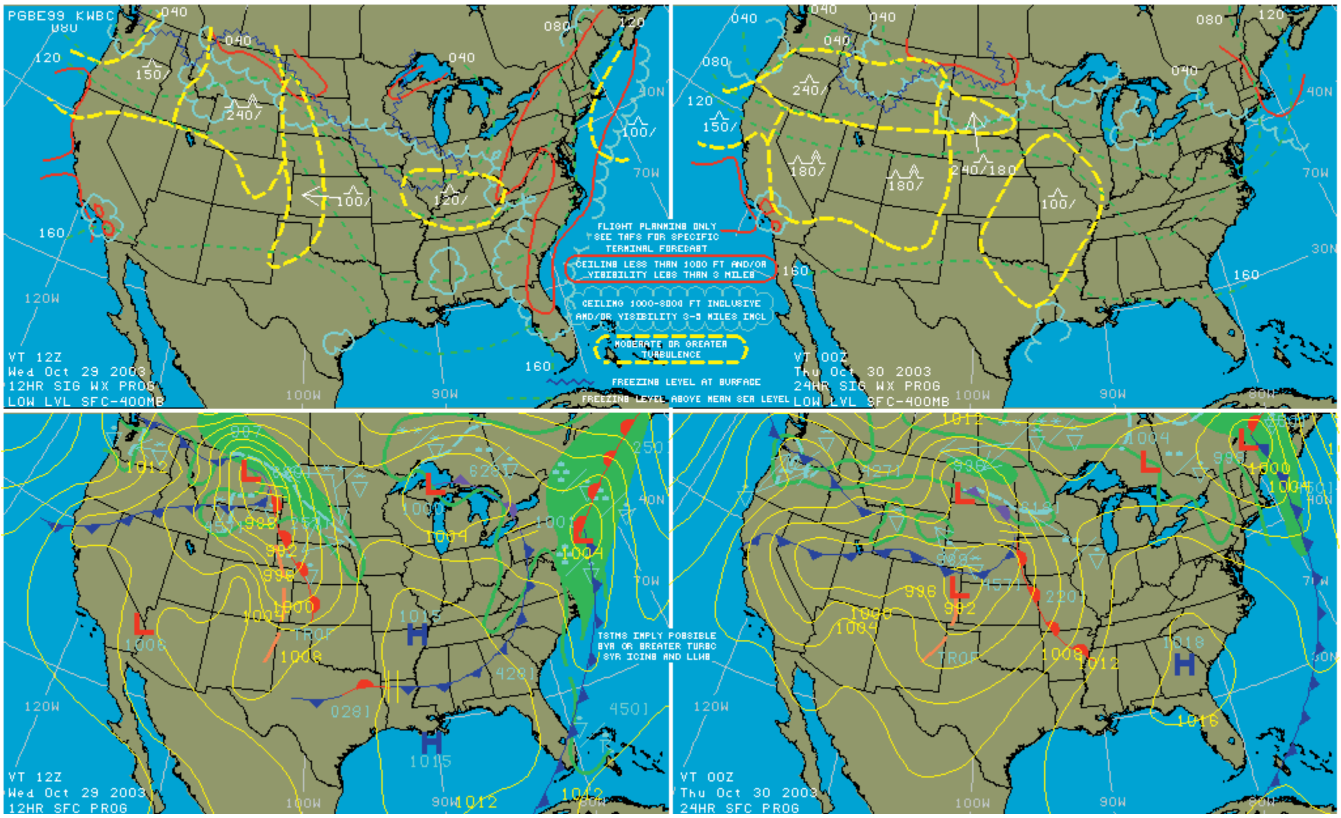


Figure 3-DOT-7. 4-panel Low Level Significant Weather graphics are produced by the Aviation Weather Center and accessible to pilots from their web site. (Source: AWC web site)

The result of this effort will be an improved icing forecasting capability that provides pilots with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

CONVECTIVE WEATHER FORECASTING

The purpose of this research effort is to establish more comprehensive knowledge of the conditions that trigger convection and thunderstorms and, in general, the dynamics of a thunderstorm's life cycle. The program will lead to enhanced capability to predict growth, areal extent, movement, and type of precipitation from thunderstorms. Gaining this forecast capability will allow better use of the airspace and help aircraft avoid areas with hazardous convective conditions (Figure 3-DOT-7).

MODEL DEVELOPMENT AND ENHANCEMENT

This research is aimed at developing or improving models to better characterize the state of the atmosphere and stratosphere in general, with specific emphasis on the flight operation environment specifically, with the aim to provide superior aviation weather products to end users.

AVIATION FORECAST AND QUALITY ASSURANCE

The Product Development Team (PDT) for the Aviation Gridded Forecast System is working on the development of products for dissemination on the Aviation Digital Data System. New algorithms will be developed to present hazardous conditions in the flight operations environment. They will develop a process for automated production of the SIGMETs. There will be capability to assure quality and a real-time verification process.

WEATHER SUPPORT TO DEICING DECISION MAKING (WSDDM)

This system develops products that provide forecasts on the intensity of snow and freezing rain, and how or when these phenomena will change in the short term. This information is needed by airport management to determine when an aircraft will require deicing before take-off. The water content of snow is believed to be an important factor. The output product is designed for non-meteorological aviation users and has been demonstrated at three different airports. Development work has been completed and FAA has made this system available to airport authorities who wish to use it as a decision aid.

CEILING AND VISIBILITY

A development and demonstration is underway in the San Francisco Bay area. The project will have unique sensors and the data will be used in new algorithms to develop improved forecasts. The project will continue over a number years as the progress is evaluated. This project is a joint effort with other Federal agencies and some of the effort is performed by academic researchers.

TURBULENCE

In addition to the work being performed by the JSAT under the Safer Skies Program, a PDT has a seven-year plan to evaluate wind shear and turbulence around and on the approaches to Juneau, Alaska. Also, they are working with certain airlines to install instruments on aircraft with the capability to measure turbulence as sensed on the aircraft and report this information automatically. The data will be used to verify forecasts and to develop a standard index to report and warn for turbulence.

NEXRAD ENHANCEMENTS

Work is continuing to develop improvements to the existing products and to develop new graphic products. Hardware and software pre-planned product improvements are are being pursued. This is a joint effort among DOT, DOD, and DOC.

Under the auspices of the OFCM, FAA is investigating the possibilities of developing multi-use phased array radar to accomplish both weather surveillance and monitor aircraft movement in controlled airspace.

SPACE WEATHER

Space Weather is of concern to the FAA in several areas of operations and regulations. Ionospheric scintillation creates certain errors in the Global Positioning System that affects navigation, especially for instrument approaches to airports. In programs for Wide Area and Local Area Augmentation Systems (WAAS and LAAS) corrections for these effects are being developed. This will be a very important advance to promote the Free Flight management of the National Airspace System. In addition, the effects on the ionosphere have grave impacts on the use of high frequency communications which are essential in air traffic control of flights across the oceans and over the poles of the Earth.

FAA is embarking in research at the Civil Aeromedical Institute in Oklahoma City, OK, on the radiation effects on fetuses of newly pregnant women when flying at high altitudes and at high latitudes where exposure is increased. The exposure of flight crews to this hazard will be measured to determine if repeated flights in this regime may accumulate deleterious results.

FAA planners for commercial space operations are working on the weather requirements to set criteria for space launch activities. The commercial launch sites in California, Florida and Virginia are co-located with government sites where the weather support is available. However, at the new commercial space launch site in Kodiak, Alaska new criteria must be developed and established for standard procedures.

FEDERAL PROGRAMS IN SUPPORT OF ROAD WEATHER

THE ROAD WEATHER MANAGEMENT PROGRAM

The Federal Highway Administration (FHWA) coordinates a number of activities aimed at improving safety, mobility, productivity, environmental quality and national security on the nation's highways during weather threats. These activities include identification of weather impacts on the roadway environment, and traffic flow, and the operational decisions that are made because of them. It includes research to advance the state of the art concerning road weather management tools, as well as documentation and promotion of the best practices. The FHWA supports these activities through the Federal-Aid Highway program and by initiating national coordination efforts since it does not operate the highway system or environmental observing systems that serve state and local highway operators, private road users, and the traveling public. The FHWA activities are conducted as partnerships with other public agencies, the private sector, and universities.

As of 1997, coordination of the FHWA's weather related activities has been centered in the Road Weather Management Program (RWMP) within the Office of Transportation Operations. From the beginning, an important goal of this program has been to help promote road weather research and development. This objective and its associated roadmap were further defined in 2005 by the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). *Title V, Subtitle C - Intelligent Transportation System Research*, *Section 5308* of this bill contains specific reference to a "*Road Weather Research and Development Program*," the scope of which includes: maximizing the use of available road weather information and technologies; expanding road weather research and development efforts to enhance roadway safety, capacity, and efficiency; minimizing environmental impacts; and promoting technology transfer of effective road weather scientific and technological advances. The bill directs the Secretary of the USDOT to solely carry out research and development called for in the National Research Council's (NRC) report entitled, *Where the Weather Meets the Road, A Research Agenda for Improving Road Weather Services*. This effort includes: integrating existing observational networks and data management systems for road weather applications; improving weather modeling capabilities and forecast tools, such as the road surface and atmospheric interface; enhancing mechanisms for communicating road weather information to users, such as transportation officials and the public; and integrating road weather technologies into an information infrastructure. The bill also includes three guiding principles which are to: enable efficient technology transfer; improve education and training of road weather information users, such as State and local transportation officials and private sector transportation contractors; and coordinate with transportation weather research program in other modes, such as aviation.

Funding authorized for Section 5308 is $5 million per year for the years 2006 to 2009, and the Secretary was directed to give preference to applications with significant matching funds from non-Federal sources. The FHWA Road Weather Management team is responsible for executing the program in coordination with the ITS Joint Program Office. The goals and objectives of the RWMP and its associated roadmap have been modified to align with the legislation, though such modification was minimal since the existing program already aligned very closely with the NRC report. Numerous efforts and initiatives within the RWMP are satisfying the requirements in the bill, including the Maintenance Decision Support System (MDSS), the Clarus initiative, and the Memorandum of Understanding between the FHWA and NOAA.

Some of the activities occurring within the RWMP include:

<u>The Strategic Highway Research Program (SHRP)</u>

Congress established the Strategic Highway Research Program (SHRP) under the 1987 Surface Transportation Act. SHRP examined a number of different subject areas including winter maintenance operations on the nation's highways. The research program was active until 1993, producing specifications, testing methods, equipment, and advanced technologies. Following the success of the five-year effort, the FHWA coordinated a national program, entitled SHRP Implementation, to work with state and local highway agencies to implement and evaluate the products. The American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB) administered this program in coordination with FHWA. The SHRP Implementation web site (www4.trb.org/trb/dive.nsf/web/shrp_implementation) contains information on the SHRP Lead States Program, SHRP products under evaluation and implementation, and SHRP in general.

<u>The Intelligent Transportation Systems (ITS) Program</u>

The Intermodal Surface Transportation Efficiency Act of 1991 established the ITS Program, including its research program that funds the FHWA Road Weather Management Program activities. This program is overseen by the ITS Joint Program Office (ITS-JPO), which is a cross-modal office hosted in the Research and Innovative Technology Administration. While ITS initially focused on automated highways and metropolitan areas, a rural focus was initiated in 1996. The rural ITS program identified maintenance and weather as additional ITS focus areas, and recognized the need for total integration of the maintenance, traffic, and emergency management functions across wide areas and between states. The following research activities are examples that fall within this overall weather-across-ITS strategy:

Vehicle Infrastructure Integration (VII) Initiative

This initiative (www.its.dot.gov /vii/index.htm) is exploring the potential of creating a data sharing communication system that can support vehicle-to-vehicle and vehicle-to-infrastructure communications. The system, once implemented, will be able to provide real-time travel and weather information to both the public sector and private industry by using vehicle-based sensors to gather a variety of data system-wide. This resulting communications network would allow weather, traffic and other information to be transmitted to transportation operators, providing a real-time view of the conditions on every major road within the transportation network. Such concepts will be explored as the initiative matures. Preliminary documentation describes some of the weather-related data items that could be directly measured or inferred from vehicle sensor systems including precipitation detection, ambient air temperature, fog or visibility information, and road traction state or mobility. The functional architecture and requirements for VII continue to be developed and a Proof-of-Concept will be taking place in Detroit, Michigan during the Fall of 2007.

National ITS Architecture and ITS Standards

Intelligent Transportation Systems use open system principles and are based upon the National ITS Architecture - a modularly defined set of information processes with known protocols for exchanging information between modules. While road weather information was not an original focus of the National ITS Architecture, it has since been captured through the Maintenance and Construction Operations (MCO) user service. MCO development included the definition of a Road Weather Information Service terminator designed to complement the existing Weather Service terminator. Together, these represent the division of responsibility for road weather information, provided largely by private vendors and based on ESS observations, and weather information in general. The interfaces between the two types of services are then defined as being outside of the ITS, although the FHWA continues to maintain an active interest in their development.

It is hoped that further detailing of weather applications in traffic and emergency management will lead to further architecture developments in the years ahead. As the interface between the ITS and evolving national weather information systems becomes better defined, the National ITS Architecture and standards will provide a technical basis for integration and promotion of open system principles. Version 5.1 of the National ITS Architecture can be found at http://itsarch.iteris.com/itsarch/.

Environmental Observing Systems (ESS)

Nearly 2,500 ESS are owned by state transportation agencies in the United States as shown in Figure 3-DOT-8. More than 2,000 of these ESS are field components of Road Weather Information Systems. Most of the ESS that are placed in the field are fixed and tend to include in situ sensors for the most common atmospheric weather variables as well as pavement and subsurface temperature probes, pavement chemical concentration and/or pavement freezing point. A growing trend is the use of mobile environmental sensors that are being deployed to observe weather and pavement conditions from vehicles. An important application of the mobile (and potentially remote) sensing is thermal mapping of road segments. This technique provides snapshots of complete pavement temperature profiles which can then be used to select fixed optimal ESS sites and to spatially predict temperatures based on time series predictors at the fixed stations. Research funded by the FHWA is also investigating the potential to extract surface weather and road condition data from standard traffic camera imagery. The potential value of this research is significant considering the fact that in 2004, there were already 4000 Closed Circuit Television (CCTV) traffic cameras deployed nationwide.

At present, ESS data from across the United States has never been collected, formatted and quality checked in a uniform manner at the national level. Nor has it then been made, available to all users from a "one-stop-shop" location so that it can be more effectively utilized by members of both the weather enterprise and the transportation community. A USDOT-sponsored initiative entitled *Clarus* aims to correct this shortfall by designing and demonstrating an integrated road weather observational network, and establishing a partnership to facilitate deployment of a nationwide surface transportation weather observing system. The long-term vision of *Clarus* is that all data from State DOT ESS will be routinely collected, quality-checked, and translated into an open standard format. Quality checking algorithms and direct feedback to state DOT points of contact will improve agency awareness of sensor status. Access to robust and calibrated data will be provided through an open Internet data portal. The *Clarus Concept of Operations* and the *Clarus* system design has been completed. A Proof-of-Concept demon-

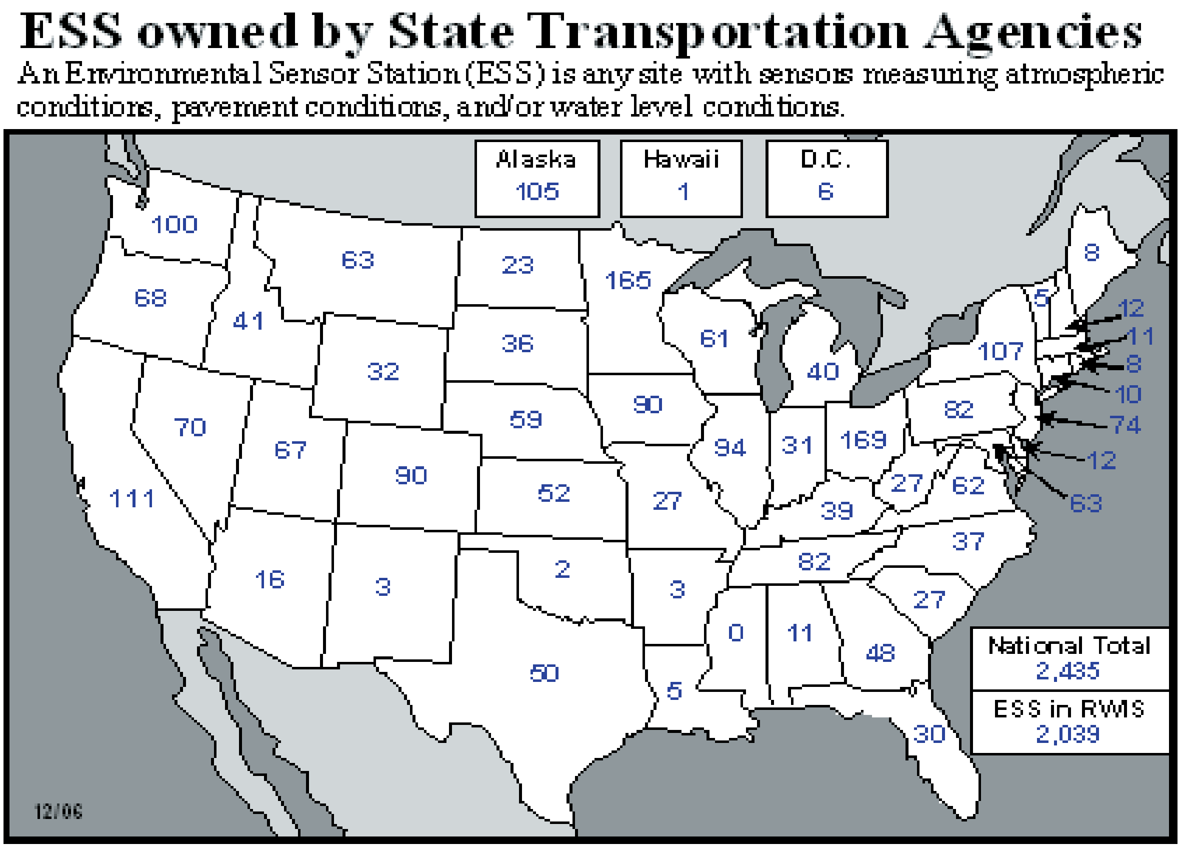


Figure 3-DOT-8. Census of deployed Environment Sensor Station (ESS) units. An ESS is a site measuring atmospheric, pavement and/or water level conditions. Many state transportation agencies deploy ESS as field components of Road Weather Information Systems (RWIS). As shown on the map, there are over 2,400 ESS owned by state transportation agencies. Most of these stations (i.e., over 2,000) are part of RWIS and used to support road maintenance activities. The other environmental sensor stations are deployed for various applications including flood monitoring and aviation.

stration occurred in 2006, and a series of regional demonstrations will be initiated during the spring of 2007.

In order to address some of the issues related to surface weather observations, the FHWA is participating in several OFCM projects including the WIST Working Group, the Phased Array Radar (PAR) Joint Action Group, the Joint Action Group for Joint Urban Test Beds (JAG/JUTB), the Fire-Weather Joint Action Group, the Committee on Environmental Information Systems and Communication, and the Committee for Environmental Services, Operations, and Research Needs (CESORN). The FHWA is also participating in NOAA efforts to explore the modernization of the cooperative observer network and development of a national surface weather observing system.

From 2001 to 2003, the FHWA sponsored five research projects, under the Cooperative Program for Meteorological Education and Training (COMET) (www.comet.ucar.edu), which became the first to add state DOTs to the traditional partnerships of NWS forecast offices and universities. The COMET projects in Iowa, Nevada, New York, Pennsylvania, and Utah fostered the sharing of environmental data and facilitated advanced meteorological modeling to enhance road weather forecasts. Ultimately, these efforts will contribute to the development of decision support tools for winter maintenance managers, traffic managers, and the traveling public. Lessons learned from these projects can help all state DOTs better manage RWIS networks and achieve maximum utility from RWIS data.

In order to enhance observation capabilities and define requirements for road weather observing systems, the Road Weather Management Program worked with the Aurora Pooled Fund Program and the AASHTO Snow and Ice Cooperative Program to produce the *Road Weather Information System ESS Siting Guidelines* (http://ops.fhwa.dot.gov/publications/ess05/). The guidelines, published in 2005, provide a set of recommendations to support uniform siting of ESS that collect road and weather observations for RWIS, and are intended to improve the usefulness of road weather information derived from these observations. The Road Weather Management program will facilitate the adoption and implementation of the guidelines in transportation agencies through targeted research and deployment activities.

Decision Support

Transportation system managers and

users identify three critical surface weather information requirements as the trinity of "relevance, accuracy and timeliness". Although significant progress continues to be made by both the public and private sectors in providing new technologies to meet these requirements, a significant gap has developed between the amount of increasingly good and plentiful surface weather information, and the amount of support available for effective operational decision-making. Assisting and supporting the research and development of ways to overcome this gap has become an important initiative within the FHWA.

Decision support is where surface weather data needs to be customized since each operational decision is specific to a type of road weather management strategy, a particular place and time, and the characteristics of the decision maker (their expertise, their location, their information processing equipment). Road weather management strategies mitigate weather impacts by advising motorists of prevailing and predicted conditions (e.g., traveler information), controlling traffic flow and roadway capacity (e.g., weather-responsive traffic signal timing, road closure), and/or treating roads to minimize or eliminate weather threats (e.g., plowing, anti-icing/deicing).

In 1999 and 2000, decision support requirements, first generally and then specifically for winter road maintenance, were studied in the Surface Transportation Weather Decision Support Requirements (STWDSR) project. This project used weather threat scenarios to identify specific decisions made in winter road maintenance, their timing, and the expected confidence of the decisions at various time horizons. General requirements for emergency managers, traffic managers, and road users were also defined. The STWDSR project became an important contributor to the OFCM's Weather Information for Surface Transportation (WIST) needs analysis, the National ITS Architecture modifications, and to the Maintenance Decision Support System (MDSS) prototype project.

Along with the Maintenance Decision Support System described below, in 2006, the FHWA and the Missouri DOT developed and tested a prototype Weather Response System (WRS) for transportation system operations. The WRS used road weather information from the NWS, and other sources to support transportation control, maintenance and operations decision-making. The results of the prototype testing and evaluation are being used to develop the concept of operations for a Maintenance and Operations Decision-Support System (MODSS) that expands the capabilities of MDSS for road maintenance beyond snow and ice control as well as into traffic management decision-making.

<u>Support for Maintenance Managers</u>

The Maintenance Decision Support System (MDSS) project is a multi-year, FHWA-sponsored effort that was envisioned to assist transportation managers and operators improve roadway levels of service during winter weather events while minimizing road treatment costs (e.g., by optimizing use of labor, materials, and equipment). This data management tool has an ensemble of advanced weather prediction and road condition prediction capabilities, including air and pavement temperatures, precipitation start/stop times, precipitation types and accumulation amounts. These predictions are fused with customized winter road maintenance rules of practice to generate route-specific treatment recommendations (i.e., strategy, timing, and material application rates).

In the spring of 2003, the first functional MDSS prototype was demonstrated and evaluated by three Iowa DOT maintenance garages. The main display of the demonstration prototype, shown in Figure 3-DOT-9, includes predicted weather and road conditions, a weather parameter selection menu, a map of roads and weather alerts, as well as forecast animation controls. During the winter of 2004-2005, the demonstration domain was moved to Colorado to assess prototype capabilities over more complex terrain. Based on lessons learned from the preliminary demonstration in Iowa, the subsequent releases of Versions 2.0 and 3.0 in 2003 and 2004 respectively, and the Colorado demonstration, Version 4.0 was made available in November 2005. Lessons learned, recommended enhancements and the future directions of the program were addressed and discussed during the 8th annual stakeholder meeting that was held in Falls Church, Virginia in August 2006, and Version 5.0 was released in 2007.

In recognition of the progress being made in the development of a MDSS, the AASHTO Technology Implementation Group (TIG) proclaimed it to be a "2006 ready-to-implement technology" (AASHTO Journal 4/7/2006), and receiving this important designation facilitated increased deployment of this tool. In addition, the FHWA and its partners have worked together to ensure that the MDSS project evolves from prototype development to proactive outreach, deployment assistance, technology transfer, and expansion of functionality to other applications, such as non-winter road maintenance and traffic management, and even other surface transportation sectors. This change is consistent with the FHWA's original deployment strategy, which included creating an environment that enables the private sector to build end-to-end products using core MDSS prototype functionality/technology as their foundation. These products will be procured by public agencies (e.g., state DOTs), enabling both the private and public sectors to benefit from millions of dollars of high-risk research. One example of

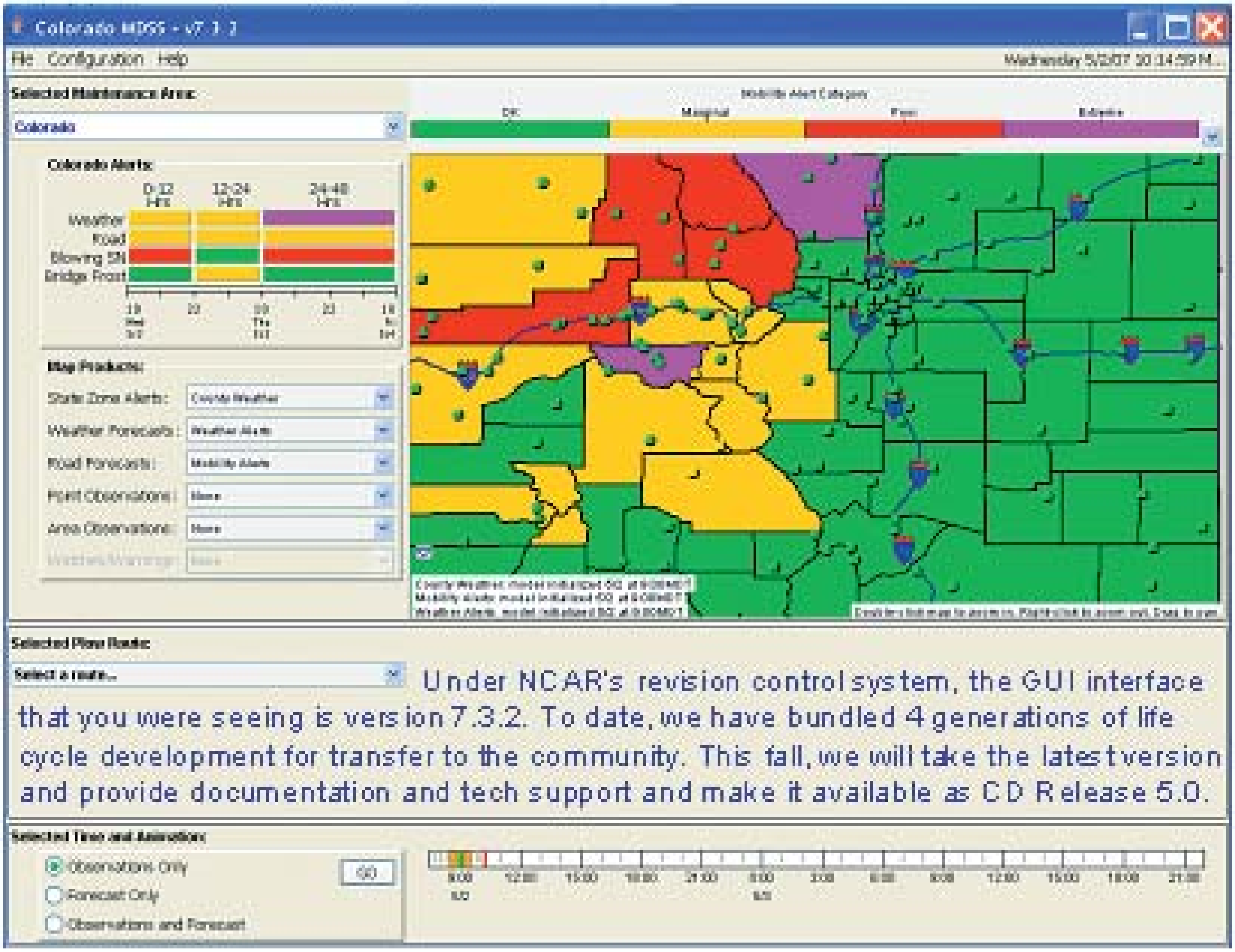


Figure 3-DOT-9 . Schematic of FHWA's Maintenance Decision Support System.

technology transfer is the MDSS Pooled Fund Study (PFS) project led by the South Dakota DOT. Other participants include the state DOTs in Colorado, Indiana, Iowa, Minnesota, Kansas, Wyoming, New Hampshire, North Dakota, and California as well as Aurora (a pooled fund research program), a private vendor, and the FHWA. The objective of the project has been to build, evaluate, and deploy an operational MDSS by refining model components and conducting extensive field tests.

An example of proactive outreach has been the development and deployment of the "MDSS RoadShow" by the FHWA Resource Center. This free seminar, which includes both an Executive Briefing and a Shop Session, is available to transportation managers, maintenance engineers and operators. The presentation describes the functions of MDSS, its capabilities, and its limitations. It also provides a level of detail that helps public agencies make more informed decisions about investing in such a tool.

Other FHWA-sponsored support activities that occurred in 2007 included: updating several components of the MDSS core system; overseeing the release of an enhanced version of the software; conducting several cost/benefit analyses to generate quantitative results that can be used by the transportation community to justify investments in MDSS, and furthering the expansion of MDSS to MODSS (Maintenance and Operations Decision Support System) to include non-winter road maintenance and traffic management modules. Results of two stakeholders meetings that were held in February of 2007 will be used to initiate the development of these modules. Additional information on the MDSS project and the RoadShow can be found at www.rap.ucar.edu /projects/rdwx_mdss and at http://ops.fhwa.dot.gov/Weather/index.asp.

Support for Traffic Managers

In 2006, the Road Weather Management Program developed a 5-year roadmap for Weather-Responsive Traffic Management. The roadmap identifies the goals and activities that FHWA will pursue in three major program areas: data collection and integration, impacts of weather on traffic flow, and traffic management strategies. The roadmap also serves as the basis for future work to identify, develop, test, and evaluate a variety of weather-responsive traffic management strategies.

Empirical studies of traffic flow in inclement weather were completed in early 2007. This study developed adjustment factors for traffic parameters including speed and capacity as a function of precipitation and visibility. A follow-up research on driver behavior in inclement weather will be initiated later in 2007. This research will improve the understanding of how traffic flow and driver behavior change under adverse weather conditions. Once these factors are better understood, the information can be incorporated into traffic simulation models and, ultimately, traffic information and control tools.

<u>511-The National Traveler Information Telephone Number</u>

Based on the concept that a standardized number for travel information would be beneficial to the traveling public, a broad coalition of ITS interests worked together to allocate a national 511 traveler information telephone number. In 2002, the FHWA sponsored a number of grants to plan for state deployment of 511 services, and guidelines were issued on service content. A survey on traveler information conducted by ITS America indicated that weather and road condition information were highest in demand by travelers, and therefore, this type of information is considered a key component of 511 services. The means of delivering this information through 511 continue to be developed, including ways to serve peak demands for emergency evacuation information, as part of the homeland defense, or other threat response capabilities.

In June 2003, the 511 Deployment Coalition released a Deployment Assistance Report, Weather and Environmental Content on 511 Systems, to recommend basic content and provide for consistency in 511 systems as they are deployed across the country. Since these systems are still relatively new, gaps exist in defining the types of road weather information travelers' desire, appropriate data formats, and the frequency and detail needed for travelers to make safe and effective decisions.

The Road Weather Management Program has participated in several 511 Deployment conferences such as the one held in San Diego, California in July 2006, and it continues its efforts to help establish road weather data requirements that can help to close these gaps. The 511 program is also exploring various ways to complement the NOAA Weather Radio broadcasts, and incorporate the NWS's official watches and warning information. The deployment of the 511 system is just one more way in which ITS is becoming a significant means for disseminating road weather information. In 2006, 511 services were accessible to approximately 37 percent of our nation's population and this number jumped to approximately 67 percent in 35 states in 2007 (Figure 3-DOT-10) . More information can be obtained on the 511 system and the status of its deployment by visiting http://www.deploy511.org.

Weather Impacts on Roadway Safety, Mobility & Productivity

While the impacts and associated costs of adverse weather on surface transportation are considered to be immense, it has been difficult to quantify specific costs related to these impacts. This is also true of the benefits (as avoidable costs) that are achieved through better information that helps support more effective responses and/or mitigation strategies. It is likely that the costs to mobility, in terms of delay due to weather, are the most significant part of this economic picture. For example, initial estimates of the economic impact of weather-related delay on trucks in the 20 major metropolitan areas most affected by adverse weather are on the order of $2 billion per year.

In an attempt to get a better understanding on the relationship between adverse weather and traffic delays, the FHWA sponsored a series of analyses that were conducted for the Seattle, Washington and Washington, District of Columbia (DC) metropolitan areas. These analyses combined surface weather observations with traffic speed data, both empirical and modeled. The results were consistent in showing about a 12 percent increase in travel time averaged over a wide range of weather events. A second analysis of delay effects in Washington, DC was conducted with archived Doppler radar data for more precise and more dynamic inference of road weather conditions. Analysis results indicated that during peak travel periods, travel time increased by roughly 24 percent when precipitation was present. It is the FHWA's belief, that achieving a better understanding of weather-traffic interactions, will lead to an improved ability to mitigate the impact of weather-related delays through traffic management practices, including speed management, access control (e.g., road closure), motorist warning systems, and weather-responsive signal timing.

<u>Road Weather Management Program Outreach and Training</u>

The Road Weather Management Program web site (http://www.ops.fhwa.dot.gov /Weather/index.asp) contains a wealth of information on the program. This includes material objectives and initiatives, weather impacts, benefits of road weather management strategies, technologies to help mitigate weather impacts, best practices, training, upcoming events, a listing of over 200 road weather related publications, and 30 case studies of road weather management systems. Each case study has six sections including a general description of the system, system com-

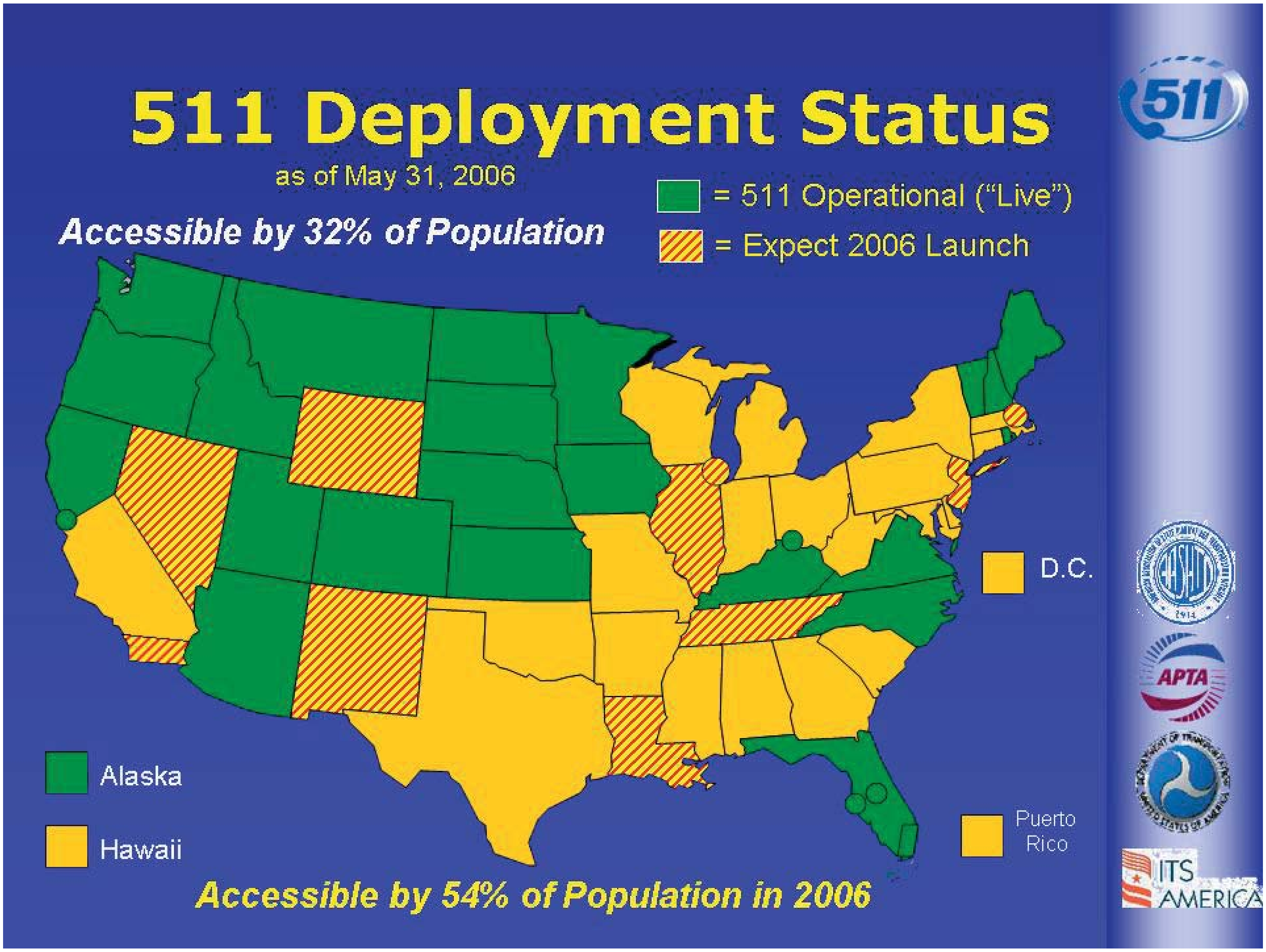


Figure 3-DOT-10 . 511 National Traveler Information Telephone Number Deployment - May 2006.

ponents, operational procedures, resulting transportation outcomes (i.e., improved safety, mobility and/or productivity), implementation issues, as well as contact information and references.

A key outreach activity of the program is the annual "Eastern Snow Expo". Over the past twelve years, the FHWA has partnered with state agencies to host the Eastern Snow Expo, which provides a forum for sharing information and technologies used to counter the effects of winter weather. AASHTO is now the lead sponsor, with the FHWA supporting this event as a co-sponsor. More information on the Eastern Snow Expo can be found at www.easternsnowexpo.org.

The FHWA sponsors training programs and conducts outreach to promote Road Weather Management Program products and activities. In 2005, a one-day training course on "*Principles and Tools for Road Weather Management*" became available through the National Highway Institute (NHI course No. 137030A). The course is aimed at helping those involved in highway maintenance and operations develop techniques and strategies for tackling road weather problems. The course provides basic knowledge of meteorology and addresses the technological resources available to support highway personnel in making effective road weather management decisions. The course was already delivered three times, and a web-based version of it will be available in mid-2007. Additional details are listed on National Highway Institute web site (www.nhi.fhwa.dot.gov).

The computer-based Anti-Icing/RWIS Training Program is a comprehensive, interactive training program for winter operations that was jointly developed by AASHTO, with support from the FHWA and Aurora. The training program covers an introduction to anti-icing and winter maintenance, winter road maintenance management, winter roadway hazards and principles of overcoming them, weather basics, weather and roadway monitoring for anti-icing decisions, computer access to road weather information, and anti-icing practice in winter maintenance operations.

The Federal Railroad Administration (FRA) supports improving the collection, dissemination, and application of weather data to enhance railroad safety through the Intelligent Weather Systems project, as part of the Intelligent Railroad Systems and Railroad System Safety research programs. These programs address safety issues for freight, commuter, intercity passenger, and high-speed passenger railroads.

Intelligent weather systems for railroad operations consist of networks of local weather sensors and instrumentation - both wayside and on-board locomotives - combined with national, regional, and local forecast data to alert train control centers, train crews, and maintenance crews of actual or potential hazardous weather conditions. Intelligent weather systems will provide advance warning of weather caused hazards such as flooding; track washouts; snow, mud, or rock slides; high winds; fog; high track-buckling risk; or other conditions which require adjustment to train operations or action by maintenance personnel (Figure 3-DOT-11).

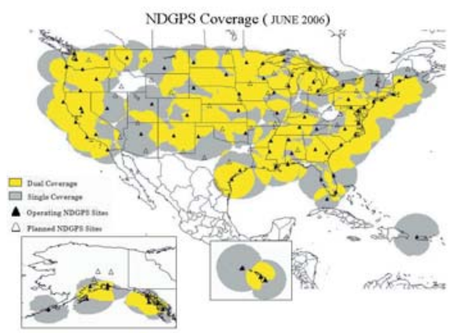
Figure 3-DOT-11. Track washed out by flood waters from Hurricane Alberto.

Weather data collected on the railroad could also be forwarded to weather forecasting centers to augment their other data sources. The installation of the digital data link communications network is a prerequisite for this activity.

FRA intends to examine ways that weather data can be collected on railroads and moved to forecasters, and ways that forecasts and current weather information can be moved to railroad control centers and train and maintenance crews to avoid potential accident situations. This is one of the partnership initiatives identified in the National Science and Technology Council's *National Transportation Technology Plan*.

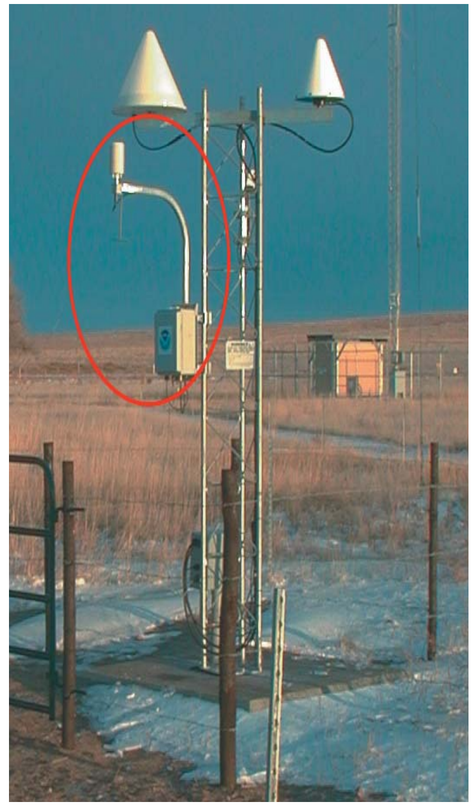
WEATHER FORECASTING ENHANCED BY NATIONWIDE DIFFERENTIAL GLOBAL POSITIONING SYSTEMS (NDGPS)

Nationwide Differential Global Positioning System (NDGPS) is a system of reference stations that monitors GPS and broadcasts corrections, which can be used by the GPS receiver to improve the accuracy, integrity and availability of the GPS position.



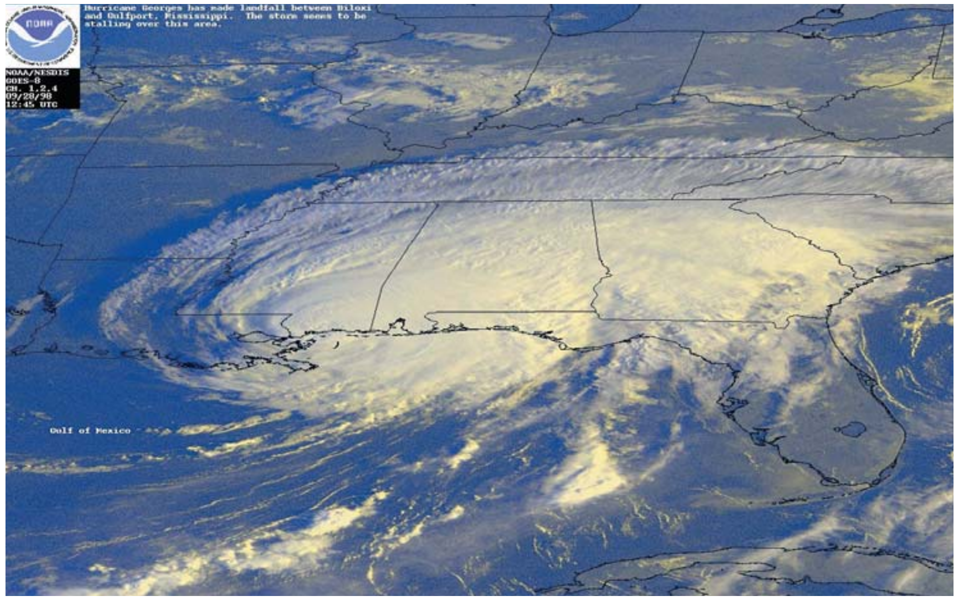
NDGPS is used in a myriad of applications including: maritime navigation, positive train control, precision farming, dredging, graphic information systems and surveying.

The Global Systems Division (GSD) of the Earth System Research Laboratory (ESRL) in the National Oceanic and Atmospheric Administration (NOAA) developed a unique application, which very accurately measures the amount of water vapor in the atmosphere by taking advantage of the dual-frequencies, reference station



receivers at the NDGPS sites and a suite of weather sensors added to each reference station. The weather sensors, circled in the photo above, measure temperature, relative humidity and barometric pressure. The GPS satellites broadcast on two frequencies, L1 and L2. GSD uses these two frequencies to correct for the ionospheric delay that is caused by changes in the refractive index associated with the concentration of free electrons in the upper atmosphere. The ionospheric delay is usually about 6-10 times greater than the signal delay caused by the neutral, non-electrically conducting, atmosphere. GSD can than estimate the signal delays caused by the neutral atmosphere by comparing the errors in position between sites that are over 500 km apart by viewing the same satellites for about 30 minutes. Most of the delay in the troposphere (lower atmosphere) is caused by the mass of the atmosphere, or the hydrostatic component, while the induced dipole moment of the water vapor molecules in the atmosphere is responsible for the rest of the delay.

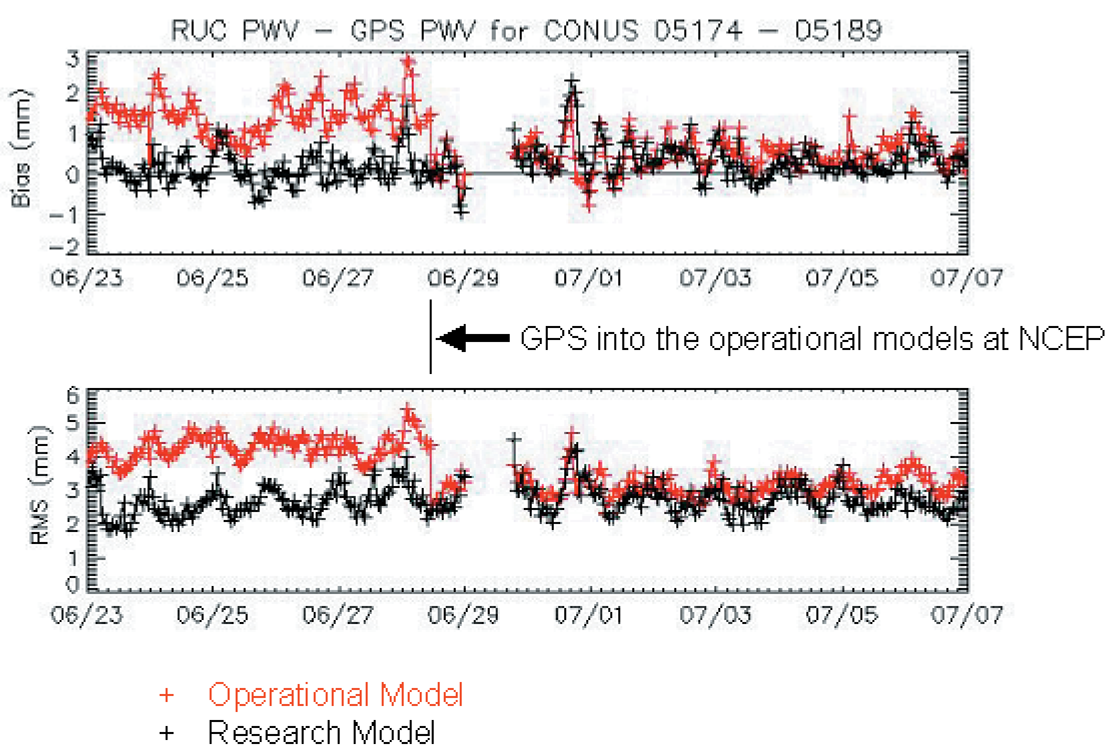
The GSD can accurately estimate the hydrostatic delay by putting a pressure sensor at the NDGPS site and mapping the surface pressure into signal delay using well-known physical relationships. Subtracting the hydrostatic delay from the observed tropospheric delay gives the wet signal delay caused by water vapor in the atmosphere. Then, the wet delay is mapped into the quantity of water vapor responsible for the delay using information about the temperature of the atmosphere and the characteristics of the air at microwave frequencies.



This results in the equivalent height of a column of water that would form if all of the water vapor in the atmosphere were to fall or precipitate. The total precipitable water vapor content is a direct measure of how much raw material is in the atmosphere in the form of rain, snow, hail and clouds. As the water vapor changes state from gas to liquid to solid and back again, it releases or absorbs energy associated with the latent heat bound-up in the molecules. This energy release and absorption is the primary energy responsible for weather. The reason that water vapor is hard to measure is that it only manifests itself when it changes state, and most instruments that can observe water in its gaseous state do not work well under all weather conditions. However, NDGPS works remarkably well in all weather conditions.

Water vapor is the most important

GPS Water Vapor Measurements Enter Service in NOAA Operational Weather Models



component of weather and the least observed. In June 2005, the research and development program to evaluate the use of NDGPS data became an operational program feeding near-real time date into NOAA's operational models. The addition of this data has greatly improved the model and short-term weather forecasts, especially during periods of active weather such as fronts, hurricanes or tornadoes.

DOT program responsibility for NDGPS will transfer from the Federal Railroad Administration to DOT's Research and Innovative Technology Administration on October 1, 2007.

NATIONWIDE SURFACE TRANSPORTATION WEATHER OBSERVING AND FORECASTING SYSTEM - *CLARUS*

The weather products available today through both public and private resources are typically insufficient to meet the demands of transportation operations. Nearly all weather forecasting today is based on observations of the atmosphere. However, the greatest impact of weather events on the safety and mobility of travelers and freight occurs on the surface. Many state DOT's have invested in road weather information systems that provide their agencies with observations on conditions at the surface and just below the surface. Other entities such as agriculture, water districts, electric utilities, and railroads also operate weather observation stations.

FRA is developing a partnership with the Federal Highways Administration (FHWA), state DOT's, NOAA and others to establish a nationwide road weather observation network known as *Clarus*. The goal of the *Clarus* project is to tie this mosaic of private and public observation stations into a cohesive weather forecasting system that is specifically focused on surface conditions.

DEPARTMENT OF AGRICULTURE WEATHER PROGRAMS

The Nation's food and fiber products are a critical resource impacting our domestic and international economic situation and are essential for ensuring our national security and shaping foreign policy. Weather is the most important factor influencing the Nation's variability in crop yields and related production. The United States Department of Agriculture (USDA) monitors global weather and agricultural developments through the Joint Agricultural Weather Facility (JAWF). The JAWF provides critical information to decision-makers formulating crop production forecasts, programs that provide natural disaster assistance to U.S. farmers and ranchers, emergency relief programs, and trade policy. USDA operates specialized weather observing networks such as SNOTEL, SCAN, and RAWS that provide vital data and information used to forecast seasonal water supplies in the West, to support national conservation programs, and to monitor the health of the Nation's forests. USDA conducts supporting research that focuses on understanding the interactions of weather and climate with plants, animals, forests, and forest ecological systems.

METEOROLOGICAL PROGRAMS

Numerous agencies within the United States Department of Agriculture (USDA) require a wide range of high quality weather and climatological data to successfully carry out their missions. Some of the diverse applications that require accurate, timely, and comprehensive data include crop monitoring and weather impact assessment, agricultural yield and productivity modeling, natural resource conservation planning, forest fire potential monitoring, irrigation scheduling, water supply information, reinsurance and compliance programs, crop disaster assistance and emergency relief programs, integrated past management, crop yield modeling, and agricultural research studies. The following is a brief description of agency weather activities.

OFFICE OF THE CHIEF ECONOMIST /WORLD AGRICULTURAL OUTLOOK BOARD

The World Agricultural Outlook Board (WAOB) is located within the Office of the Chief Economist (OCE). The WAOB's primary objectives are consistency, objectivity, and reliability of outlook and situation-related material, including weather information, developed within the USDA. The WAOB coordinates all weather and climate information and monitoring activities within USDA. The WAOB also manages the Joint Agricultural Weather Facility (JAWF), which serves as the focal point in the Department for weather and climate information and impact assessment.

JAWF was created in 1978 as an operational unit, and is jointly managed by the USDA/OCE/WAOB and the U.S. Department of Commerce (DOC)/National Oceanic and Atmospheric Administration (NOAA)/National Weather Service (NWS)/National Centers for Environmental Prediction (NCEP)/Climate Prediction Center (CPC). The primary mission of the JAWF is to routinely collect global weather data and agricultural information to assess the impact of growing season weather conditions on crops and livestock production prospects. JAWF meteorologists work as a team, monitoring global weather conditions and crop developments on a daily basis, and preparing real-time agricultural assessments (Figure 3-USDA-1). These assessments keep USDA commodity analysts, the OCE, and the Secretary of

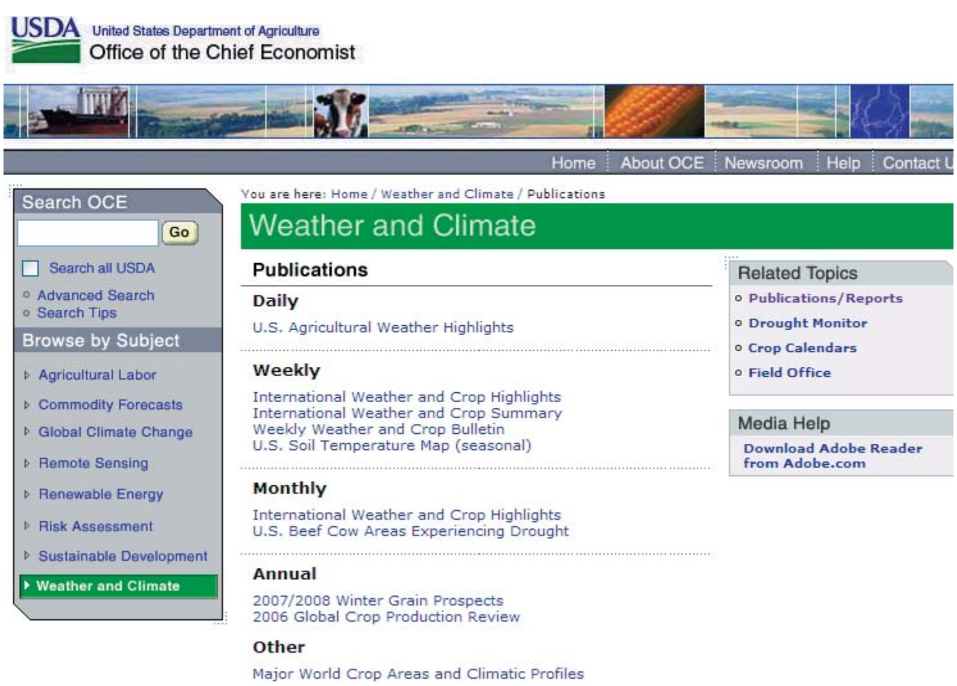
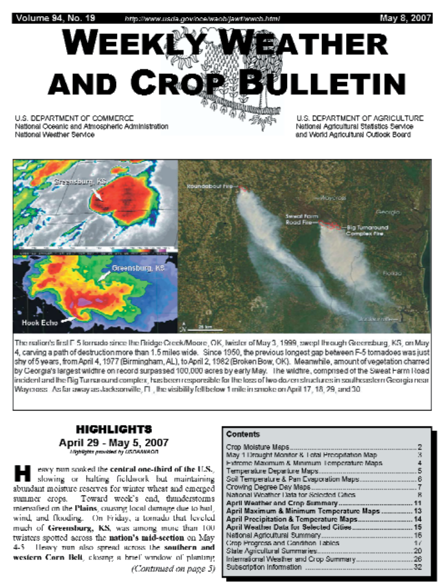


Figure 3-USDA-1. Joint Agricultural Weather Facility Web Site.

Figure 3-USDA-2. Special agricultural assessment example - severe freeze in California citrus areas from January 11-16, 2007.

Agriculture and top staff well informed of worldwide weather-related developments and their effects on crops and livestock. In addition to providing routine assessments, OCE/WAOB agricultural meteorologists at JAWF are frequently requested to prepare special assessments when adverse or anomalous weather conditions (e.g., droughts, heat waves, freezes, floods, and hurricanes) are observed in major crop-producing regions. Many of these special assessments are prepared using a Geographic Information System (GIS) to overlay weather data and information on crop-producing areas for detailed analysis. An example of an assessment made during a significant freeze event in California citrus areas from January 11-16, 2007, is shown in Figure 3-USDA-2. When integrated with economic analyses and information, these routine and special crop-weather assessments and analyses provide critical information to decision-makers formulating crop production forecasts, trade policy, and disaster relief. They also help identify potential agricultural markets for U.S. products around the world. Inputs from OCE/WAOB/JAWF are integrated into USDA's monthly foreign crop production estimates. Weekly briefings on global weather and crop developments are provided to USDA top staff.

JAWF serves as the USDA focal point for weather data received from the Global Observing System, a worldwide network of nearly 8,000 meteorological reporting stations managed by the World Meteorological Organization (WMO). The WMO data are stored and maintained at JAWF in a sophisticated data warehouse that utilizes advanced database technology. These data are used at JAWF and other USDA agencies for a number of agricultural applications. The agricultural meteorologists of OCE/WAOB/JAWF merge these weather data with climatological analyses and global agronomic data to determine the weather's impact on crop development and yield potential. A major source of domestic weather and climate data that are often used in special operational crop and weather analyses for the United States comes from the NWS's Cooperative


Volume 94, No. 19 http://www.usda.gov/oce/waob/jawf/wwcb.html May 8, 2007

WEEKLY WEATHER AND CROP BULLETIN

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

U.S. DEPARTMENT OF AGRICULTURE
National Agricultural Statistics Service
and World Agricultural Outlook Board

The nation's first F-5 tornado since the Bridge Creek/Moore, OK, twister of May 3, 1999, swept through Greensburg, KS, on May 4, carving a path of destruction more than 1.5 miles wide. Since 1950, the previous longest gap between F-5 tornadoes was just shy of 5 years, from April 4, 1977 (Birmingham, AL), to April 2, 1982 (Broken Bow, OK). Meanwhile, amount of vegetation charred by Georgia's largest wildfire on record surpassed 100,000 acres by early May. The wildfire, comprised of the Sweat Farm Road incident and the Big Turnaround complex, has been responsible for the loss of two dozen structures in southeastern Georgia near Waycross. As far away as Jacksonville, FL, the visibility fell below 1 mile in smoke on April 17, 18, 29, and 30.

HIGHLIGHTS
April 29 - May 5, 2007
Highlights provided by USDA/WAOB

Heavy rain soaked the **central one-third of the U.S.**, slowing or halting fieldwork but maintaining abundant moisture reserves for winter wheat and emerged summer crops. Toward week's end, thunderstorms intensified on the **Plains**, causing local damage due to hail, wind, and flooding. On Friday, a tornado that leveled much of **Greensburg, KS**, was among more than 100 twisters spotted across the **nation's mid-section** on May 4-5. Heavy rain also spread across the **southern and western Corn Belt**, closing a brief window of planting

(Continued on page 5)

Contents

Figure 3-USDA-3. *Weekly Weather and Crop Bulletin* is a joint effort of between the Departments of Agriculture and Commerce.

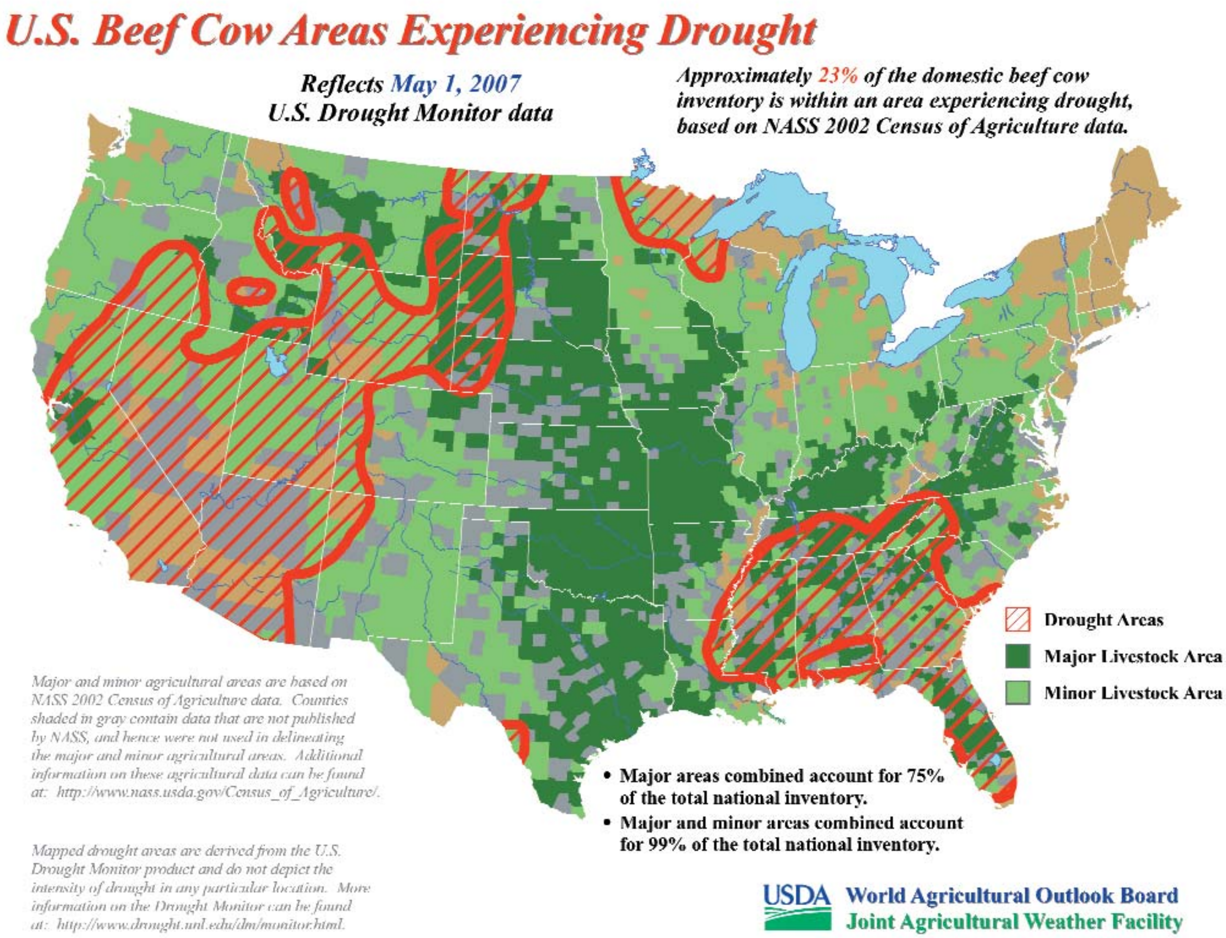


Figure 3-USDA-4. A monthly update of United States beef cow areas experiencing moderate or more intense drought.

Observer (COOP) Network of over 3,500 daily reporting stations.

JAWF's flagship publication is the *Weekly Weather and Crop Bulletin (WWCB)*. The WWCB is jointly produced by USDA/OCE/WAOB, USDA/National Agricultural Statistics Service (NASS), and the DOC/NOAA/NWS/NCEP/CPC. First published in 1872 as the *Weekly Weather Chronicle*, the publication has evolved over the past 135 years into one that provides a vital source of information on weather, climate, and agricultural developments worldwide. The publication is a shining example of how two major departments (USDA and DOC) within the Federal government can mutually cooperate, combining meteorology and agriculture to provide a service that benefits the economic well being of the nation. The WWCB highlights weekly meteorological and agricultural developments on a national and international scale, providing written summaries of weather and climate conditions affecting agriculture, as well as detailed maps and tables of agrometeorological information that is appropriate for the season (Figure 3-USDA-3). The WWCB also provides timely weather and crop information between the monthly *Crop Production and World Agricultural Supply and Demand Estimates* reports, issued by USDA/NASS and USDA/OCE/WAOB, respectively. The WWCB is available in electronic form from the OCE web site at http://www.usda.gov/oce/weather/index.htm.

Knowledge of historical climate data and agricultural production patterns in agricultural regions around the world is critical in JAWF's assessments of weather's impact on crop yields. In September 1994, OCE/WAOB/JAWF published the *Major World Crop Areas and Climatic Profiles (Agricultural Handbook No.664).* This reference handbook provides the framework for assessing the weather's impact on world crop production by providing information on climate and crop data for key producing regions and countries. Coverage includes major agricultural regions and crops, including coarse grains, winter and spring wheat, rice, major oilseeds, sugar, and cotton. World maps show the normal developmental stage of regional crops by month. An electronic version of the handbook was developed to provide periodic updates to the printed version as additional data become available. The electronic version is available from the OCE web site at http://www.usda.gov/oce/weather/pubs/Other/MWCACP/index.htm.

Drought is one of the most costly natural disasters affecting the United States. In the summer of 1999, a monitoring tool known as the *Drought Monitor* was developed to help assess drought conditions in the United States. The *Drought Monitor* is a collaborative effort between Federal and academic partners, including the University of Nebraska-Lincoln National Drought Mitigation Center, OCE/WAOB/JAWF, NOAA/NWS/CPC, and NOAA/NESDIS/National Climatic Data Center. Approximately ten lead-authors rotate the responsibility of preparing the *Drought Monitor*. Produced on a weekly basis, the *Drought Monitor* is a synthesis of multiple indices, outlooks, and impacts depicted on a map and in narrative form. The official Web site for the *Drought Monitor* can be found at http://www.drought.unl.edu/dm/monitor.html. The *Drought Monitor* is released each Thursday at 8:30 a.m. Eastern time. Because the *Drought Monitor* is prepared in a GIS system, it can be overlaid on agricultural data, to create agricultural weather products that quantify the spatial extent of drought affecting various agricultural commodities (Figure 3-USDA-4). These agricultural weather products, along with the *Drought Monitor*, serve as the main source of information for briefing the Department's Drought Task Force on U.S. drought developments.

The *North American Drought Monitor (NADM)* is a cooperative effort between drought experts in Canada, Mexico, and the United States to monitor drought across the continent. The NADM was initiated at a workshop in April 2002, and is part of a larger effort to improve the monitoring of climate extremes on the continent. Issued monthly since March 2003, the NADM is based on the end-of-month U.S. *Drought Monitor* analysis and input from scientists in Canada and Mexico. Major participants in the NADM program include the entities involved with the production of the U.S. *Drought Monitor*, as well as Agriculture and Agrifood Canada, the Meteorological Service of Canada, and the National Meteorological Service of Mexico. The NADM Web site is: http://www.ncdc.noaa.gov/oa/climate/monitoring/drought/nadm/nadm-map.html.

USDA's Chief Meteorologist is currently serving on the Management Group of the World Meteorological Organization's (WMO's) Commission for Agricultural Meteorology (CAgM). He continues to lead an effort to enhance the flow of more accurate and timely global agricultural weather information through an ongoing project utilizing Internet technology. The World AgroMeteorological Information Service (WAMIS) is a dedicated web server that provides agrometeorological bulletins and advisories issued by WMO Members to the global agricultural community as well as training modules to aid Members in improving their agrometeorological products. Currently, 29 member services contribute advisories and bulletins to the WAMIS web server. The WAMIS web site is: http://www.wamis.org. The Chief Meteorologist also serves as CAgM's focal point to WMO's Natural Disaster Prevention and Mitigation (DPM) Program.

The OCE/WAOB/JAWF opened a field office in Stoneville, Mississippi, in October 1998. The OCE field office in Stoneville, Mississippi is co-located with the Mississippi State Delta Research and Extension Center (DREC) and USDA's Agricultural Research Service (ARS) Mid-South Area Jamie Whitten Delta States Research Center. The field office was established to build an agricultural weather network. The goal of the network is to link agricultural weather data collection networks already in existence but not part of the current National Weather Service (NWS) basic reporting network. In partnership with USDA's Natural Resources Conservation Service (NRCS), Soil Climate Analysis Network (SCAN) sites were installed in the Delta to enhance the regional network.

FOREST SERVICE

Research

Air pollution effects (primarily nitrogen deposition and ozone) remain a serious threat to forest health in some parts of the U.S. Forest Service Research (FSR) is describing long-term effects of air pollution on forests of the Sierra Nevada, Colorado, the North East and southwestern Wyoming. Although nitrogen and sulfur atmospheric deposition have been studied for many years in eastern forest watersheds, and FSR has demonstrated that increased nitrogen deposition can affect water quality and ecosystem function in western forests. FSR has been developing, in cooperation with the European Union ICP and National Forest Systems, a comprehensive approach to critical loads in selected forest ecosystems across the U.S. to improve knowledge of potential nationwide impacts. FSR is also working closely with universities on developing measures for critical levels of ozone on public lands. During 2006, FSR SRS developed the first critical loads map for the entire United States which is being published after peer review.

Smoke from forest fires and other biomass burning is a national concern as use of prescribed fire in ecosystem management increases. Exposure of fire fighters and citizens to forest fire smoke, changes in visibility and haze, and smoke contributions to regional and local air pollution are of concern. FSR is the world leader in developing emissions factors from fires and modeling its dispersion. FSR has conducted research on impacts of smoke on human health; relationships between on-site meteorology and smoke dispersion; consequences of smoke to visibility in Clean Air Act Class I Areas; and potential of smoke to exacerbate ozone episodes. FSR has provided basic research to support states' air regulatory programs and EPA's development of air quality standards. Through five consortia for advanced atmospheric modeling (www.fs.fed.us/fcamms), real-time smoke and fire weather research products are supplied to fire and air quality managers continuously with predictions of impacts made out to 72 hours in the future.

National Forest Service

The weather program provides key liaison with the Satellite Telemetry Interagency Working Group (STIWG) on satellite services and with the National Weather Service, USDI, and NWCG on the delivery of fire weather forecasting, critical for safety and effectiveness of fire fighting and for flash flood warnings and water supply forecasts. The weather program oversees the standards for approximately 1000 remote automated weather stations across the country. These stations form the basis for the assessment of fire danger, the pre-positioning of fire fighting resources and the conducting of prescribed fire operations. The costs include contracts for the delivery of this information to agency personnel, fire weather forecasters, and state forestry agencies that use the data in real-time for critical decisions.

Wildland Fire Management

This program uses meteorological data and interpretation skills data for decision making regarding wildland fire management. The Forest Service State and Private Forestry, Fire and Aviation Management program operates a network of over 850 remote automated weather stations (RAWS) in a national network of over 2200 stations. The network provides real-time information which is key in the highly utilized weather information management system (WIMS) used by fire agencies across the country.

The program provides liaison with the Satellite Telemetry Interagency Working Group (STIWG) and its associated Technical Working Group, the National Weather Service (NWS) USDI agencies including the Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), Bureau of Indian Affairs (BIA), and National Park Service (NPS), State fire protection agencies, and NWCG on the delivery of fire weather forecasting, critical for safety and effectiveness of fire fighting and for flash flood warnings. The RAWS Program oversees the standards for over 2200 remote automated weather stations across the country and manages the Interagency RAWS Website to support the program. The website address is: http://www.fs.fed.us/raws. These stations form the basis for the assessment of fire danger, the pre-positioning of fire fighting resources and the conducting of prescribed fire operations. The costs include maintenance support contracts, maintenance training sessions, contracts for the delivery of this information to agency personnel, fire weather forecasters, and state forestry agencies that use the data in real-time for critical decisions.

The agency weather program works with the predictive services unit at the National Interagency Fire Center (NIFC, Boise, ID) in providing technical support and oversight to 10 Geographic Coordination Centers and works closely with the Forest Service Research and Development staff in the oversight of the 5 fire consortia for Advanced Modeling of Meteorology and Smoke locations. This effort, in cooperation with NOAA and EPA, will provide valuable smoke forecasting and air quality information to fire and air quality programs.

NATURAL RESOURCES CONSERVATION SERVICE)(NRCS)

Snow Survey and Water Supply Forecasts - Monitoring

Snowmelt provides approximately 80 percent of the streamflow in the West. The NRCS, in partnership with other Federal and state agencies, operates the Snow Survey and Water Supply Forecasting Program (SS&WSF) in 11 Western States and Alaska. To accurately forecast seasonal water supplies, the program collects critical snow and climate data from high elevation snowpacks in the mountainous West. The data collection system includes 935 manual snow courses and 732 automated SNOTEL (SNOw pack TELemetry) monitoring stations throughout the Western States and Alaska. These data, along with information from 740 stream gauges, 399 major reservoirs, and 3,200 climatological observing stations are merged into a hydroclimatic database that is used to produce real-time watershed analyses and water supply forecasts. Monitoring is done in partnership with Federal, state, and local agencies, power companies, irrigation districts, and the Provincial Government of British Columbia. This information is the basis for water management decisions under international treaties with Canada and Mexico.

The SNOTEL automated data collection system plays an important role by providing near real-time remote hydrometeorological data required to evaluate snowpacks, potential instream water supplies and drought risk. The SNOTEL network can provide hourly precipitation, temperature, and snowpack depletion information that significantly improves flood stage forecasts and the monitoring of other life threatening snow-related events. SNOTEL information enables emergency management agencies to effectively mitigate drought and flood damages. An added benefit during the late spring and summer is the availability of hourly climate data which is used to monitor and assess forest and wildfire potential.

Additionally, the SS&WSF Program supports research to improve monitoring technology, data reliability, data quality, water supply forecasting, and water resource modeling.

Water Supply Forecasts

Monthly water supply forecasts are produced each year, January through June, in partnership with the National Weather Service (NWS). The purposes of water supply forecasts are to: (1) help irrigators make the most effective use of limited water supplies for agricultural production needs; (2) assist the Federal government in administering international water treaties with Canada and Mexico; (3) assist state governments in managing intrastate streams and interstate water compacts; (4) assist municipalities in planning the early management of anticipated water supplies and drought mitigation; (5) operate reservoirs to satisfy multiple use demands including hydropower generation; (6) mitigate flood damages in levied areas and downstream from reservoirs; and (7) support fish and wildlife management activities associated with species protection legislation.

During a typical forecast season, the NRCS SS&WSF Program issues over 11,000 seasonal water supply forecasts for 711 locations in 12 Western States. The water supply forecasts are coordinated and peer-reviewed by a number of Federal agencies and cooperators to ensure highest quality and accuracy. Major cooperators include the Bureau of Reclamation, Corps of Engineers, Bonneville Power Authority, state and local agencies, power utilities, irrigation districts, Tribal Nations, the Provincial Government of British Columbia, the Yukon Territory, and Mexico. The primary users of this information include agricultural, municipal, industrial, hydropower, and recreation. Recent Federal legislation related to endangered species protection has placed increased emphasis on timely and accurate forecasts.

The NWCC recently implemented a *Daily Water Supply Guidance Forecast* product for 138 western basins. The procedure uses SNOTEL snowpack and precipitation to calibrate and generate an updated water supply volume forecast everyday. This product provides water managers with intra-month water supply forecast trend analysis between the coordinated monthly water supply forecasts. The product is accessible from the following location http://www.wcc.nrcs.usda.gov/wsf/daily_forecasts.html.

The Natural Water and Climate Center (NWCC) web site (http://www.wcc.nrcs.usda.gov) provides snow data, analyses, GIS maps, and forecasts to approximately 80,000 users. The web site logged over 16 million user accesses to data reports and products during the water year 2006.

Drought Assessment

The SS&WSF Program provides a variety of climate and water supply products that are used to assess Western drought. These include SNOTEL snowpack and precipitation analysis in the mountains, water supply forecasts, and state Surface Water Supply Indexes (SWSI). These products are critical to the weekly production of the interagency *Drought Monitor* web based report. A cooperative, nationwide network of approximately 143 Soil Climate Analysis Network (SCAN) sites in 39 states monitors soil temperatures and soil moisture to support national drought monitoring, production agriculture, and climate change research.

Climate Information

NRCS provides climate data and products that directly support agriculture and conservation activities nationwide through the NWCC webpage and AgACIS (Agricultural Applied Climate Information System) which is accessible through the NRCS Electronic Field Office Technical guide webpage. AgACIS is an internet-based climate data delivery system developed in partnership with the six NOAA Regional Climate Centers. AgACIS provides the NRCS field offices, USDA, and partners with Internet access to thousands of climate datasets collected by scores of Federal, state, and county networks. Digital maps of monthly and annual precipitation and temperature for the United States are available from the NWCC webpage (Figure 3-USDA-5). NRCS' long-range planning is supported by the Generation of Weather Elements for Multiple (GEM) applications model, which has been used to generate future climate data sets for more than 250 locations nationwide. GEM is being integrated with several NRCS environmental models and is being used for the NRCS Conservation Effects Assessment Program (CEAP). Monthly precipitation averages and growing season length information required for wetlands analysis are also available from the NWCC webpage at over 6,000 locations in the United States, plus Guam and Puerto Rico. Finally, wind roses for 237 NWS stations in the United States, plus offices in Guam and Puerto Rico are now available from the NWCC webpage. A wind rose gives a very succinct but information-laden view of how wind speed and direction are typically distributed at a particular location. Wind roses are useful planning tools for agricultural and natural resource planning.

AGRICULTURAL RESEARCH SERVICE

Research in this area focuses on how annual variation in weather impacts crop and animal production, hydrologic processes, the availability of water from watersheds, and the environmental and economic sustainability of agricultural enterprises. ARS scien-

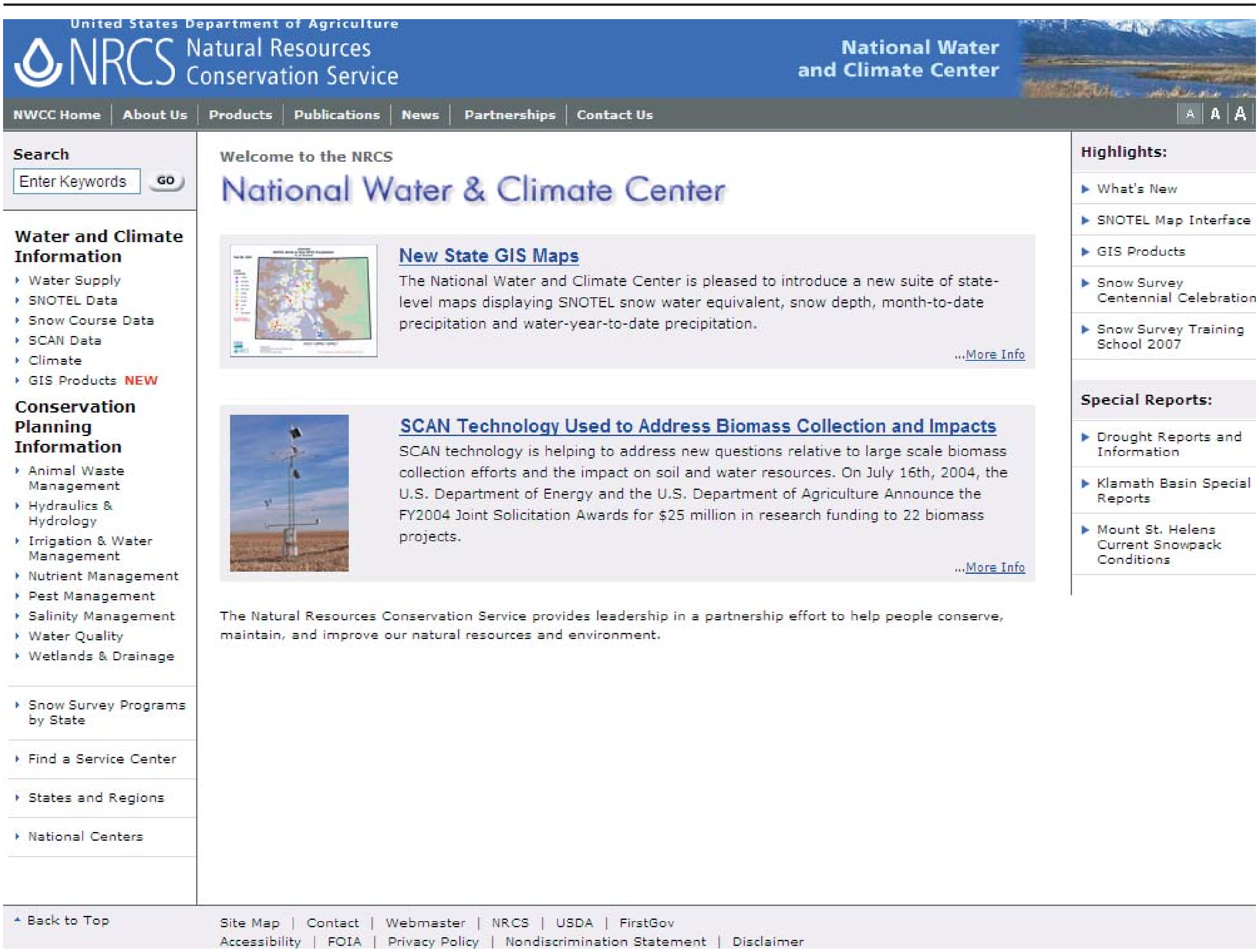


Figure 3-USDA-5. Natural Resources Conservation Service Web Site, where digital maps of monthly and annual precipitation and temperature are available.

tists are developing algorithms and decision support systems with the NRCS, NASA, and NOAA to improve prediction of snowpack distribution and timing of snowmelt and water availability in the Western United States. ARS is working with scientists at NOAA, NASA, OCE/WAOB/JAWF, and various land grant universities to improve the accuracy and precision of predicting and assessing the impact of drought across the United States. ARS scientists are leading development of new technology to mitigate the impact of drought by developing agricultural management systems that are more water efficient and which use non-potable water supplies to augment irrigation water supplies during times of drought.

Other research includes development of a new stochastic storm-generator model, and methodology that uses contemporary weather radar systems to determine rainfall amounts and spatial distributions to better characterize the variability of precipitation associated with individual storms. This information will be useful for developing best management practices to reduce soil loss and sedimentation, and for predicting when and where flooding may occur.

Additional research is being conducted to integrate seasonal weather forecasts, information on extended climate departures from normal, the occurrence of extreme weather events, corresponding agricultural responses to weather and climate variations, and associated uncertainties into planning and management decision aids readily useable by agricultural producers. The research is conducted in collaboration with the NOAA, NASA, and land grant university scientists forecast developers. The ARS experimental watershed program actively participates in the NWS effort to modernize the Cooperative Observer (COOP) Network to ensure agriculture's needs are addressed by the national surface observation network.

ARS scientists conduct research to understand the processes of air pollution emissions from agricultural enterprises and the effects of air quality upon agriculture production. ARS scientists are working with agricultural producers, EPA, industry, and university scientists to develop and test control measures that will reduce gas emissions for a wide variety of agricultural enterprises. ARS scientists have recently developed and transferred to NRCS a new decision support system to predict and help minimize wind erosion in the Great Plains region of the Nation.

COOPERATIVE STATE RESEARCH, EDUCATION AND EXTENSION SERVICE

CSREES funding supports research projects that collect, process and utilize long-term weather and climate data to provide current and future use as a base of information for the projection and prediction of climatic trends related to environmental impacts of human activities, soils, crops and domestic animals on agro ecosystems, forests, and rangelands. Broader areas of study involve climate dynamics, carbon and water cycling, and their role in global change. The impact of changes in UV and ozone level studies also fit into this broad global category.

Historical climate changes are related to trends visible from present data gathering studies, enabling prediction of future crop production and irrigation needs. CSREES funding supports studies on the impact of climate and weather on food and fiber production and on natural resource protection. These studies relate to forest plant growth, rangeland productivity, cropping system selection, livestock production practices and natural resource management.

Man's impact on climate systems is also well represented in studies of both micro-and macro-climatic change. These involve studies dealing with the climatic impact on air quality, water quality and point/non-point pollution related to agricultural practices and forest and urban development. Studies on climatic impact on nutrient cycling and carbon sequestration and emission are supported with CSREES funds. Research is also being supported that quantifies the impact of climate change on the incidence and severity of plant and animal diseases and pest, invasive species, and biodiversity.

The National Research Initiative (NRI) has funded projects on a wide variety of weather and climate related research in collaboration with other US Federal agencies. NRI's Global and Climate Change Program's current focused research areas are carbon cycling and land use dynamics. Other NRI areas of research related to weather and climate change range from fundamental plant drought tolerance studies to using meteorological data to forecast market performance.

DEPARTMENT OF ENERGY AND NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA) OPERATIONAL AND RESEARCH WEATHER PROGRAMS

For almost 60 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), have established and supported meteorological operations and atmospheric research at the DOE field facilities. The need for meteorological services began in 1944 with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. Meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act, which is enforced by the Environmental Protection Agency (EPA) under 40 CFR enabling regulations, and reinforced by several DOE Orders that specify requirements for meteorological services to protect public health and safety and the environment. Consequently, a meteorological monitoring program has become an even more essential component of each DOE site. Moreover, the acquisition of quality-assured meteorological data and the provision of weather forecasting services is an important element of a DOE Integrated Safety Management System (ISMS). It significantly contributes to the implementation of site-wide personnel safety programs along with site evaluations. These evaluations include, but are not limited to the following: protection of facility workers and the public; development of Authorization Basis (AB) safety documentation; diagnostic and prognostic consequence assessment elements of an emergency management system; preparation of permits to support environmental compliance activities; and, impact analyses of construction and operation of projects and missions requiring National Environmental Protection Act (NEPA) determinations.

OVERVIEW OF DOE AND NNSA OPERATIONAL METEOROLOGICAL PROGRAMS AND SUPPORTING RESEARCH

Recognition of the need for site-specific meteorological services began more than 60 years ago in 1944, with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. In response to this need, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), as well as the National Nuclear Security Administration (NNSA) in the present, have established and supported operational meteorological programs and atmospheric research projects at many DOE and NNSA field sites.

Operational meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act (CAA), enforced by the Environmental Protection Agency (EPA) under 40 Code of Federal Regulations (CFR) enabling regulations, and reinforced by several DOE Orders (e.g., O 231.1) that specify requirements for meteorological services to protect facility worker health and safety, public health and safety, and the environment. Since that time, the CAA has been amended on three occasions, each time including broader requirements, inclusive of stratospheric ozone protection regulations. Consequently, an effectively managed meteorological monitoring program has become an even more essential component of each DOE and NNSA site. Moreover, the acquisition of quality assured meteorological data, the provision of weather forecasting services, and the development of site-specific climatology from these meteorological programs is an important element of a DOE Integrated Safety Management System (ISMS), since it significantly contributes to the implementation of site-wide personnel safety programs and supports multiple evaluations. These evaluations include, but are not limited to the following:

- Protection of facility workers and the public;
- Development of nuclear and chemical safety documentation (e.g., Safety Analysis Reports (SAR) and Documented Safety Analysis (DSA));
- Diagnostic and prognostic consequence assessment elements of an emergency management response system;
- Preparation of air, surface water, ground water and waste management permits to support environmental compliance activities; and,
- Impact analyses for construction, operation and decommissioning of projects, and missions requiring National Environmental Protection Act (NEPA) determinations.

DOE and NNSA continue to address their fundamental mission areas of national security, science and technology, energy security, safety and health, and environmental quality. Meteorology and the atmospheric sciences contribute to the successful implementation of many of these mission elements. Consequently, atmospheric science research programs, meteorological data acquisition programs, analytical assessments requiring meteorological information, and weather forecasting operations have been an integral part of DOE, NNSA and its predecessor agencies since World War II. World-wide energy production is modifying the chemical composition of the atmosphere, which is linked not only with environmental degradation and human health problems, but also with changes in the most sensitive parts of the physical climate system. The Intergovernmental Panel on Climate Change's (IPCC's) Fourth Assessment Report (AR4) recently assessed how the Earth system's energy balance has been and will be affected, thus underpinning the importance of continual monitoring of the atmosphere.

DOE administers programmatic activities throughout its various offices, such as the Offices of Science (SC), Health, Safety and Security (HS), and Environmental Management (EM) that have some linkage to the atmospheric sciences. NNSA administers the nation's nuclear weapons and non-proliferation programs, and includes the National Atmospheric Release Capability (NARAC) in its nuclear weapons incident response program. Some of these program offices are responsible for the management of scientific research programs, such as Global Climate Change Research (GCCR), and various environmental cleanup activities at former DOE production sites. Additional activities at DOE and NNSA sites include support to daily operations and national defense programs; all of which require a fundamentally sound well-managed meteorological monitoring program.

Meteorological services at DOE and NNSA facilities range from the conduct of cutting-edge basic research to providing daily support to operational programs and construction projects. Some examples of research and development are investigations of potential global climatic change, radiation transfer mechanisms and cloud studies, lightning and thunderstorm studies, atmospheric chemistry, atmospheric tracer studies, and studies of atmospheric planetary boundary layer processes. Operational support programs include daily-customized weather forecasting services, support to national defense projects and homeland security, onsite meteorological monitoring programs, climatology services, occupational health and safety program support, and emergency preparedness and response program support.

Some DOE and NNSA sites maintain 24-hour weather watches for severe weather conditions that have the potential to impact site operations, damage property, or threaten lives. DOE-wide and NNSA-wide lightning safety initiatives, which are becoming integral elements of ISMS, are supported by DOE and NNSA operational meteorological programs (e.g., Nevada Test Site [NTS], Hanford, Savannah River Site [SRS], Idaho National Laboratory [INL]).

Several DOE and NNSA field offices and their associated sites and facilities cover large areas (e.g., INL, Oak Ridge Reservation [ORR], NTS, Hanford, and SRS). In addition, several DOE and NNSA sites are situated in areas of complex topography and heterogeneous surface characteristics (e.g., land-water interface), creating mesoscale conditions that locally influence onsite weather and more importantly, airflow trajectories associated with atmospheric transport and dispersion.

For these reasons, and to ensure the protection of public health and safety and the environment, onsite meteorological monitoring programs have been, remain, and will always be an essential part of DOE and NNSA atmospheric science programs. Moreover, partnerships have been forged with other Federal agencies (i.e., Department of Defense [DOD], Department of Transportation [DOT], Department of Commerce [DOC], Department of Agriculture [DOA], Department of Interior [DOI] and the National Aeronautical and Space Administration [NASA]). In some cases, Interagency Agreements (IA) have been developed with other Federal agencies (e.g., NTS), and have been in place for more than 45 years.

Some DOE and NNSA sites enhance the spatial resolution of the National Weather Service (NWS) observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where NWS and community weather observations would otherwise be limited. Weather observations taken at a few DOE and NNSA field sites are entered into the database via the NWS meteorological data distribution and display system. This distribution and display system interconnects field offices and serves as the distribution system for NWS meteorological products that are centrally produced by the National Centers for Environmental Prediction (NCEP). Some DOE and NNSA sites [e.g., NOAA Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD), Las Vegas, NV] employ the National Oceanic and Atmospheric Administration (NOAA) Advanced Weather Information Processing System (AWIPS), as well as vertical profilers and meteorological monitoring networks.

An accidental release of radioactive, chemical, or biological toxic material into the atmosphere can have potentially serious health effects, as well as environmental consequences. Meteorological transport and dispersion processes play a key role in determining the fate of radioactive, chemical, or biological agents released into the atmosphere; including those resulting from malevolent acts. Consequently, a central theme within the DOE and NNSA community has been to protect public health, safety, and the environment on and around DOE and NNSA facilities by accurately measuring and characterizing the important local atmospheric processes necessary to characterize atmospheric transport and dispersion.

In recognition of the aforementioned needs and requirements, DOE and NNSA have established and continue to support onsite meteorological monitoring programs since the commissioning of an operational meteorological program in 1944 at Hanford. Each meteorological program is primarily directed towards the support of emergency preparedness and response programs and focused towards the protection of the environment and the safety and health of the onsite work force and the public. In addition, research on the modeling of the transport, dispersion, deposition, and resuspension of radioactive, chemical, and biological agent materials is undertaken to refine the transport and dispersion models used in these endeavors. New remote sensing techniques are being developed, such as the "Best" Aircraft Turbulence probe at the ARL Field Research Division (FRD), in Idaho Falls, ID. Onsite weather forecasting services, each tailored specifically for the special operational and emergency management requirements at each DOE and NNSA site, provide necessary support to the safety and health programs designed to protect site personnel, the public, and the environment.

A large majority of the research and operational support has been provided by the atmospheric research programs at the five major offices directly involved in national defense programs. Over the years, these programs have grown to address and support many environmental, safety, and health issues. Due to the complexity of these activities, it was recognized that efforts should be made to coordinate meteorological operations and research among the field offices to enhance cost effectiveness and productivity. To address these considerations, the DOE Meteorological Coordinating Council (DMCC) was formed in 1994 and has been providing support to DOE and NNSA meteorological programs for over 10 years.

The following narrative highlights the DMCC and the meteorological activities at 14 separate DOE and NNSA sites. These activities are subdivided into operational and research components.

DMCC

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DMCC (i.e., the Council) was established on December 2, 1994, in Las Vegas, NV, under the direction and oversight of NNSA's Nevada Site Office. Its central focus is to coordinate activities of the meteorological programs that exist throughout the DOE and NNSA in the absence of such function anywhere within the DOE organization.

In April, 2004, the DMCC program was integrated with other programs associated with the Emergency Management Issues Special Interest Group (EMI SIG) under the oversight DOE Office of Emergency Management (OEM).

The DMCC objectives are to:

1. Promote cost-effective support for all DOE facilities;
2. Facilitate the use of common methods, procedures, and standards;
3. Plan for future needs, requirements and missions; and,
4. Advocate awareness of atmospheric science applications and benefits to DOE.

The DMCC accomplishes its objectives by using the following methods:

1. Encourage interchange of technical information between DOE offices;
2. Foster the development of atmospheric monitoring equipment and systems;
3. Acquire and disseminate atmospheric data products to meet Departmental needs and requirements;
4. Promote consistency of monitoring and assessment products and services;
5. Interface with appropriate agencies, academics, and professional organizations;
6. Make recommendations on equipment procurements, replacements and modifications to benefit DOE operations; and,
7. Provide consultation and technical assistance to foster cooperation and research among the DOE meteorological programs.

Council oversight is provided by a steering committee consisting of DOE and NNSA headquarters and field element representatives (i.e., NA, HS, and SC).

The DMCC conducts technical/business meetings on a periodic basis and also conducts site-funded Assist Visits. The technical/business meeting, assist visits, and other activities are focused on helping DOE meteorological program managers and their staff of meteorologists to effectively execute their mission of protecting the health and safety of DOE workers and the public.

The DMCC also supports activities of the OEM, the Office of Health, Safety and Security, and the Office of Science. DMCC works with similar Departmental groups to improve the provision of quality-assured meteorological information and execution of transport and dispersion models that meet Software Quality Assurance (SQA) requirements.

Products of the DMCC include evaluations of meteorological requirements contained in DOE orders and guidance documents, site meteorological program peer reviews, and, as needed, customized technical assistance. Assist Visits have been conducted at NNSA/Nevada Site Office (NSO), Waste Isolation Pilot Plant (WIPP), Pantex, DOE/Oak Ridge Reservation (ORR), Sandia National Laboratory (SNL)-Albuquerque, Y-12 and Idaho National Laboratory (INL). Three follow-up assist visits were also conducted at WIPP, the latest in 2005. Additional assist visits are in the planning stages and will be conducted over the next several years.

The DMCC membership, which encompasses subject matter experts (SME) within the DOE complex, involves three specific components:

- Department of Commerce (DOC) captive contractors under an Interagency Agreement (IA);
- Management & Operating (M & O) contractors; and,
- Private contractors.

Dr. Darryl Randerson, National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory/Special Operations and Research Division (ARL/SORD) has served as the DMCC Chairman since its inception.

DOE has delegated the operation of its site/facility meteorological programs to captive DOC contractors and non-Federal for-profit M & O contractors.

The DMCC web page has been broadened and can be accessed at www.sord.nv.doe.gov. As part of the NA-41 Emergency Management Issues Special Interest Group (EMI SIG) program, DMCC can also be accessed through the web page of the Subcommittee for Consequence Assessment and Protective Actions (SCAPA).

ARGONNE NATIONAL LABORATORY (ANL)

Operational

Argonne National Laboratory (ANL) is one of the largest research centers that is associated with DOE. It is also the nation's first national laboratory, chartered in 1946. ANL is managed and operated by the University of Chicago (UC) for the DOE Chicago Operations Office. Argonne occupies two sites, designated as ANL-East in Illinois and ANL-West in Idaho. The Illinois site is surrounded by forest preserve on 1,500 wooded acres about 25 miles southwest of Chicago's Loop. The site also houses the DOE Chicago Operations Office. Argonne-West occupies about 900 acres about 50 miles west of Idaho Falls in the Snake River Valley. It is the home of most of the ANL major nuclear reactor research facilities.

There are three divisions, Environmental Research (ER), Decision and Information Sciences (DIS) and Environmental Assessment (EAD) at ANL with meteorological research or operational program support. Two cross-divisional groups are involved in these programs at ANL: the Atmospheric Research Section (ARS) and the Atmospheric Emergency Preparedness (AEP) Group. The ARS is composed of scientists doing research activities in both basic and applied science; particular technical strengths are in the areas of air-surface exchange, remote sensing, atmospheric chemistry, and numerical modeling. About half of the ARS support is currently devoted to activities associated with the DOE Atmospheric Radiation Measurement (ARM) Program. The AEP is composed of scientists and engineers in two divisions involved in programs with a greater emphasis on applied science. Particular technical strengths include air pollution meteorology, emergency preparedness and response, and stochastic systems simulations. More than half of the AEP support is associated with the DOE PROTECT Critical Infrastructure Program involving chemical and biological agents.

ARS has operated and maintains a 200-ft meteorological tower and supplies meteorological data for emergency response, facility operations, and regulatory compliance for ANL operations. Wind and temperature measurements are taken at the 33-ft and 200-ft levels. Real-time and historical data are available via the Web (http://gonzalo.er.anl.gov/ANLMET).

Research

As part of a larger program for the protection of subway systems from terrorist attacks using chemical agents, AEP is installing sonic anemometers as well as temperature and pressure sensors in the subway tunnels of a large urban subway system. These instruments will assist in the understanding of flows in the tunnels, which are driven by a combination of:

- The "piston" action of train motion; and,
- Buoyancy effects and above-ground forcing.

Measurements from these instruments will be correlated with the above ground measurements to develop and validate predictive and emergency response models for flow and dispersion in subway systems.

The AEP group research also focuses on the analysis of routinely measured meteorological data to provide atmospheric boundary layer turbulence information for atmospheric dispersion calculations. Under the Department of the Army Chemical Stockpile Emergency Preparedness Program (CSEPP), ANL provides support to improve the collection efficiency and quality of meteorological data measured at the Army's Demilitarization towers. The data are used the emergency operation centers in support of emergency response exercises and for use in real-time in the event an actual accident. The goal of the CSEPP support is to improve the accuracy and robustness of the data obtained from the meteorological monitoring stations and to develop unified quality control and analyses procedures of the data collected by the towers.

Key support is also provided to Department of Transportation (DOT) in applying an ANL-developed 5-year meteorological database for over 100 locations in the United States to conduct statistical analyses of hazardous materials incidents on a national basis. Recent work for DOT has centered on development of the *Table of Initial Isolation and Protective Action Distances* for the *2000 Emergency Response Guidebook.* Protective Action Distances are given in the Table for over 200 toxic-by-inhalation chemicals and generic compounds for both daytime and nighttime accidents, and represent the safe distance for 90 percent of hazardous materials transportation accidents considering variability in meteorology and spill size. Recent work for DOT has also involved conducting national risk assessments for transportation of certain high volume toxic chemicals like chlorine, ammonia, hydrogen fluoride and sulfur dioxide.

The Atmospheric Boundary Layer Experiments (ABLE) is one of several DOE supported research programs conducted by the ARS. ABLE is located on the lower Walnut Watershed, mostly in Butler County east of the city of Wichita, KS. This location is within the existing boundaries of the DOE ARM Southern Great Plains (SGP) Clouds and Radiation Test-bed (CART) site. The establishment of this facility offers a virtual atmospheric observatory and provides essential research tools for addressing a myriad of unresolved fundamental questions in atmospheric research. The ABLE provides a continuous view of processes in the lower atmosphere over a limited domain within the SGP CART site.

The initial focus of the ABLE is measurements of the planetary boundary layer (PBL) where almost all interactions between the atmosphere and humans take place. Many scientific issues may be addressed by use of such a facility, including:

- Natural disaster reduction and public safety;
- Safe and efficient aviation and other transportation;
- Agriculture;
- Water resource management;
- Effective energy production, use and environmental protection;
- Space flight operations;
- Defense; and,
- Related areas of earth science.

Instrumentation at the ABLE site includes winds, temperatures, moisture, surface net radiation and soil moisture as the minimum set of atmospheric observations.

The initial set of equipment, which is be available at the ABLE includes:

- Three 915 MHz RWP-RASS (wind speed and direction, virtual temperature profiles);
- Three minisodars (wind and turbulence profiles between heights of 33 ft and 656 ft);
- One lidar ceilometer (cloud base height);
- One balloon-borne sounding system (wind, temperature, moisture profiles);
- Five surface flux stations (surface sensible and latent heat, ground heat storage);

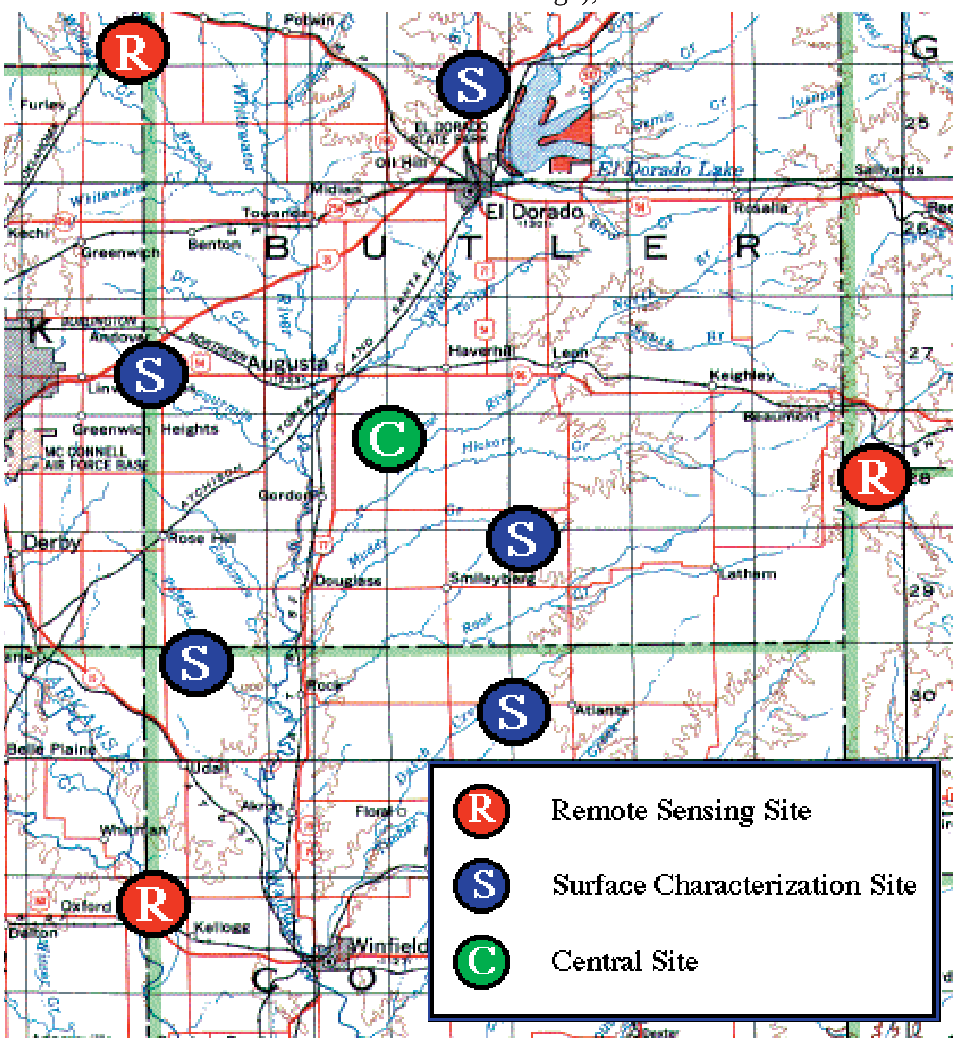


Figure 3-DOE-1. DOE Atmospheric Boundary Layer Experiment (ABLE) site locations in the Midwest.

• Five soil moisture sampling stations (soil moisture, soil temperature);
• One satellite data receiver-processor;
• One data hub/central location for data collection; and,
• One (extra) instrument pad for visiting scientist instrument accommodation.

BROOKHAVEN NATIONAL LABORATORY (BNL)

Operational

The BNL, under the responsibility of the Brookhaven Site Office, has been active in both operational meteorology and atmospheric sciences for the past 50 years. BNL is now managed by Brookhaven Science Associates, which is a joint venture by Battelle Memorial Institute Incorporated, The Research Foundation of the State University of New York at Stony Brook, and six other core university partners. Meteorological operations and research cover a wide range of programs encompassing interpretive and theoretical studies. BNL is located near the geographical center of Long Island, New York. Long Island is glacial in origin and, as a result, has sandy soil, mostly gentle undulating contours, and a single water aquifer for the entire island. Elevations vary between 65 ft and 115 ft. The BNL site is rectangular and approximately 5,200 acres in area. Winds are predominantly southwesterly, and plume dispersion studies show that it is essential to monitor winds well beyond laboratory borders. The NWS' New York City Weather Forecast Office is located at BNL. This office has an umbrella of coverage that includes an estimated population of one million. Nearby, in Bohemia, is the NWS' Eastern Regional Headquarters that administers a 12-state region.

The mesoscale meteorological measurements necessary for emergency response are the responsibility of the Meteorological Services Group, a support group under the Department of Applied Science, Environmental Biology and Instrumentation Division (EBID).

The Meteorological Services Group maintains two meteorological towers, 10-meter and 88-meter, and an instrument shelter. By integrating redundant pairs of standard, approved meteorological sensors throughout the system, an overall data availability of better than 99 percent is achieved. The real-time data are merged into the laboratory emergency response network. A database of 50 years (in digital format since 1960), one of the longest continuous meteorological time series in the United States, is archived and is available. A real-time monitoring network with worldwide web access covers the eastern end of Long Island. Coastal weather stations at Smith Point and Orient Point transmit data each minute. Pollution-monitoring data buoys are added during field programs.

The Meteorological Services Group provides a locally tuned forecast twice daily during normal working hours. Weather forecasts and data are available by telephone or the Internet (www.weather.bnl.gov). During severe weather events updates are given every three hours and, in the case of a hazardous material or radiological release, a member of the Meteorological Services Group will assist the emergency coordinator with regular forecasts and information on local wind fields and gustiness.

Research

Areas of meteorological research at BNL include:

• Instrumentation development for field studies of atmospheric constituents, air-sea interaction, and laboratory experiments;
• Gaseous tracer studies of atmospheric transport and dispersion;
• Aerosol formation and behavior;
• Atmospheric pollution studies
• Modeling of atmospheric chemical reactions;
• Acid rain studies both in the field and in the laboratory;
• Theoretical and observational studies of radiation transfer and fluxes; and,
• Analysis of data and development of parameterizations relevant to global climate change.

The ARM Program provides the stimulus for a wide range of climate-related studies. The ARM ocean monitoring program is developing instrumentation and a broad ship- and buoy-based observational network in the tropical western Pacific Ocean. The Atmospheric Chemistry Program (ACP) provides the Atmospheric Chemistry Division's (ACD) concern with aerosol sources, transport, and fate in the global atmosphere and the overall, and the little understood impact of aerosols on global climate dynamics. The ARM External Data Center is the center for collection, archival, and dissemination of all climate-related data sets for the ARM program.

An exciting new effort in radar meteorology focuses on algorithms for cloud detection and cloud mapping using both the WSR-88D radar network and research radar. BNL is a site in the National Aeronautical and Space Administration (NASA) Solar Irradiance Network and continuous short wave absorption measurements are made here. In a related NASA study, oceanic aerosol optical depths are measured and used to validate absorption algorithms in the SeaWiFS ocean color program.

The Optical Remote Sensing (ORS)

group within the Department of Advanced Technology (DAT) is presently modifying one of its Raman lidar systems for vertical profiling of carbon dioxide. The Raman lidar instrument is a self-calibrating sensor that means that data from a variety of locations in the world can be compared. With the incorporation of a large (4.1 foot) antenna and advanced filters and detectors, a vertical profile of CO2 concentration with a precision of 1 part per million (ppm) (Note: atmospheric mean = 370 ppm) and maximum height of two to three km can be produced routinely. These profiles will support model development and validation. Importantly, comparison of CO2 concentrations collected throughout the world and over time will prove invaluable in confirming adherence to the Kyoto protocols.

IDAHO NATIONAL LABORATORY (INL)

Operational

INL is managed by the Idaho Operations Office and is on 890 square miles of rolling, arid terrain in southeastern Idaho at the foot of the Lost River and Lemhi mountain ranges. The primary mission of the INL for years has been nuclear reactor research with a focus on cleanup and environmental restoration. Meteorological services and supporting research are provided to INL via NOAA ARL Field Research Division (FRD). The Division, under administration from various agencies, has provided support to INEEL for over 50 years. Its current mission to DOE/ID is to support emergency response and operations with real-time meteorological data, climatology data, weather predictions, dispersion calculations, and consultation. ARL FRD maintains other capabilities that are not funded directly by DOE. ARL FRD designs, arranges, and conducts field studies as needed to evaluate the performance of transport and dispersion models over local, regional, and continental scales, and to obtain high quality databases for model improvement. An airborne geosciences program is also maintained to measure fluxes of carbon dioxide, water vapor, and other atmospheric constituents that affect climate. These interactions provide ARL FRD staff with additional insights that aid in the understanding of local meteorological phenomena.

ARL FRD operates a large meteorological monitoring network to characterize the meteorology and climatology of the INL site. The network consists of 33 meteorological towers that are deployed both onsite and offsite. The overall meteorological measurement program is designed to provide representative data for the INL to meet specific operational and potential emergency response situations. The network covers an area of approximately 15,000 square miles. Many of the towers are 49 ft tall and provide wind speed and direction at 49-ft and air temperature at 6-ft and 49-ft. Instrumentation on 15 of the 49-ft towers also measure relative humidity at 6-ft, precipitation, and global solar radiation. Barometric pressure is provided on 11 of the towers. The other three towers range from 151-ft to 249-ft in height and are instrumented at multiple levels. The sensors at all stations are scanned every second and averaged or totaled over five minutes.

The data are subsequently retrieved into the data display and archive system at the ARL/FRD office through a radio repeater located at an elevation of 8,930 ft MSL. Continuous wind and temperature profiles are obtained from a 915 MHz radar wind profiler and RASS. A Doppler SODAR supplements the wind profile at lower levels with higher resolution data. Meteorological data are quality-controlled through automated and manual processes.

INL meteorological monitoring and emergency response efforts are enhanced with the use of an ARL FRD meteorological data display and visualization program known as INEELViz. This program has been widely deployed at 50 sites on and around the INL for access by Federal, state, and Indian tribes via the Internet.

Within INEELViz, meteorological data are displayed in real-time and overlaid on maps of the local area that include political and terrain features. In addition, the local MDIFF puff dispersion model can be accessed through the INEELViz front-end and the model output can be displayed as trajectories or concentration isopleths on the INEELViz display screen. The incorporation of RSAC dose conversions permits the user to also view real-time

Figure 3-DOE-2. Meteorological towers record temperature and wind direction and speed at various levels.

dose estimates from the model output. These features have become very useful enhancements to the INL emergency response capability.

Research

Partnerships forged with DOE/ID, the State of Idaho INL Oversight Program, and the Shoshone-Bannock Indian Tribes have resulted in additional methods of meteorological data dissemination. Meteorological and background nuclear radiation data from four public access sites on and surrounding the INL are displayed at nearby kiosks in real-time. Additional information on nuclear radiation and meteorological tutorials are presented at the kiosks. The data are also available on the Internet at http://oversite.inel.gov. ARL FRD maintains its own web site at www.noaa.inel.gov.

LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

Operational

LLNL is located in a valley in California's Coast Range Mountains about 25 miles east of Oakland. LLNL covers approximately 2 square miles and is operated by the University of California for the DOE Oakland Operations Office. Two groups are involved in the operational aspects of atmospheric sciences at LLNL:

1. Environmental Protection Department (EPD); and,
2. Energy and Environment Directorate (EED)

EPD operates a 40 m tower and supplies meteorological data for facility operations, regulatory compliance, and emergency response. Real-time and historical data are available at http://www-metdat.llnl.gov/.

Within EED, the NARAC supports Federal agencies with a world-wide centralized emergency response service (http://narac.llnl.gov/). NARAC scientists model the behavior of radiological, chemical, biological, and natural (e.g., smoke) materials on global, regional, or local scales. NARAC operations scientists deliver realistic real-time graphical dose and exposure assessments to emergency decision-makers to assist in the protection of populations at risk for releases of radiological and other hazardous material to the atmosphere. The Center provides simulation tools and customer products (e.g., high-resolution geographical displays of hazard areas, affected populations, health effects) as well as operational services and subject matter experts to a wide range of Federal, state, and local agencies.

NARAC's central emergency response system consists of automated continuous worldwide meteorological data acquisition, detailed worldwide terrain and geographic mapping databases, a suite of atmospheric dispersion models and source models to assess explosions, fires, spills, or other types of radiological, chemical, biological releases. The system includes a high-resolution, terrain-following, variable-gridded diagnostic meteorological model (ADAPT) and a prognostic model with parameterizations for urban settings (COAMPS) coupled with a generalized Lagrangian particle dispersion model (LODI). NARAC also provides stand-alone rapid-response models (e.g., HOTSPOT), specialized fallout models (KDFOC and LODIFOC), and SNL's explosive source prompt effects models. NARAC utilizes real-time meteorological observational data and forecast model output obtained from the National Weather Service (NOAA), the Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the Air Force Weather Agency (AFWA).

NARAC provides 24/7 service 365 days/year. Supported sites and organizations can use the client-server-based NARAC iClient tool or NARAC Web tools to run models and seamlessly distribute products to multiple organizations over the worldwide web. Automated NARAC mapped products are delivered in 5-10 minutes to organizations with NARAC Web or iClient access.

NARAC supports the DOE Nuclear Incident Response Teams (NIRT), the regional Radiological Assessment Program (RAP) teams, the Aerial Measuring System (AMS), the Federal Radiological Monitoring and Assessment Center (FRMAC), the Department of Homeland Security under a DOE-DHS Memorandum of Agreement, and 40 DOE and DoD on-line sites. NARAC operational support of 5 cities and 53 state and Federal organizations across the country has been successfully tested under DHS and DOE support. The NARAC DOE/NNSA customer base and usage has increased dramatically in recent years, including a three-fold increase in the number of user base and a ten-fold increase in the number of DOE NA-40 test, drills, exercises and responses.

On April 15, 2004, the Homeland Security Council created an Interagency Modeling and Atmospheric Assessment Center (IMAAC) to consolidate and integrate the Federal efforts to model the behavior of various airborne releases into one emergency response organization for homeland security. NARAC was designated as the primary interim provider of IMAAC capabilities and is currently supporting over 350 new Department of Homeland Security (DHS) stakeholders. The IMAAC was formally stood up by the DHS S&T Directorate in April, 2004. Under DOE or DHS direction according to the National Response Plan (NRP), NARAC supports Incidents of National Significance and National Special Security Events.

<u>Research</u>

Scientists in the LLNL Energy and Environment Directorate (http://eed.llnl.gov/) perform pioneering research on global and regional climate, atmospheric chemistry, and the local, urban, regional, and global transport and fate of hazardous releases to the atmosphere. Research is focused on major national energy and security policy issues and is based primarily on development and use of advanced computational simulations of the atmosphere, oceans, and biosphere.

LLNL Energy and Environment Directorate conducts research in four areas related to atmospheric science:

- Carbon cycle and climate model physics;
- Climate change & model evaluation;
- Atmospheric hazards and consequence assessment; and,
- Atmospheric transport & fate.

Major programs at EE&D include:

- Program for Climate Model Diagnosis & Intercomparison (PCMDI);
- Climate and Carbon Cycle Modeling (CCCM);
- Institute for Research on Climate Change & Its Societal Impacts (IRCCSI); and,
- NARAC/IMAAC Program.

The PCMDI mission is to develop improved methods and tools for the diagnosis and intercomparison of general circulation models (GCMs) that simulate the global climate (http://www-pcmdi.llnl.gov/). The need for innovative analysis of GCM climate simulations is apparent, as increasingly more complex models are developed, while the disagreements among these simulations and relative to climate observations remain significant and poorly understood. The nature and causes of these disagreements must be accounted for in a systematic fashion in order to confidently use GCMs for simulation of putative global climate change.

The mission of PCMDI demands that we work on both scientific projects and infrastructural tasks. Our current scientific projects focus on supporting model intercomparison, on developing a model parameterization test bed, and on devising robust statistical methods for climate-change detection/attribution. Examples of ongoing infrastructural tasks include the development of software for data management, visualization, and computation; the assembly/organization of observational data sets for model validation; and the consistent documentation of climate model features.

We now also are applying our collective expertise to support modeling studies initiated by the Intergovernmental Panel on Climate Change (IPCC). PCMDI is providing facilities for the storage and distribution of terrascale data sets from multiple coupled ocean-atmosphere GCM simulations of present-day climate as well as climate changes resulting from large transient increases in carbon dioxide. Extensive analysis of these simulations by members of the international climate community will provide an important scientific basis for the IPCC's Fourth Assessment Report on Climate Change, which is scheduled for publication in 2006.

The Climate and Carbon Cycle Modeling Group (CCCM) engages in research designed to help predict the consequences, and help minimize the adverse impacts, of human activities on Earth's climate system. Furthermore, we are a source of information and expertise on the climate system and carbon cycle, available to policy makers, DOE, other scientists, and the public. CCCM is working towards coupled simulations of the oceans, atmosphere, and land surface, incorporating both the physical climate system and the carbon cycle. The Group is the home of the simulation capability for the DOE Center for Research on Ocean Carbon Sequestration (DOCS).

Examples of recent CCCM work include analysis of:

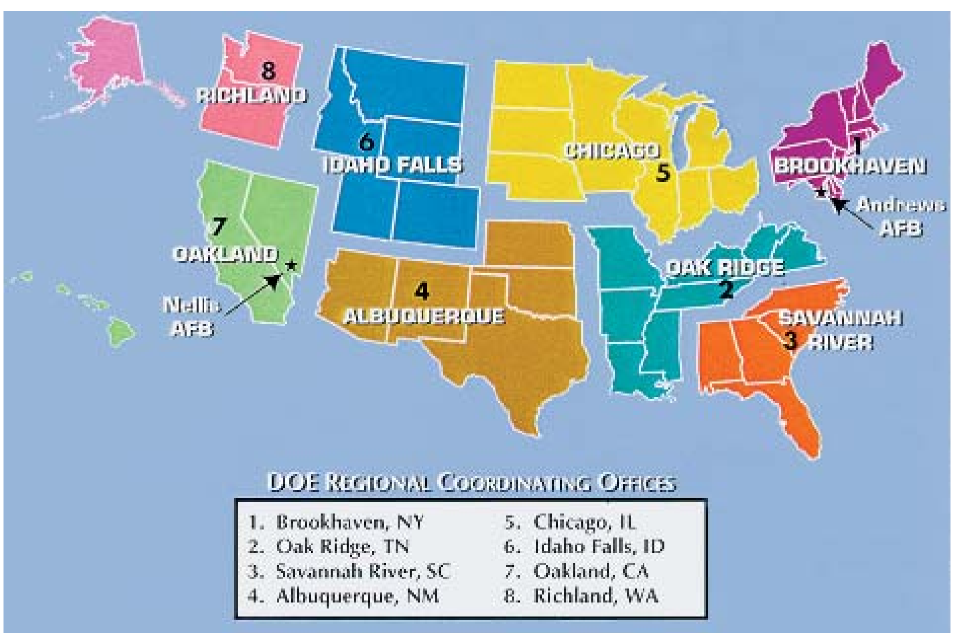
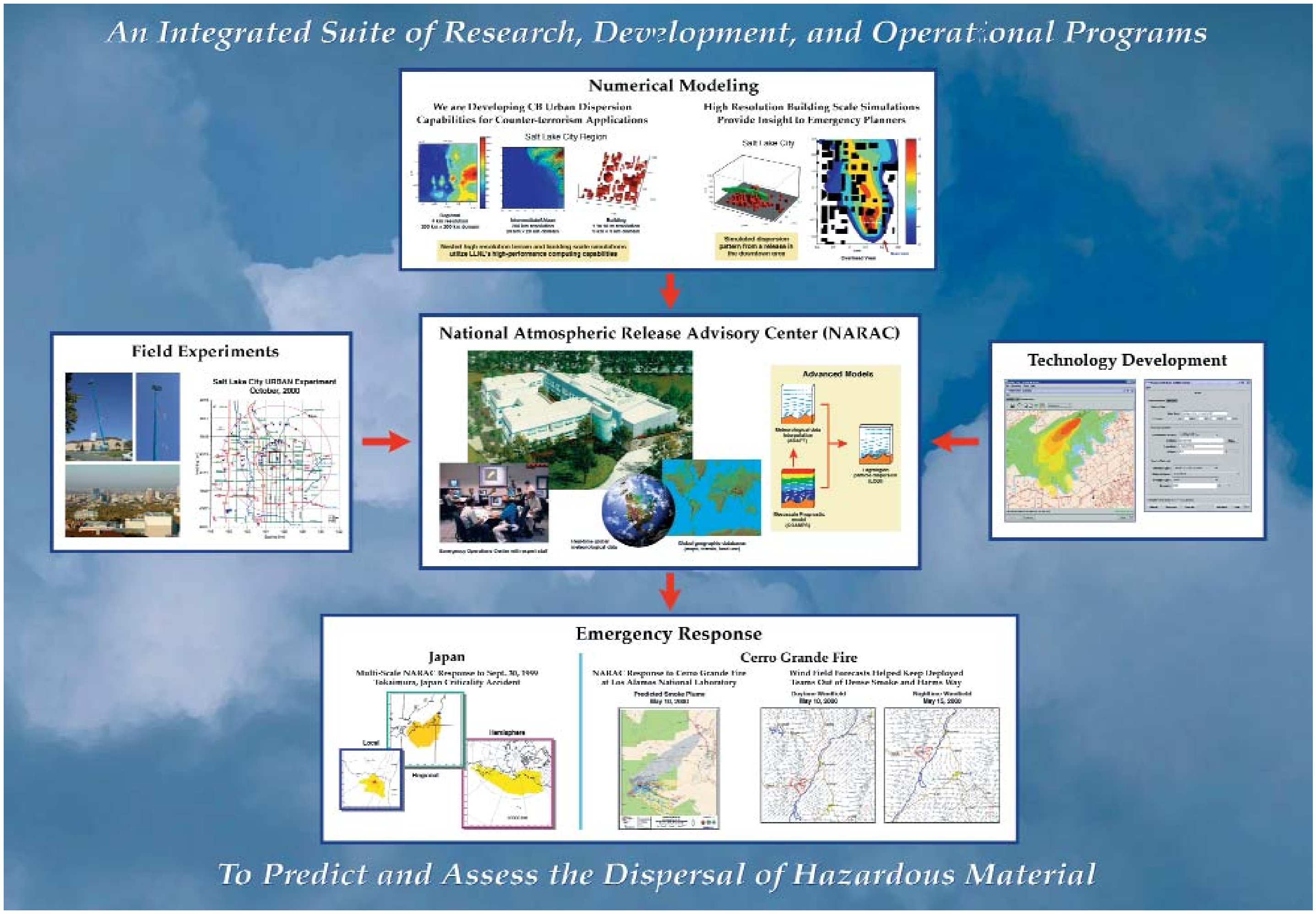


Figure 3-DOE-3. Each of DOE's eight Regional Coordinating Offices maintain a 24-hour response capability for radiological emergencies that may occur in states served by its region.



- The robustness of historical temperature trends;
- Variability in coupled ocean-atmosphere climate simulations;
- The effect of land-use changes on global temperature;
- The role of the Southern Ocean in absorbing anthropogenic carbon dioxide;
- The effectiveness of proposed geo-engineering schemes;
- The amount of carbon-free energy needed to meet global energy demand with climate stabilization;
- A proposal for storing carbon in the ocean through carbonate dissolution; and,
- The effectiveness and environmental impacts of ocean carbon sequestration options.

The mission of Atmospheric Chemistry and Aerosols Group (AC&A) is to improve the scientific understanding of the mechanisms of global environmental and climate change through the development and diagnosis of state-of-the-art models that represent key processes affecting the chemistry and microphysics of the atmosphere. We pursue this mission for the purpose of improving national energy and security policies that impact climate and environmental change.

The mission of IRCCSI is to improve understanding of climate change and its societal impacts, by facilitating collaborations between the University of California-operated DOE laboratories (i.e., LANL, LLNL, and LBNL) and University of California campuses (http://irccsi.llnl.gov/). In particular, we wish to link the Laboratories' capabilities in high-end climate modeling and climate science with the expertise in regional climate and societal impacts issues resident at the University of California campuses.

EED's Atmospheric Transport and Hazards Assessment Group support NARAC/IMAAC operations as well as supporting research. This group investigates diagnostic and prognostic tools from the building to urban to regional scales. Strategic R&D thrusts include integrating new operational capabilities, working closely with emergency planning and response user communities, and implementing improved tools to support a growing customer base.

Recent accomplishments include the following:

- NARAC co-led the Joint Urban 2003 field study (July 2003) in Oklahoma City, the largest and most complex urban tracer experiment performed to date. The study was jointly supported by DHS and the Defense Threat Reduction Agency (DTRA). Data from this study are being used to identify key urban physics issues and to evaluate the NARAC suite of urban models. NARAC is currently participating in the multi-institutional DHS/DTRA funded Urban Dispersion Program in New York City led by PNNL; and,

• NARAC is developing a multi-scale suite of models to simulate the flow and dispersion of airborne agents within urban areas. This effort is focused on the development of both a computational fluid dynamics (CFD) model, which explicitly incorporates the effects of individual buildings, and an urban canopy numerical weather-prediction model. A next-generation building-scale CFD code is being created which couples rapid geometry-to-mesh capabilities, treatment of complex building geometries, advanced numerical solvers, and parallelization. Evaluation of both models against Urban 2000 Salt Lake City and the Joint Urban 2003 Oklahoma City field study data has shown that these models can successfully simulate atmospheric transport in urban areas. Other recent accomplishments include the implementation and evaluation of time-dependent boundary conditions and the development of a significantly more computationally efficient version of the CFD model that represents outlying buildings by drag elements without significant loss of fidelity

Example of collaborative efforts with other institutions, including the following projects:

• Integration of mapping systems for field measurements, modeling results, and dose assessment to support DOE nuclear incident response capabilities, with Sandia and DOE Nevada's Remote Sensing Laboratory (RSL);

• Enhancement of source-term models for radiological, chemical, and biological releases and model for explosion prompt effects (blast, thermal, and radiation effects), with Sandia Albuquerque;

• Improved dose-response and toxic load models, with the Army's Edgewood Chemical and Biological Center;

• Development of building infiltration models to predict indoor exposures, with LBNL;

• Incorporation of an empirical urban model, with the United Kingdom (UK) Defense Science and Technology Laboratory (DSTL);

• Meteorological and outdoor dispersion modeling for an operational subway system, with Argonne National and Sandia Labs; and,

• Standardization and integration with the EPA/NOAA CAMEO/ALOHA toxic chemical databases and atmospheric dispersion models, with the NOAA Hazardous Materials Response Division.

A new multi-directorate LLNL research project is developing a data-driven event reconstruction capability to seamlessly integrate observational data streams with predictive models to provide probabilistic estimates of unknown source term parameters (location, time-varying release rate) and produce optimal situation analyses consistent with both models and data. The principal activity is focused on developing Bayesian inference and stochastic sampling methodologies coupled with a variety of predictive models to treat multiple resolutions.

Other LLNL research projects are providing improved capabilities for rain-rate and particle-size-dependent precipitation scavenging, treatment of high-altitude releases, and chemical reactions (i.e., gas and gas-aerosol) integrated into Computational Fluid Dynamics (CFD) simulations.

NARAC is exploiting rapidly developing Internet- and Web-based technology to enhance NARAC iClient and NARAC Web remote-access software that provides easy access to NARAC plume predictions. Development and deployment of these tools is key to NARAC's ability to support, manage information flow, and share a common operating picture with a large (and expanding) number of users. Upgrades include the development of pre-defined source term libraries; enhanced capabilities to support the importation, processing, and display of field measurement data; and new geographical and mapping features

The DHS Local Integration of NARAC with Cities (LINC) demonstration program has been demonstrating the value and developing approaches for providing NARAC support of local agencies. At present, five cities are participating in LINC: Seattle, New York City, Cincinnati, Albuquerque, and Fort Worth.

LOS ALAMOS NATIONAL LABORATORY (LANL)

<u>Operational</u>

LANL is operated by the University of California (UC) for DOE and NNSA, and is spread across 43 square miles of the Pajarito Plateau at the foot of the Jemez Mountains that extend up to around 3000 ft above the plateau. LANL is about 30 miles northwest of Santa Fe in north central New Mexico. The Pajarito Plateau slopes to the east-southeast, dropping 1300 ft across the Laboratory, with canyons and mesas running along the slope of the plateau. The broad Rio Grande Valley lies to the east of the laboratory. Los Alamos has a semi-arid, temperate, mountain climate.

The operational meteorological program at Los Alamos operates a network of six towers (ranging in height from 75 ft to 300 ft), a mono-static Doppler SODAR, and three supplemental precipitation stations. Data from four instrumented meteorological towers that are located on the Pajarito plateau drives a diagnostic wind field for the program's plume modeling capability. A fifth tower is located in Los Alamos Canyon to give information on the larger canyons in the area, and a sixth tower is located on top of Pajarito Mountain to measure ambient conditions. The SODAR gives information on winds up to the level of the Pajarito Mountain tower.

More than 100 instruments, consisting of over 20 different types of sensors, are used to collect data throughout the network. Variables measured by the program can be grouped into the categories of wind, SODAR-derived wind, atmospheric state, precipitation-related, radiative fluxes, eddy heat fluxes, subsurface measurements, and fuel moisture. Data collected by the network are checked for quality before its archiving, and raw data and real-time displays of graphs and tables are made available via the Internet.

The LANL Air Quality Group provides regulatory and environmental surveillance leadership and services to meet LANL air quality obligations and public assurance needs. The group develops and implements programs to ensure and address institutional compliance with State and Federal laws related to air quality regulations, DOE orders for emergency management, air quality surveillance, dose assessment activities, and community concerns related to air quality issues. The group takes a proactive approach to managing air emissions by providing continuous air monitoring and measurement of external penetrating radiation onsite and offsite. The group also coordinates LANL activities to ensure full compliance with air emission regulations, providing monitoring and modeling for emergency response, and assisting operating groups in developing and implementing new methods and systems to reduce emissions to as low as reasonably achievable. The monitoring capabilities of the Air Quality Group (AQG) are supplemented by the Atmospheric and Climate Sciences Group (ACSG) field team, which operates various sensor systems including a unique Raman lidar system to obtain images of atmospheric water vapor distributions.

Research

Research within the LANL Atmospheric and Climate Sciences Group supports DOE missions in both the defense and civilian sectors, such as work in the propagation of very-low-frequency sound (i.e., infra-sound) waves. Modeling studies contributed to understanding of propagation and, in particular, sources of "infra-sound". Just as it is possible to infer earthquake epicenters from seismic wave observations, "infra-sound" sources can be inferred from atmospheric observations. This work is an important component of monitoring compliance with the proposed Comprehensive Test Ban Treaty (CTBT). The CTBT work involves a number of organizations within DOE and DOD community, including interactions with other DOE laboratories within the CTBT Research and Development program.

Operational issues involve close work with the Air Force Technical Applications Center (AFTAC) at Patrick AFB, Florida, the DOD organization that handles monitoring systems. In addition, several active international collaborations with other infrasound researchers are ongoing.

The Meteorology Team within the ACSG at LANL conducts analysis and modeling on microscale to mesoscale atmospheric flows and phenomena. In support of the DOE CBNP, a model for High Resolution and Strong Gradient (HIGRAD) applications is being used to study the effects of radiative heating and shading around groups of buildings. The objective of this study is to determine how these processes may influence the transport of agents within the urban environment. On larger scales, the team is examining the influence of flow merger and urban roughness on the vertical transport and mixing of pollutants with the Regional Atmospheric Modeling System (RAMS) for several western U.S. valleys and basins. This project is in support of the DOE Environmental Meteorology Program (EMP) and for the EPA. As part of the LANL initiative in Coupled Environmental Modeling, researchers within the Meteorology Team are developing a physics-based fire behavior model, FIRETEC, and coupling this model to the HIGRAD atmospheric dynamics code to examine the details of the interaction between local winds and the intense heat generated by wildfires. Also as part of this initiative, a land surface model is being coupled that includes hydrologic processes (i.e., SPLASH) to the RAMS mesoscale model for multi-seasonal simulations of the water resources of the upper Rio Grande Basin.

Meteorology team members are also working on the LANL Urban Security project, which is linking physical and urban growth models to address the needs of cities. In this framework, we are using the RAMS model to provide meteorological fields for use by air chemistry, urban runoff, and other models. The Meteorology team within the ACSG conducts analysis and modeling on microscale to mesoscale.

On global scales, research within the LANL meteorological community involves the study of climate change and variability. A major project is the development of a global coupled ocean-atmosphere model sponsored by the DOE Climate Change Prediction Program. The global model being developed consists of a Los Alamos global ocean Global Climate Models (GCMs) Parallel Ocean Program (POP), the Los Alamos sea-ice model (CICE), the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM3), and a "flux coupler" to link the media consistently. The two GCM's and the CICE model exchange heat, momentum, and water mass across the air-sea boundary. A ten-year synchronized simulation revealed the synoptic weather events, seasonal cycles and inter-annual variations.

Observations related to understanding global climate are the focus of the Tropical Western Pacific (TWP) Program Office LANL, an element of the DOE ARM Program. The TWP Program Office is responsible for the development and operation of the TWP CART locale, a large expanse of tropical-ocean and maritime-continent lying roughly between 10 degrees S and 10 degrees N latitude and from 135 degrees E to 150 degrees W longitude. The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. The local climate is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño Southern Oscillation (ENSO) phenomenon.

Scientific questions that need to be addressed in the TWP can be grouped under three main headings:

- Radiation budget and cloud forcing;
- Water and energy budgets; and,
- Ocean-atmosphere interactions.

The program supports a variety of operations at LANL. The primary client of the program is the Emergency Management Group, for which the program provides a plume modeling capability. Other clients use the program's data for such activities as operations and planning, hazard and accident analyses, environmental studies, support for experiments, compliance, and documentation.

NEVADA TEST SITE (NTS)

<u>Operational</u>

The NTS is managed and operated by the National Nuclear Security Administration/Nevada Site Office (NNSA/NSO). The NTS has been the

Nations' underground nuclear weapons testing facility and is now used to support sub-critical experiments and other national defense missions of the United States. The NTS occupies 1,350 square miles of south central NV and is approximately 75 miles northwest of Las Vegas, NV. The topography of the NTS is complex with a system of dry lakebeds and mountains. Elevations range from nearly 2,700 feet (ft) above mean sea level (MSL) to 7,600 ft MSL. The climate is arid.

Meteorological services are provided to NNSA/NSO by components of the Department of Commerce (DOC), NOAA. The DOC has had a presence on the NTS for more than 45 years through the implementation of Interagency Agreements (IA). During this time, NOAA personnel have built a solid technical reputation in meteorological operations and emergency response. Presently, NOAA support is provided by Air Resources Laboratory Special Operations and Research Division (ARL/SORD) recognized for its expertise in the transport, dispersion, and deposition of radioactive and toxic materials. ARL/SORD has developed a rapid emergency response capability for the unlikely occurrence of an accidental release of radioactive or hazardous material into the atmosphere.

ARL/SORD provides full meteorological support to all NNSA/NSO operations on and off the NTS. Meteorology plays a key role in environmental, safety, and health responsibilities of NNSA/NSO. The ARL/SORD staff is responsible for conducting a modern program in support of nuclear and non-nuclear projects authorized by NNSA/NSO. Furthermore, the mission of ARL/SORD involves technical support to the emergency preparedness and response activities of NNSA/NSO. ARL/SORD supports a comprehensive meteorological program on the NTS, and provides meteorological and climatology services required in supporting the NNSA/NSO and contractor programs at the NTS, and elsewhere, as necessary.

Personnel at ARL/SORD also consult with senior scientists and engineers at the DOE National Laboratories, NASA, private contractors, Desert Research Institute (DRI), United States Geological Service (USGS), United States Forest Service (USFS), and other NOAA laboratories.

ARL/SORD operates and maintains a large meteorological monitoring network (MEDA) to characterize the meteorology and climatology of the NTS. This network consists of 29 33-ft towers and two, 100-ft towers. Wind direction and speed is measured at the 33-ft level on all the towers and temperature and relative humidity is sampled at the 6-ft level. Data from these towers are transmitted via microwave radio to a central processor that checks the data, creates data files, and archives the data every 15 minutes. The data files are accessed by microcomputer to create graphics products for operational use and for immediate display at 15-minute intervals. The MEDA system was upgraded in 2004 to include sonic anemometers.

SORD also operates two, 915MHz vertical profilers on the NTS. One tower is located in the middle of Yucca Flat and the other tower is located at the Hazardous Materials Spill Center (HMSC) in Frenchman Flat near Mercury, NV. In addition, a NOAA full surface radiation (SURFRAD) budget station is operated and maintained at the Desert Rock Meteorological Observatory (DRA) located in the southern part of the NTS. Upper-air soundings are taken twice daily, at 00 and 12 Universal Time Coordinated

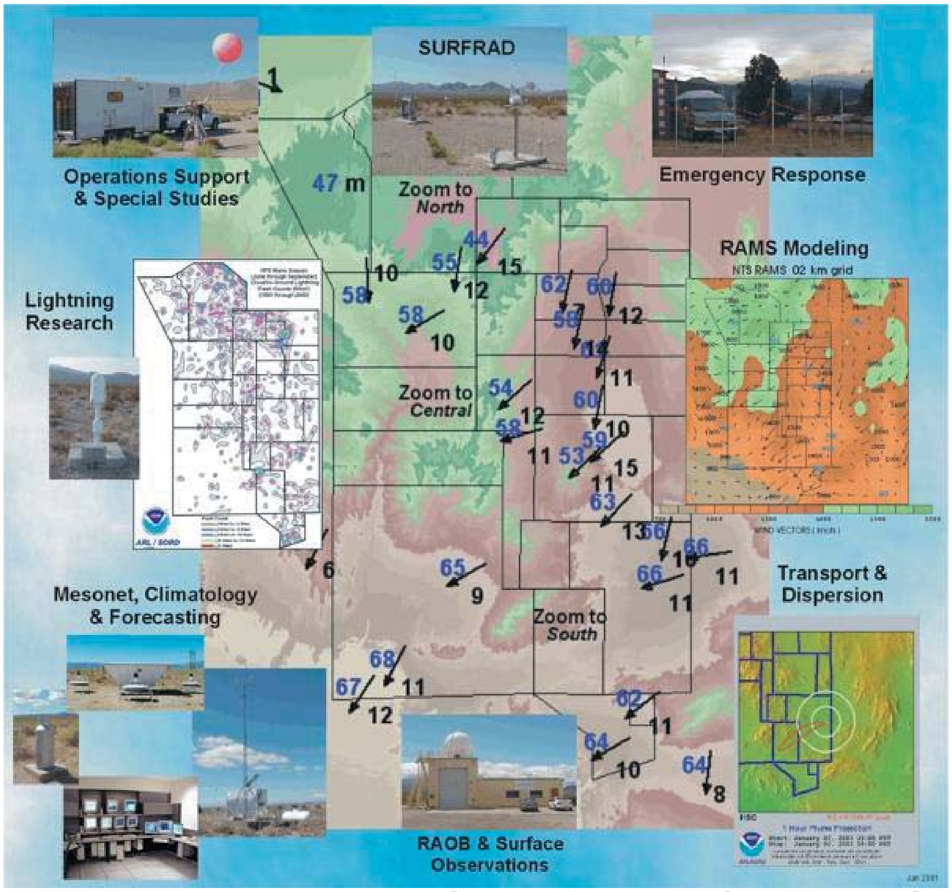


Figure 3-DOE-4. Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD) conducts basic and applied research on problems of mutual interest to National Oceanic and Atmospheric Administration (NOAA) and Department of Energy (DOE), that relate to the Nevada Test Site (NTS), its atmospheric environment, and its emergency preparedness and emergency response activities.

(UTC) from the DRA facility. ARL/SORD also operates mobile upper-air sounding systems and mobile pilot balloon (PIBAL) equipment to support special projects requiring winds aloft data in real-time.

Large-scale meteorological data and National Center for Environmental Predictions (NCEP) weather forecast products are received via AWIPS, or from the University Center for Atmospheric Research (UCAR) and ARL-Silver Spring, MD. Weather products supplied to DOE contractors, the National Laboratories (e.g., SNL, LANL, and LLNL), the NWS, and Nellis AFB, include real-time cloud-to-ground lightning flash graphical products and local forecast products. Furthermore, a three-tiered lightning alert and warning procedure has been implemented as part of the NTS Integrated Safety Management program.

ARL/SORD has also implemented the RAMS model for the NTS and Southern Nevada. This model predicts boundary layer airflow and precipitation over complex terrain. The RAMS code accesses the NCEP predictive model outputs and is run twice daily at the University of Nevada at Las Vegas (UNLV) Supercomputer Center on a daily basis. In addition, the NOAA HYSPLIT/HARM dispersion model has been installed on microprocessors in the SORD Meteorological Assessment Center.

ARL/SORD provides meteorological monitoring support and project-specific weather forecast services to NEST, FRMAC and ARG activities. Monitoring support includes surface and upper-air data collection and analysis. Weather forecast service entails maintaining a constant weather watch for conditions that might impact NEST, FRMAC, or ARG operations and personnel, issuing site-specific mesoscale wind, stability, and weather forecasts, aviation weather support, and providing consultation to the On-Scene Commander (OSC) and to National Laboratories personnel. ARL/SORD maintains a web site (www.sord.nv.doe.gov) that includes graphical products that display current meteorological conditions on and around the NTS, including data from ARL/SORD vertical profilers, climatology data, cloud-to-ground lightning information and time-relevant plume transport and dispersion calculations.

Research

Both basic and applied research is carried out on problems of mutual interest to DOE and to NOAA. Emphasis is on the maintenance of meteorological support to national defense projects and to the stewardship of nuclear weapons. These capabilities focus on those facets of meteorology having a direct bearing on the transport, dispersion, deposition (i.e., fallout), and resuspension of radioactive and/or toxic materials. Other research includes documentation and study of extreme precipitation events, desert thunderstorms, cloud-to-ground lightning, and environmental issues related to air quality and visibility. In addition, the SORD program serves as a test bed for advanced NOAA mesoscale prediction models.

A NOAA Climate Reference Station was installed at the Desert Rock Meteorological Observatory in April 2004.

OAK RIDGE NATIONAL LABORATORY

OAK RIDGE RESERVATION (ORR)

Operational

The ORR is home to four DOE/NNSA sites: Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex, the East Tennessee Technology Park (ETTP, formerly K-25 Site), and the Oak Ridge Institute for Science and Education (ORISE). Managed by the Oak Ridge Operations Office (OROO), the ORR encompasses nearly 100 square miles of hilly and heavily vegetated terrain in eastern TN. There are some additional SC facilities in Oak Ridge, TN.

Formerly known as the Oak Ridge Y-12 Plant, and constructed in the early 1940's as part of the Manhattan Project to manufacture nuclear weapons components, the Y-12 National Security Complex (NSC) has now assumed a national security role under the NNSA. Y-12 is an 811-acre facility located within the city limits of Oak Ridge, TN (population nearly 30,000), 10 miles from the ORNL and 12 miles from the ETTP, once known as the Oak Ridge Gaseous Diffusion Plant.

Currently operated by BWXT Y-12, the national security programs at Y-12 include manufacturing and reworking nuclear weapon components, dismantling nuclear weapon components returned from the national arsenal, serving as the nation's safe, secure storehouse of special nuclear materials, providing the U.S. Navy with safe, militarily-effective nuclear propulsion systems, and reducing the global threat from terrorism and weapons of mass destruction. In early 2004, the Y-12 NSC received, stored and secured a shipment of Libyan nuclear materials.

Meteorological network systems, which support day-to-day operations, are managed and operated at the three main sites by the University of Tennessee (UT)/Battelle, BWXT Y-12 and Bechtel Jacobs Company. These network systems provide data that support environmental management (e.g., permitting, facility siting and environmental impact assessment), facility safety (e.g., safety analyses), emergency management (e.g., hazards and consequence assessment), operations (e.g., work planning) and substantial research.

The BWXT Y-12 meteorological program is operations-, environment-, and safety-oriented. Y-12 is located in the narrow Bear Creek Valley, and it is bordered by two SW- to NE-oriented ridges, mostly covered with mature pines and hardwoods. Two meteorological towers have long formed the basis for the meteorological program. There is a 328-ft tower, instrumented at 33-, 100-and 328-ft, located on the valley floor at the East end of Y-12, and a 200-ft tower, instrumented at 33- and 200-ft, located on a ridgeline at the West end. In 2003, the data acquisition system was upgraded to an Environmental Systems Corporation (ESC) Windows-based software package, accessing via Ethernet the ESC 8832 data loggers at the towers. This data acquisition package is widely used in air pollution monitoring and in other environmental compliance applications.

Given the complex terrain setting of the Y-12 NSC, a REMTECH PA-2 SODAR is used to characterize the winds from 164-ft, extending above the surrounding ridges to a height of 1,640-ft. Redundant Windows XP polling computers collect 1-hour average SODAR data, plus 1-hour, 15-minute, and 1-minute tower data. Displays of the 15-minute data are available in the operations center, in the emergency centers, including the State Emergency Operations Center (EOC), and on an internal web page for general use by the Y-12 employees. For real-time emergency response modeling purposes, 15-minute data is also routed to the NARAC meteorological database, and to a specially-formatted file on the Y-12 EOC modeling computers. There, it is accessible by the local chemical model, CHARM®, a commercially available 3-D grid model with an extensive chemical database and source term modeling features. For most other modeling needs, the NARAC iClient model is used at Y-12, where the ridge-valley and generally complex terrain setting has represented a prototype test and demonstration site for 3-D wind field and terrain models.

In early 2006, the BWXT Y-12 meteorological program was in the early stages of a major change as a result of the 328-ft East Tower being displaced by a new "public interface facility". After 20 years of continuous operation near the Y-12 entrance, the East Tower is in the process of being dismantled. The nearby REMTECH PA-2 SODAR has illustrated that a 328-ft tower is replaceable, and by upgrading the REMTECH to a new Atmospheric Systems Corporation (formerly Aerovironment) Model 3000, there will continue to be a reliable monitoring capability to 100-meters and beyond. In addition, a shorter free-standing tower is scheduled for installation closer to the area of Y-12 operations where it will better represent 3-D turbulence parameters nearby the source of any hazardous releases.

There is no on-site weather forecasting service at Y-12, but since it is in the city limits of Oak Ridge, representative forecasts are readily available from the local media, the national network services, and the Internet. Local severe weather advisories and warnings are issued by the nearby NWS Office at Morristown, TN, and they are received and disseminated by the Plant Shift Superintendent (PSS) Office at Y-12. Also available to the PSS is a subscription weather and doppler radar service, as well as lightning detection and prediction equipment. The Y-12 Meteorologist and a Systems Hardware/Software Engineer maintain the program, train and assists others, as needed.

The meteorological data acquisition program at ETTP has two main towers. K-1209 is 200 ft high while K-1208 is 100 ft in height. In addition, two 33-ft supplemental towers are still operating. Lastly, a NEXRAD radar system, and The Weather Channel (TWC) are available to each of the control rooms and emergency response facilities.

The data acquisition program at the ORNL consists of three (two 100-ft and one 328-ft) meteorological towers. Meteorological data is fed to an ORNL central computer system for analysis and dissemination.

Research

NOAA Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division (ARL/ATDD) is located in Oak Ridge near the ORR. The primary mission of ATDD is atmospheric research. Substantial research programs at ATDD are undertaken with the assistance of staff from ORISE/Oak Ridge Associated Universities (ORAU) and scientists from other national laboratories and organizations in the United States and abroad. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

ARL/ATDD research attention is focused on the physics of the lower atmosphere, with special emphasis on the processes contributing to atmospheric transport, dispersion, and air-surface exchange, and on the development and improvement of predictive capabilities using the results of this research. Many other projects are underway such as surface energy balance and CO2 exchange studies and long-term studies of CO2 exchange aimed at process-level understanding.

Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data for air quality analyses, environmental reports, and hazard assessments and consequence assessments. Local climatology data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional network of 15 towers ranging from the Cumberland Mountains (middle Tennessee) to the Smoky Mountains on Tennessee's eastern border. Wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users.

ARL/ATDD incorporates NWS forecast products into the high-resolution, regional, meteorological model (i.e., RAMS) to produce twice daily 12-hour, 24-hour, and 36-hour predictions of surface winds for eastern Tennessee, and transport trajectory predictions for the ORR.

PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL) / HANFORD SITE

Operational

The mission of Pacific Northwest National Laboratory (PNNL) is to deliver breakthrough science and technology to meet key national needs. PNNL is operated for the DOE by Battelle Memorial Institute. In support of its mission, the PNNL Fundamental Science Directorate (http://www.pnl.gov/fsd/) operates a diverse atmospheric sciences research program and provides meteorological support services to the Hanford Site through the Meteorological and Climatological Services Project (MCSP).

The Hanford Site has played a pivotal role in the nations defense for more than 40 years, beginning in the 1940's with the Manhattan Project. A plutonium production complex with nine nuclear reactors and associated fuel fabrication and material processing facilities, Hanford is currently engaged in the world largest environmental clean-up project. The Hanford Site occupies 586 square miles in a semiarid region along the Columbia River in southeastern Washington State.

The MCSP operates a meteorological monitoring network on and around the Hanford Site that consists of an array of 26, 33-ft towers, three, 200-ft towers and one, 410-ft tower instrumented with temperature, wind direction, wind speed, and other meteorological sensors. Meteorological data from this network is transmitted via Ultra High Frequency (UHF) radio to the Hanford Meteorology Station, where the data are processed, plotted for immediate display and use by station personnel, and copied to several file servers to provide data for emergency response and research applications. In addition to this extensive data acquisition program, the MCSP provides weather observation, analysis, and forecasting services 21 hours per day, Monday through Friday, and eight hours per day on weekends and holidays. The MCSP also generates monthly and annual climatology data summaries and provides input for annual site environmental reports.

Independent of the MCSP, the PNNL atmospheric science staff members operate meteorological and atmospheric dispersion workstations at the Hanford Site Emergency Operations Center (EOC). Atmospheric sciences personnel are involved in exercise planning, exercise control, and staff training activities for Hanford's emergency preparedness and response program. Assistance is also provided to state and county emergency operations facilities. PNNL staff members have developed MetView software that is used to graphically display Hanford Site and regional meteorological data to support a variety of emergency preparedness and research applications. Staff members have also developed Air Pollutant Graphical Environmental

Modeling System (APGEMS) software that realistically and rapidly models atmospheric dispersion and human health/environmental consequences that may be associated with a contaminant release on or near the Hanford Site. The easy-to-use interface and graphical output capabilities of APGEMS allow it to efficiently support a range of users including first responders, experienced hazard assessors, and decision makers.

Research

The Atmospheric Science and Global Change Division within the PNNL Fundamental Science Directorate (http://www.pnl.gov/atmospheric/) provides scientific leadership, intellectual knowledge, and advanced research capability in areas related to energy production and use, environmental stewardship, homeland security, and science and technology policy. A key element of this work involves research to understand and mitigate the effects of the production and use of energy on the atmospheric environment. The Laboratory's capabilities include investigator-initiated research, multi-institutional collaborative research, unique scientific instrumentation, and national thought and program leadership.

Fundamental investigations are undertaken that integrate theoretical studies with both large and small scale experiments and advanced modeling techniques to enhance our understanding of atmospheric chemistry and meteorology, transport and dispersion phenomena, and climate physics. Design and development of innovative scientific measurement equipment to advance fundamental understanding of atmospheric phenomena, from particles to clouds, is an important element to the Laboratory's work.

PNNL plays both management and developmental roles in the DOE Atmospheric Radiation Measurements (ARM) program (http://www.arm.gov/). The ARM program is focused on the development of cloud and radiation databases and data products that are critical to improved understanding of global and regional climate change and the improvement of climate research and prediction models.

PNNL conducts research into the processes affecting radiation transfer through the atmosphere and the effects of greenhouse gases, aerosols, and clouds on regional and global climate. The PNNL Atmospheric Remote Sensing Laboratory (ARSL) is a portable system for studying the vertical structure of atmospheric constituents, particularly clouds, which govern radiation transfer through the atmosphere. Capabilities of the Environmental and Molecular Sciences Laboratory (EMSL) are used to examine the structures and dynamics of molecular species important in contaminant chemistry, photochemistry, and atmospheric processes, including molecular level research into aerosol formulation and aging. Carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other gases of radiative importance.

PNNL provides leading integrated assessment modeling capabilities for linking climate science and carbon cycle behavior to human activities and ecosystems. Advancing the state of the art of this modeling framework and related tools, and delivering policy analysis and related research products for understanding and evaluating the impacts of global environmental change is another major focus of the work of PNNL.

In support of the DOE Atmospheric Science Program (ASP), ground-based and airborne measurements systems, numerical and conceptual modeling, and data analysis are used to conduct research into the vertical transport and mixing processes that govern the distribution in the lower troposphere of trace gases and aerosols released during energy production or use and on chemical processes that govern the transformation and fate of gaseous and particulate pollutants. PNNL manages the DOE Research Aircraft Facility, a Gulfstream 159 twin turboprop aircraft, that supports research in atmospheric chemistry, radiation transfer, and aerosol characteristics for DOE.

A hierarchy of atmospheric dispersion models is being developed within the Chemical Biological National Security Program (CBNP) of DOE covering transport distances ranging from around individual buildings, through the urban area and beyond the urban area into the surrounding region. These models will allow individuals in intelligence, law enforcement and emergency management to adequately plan against, train for and respond to potential terrorist attacks. PNNL scientists, in collaboration with other government and private scientists, are conducting atmospheric tracer and meteorological field studies for evaluating the models being developed within CBNP. The field studies will provide valuable information to all investigating urban dispersion, urban air quality and atmospheric transport and dispersion in general.

PANTEX PLANT

Operational

The Pantex Plant covers 15,977 acres and is located 17 miles northeast of Amarillo, TX, in Carson County. The Plant was a World War II munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation's only assembly/disassembly facility supporting the nuclear weapons arsenal. The Pantex Plant is a government-owned, contractor-operated facility. NNSA oversees the operation of the Pantex Plant through the Amarillo Site Office, which reports to the Albuquerque Operations Office. Mason and Hanger

Corporation had been the operating contractor since 1956. On February 1, 2001, BWXT Pantex assumed the Pantex contract.

The Plant is composed of several functional areas, commonly referred to as numbered zones. These include a weapons assembly/disassembly area, a weapons staging area, an area for development of experimental explosives, a drinking water treatment facility, a sanitary wastewater treatment facility, and vehicle maintenance and administrative areas. Other functional areas include a utility area for steam and compressed air, an explosive test-firing facility, a burning ground for thermally treating explosive materials, and landfills. Overall, there are more than 700 buildings at the Pantex Plant.

The Pantex Plant maintains a meteorological monitoring station located on the northeast corner of the site. The monitoring station is an instrumented 197-ft tower that was erected approximately 2.3 miles north of the Zone 12 production area in the late 1970s to support the gathering of meteorological data for construction of a commercially owned and operated power plant in the Texas Panhandle near Amarillo. The project was abandoned in the early 1980s and the tower was left in place and turned over to Pantex Plant management.

The Environmental Protection/Restoration Department (EP/RD) of the Environment, Safety and Health Directorate is tasked with the implementation of the quality assurance program for the meteorological data captured by the onsite two-level meteorological tower. The data from this tower, monitored at the 33-ft and 197-ft elevations are collected and used by the DOE National Atmospheric Release Advisory Center (NARAC) site workstation, located in the Plant EOC. These data are collected and archived as 15-minute averages plus maximum and minimum values for each 15-minute period. They are primarily used for input to the NARAC emergency response models that could be used for consequence assessment purposes for off-normal events involving radionuclides. Annual dispersion model calculations of offsite radiation doses from routine emissions of onsite sources, required by 40 CFR 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants (NESHAP)*, are accomplished by the EP/RD. EP/RD uses the EPA-approved CAP88-PC atmospheric transport and dispersion model and the Pantex meteorological tower data processed into the STAR format. This department also maintains the Pantex Plant climatology database.

The tower is equipped with two sets of sensors, located at the 33-ft and 197-ft levels. Wind speed, wind direction, and temperature sensors are located at both levels, with a dew point sensor located at the 33-ft level. A barometric pressure sensor is located on the tower approximately 6 ft above the tower base. A solar insolation pyranometer and a tipping bucket rain gauge are located adjacent to the tower at approximately 3.3 ft above ground level. In 1992, a photovoltaic panel was added to provide backup power for the main 110-volt AC power/battery system. The system is more fully described in a 1993 report prepared by PNNL (Snyder, 1993a).

Meteorological tower data is also used by the Authorization Basis (AB) and Nuclear Explosives Safety Departments for plume transport and dispersion modeling applied to the Plutonium Dispersal Consequence Analysis for the Safety Analysis (SAR) and Basis for Interim Operations (BIO) validation and upgrade reports, other operations directives, and other safety analyses.

Routine preventive maintenance on the meteorological instruments as well as calibration and certification was performed semi-annually by the United States Bureau of Land Management (BLM) until the contract ended. The older meteorological sensors and associated equipment that were installed and maintained by the BLM will be replaced with equipment selected by personnel from NARAC. Annual meteorological data are used in the U.S. Environmental Protection Agency (EPA) atmospheric dispersion model CAP88-PC to assess the radiological dose to the public from potential radiological releases at Pantex Plant, as required under 40 CFR 61.92. Through 1992, the data employed in all atmospheric dispersion modeling were National Oceanic and Atmospheric Administration (NOAA) meteorological data collected at the Amarillo International Airport, about 10 miles southwest of Pantex Plant. Beginning in 1993, meteorological data collected from the Pantex Plant meteorological tower were employed in atmospheric dispersion calculations and for other activities requiring meteorological data, such as preparation of the annual Site Environmental Report (ASER) for the Pantex Plant.

Temperature differences between the two tower levels are examined on almost a daily basis by operators of the Plant Burning Ground. Operation of the Burning Ground is limited under the terms of the Plant Hazardous Waste Permit to times when no low-level temperature inversion is present. Burning Ground operations are also restricted to low wind-speed conditions. Plant meteorological data are also employed in short-term (i.e., puff) and long-term (i.e., plume) atmospheric dispersion calculations for emergency response to accidental radiological releases to the atmosphere, through NARAC. Other onsite users of Pantex Plant meteorological data include the building freeze-protection program, which is designed to alert building managers and the Utilities Department to the possibility of freezing pipes during winter months; the Pantex Plant Fire Department, which obtains wind direction and wind speed information before responding to alarms; the Texas Tech Research Farms, which use the data in crop-spraying operations; and Plant Security, which uses the data to control operations at the pistol and rifle ranges. Other onsite users include construction contractors, who use the data to validate adverse weather-caused work stoppages; explosive test-fire facilities, which use the data to limit downwind noise nuisances; and the emergency spill response teams, who use the data to predict plume movement. The data are also being used in support of routine air monitoring, present and future Plant operations, air permit submissions to the State of Texas, and state agencies doing environmental work in the area under the Agreement in Principle between DOE and the State of Texas.

In 2005, the sensors and most of the other components of the Pantex Weather tower will be replaced with Campbell Scientific equipment. New vendors are being evaluated to take over the maintenance and calibration work.

<u>Research</u>

There is no current or projected meteorological research activities planned at the Pantex Plant.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (RFETS)

<u>Operational</u>

The RFETS is managed by the Rocky Flats Office (RFO) and is located approximately 16 miles northwest of downtown Denver, CO. One of the smaller DOE sites, the facility occupies a 10 square mile area along the foothills of the Rocky Mountain Front Range. This site has been decommissioned and after verification of closure criteria by DOE, the entire reservation will be transferred to the Department of Interior (DOI).

A 200-ft meteorological tower at the west-end of the site continuously monitors meteorological conditions at surface, 33-ft, 82-ft, and 197-ft above ground level. The data are analyzed, quality assured, and assembled into data sets for use in atmospheric modeling, climatology, and other analyses at the site. Data from the 200-ft and 33-ft towers are also transmitted back to the main site every 15 minutes by telemetry for use in emergency response modeling. The Regional Atmospheric Response Center (RARC) conducts meteorological activities associated with emergency preparedness and response at the site. An upper air remote sensing Sound Detection and Ranging/Radio Acoustic Sounding System (SODAR/RASS) continuously monitors winds, temperatures, and atmospheric stability above the RFETS site.

Through a cooperative agreement with the Colorado Department of Public Health and Environment (CDPHE), meteorological data are transmitted to the site from five surface meteorological stations by telemetry that form a ring around the site perimeter. Another cooperative agreement with NOAA provides near real-time data from multiple monitoring sites throughout the Denver metropolitan area. These data are all received, quality assured, and combined into a three-dimensional observation set for emergency response modeling every 15 minutes, 24 hours per day.

The RARC provides 24-hour consequence assessment support for any unplanned radiological or chemical releases from the site. The Center responds with customized weather forecasts, plume projections, and dose modeling results that lead to event classifications and protective actions for on-site and off-site populations. RARC also conducts specialized consequence assessments in support of emergency preparedness, hazard assessments, and risk assessments for RFETS. Weather forecasts are provided for severe weather events, such as winter storms, windstorms, and severe thunderstorms.

A customized modeling system has been developed and implemented at RFETS to predict the pathway and impacts from any radiological emergency at the site. Called the Computer-Assisted Protective Action Recommendation System (CAPARS), the new capability addresses the need for fast, accurate plume predictions in a complex atmosphere.

CAPARS provides a variety of plume, weather, hazard, and related products with the accuracy and speed needed for response to an emergency at RFETS. Eleven integrated major subsystems form the overall CAPARS capability.

The State of Colorado has formally accepted the CAPARS modeling system for emergency response and planning applications at RFETS. A specialized planning version of the CAPARS system has been developed, implemented, and applied for emergency planning at the RFETS. Called the TRAC Risk Assessment/Hazards Assessment Model, the capability is designed to support hazards and risk assessments for RFETS and to form the basis for an evaluation of the size and shape of the Emergency Planning Zone (EPZ) surrounding RFETS.

Research

There is no current or projected meteorological research activities planned at RFETS.

SANDIA NATIONAL LABORATORY (SNL) - ALBUQUERQUE

Operational

The DOE Site Office manages SNL in Albuquerque, NM, located between the Rio Grande Valley and Manzano Mountains. SNL covers approximately 80 square miles of flat to mountainous arid terrain. Meteorological Programs at SNL include both operational support and research activities.

Meteorological services and support are provided through the EOC in the Laboratory Services Division (LSD). The mission is to provide meteorological support for various operations including:

- Emergency response;
- Environmental surveillance and characterization; and,
- Regulatory compliance.

The monitoring network consists of six, 33-ft and two, 197-ft towers used to measure wind direction and speed, ambient temperature, and relative humidity. There are also three precipitation gauges, two barometric pressure sensors, and one solar radiation pyranometer in the network.

Research

Key research activities are provided through the Energy and Critical Infrastructure Center in the Energy, Information, and Technology Division. SNL scientists are involved in the ARM program and the Surface Heat Budget of the Arctic Ocean (SHEBA). The ARM project is a combined measurement and modeling program. The goal is to gain a better understanding of clouds and their effect on atmospheric radiation, with the final goal of developing better climate models. The SHEBA program addresses the interaction of the surface energy balance, atmospheric radiation and clouds over the Arctic Ocean.

SAVANNAH RIVER SITE (SRS)

Operational

The SRS is under the responsibility of the Savannah River Operations Office (SROO) and operated by the Washington Savannah River Company (WSRC). SRS is located in southwestern South Carolina, along the banks of the Savannah River. The SRS covers an area of approximately 300 square miles and is thickly forested with pine trees. There are also several small streams, a large swamp, and two reservoirs built as cooling ponds for nuclear plant reactors. The topography of SRS is characterized by gently rolling hills with an adjacent flood plain near the Savannah River. The climate at SRS is typical of the southeastern United States with long, hot and humid summers and short, mild winters.

The Atmospheric Technologies Group (ATG) of the Savannah River National Laboratory (SRNL) has developed and operated a meteorological monitoring and modeling program at the SRS since the early 1970's. This program supports SRS operations in emergency response consequence assessment, weather forecasting, radiological and non-radiological air quality calculations for regulatory compliance, safety analyses, environmental impacts, engineering studies, environmental sciences research and non-proliferation activities.

The ATG meteorological data sources are extensive and quite varied. Onsite meteorological data are obtained from a network of either 200-ft meteorological observing towers located near the major production sites. The instrumentation on those towers includes sensitive bi-directional vanes (i.e., bivanes), cup anemometers, resistance thermometers and lithium chloride humidity sensors. Another tower is located at the Central Climatology facility, located near the geometric center of the SRS. It includes like instruments near ground level, 60-ft, 120-ft, and 200-ft. Additional meteorological instruments at the Central Climatology facility include precipitation, evaporation, barometric pressure, soil temperature, solar and long wave radiation. Data are collected with dedicated data loggers at each tower site. Each logger is then polled by a remote computer that, in turn, populates a relational database with meteorological data.

A network of twelve manually-read rain gauges is located throughout the SRS. Additional local upper-air data are collected for special cases from a balloon-launched airsonde system and a portable tethersonde system. Portable towers are available for special studies.

ATG also has access via satellite to real-time regional, national, and international meteorological data from a commercial weather data provider. The data include surface observations, satellite and radar imagery, and predictive model information from the US and abroad.

In addition, ATG has developed the Weather INformation and Display (WIND) System as an automated resource for conducting real-time consequence assessments following unplanned releases of hazardous material. The WIND System is a multi-computer platform network that links the real time meteorological observations and forecasts with a suite of atmospheric and aqueous transport and dispersion models. A rolling 24-hour data file is created from data archived in the meteorological database and disseminated to a pc-based workstation that can operate the WIND System modeling and display software.

In the mid 1990's, a mutual aid agreement with surrounding counties emergency management agencies was created to install and operate four meteorological towers at nearby chemical plants in support of emergency response activities. Data from these towers are incorporated into the SRS meteorological database, integrated into the 24-hour data file, and made available beyond the SRS firewall for use by the off-site partners using appropriate WIND System software.

Two television stations, WJBF and WAGT, have built a new television tower near SRS, where SRNL has installed meteorological instrumentation at 100-ft, 200-ft, and 1000-ft. This local television transmitter tower was instrumented with fast response three-dimensional sonic anemometers and optical water vapor and CO2 sensors at each of the three levels along with slow-response temperature and humidity sensors at 200-ft and 1000-ft. The data from this tower is used for both operational emergency response and for USFS controlled burns. The data is also used for research projects in the atmospheric boundary layer.

A joint partnership between Westinghouse Electric Company and a local television station provides real-time local Doppler radar data to SRS and the local community. The data (e.g., static and time lapse - movie- images) are available through the site internal computer network at employees' desktop computer for assistance in site operations.

ATG utilizes a regional mesoscale model, RAMS, for detailed 24-hour forecasts which are input to the predictive component of the WIND System models. Transport calculations blend observed meteorological data with RAMS forecasts to make timely and accurate assessments. The grid resolution used in RAMS varies from 2 km for the inner grid (i.e., 100 km x 100 km centered on the SRS) to 8 km for the outer grid (i.e., 250 km x 250 km).

The SRNL Atmospheric Technology Center supplies local, national, and international meteorological data to support SRS and Weather Field Office (WFO) customers and daily weather forecasts to support site operations. Typical customers include waste handling groups where wind and rain forecasts often determine daily activities. Also, ATG supports the United States Forest Service (USFS) prescribed burn program and site heat stress program with detailed observations and forecasts. Custom forecasts are also provided to facility and other senior managers to support protective action decisions for severe weather.

<u>Research</u>

SRS meteorological data are used to validate and improve operational RAMS mesoscale model forecasts and to support environmental and engineering studies.

WASTE ISOLATION PILOT PLANT (WIPP)

<u>Operational</u>

The Waste Isolation Pilot Plant (WIPP) is operated by Westinghouse TRU Solutions (WTS) for the DOE Carlsbad Field Office (CBFO). A cornerstone of the DOE national clean-up strategy, the WIPP is designed to permanently dispose of transuranic (TRU) radioactive waste generated by defense-related activities in the Salado salt formation 2,150 feet beneath the surface. WIPP is located in Eddy County in southeastern New Mexico, 32 miles east southeast of Carlsbad, NM, and occupies 16 square miles of a region know as Los Medanos. Geographically, the region is regarded as a relatively flat, sparsely inhabited plateau with little surface water.

The WIPP Environmental Monitoring and Hydrology (EM & H) Section performs meteorological monitoring as part of the Non-radiological Environmental Monitoring Program (NEMP). The meteorological station provides measurement of wind direction and wind speed, and temperature at 6-ft, 33-ft, and 164-ft, as well as ground level measurements of barometric pressure, relative humidity, precipitation, and solar radiation. The main function of the meteorological station is to generate data for operational support, emergency response and regulatory atmospheric transport and dispersion modeling applications. Parameters are monitored continuously and the data are stored in the Central Monitoring System (CMS), a computerized system including automated parameter checks, real- time displays in the Central Monitoring Room (CMR), and data archiving. Meteorological data are compiled and distributed to stakeholders, including the NOAA NWS at Midland-Odessa, TX, on a monthly basis.

WIPP also, under a cooperative agreement with the NWS, maintains a Cooperative Weather Observing Station nearby the primary meteorological tower. Data from this station are compiled monthly and the Record of Climatological Observations form is submitted to the Weather Forecast Office in Midland-Odessa, TX. Under the same cooperative agreement, the Midland-Odessa office is given access to real-time data from the primary meteorological station.

<u>Research</u>

There is no current or projected meteorological research activities planned at WIPP.

YUCCA MOUNTAIN PROJECT (YMP)

Operational

As part of the DOE Office of Civilian Radioactive Waste Management (OCRWM), the Yucca Mountain Project (YMP) studies may eventually support a recommendation of Yucca Mountain for the nation's first geologic repository for spent nuclear fuel and other high level radioactive waste. The current meteorological program within the YMP focuses on environmental compliance and operational health and safety considerations, for both employees and the general public.

As with a number of DOE sites, the Yucca Mountain area is one of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influence onsite weather. The YMP meteorological program, therefore, includes four full stations for measuring atmospheric dispersion and general meteorological conditions, as well as nine precipitation stations. These stations serve to monitor the significant variations in airflow, rainfall, and temperature caused by the area's complex terrain environment. The meteorological stations are key to the thorough monitoring of these variations that is essential for the YMP ongoing commitment to environmental compliance and to the health and safety of employees and the public.

The YMP meteorological program also provides essential data for the studies necessary to evaluate the site's suitability for a potential repository. Should the site be deemed suitable and a repository licensed, built, and operated, water would be the primary means by which radioactive materials could be transported to the accessible environment. Thus, movement of water from the atmosphere to the surface and on through the mountain is a key concern. The meteorological program provides essential data for the infiltration model of the mountain. Data about precipitation, humidity, evapotranspiration, surface water run-on, solar radiation, air temperatures, and wind patterns all contribute to the overall infiltration model. The model gives special emphasis to the transient, or temporal, versus steady-state rates of water movement through the unsaturated zone of rock at Yucca Mountain. The temporal variation of infiltration may be short term, due to weather fluctuations that drive episodic flow, or much longer term, in periods corresponding to climate change. Data from the meteorological program's ongoing monitoring programs are supplemented by the program's paleoclimatology studies. Together, they provide essential information for the YMP modeling of past, present, and future infiltration rates.

If the potential repository were actually built and operated, continuous meteorological monitoring and analysis would also be essential for the operational facilities on the surface of the mountain, at least until the final closure of the repository. Buildings would be built to withstand the probable maximum flood and wind conditions, and administrative controls would be in place to suspend operations during severe weather conditions. An integral part of the emergency response system would include monitoring the overall environmental situation at the repository site.

In turn, an integral part of the overall environmental monitoring system would be the meteorological monitoring system. This system would collect real-time meteorological information about the site and provide weather forecasting and climatology data. Such data would be essential for management decisions regarding the health and safety conditions for employees and the public.

Research

There is no current or projected meteorological research activities planned at the Yucca Mountain site.

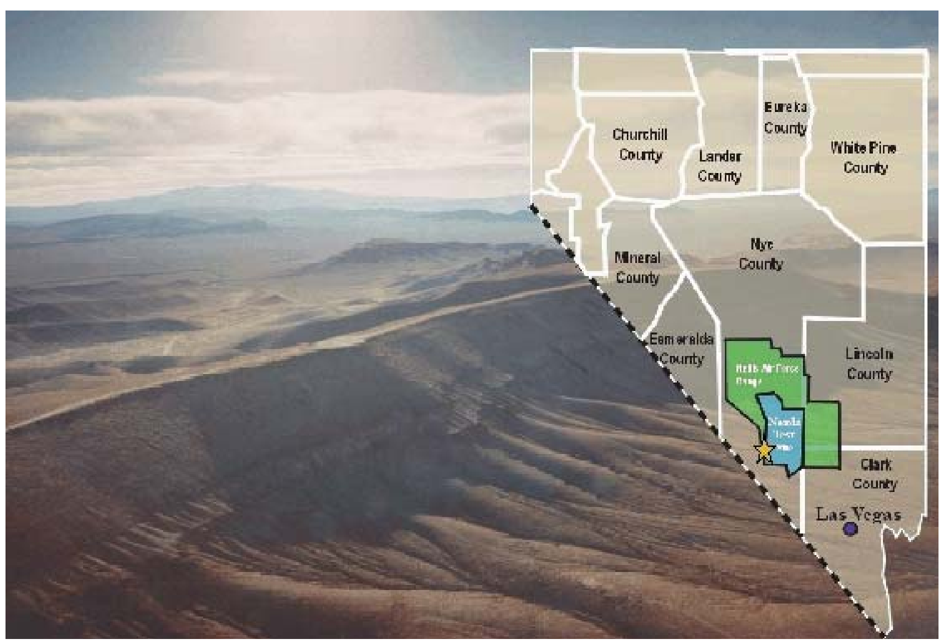


Figure 3-DOE-5. Yucca Mountain (100 miles northwest of Las Vegas, Nevada) is unpopulated land owned by the Federal Government and adjacent to the nation's nuclear weapons test site.

DEPARTMENT OF HOMELAND SECURITY WEATHER PROGRAMS

The Department of Homeland Security (DHS) has three primary missions: Prevent terrorist attacks within the United States, reduce America's vulnerability to terrorism, and minimize the damage from potential attacks and natural disasters. The department's first priority is to protect the nation against further terrorist attacks. Component agencies will analyze threats and intelligence, guard our borders and airports, protect our critical infrastructure, and coordinate the response of our nation for future emergencies. Besides providing a better-coordinated defense of the homeland, DHS is also dedicated to protecting the rights of American citizens and enhancing public services, such as natural disaster assistance and citizenship services, by dedicating offices to these important missions.

Homeland Security Presidential Directive #5 (HSPD 5), states that "to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies, the U.S. Government shall establish a single, comprehensive approach to domestic incident management." It also assigns the Secretary of the Department of Homeland Security the role of principal Federal official for domestic incident management. Based on previous Federal guidelines and legal authorities, a number of Federal agencies have responsibilities, depending on the scenario, and each agency has developed or has access to source-term estimates, dispersion modeling, and consequence assessment capabilities to meet their responsibilities. For a domestic incident, these capabilities would be coordinated by the Secretary of the Department of Homeland Security in cases where a Federal response is required and authorized.

Over the coming year, the goal is to develop an all-hazards dispersion support framework, initially based on atmospheric dispersion modeling and consequence assessment, to support the DHS Secretary in his role as principal Federal official for planning, preparing, and responding to domestic incidents. This framework will provide tailored all-hazards dispersion support to DHS and its Homeland Security Operations Center (HSOC). The primary and most urgent objective is to provide the best available information for atmospheric hazard predictions so that DHS can make appropriate emergency response and consequence management decisions. This effort is based on the work and recommendations of the OFCM-sponsored Joint Action Group on the Selection and Evaluation of Atmospheric Transport and Dispersion Models (JAG/SEATD) report, *Atmospheric Modeling of Releases from Weapons* of *Mass Destruction: Response by Federal Agencies in Support of Homeland Security*, August 2002, and the National Research Council's (of the National Academies) Board on Atmospheric Sciences and Climate report, *Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security, 2003*.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

In carrying out its role, FEMA works with all of the agencies to assure that the delivery of meteorology-related information is conducted in keeping with established goals and objectives. As administrator of the National Flood Insurance Program (NFIP), FEMA publishes Flood Insurance Rate Maps for all flood-prone communities, which serve as the official demarcation for flood risk. FEMA also administers the National Hurricane Program and, for regions subject to hurricanes, publishes hurricane evacuation zone maps based on surge model simulation results from the National Weather Service's National Hurricane Center.

FEMA priority interests with OFCM are in supporting the FEMA pre-disaster initiatives and in promoting standards and procedures which will enhance the ability of the Nation to mitigate and recover from emergencies and disasters (Figure 3-DHS-1). These interests extend to national standards for geographic information systems (GIS) used for delivery of meteorological products and services by other agencies. FEMA also actively supports the OFCM-sponsored Working Group for Post-Storm Data Acquisition (WG/PSDA) and the WG/PSDA's efforts to develop a National Plan for Post-Storm Data Acquisition to coordinate and support the collection, by the Federal agencies, of perishable data after major storms. These data have potential applications in post-disaster mitigation activities, the NFIP flood hazard analysis, the FEMA National Hurricane Program hurricane evacuation studies, and other FEMA risk analysis activities, such as the Multi-Hazard Loss Estimation Methodology (HAZUS). The Risk Analysis Branch is the principal contact for hurricane evacuation studies and flood risk analysis as well as the FEMA contact point for meteorology-related matters. For additional information see www.fema.gov.

UNITED STATES COAST GUARD (USCG)

Although no USCG cutters or shore units are solely dedicated to meteorology, they collectively perform a variety of functions in support of the national meteorology program. USCG ocean-going cutters and coastal stations provide weather observations to the National Weather Service (NWS). Coast Guard communications stations broadcast NWS marine forecasts, weather warnings, and weather facsimile charts and, also, collect weather observations from commercial shipping for the NWS.

The Coast Guard operates three polar icebreakers - USCGC POLAR STAR, USCGC POLAR SEA, and USCGC HEALY - to serve our Nation's security, economic, environmental, and scientific interests. These vessels make important marine environmental measurements during dedicated science deployments or in conjunction with other missions.

The USCGC HEALY, a new icebreaking research vessel, was delivered to the Coast Guard in November 1999 and conducted successful shakedown tests of the hull, machinery, and scientific equipment during January-August 2000. Scientific systems and gear include a bottom mapping multibeam sonar system; a sub-bottom profiling system; a conductivity-depth-temperature data system; an expendable oceanographic probe system; an Acoustic Doppler Current Profiler; a jumbo coring system; a continuous flow, seawater sampling system; a meteorological measurement system; and a bow tower for clean air experiments. To schedule time on HEALY, see the UNOLS web site, *www.unols.org*. For more information, see the Coast Guard web page for HEALY, *www.uscg.mil/pacarea/healy/*.

The USCG conducts the International Ice Patrol (IIP) under the provisions of the International Convention for Safety of Life at Sea (SOLAS). The IIP uses sensor-equipped aircraft to patrol the Grand Banks of Newfoundland to locate and track icebergs which pose a hazard to North Atlantic shipping. Direct observations are supplemented and extrapolated using a numerical iceberg drift and deterioration model. IIP determines the geographic limits of the iceberg hazard and, twice daily, broadcasts iceberg warning bulletins and ice facsimile charts which define the limits of the iceberg threat during the iceberg season (spring and summer). IIP annually archives data on all confirmed and suspected icebergs, and forwards these data to the National Snow and Ice Data Center. These data can be accessed via the IIP web page *www.uscg.mil/lantarea/iip/home.html*. Archived data contains all iceberg sighting data along with the last model-predicted position of each berg.

The Coast Guard participates with the Navy and NOAA in conducting the National Ice Center, a multi-agency operational center that produces analyses and forecasts of Arctic, Antarctic, Great Lakes, and coastal ice conditions.

The Coast Guard also collaborates with NOAA in operating the National Data Buoy Center (NDBC) which deploys and maintains NOAA's automated network of environmental monitoring platforms in the deep ocean and coastal regions. Five Coast Guard personnel fill key technical and logistics support positions within NDBC. Coast Guard cutters support the deployment and retrieval of data buoys, and provide periodic maintenance visits to both buoys and coastal stations, expending approximately 180 cutter days annually. Coast Guard aircraft, small boats, and shore facilities also provide NDBC support.

Meteorological activities are coordinated by the Ice Operations Division of the Office of Marine Transportation Systems at Coast Guard Headquarters. Field management of Coast Guard meteorological support services is accomplished at the Coast Guard Area and District levels.

Figure 3-DHS-1. Greensburg, KS May 16, 2006 - FEMA Disaster Assistance Employees Shirley Marlett, Mike Farrell, Donna Johnson, Shelagh Keleyhers, and Bruce Bowman process applications for assistance from residents of Greensburg at a Mobile Disaster Recovery Center. On May 4 an F5 super-tornado flattened the Kansas town of 1600. Photo by Greg Henshall / FEMA

DEPARTMENT OF THE INTERIOR WEATHER PROGRAMS

The Department of the Interior (DOI), is the nation's principal conservation agency, charged with the mission "*to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.*" The following operational and research programs contribute to the Federal Meteorological Plan.

UNITED STATES GEOLOGICAL SURVEY (USGS)

WATER DATA

The USGS's Water Resources Discipline (WRD) collects streamflow, precipitation, water quality, ground-water level, and other water resources and climatological data as part of a national network and for a number of projects concerning rainfall-runoff, water quality and hydrologic processes. Currently, the USGS collects continuous hydrologic and meteorological data at about 8,900 surface water sites, 2,700 ground water level sites, and 1,600 water quality sites. Periodic records are collected at approximately 1,500 additional surface water sites, 20,200 ground water sites, and 10,300 water quality sites. Precipitation records are collected at about 800 sites.

Data collected at most continuous-record USGS sites are transmitted from remote Data Collection Platforms (DCPs) to Wallops Island, Virginia via a Geostationary Operational Environmental Satellite (GOES). From the Wallops Island facility, data are rebroadcast to a domestic communication satellite (DOMSAT). Data are received from the DOMSAT by local readout ground stations (LRGS) procured by USGS. The USGS currently operates 21 LRGS which provide near-real-time data to the USGS's computerized National Water Information System (NWIS). Near-real-time streamflow data and ancillary information are provided to National Weather Service River Forecast Centers for river forecast points (Figure 3-DOI-1). Additional historical and real-time water resources data are available from the USGS database at NWIS Web (http://waterdata.usgs.gov/nwis/).

The USGS also collects precipitation samples at a number of sites to determine the atmospheric contribution of chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment.

CLIMATOLOGICAL RESEARCH

USGS carries out research in climate change, regional hydrology, the carbon cycle, coastal erosion, and glaciology. The Water, Energy, and Biogeochemical Budgets (WEBB) program is studying processes controlling water, energy, and biogeochemical fluxes at five small research watersheds in the U.S. This program includes research on the effects of atmospheric and climatic variables on watershed processes. There are also a number of ongoing studies to characterize trends in hydrologic data and to relate these trends to climatic variables. Researchers are also using global and regional climate models to enhance understanding of the potential effects of climate change and climate variability on U.S. land and water resources.

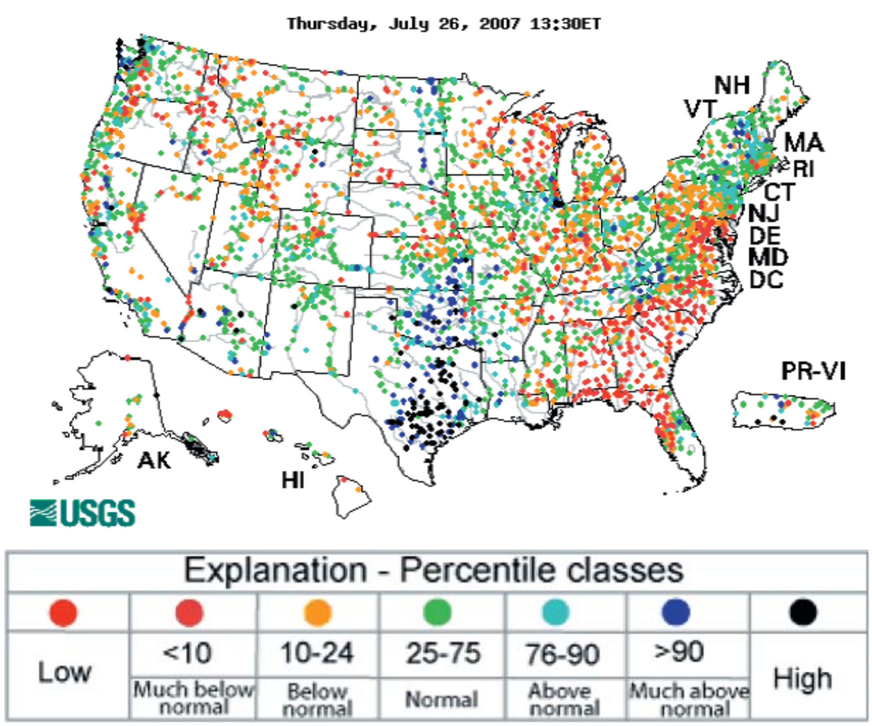


Figure 3-DOI-1. Sample USGS Water Watch map of real-time streamflow compared to historical streamflow for the day of the year. Source: USGS Website (http://water.usgs.gov/waterwatch)

As part of its glaciology program, the USGS maintains an observation program on three benchmark glaciers representative of different climatic zones of the western United States, one in Washington, one on the south coast of Alaska, and one in the interior of Alaska. At each glacier, the program measures the winter snow accumulation, summer snow and ice ablation, air temperature, and runoff in the glacier basin. Beginning in 1959, this is the longest such record in North America. Analysis of this record is providing a greater understanding of the climate variability and its effects on water resources of the western United States. The record clearly shows the effects of changing winter precipitation patterns associated with atmospheric conditions in the northeast Pacific Ocean, including El Niño - La Niña events and the Pacific Decadal Oscillation.

To augment its glacier monitoring efforts, the USGS is using National Systems data to measure fluctuations of glaciers in Alaska, Washington, and Montana. Mountain glaciers are ideal subjects for these systems because they are remote, have an appropriate space scale, and require infrequent but repetitive observations. The observations have established a baseline of regional glacial conditions. The resulting and on-going archive of observations is now 5 years long and is being used to determine recent trends in glacier size and terminus location. In addition, techniques have been developed to generate derived products that provide critical glacial parameters, including DEMs, equilibrium line altitudes, and ablation rates. These products are being incorporated into a glacial runoff model of the South Cascade Glacier, Washington, where they are proving to be a valuable source of otherwise unavailable data.

SNOW AND ICE STUDIES

USGS scientists are cooperating with scientists at the University of Washington, Seattle, to improve hydrologic runoff modeling of the snow pack in the Pacific Northwest through the application of data assimilation techniques. The assimilation uses passive microwave observations from the Advanced Microwave Scanning Radiometer, AMSR-E, and numerical integration of Maxwell's equations constrained by a snow pack model to determine the distribution of snow water equivalent across select drainage basins. Then the UW Variable Infiltration Capacity (VIC) model calculates the subsequent runoff, which is compared to USGS discharge measurements. If the calculated runoff is not within a specified amount of the measured runoff, the assimilation technique adjusts the snowpack characteristics and another iteration is carried out.

USGS, in cooperation with BLM, is using a variety of remote sensing data to monitor the rapid wastage of the piedmont lobe of Bering Glacier, Alaska. Landsat, Radarsat, ICESat, and Ikonos observations show that Bering Glacier is retreating rapidly and thinning in an accelerating retreat from an advanced position that resulted from a major glacial surge in 1993-95. The satellite data and ground-based observations have been combined to determine the surface flow velocities and calving rates of the glacier, and to monitor the expansion of Vitus Lake and Berg Lake, two large lakes whose boundaries include the glacier terminus. The rapid change in glaciation is having a large impact on nearby terrestrial and aquatic ecosystems.

GEOMAGNETIC DATA

The Geomagnetism Program (http://geomag.usgs.gov) of the USGS Central Region Geohazards Team provides real-time, ground-based measurements of the Earth's magnetic field, which are an important contribution to the diagnosis of conditions in the near-Earth space environment of the sun, the solar wind, the magnetosphere, the ionosphere, and the thermosphere. During geomagnetic storms, brought about by the complex interaction of the Earth's magnetic field with that of the Sun's, both high- and low-frequency radio communications can be difficult or impossible, global positioning systems (GPS) can be degraded, satellite electronics can be damaged, satellite drag can be increased, and astronauts and high-altitude pilots can be subjected to enhanced levels of radiation.

Ground-based geomagnetic observatory data are complementary to those collected by space-based satellites; indeed, most of the hazardous effects on technological systems brought about by magnetic storms occur at or near the Earth's surface. Therefore, the Geomagnetism Group monitors the surficial magnetic field by operating 14 magnetic observatories in the United States and its Territories. The data from these observatories, plus 15 foreign observatories, are transmitted to the Group's headquarters in Golden, Colorado, where they are processed and analyzed. Data are then transmitted to the Space Environment Center (SEC) of the National Oceanic and Atmospheric Administration (NOAA) and to the U.S. Air Force's (USAF) Weather Agency at Offutt Air Force Base, Nebraska.

USGS observatories are operated in cooperation with Intermagnet (www.intermagnet.org), an international consortium overseeing the operation of nearly 100 geomagnetic observatories distributed around the globe. The USGS Geomagnetism Program is also an integral part of the National Space Weather Program (http://nswp.gsfc.nasa.gov).

VOLCANOLOGY AND VOLCANIC ASH PLUMES

Through its Volcanic Hazards Program, the USGS is responsible for monitoring volcanoes in the United States and issuing eruption forecasts and notifications. The USGS participates in the Working Group for Volcanic Ash (WG/VA) of the OFCM. This working group is preparing a National Volcanic Ash Operating Plan for Aviation. The purpose of the plan is to provide operational guidance by documenting the required procedures and information products of the government agencies responsible for ensuring safety of flight operations when volcanic ash has been erupted into the atmosphere. The agencies involved are the USGS, Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Air Force. Timeline for completion of the plan is FY08.

The OFCM helps to administer funding from the FAA to the USGS to improve aviation safety through expanded volcano monitoring in Alaska, where many historically active volcanoes underlie the heavily traveled air routes of the North Pacific region. Over the past decade, with FAA support, the USGS's Alaska Volcano Observatory (AVO) has installed seismic networks at approximately two dozen volcanoes in the Aleutian Islands, bringing to 31 the number of Alaska's volcanoes under continuous real-time geophysical surveillance. Data and information from the AVO monitoring activities are integrated directly into the regional operational activities of the FAA, DOD, and NOAA/NWS to provide warnings for pilots and aircraft operators in the Alaskan region.

The U.S. has experienced significant levels of volcanic activity recently. Augustine Volcano, located near Anchorage, Alaska, erupted from January to April 2006, finally settling back into quiescence that summer. AVO mounted a 24/7 monitoring response to characterize ash-cloud hazards to aviation and worked closely with the National Weather Service to provide ash-fall information to the public. AVO also has continued to closely monitor Cleveland volcano in Alaska, which has been erupting intermittently since 2001. Mount St. Helens, Washington, reawakened in September 2004 from 18 years of quiescence. The eruption has largely consisted of the extrusion of lava with activity confined to the summit area. However, occasional explosions have erupted ash to heights as great as 30,000 feet above sea level. USGS, NWS, and FAA have worked together to develop procedures and protocols to handle an erupting volcano situated between two major metropolitan centers.

Recognizing that many potentially dangerous U.S. volcanoes have inadequate or no ground-based monitoring, the USGS recently evaluated U.S. volcano-monitoring capabilities and published *An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for a National Volcano Early Warning System (NVEWS)* (http://pubs.usgs.gov/of/2005/1164/). Results of the NVEWS volcanic threat and monitoring assessment are being used to guide long-term improvements to the national volcano-monitoring infrastructure operated by the USGS and affiliated groups.

The most threatening volcanoes, those near communities and transportation infrastructure (ground and air) and with a history of frequent and violent eruptions, need to be well monitored in real time with an extensive suite of instrument types to detect the earliest symptoms of unrest and to reliably forecast behavior of the volcano. Waiting until unrest escalates to augment monitoring capabilities at these high-threat volcanoes puts people (including scientists in the field) and property at undue risk. Remote, isolated, or less frequently erupting volcanoes that nevertheless can pose hazards to air-traffic corridors require sufficient monitoring capability with ground-based instruments to detect and track unrest in real-time so that other agencies responsible for enroute flight safety can be kept apprised of the potential for explosive, ash-cloud-forming eruptions.

The Volcano Hazards Program has posted pages on its website devoted to practical guidance for dealing with ash hazards to transportation, communications, agriculture, water supplies, etc. See http://volcanoes.usgs.gov/ash.

BUREAU OF LAND MANAGEMENT (BLM)

The BLM is one of five Federal Land Management agencies which have centralized Wildland fire weather operations at the National Interagency Fire Center (NIFC), in Boise, Idaho. The BLM's Initial Attack Management System (IAMS) was designed in the mid-1980's to provide real-time data access and modeling for the fire management organization. The IAMS required a considerable dedicated telecommunications network for data distribution. In an effort to reduce these inherent telecommunications costs, the BLM has moved into a "web server" environment. Many of the capabilities that were centrally located in the old IAMS have been moved to other web sites.

FIRE WEATHER WEB SITES

The principal Wildland Fire Management Information System (WFMIS) inputs remain the same with Remote Automatic Weather Station (RAWS) and National Lightning Detection Network (NLDN) information (Figure 3-DOI-2). BLM's new server system is called the BLM Wildland Fire Management Information Site (www.nifc.blm.gov). Additional fire management information is summarized and made available at the Desert Research Institute (wrcc.dri.edu and cefa.dri.edu) and the United States Forest Service Wildland Fire Assessment System (//svinet2.fs.fed.us /land/wfas/). Additionally, the BLM has utilized the Desert Research Institute's capabilities to respond quickly for website support.

AUTOMATED WEATHER STATIONS

The BLM's RAWS Program primarily collects meteorological data for fire weather forecasting. However, use of BLM's RAWS data set by other non-fire users has generated sufficient funding to permit year-round operation of the entire network. The BLM's Resource Management and Oregon O&C (West-Side) also operate RAWS networks which are much smaller and have specific program requirements that differ from fire management.

LIGHTNING DETECTION

In 1997, the BLM began contracting with a private vendor via the National Weather Service for lightning location data. Data are received at the NIFC in Boise, Idaho, and placed on the BLM WFMIS for qualified user access. Current plans are to continue the operation of the Alaska Automatic Lightning Detection System as an independent government-owed and operated system.

FIRE WEATHER SUPPORT

The BLM's Remote Sensing / Fire Weather Support Unit (RSFWSU) at NIFC provides the full range of program management, equipment dispatch, field and depot maintenance, support and data services for the BLM and numerous other government agencies. This interagency-staffed and funded facility performs work under long term agreements with those agencies within the government having similar equipment and requirements.

CLIMATE MONITORING

In addition to the meteorological monitoring BLM conducts primarily to support wildland fire management activities, the BLM also conducts site-specific climate monitoring at over 200 manual weather station locations on the public lands in the 11 western states and Alaska. The operation of these sites ranges from seasonal to annual, taking measurements of precipitation, temperature, soil moisture, and other meteorological parameters necessary to assess local climactic influences. These data are primarily used for natural resources management and planning at the local level.

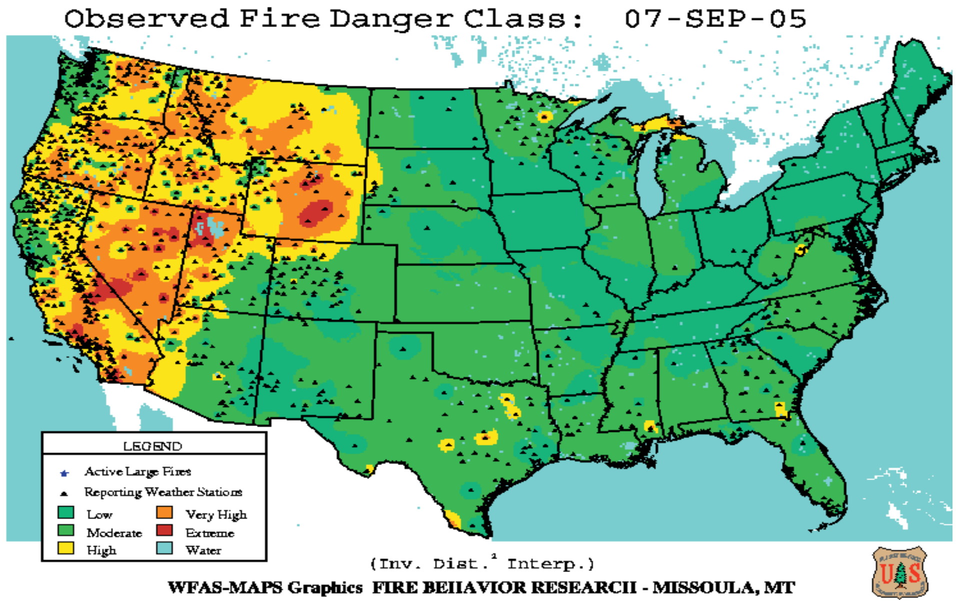


Figure 3-DOI-2. A National Interagency Coordination Center (NICC) graphic of Observed Fire Danger Class for the lower 48 states.

PORTABLE WEATHER STATIONS

During the 1999 fire season, the Remote Sensing/Fire Weather Support Unit began a 2-year "proof of concept" effort with a portable weather station referred to as the Fire RAWS (FRWS). FRWS are intended for use on or near a fire line and can be rapidly relocated to points desired by Fire Behavior Analysts for real-time weather data. Due to the extreme fire season in both 1999 and 2000, the FRWS was used extensively and was found to be a valuable asset for firefighter safety and fire weather forecasting. Fire managers have also increased the use of FRWS to monitor intentionally-initiated prescribed burns.

Currently, 42 FRWS systems are cached at NIFC. FRWS collect, store, and forward data by interrogated voice radio with new data available every fifteen minutes. Satellite data can be retrieved from multiple websites, and hourly satellite data is available to Fire Weather Forecasting Staff for spot forecasts and fire support from all central locations (Geographic Area Coordination Centers, NIFC, etc.).

ALL RISKS SUPPORT

After the terrorist attack on September 11th, 2001, the RSFWSU was tasked to provide near real-time meteorological data collection at the World Trade Center (Figure 3-DOI-3). This effort was in direct support of the Environmental Protection Agency's task of monitoring air quality in the vicinity of the collapsed towers. The unit also provided remote meteorological support for the Columbia Shuttle accident investigation and Hurricane Katrina recovery efforts. Using the personnel and resources available at the RSFWSU, the BLM offers a rapid meteorological support capability that is unique across the Federal government.

BUREAU OF INDIAN AFFAIRS (BIA)

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the

Figure 3-DOI-3. Remote Sensing/Fire Weather Support Unit providing near-real-time meteorological data collection at the World Trade Center.

Southwest. The Bureau also collects and shares fire weather data with other Federal agencies while participating in fire management activities for local and interagency use.

Currently, BIA operates the following instrumentation:

- 69 fire weather RAWS stations (permanent stations)
- 5 "manual" weather stations
- 13 portable RAWS stations used for Prescribed Fire
- 10 RAWS deployed on emergency stabilization projects.

MINERALS MANAGEMENT SERVICE (MMS)

The Minerals Management Service (MMS) gathers offshore meteorological data for use in the management of offshore oil and gas resources and sources of alternative energy. The data are used in air quality and oil-spill modeling, model development, and other research projects.

MMS operates a radar wind profiler (RWP) at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, Louisiana (Figure 3-DOI-4). Data collected at this site may be accessed at http://weather.lumcon.edu/weather-data/doppler. The data will be applied to regional models for evaluating impacts from emission sources on ozone, fine particulate matter, and regional haze. The Service, in a cooperative agreement with The University of Houston (UH), operates an RWP at the UH Coastal Research Center (UHCRC) near Galveston, TX. The profiler will collect data for three years through FY 09.

The MMS has completed a meteorological and air quality modeling analysis in and around the Breton National Wilderness Area (NWA), which is a PSD Class I area located off southeastern Louisiana. MMS is currently sponsoring the operation of a visibility monitoring station near the Breton NWA IMPROVE site. The objective is to study the relationships between visibility, haze, ozone, PM2.5, dew point depression, and mixing height and to determine the source region(s) for haze, haze precursors, resulting is low visibility conditions near the Breton Island NWA. The study will utilize two additional visibility monitors operated by the Coastal Marine Institute (CMI) at Louisiana State University (LSU). Satellite data will be collected to measure optical depth and to determine source regions of atmospheric pollutants. This project should be completed sometime in FY 08.

Other ongoing studies in the Gulf of Mexico include (1) an effort to evaluate the effects of ozone deposition/chemical mechanism enhancements on air quality model performance over the coastal marine environment and (2) a study to evaluate of the effects of satellite data assimilation on meteorological/air quality model performance. Copies of all final reports in past meteorological and air quality studies in the Gulf of Mexico may be found at http://www.gomr.mms.gov/homepg/regulate/environ/techsumm/rec_pubs.html.

A meteorological data collection effort was conducted by MMS along the Beaufort Sea shoreline in Alaska; five meteorological stations collected data starting in 2001 (see http://www.resdat.com/mms/). Four of these stations will still be operating in FY 08 through an interagency cooperative program. The Service is analyz-

Figure 3-DOI-4. The MMS Profiler at LUMCON facility in Cocodrie, Louisiana.

ing the data gathered by these stations and will develop a mesoscale meteorological model for predicting ocean and ice circulation.

Another ongoing study in Alaska is an effort to develop an atmospheric modeling capability for the Cook Inlet/Shelikof region suitable for nowcast/forecast and research purposes. Among the objectives of this project is to develop an understanding of the mechanisms which drive low-level wind jets in the region, describe the vertical and thermal structure of wind jets, and study the cloud fields and precipitation associated with high wind events in the region. For more information on the MMS Alaska Region Studies Program see http://www.mms.gov/alaska/ess/index.htm.

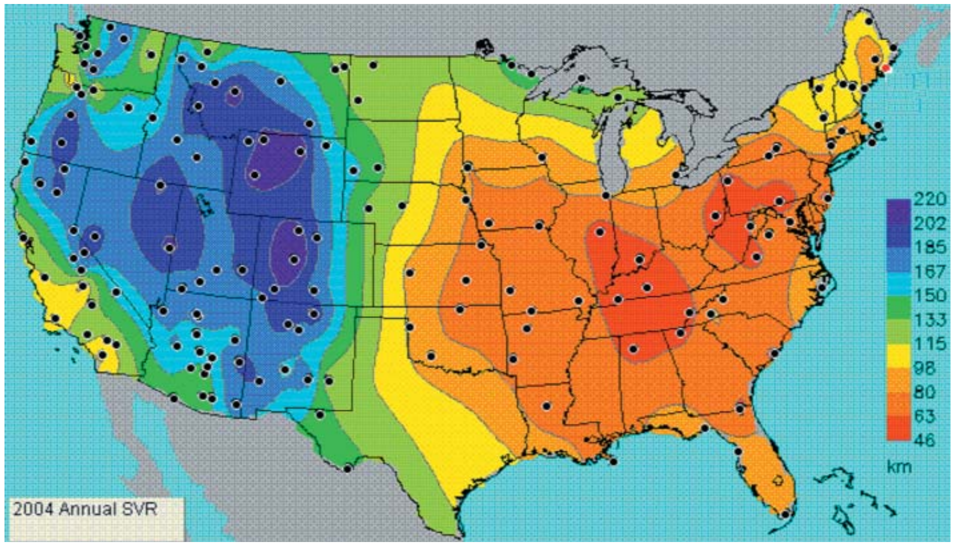


Figure 3-DOI-5. Map of annual average standard visual range (SVR), in kilometers, calculated from IMPROVE particle concentrations. Also shown are the locations of most of the IMPROVE and IMPROVE protocol sites. (http://vista.circa.colostate.edu/views).

NATIONAL PARK SERVICE (NPS) AND FISH AND WILDLIFE SERVICE (FWS)

The National Park Service monitors air quality and visibility in a number of national parks and monuments. Gaseous pollutant data are collected on continuous and integrated (24-hour to weekly) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four-hour-average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured every third day. Atmospheric light extinction is measured continuously and relayed to a central location for analyses.

MODELING

The NPS also conducts and contracts research to develop and test air quality models to assess long-range transport, chemical transformation, and deposition of air pollutants. These models are used to estimate source contributions to, and to identify source regions responsible for, observed pollutant loadings.

JOINT MONITORING AND RESEARCH

The Fish and Wildlife Service Air Quality Branch and the NPS Air Resources Division operate under an interagency agreement and are collocated in Lakewood, Colorado. Expertise from both agencies is pooled to address the air quality issues that are the responsibility of the Assistant Secretary of the Interior for Fish and Wildlife and Parks.

The NPS oversees the operation of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the IMPROVE Protocol network in cooperation with the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the United States Forest Service (USFS), the FWS, the BLM, and various State organizations. Currently, the network has about 170 sites, mostly funded by the EPA in support of their regional haze regulations and through other cooperators. The enhanced network allows a better characterization of visibility and fine particle concentrations throughout rural and remote areas of the country (Figure 3-DOI-5).

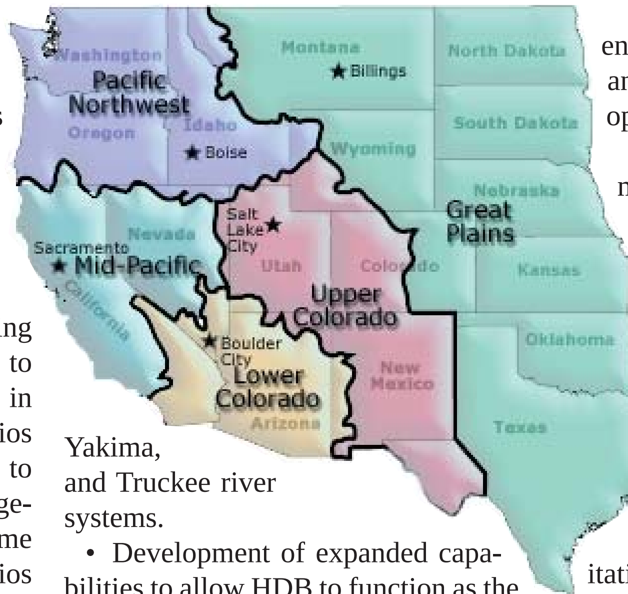
BUREAU OF RECLAMATION

The Bureau of Reclamation (Reclamation) activities requiring the collection and use of meteorological data include water supply forecasting, snowpack water equivalent assessment, river system management, reservoir operations, irrigation scheduling, drought status assessment, flood hydrology, and projects related to hydroelectric energy resources. One example of such an ongoing activity is the Watershed and River System Management Program (WaRSMP), which is being developed in partnership with the USGS. Information on WaRSMP is at http://www.usbr.gov/pmts/rivers/rsmgwtrmg.htm.

Other key players in this effort include TVA, the Corps of Engineers, NOAA, NASA, NRCS, the University of Colorado and Colorado State University. This program provides a data-centered framework for science-based water resources decision making. Major components are:

- Hydrologic Database (HDB),

• Modular Modeling System (MMS),
• RiverWare river system modeling framework,
• Stochastic Analysis, Modeling and Simulation (SAMS) system,
• Agricultural WAter Resources Decision Support (AWARDS) and
• Evapotranspiration Toolbox (ET Toolbox) system.



HYDROLOGIC MODELING

The SAMS hydrologic modeling system is being used in WaRSMP to assist water resource managers in developing likely hydrologic scenarios for water supplies. It allows users to test various water resources management strategies, including extreme drought and high-flow scenarios which haven't been encountered in the historical period of record.

The RiverWare and HDB data-centered decision support system enables water managers to examine a variety of observed and forecast hydrologic scenarios using hourly, daily, or monthly data within the legal and physical constraints on operations of the river system. This model provides a holistic management tool for watershed and river systems, in order to meet a variety of competing demands for water.

Each new river system requires considerable development work (2-3 years) for RiverWare and HDB implementation. However, such a system can provide for efficient water operations management, and is especially useful during periods of drought and surplus - as demonstrated by the recent *Colorado River Interim Surplus Criteria: Final Environmental Impact Statement*.

Current Reclamation projects under WaRSMP include:

• Planning and developing HDB, MMS and RiverWare systems for the Gunnison, San Juan, Rio Grande, Yakima, and Truckee river systems.

• Development of expanded capabilities to allow HDB to function as the Database of Record which will document management decisions and the data used to make them for Reclamation's Upper and Lower Colorado regions as well as other participating offices.

• SAMS integration and testing for the lower Colorado and Truckee River Basins.

• Implementing AWARDS systems to improve the efficiency of water management and irrigation scheduling for the Tualatin Project, Upper Columbia project areas, and Lower Colorado area.

• Developing the AWARDS/ET Toolbox system in the Middle Rio Grande and providing 24-hour water use estimates for input, via the Corps of Engineers' Hydrologic Engineering Center Decision Support System or a new HDB, to the Rio Grande RiverWare.

• Implementing similar AWARDS/ET Toolbox systems with input to local HDBs and RiverWare systems in the Upper Columbia, Lower Colorado, and possibly the Truckee-Carson areas.

• Integration and testing of emerging Land Surface Modeling Products from NASA's Global Land Data Assimilation Systems for snow mapping, surface energy and water budgets and ET analysis and prediction for water operations management.

• Testing and development of weather and climate products from the Global Energy and Water Cycle Experiment (GEWEX) for water supply and demand forecasting.

INSTRUMENTATION AND DATA ACQUISITION

NEXRAD estimates of precipitation are used for water supply and water delivery decision-making. Water managers can view the distribution of precipitation over watersheds that supply water to storage facilities, and examine the detailed spatial distributions of precipitation over the irrigated areas along with estimates of soil moisture, and evapotranspiration from crops and riparian vegetation.

The Watershed and River Systems Management Program focuses on integrating multi-disciplinary science into decision support systems that enable water managers to make the best deliveries of water to stakeholders.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in real-time through GOES to Reclamation's DRGS in Boise, Idaho. AGRIMET is another network of 60 DCPs dedicated to analysis of crop water use and water conservation in the Pacific Northwest.

Data collected and products created in Boise are electronically transferred to other BLM, Federal and state offices. Reclamation's primary real-time hydrometeorological information from the NWS, USGS, NASA, and other agencies is displayed on the AWARDS / NEXRAD / ET Toolbox web site: http://www.usbr.gov /pmts/rivers/awards/index.html

Water supply information from cumulative precipitation estimates from radar is also provided in areas where snowfall is an important source of water. Links directly to USDA Natural Resources Conservation Service and NOAA/National Centers for Environmental Prediction analysis and forecasting web sites are provided to further document the latest information.

TECHNICAL INFORMATION

The National Xeriscape Demonstration Program (NXDP) is nearing an end. The NXDP was initiated by Reclamation to estimate the benefits of water conserving landscaping. In partnerships with States, field demonstration projects were conducted in Fargo ND, Austin TX, the Colorado Front Range, Phoenix AZ, and southern Nevada. Water savings ranged from 18 to over 50 percent in the demonstration projects, strongly suggesting water planners should consider this water conservation alternative as a supply development option.

SNOWPACK ASSESSMENT

Snowmelt represents about 80 percent of reservoir storage in Colorado and is largely responsible for spring flooding events in the state. Therefore it is highly desirable to know snowpack characteristics, such as its snow water equivalent (SWE), its spatial and elevation distribution, and its evolution with time during the water year. With support of the Colorado Water Conservation Board (CWCB), Reclamation has adapted the Snow Data Assimilation System (SNODAS) for enhanced snowpack assessment in the state of Colorado. The SNODAS was developed by the National Operational Hydrologic Remote Sensing Center (NOHRSC), a National Weather Service unit, and data are acquired through the National Snow and Ice Data Center.

SNODAS consists of a spatially distributed snow energy and mass balance model, coupled with an assimilation of all available SWE, snow depth, and snow cover data (from surface, aircraft, radar, satellite). Model outputs are at 1 km resolution and include SWE, snow depth, snowmelt, pack temperature, and sublimation. Comparison with data from Snow Telemetry (SNOTEL) sites and satellite imagery shows faithful representation of SWE and snow cover, respectively. Basin average SWE is substantially reduced over that of SNOTEL because the former is a basin-wide spatial average instead of an arithmetic average of a few high-elevation points. This difference is important hydrologically and holds the promise of coupling snowmelt with a hydrologic model to produce streamflow hydrographs. Such hydrographs would be extremely useful to the decision support systems of water management agencies such as the CWCB and Reclamation, with the ultimate aim of improved forecasting of water supplies and flooding. Colorado SNODAS products have been posted daily at http://www.usbr.gov/pmts/rivers/awards/SNODAS/SNODAS_CO_hist.html since October 2003. Future work will consist of verification of SNODAS outputs, improvement of precipitation inputs, and coupling to a hydrologic model. An example of such an online product is given by Figure 3-DOI-6.

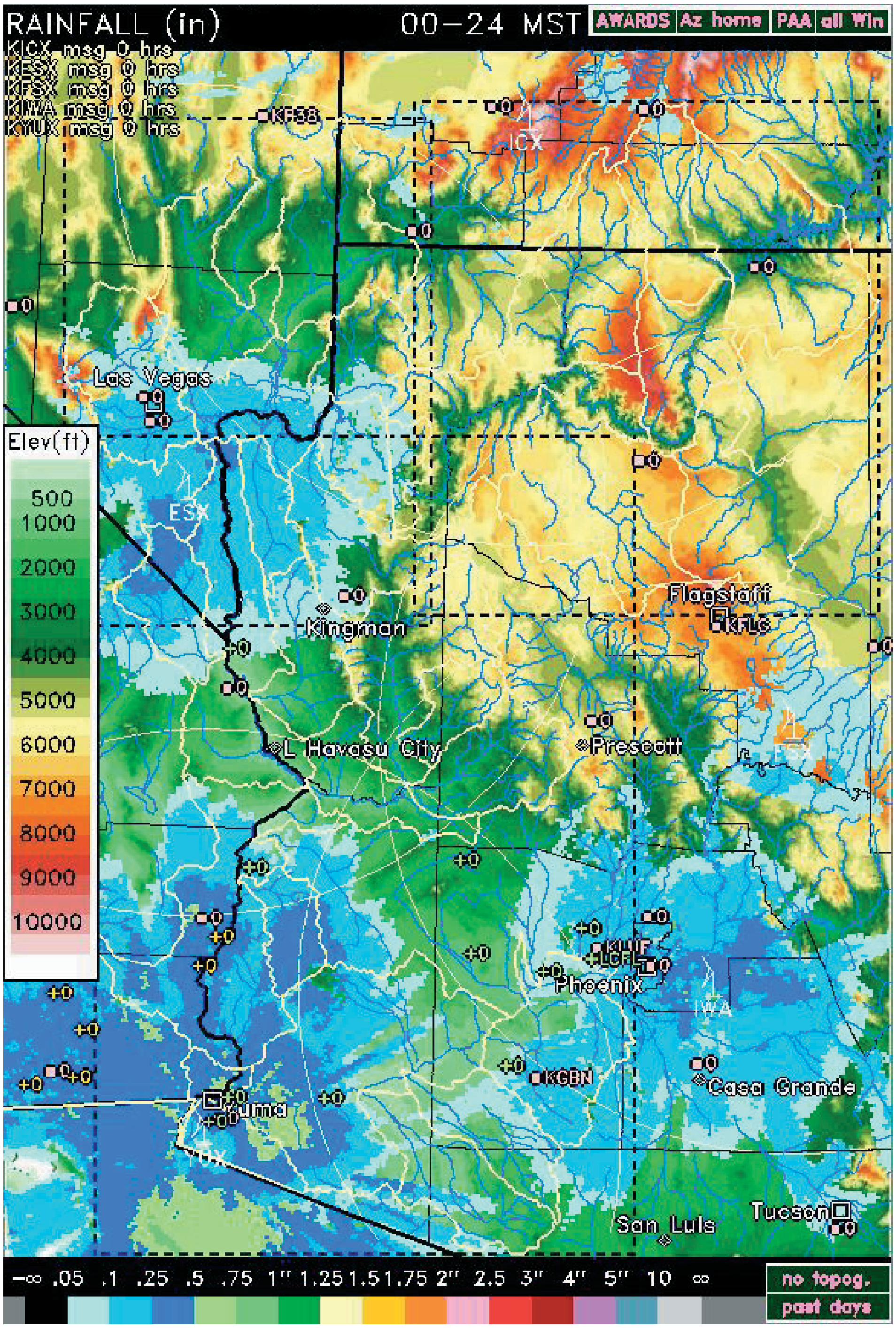


Figure 3-DOI-6. Agricultural Water Resources Decision-Support (AWARDS)/ET Toolbox example for the Lower Colorado River basin. AWARDS merges the precipitation accumulation algorithm (PAA) estimates from five WSR-88D (or NEXRAD) radars into a 2x2km grid.

DEPARTMENT OF STATE CLIMATE AND ATMOSPHERIC PROGRAMS

The Department of State (DOS) plays an active role in international climate/meteorological policy making as a result of the growing worldwide concern with global environmental issues, including the depletion of the stratospheric ozone layer and climate change. The role of DOS has principally revolved around preparation and negotiation of the United States position in three fora: (1) the Conference of the Parties to the Vienna Convention and its Montreal Protocol on Substances that Deplete the Ozone Layer, (2) the Intergovernmental Panel on Climate Change (IPCC); and (3) negotiation under the United Nations Framework Convention on Climate Change (FCCC). In addition, over the past few years the DOS has played a central and active role in the development and implementation of a number of international science and technology initiatives including the Group on Earth Observations, the Carbon Sequestration Leadership Forum, the International Partnership for the Hydrogen Economy, the Methane-to-Markets Partnership, and Generation IV (a U.S.-led program working on new fission reactor designs that will be safer, more economical and secure).

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Stratospheric ozone depletion has been recognized as a critical health and environmental problem for more than a decade. Under DOS leadership, the United States worked to negotiate international agreements to phase out ozone-depleting substances, which should lead to a recovery of the ozone layer in the next century. To date, these treaties have been signed and ratified by more than 170 countries (including the United States). These countries represent 99 percent of the world's production of ozone depleting substances.

The Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), held its first session in 1988. This organization serves as a government forum to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.. In doing so, the Panel draws on the expertise of thousands of scientists and technical experts. The IPCC is currently organized into three working groups, which examine (1) the state of the science, (2) impacts and adaptation, and (3) mitigation. The IPCC released its first and second assessment reports in 1990 and 1995, respectively, and a third assessment report from each of the working groups was published in 2001. The fourth assessment report, due in 2007, is currently under preparation. In addition to preparing assessment reports, the IPCC also contributes to international negotiations through preparation and review of special reports and development of methodologies requested by the Framework Convention on Climate Change (FCCC).

The FCCC was negotiated beginning in February 1991; the Convention was open for signature in Rio de Janeiro at the Earth Summit in June 1992. As of May 2004, it had been ratified by 189 countries, including the United States. The ultimate objective of the Convention is to stabilize greenhouse gas emissions at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. It states that such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner. The Convention calls for all countries to develop inventories of their emissions and sinks of greenhouse gases and calls upon developed countries and economies in transition to aim to return these emissions to their 1990-levels by the year 2000.

In December 1997, Parties to the

Convention adopted the Kyoto Protocol, which commits developed countries to reducing their collective emissions of greenhouse gases by at least 5 percent by the period 2008-2012. Following Russian ratification in late 2004, the Kyoto Protocol entered into force in February 2005. In early 2001, the United States had announced that it would not ratify the Kyoto Protocol. The U.S. approach to addressing the challenge of climate change harnesses the power of markets and technological innovation. It also holds the promise of a new partnership with the developing world and it recognizes that climate change is a complex, long-term challenge that will require a sustained effort over many generations. Today the United States is actively engaged in addressing climate change through the Convention, through a wide range of international science and technology initiatives, through multilateral efforts such as the Asia-Pacific Partnership for Clean Development and Climate and bilateral partnerships with 15 countries including Australia, Brazil, Canada, China, India, Italy, Japan, and other countries. Together these initiatives will help improve our global capability to understand and address issues associated with climate change in a manner that supports broader sustainable development goals.

In addition to its primary role in the fora listed above, DOS is active in several relevant interagency processes, including the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council and the Interagency Working Group on Climate Change Science and Technology (IWGCCST). The CENR was established in 1993 to coordinate scientific domestic programs. Created in 2002, the IWGCCST is a sub-Cabinet level group that reviews all programs that contribute to climate change science and technology.

Furthermore, while the emphasis on global environmental issues is a key new component of the department's focus, traditional DOS responsibilities, described in earlier Federal plans, continue. These include, but are not limited to, international aspects of food policy, disaster warnings and assistance, WMO and UNEP activities, and international meteorological programs.

ENVIRONMENTAL PROTECTION AGENCY WEATHER PROGRAMS

Environmental Protection Agency (EPA) is responsible for working with state, local, and other Federal government agencies to provide user-appropriate and scientifically-credible air quality and meteorological programs to support regulatory applications. Applied research and meteorological support are furnished primarily by EPA's National Exposure Research Laboratory and EPA's Office of Air Quality Planning and Standards, both located in Research Triangle Park, North Carolina. This activity is provided through interagency agreements with the National Oceanic and Atmospheric Administration (NOAA), which assigns approximately 50 research meteorologists to the EPA.

Meteorological support to EPA's Office of Research and Development, EPA's Office of Air and Radiation, EPA Regional Offices, and to state and local agencies includes:

- Development and application of air quality models for pollution control, direct and indirect exposure assessments, and emission control strategy assessment;
- Preparation and performance of dispersion studies and air quality model evaluations;
- Review of meteorological aspects of environmental impact statements, state implementation plans, and pollution variance requests;
- Air quality forecasting; and
- Emergency response planning in support of homeland security.

Meteorological expertise and guidance are also provided for the national air quality standards, modeling guideline, and policy development activities of the EPA.

In light of the 1990 Amendments to the Clean Air Act and the recent national rules, air quality models and the manner in which they are used are expected to continue to grow over the next few years. In the area of pollutant deposition, the evaluation of nitrogen, oxidant, sulfur and aerosol chemistries will help to clarify the roles of model formulation, cloud processes, aerosols, radiative transfer, and air/surface exchanges in air quality model predictions, leading to a better understanding of model predictions relative to control strategy assessments. Further development and evaluation of existing air quality models will take place to accommodate the inter-pollutant effects resulting from the variety of control programs that are now or may be in place, such as the new National Ambient Air Quality Standards for ozone and particulate pollution. These inter-pollutant effects include trade-offs among controls on ozone, sulfur oxides, nitrogen oxides, and volatile organic compounds, as well as developing predictable methods of forecasting the impacts on various measures of air quality.

With respect to the fine particulate model development, air quality models are being enhanced to accurately predict aerosol growth from precursors over local and regional transport distances. To assist in the evaluation of the contribution of various sources to regional air degradation, inert tracer and tagged species numerical models have been developed. These models will introduce separate calculations for inert or reactive chemical species emitted from a particular source or region. The calculations will proceed to simulate transport and transformation to a receptor point, where the contribution of emission sources can be discerned.

Atmospheric research is the area of the effects of climate change on regional air quality involves both analytical and statistical climatology as well as support for regional-scale climate model development.

Research in human exposure modeling includes micro-environmental monitoring and modeling, and development of exposure assessment tools. Micro-environmental algorithms are being developed based on field data to predict air quality in buildings, attached garages, and street canyons. These improved algorithms are then incorporated into micro-environmental simulation models for conducting human exposure assessments within enclosed spaces in which specific human activities occur.

In addition to the above major areas, dispersion models for inert, reactive and toxic pollutants are under development and evaluation on all temporal and spatial scales, e.g., indoor, urban, complex terrain, mesoscale, regional, and global. Other efforts include modeling nutrient deposition to Chesapeake Bay and mercury deposition to the Florida Everglades; and determination of meteorological effects on air quality. Atmospheric flow and dispersion experimental data obtained from wind tunnel and convection tank experiments in the EPA Fluid Modeling Facility will be used to continue development and evaluation of these models along with providing researchers with insight into the basic physical processes that affect pollutant dispersion around natural and man-made obstacles. For example, the transport and dispersion of airborne agents in the Manhattan, New York area were simulated in the wind tunnel to evaluate Computational Fluid Dynamics modeling systems in an effort to help build confidence in mod-

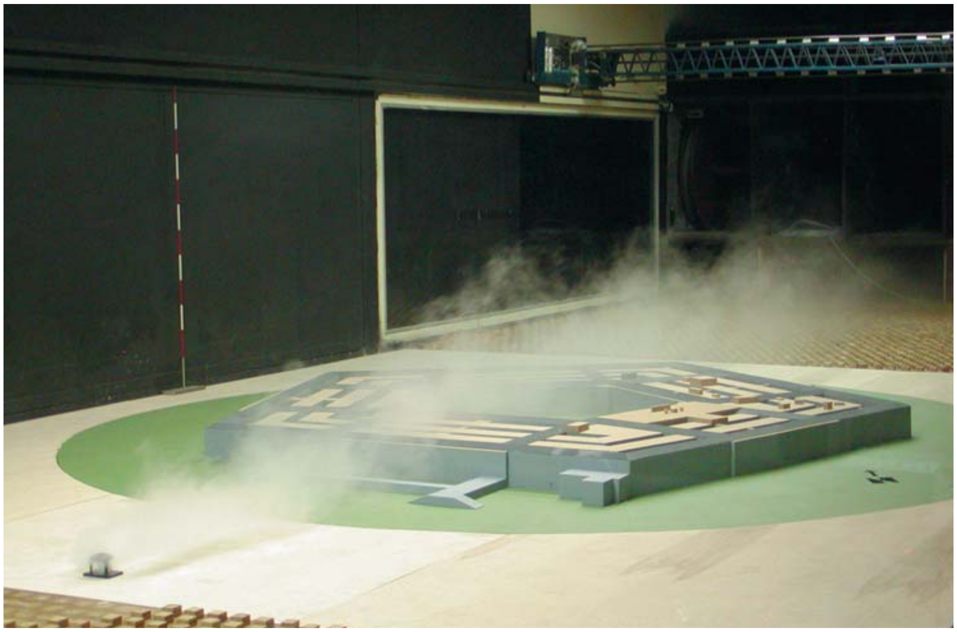


Figure 3-EPA-1. Model of the Pentagon used in the wind tunnel of the Fluid Modeling Facility to study the transport and dispersion of airborne agents.

eling assessment source-receptor relationships for horrific events such as the one that occurred on September 11, 2001 A similar study was conducted for the Pentagon (Figure 3-EPA-1) and will be conducted for the Washington, DC area.

Over the past twenty-five years, numerous air quality simulation models have been developed to estimate reductions in ambient air pollutant concentrations resulting from potential emission control strategies. Separate models were developed, for example, for tropospheric ozone and photochemical smog, for acid deposition, and for fine particles. Distinct models also existed for addressing urban scale problems and the larger regional scale problems. It has been recognized, however, that the various pollutant regimes are closely linked chemically, spatially/temporally in the atmosphere. The principal purpose of the Community Multi-scale Air Quality (CMAQ) modeling project was to develop a "one atmosphere" flexible environmental modeling tool that integrates the major atmospheric pollution regimes in a multi-scale, multi-pollutant modeling system. This system will enable high-level computational access to both scientific and air quality management users for socio-economic applications in community health assessments and ecosystem sustainability studies.

After seven years of development, the Models-3/CMAQ was first released in June 1998, and is being updated annually for use by Federal and state agencies, industry, and academia. The latest version of CMAQ, which includes science enhancements and computational efficiencies, was released in September 2006. It is also intended to serve as a community framework for continual advancement and use of environmental assessment tools. CMAQ, configured for the Windows-NT computer system, is available on tapes from the National Technical Information Service (NTIS). It is accompanied by an Installation and Operations Manual, a User Manual, a Science Document, and a tutorial providing step by step instructions for use of the modeling capabilities. Additional information is available at the Models-3 web site at http://www.epa.gov/asmdnerl/models3/. Figure 3-EPA-2 illustrates the results of CMAQ for ozone and fine particulate matter (PM2.5), sulfates, and visibility for August 8, 2001, for the contiguous U.S. at 36-km horizontal grid dimension, a period of widespread ambient pollution in the nation.

In FY 2005, EPA worked closely with the National Center for Environmental Prediction of the National Weather Service (NWS) in the continued development, evaluation, and use of a coupled meteorological-chemical transport model (WRF-CMAQ) for predicting ambient air quality over the Continental U.S.. This capability is built on years of research in air quality, exemplified by the NOAA-led New England Pilot Air Quality Study in 2002 and 2004. In the first phase of the forecasting project, NWS implemented the Eta-CMAQ modeling system, to provide daily forecast guidance for ozone for the northeastern U.S. starting from September 2004. Within the next few years, the system for ozone will deploy nationwide. Within ten years, the operational forecast capability is projected to be able to forecast particulate matter. State and local air quality management agencies will continue to forecast local air quality, assisted in their efforts by the addition of national forecast guidance for the concentrations of ozone and other air pollutants.

EPA participation in the interagency Information Technology Research and Development (IT R&D) Program is developing a modeling framework that supports integration of diverse models (e.g, atmospheric, land surface, and watershed) as part of EPA's Multimedia Integrated Modeling System (MIMS) project, described at http://www.epa.gov/asmdnerl/mims/. EPA's IT R&D work also enables increased efficiency in air quality meteorological modeling through research on parallel implementation of the CMAQ modeling system. The evolving MIMS research seeks to improve the environmental manage-

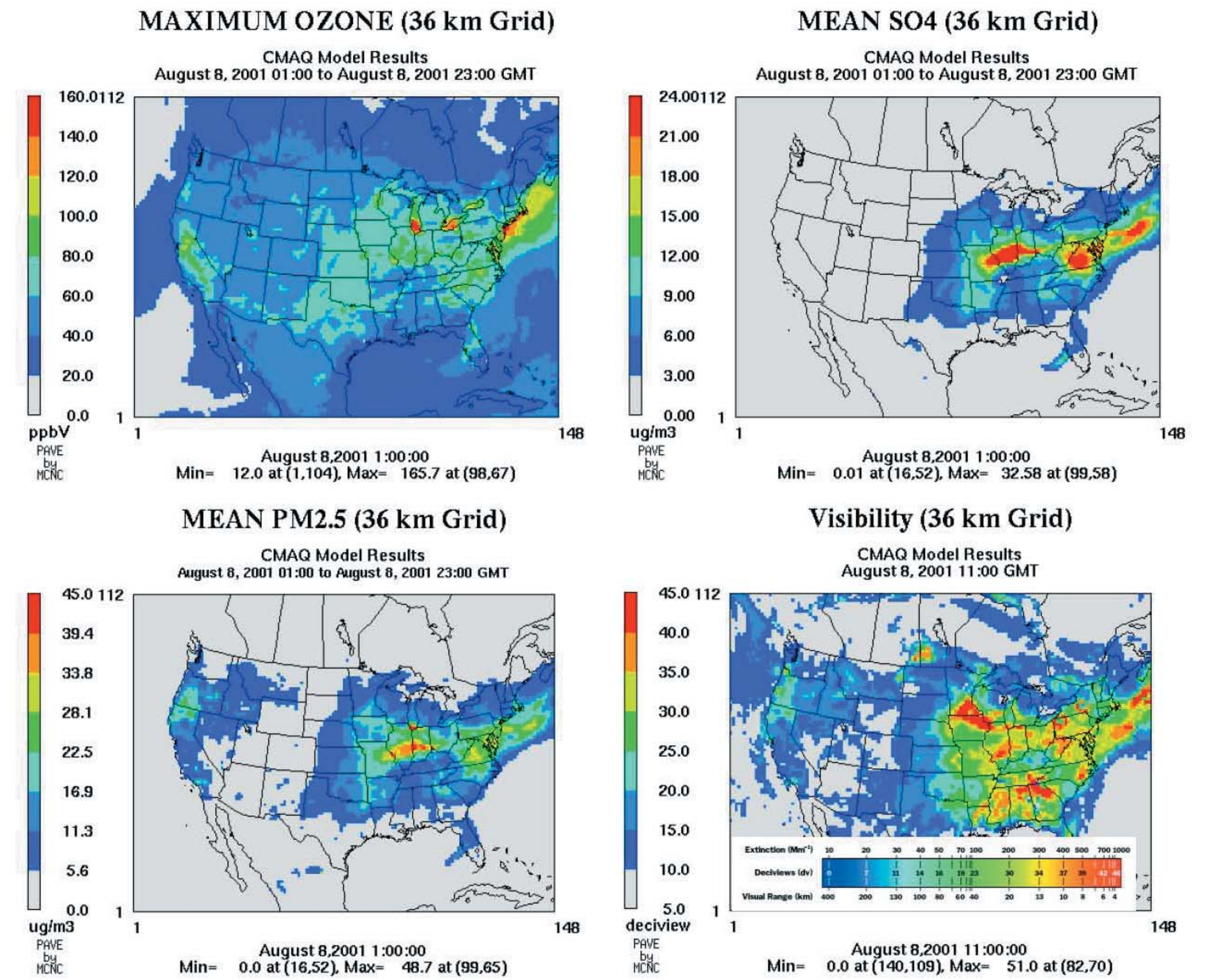


Figure 3-EPA-2. CMAQ simulation results for August 8, 2001, for the contiguous U.S. at 36-km horizontal grid spacing showing: (upper left) maximum 1-hour average ozone concentrations (ppbV) in each grid cell; (upper right) 24-hour averages of sulfate concentrations (micrograms/m3); (lower left) 24-hour averages of PM2.5 concentrations (micrograms/m3) in each 36-km grid cell; and (lower right) visibility (deciview - see insert) in each grid cell.

ment community's ability to evaluate the impact of air quality and watershed management practices, at multiple scales, on stream and estuarine conditions. Toward this goal the primary objectives include:

• Developing a prototype multiscale integrated modeling system with predictive meteorological capability for transport and fate of nutrients and chemical stressors;

• Enabling the use of remotely sensed meteorological data; and

• developing a computer-based problem solving environment with ready access to data, models, and integrated visualization and analysis tools for water and air quality management, local and regional development planning, and exposure-risk assessments. Under the MIMS project, a variety of research areas are being pursued such as the integration of the National Weather Service Next Generation Radar (NEXRAD) Stage IV data into watershed modeling applications; enhanced atmospheric dry deposition models; multi-scale, spatially explicit watershed modeling tools; and model-coupling technology for integrating media specific models. The MIMS development extends the open architecture approach demonstrated in the third generation modeling system, CMAQ, and is the next generation of modeling frameworks under the IT R&D program.

EPA also maintains relations with foreign countries to facilitate exchange of research meteorologists and research results pertaining to meteorological aspects of air pollution. For example, agreements are currently in place with Canada, Greece, Japan, Korea, China, India, and Mexico, and with several European countries under the NATO Committee on the Challenges of Modern Society (CCMS).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WEATHER PROGRAMS

The National Aeronautics and Space Administration (NASA) Headquarters Weather Support Office has continued to improve NASA's weather support capabilities for both manned and unmanned space launch vehicles. It is expected that these improvements will strengthen and enhance the information provided to the ground-based decision makers and astronaut observers to insure that NASA achieves the best operational posture for Space Shuttle launches and landings. The goal of the operations program is to provide the specialized meteorological data needed by operational forecasters at the Kennedy Space Center (KSC) and Johnson Space Center (JSC). NASA also maintains a sophisticated fleet of eighteen Earth-monitoring satellites, measuring a vast number of Earth properties. The focus of Earth Science Research is to integrate satellite observations, numerical model and theoretical studies of various Earth system attributes. These attributes include ocean currents, temperature and biological activity; atmospheric ozone and aerosols; tropical rainfall, lightning; atmospheric temperature and humidity structure; Antarctic and Arctic sea ice; volcanic emissions and gravitational anomalies in the Earth's crust. NASA also performs aviation research to improve safety, develop weather information technologies, and increase aviation system capacity. Advanced operations technologies can increase the number of operations per runway in all weather conditions. The research applies to both commercial and general aviation.

OPERATIONS

BACKGROUND

The goal of the National Aeronautics and Space Administration (NASA) weather operations program is to provide specialized meteorological data and techniques needed by Air Force forecasters at Cape Canaveral Air Force Station (CCAFS), adjacent to Kennedy Space Center (KSC); by the NWS' Spaceflight Meteorology Group (SMG) at Johnson Space Center (JSC); and by MSFC Natural Environments Branch to support NASA's Space Shuttle and Expendable Launch Vehicle (ELV) programs. The greatest challenge is to accurately measure and forecast the mesoscale weather events that strongly impact ground processing, launch, and landing operations. To successfully support the diverse, unique and complex requirements of the many customers' 24/7 operations, in the mesoscale driven lightning capital of America, requires:

1. A sophisticated weather infrastructure which includes systems normally found only in research field programs rather than operations;

2. A dedicated capability to transition research and technology to support new or poorly satisfied operational requirements;

3. Rigorous training to ensure the weather infrastructure, diverse customer requirements, and dynamic, mesoscale weather are thoroughly understood; and

4. At least 2-3 years on-site experience to adequately master the infrastructure, the weather, and the requirements to provide timely, tailored, accurate support to NASA's many weather sensitive daily operations.

The KSC Weather Office is also responsible for ensuring the weather support for NASA missions aboard Expendable Launch Vehicles meets requirements. Thus, if NASA launches a payload on an ELV from Vandenberg AFB (VAFB) (Western Range) or from the Kodiak, AK Launch Complex (KLC), or from Wallops Flight Facility, the Weather Office coordinates with the local weather support agency, such as 30th Weather Squadron at VAFB, to ensure the unit understands NASA's requirements and has the infrastructure and skilled forecasters to satisfy them. For instance, KLC had neither, thus the KSC Weather Office determined the requirements and coordinated the procurement, installation and testing of needed sensors; and identified a skilled 45WS Launch Weather Officer to provide on scene support during ground processing and launch operations.

The most vexing, unsolved atmospheric problem for space launches and landings is *triggered* lightning. Today's spacecraft, payloads, and flight termination systems are insufficiently protected from the damaging impacts of direct or nearby lightning strikes. Unfortunately when the spacecraft penetrates even a weak electric field it can trigger lightning strikes which would not have otherwise occurred, especially during launch while trailing a long ionized plume. Also unfortunately, we've been unable to identify a method to directly and cost effectively measure the electric field aloft with sufficient spatial and temporal resolution. Thus to assess the threat of triggered lightning we must infer whether the electric field aloft is sufficient to trigger a strike based on a very complex and restrictive set of meteorological conditions such as cloud thicknesses and temperature levels, radar reflectivity, surface based field mills, etc. Weather is responsible for 50 percent of all launch scrubs from the Eastern Range and KSC, and triggered lightning constraints are the leading weather impact by far.

Triggered lightning is a threat no matter where vehicles are launched, even at locations with little or no natural lightning such as Vandenberg AFB, CA and Kodiak, AK - all that's needed is a weak electric field aloft. Thus research into triggered lightning and the impact of launch vehicles on weak electric fields significantly benefits the entire Space Program

APPLIED METEOROLOGY UNIT

The focal point for satisfying the launch support requirements is the Applied Meteorology Unit (AMU). The AMU, co-located with the Air Force's Range Weather Operations at CCAFS, develops, evaluates and, if warranted, transitions new meteorological technology into operations. For instance, the AMU strives to develop techniques and systems to help predict and avoid the impacts of Central Florida's frequent thunderstorms which endanger the ground processing, launch, and landing operations of the American Space Program - Space Shuttle, DOD, and commercial. The AMU has focused special attention on evaluating and transitioning mesoscale numerical models, and developing forecast techniques applicable to Central Florida. The AMU functions under a joint NASA, Air Force, and National Weather Service (NWS) Memorandum of Understanding.

KSC RESEARCH AREAS

LIGHTNING RESEARCH

<u>Lightning Launch Commit Criteria (LLCC) [Airborne Field Mill (ABFM)] Program</u>

The Weather Office continued to direct the analysis of data gathering from KSC's major field research program called the Lightning Launch Commit Criteria (LLCC) program. The LLCC program used an aircraft equipped with field mills and cloud physics sensors, in combination with several ground based radars and other sensors, to collect the data necessary to relax the lightning launch constraints while making them even safer. LLCC was cooperatively funded by the Shuttle program, NASA ELVs and the USAF. The team included more than 50 personnel from eleven organizations including other Governmental agencies, NASA Centers, universities and their contractors.

Based on analyses of the extensive data base of in-situ and radar measurements, the team developed revised LLCC for both Attached Anvils and Detached Anvils. These revised LLCC use a new radar quantity, the Volume Averaged Height Integrated Radar Reflectivity (VAHIRR). VAHIRR is not available as a standard product on either the WSR-88D used at the Eastern and Western Range or the Eastern Range WRS-74C weather radar. Software to generate the VAHIRR product for WSR-88D installations is being developed by the AMU. Meanwhile, a conservative work-around using conventional cross-section and maximum reflectivity products was developed by KSC and implemented by the 45th Weather Squadron at the Eastern Range. The team has begun additional analyses to determine if additional improvements to the LLCC can be derived from the ABFM data set. The two primary targets are application of the VAHIRR quantity to the Debris Cloud Rules, and reduction of the "stand-off distances" in the anvil and debris cloud rules. The stand-off distance is the distance by which a launch vehicle must avoid flying near to a subject cloud.

<u>Improve Lightning Launch Criteria and Lightning Forecasts</u>

Improved natural lightning Launch Commit Criteria evaluations and natural lightning warnings and strike point assessments needed to be studied. The following tasks were undertaken.

1. Initiated and managed Grant to U. of Arizona to:

   a. Develop improved field mill algorithm for locating lightning discharge centers outside field mill network;

   b. Install field mill on Western Range (WR) to study triggered lightning threat and validity of lightning LCC on WR;

   c. Provide data analysis to Airborne Field Mill program; and

   d. Chair Lightning Advisory Panel.

2. Sound Lightning Location (SOLLO) system: Over a period of several years, initiated and funded Task Orders to KSC Engineering Contractor to develop accurate lightning detection/location system using time delay of arrival from thunderstorm sound waves (SOLLO). Also issued new Task Orders to:

   a. Revise/simplify installation

design to deploy SOLLO operationally--less expensive design enabled sufficient funds to begin development testing.

b. Add following to SOLLO: lightning amperage, 10-90 percent rise time, mean duration and number of strokes, and wave shape with 100-nanosecond resolution (Complete); and

c. Ruggedize system components to ensure SOLLO is more operationally robust in outdoor environment.

Data was gathered by U of AZ and analyzed on threat of triggered lightning at Eastern Range and other launch sites where NASA launches unmanned launch vehicles. Data is being incorporated into improved, safer ground operations procedures, lightning launch commit criteria, and landing weather rules. In addition, SOLLO will improve lightning location accuracy from 400 meters to 5 meters and thus eliminate much of the risk caused by guessing lightning occurrence/location from cameras. KSC/Advanced Technology unit is currently testing SOLLO to resolve echo problems when SOLLO is too close to facilities. Further, KSC Engineering Contractor added current characteristics (amperage, rise time, polarity, etc.) to SOLLO -- greatly increased its value by allowing much more precise risk estimates of possible damage to electronic components on orbiter, ground support equipment, and payloads. Hardening SOLLO enables more reliable outdoors operations.

<u>Lightning Cessation Forecasts</u>

Many operational support requirements were not receiving full benefit from technology advances. We worked with Chief 45th Weather Squadron Staff Meteorologist to solicit and exploit untapped potential of numerous graduate students with requirements to research and publish solutions to problems in the atmospheric sciences. Provided students list of topics with important operational value to NASA space flight; data from our extensive weather infrastructure; and mentoring. Larger projects were divided into smaller sequential pieces to fit students' fiscal and time budgets. Following is a list of examples of high quality research projects currently underway or just completed:

1. Florida State University and Univ of Oklahoma: Tools consisting of statistical relationships between lightning cessation and radar and lightning data to predict which lightning strike was the final one and thus reduce the unnecessary downtime caused by excessively long lightning warnings

2. Plymouth State Univ.: Development of forecast tool to improve prediction of convective wind gusts.

3. Penn State Univ.: Detailed lightning climatology that fed into larger AMU task supporting 45WS, SMG, MSFC and NWS/MLB forecast and design support requirements.

4. AF Institute of Technology: Analysis of accuracy and value of new Hurricane Center product to provide objective probabilities of wind speed as function of wind speed, location, and time.

WINDS

<u>915 MHz Wind Profilers</u>

The KSC Weather Office provided additional data and analyses on boundary layer winds measured with the Eastern Range network of five 915 MHz wind profilers requested by the Shuttle Program. These data and analyses assisted the Natural Environments Group at Marshall Spaceflight Center to respond to the Shuttle Program request for a detailed analysis of proposed Shuttle launch constraints on boundary layer wind changes. In response to an inquiry concerning the extent to which the five profilers in the Eastern Range network may be redundant, a correlation and coherence analysis was undertaken. The results show that the data are independent for atmospheric phenomena with time scales less than one to two hours.

<u>Continuous Balloon-Sonde Measurements</u>

Using NASA Innovative Partnership Program (IPP) funding, KSC and Ensco, Inc. began a one year project in late FY06 to develop a long-duration constant density altitude autonomous balloon sonde to measure temperature, relative humidity and winds. The project, called GEMSTONE (GEMS Sonde Test Operations in the Natural Environment), is based on previous ENSCO work on GEMS (Global Environmental MEMS Sensors) miniaturized sensing technology. The sondes will be solar powered and transmit their data to the ground by satellite link. They are expected to have a residence time in the atmosphere of up to two weeks. The GEMSTONE project is complete. Several atmospheric test flights were made that validated the concepts and demonstrated the prototype hardware and software. Additional development will be necessary to improve the reliability of power, GPS tracking and data communications before the system is suitable for operational support.

INFRASTRUCTURE FOR OPERATIONS

In addition to Supporting Research, the KSC Weather Office continues to work with the Eastern Range (ER) to improve the KSC and ER weather infrastructures and improve operational processes and facilities.

50 MHZ DOPPLER RADAR WIND PROFILER (DRWP)

The upgrades the AF installed on the DRWP in FY04 and FY05 have been thoroughly tested and the end to end accuracy of the system verified as meeting or exceeding the accuracy of the pre-modification system. Overall system accuracy, about 1 m/s RMS with zero bias, is comparable with high-resolution wind-finding balloons such as Jimspheres or AMPS HR balloons. The vertical resolution of the DRWP was not affected by the modification. It is Nyquist limited at 300m compared with AMPS HR vertical resolution of about 100m. Despite the excellent performance of the modified instrument, the Eastern Range withdrew from its agreement to accept the DRWP into the ER inventory because of maintenance and documentation concerns. KSC will continue to operate, maintain, and sustain the DRWP through the life of the Shuttle Program (~2010). The 45th Weather Squadron has submitted a requirements statement for the acquisition of a COTS 50 MHz DRWP to replace the KSC instrument before it becomes unmaintainable and/or Shuttle operations and maintenance funding ceases.

LIGHTNING DETECTION AND RANGING (LDAR) SYSTEM

LDAR provides real-time 4D lighting data. Since LDAR was originally developed as a research system by KSC in the late 80s, its components are increasingly subject to obsolescence, thus costs and the risk of system failure are increasing. KSC worked with the Eastern Range and SLRS-C to help the Range acquire and install a COTS replacement for LDAR. The new system, LDAR-II by Vaisala, was installed in FY06. Testing and certification is expected to be completed in FY07. At that time KSC will decommission LDAR and the Range will own, operate and maintain, and sustain the LDAR II system (called the 4-D Lightning Surveillance System).

AIRCRAFT TRIGGERED LIGHTNING

Major airlines are concerned about their aircraft lightning strikes. Their data indicated maximum strike rate was in April, not during summer. A clarification of this fact was required. We provided airlines information on triggered lightning, its causes, NASA/AF lightning launch commit criteria, and why the strikes were more prevalent in Spring and not in Summer. (Aircraft more likely to fly in seemingly innocuous layered clouds between 0 degrees C and -20 degrees C during Spring.). We have responded to several lists of questions from Airline as they considered the information and studied changes to their procedures.

LAUNCH COMPLEX ELECTROMAGNETIC PULSE (EMP) DETECTION SENSORS

The Shuttle Lightning Hazard Analyses concluded existing on-pad electromagnetic pulse (EMP) detection sensors were inadequate. An alternate, faster, method to determine if retest of GSE, launch vehicle, or payloads is required was needed. We initiated and led project to provide lightning strike data (time, location, current strength, and polarity) from weather infrastructure lightning detection systems via e-mail to pre-designated individuals every hour lightning strikes were within a specified distance from a specific location. Currently working to integrate National Lightning Detection Network (NLDN) data into database to supplement Cloud-Ground Lightning Surveillance System (CGLSS) data. The task involved resolution of licensing, data format, security, and communication issues. The project is 90 percent complete within just 2 months and formal testing is underway. Will provide 24/7 hourly lightning strike information to key Shuttle engineers and managers. This work will likely be expanded to Atlas, Delta, and other EMP sensitive customers once fully operational for Shuttle.

WEATHER WARNING DISSEMINATION SYSTEM

Weather Warning and Advisory dissemination system primarily relied on antiquated public address system which most people either didn't hear the warnings or misunderstood them or couldn't remember all the specifications-start/stop time, location, hazard, etc. We sought and gained funding to take advantage of new technology to greatly reduce the communication shortfall. Identified competent software engineers and managers to design solutions; and helped coordinate project thru the complex Eastern Range, KSC, contractors, and off-site customer's bureaucracies to overcome communications, security fiefdoms and other hurdles. When fielded, the system will disseminate warnings over TV as scrolling information at bottom of screen; as icons on PCs alerting personnel of warnings; on pagers/cell phones/PDAs, etc. The last of the system bugs now being corrected, and IT security issue with off-base contractor being resolved, before final testing and implementation.

ENGINEERING STUDIES

Return to Flight and the Constellation project (CxP) established under the President's Space Exploration Vision generated dozens of engineering studies involving operational anomalies; proposed operations concept and sub-system changes; and design issues. CxP included the new Crew Launch Vehicle (Aries I); Crew Exploration Vehicle (Orion); and Heavy Lift Vehicle (Aries V). Each study required KSC Weather Office to provide and apply environmental data. Before we supplied any weather or climatological data to a project manager, we asked numerous questions about the project's goal and the proposed application of requested data. The purpose of this interaction was to ensure atmospheric and space weather impacts were properly identified and understood; to provide correct environmental data; and ensure the data was properly used. We worked with 45th

Weather Sq, AF Combat Climatology Center, MSFC, or just internally, to provide analyses, evaluations, data and products assessing risks to Constellation designs and concepts of operations options due to lightning, wind, temperature, moisture, pressure, etc and their various combinations.

SUPPORTING RESEARCH

The Earth is a complex, dynamic system not yet fully understood. The Earth system, like the human body, is comprised of diverse components that interact in complex ways. We need to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system.

From space the Earth can be viewed as a planet, with evident interconnectedness of the oceans, atmosphere, continents, ice sheets, and life itself. Global-scale changes are observed and tracked, and regional changes can be studied in their global context. The role that human civilization increasingly plays as a force of change can be observed. NASA studies this dynamic planet to trace effect to cause, connect variability and forcing with response, and vastly improve national capabilities to predict climate, weather, natural hazards, and conditions in the space environment. NASA's Earth science portfolio addresses six focus areas:

1. Climate Variability and change;
2. Atmospheric composition;
3. Carbon cycle, ecosystems, and biogeochemistry;
4. Water and energy cycles;
5. Weather; and
6. Earth surface and interior.

In each of these areas, NASA seeks the input of the Earth science community in universities and elsewhere to identify the scientific questions to be addressed and to define effective strategies to pursue the answers to those questions.

NASA answers these questions by:

1. conducting selected Earth science missions which extend our knowledge of Earth systems;
2. managing mission observation data so that it is widely available to the broader scientific community;
3. conducting and sponsoring research to answer fundamental science questions about observed changes in climate, weather, and natural hazards;
4. enabling partner organizations to apply NASA's science results to help improve the Nation's observational and forecasting systems; and
5. developing technologies that will improve future Earth measurement capabilities.

The NASA Earth Science Division (ESD) consists of seven programs: Earth Systematic Missions, Earth Science Pathfinder, Research, Applied Sciences, Multi-Mission Operations, Technology and Education and Outreach. ESD has 14 operational missions on orbit, 5 missions in implementation, and 2 missions in formulation.

NASA's Earth Science Program is dedicated to advancing Earth remote sensing and pioneering the scientific use of global satellite measurements to improve human understanding of our home planet in order to inform economic and policy decisions and improve operational service s of benefit to the nation. The program is responsive to several Congressional mandates and Presidential initiatives. Perhaps more than any other human activity, decades of progress in flight and advances in the space-related technology have steadily changed our perception of the Earth as a home planet. Satellite measurements of essential characteristics have enabled human understanding of the Earth as a system of tightly coupled parts. It is now clear for example that the characteristics of Earth's atmosphere so critical to human habitability are maintained by complex and tightly coupled circulation dynamics, chemistry, and interactions with the oceans, ice and land surface; all driven by solar radiation and gravitational forces. All these natural interactions and the human-induced changes require continuous and global observations. These observations detail the variability and change and enable us to analyze and document the forces involved, the nature of the underlying processes and how these are coupled within the Earth system. To inform resource management decisions and policies we need ongoing predictions derived from Earth observations to expose the responses that determine further change. All these observations and analysis are geared to solving the underlying fundamental question: "*How is the Earth changing and what are the consequences for life on Earth?*" NASA's mission in Earth science, as mandated by the Space Act, is to "*... conduct aeronautical and space activities so as to contribute materially to ...the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space*". Thus, NASA's role is unique and highly complements those of other Federal agencies.

NASA's Earth science programs are essential to the implementation of three major Presidential initiatives: *Climate Change Research* (June 2001), *Global Earth Observation* (July 2003), and the *U.S. Ocean Action Plan* (December 2004). The first is the subject of the *U.S. Climate Change Science Policy (CCSP)*, combining the congressionally mandated Global Change Research Program (USGCRP) with the Climate Change Research Initiative. The second is related, and focuses on national and international coordination of Earth observing capabilities to enhance their use in meeting important societal needs. An Earth Observation Summit in Brussels, Belgium, in February 2005, adopted a 10-year plan for a Global Earth Observation system of systems. The third is the U.S. Government response to the Congressional Commission on Ocean Policy of 2002, and its final recommendations report, *An Ocean Blueprint for the 21st Century*. NASA's unique role in these coordinated efforts is to advance remote sensing technology and computational modeling for scientific purposes, and facilitate the transition of mature observations and technologies to partner agencies that provide essential services using Earth science information. Earth Science at NASA contributes to the Presidents initiative *Vision for Space Exploration* (February 2004) by providing leverage of observing technologies and knowledge of Earth as a planet to aid in the Nation's exploration of worlds beyond. NASA will use the recently completed first decadal survey by National Research Council for Earth science and application from space to set priorities for future missions and research. The missions, programs and research objectives in this section are based on heritage roadmaps developed with the science community in each of the science focus areas defined below. The most recent Earth Science Research Plan can be found at http://science.hq.nasa.gov/ strategy/past.html.

From the 1960s through the 1980s, space and airborne observations allowed the first global view of the Earth and led to important discoveries such as the processes behind Antarctic ozone depletion, the Earth's response to incoming solar radiation, and the extent, causes, and impacts of land use and land cover change. In the 1980s and 1990s, NASA's comprehensive suite of global measurements together with the associated temporal scales of observation led to the development of the interdisciplinary field of Earth System Science. NASA deployed the first set of platforms in the Earth Observing System (EOS) and promoted research focused on the Earth as a system of dynamic set of interactions among continents, atmosphere, oceans, ice, and life. In this decade, NASA has begun to deploy new types of sensors to provide three-dimensional profiles of Earth's atmosphere and surface. Emphasis is placed into linking together multiple satellites into a constellation, developing the means of utilizing a multitude of data sources to form coherent time series, and facilitating the use of the extensive data in the development of comprehensive Earth system models.

An example of the advantage of such framework is starting to emerge from the A-Train: a set of six satellites which are carefully choreographed by NASA ground controllers to observe the same portion of the Earth over the time span of twenty three minutes. The five satellites now in orbit include Aura, Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL), CALIPSO, Cloudsat, and Aqua. The instruments include spectrometers, radiometers, polarimeters, and lasers, which map or determine vertical distributions beneath the A-Train. A particular target is the composition of the Earth's atmosphere, which is being studied by a full range of A-Train instruments, resulting in tremendous synergy by combining datasets. For example, simultaneously measured cloud and trace gas properties can be studied to better understand the formation of clouds and aerosols and their interactions with gases from near the ground into the stratosphere. This will be valuable in understanding the connections between atmospheric chemistry and climate. The launch of Orbiting Carbon Observatory (OCO), the sixth satellite, in 2008, will complete the constellation and make the first global measurements of CO2 sources and sinks.

The complexity of the Earth system, in which spatial and temporal variability exists on a range of scales, requires that an organized scientific approach be developed for addressing the complex, interdisciplinary problems that exist, taking good care that in doing so there is a recognition of the objective to integrate science across the programmatic elements towards a comprehensive understanding of the Earth system. In the Earth system, these elements may be built around aspects of the Earth that emphasize the particular attributes that make it stand out among known planetary bodies. These include the presence of carbon-based life; water in multiple, interacting phases; a fluid atmosphere and ocean that redistribute heat over the planetary surface; an oxidizing and protective atmosphere, albeit one subject to a wide range of fluctuations in its physical properties (especially temperature, moisture, and winds); a solid but dynamically active surface that makes up a significant fraction of the planet's surface; and an external environment driven by a large and varying star whose magnetic field also serves to shield the Earth from the broader astronomical environment. The resulting structure is comprised of six interdisciplinary science Focus Areas: Atmospheric position, Carbon Cycle and Ecosystems, Water and Energy Cycle, Climate Variability and Change, Weather and Earth Surface and Interior. These six focus areas include research that not only addresses the challenging hierarchy of science questions but drives the development of an Earth observing capability and associated Earth system models as well.

NASA conducts Earth science research within a larger national and international context. This implies both opportunities for task sharing with partner agencies and the responsibility to seek optimal coordination of mutually supportive programs of these national and international partners. In particular, NASA has been actively seeking the cooperation of operational agencies in the US (DoD, NOAA, USGS) and elsewhere to ensure the long-term continuity of key environmental measurements in the long term. To achieve this goal, NASA will promote the convergence of the operational observation requirements of partner agencies with its research data needs for systematic observations, share the cost of new developments, and develop precursor instruments and spacecraft technologies for future operational application missions. NASA will also encourage the continuing involvement of scientific investigators in the calibration and validation of operational measurements, the development of more advanced information retrieval algorithms, and the analysis of operational data records. From this perspective, the potential for serving operational needs or commercial-applications is a priority for NASA Earth science programs.

Focusing on partnerships with domestic Federal agencies and other international organizations, the Earth Science Enterprise also seeks to facilitate the assimilation of NASA's Earth science observations, measurements and model output into the decision support tools or systems of the partner organizations to provide essential services to society. The NASA ESE Applied Science Program has identified twelve elements of applications of national priority in: Agricultural Efficiency, Aviation, Air Quality, Carbon Management, Coastal Management, Disaster Management, Ecological Forecasting, Energy Management, Homeland Security, Invasive Species, Public Health, and Water Management. This program focuses on applications of national priority to expand and accelerate the use of knowledge, science, and technologies resulting from the NASA goal of improving predictions in the areas of weather, climate, and natural hazards. The intended outcome of the applications program is to serve the nation through the benefits of routine, sustained use of NASA Earth science observations, data products, Earth system model outputs, and technology in the decision support tools employed by national organizations and Federal agencies to meet their mandated policy and management responsibilities. The Earth Science Enterprise Applications Strategy, available online at http://science.hq.nasa.gov/earth-sun/applications/index.html, provides a detailed discussion of the systems approach that NASA takes to benchmark its partners' decision support tools and the linkages between the six science focus areas and the twelve elements of applications of national priority.

Interagency and international partnerships are also important for maximizing the scientific value of any research while minimizing costs. The need for partnerships in process-oriented field measurement activities is crucial, especially when investigators' access to particular regions of scientific interest is needed. For space-based measurements, partnerships provide the opportunity for leveraging additional contributions onto those that would be made by NASA, and allow for benefiting from the technological and scientific skills resident in other agencies and countries, as well as access to information needed for validation under a broad range of biological and geophysical conditions. Partnership opportunities will typically be encouraged in all relevant solicitations as long as they are consistent with national policy objectives such as export control of sensitive technology. Commercial partnerships also provide the opportunity for NASA to obtain needed data or services, and NASA has committed to working with the private sector to avoid duplicating capability that already exists in it.

NASA's Earth Science Program is an end-to-end program that starts with the development of observational techniques and the instrument technology needed to implement them; tests them in the laboratory and from an appropriate set of suborbital (surface, balloon, aircraft) and/or space-based platforms; uses the results to increase basic process knowledge; incorporates results into complex computational models that can be used to more fully characterize the present state and future evolution of the Earth system; and develops partnerships with other national and international agencies that can use the generated information in environmental forecasting and in policy and resource management. Since its inception, NASA has exploited satellite platforms to observe the Earth, providing a critical resource for Earth science research. As a result of growing research efforts, many measurements from space are now routine and essential. For example, satellite remote sensing has become indispensable for accurate weather forecasts and severe storm warnings.

TABLE 3.4 A BRIEF DESCRIPTION OF OPERATING NASA EARTH SCIENCE SATELLITES

Jason	Jason is an oceanography mission to monitor global ocean circulation, improve global climate predictions, and monitor events such as El Nino conditions and ocean eddies. The Jason satellite carries a radar altimeter and continues the precise sea surface height measurement record begun by the TOPEX/Poseidon mission in 1992. Jason measurements support the Climate Variability and Change science focus area. It is a collaboration with France. Jason was launched on December 7, 2001 and is in an extended mission having exceeded its 3 year design life.
ICESat	Ice, Clouds, and Land Elevation Satellite (ICESat): ICESat's primary objective is to quantify ice sheet mass balance and understand how changes in the Earth' atmosphere and climate affect polar ice masses and global sea level. It also measures the distribution of clouds and aerosols, as well as surveying land topography, sea ice, and vegetation cover. ICESat observations support the Climate Variability and Change, Earth Surface and Interior, and Water and Energy Cycle science focus areas. The primary instrument is a laser altimeter. ICESat was launched on January 12, 2003 and is in an extended mission having exceeded its 3 year design life.
Landsat 7	Landsat 7 systematically provides calibrated, multispectral, moderate resolution images of the Earth's continental and coastal areas with global coverage on a seasonal basis. It covers the United States every 16 days. These images form a unique resource for global change research and various applications. Landsat 7 measurements support the Carbon, Ecosystems and Biogeochemistry science focus area. Landsat 7 is a collaboration with the U.S. Geological Survey which took over spacecraft operations in the Fall of 2000. Landsat 7 was launched on April 15, 1999 and is in an extended mission having exceeded its 5 year design life.
EO-1	Earth Observing-1 (EO-1): EO-1 is an advanced land-imaging mission to demonstrate new instruments and spacecraft systems. EO-1 validated technologies contributing to the significant reduction in cost of follow-on Landsat missions. It supports the Carbon, Ecosystems and Biogeochemistry science focus area. EO-1 was launched on November 21, 2000 and is in an extended mission having exceeded its 2 year design life.
TRMM	Tropical Rainfall Measuring Mission (TRMM): TRMM monitors tropical and subtropical rainfall and the associated release of energy that helps to power the global atmospheric circulation shaping both weather and climate around the world. Its measurements support the Climate Variability and Change, Water and Energy Cycle, and Weather science focus areas. The TRMM satellite carries the first precipitation radar flown in space and several microwave and optical radiometers. It is a collaboration with Japan. TRMM was launched on November 27, 1997 is in an extended mission having exceeded its 3 year design life.
Terra	Terra, Latin for land, provides global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation and with one another. Its name reflects an emphasis on observations of terrestrial surface features although its measurements have a truly interdisciplinary character. Terra measurements support the Atmospheric Composition; Carbon, Ecosystems and Biogeochemistry; Climate Variability and Change; Earth Surface and Interior; Water and Energy Cycle; and Climate Variability and Change science focus areas. Terra employs five optical instruments on a single satellite. It is the first, of the series of large satellites devoted to characterizing the Earth system and identifying and tracking changes. It is a collaboration with Japan and Canada. Terra was launched on December 18, 1999 and is in an extended mission having exceeded its 5 year design life.
ACRIMSAT	The Active Cavity Radiometer Irradiance Monitor III (ACRIM III) instrument onboard ACRIMSAT monitors total radiant energy from the Sun. Measurements of total solar irradiance are directly relevant to the Climate Variability and Change science focus area. When combined with other scientific data, these measurements will help climatologists to improve their predictions of long-term climate. They extend the database initiated by ACRIM I in 1980. ACRIMSAT was launched on December 20, 1999 and is in an extended mission having exceeded its 5 year design life.

TABLE 3.4 (CONTINUED) A BRIEF DESCRIPTION OF OPERATING NASA EARTH SCIENCE SATELLITES

QuickSCAT	Quick Scatterometer (QuikSCAT): QuikSCAT records sea-surface wind speed and direction data for global climate research and operational weather forecasting and storm warning. These data support the Climate Variability and Change and Water and Weather science focus areas. It replaces the data lost by the failure of the Japanese Advanced Earth Observing Satellite (ADEOS) in 1997. SeaWinds, a radar scatterometer, is the main instrument on the QuikSCAT satellite. QuickSCAT was launched on June 19, 1999 and is in an extended mission having exceeded its 3 year design life.
GRACE	Gravity Recovery and Climate Experiment (GRACE): The primary goal of the GRACE mission is to accurately map variations in the Earth's gravity field. GRACE studies gravity changes due to surface and deep currents in the ocean; runoff and ground water storage on land masses; exchanges between ice sheets or glaciers and the oceans; and variations of mass within the earth. The tandem two satellite mission supports the Earth Surface and Interior, Climate Variability and Change, and Water and Energy Cycle science focus areas. GRACE maps the Earth's gravity fields by making accurate measurements of distance between the two satellites using high quality Global Positioning System (GPS) receivers and a microwave ranging
SORCE	SOlar Radiation and Climate Experiment (SORCE): SORCE provides data continuity with ACRIMSAT and operational successors to ensure long-term systematic measurement of total and spectral (1–2000 nm) solar irradiance, the dominant energy source in the Earth's atmosphere and one of its primary climate variables. Its measurements support the Climate Variability and Change science focus area. SORCE was launched on January 25, 2003 and is in its prime 5 year mission.
Aqua	Aqua, Latin for water, was named for the large amount of information that the mission collects about the Earth's water cycle, including evaporation from the oceans, water vapor in the atmosphere, clouds, precipitation, soil moisture, sea ice, land ice, and snow cover on the land and ice. In addition to the Water and Energy Cycle science focus area, its six optical and microwave sensors provide interdisciplinary measurements supporting the Climate Variability and Change; Weather; Carbon Cycle, Ecosystems and Biogeochemistry; and Atmospheric Composition science focus areas. It is the second, following Terra, of the series of large satellites devoted to characterizing the Earth system and identifying and tracking changes. It is a collaboration with Japan and Brazil. Aqua was launched on May 4, 2002 and is in its prime 6 year mission. Aqua was the first member launched of a group of satellites termed the Afternoon Constellation, or sometimes the A-Train. Envisioned to eventually comprise 6 satellites, the A-Train will provide synergistic measurements from multiple satellites that together will contain comprehensive information about key atmospheric components and processes related to climate change and atmospheric composition.
Aura	Aura, Latin for air, was named for the unique global view it provides of the Earth's atmosphere in direct support of the Atmospheric Composition science focus area. It additionally supports Climate Variability and Change science focus area. Aura's objective is to study the chemistry and dynamics of the Earth's atmosphere with emphasis on the upper troposphere and lower stratosphere by employing four optical and microwave instruments on a single satellite. It is the third, following Aqua, of the series of large satellites devoted to characterizing the Earth system and identifying and tracking changes. It is a collaboration with the UK, Netherlands, and Finland. Aura was launched on July 15, 2004 and is in its prime 6 year mission. Aura is the second member to joint the A-Train or Afternoon constellation of satellites.

CloudSat	CloudSat uses advanced radar to "slice" through clouds to see their vertical structure, providing a completely new observational capability from space. CloudSat is one of the first satellites to study clouds on a global basis. It will look at their structure, composition and effects in support of the Climate Change and Variability and Weather science focus areas. It is a collaboration with Canada. CloudSat was launched on April 28, 2006 with CALIPSO and is early in its prime 22 month mission. CloudSat maintains a close formation with Aqua and particularly CALIPSO, providing near-simultaneous and collocated observations with the instruments on these two A-Train satellites.
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO): CALIPSO will help answer significant questions about the effects of thin clouds and aerosols on changes in the Earth's climate. Understanding these components will provide the more comprehensive data set that is essential for better understanding the Earth's climatic processes in support of the Climate Change and Variability science focus area. CALIPSO combines a laser radar (backscatter lidar) with passive infrared and visible imagers to probe the vertical structure and properties of thin clouds and aerosols. It is a collaboration with France. CALIPSO was launched on April 28, 2006 with CloudSat and is early in its prime 3 year mission. It flies within seconds of CloudSat in the A-Train formation to take advantage of its complementary millimeter-wave radar measurements of clouds.

NUCLEAR REGULATORY COMMISSION WEATHER PROGRAMS

The United States Nuclear Regulatory Commission (NRC) licenses and regulates all nuclear facilities subject to the Atomic Energy Act of 1954 as amended. The licensing and operation of these nuclear facilities require the identification of meteorological and climatological conditions that can affect the safe operation of the facility, and that provide input to the assessment of the radiological impacts of any airborne releases from the facility.

Within the NRC, the Offices of Nuclear Reactor Regulation and New Reactors conduct reviews of nuclear power plant siting, design, construction, and operation while the Offices of Nuclear Material Safety and Safeguards and Federal and State Materials and Environmental Management Programs conduct similar reviews of materials and waste facilities. These reviews include consideration of meteorological factors. The offices also conduct rulemaking to establish regulatory requirements.

The NRC Regional Offices assure that NRC licensees comply with the regulatory requirements. Together with the NRC Incident Response Operations, they also carry out NRC responses to nuclear facility emergencies. The NRC Office of Nuclear Security and Incident Response has been evaluating performance of large scale (greater than 1000 people) evacuations due to natural and man-made causes in the contiguous 48 states. This is documented in NUREG/CR-6864, "Identification and Analysis of Factors Affecting Emergency Evacuations". An additional study continues to analyze the large evacuations of 2005. In addition, a project is underway to perform a telephone survey of populations within nuclear plant emergency planning zones to determine public views of protective action implementation.

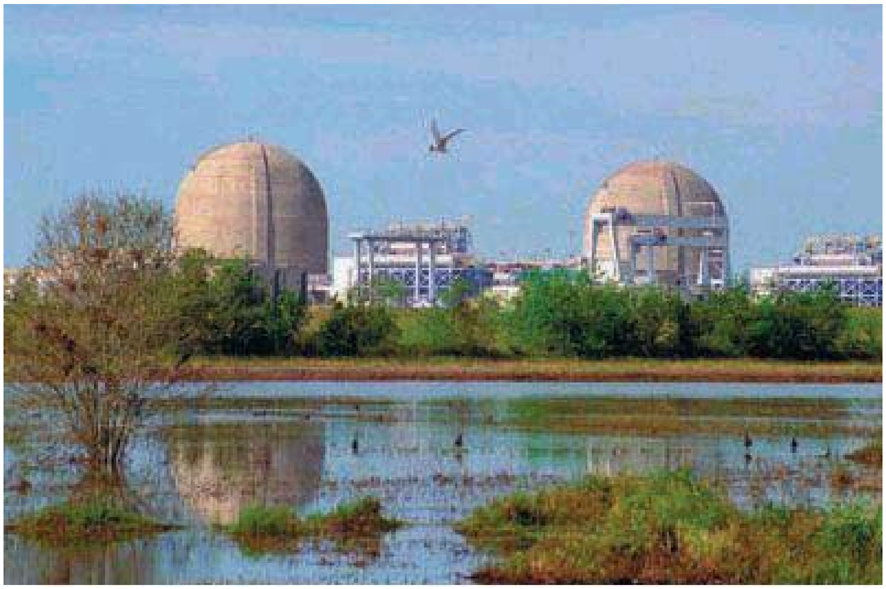


Figure 3-NRC-1. South Texas Project Units 1 and 2 (STP Nuclear Operating Company Image)

The Office of Nuclear Regulatory Research (RES) plans, recommends, and implements a program of nuclear regulatory research for nuclear power plants and other facilities regulated by the NRC. RES provides technical support, technical tools, and information to identify and resolve safety issues for current and new designs and technologies through testing, data development, analysis and national and international collaboration. RES also develops regulatory guidance and participates in the development of criteria and consensus standards related to the protection of the public health and safety and the environment.

At the present time, the NRC is a user of meteorological information, rather than a performer of research in this field. Meteorological data will be used to assess radiological impacts of routine airborne releases from facilities, to evaluate the impact of proposed changes in plant design or operation on unplanned releases, and to evaluate new reactor designs or sites. Information of this type is also important for developing scenarios of climatological impacts on the isolation of long-lived nuclear wastes. The NRC also maintains an interest in the transport and dispersion of airborne, hazardous, nonradioactive materials, and the effects of extreme meteorological events on the safe operation of nuclear facilities.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent agency of the Federal Government established to promote and advance scientific and engineering progress. The NSF sponsors and funds scientific and engineering research and education projects and supports cooperative research to gain new understanding of the behavior of the Earth's atmosphere and oceans. NSF does not itself conduct research but funds research performed by scientists at universities and other entities. In addition, NSF provides support for the maintenance and operation of the National Center for Atmospheric Research (NCAR) which is devoted to large-scale atmospheric research projects conducted in cooperation with universities and other Federal, state and/or local organizations.

The Division of Atmospheric Sciences manages NSF's basic atmospheric research support. This research focuses on new and fundamental knowledge needed to better understand the atmosphere and related sciences, and to manage atmospheric science programs including natural disaster reduction, space weather, global change, and air quality.

NATURAL DISASTER REDUCTION

NSF supports fundamental and applied research on weather phenomena that are either life threatening or economically disruptive. Focus areas include:

- Better understanding and forecasting of hurricane track and intensity;
- Better quantitative precipitation forecasting and estimation;
- Optimal use of observations in numerical models; and
- The societal/economic impacts of improved weather information.

To help support this type of research, an excellent data set was gathered on hurricanes Katrina and Rita in 2006. Analysis of this data set is ongoing. The total research support for FY 2007 was approximately $14 million. In FY 2008, support is expected to remain at the FY 2007 level.

SPACE WEATHER

NSF supports research under the National Space Weather Program (NSWP). The objective of the NSWP is to perform the research and technology transfer needed to improve the specification and forecasts of space weather events that can cause disruption and failure of space-borne and ground-based technological systems or can endanger human health. Examples of NSF support of space weather include conducting a highly successful competition for space weather research grants and providing support for the Center for Integrated Space Weather Modeling (CISM), a multi-institutional effort led by Boston University dedicated to providing advance warning of potentially harmful space weather events. NSF NSWP support in FY 2007 was about $14 million, and is expected to be about the same in FY 2008.

GLOBAL CHANGE

Under the United States Climate Change Research Program, NSF supports research and related activities that advance fundamental understanding of dynamic, physical, geochemical, biological, and socioeconomic systems as well as interactions among those systems. In addition to research on Earth system processes and the consequences of changes in those systems, NSF facilitates data acquisition and data management activities necessary for basic research on global change, promotes the enhancement of modeling designed to improve representations of Earth system interactions, and develops advanced analytic methods to facilitate fundamental research. NSF also supports fundamental social and economic research on the general processes used by governments and other organizations to identify and evaluate different types of policies for mitigation, adaptation, and other responses to changing global environmental conditions. The total NSF FY 2007 funding for this area of research was about $195 million; in FY 2008 the funding level is expected to be about $200 million.

AIR QUALITY

NSF supported fundamental research in the area of air quality helps develop improved understanding of the sources, formation, atmospheric processing and fates of ambient air pollutants. Atmospheric oxidant species (and their precursors), sulfur dioxide, nitrogen oxides, carbon monoxide, fine particles (and their precursors), and acids are important atmospheric constituents that influence air quality, and in turn habitability, human health and climate. Field experiments, laboratory studies, instrument development, new methods of chemical analysis, and improved models of atmospheric chemical reaction mechanisms, transport and depositional phenomena are examples of air quality research supported by NSF. These categories provide scientific and technical input for management and control of atmospheric pollutant gases and particles.

NOTE: NSF budget data is not captured in Tables 2.1-2.5.

APPENDIX A

FEDERAL COORDINATION AND PLANNING

BASIS FOR FEDERAL COORDINATION PROCESS

In 1963, Congress and the Executive Office of the President expressed concern about the adequacy of coordination of Federal meteorological activities. In response, Congress directed in Section 304 of Public Law 87-843--the Appropriations Act for State, Justice, Commerce, and Related Agencies--that the Bureau of the Budget prepare an annual horizontal budget for all meteorological programs in the Federal agencies.

The Bureau of the Budget (now the Office of Management and Budget) issued a report entitled "Survey of Federal Meteorological Activities" (1963). The report described each agency's program in some detail, particularly its operational services, and detailed the relationship between the programs of the various agencies. The report revealed close cooperation but little evidence of systematic coordination. Based on this study, the Bureau of the Budget issued a set of ground rules to be followed in the coordination process. It established a permanent general philosophy for assignment and assessment of agency roles in the field of meteorology and set certain goals to be achieved by the coordination process. The Bureau of the Budget tasked the Department of Commerce (DOC) to establish the coordinating mechanism in concert with the other Federal agencies. It also reaffirmed the concept of having a central agency--the DOC--responsible for providing common meteorological facilities and services and clarified the responsibilities of other agencies for providing meteorological services specific to their own needs.

The implementation of these directives by DOC led to the creation of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) which operates with policy guidance from the Federal Committee for Meteorological Services and Supporting Research. The principal work in the coordination of meteorological activities and in the preparation and maintenance of Federal plans is accomplished by the OFCM staff with the advice and assistance of the Interdepartmental Committee for Meteorological Services and Supporting Research, and over 30 program councils, committees, working groups, and joint action groups.

MISSION OF THE OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY (OFCM)

The mission of the OFCM is to ensure the effective use of Federal meteorological resources by leading the systematic coordination of operational weather requirements, services, and supporting research, among the Federal agencies. The high level focus and output as a result of carrying out this mission includes needs and requirements; issues and problems; studies, reports, plans, and handbooks; and crosscut reviews, assessments, and analyses.

OFCM's objectives in carrying out its mission include:

- Documenting agency programs and activities in a series of national plans and reports that enable agencies to revise/adjust their individual ongoing programs and provide a means for communicating new ideas and approaches to fulfill requirements.
- Providing structure and programs to promote continuity in the development and coordination of interagency plans and procedures for meteorological services and supporting research activities.
- Preparing analyses, summaries, or evaluations of agency meteorological programs and plans that provide a factual basis for the Executive and Legislative branches to make appropriate decisions related to the allocation of funds.
- Reviewing Federal weather programs and Federal requirements for meteorological services and supporting research. This review may suggest additions or revisions to current or proposed programs, or identify opportunities for improved efficiency, reliability, or cost avoidance through coordinated actions or integrated programs.

As detailed in the report which follows, this has been an excellent year for OFCM in carrying out its interagency activities. The accomplishments of FY07 were substantial and meaningful for the nation, and the foundation has been placed for a similarly productive FY08.

FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

The Federal Committee for Meteorological Services and Supporting Research (FCMSSR), established in 1964, provides policy-level agency representation and guidance to the Federal Coordinator to address agency priorities, requirements, and issues related to services, operations, and supporting research, and also resolves agency differences that arise during the coordination of meteorological activities and the preparation of Federal plans. The Under Secretary of Commerce for Oceans and Atmosphere, who is also the Administrator of the National Oceanic and Atmospheric Administration (NOAA), serves as the FCMSSR Chairperson.

The 15 Federal agencies that engage in meteorological activities, or have a need for meteorological services, are represented on FCMSSR. The FCMSSR membership includes: DOC, DOD, DOT, the Departments of Agriculture (USDA), Energy (DOE), Homeland Security (DHS), Interior (DOI), and State (DOS), the Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), National Transportation Safety Board (NTSB), Nuclear Regulatory Commission (NRC), the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB).

HIGHLIGHTS FOR FISCAL YEAR 2007 AND PLANS FOR FISCAL YEAR 2008

NATURAL DISASTER REDUCTION

INTERDEPARTMENTAL HURRICANE CONFERENCE

The OFCM annually hosts the Interdepartmental Hurricane Conference (IHC) to provide a forum for the responsible Federal agencies, together with representatives of the user communities such as emergency management, to review the nation's hurricane forecast and warning program and to make recommendations on how to improve the program. The OFCM hosted the 61st IHC in New Orleans, Louisiana, March 5-9, 2007. The theme of the 2007 conference was *The Nation's Hurricane Program: An Interagency Success Story*. The conference attendance was more than 190 for the eighth consecutive year. VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Under Secretary of Commerce for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA), set the tone for the meeting during his Monday afternoon keynote address-*The Nation's Hurricane Program: An Interagency Success Story*. He also paved the way for the rollout of the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*, one of the conference's principal objectives, by stating that the plan provides a comprehensive strategy to help meet the needs of the tropical cyclone warning and forecast centers and guide improvements in the nation's tropical cyclone forecast and warning program over the next decade. Objectives of the 2007 IHC included the following: (1) review the nation's tropical cyclone forecast and warning program from end-to-end, and update the *National Hurricane Operations Plan* for 2007; (2) evaluate the 2006 Joint Hurricane Testbed (JHT) results and successfully transition research results into operations, as well as potential candidates for 2007 and beyond; and (3) address and build upon the actions and results from the 60th IHC [rollout the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead* and begin addressing recommendations; and examine how hazard risk reduction improvements can be made through stronger partnerships and alliances]. The IHC proved to be an extremely valuable forum to bring the operational and research communities together to produce the best possible tropical cyclone forecast and warning program, to address the needs of the Federal agencies and user communities that have a stake in the nation's tropical cyclone program, and also to build interagency consensus for the new strategic research plan for tropical cyclones. Actions resulting from the conference are: (1) publish the *2007 National Hurricane Operations Plan* by May 15, 2007; (2) establish the Working Group for Tropical Cyclone Research to implement the recommendations of the new strategic research plan for tropical cyclones the *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*; (3) work with diverse user groups to develop and test message format modifications (60th IHC action); and (4) coordinate bringing together the appropriate Federal agencies to begin the process of reviewing and improving the national hurricane warning "system" (60th IHC action). In May 2007, the 45th edition of the *National Hurricane Operations Plan* (NHOP), which provides the basis for hurricane reconnaissance for the 2007 season and details Federal agency responsibilities, operations, and procedures; products; aircraft, satellite, radar, and buoy data collection; and marine weather broadcasts, was published based on the inputs and discussions from the 61st

IHC. The 2008 IHC is being planned for Charleston, South Carolina.

TROPICAL CYCLONE RESEARCH AND DEVELOPMENT PLAN

The tropical cyclone forecast and warning program is an interdepartmental collaboration to provide the United States and designated international recipients with forecasts, warnings, and assessments concerning tropical and subtropical weather systems. The three centers that cooperate to provide the operational forecast and warning services are the Tropical Prediction Center/National Hurricane Center (TPC/NHC), the Central Pacific Hurricane Center (CPHC), and the Joint Typhoon Warning Center (JTWC). The plan, *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*, was published in February 2007, and provides a strategy for continuing to improve the effectiveness of operational forecasts and warnings through strategic coordination and increased collaboration among the major players in the operational and research and development (R&D) communities. The plan represents extensive efforts by the Joint Action Group for Tropical Cyclone Research (JAG/TCR), established by the Federal Coordinator for Meteorological Services and Supporting Research in 2005, to respond to a principal action item, proposed at the 58th Interdepartmental Hurricane Conference in 2004, to develop a comprehensive strategy for tropical cyclone R&D to guide interagency efforts over the next decade. The action item was reviewed and supported by both the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) in November 2004, and the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) in December 2004. The plan notes that vast improvements in tropical cyclone prediction are attainable with focused research efforts; enhanced transition of research to operations capabilities; strong interagency partnerships, coordination, and planning; and most importantly, sufficient resources-both human and infrastructure. The capability to gain skill in forecasting rapid intensity changes and to improve predictions of hurricane intensity and structure, sea state/storm surge, and precipitation is currently on the horizon, much as improving hurricane track was two decades or so ago. The ultimate goal is to prevent loss of life and injuries and to reduce the nation's vulnerability to these potentially devastating storms. This goal can and must be accomplished for the good of the nation.

EXPLORATORY REVIEW

During this period, the OFCM conducted an exploratory review, a first step in an end-to-end assessment of our national warning system for natural and technological hazards (with an initial focus on tropical cyclones). The exploratory review was responsive to an Interdepartmental Hurricane Conference action item as well as a recommendation of the *Interagency Strategic Research Plan for Tropical Cyclones-The Way Ahead*. It was performed in two locations prone to tropical cyclones-Mobile County, Alabama, and Charleston County, South Carolina. The emphasis of the review was on the tropical cyclone information flow from the emergency management community to the various organizations and entities and citizens of a community. The objectives of the exploratory review were to: (1) understand and document the information flow; (2) summarize information flow requirements and gaps; and (3) provide follow-on considerations to improve the flow that would ultimately aid in saving lives, reducing injuries, and protecting property. The review noted that the majority of citizens receive tropical cyclone information through one or more communications means: television, radio, newspaper media; computer internet and email; and NOAA Weather Radio. The review also noted the need to continue efforts to ensure the poor, elderly, disabled, non-English speaking, individuals with medical concerns, and those in outlying areas receive vital tropical cyclone information. The review also noted that NOAA Weather Radio should be used as much as possible to disseminate evacuation notices as well as tropical cyclone and other weather warnings; community-based organizations such as churches, civic groups, and neighborhood associations should be encouraged to form notification call trees to further disseminate information; and Mobile and Charleston Counties and the entire network of public and private entities involved in improving the public alert and warning system must continue to account for the entire demographics of the at-risk population. The OFCM is preparing the report for the exploratory review which the office has begun, with an initial focus on tropical cyclones, in an end-to-end assessment of our national warning system for natural and technological hazards. The report will include recommendations for future work and inclusion of information dissemination issues for other hazards such as tornadoes and human-caused hazards.

POST-STORM DATA ACQUISITION

The OFCM continued to coordinate, as required, timely post-storm data acquisition surveys in response to Presidentially declared natural disasters and other agency requirements to evaluate, for example, the impact on the coastal ecosystems. These natural disaster reduction efforts contribute to the determination of the intensity and magnitude of storms, and, in many cases, help to determine the extent of damage for use in Presidential disaster declarations. The additional data collected after hurricane landfall is also used in validating modeling efforts with both emergency management models (e.g., FEMA's HAZUS) and hurricane storm-surge models (e.g., NOAA's SLOSH). These models are used in real time to assist decision makers in evacuation decisions and procedures. Post-storm data are also used to update FEMA Flood Insurance Rate Maps. A senior OFCM staff person spearheaded efforts to develop Memorandums of Understanding (MOU) between the Department of Commerce (DOC)/OFCM and the Department of Defense/Office of the Secretary of Defense to provide continued USAF Auxiliary-Civil Air Patrol aerial support and reconnaissance for post-storm and natural disaster data assessment. The 5-year (FY 2007 - FY 2011) Umbrella Agreement and the 1-year Annual Agreement (FY 2007) were approved by NOAA and DOC, and the DOD; they were signed by the Federal Coordinator for Meteorology and the Deputy Chief of Staff, Operations, Plans and Requirements of the United States Air Force, in May 2007.

ENHANCED FUJITA SCALE IMPLEMENTATION

Following OFCM coordination with the interagency meteorological community, in February 2007, the NOAA National Weather Service fully implemented the Enhanced Fujita (EF) Scale to rate tornadoes, replacing the original Fujita Scale. The Fujita Scale was developed in 1971, by T. Theodore Fujita, Ph.D., to rate tornadoes and estimate associated wind speed based on the damage they cause. The EF Scale refines and improves the original scale. It was developed by the Texas Tech University Wind Science and Engineering Research Center, along with a forum of wind engineers, universities, private companies, government organizations, private sector meteorologists, and NOAA meteorologists from across the country. The EF Scale incorporates more damage indicators and degrees of damage than the original Fujita Scale, allowing more detailed analysis and better correlation between damage and wind speed. A correlation between the original Fujita Scale and the EF Scale has been developed; this makes it possible to express ratings in terms of one scale to the other, preserving the historical data base.

URBAN METEOROLOGY

NATIONAL WILDLAND FIRE WEATHER NEEDS ASSESSMENT

An important contribution to urban meteorology during the period of this report is related to the *National Wildland Fire Weather Needs Assessment* which is being conducted by OFCM. The formation of the Joint Action Group for National Wildland Fire Weather Needs Assessment (JAG/NWFWNA) and conduct of the assessment is responsive to ICMSSR Action Item 2005-1.1 where ICMSSR "concurred that OFCM should move forward to form a Joint Action Group (JAG) under the Committee for Environmental Services, Operations, and Research Needs (CESORN), to review the needs and requirements for wildland fire weather information, to include identifying organizational responsibilities and addressing the following issues: data collection, fire weather research, weather forecast services, data assimilation, air quality, information dissemination, education and outreach, and user response." An abundance of accumulated biomass in forests and rangelands, persistent drought conditions, and encroaching urbanization are contributing to larger, more costly wildland fires; and to effectively manage and suppress wildland fires, fire managers need timely, accurate, and detailed fire weather and climate information. 2005 and 2006 were record years for acres burned; acres burned have trended upwards more than 100 percent since the mid-1980's; and wildland fire suppression, preparedness, fuels management, and other activities receive approximately $2.7 billion in Federal funding annually.

An important benchmark is the June 2005 Western Governors' Association (WGA) meeting where they approved Policy Resolution 05-04: National Wildland Fire Weather Program. Within the policy, the WGA urged NOAA to have the OFCM complete a *National Needs Assessment Report* of Federal, state, and local fire managers' needs for weather information in their wildfire and prescribed fire decision making processes and a framework to meet those needs by the National Weather Service and Predictive Services. The JAG/NWFWNA was established in December 2005, and has moved forward to conduct the assessment. Validated needs have been found in the eight functional areas of the assessment: (1) Data collection, integrity, processing, and archival, (2) Fire weather research and development, (3) Forecast products and services, (4) Modeling, prediction, and data assimilation, (5) Information dissemination and technologies, (6) Education, training, outreach, partnering, and collaboration, (7) User response, decision support, and resulting user impacts, and (8) Socioeconomic factors. The OFCM conducted a Special Session on wildland fire weather and climate use in decision making at the 3rd International Fire and Ecology Congress, November 14, 2006, in San Diego, California; briefed the Interdepartmental Committee for Meteorological Services and Supporting Research at its July 18, 2006, and May 31, 2007, meetings; presented a summary of user needs and issues at the June 10-12, 2007, Western Governors' Association meeting in Deadwood, South Dakota; and is completing a detailed report of user needs and issues, and a framework to meet the needs. In connection with this activity, the Chairman of the Western Governors' Association, Governor M. Michael Rounds, in a June 26, 2007 letter, thanked the Federal Coordinator and the OFCM team for the great work on the wildland fire needs assessment, and for the Federal Coordinator's presentation of the initial assessment to the governors at the WGA Annual Meeting in Deadwood, South Dakota.

ATMOSPHERIC TRANSPORT AND DIFFUSION RESEARCH AND DEVELOPMENT

The OFCM developed an atmospheric transport and diffusion (ATD) implementation strategy for the recommendations for which OFCM has primary responsibility in the *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion Modeling* (September 2004) report. The implementation strategy has three parts: (1) working with the agencies to identify and improve a baseline set of national ATD modeling capabilities; (2) helping the agencies implement a common framework for model development and evaluation; and (3) recommending criteria for multifunctional joint urban test beds ["urban" describes a metropolitan area and its interfaces with surrounding areas]. In accordance with this, OFCM formed a Joint Action Group for Joint Urban Test Beds (JAG/JUTB) under the Working Group for Urban Meteorology (WG/UM); and this joint action group has met frequently, and is continuing work to develop an operational concept document for multifunctional joint urban test beds to provide services and data to model developers, test and evaluation personnel, and users. The operational concept document will include capabilities and benefits, management structure, infrastructure requirements, selection process, implementation framework, definitions, and characteristics of urban scales. The joint urban test beds will support the following functional areas: severe weather (e.g., hurricanes, tornadoes, heat waves and cold spells, drought, and wildland fires), homeland security (dispersion of hazardous materials), climate, air quality (e.g., particulate matter aerosols), and water quality (e.g., deposition of airborne contaminants on water sources and waterborne transport of contaminants). JAG/JUTB is currently planning to pursue implementation of a JUTB over the National Capital Region first; this JUTB would be the proof of concept and our experience with it would allow for the improved development of an operational concept document based upon experiences with this first JUTB.

GEORGE MASON UNIVERSITY ATMOSPHERIC TRANSPORT AND DISPERSION MODELING CONFERENCE

George Mason University (GMU), Fairfax, Virginia, conducted its *11th* Annual Conference on Atmospheric Transport and Dispersion Modeling, July 10-12, 2007. The OFCM cosponsored the event, together with the Joint Science and Technology Office for Chemical and Biological Defense, Defense Threat Reduction Agency (DTRA); the Naval Surface Warfare Center, Dahlgren Division (NSWCDD); and GMU. Themes for the conference were: improve understanding of atmospheric transport and dispersion processes; support homeland security requirements; and share experience across different sectors. Participants included representatives from DOD, EPA, DOE, NOAA, universities, private companies and other agencies doing related research, as well as scientists from other countries. Technical topics of interest for the conference were: new developments in basic theories of boundary layer models and transport and dispersion models; urban-scale meteorological and dispersion experiments and models; computational fluid dynamics (CFD) model theory and applications; field experiments and laboratory experiments concerned with boundary layer studies and turbulence and dispersion studies; mesoscale meteorological modeling for input to transport and dispersion models; the use of remote sensing technology in boundary layer and transport and dispersion studies; model evaluation methods, uncertainty/sensitivity analyses, and risk assessments; improvements in model inputs (e.g., land-use data, 3-D building data) and output visualizations; and methods and criteria for emergency response and decision making.

The OFCM conducted a special session related to the OFCM's ongoing work with other members of the Federal meteorological community to implement the recommendations in the report, *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion Modeling*. The special session provided much information on benefits of joint urban test beds; it was chaired by Dr. Walter Bach, Jr., Program Manager of the Environmental Sciences Division of the U.S. Army Research Office. The special session provided much information on joint urban test beds, including NOAA/Air Resources Laboratory's national capital region experience; enabling advanced urban meteorology, dispersion and air quality modeling with high resolution urban databases and access portal tools; applying joint urban test bed results to the meteorological needs of the Army; a responder view of urban test beds; and opportunities for satellite and aircraft remote sensing within a joint urban test bed.

CLIMATE

The OFCM supports the U.S. Climate Change Science Program (CCSP). The OFCM arranged for the former Director of the CCSP to brief the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) so that member agencies can stay abreast of the program and coordinate priorities for atmospheric requirements through the OFCM for inclusion in CCSP, and forwarded to the CCSP results of a Climate Services Survey to identify new climate products and services that have been developed and implemented since the Board on Atmospheric Sciences and Climate defined "climate services" in 2001, as "the timely production and delivery of useful climate data, information, and knowledge to decision makers." The Federal Coordinator, through his participation on the Committee on Environment and Natural Resources (CENR), reviewed and provided concurrence on a number of U.S. CCSP Synthesis and Assessment Products. Also during FY 2007, an OFCM staff person provided a presentation at the fall 2006 American Geophysical Union (AGU) conference on *Climate-Induced Wildland Fires in the Wildland-Urban Interface (WUI) and Their Aftereffects*. The presentation (1) documented the close linkages between climate, changes in climate, drought, and WUI fires, (2) focused on the repercussions of the interconnectedness between climate, drought, and WUI fires, and (3) presented a holistic approach to considering climate, potential climate changes, drought, WUI fires, and the possible environmental, social, economic, and human-health consequences.

In addition, the OFCM is preparing for a meeting of the Committee for Climate Analysis, Monitoring, and Services which will be centered on extreme weather events. The goal is to be proactive in answering a number of questions, to include:

- Are the numbers and magnitude of extreme weather events on the increase?
- Can these extreme weather events be related to climate change?
- What is our capability to model and forecast these extreme events?
- Do our climate models have any skill in forecasting extreme events?
- What are the needs and requirements for climate services related to extreme weather events?
- What are the gaps in our capabilities to meet these needs?
- What will it take to fill these gaps-more research (basic and applied), more/better observations, improved models, etc.?

OPERATIONAL PROCESSING

OFCM's activities regarding Operational Processing Centers (OPC) continue to improve processing and backup capabilities of NOAA's National Centers for Environmental Prediction and Office of Satellite Data Processing and Distribution, the Air Force Weather Agency, and the U.S. Navy's Fleet Numerical Meteorology and Oceanography Center and Naval Oceanographic Office. Efforts continue to improve backup support and capabilities and to coordinate preparation for the implementation of the Weather Research and Forecasting (WRF) modeling system, in accordance with the *National Concept of Operations Framework for the Operational Processing Centers*, which is contained in an April 1, 2004, memorandum of agreement signed by the directors of the OPC's. Of particular significance during FY 2006, was the establishment of a National Operational Processing Centers (NOPC) Program Council within the OFCM coordinating infrastructure, to help achieve national priorities by focusing agency efforts and leverage resources to gain the maximum return. This was in response to the OPC Directors' determination that effectively coordinating the OPCs' efforts and providing the resources to support those efforts necessitated high-level policy guidance and oversight. OFCM's previously existing Committee for Operational Processing Centers (COPC) and its Working Group for Cooperative Support and Backup (WG/CSAB) and joint action groups for operational community modeling, centralized communications management, and operational data acquisition for assimilation, were placed under the new NOPC Program Council. During FY 2007, and in response to a request from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Senior Users Advisory Group (SUAG), COPC agreed to foster the synergistic coordination, program development, and implementation of NPOESS data exploitation strategies.

ANNUAL FEDERAL PLAN

In October 2006, the OFCM issued *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2007*. The Federal Plan is congressionally mandated and is a one-of-a-kind document which articulates the meteorological services provided and supporting research conducted by agencies of the Federal government. The Federal Plan helps to reduce overlap and duplication among the agencies. It is a comprehensive publication that documents proposed programs for FY 2007, and reviews agency programs in FY 2006. The feature article for the FY 2007 Annual Federal Plan is *Roadmap for Tropical Cyclone Research to Meet Operational Needs*. The article reviews three projects focused on tropical cyclone research and development to improve the nation's tropical cyclone forecast and warning service, and provides details on one of the projects, the development of an OFCM-sponsored interagency tropical cyclone research plan. The feature article for the FY 2008 Annual Federal Plan describes a cross-cutting assessment of Federal agency hydrometeorological products, services, and supporting research.

WEATHER INFORMATION FOR SURFACE TRANSPORTATION

Since 1998, OFCM has made weather services and research and development (R&D) activities supporting the surface transportation community a priority for the Federal meteorological community. In December 2002, OFCM published the comprehensive report, *Weather Information for Surface Transportation-National Needs Assessment Report*, which provides the first-ever compilation and analysis of weather support needs across six surface transportation sectors (roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations). In August 2004, OFCM established the Working Group for Weather Information for Surface Transportation (WG/WIST) to develop both a *WIST R&D Plan* and a *WIST Implementation Plan*. OFCM also conducted two WIST workshops June 6-7 and June 13-14, 2006, with the objectives to: (1) help determine the priorities for the surface transportation weather information research needed to provide improved weather information and services to the surface transportation community; (2) gather and crossfeed information concerning ongoing or planned (next 3 years) surface transportation weather-related research and development; and (3) hear from workshop attendees on what they see as a vision (3-10+ years) on how weather information will be used to optimize surface transportation operations and safety, and what specific hurdles must be overcome to reach such a vision. Information from these workshops has been reviewed and organized to support continued progress in this important area, which will lead to the *WIST R&D Plan* and *WIST Implementation Plan* mentioned above. In addition, in August 2006, OFCM published the report, *Weather Information for Surface Transportation-Update on Weather Impacts and WIST Results*. This update focused on the status of transportation weather issues in the nation and the results achieved since the first WIST report in 2002. It also highlighted areas where further steps can be made in the near term. When statewide transportation incident reporting systems are implemented, we will be able to monitor, assess, and manage transportation weather risks, as well as evaluate the benefits of WIST-informed transportation decisions. R&D programs are in progress to improve warnings and decision support systems, implement weather-responsive traffic management in communities, and provide the observational support necessary for location-specific WIST

During the period of this report, OFCM attended and participated in the National Research Council Transportation Research Board (TRB) 86th Annual Meeting in Washington, D.C., January 21-25, 2007; the Intelligent Transportation Society of America (ITS-A) 2007 Annual Meeting and Exposition in Palm Springs, California, June 4-6, 2007; and the Mid-Continent Transportation Research Symposium in Ames, Iowa, August 16-17, 2007.

Very importantly, from July 25-27, 2007, OFCM and the Federal Highway Administration Road Weather Management Program cosponsored the Third National Symposium on Surface Transportation Weather in Vienna, Virginia. The symposium theme was *Improving Commerce and Reducing Deaths and Injuries through Innovative, Weather-related R&D and Applications for the Surface Transportation System*. The goal of the symposium was to advance the state of the surface transportation weather enterprise, including the use of weather and climate information to support decision making, safety, and productivity within the six surface transportation modes and related industries. Objectives were to: (1) Articulate a clear observation strategy for surface transportation weather that defines the types of data that are needed and the optimal mix of observing platforms required to meet those needs; (2) Identify the priorities, challenges, and opportunities for research and development that will contribute to saving lives, reducing injuries, and improving efficiency in the nation's surface transportation infrastructure; (3) Define the needs for advanced computing capacity required for surface transportation weather modeling and for the assimilation of data from multiple data sources; (4) Identify the needs for new products and services driven by current operations or concepts for future surface transportation systems; (5) Investigate opportunities to document and substantiate the socioeconomic impacts of improved surface transportation weather products and services; (6) Identify the potential and emerging information dissemination technologies available to get the "right message" to surface transportation weather stakeholders; and (7) Establish partnerships with the stakeholder community to ensure that customers and stakeholders understand how to effectively use surface transportation weather products and services in their decision-making processes. Keynote addresses were given by Mr. Jeffrey N. Shane, Undersecretary of Transportation for Policy, U.S. Department of Transportation; VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, U.S. Department of Commerce; and Dr. Gene Whitney, Assistant Director for Environment, Science Division, White House Office of Science and Technology Policy.

Information stemming from the eight symposium sessions was summarized into categories that cut across many of the sessions. The categories are: current and emerging capabilities and transition of research to operations activities to improve products and services; getting the right message out-need for social science involvement; education and outreach; need for metrics to measure success and guide resource allocation; gaps and research priorities; and opportunity for a near-term intermodal initiative. Action items from the symposium are:

- The background work has been done and there is a need for more significant interagency coordination and support.
- Within the OFCM infrastructure, ICMSSR should consider raising the level of agency representation for WG/WIST to a level more appropriate for supervising work that falls within and under the WG/WIST's purview.
- The community should seriously consider requesting OFCM-sponsored Joint Action Group(s) be formed to accomplish actions outlined below. The JAG(s) would be aligned under the WG/WIST.
  - Develop an integrated observing strategy to include identification of critical new surface transportation weather and road condition sensor needs.
  - Establish several high-level R&D priorities for agencies to focus on and to collaborate with the academic community and the private sector.
  - Improve interagency coordination of products and services for common applications (joint use/cross-feed/new requirements).
  - Consider sponsoring a multi-mode surface transportation weather demonstration project (road/rail/maritime/pipeline/etc.).
  - Conduct socioeconomic surveys of impacts and needed format/semantic changes to improve understanding and usability of required products and services.
  - Consider fast tracking a Post-Doctoral position assigned to the National Centers for Environmental Prediction/Environmental Modeling Center, focused on surface transportation needs for modeling and prediction and products and services.

AVIATION WEATHER

In August 2007 OFCM published an important document in the area of aviation weather support, *The National Volcanic Ash Operations Plan for Aviation and Support of the International Civil Aviation Organization International Airways Volcano Watch (NVAOPA)*. This plan is the national operations plan in support of observing, tracking, monitoring, forecasting and reporting volcanic ash in the atmosphere that affects the safety of flight operations in the U.S. National Airspace System (NAS). It identifies the Federal agencies that implement these actions and describes their responsibilities, procedures, actions, and message formats. It also provides information on how the Federal Aviation Administration (FAA) meets its obligations to the International Airways Volcano Watch, sponsored by the International Civil Aviation Organization. Participating agencies include, in addition to FAA, the Department of Commerce National Oceanic and Atmospheric Administration's National Environmental Satellite, Data, and Information Service, the National Weather Service, and the Office of Oceanic and Atmospheric Research; the Department of Defense U.S. Air Force; and the Department of Interior's U.S. Geological Survey. The National Aeronautics and Space Administration (NASA) and the Smithsonian Institution also provide support to the Federal agencies through extending the benefits of earth science research in the areas of volcanic ash monitoring and tracking.

The OFCM continues to facilitate the continuation of interagency funding for the acquisition of automated meteorological observations from aircraft in partnership with several major U.S. commercial airlines.

The OFCM attended the Next Generation Air Transportation System (NGATS) Weather Integrated Product Team (IPT) Executive Committee and Friends and Partners in Aviation Weather meetings held in Orlando, Florida, in October 2006. OFCM also continued to implement the National Aviation Weather Program during FY 2007. The Federal interagency National Aviation Weather Program has resulted in a major reduction of weather-related accidents. The program remains on track toward meeting the established goal to reduce weather-related accidents by 80 percent by 2007. The OFCM continues to monitor progress in meeting this goal by monitoring weather-related aviation accident events and trends. *A National Aviation Weather Program Mid-Course Assessment* was completed in August 2003. OFCM is preparing a final assessment for 2007, the ten year point of the National Aviation Weather Program.

The OFCM continues to implement the National Aviation Weather Program, and is working with the agencies to advance meteorological standards, improve products, enhance services, and participate in research that contributes to the overall goal of providing the best state-of-the-art information to aviation end users where and when they need it. OFCM is a member of the Executive Committee of the interagency Joint Planning and Development Office (JPDO) Weather Integrated Product Team (WxIPT), and has monitored the early development of the Next Generation Air Transportation System concept of operations with special emphasis on how weather support will be integrated into the concept of operations for the overall NAS 2025. OFCM's coordinating infrastructure will continue to contribute to collaboration and coordination in the aviation community.

SPACE WEATHER

It was noted at the November 16, 2004, and December 1, 2004, meetings of the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) and Federal Committee for Meteorological Services and Supporting Research (FCMSSR), respectively, that the National Space Weather Program (NSWP) was nearing the end of its 10-year period to accomplish its overarching goal to achieve an active, synergistic, interagency system; providing timely, accurate, and reliable space weather warnings, observations, specifications, and forecasts by 2007. It was also noted that it was time to perform an interagency assessment to look at the progress toward meeting its goals. A National Space Weather Program Assessment Committee was formed by OFCM to perform the assessment, which was led by Dr. Louis J. Lanzerotti, Distinguished Research Professor, Center for Solar-Terrestrial Research, New Jersey Institute of Technology. The charge to the Assessment Committee was to review the NSWP to quantify and document the progress toward meeting the NSWP stated goals in observations, research, modeling, transition of research to operations, and education and outreach; to see if the program is still on target and moving in the direction pointed to by the *Strategic Plan*; to determine whether the strategic goals should be adjusted at this time based on emerging/evolving requirements; and to suggest a way ahead which will form a basis for a new strategic plan covering the next 10 years. The committee's activities in conducting the assessment included briefings at OFCM; visits to the National Security Space Office, National Reconnaissance Office, NOAA's Space Environment Center, U.S. Geological Survey, Air Force Space Command, Air Force Weather Agency, Air Force Space Weather Operations, STRATCOM, and Air Force Research Laboratory; community and user questionnaires; and issuance of a September 2005 interim report. Important reference sources were the *National Security Space Architecture 2000: Space Weather Architecture*; U.S. Department of Commerce Service Assessment, April 2004; and the *National Academies report, The Sun to the Earth-and Beyond: A Decadal Research Strategy in Solar and Space Physics, 2002*.

In its R*eport of the Assessment Committee for the National Space Weather Program* (June 2006), the Assessment Committee concluded that, since the program's inception in 1995, it has had a number of noteworthy achievements, most of which likely would not have been attained without the program's existence. The committee also found shortfalls in the program. Based on the conclusions of the committee as contained in the report, continuation of the *NSWP* is strongly warranted because of the enormous potential to enhance the nation's space weather mission over the next 10 years through improved operational capabilities, which capitalize on the transition of innovative research. Moving NOAA's operational space weather prediction center (i.e., the Space Environment Center) from its research organization to the National Weather Service was a positive step to improve operational focus within the NSWP. The committee made a number of recommendations to further strengthen the NSWP in the areas of (1) centralized program management, national priorities, and increased effectiveness; (2) continuity of data sources; (3) strengthening the science-to-user chain; and (4) public and user awareness of space weather.

It was agreed that the *Report of the Assessment Committee for the National Space Weather Program* should proceed for consideration by the National Space Weather Program Council (NSWPC), and that the Program Council should be the executive agent for FCMSSR for continuing activities in this area. The NSWPC has accepted the report and has begun taking actions to address the report's recommendations.

Space weather activities also include creating a Space Weather Implementation Plan (SWxIP) as requested by the Committee on Environment and Natural Resources (CENR) Subcommittee for Disaster Reduction (SDR). Space weather was identified as one of the SDR's Grand Challenges for Disaster Reduction and SDR requested that the OFCM spearhead an effort, through the NSWP, to develop the SWxIP.

In addition the OFCM sponsored the American Meteorological Society policy workshop on "Integrating Space Weather Observations and Forecasts into Aviation Operations" which was held November 29-30, 2006, in Washington, D.C., that led to recommendations on how to improve the safety and operations of the aviation system through better integration of space weather information. The workshop revealed that there are four main policy issues that need to be addressed to ensure the best use of current space weather information: communication, standardization of information and regulations, education and training, and cost benefit and risk analysis. The report of the policy workshop was issued in March 2007; it provided detailed recommendations for each of the main policy areas.

The OFCM also formed a Joint Action Group for Space Environment Sensors (JAG/SES) to address guidance from the Office of Science and Technology Policy (OSTP), requesting that the OFCM conduct, through its Federal coordinating infrastructure, an assessment of the impacts on the National Space Weather Program of Nunn-McCurdy certification of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program, which resulted in a significant decrease in the capability of the space environment sensor (SES) suite previously manifested on NPOESS. The assessment will be completed in the fall of 2007.

PHASED ARRAY RADAR

The OFCM Joint Action Group for Phased Array Radar Project (JAG/PARP) completed the report, *Federal Research and Development Needs and Priorities for Phased Array Radar* (June 2006). It is responsive to ICMSSR Action Item 2004-2.3 where ICMSSR supported the joint action group's "continued work to identify and document the potential needs and benefits that phased array radar and an adaptive radar sensing strategy would address, and to integrate those identified needs into a multiagency-coordinated R&D plan that would focus R&D efforts on meeting each agency's need." The report identified research and development for the next 9 years to capitalize on the replacement opportunity. This would support the research needed to reduce risk, determine the capability of multifunction phased array radar (MPAR) to meet multiple user needs concurrently, develop a full MPAR prototype, and perform a cost analysis to determine system affordability. Delays in performing the necessary MPAR research, development, and testing could result in a missed opportunity to replace legacy radars. At its July 18, 2006, meeting, ICMSSR decided that an MPAR interagency working group should be established within the OFCM infrastructure with a defined charter to develop a strategy to address the key findings and recommended next steps in the MPAR report, and agency comments from the ICMSSR meeting. The Working Group for Multifunction Phased Array Radar (WG/MPAR) was established in September 2006. Cochairs for WG/MPAR are Dr. James F. Kimpel, Director of the NOAA National Severe Storms Laboratory (NSSL); Col Michael Babcock, USAF, Air Force Weather Deputy for Federal Programs; Mr. James H. Williams, Director of Systems Engineering for the Federal Aviation Administration; and Mr. Kevin "Spanky" Kirsch of the Science and Technology Directorate, Department of Homeland Security.

Benefits of an affordable MPAR include: potential replacement for the aging fleet of mechanically scanning radars over the next 20 years; allows consolidation of multiple single-mission radars into a single system, reducing the national radar fleet by more than 40 percent, saving nearly $5 billion over a 30-year lifecycle; provides both air and weather surveillance from a single radar site; no moving parts, lower maintenance costs; multiple transmit/receiver components, avoiding single point of failure; scalable design of prototype will provide proof of concept for future MPAR; better weather measurements; increased safety and capacity in severe weather conditions; terminal and en route surveillance; homeland security; and discrimination of non-meteorological hazards such as volcanic ash, airborne debris, smoke detection and tracking, and biological scatterers such as bird flocks.

Future efforts include: (1) Develop an affordable MPAR prototype for civilian use; (2) Refine radar requirements and lay the groundwork for MPAR cost/benefit analysis; (3) Implement the 9-year research and development plan proposed in the report, *Federal Research and Development Needs and Priorities for Phased Array Radar*; (4) Establish contacts and initiate partnerships with industry leaders in phased array technology; (5) Coordinate agency programming for the MPAR risk reduction effort; (6) The Board on Atmospheric Sciences and Climate evaluation of the MPAR planning process to date, *Evaluation of the Multifunction Phased Array Radar Planning Process*; (7) The MPAR Symposium, October 10-12, 2007, in Norman, Oklahoma, which will engage Federal stakeholders, academia, and industry; (8) Working Group for Multifunction Phased Array Radar (WG/MPAR) continue to refine user requirements; and (9) solidify technical requirements for the MPAR system, including engineering trade studies to balance user needs with lowest cost.

In a June 1, 2007 letter of commendation to the Federal Coordinator, Brig Gen Lawrence A. Stutzriem, USAF, Director of Weather, emphasized that MPAR will have a direct influence on the Air Force's capabilities. He also noted that other relevant, important projects in which OFCM is engaged include space weather, wildland fire, tropical cyclones, weather information for surface transportation, and volcanic ash. Also, in a January 31, 2007, Program Decision Memorandum issued by VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, the Admiral emphasized evaluating the electronically steered MPAR as an alternative to mechanically steered conventional radar to meet severe and non-severe weather and aviation weather service requirements and to track the release of toxic agents as input into atmospheric dispersion forecasts; and, also, if the technical trade-off study and preliminary cost-benefit analysis support transitioning MPAR to operations, development of a transition plan for this purpose. The Program Decision Memorandum also included highlights for OFCM's hurricane, wildland fire, and weather information for surface transportation activities.

ATMOSPHERIC RESEARCH AND DATA ASSIMILATION/DATA MANAGEMENT

Advances in data assimilation are key to meeting virtually any forecast goal relating to model performance. It was stated in the *Strategic Plan for the U.S. Integrated Earth Observation System* (April 2005) that "In order to take the 'pulse of the planet,' we must establish a valid end-to-end process that will take us from observations to user-related products. Scientific needs for this end-to-end process require that we … assimilate the Earth observation data streams into models (eventually in real time) …" and "Data assimilation may be the most critical path through which advances in forecasting convective precipitation will be modulated." At its November 16, 2004, meeting, the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) supported action to examine gaps in data assimilation and data management capability, articulate challenges that lie ahead in meeting future requirements, and propose strategy to address gaps in capability and future challenges. And Action Item 2004-1.2 from the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) December 1, 2004, meeting, recommended that: FCMSSR agencies will support R&D needs and requirements based on agency priorities and will continue to identify issues and concerns that are necessary for the development of capabilities required to realize societal benefits; Federal requirements and capabilities in key areas like data assimilation need to be surveyed and further addressed; and FCMSSR agencies will support and facilitate opportunities for the transition of research into operational applications.

The data assimilation survey and follow-on strategy was briefed at the July 18, 2006, ICMSSR meeting. It was noted that the focus of the report which is being prepared is on data assimilation for the purpose of improving forecast skill of a numerical weather prediction (NWP) model; the scope of data assimilation is restricted to incorporation of observational data as a forcing factor in cycles of forward NWP models; and broader definition of data assimilation would be addressed through inclusion of related activities such as climate reanalysis, trace constituent monitoring, and air quality. Key data assimilation issues are:

- Data delivery and standard formatting.
- How best to evolve assimilation techniques over time to meet future application challenges.
- Early delivery of new instrument data.
- Testing and transitioning new data assimilation techniques and concepts into "hardened" data assimilation instruments for operational use.
- Availability of high performance computing and trained personnel
- Data staging and delivery required for Global Earth Observation System of Systems (GEOSS)-level infrastructure capability.
- Education and public outreach: implications for data assimilation and modeling.

Data gathering and data assimilation activity analysis tasks are essentially complete; the report framework and key issues have been defined by the data assimilation group; and next steps are being defined. The draft report, *Federal Meteorological Data Assimilation Capabilities*, will be coordinated with ICMSSR at its November or December 2007 meeting.

CROSSCUTTING HYDROMETEOROLOGICAL ASSESSMENT

During this period OFCM began a crosscutting assessment of Federal agency hydrometeorological products, services, and supporting research. The three primary objectives of the assessment are: (1) Define the needs and requirements for hydrometeorological products, services, and supporting research for the Federal agencies and the customers they support; (2) Investigate agency plans and alternatives for satisfying new requirements; and (3) Create more efficient and effective partnerships among the agencies to better leverage subject-matter expertise and resources to meet the growing needs for better hydrometeorological products and services. Agencies which will be involved include: NOAA (National Weather Service and National Ocean Service-principal providers); Department of Interior (U.S. Geological Survey-stream flow, streamgaging, flood monitoring, ground-water climate response network; U.S. Bureau of Reclamation-dams, reservoirs, and *Agrimet* and *Hydromet* operations; U.S. Fish and Wildlife Service-coastal ecosystems; and National Park Service-tourism and natural resource monitoring and management); Department of Agriculture (USDA-drought monitor; National Resources Conservation Service-conservation and watershed planning); Department of Defense (U.S. Army Corps of Engineers-flood plain management, Gulf Coast Hurricane Protection System); Department of Homeland Security (Federal Emergency Management Agency-National Flood Insurance Program, flood hazard mapping, post-storm data acquisition; U.S. Coast Guard-protect against degradation of natural resources associated with maritime transportation, fishing, and recreational boating); Environmental Protection Agency-water resource protection; and National Aeronautics and Space Administration-remote sensing. A key element of the assessment is to engage the users of this Federal information and OFCM is ensuring that we understand the needs of user groups such as the National Emergency Management Association, International Association of Emergency Managers, Association of State Floodplain Managers, National Hydrologic Warning Council, American Meteorological Society, and the media (e.g., The Weather Channel and other TV broadcasters).

ENVIRONMENTAL LITERACY

The OFCM has laid out a vision, framework, and methodology which the office will embrace to systematically promote and execute environmental literacy through interdepartmental collaboration within the OFCM coordinating infrastructure. The methodology defines how to determine if an opportunity to promote environmental literacy exists. It also describes the method to be used to determine the target public, private, and/or academic sector audiences and how to reach them. Determining the target audiences' needs and a means for assessing how those needs are being met is incorporated into the methodology as well. Executing this methodology will result in a nation better able to understand the linkages between weather and climate and personal and professional choices and build a national capacity to solve problems and respond to change. It will provide for a more environmentally literate citizenry. In this regard, the OFCM developed an implementing strategy/action plan to make environmental literacy a crosscutting priority within the OFCM coordinating infrastructure. An *Implementing Strategy for Promoting Environmental Literacy as an OFCM Crosscutting Priority* was presented to the science community at the American Geophysical Union (AGU) Fall Meeting, December 5-9, 2005, in San Francisco, California. OFCM is also making environmental literacy an important part of the *National Wildland Fire Weather Needs Assessment* discussed earlier in this report. The OFCM is also continuing its support of an American Meteorological Society undergraduate scholarship in the atmospheric and related oceanic and hydrologic sciences.

FREQUENCY MANAGEMENT

Both international and domestic spectrum policy are of critical importance to the Federal meteorological community and can significantly impact our ability to carry out our assigned duties and responsibilities. The OFCM Working Group for Frequency (Radio Spectrum) Management (WG/FM) acts as a two-way clearinghouse for information on environmental use of the radio spectrum. It fosters cooperation and coordination among Federal agencies for the collection and consolidation of agency needs and requirements related to frequency management issues as they affect meteorological services, and for planned non-environmental spectrum uses that may affect the environmental community for good or ill. During FY 2007, the OFCM updated its frequency management issues document to provide the interagency community with background information, current status of meteorological uses, potential future technology that could impact spectrum bandwidth, identification of other new frequency management issues, and recommendations for agency involvement in the radio spectrum area.

GUIDANCE AND PRACTICES FOR XML

During FY 2007, the charter for the Committee for Environmental Information Systems and Communications (CEISC) Joint Action Group for Extensible Markup Language and Web Services (JAG/XMLWS) was enhanced so that this group would serve as the primary national collaboration forum to work on three primary objectives. These include: (1) Establish agreed national standards (develop by JAG/XMLWS or obtained from national or international standards bodies) and common services and components for common weather information exchange in a net-centric operations environment. (2) Serve as the national working body to develop the U.S. position and candidate standards for adoption consideration for the newly formed World Meteorological Organization (WMO) Expert Team on the Assessment of Data Representation Systems. And (3) Support the development of a specialty subset of national standards specifically related to aviation weather. This is needed both in support of the Next Generation Air Transportation System (NextGen) and to support the Federal Aviation Administration (FAA) engagement with EUROCONTROL on a similar need for equivalent aviation system modernization. The desired intent is to develop common standards to be used both by EUROCONTROL and by NextGen.

COLLABORATION WITH NAS/NRC BOARD ON ATMOSPHERIC SCIENCES AND CLIMATE

The OFCM continued its mutually beneficial interactions with the National Academy of Sciences/National Research Council (NAS/NRC). The NAS/NRC Board on Atmospheric Sciences and Climate (BASC) conducted a strategic planning workshop on August 8-9, 2006, in which the Federal Coordinator for Meteorology participated. The workshop was held at the J. Erik Jonsson Woods Hole Center of the National Academy of Sciences in Woods Hole, Massachusetts. The purposes of the meeting were to identify emerging issues facing the atmospheric sciences and climate communities, and to discuss future goals of BASC and set priorities for action. Emerging issues were examined in meteorology, weather, atmospheric composition and other areas relevant to the BASC mission. A balance was achieved in considering issues in basic and applied science, and policy; varied disciplines and interdisciplinary areas; and technology as well as research. In addition, during FY 2007 the OFCM initiated an activity with BASC to evaluate the planning to date related to continued development of multifunction phased array radar (MPAR). Specifically, a BASC committee will evaluate whether the planning process to date has been comprehensive and inclusive;

whether the June 2006 OFCM report, *Federal Research and Development Needs and Priorities for Phased Array Radar*, has identified the full range of benefits, costs, challenges, and potential participants; whether cost estimates to date are realistic, represent the best available information, and exclude any potential life-cycle benefits or costs; whether there are any significant gaps or errors in initial planning; whether appropriate areas of uncertainty have been identified and follow-on risk assessments conducted; and, based on the information available to the committee, whether the MPAR planning process should go forward and what improvements could be recommended.

COLLABORATION WITH THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES

CENR PRINCIPALS

The Federal Coordinator continued to be a participant on the CENR, and continued to assist CENR through review and concurrence of CENR reports and materials. At the request of the Office of Science and Technology Policy (OSTP), the Federal Coordinator also reviewed and approved the reports, *A Strategy for Federal Science and Technology to Support U.S. Water Availability and Quality*, and *National Assessment of Efforts to Predict and Respond to Harmful Algal Blooms in U.S. Waters*.

SUBCOMMITTEE ON DISASTER REDUCTION

The OFCM has been an active participant in the work of the CENR Subcommittee on Disaster Reduction (SDR). SDR has developed Grand Challenges implementation plans, to improve the nation's capacity to prevent and recover from disasters. These disaster scenarios serve as a useful tool for sharing the ideas behind the 2005 SDR Grand Challenges document and demonstrating their possible application. The implementation plans include such topics as assessing disaster resilience, understanding the natural processes that produce hazards, promoting risk-wise behavior, etc. Space weather was identified as one of the SDR's Grand Challenges for Disaster Reduction, and during FY 2007, SDR requested that the OFCM spearhead an effort, through the National Space Weather Program, to develop a Space Weather Implementation Plan (SWxIP). SDR has also completed a Windstorm Impact Reduction Implementation Plan which is the culmination of an SDR-led, coordinated Federal effort, in cooperation with other levels of government, academia, and the private sector, to improve understanding of windstorms and their impact, and develop and encourage implementation of cost-effective mitigation measures to reduce those impacts while promoting community resilience. In addition, the SDR working group on satellite issues has participated in the creation of a waiver for the 24-hour wait period on high resolution commercial satellite imagery. The need of state and local governments as well as private entities to respond quickly in the aftermath of Hurricane Katrina and other natural disasters was the impetus behind the waiver request, which has been instituted domestically. OFCM is committed to working with SDR to provide a forum for information sharing, development of collaborative opportunities, and interactive dialogue with the U.S. policy community to advance informed strategies for managing risks associated with natural and technological disasters.

AMERICAN METEOROLOGICAL SOCIETY

During FY 2007, the OFCM supported the 2007/2008 American Meteorological Society (AMS) Freshman Undergraduate Scholarship Program. The scholarship program is open to all high school students and designed to encourage study in the atmospheric and related sciences. The scholarships will be awarded, based on academic excellence, to high school seniors entering their freshman year of study in the atmospheric, oceanic, or hydrologic sciences. The scholarships are for the freshman and sophomore years, with second-year funding dependent on successful completion of the first year. The OFCM also supports AMS endeavors by participating in AMS conferences and workshops and other environmental science education and outreach programs, including for example the January 14-18, 2007, 87th AMS Annual Meeting in San Antonio, Texas; the April 16-17, 2007, AMS Policy Forum in Washington, D.C.; the June 24-29, 2007, AMS 22nd Conference on Weather Analysis and Forecasting/18th Conference on Numerical Weather Prediction, Park City, Utah; and the September 10-13, 2007, 7th AMS Symposium on the Urban Environment in San Diego, California. The OFCM also sponsored the American Meteorological Society policy workshop on "*Integrating Space Weather Observations and Forecasts into Aviation Operations*" which was held November 29-30, 2006, in Washington, D.C., that led to recommendations on how to improve the safety and operations of the aviation system through better integration of space weather information. In addition, during this period an OFCM staff member was Chairperson of the AMS Weather Analysis and Forecasting Committee; and served as Cochair of the 2007 AMS Annual Meeting held in San Antonio, Texas. Another OFCM person initiated and is serving as lead for an AMS Hurricane Disasters Annual Partnership Topic (APT) on *Building America's Resilience to Hurricane Disasters,* which is exploring how the private sector can engage more fully in hurricane disaster prevention, preparedness, and recovery actions; protecting the poor and most vulnerable in hurricane disasters; and education issues on responses to forecasts and warnings for hurricanes. And the Federal Coordinator was selected to serve as a member of the AMS Commission on the Weather and Climate Enterprise (CWCE) and its Commission Steering Committee (CSC).

INTERNATIONAL COLLABORATION

During FY 2007, the China Meteorological Administration (CMA) completed the task of translating the OFCM document, *Weather Information for Surface Transportation-National Needs Assessment Report (2002)*, into the Chinese language. This OFCM report is a first-ever compilation of weather information for surface transportation (WIST) needs across the six surface transportation sectors-roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations-and an analysis of these needs. In a preface to the Chinese edition of the WIST report which was provided by the U.S. Federal Coordinator for Meteorology, the Federal Coordinator noted that the commitment to translate the document into Chinese shows that the value of weather information for surface transportation is becoming recognized around the world, and that it offers substantial returns on investment to every society that desires safe and efficient transportation systems. He also noted that WIST is a wonderful example of the need for every modern society to view its meteorological services from the perspective of end-to-end systems: from the atmospheric and other environmental observations all the way to the decision processes of the users. OFCM continued to participate in other opportunities as they arose during FY 2007. The OFCM Committee for Environmental Information Systems and Communications (CEISC) Joint Action Group for XML and Web Services (JAG/XMLWS) served as the national body to develop the U.S. position and candidate standards for adoption consideration for the newly formed World Meteorological Organization (WMO) Expert Team on the Assessment of Data Representation Systems, and also supported the development of a specialty subset of national standards specifically related to aviation weather.

PUBLICATIONS

The following publications were prepared in hard copy and/or have been placed on OFCM's Web site (www.ofcm.gov):

- *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2007*
- *National Hurricane Operations Plan*
- *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*
- *Federal Plan for Cooperative Support and Backup Among Operational Processing Centers*
- *The National Volcanic Ash Operations Plan for Aviation and Support of the International Civil Aviation Organization International Airways Volcano Watch*
- *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part A-System Concepts, Responsibilities and Procedures*
- *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part C-WSR-88D Products and Algorithms*

The following documents are planned for publication during FY 2008:

- *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2008*
- *National Hurricane Operations Plan*
- *Strategic Plan for Improved Tropical Cyclone Reconnaissance Systems*
- *Exploratory Review of Information Dissemination Flow*
- *National Wildland Fire Weather: User Needs and Issues*
- *National Wildland Fire Weather: Strategic Framework to Meet User Needs*
- *Federal Meteorological Data Assimilation Capabilities*
- *Criteria for Selection of Joint Urban Test Beds (JUTB)*
- *The National Space Weather Program: Strategic Plan - 2nd Edition*
- *The National Space Weather Program: Implementation Plan - 3rd Edition*
- *National Wildland Fire Weather: A Summary of User Needs and Issues*

Table A.1 Current OFCM Publications

Publication Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 2007	*October 2006*	*FCM-P1-2006*
National Plan for Space Environment Services and Supporting Research: 1993-1997	August 1993	FCM-P10-1993
National Severe Local Storms Operations Plan	*May 2001*	*FCM-P11-2001*
National Hurricane Operations Plan *WSR-88D Tropical Cyclone Operations Plan*	*May 2007*	*FCM-P12-2007*
National Winter Storms Operations Plan	*December 2005*	*FCM-P13-2005*
Federal Plan for Cooperative Support and Backup Among Operational Processing Centers	Mar 2007	FCM-P14-2007
National Plan for Stratospheric Monitoring, 1988-1997	July 1989	FCM-P17-1989
National Aircraft Icing Technology Plan	April 1986	FCM-P20-1986
National Plan to Improve Aircraft Icing Forecasts	July 1986	FCM-P21-1986
Federal Plan for the Coordination of Automated Weather Information System Programs	May 1988	FCM-P23-1988
Federal Plan for Meteorological Information Management	July 1991	FCM-P24-1991
National Plan for Tropical Cyclone Research and Reconnaissance (1997-2002)	January 1997	FCM-P25-1997
National Aviation Weather Program Plan	September 1992	FCM-P27-1992
National Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS) Operations Plan	August 1997	FCM-P28-1997
Federal Plan for Marine Environmental Data, Services, and Supporting Research	June 1996	FCM-P29-1996
The National Space Weather Program: Strategic Plan	*August 1995*	*FCM-P30-1995*
The National Space Weather Program: Implementation Plan - 2nd Edition	*July 2000*	*FCM-P31-2000*
National Aviation Weather Strategic Plan	*April 1997*	*FCM-P32-1997*
National Post-Storm Data Acquisition Plan	*March 2003*	*FCM-P33-2003*
National Aviation Weather Initiatives	*February 1999*	*FCM-P34-1999*
National Volcanic Ash Operations Plan for Aviation and Support of the ICAO International Airways Volcano Watch	*August 2007*	*FCM-P35-2007*
Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead	*February 2007*	*FCM-P36-2007*
Tropical Cyclone Studies Tropical Cyclone Studies Supplement	December 1988 August 1989	FCM-R11-1988 FCM-R11-1988S
Interdepartmental Meteorological Data Exchange System Report, IMDES	*August 1998*	*FCM-R12-1998*

Table A.1 Current OFCM Publications (cont.)

Publication Title	Date	Number
Federal Meteorological Requirements 2000	October 1990	FCM-R13-1990
U.S. Wind Profiler: A Review	*March 1998*	*FCM-R14-1998*
Aviation Weather Training: A Report on Training for Emerging and Recently Implemented Aviation Weather Programs	*April 2002*	*FCM-R16-2002*
Atmospheric Modeling of Releases from Weapons of Mass Destruction	August 2002	FCM-R17-2002
Weather Information for Surface Transportation--National Needs Assessment Report	*December 2002*	*FCM-R18-2002*
Report on Wind Chill Temperature and Extreme Heat Indices: Evaluation and Improvement Projects	*January 2003*	*FCM-R19-2003*
National Aviation Weather Program Mid-Course Assessment	*August 2003*	*FCN-R20-2003*
Aviation Weather Programs/Projects-2004 Update (Tier ¾ Baseline Update)	*December 2004*	*FCM-R21-2004*
Urban Meteorology: Meeting Weather Needs in the Urban Community	*January 2004*	*FCM-R22-2004*
Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling	*September 2004*	*FCM-R23-2004*
Report of the Assessment Committee for the National Space Weather Program	*June 2006*	*FCM-R24-2006*
Federal Research and Development Needs and Priorities for Phased Array Radar	*June 2006*	*FCM-R25-2006*
Weather Information for Surface Transportation - Update on Weather Impacts and WIST Results	*August 2006*	*FCM-R26-2006*
Federal Meteorological Handbook No. 1 - Surface Weather Observations and Reports	*September 2005*	*FCM-H1-2005*
Federal Meteorological Handbook No. 2 - Surface Synoptic Codes	December 1988	FCM-H2-1988
Surface Synoptic Code Tables (Update)	July 1990	FCM-T1-1990
Federal Meteorological Handbook No. 3 - Rawinsonde and Pibal Observations	*May 1997*	*FCM-H3-1997*
Federal Meteorological Handbook No. 10 - Meteorological Rocket Observations	December 1988	FCM-H10-1988
Federal Meteorological Handbook No. 11 - Doppler Radar Meteorological Observations		
Part A - System Concepts, Responsibilities and Procedures	*May 2007*	*FCM-H11A-2007*
Part B - Doppler Radar Theory and Meteorology	*December 2005*	*FCM-H11B-2005*
Part C - WSR-88D Products and Algorithms	*Apr 2006*	*FCM-H11C-2006*
Part D - WSR-88D Unit Description and Operational Analysis	*February 2006*	*FCM-H11D-2006*
Federal Meteorological Handbook No. 12 - United States Meteorological Codes and Coding Practices	*December 1998*	*FCM-H12-1998*
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	November 1994	FCM-S2-1994
Standard Telecommunication Procedures for Weather Data Exchange (under revision)	October 1991	FCM-S3-1991

Table A.1 Current OFCM Publications (cont.)

Publication Title	Date	Number
Federal Standard for Siting Meteorological Sensors at Airports	*August 1994*	*FCM-S4-1994*
Directory of Atmospheric Transport and Diffusion Consequence Assessment Models	*March 1999*	*FCM-I3-1999*
Federal Directory of Mobile Meteorological Equipment and Capabilities	*December 1995*	*FCM-I5-1995*
A Guide to WMO Code Form FM 94 BUFR	*March 1995*	*FCM-I6-1995*
Proceedings for the Symposium on Weather Information for Surface Transportation: Delivering Improved Safety and Efficiency for Tomorrow	*February 2000*	
Proceedings of the Workshop on Multiscale Atmospheric Dispersion Modeling within the Federal Community	*June 2000*	
Proceedings of the Aviation Weather User Forum--Aviation Weather: Opportunities for Implementation	*July 2000*	
Proceedings of the Symposium on Weather Information for Surface Transportation -- Preparing for the Future: Improved Weather Information for Decision Makers	*March 2001*	
National Aviation Weather Initiatives, Final Baseline Tier 3 and 4 Report	April 2001	
Proceedings of the Forum on Risk Management and Assessment of Natural Hazards	*July 2001*	
Proceedings of the Workshop on Strategy for Providing Atmospheric Information	*March 2002*	
Proceedings of the Workshop on Effective Emergency Response	*May 2002*	
Proceedings of the 2nd International Conference on Volcanic Ash and Aviation Safety	*November 2004*	
Proceedings of the User Forum on Urban Meteorology	*March 2005*	

Italics = publication available online at *www.ofcm.gov*

APPENDIX B

WORLD WEATHER WATCH PROGRAM

The Department of Commerce (DOC) was designated by the President, following Senate Concurrent Resolution 67 (1968), to be the lead agency for coordinating United States participation in the World Weather Watch (WWW) program. Until 1983, DOC published a separate report on WWW plans. Beginning with the 1983 edition of the Federal Plan for Meteorological Services and Supporting Research, a section on the WWW has been included, obviating the need for a separate report. The last segment of this narrative includes information on bilateral and regional international cooperative activities which are not under the WWW.

GOALS AND ORGANIZATION

The World Weather Watch (WWW) program is the World Meteorological Organization's (WMO) core program. The WWW program goals are to extend the time, accuracy, range, and scope of weather prediction and to understand the physical basis of climate and climatic change. The ability of the U.S. and other nations to use their existing scientific capability to understand the climate and to increase their weather predicting skills is limited by the lack of global weather data. Available weather data are inadequately observed over a significant portion of the Earth's surface, especially over isolated areas including the oceans.

Development of the technology and the systems to obtain these observations, especially over the oceans, presents formidable problems. With the use of satellites, aircraft, ships, radar, anchored and drifting buoys, and balloons, however, an integrated system can be developed to observe and collect comprehensive data about the atmosphere over the entire globe. This system is too complex and expensive to be implemented by a single nation--a fact clearly recognized by the leaders of many nations whose international cooperation in meteorology has been a tradition for more than a century. In 1961, this continuing need for international cooperation prompted the President of the United States to propose to the United Nations (UN) the establishment of an international effort in weather prediction. The UN responded by calling upon the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) to develop measures to improve weather forecasting capabilities and to advance the knowledge of the basic physical forces that determine climate.

The WMO, with 181 member states and 6 member territories, is an intergovernmental organization affiliated with the UN to facilitate international cooperation in the fields of meteorology, climate, and operational hydrology. The WMO responded to the UN request with the concept of the WWW, an operational system to bring the global atmosphere under improved surveillance and to provide for the rapid collection and exchange of weather data as well as for the dissemination of weather products from centralized processing centers.

More recently, the WMO is working towards the design and implementation of improved observations for a Global Climate Observing System (GCOS) through enhancements to the Global Observing System (GOS) and other appropriate measures. These efforts are expected to yield an enhanced GOS for both operational and research purposes and are part of the effort to strengthen the WMO's commitment to improve the understanding of climate and related environmental matters, as articulated by the Second World Climate Conference in 1990, and repeated at the UN Conference on the Environment and Development in 1992. The WMO has established the concept of a Regional Basic Climate Network (RBCN); most observing stations would function as part of both the Regional Basic Synoptic Network (RBSN) and the RBCN.

The responsibilities of U.S. Federal agencies in the WWW are as follows:

- Department of Commerce (DOC). Represents the U.S. at WMO and, through the National Oceanic and Atmospheric Administration (NOAA), provides the focal point to coordinate our Nation's efforts in these international programs, implements those service improvements in the existing international weather system for which the U.S. accepts responsibility, and develops new technology. The U.S. is one of three (Russia and Australia are the other two) World Meteorological Centers, which include World Data Centers and the principal telecommunication gateway for the WMO's Global Telecommunication System (GTS).
- Department of State (DOS). The DOS is the principal source for U.S.-appropriated funds to the WMO. The DOS maintains relations with developing nations and, through NOAA and the WMO, assists developing nations through the Voluntary Cooperation Program (VCP) to improve their national weather services. DOS also develops appropriate multilateral and bilateral arrangements to further international participation.
- National Science Foundation (NSF). The NSF stimulates and supports basic and applied research by scientists primarily in academia on atmospheric and ocean circulation and models. It also promotes the education and training of atmospheric and ocean scientists at universities.

• Department of Defense (DOD). Although the mission of DOD weather services is basically internal, the nature of the DOD's operations is global. As such, the observation, telecommunications, and data-processing programs of the DOD weather services provide significant indirect support to the WWW through DOD's interface with NOAA's National Weather Service (NWS). Information from the research and development activities of these services is exchanged routinely with other similar national agencies and is often presented at national forums. DOD also operates a polar-orbiting meteorological satellite program.

• Department of Transportation (DOT). DOT's Federal Aviation Administration's terminal aerodrome meteorological observations and air traffic telecommunication network provides an important source of data to the WWW.

• Department of Homeland Security (DHS). Through the U.S. Coast Guard, DHS provides personnel to support NOAA's National Data Buoy Center (NDBC) in developing, deploying, operating, and evaluating data buoy systems.

• National Aeronautics and Space Administration (NASA). NASA performs research, develops aerospace technology required for an effective global weather system, and provides data from R&D satellites to the WWW. NASA launches for NOAA both polar-orbiting and geostationary satellites.

• Department of the Interior (DOI). DOI's U.S. Geological Survey (USGS) is an important source of hydrologic data used in flood forecasting. The USGS, in addition to its advisory role on water issues in the WMO, will assume a greater functional role in the WMO's emerging water program.

• Department of Agriculture (USDA). USDA is a valuable resource for surface climatological meteorological data from cooperating observers. The department's World Climate Observing Board is responsible for monitoring the impact of climate and extreme weather on both national and international commercial crops. USDA is on the WMO technical commission that works on agrometeorological issues.

THE WORLD WEATHER WATCH (WWW)

The WWW is an integrated member-operated observing system linked by the GTS and it functions on three levels -- global, regional, and national. The WWW is divided into three essential elements that are closely linked and interdependent - the Global Data Processing System (GDPS), Global Telecommunication System (GTS), and the Global Observing System (GOS).

These elements are coordinated and closely integrated through three WWW support functions:

• The data management function coordinates, monitors, and manages the flow of data and products within the WWW system to assure their quality and timely delivery. It also includes the definition and use of code forms for data exchange.

• The systems support activity provides guidance, technical and scientific information, and training to those involved in the planning, development, and operation of WWW components.

• The implementation and coordination function assures the timely completion of the WWW implementation and effective support and maintenance of the WWW system.

GLOBAL OBSERVING SYSTEM (GOS)

The GOS is a coordinated observing system, employing standardized techniques for making meteorological and marine surface observations on a worldwide scale. It is a composite system, containing surface-based (national networks), airborne (civil aviation), and space-based (satellite) subsystems. The main elements of the network and airborne subsystems include:

• The Regional Basic Synoptic Network (RBSN), staffed and automated, for both surface and upper-air observations.

• Fixed observing stations at sea, composed of fixed and anchored platform stations, and island and coastal stations.

• Mobile sea stations, including moving ships.

• Moored and drifting buoys.

• Aircraft meteorological stations, including automated aircraft reporting systems.

AIRBORNE OBSERVATIONS

The WWW has pursued a class of automated airborne reporting systems such as the Automated Meteorological Data and Reporting (AMDAR) systems. Over 3000 aircraft now provide reports of pressure, winds, and temperature during flight. The amount of data from aircraft has increased dramatically during recent years -- from 78,000 reports in 2000 to 190,000 reports in 2006. These systems are making a major contribution to the upper-air component of the GOS in regions where there is little or no radiosonde data.

The U.S. AMDAR program began in the early 1980's as a cooperative effort among ARINC (Aeronautical Radio, Inc.), the NWS, and the FAA. Over 150,000 reports of wind and temperature are sent every day in the Binary Universal Form for Representation of Meteorological Data (BUFR) code. These reports are provided by seven airlines: American, Delta, Federal Express (FedEx), Northwest, Southwest, United, and United Parcel Service (UPS). Global cooperation on AMDAR is facilitated by the WMO AMDAR Panel established in 1998 by a number of WMO members operating or intending to operate AMDAR programs. Australia, Canada, China, EUMETNET/E-AMDAR, Japan, New

Zealand, Republic of Korea, Russia, Saudi Arabia, South Africa, and the U.S. have AMDAR programs. A number of new countries have directly indicated interest in the past year in developing AMDAR including Slovenia, the Czech Republic, Malaysia, Kenya, and Mauritius, who have also appointed focal points, and Singapore has recommenced exploring possibilities of using targeted data. Specific information and guidance has been provided to all countries. Additionally, Bulgaria and Croatia have begun exploring the potential of using AMDAR in their own national programs.

In addition to wind and temperature data collection, the U.S. program is expanding the operational parameters collected to also include water vapor and turbulence. Water vapor observations from over 75 aircraft, from two different sensors have been routinely available for assessment since early 2005. A new turbulence algorithm, developed by the National Center for Atmospheric Research (NCAR) derives an objective, aircraft-independent measure of turbulence (eddy dissipation rate (EDR)) from aircraft vertical acceleration. The EDR algorithm is currently installed on 400 United Airlines aircraft, is available through the AirDat TAMDAR sensor, and will be added to several additional Southwest Airlines aircraft in the next year as well. EDR reports are being experimentally ingested into the FAA Graphic Turbulence Guidance (GTG) and as an initialization parameter.

SURFACE-BASED OBSERVATIONS

GOS employs both marine and land surface-based observing systems. Approximately 11,000 stations on land take observations at least once every three hours and often hourly of thermodynamic and wind-field parameters of the atmosphere. About 4,000 of the world's surface stations comprise the RBSN. Data from these stations are exchanged globally in real time. A subset of these surface stations are used in the Global Climate Observing System (GCOS) Surface Network (GSN). The U.S. operates 87 surface stations as part of the GCOS network. Many countries, including the U.S., have available additional surface data from specialized mesoscale networks, such as Oklahoma's Mesonet, used for research, water management, and transportation needs. The U.S. operates about 73 surface stations on the Antarctic continent. Twenty are U.S. government sponsored of which only 4 report regular observations. The other 53 sites are sponsored through university programs.

The lower atmosphere is vertically profiled using a land-based global array of about 900 upper-air stations which deploy at least once per day a balloon-borne radiosonde capable of providing in-situ measurements of basic state parameters. Approximately 15 specially outfitted commercial ships provide upper-air observations over sparsely instrumented oceanic regions. The NWS operates 92 upper-air stations and supports 15 additional sites in the Caribbean and Pacific. For all U.S. activities (including DOD and other agencies), we have reported to WMO a total of 132 sites. The U.S. has also implemented experimental or quasi-operational networks or single sites of ground-based Doppler radars called wind profilers to provide nearly continuous wind soundings. A network of 32 tropospheric wind profilers is being operated quasi-operationally at 404 MHZ, primarily in the central part of the U.S.

MARINE OBSERVATIONS

Over the oceanic regions, the global observing system relies on ships, moored and drifting buoys, profiling floats, and stationary platforms, in addition to derived data from satellite observations. The Volunteer Observing Ship fleet is comprised of some 5,000 commercial ships. About 900 ships report marine meteorology observations at least 25 times per month. A subset of the volunteer ships routinely deploys expendable bathythermograph probes to measure upper-ocean temperatures to a depth of 750 meters; about 20,000 probes are deployed annually. An array of 1250 surface drifting buoys provides 30,000 sea surface temperature and surface air pressure reports per day. Surface currents are derived by tracking the drifter movements. A network of 375 moored buoys provides about 9000 reports of surface marine observations per day. The moored buoys are located offshore of several maritime nations and also span the tropical Pacific and Atlantic Oceans. Implementation of a tropical Indian Ocean moored array is now underway. The Indian Ocean array is planned to be completed by about 2012. Argo--a global array of profiling floats--provides profiles of ocean temperature and salinity to depths of 2000 meters. Each float reports via satellite once every 10 days. As of October 2006, about 2500 Argo floats were in operation around the globe and it is expected that the array will reach its design goal of 3000 floats by early 2007.

GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)

The U.S. has been involved with GCOS since its inception. NOAA's National Climatic Data Center (NCDC) in Asheville, North Carolina, supports a number of GCOS data management activities and hosts the U.S. GCOS Program Office based in Silver Spring, Maryland [see http://www.ncdc.noaa.gov/oa/usgcos/index.htm]. This support fits in with a proactive process approach for GCOS implementation planning with the goal of obtaining a sustainable and robust GCOS observing network for international atmospheric, oceanographic, and terrestrial climate observing. The U.S. national program has taken a three-tiered approach to fostering the GCOS program. This approach involves providing support:

• Internationally to improve and enhance monitoring stations in developing nations that require assistance as identified by the international GCOS Atmospheric Observations Panel for Climate.

• Regionally for workshops and projects such as those in the Pacific Ocean region for ensuring a robust and sustainable GCOS observing program; and

• On a bilateral basis with nations that have entered into agreements with the U.S. on improving climate observing activities.

Meteorological surface-based networks, utilized for climate purposes, make observations of important climate factors; atmospheric profiles; and pollutant emissions, aerosols, and ozone. These surface-based networks are intended to provide the basic observational set needed to define the status and trends in climate of the world, and also to calibrate and validate satellite-based observations. NOAA's U.S. GCOS Program Office has committed to leading the way, in partnership with the GCOS Secretariat at the WMO, to facilitate improvements in the management and operation of GCOS and GCOS-related networks.

In general, GCOS performance measures used by NOAA in managing its international support are intended to gradually increase the quality and quantity of data from the GCOS Surface Network (GSN) and GCOS Upper-Air Network (GUAN) over the next several years. The performance measures focus on observing system improvements in developing nations in Africa, South America, and the Pacific Islands. The support for developing nations has primarily been for retrofitting surface and upper-air observing stations that have up-to-now been silent, but yet are key to global climate monitoring activities. Countries that have received new equipment and expendables over the past three years include: Argentina, Armenia, Congo, Cook Islands, Costa Rica, Ecuador, Ivory Coast, Kenya, Maldives, Namibia, the Philippines, and Zimbabwe. The U.S. State Department has been instrumental in aiding in the establishment of regional GCOS maintenance facilities which have been established in the Pacific and the Caribbean. Another one is being planned for Southern and Eastern Africa in order to further the sustainability of the GCOS network in the developing nations of that region.

Additionally, for the GSN, the performance measure is the percent explained variance in mean annual temperature in the developing world. The long-term goal is 90 percent explained variance with a network of 75 stations. This will be accomplished by deploying new observing stations that meet the same stringent requirements as those in the U.S. Climate Reference Network. For the GUAN, the long-term objective is to increase the percent of GUAN sites in the developing world that meet GCOS reporting requirements (i.e., two soundings per day for 25 days in the month, each sounding with temperature/wind data up to 5 hPa and humidity data up to the tropopause). This will be accomplished by modernizing 75 existing GUAN stations. The long-term goal is to have 90 percent of the GUAN stations in the developing world meeting GCOS requirements. The U.S. GCOS Program, in conjunction with the GCOS Secretariat and other elements in NOAA, is working towards the development of a high-quality GCOS Atmospheric Reference Observations Network (GARON). Finally, support for the chemical constituent portion of GCOS, the Global Atmosphere Watch (GAW) program is part of the integrated GCOS support provided.

GLOBAL DATA PROCESSING AND FORECASTING SYSTEM (GDPFS)

The purpose of GDPFS is to make available all processed information required for both real-time and non-real-time applications. GDPFS provides products and processed information, based on recent advances in atmospheric science, using powerful numerical computer methods. Members have real-time, unrestricted access through the GTS to GDPFS products which allow all countries to benefit from their participation in the WWW.

The GDPFS is organized as a three-level system. It consists of World Meteorological Centers (WMC), Regional/Specialized Meteorological Centers (RSMC), and National Meteorological Centers (NMC). Products of RSMCs can be used by members at the national level for further processing or interpretation to provide assistance or service to users. NMCs carry out GDPFS functions at the national level.

In general, real-time functions of the system involve preprocessing of data to include real-time quality control, analysis, and prognosis, and the derivation of appropriate meteorological parameters. The non-real-time functions include data collection and archival, and additional quality control, storage, and retrieval, to include cataloging observational data and processed information for operational and special applications and for research. WMCs are located in Melbourne, Moscow, and Washington, and they provide guidance products used for general short-, medium-, and long-range weather forecasts on a global scale. Melbourne specializes in forecast products for the Southern Hemisphere.

RSMCs with geographical specialization include Algiers, Beijing, Bracknell, Brazilia, Buenos Aires, Cairo, Dakar, Darwin, Jeddah, Khabarovsk, Melbourne, Miami, Montreal, Moscow, Nairobi, New Delhi, Novosibirsk, Offenbach, Pretoria, Rome, Tashkent, Tokyo, Tunic/Casablanca, Washington and Wellington. RSMCs with specialization for tropical cyclone forecasting are: Miami - Hurricane Center, Nadi -

Tropical Cyclone Center, New Delhi - Tropical Cyclone Center, Saint Denis, La ReUnion - Tropical Cyclone Center, Tokyo - western Pacific Typhoon Center, and Honolulu - central Pacific Typhoon Center. The European Center for Medium-Range Weather Forecasts (ECMWF) is an RSMC operated by the European community out of Bracknell, UK. The regional centers at Bracknell, Honolulu, Miami, Montreal, New Delhi, and Tokyo also have dual geographical and activity specialization responsibilities. These centers provide regional products used for short- and medium-range forecasting of small, mesoscale, and large-scale meteorological systems by WMCs. The RSMCs located at Beijing, Bracknell, Melbourne, Montreal, Obninsk, Tokyo, Toulouse, and Washington provide, upon request, atmosphere aerosol and chemical transport model products for environmental emergency responses.

Other WMO-designated specialized centers serve emerging development needs: African Center of Meteorological Applications for Development (ACMAD) - Niamey, Niger; ASEAN Specialized Meteorological Center (ASMC) - Singapore; Drought Monitoring Centers (DMC) - Nairobi, Kenya, and Harare, Zimbabwe; National Institute of Space Research - Sao Paulo, Brazil; National Center for Medium Range Weather Forecasting - New Delhi.

INTERNATIONAL SATELLITE COMMUNICATION SYSTEM (ISCS)

The World Area Forecast System (WAFS) has two centers (Washington and London) which are designated by the International Civil Aviation Organization (ICAO) as World Area Forecast Centers (WAFC). The dissemination of aeronautical information via global satellite broadcast began in 1995, through the International Satellite Communication System (ISCS). The U.S. provides the links to two of the three satellites specified in the system. The WAFS issue upper-level wind and temperature forecasts with global coverage and forecasts of weather elements defined by ICAO as significant.

The U.S. continues to support ten ISCS/WAFS workstations of the Regional Meteorological Telecommunication Network in the Caribbean and also supports the Caribbean weather website (www.caribweather.net).

GLOBAL TELECOMMUNICATION SYSTEM

The GTS provides communication services for the collection, exchange, and distribution of observational data and processed information among the WMCs, RSMCs, and NMCs of the WWW to meet the member needs for real-time or quasi-real-time exchange of information for both operational and research purposes. The GTS also supports other WMO programs, joint programs with other international organizations, and environmental programs as decided by the WMO and is organized on three levels:

- The Main Telecommunication Network (MTN).
- The Regional Meteorological Telecommunication Networks (RMTN).
- The National Meteorological Telecommunication Networks (NMTN).

The GTS is supported by the telecommunications functions of the WMCs, Regional Telecommunications Hubs (RTH), RSMCs, and NMCs. The MTN links the WMCs at Melbourne, Moscow, and Washington with the RTHs at Algiers; Beijing; Bracknell; Brasilia; Buenos Aires; Cairo; Dakar; Jeddah; Maracay, Venezuela; Nairobi; New Delhi; Norrköping, Sweden; Offenbach; Prague; Rome; Sofia; Tokyo; Toulouse; and Wellington. It ensures the rapid and reliable exchange of observational data and processed information required by the members.

The RMTNs consist of an integrated system of links which interconnects RTHs, NMCs, and RSMCs to WMCs. The RMTNs provide for the collection of observational data and the selective distribution of meteorological information to member nations.

In summary, the GTS enables the NMCs to receive and distribute observational data and meteorological information to meet the requirements of members. Ongoing WWW activities include:

- GTS network redesign, referred to as the WMO Information System (WIS), to take into consideration new technical opportunities, such as Internet-like services.
- Improvement of the capacity of MTN links and inclusion of graphics (e.g., Washington-Brasilia, Washington-Buenos Aires, Washington-Tokyo).
- Upgrade of the GTS in the Indian Ocean Basin to facilitate real-time movement of tsunami and natural hazard warnings.
- Continued implementation of satellite-serviced data collection platforms to enhance the collection of meteorological data from upper-air and surface-observing sites.
- Continued implementation of satellite direct-readout stations that are compatible with polar-orbiting satellites and the weather facsimile (WEFAX) component of the geostationary satellites. Planning is underway for eventual conversion of WEFAX to Low-Rate Information Transmission (LRIT) and Automatic Picture Transmission (APT) to Low Rate Picture Transmission (LRPT) formats with the advent of a new generation of satellites.

VOLUNTARY COOPERATION PROGRAM (VCP)

The WMO Voluntary Cooperation Program (VCP) is a technical cooperation program, managed by the WMO, focused on meeting the needs of member countries to implement WMO scientific and technical programs. The VCP endeavors to complement activities being implemented through national meteorological services and WMO trust-fund arrangements, and through other UN organizations such as United Nations Development Programme (UNDP).

The U.S. participates in the WMO VCP with coordination assistance provided by NOAA's National Weather Service. Each year, the U.S. contributes nearly $2 million dollars to the VCP to support projects and training which enhance the sciences of meteorology and hydrology.

U.S. VCP funds provided assistance to developing countries to help develop and improve their WMO telecommunications infrastructure for tsunami and natural disaster warning networks. Through the NWS' National Centers for Environmental Prediction (NCEP), the U.S. VCP supports weather forecast training for the Americas and the Caribbean countries and climate prediction training for Africa. Additionally, in the Pacific, NCEP provides forecaster training for islanders, and new funding is now dedicated to working with regional associations to enhance communications by upgrading of Low-Rate Users Stations in the Island Developing States to provide access to meteorological satellite images in LRIT format for 17 Pacific Island countries and territories.

The U.S. VCP will also support training programs in the Americas to advance satellite data applications and build capacity as part of the Earth Observations Partnerships of the Americas (EOPA) initiative and supported the move of the GOES-10 satellite in late 2006, to provide more regional coverage.

APPENDIX C
PREVIOUS FEATURE ARTICLES

Year	Edition	Title	Author
2006	FY 2007	Roadmap for Tropical Cyclone Research to Meet Operational Needs	Mr. Mark Welshinger, OFCM
2005	FY 2006	Living With Wildland Fire in the Urban Environment	Ms. Mary M. Cairns, OFCM
2004	FY 2005	The Rewards of Managing Weather-Related Risks	Mr. Samuel P. Williamson, OFCM
2003	FY 2004	Weather and The Urban Environment: Meeting The Needs of Urban Communities	Ms. Margaret R. McCalla, OFCM
2002	FY 2003	The Need For Weather Information For Surface Transportation: Keeping The Country Safe and On The Move	Ms. Mary M. Cairns, OFCM
2001	FY 2002	Research to Operations: Bridging the Valley of Death	Mr. Robert Dumont, OFCM
2000	FY 2001	The Legacy of Hurricane Floyd--Inland Flooding and a Massive Evacuation	Mr. Robert Dumont, OFCM
1999	FY 2000	Natural Disaster Reduction--Reducing the Impacts of Natural Hazards	OFCM Staff in collaboration with Dr. William Hooke, OAR, and Ms. Keli Tarp, NOAA Public Affairs
1998	FY 1999	Aviation Weather: Taking A Leadership Role	FAA's Aviation Weather Policy Division (ARW-100) Staff
1997	FY 1998	Owning The Weather--An Army Force Multiplier	Mr. Richard J. Szymber, Army
1996	FY 1997	Space Weather - A New Challenge for Meteorologists	Col Jud Stailey, USAF
1995	FY 1996	The Role of Federal Agencies in International Aviation Meteorology	Mr. Blaine K. Tsugawa, OFCM
1994	FY 1995	Data Continuity in the Climatological Record	Dr. Nathaniel B. Guttman, NCDC Mr. Andrew H. Horvitz, NWS Mr. Arthur L. Booth, NOAA-EOSDIS
1993	FY 1994	Training and Professional Development in the Modernized Weather Services	Mr. Eli Jacks, NWS Mr. LeRoy Spayd, NWS
1992	FY 1993	Mesoscale Meteorology	Mr. Floyd F. Hauth, OFCM

Year	Edition	Title	Author
1991	FY 1992	Some Recent Developments in Lightning Mapping Systems	Dr. Donald R. MacGorman, NOAA Dr. Frederick R. Mosher, NOAA Ms. Jan S. Lewis, NOAA
1990	FY 1991	The Next Generation Weather Radar - A System for Locating and Tracking Severe Weather	Mr. E. Don Sarreals, NEXRAD JSPO
1989	FY 1990	Strategic Plan for the Modernization and Associated Restructuring of the National Weather Service	Verbatim reproduction of a plan required by Congress and submitted by DOC and OMB
1988	FY 1989	Supercomputers for Meteorological Services and Supporting Research	(Source or author unknown)

APPENDIX D
ACRONYMS AND ABBREVIATIONS

3D-VAR	Three Dimensional VARiational (DOD)
4DWX	Four Dimensional Weather (DOD)
AA	Active Army
AAO	Amarillo Area Office (DOE)
AASHTO	American Association of State Highway and Transportation Officials (FHWA)
AAU	Alaskan Aviation Unit (NOAA/NCEP)
AB	Authorization Basis
ABCS	Army Battle Command System (DOD)
ABFM	Airborne Field Mill (NASA)
ABL	Airborne Laser (DOD)
ABLE	Atmospheric Boundary Layer Experiment (DOE)
AC	Active Component (DOD)
AC&A	Atmospheric Chemistry and Aerosols (DOE)
ACARS	ARINC Communication Addressing and Reporting System
ACD	Atmospheric Chemistry Division (DOE)
ACE	Aviation Combat Element (DOD)
ACE-IDS	ASOS Controller Equipment - Information Display System (FAA)
ACIS	Applied Climate Information System (USDA)
ACP	Atmospheric Chemistry Program (DOE)
ACSG	Atmospheric and Climate Sciences Group (DOE)
ADA	Atmospheric Decision Aid (DOD)
ADAPT	Atmospheric Data Assimilation and Parameterization Tool (DOE)
ADAS	AWOS/ASOS Data Acquisition System (FAA)
ADEOS	Advanced Earth Observing System (NASA)
AEC	Atomic Energy Commission (DOE)
AEP	Atmospheric Emergency Preparedness (DOE)
AESS	Allied Environmental Support System (DOD)
AF	Air Force
AFB	Air Force Base
AFCCC	Air Force Combat Climatology Center
AFCWC	Air Force Combat Weather Center
AFFSA	Air Force Flight Standards Agency
AFGS	Aviation Forecast Gridded System
AFJI	Air Force Joint Instruction
AFR	Air Force Reserve
AFRL	Air Force Research Laboratory
AFSOC	Air Force Special Operations Command
AFTAC	Air Force Technical Applications Center
AFW	Air Force Weather
AFWA	Air Force Weather Agency
AFWIN	Air Force Weather Information Network
AFWWS	Air Force Weather Weapon System
AF/XOO	Air Force Director of Operations and Training (DOD)
AF/XO	Air and Space Deputy Chief of Staff for Air and Space Operations (DOD)
AF/XOO-W	Air Force Director of Weather
AGFS	Aviation Gridded Forecast System (FAA)
AGRIMET	A conjunction of the words "agricultural" and "meteorology", is a satellite-based network of automated agricultural weather stations operated and maintained by the U.S. Bureau of Reclamation (DOI)
AHPS	Advanced Hydrologic Prediction Services (NOAA/NWS)
AI	Aircraft Icing (NASA)
AIP	Airport Improvement Program (FAA)
AIRMAP	Atmospheric Investigation Regional Modeling, Analysis, and Prediction (NOAA/OAR)

AIRMoN	Atmospheric Integrated Research Monitoring Network (NOAA/OAR)
AIRS	Atmospheric Infrared Sounder (NASA)
AL	Aeronomy Laboratory (NOAA/OAR)
ALDARS	Automated Lightning Detection and Reporting System (FAA)
ALOHA	Areal Locations of Hazardous Atmospheres (a transport and dispersion code)
ALOO	Albuquerque Operations Office
AMC	Army Materiel Command
AMDAR	Aircraft Meteorological Data Relay (WWP)
AMIS	Automated Meteorological Information System (DOD)
AMPS	Automated Meteorological Profiling System (NASA)
AMOS	Automated Meteorological Observing System (DOD)
AMS	Acquisition Management System (FAA)
	American Meteorological Society
AMSR-E	Advanced Microwave Sounding Radiometer
AMSU	Advanced Microwave Sounding Unit
AMU	Applied Meteorology Unit (NASA)
ANG	Air National Guard (DOD)
ANL	Argonne National Laboratory (DOE)
AOC	Aircraft Operations Center (NOAA)
	Air and Space Operations Center (DOD)
AOML	Atlantic Oceanographic and Meteorological Laboratory (NOAA/ERL)
AOR	Area of Responsibility (DOD)
AOT	Aerosol Optical Thickness (NOAA/NESDIS)
APGEMS	Air Pollutant Graphical Environmental Monitoring System
APS	Aerosol Polarimetry Sensor (APS)
APT	Automatic Picture Transmission (NOAA/NESDIS)
AQG	Air Quality Group (DOE)
AR	Army Regulation
ARAC	Atmospheric Release Advisory Capability (DOE)
ARCS	Atmospheric Radiation CART Sites (NOAA/OAR)
ARG	Accident Response Group (DOE)
ARGO	Global Array of Profiling Floats (NOAA/OAR)
ARGOS	French Satellite Data Collection System
ARINC	Aeronautical Radio Incorporated
ARL	Army Research Laboratory
	Air Resources Laboratory (NOAA and DOE)
ARM	Atmospheric Radiation Monitoring (DOE)
ARNG	Army National Guard
ARO	Army Research Office
ARS	Agricultural Research Service (USDA)
	Air Traffic System Requirements Service (FAA)
	Atmospheric Research Section (DOE)
ARSL	Atmospheric Remote Sensing Laboratory
ARSPACE	Army Space Command
ARSR	Air Route Surveillance Radar (FAA)
ARSST	Army Space Support Team
ARTCC	Air Route Traffic Control Center (FAA)
ARTYMET	Artillery Meteorological (DOD)
ARW	Aviation Weather Directorate (FAA)
ASCAT	Advanced Scatterometer
ASD	Atmospheric Sciences Division (DOE)
ASDAR	Aircraft to Satellite Data Relay
ASNE MSEA	Air and Space Natural Environment Modeling and Simulation Executive Agent (DOD)
ASOG	Air Support Operations Group (DOD)
ASOS	Automated Surface Observing System
	Air Support Operations Squadron (DOD)
ASP	Atmospheric Science Program (DOE)

ASR	Airport Surveillance Radar (FAA)
ATC	Air Traffic Control (FAA)
ATCCS	Army Tactical Command and Control System
ATD	Atmospheric Turbulence and Diffusion
ATDD	Atmospheric Turbulence and Diffusion Division (NOAA/ARL)
ATEC	Army Test and Evaluation Command
ATG	Atmospheric Technologies Group (DOE)
ATLAS	Autonomous Temperature Line Acquisition System (NOAA/OAR)
ATMS	Advanced Technology Microwave Sounder
ATO	Air Traffic Organization (FAA)
	Air Tasking Order (DOD)
ATOS	Appalachian Tropospheric Ozone Study (NOAA/AOC)
ATWIS	Advanced Transportation Weather Information System (FHWA)
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
AVO	Alaskan Volcano Observatory (DOI/USGS)
AVP	Advanced Vehicle Technologies Program (FTA)
AWARDS	Agricultural Water Resources Decision Support (DOI/BUREC)
AWC	Aviation Weather Center (NOAA/NCEP)
AWIPS	Advanced Weather Interactive Processing System (NOAA)
AWIS	Automated Weather Information System
AWN	Automated Weather Network (DOD)
AWOS	Automated Weather Observing System (FAA)
AWR	Aviation Weather Research (FAA)
AWSS	Aviation Weather Sensor System (FAA)
AWTT	Aviation Weather Technology Transfer (FAA)
BAMP	Breton Aerometric Monitoring Program (DOI)
BASC	Board on Atmospheric Sciences and Climate
BCTP	Battle Command Training Program (DOD)
BE	Battlefield Environment (DOD)
BER	Biological and Environmental Research (DOE)
BFA	Battlefield Functional Areas (DOD)
BIO	Basis for Interim Operations (DOE)
BLM	Bureau of Land Management (DOI)
BMDO	Ballistic Missile Defense Office (DOD)
BNL	Brookhaven National Laboratory (DOE)
BUFR	Binary Universal Form for the Representation of Meteorological Data
BUREC	Bureau of Reclamation (DOI)
C^2	Command and Control (DOD)
C^4I	Command, Control, Communications, Computers, and Intelligence (DOD)
CAAM	Computer Assisted Artillery Meteorology (DOD)
CAC	Combined Arms Center (DOD)
CAIB	Columbia Accident Investigation Board
CALJET	California Land-falling Jets Experiment (NOAA/OAR)
CAMEO	Computer Aided Management of Emergency Operations
CAMEX	Convective and Moisture Experiment (NASA)
CAO	Carlsbad Area Office
CAP	Civil Air Patrol
CAP88-PC	Clean Air Act Assessment Package-1988 - Personal Computer (DOE)
CAPARS	Computer-Assisted Protective Action Recommendation System (DOE)
CARDS	Comprehensive Aerological Reference Data Set (NOAA/NCDC)
CARS	Condition Acquisition and Reporting System (FHWA)
CART	Clouds and Radiation Testbed (DOE)
CASPER	Computer Aided System For Planning Efficient Routes (FHWA)
CAST	Commercial Aviation Safety Team (FAA)
CAT	Clear Air Turbulence

CAWIS	Committee for Automated Weather Information Systems (OFCM)
CBFO	Carlsbad Field Office
CBIRF	Chemical Biological Incident Response Force (DOD)
CBAP	*Catastrophic Backup Action Plan*
CBNP	Chemical Biological Non-Proliferation Program (DOE)
	Chemical Biological National Security Program (DOE)
CBOFS	Chesapeake Bay Oceanographic Forecasting System (NOAA/NOS)
CBRNE	Chemical, Biological, Radiological, Nuclear, or High-Yield Explosive (DOD)
CBS	Commission on Basic Services (WWP)
CCAFS	Cape Canaveral Air Force Station
CCCM	Climate and Carbon Cycle Modeling (DOE)
CCM	Community Climate Model used at LANL (DOE)
CCMC	Community Coordinated Modeling Center (DOD)
CCMS	Committee on the Challenges of Modern Society (EPA)
CDA	Command and Data Acquisition
CDF	Cloud Depiction and Forecasting (DOD)
CDFS	Cloud Depiction and Forecast System (DOD)
CDPHE	Colorado Department of Public Health and Environment (DOE)
CECOM	Communications and Electronics Command (DOD)
CEMSCS	Central Environmental Satellite Computer System (NOAA/NESDIS)
CENR	Committee on Environment and Natural Resources
CEOS	Committee on Earth Observation Satellites (NOAA/NESDIS)
CERES	Clouds and Earth's Radiant Energy System (NASA)
CFD	Computational Fluid Dynamics
CFIT	Controlled Flight Into Terrain (NASA)
CFR	Code of Federal Regulations (DOE)
CGSC	Command and General Staff College (DOD)
CHAMMP	Computer Hardware Advanced Mathematics and Model Physics (DOE)
CHARM	An Atmospheric Transport and Dispersion Model
CIASTA	Cooperative Institute for Atmospheric Studies and Terrestrial Applications (NOAA/OAR)
CICE	Sea Ice Code at LANL
CIDE	Communications Interfaces and Data Exchange (OFCM)
CIOS	Committee for Integrated Observing Systems (OFCM)
CIRES	Cooperative Institute for Research in Environmental Sciences
CIWS	Corridor Integrated Weather System (FAA)
CLASS	Comprehensive Large Array-Data Stewardship System (NOAA/NESDIS)
CLIVAR-GEWEX	Climate Variability and Predictability - Global Energy and Water Cycle Experiment
CLIVAR-VAMOS	Climate Variability and Predictability - Variability and Predictability of the American Monsoon System
C-MAN	Coastal-Marine Automated Network
CMAQ	Community Multi-scale Air Quality (EPA)
CMDL	Climate Monitoring and Diagnostics Laboratory (NOAA/OAR)
CME	Coronal Mass Ejection
CMFC	Coordinating METOC Forecast Center (DOD)
CMIS	Conical Scanning Microwave Imager Sounder
CMR	Central Monitoring Room
CMS	Central Monitoring System
COADS	Comprehensive Ocean-Atmosphere Data Set (NOAA/NCDC)
COAMPS	Coupled Ocean-Atmosphere Mesoscale Prediction System
COARE	Coupled Ocean-Atmosphere Response Experiment
COE	Corps of Engineers (DOD)
COMET	Cooperative Program for Operational Meteorology, Education and Training
CONUS	Continental United States (DOD)
CONUSA	Continental United States Armies (DOD)
COPC	Committee for Operational Processing Centers (OFCM)
COOP	Cooperative Observer Program (NOAA/NWS)
CORMS	Continuous Real-time Monitoring System (NOAA/NOS)

COSMIC	Constellation Observing System for Meteorology, Ionosphere, and Climate (DOD)
COTS	Commercial Off-the-Shelf
CPC	Climate Prediction Center (NOAA/NCEP)
CPHC	Central Pacific Hurricane Center (NOAA/NCEP)
CRADA	Cooperative Research and Development Agreement
CrIS	Cross-track Infrared Sounder
CRN	Climate Reference Network (NOAA)
CRREL	Cold Regions Research and Engineering Laboratory (DOD)
CS	Climate Services
CSD	Climate Services Division (NOAA/NWS)
CSEPP	Chemical Stockpile Emergency Preparedness Program (DOE)
CSRA	Central Savannah River Area (DOE)
CSREES	Cooperative State Research, Education, and Extension Service (USDA)
CSW	Committee for Space Weather (OFCM)
CTA	Common Table of Allowances (DOD)
CTBT	Comprehensive Test Ban Treaty (DOE)
CWS	Combat Weather Squadron (DOD)
CWSU	Center Weather Service Unit (FAA)
CWT	Combat Weather Team (DOD)
CXD	Combined X-ray Dosimeter (DOE)
CY	Calendar Year
DAC	Data Assembly Center (NOAA/OAR)
DAMPS	Distributed Atmospheric Modeling Prediction System (DOD)
DAT	Department of Advanced Technology (DOE)
DCO	Data Collection Office (NOAA/NWS)
DCP	Data Collection Package
	Data Collection Platform (DOI)
DCS	Data Collection System (NOAA/NESDIS)
DEPSCoR	Experimental Program to Stimulate Competitive Research (DOD)
DGPS	Differential Global Positioning System (USGS)
DHS	Department of Homeland Security
DIS	Decision and Information Sciences (DOE)
DISS	Digital Ionospheric Sounding System (DOD)
DMCC	DOE Meteorological Coordinating Council (DOE)
DMS	Dynamic Message Sign (FHWA)
DMSO	Defense Modeling and Simulation Office (DOD)
DMSP	Defense Meteorological Satellite Program (DOD)
DNT	Dinitrotoluene (DOE)
DOA	Department of Agriculture
DOC	Department of Commerce
DOCS	DOE Center for Research on Ocean Carbon Sequestration
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOMSAT	Domestic Communications Satellite (DOI)
DOS	Department of State
DOT	Department of Transportation
DRA	Desert Rock Meteorological Observatory at NTS (DOE)
DREC	Delta Research Extension Center (USDA)
DRGS	Direct Readout Ground Stations (DOI)
DRI	Desert Research Institute (DOE)
DRWP	Doppler Radar Wind Profiler (NASA)
DSA	Documented Safety Analysis
DSTL	Defense Science and Technology Laboratory
DTC	Developmental Test Command (DOD)
DTED	Digital Terrain Elevation Data (DOD)

DTRA	Defense Threat Reduction Agency
DTSS	Digital Topographic Support System (DOD)
DUAT	Direct User Access Terminal (FAA)
DURIP	Defense University Research Instrumentation Program (DOD)
EAC	Echelon Above Corps (DOD)
EAD	Environmental Assessment Division (DOE)
EBID	Environmental Biology and Instrumentation Division (DOE)
ECDIS	Electronic Chart Display Information System (NOAA/NOS)
ECMWF	European Centre for Medium-Range Weather Forecasting
EDAS	Eta Data Assimilation System (NOAA/NESDIS)
EDIS	Environmental Data and Information Service (NOAA)
EED	Energy and Environment Division
EERE	Office of Energy Efficiency and Renewable Energy (DOE)
EH	Environmental Health
ELV	Expendable Launch Vehicle (NASA)
EM	Office of Environmental Management (DOE)
EMC	Environmental Modeling Center (NOAA/NCEP)
	European Modeling Center (NOAA/NCEP)
EM&H	Environmental Monitoring & Hydrology
EMI SIG	Emergency Management Issues Special Interest Group
EMP	Environmental Meteorology Program (DOE)
EMS	Environmental Monitoring Section (DOE)
EMSL	Environemtal and Molecular Sciences Labratory
ENSO	El Niño-Southern Oscillation
EO	Electro-optical
	Earth Observation (NASA)
EOC	Emergency Operations Center
EOS	Earth Observing System (NASA)
EOSDIS	EOS Data and Information System (NASA)
EPA	Environmental Protection Agency
EPD	Environmental Protection Department (DOE)
EPIC	Equatorial Pacific Investigation of Climate (NOAA/AOC)
EPR	Emergency Preparedness and Response Directorate (FEMA)
E-PIREPS	Electronic Pilot Reports (FAA)
EP/RD	Environmental Protection/Restoration Department (DOE)
EPZ	Emergency Planning Zone (DOE)
ER	Eastern Range (NASA)
	Environmental Research (DOE)
ERBS	Earth Radiation Budget Satellite (NASA)
ERC	Extended Research Checkout
ERDA	Energy Research and Development Administration (DOE)
ERDAS	Eastern Range Dispersion Assessment System (NASA)
ERDC	Engineering Research and Development Center (DOD)
ERL	Environmental Research Laboratories (NOAA)
ESC	Environmental Systems Corporation
ESD/IPC	Environmental Satellite Distribution/Interactive Processing Center (NOAA/NESDIS)
ESE	Earth Science Enterprise (NASA)
ESP	Energy Spectrometer for Particles (DOE)
	Ensemble Streamflow Prediction (NWS)
ESS	Environmental Sensor Station (FHWA)
ESSP	Earth System Science Pathfinders (NASA)
ETIS	Evacuation Traffic Information System (FHWA)
ETL	Environmental Technology Laboratory (NOAA/OAR)
ETOS	East Tennessee Ozone Study (NOAA/OAR)
ETTP	East Tennessee Technology Park (DOE)
ET Toolbox	Evapotranspiration Toolbox (DOI)

EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EUSA	Eighth U.S. Army
EUV	Extreme Ultraviolet
EWR	Ellason Weather Radar (DOD)
FAA	Federal Aviation Administration
FALOP	Forward Area Limited Observing Program (DOD)
FAS	Foreign Agricultural Service (USDA)
FBA	Fire Behavior Analysts (DOI)
FCC	Federal Communications Commission
FCCC	Framework Convention on Climate Change (DOS)
FCMSSR	Federal Committee for Meteorological Services and Supporting Research (OFCM)
FCS	Future Combat System (DOD)
FDD	First Digitized Division (DOD)
FDIC	Force Development and Integration Center (DOD)
FEM3MP	LLNL finite element model (DOE)
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRETEC	Fire Code at LANL (DOE)
FIRST	FAA Icing Remote Sensor Testbed (NOAA/OAR)
FIS	Flight Information System (FAA)
FITL	Forecaster-in-the-Loop (DOD)
FLENUMMETOCCEN	Fleet Numerical Meteorology and Oceanography Center, Monterey, California
FMF	Fleet Marine Force
FMH	Federal Meteorological Handbook (OFCM)
FNMOC	Fleet Numerical Meteorology and Oceanography Center (DOD)
FOA	Field Operating Agency (DOD)
FORSCOM	U.S. Army Forces Command
FOV	Field of vision
FR	Flight Rules
FRA	Federal Railroad Administration
FRD	Field Research Division (NOAA/ARL)
FRERP	Federal Radiological Emergency Response Plan (DOE)
FRMAC	Federal Radiological Monitoring and Assessment Center (DOE)
FRWS	Fire RAWS (DOI)
FS-21	Forecasting System 21st Century (DOD)
FS	Forest Service (USDA)
FSA	Farm Services Agency (USDA)
FSL	Forecast Systems Laboratory (NOAA/OAR)
FSR	Forest Service Research (USDA)
FTA	Federal Transit Administration
FTE	Full-time Equivalent
FTP	File Transfer Protocol
FU	Forecast Unit
FWS	Fish and Wildlife Service (DOI)
FY	Fiscal year
G-IV	Gulfstream IV (NOAA)
GAA	GOES Active Archive (NOAA/NESDIS)
GAC	Global Area Coverage
GACC	Geographic Areas Coordination Center (DOI)
GACP	Global Aerosol Climatology Project (NASA)
GAIM	Global Assimilation of Ionospheric Measurements (DOD)
GAPP	GEWEX Applications Prediction Program (DOI/BUREC)
GAO	General Accounting Office
GCCR	Global Climate Change Research (DOE)
GCCS	Global Command and Control System (DOD)
GCIP	GEWEX Continental-scale International Project (DOI)

GCM	Global Climate Models (DOE)
GCOS	Global Climate Observing System (WWP)
GCPS	Global Climate Perspectives System
GCRP	Global Change Research Program
GDPC	Global Data Processing Centers (WWP)
GDPFS	Global Data Processing and Forecast System (WWP)
GEM	Generation of weather Elements for Multiple (USDA)
GEOSAR	Geostationary Earth Orbit Search and Rescue (NOAA/NESDIS)
GEOSS	Global Earth Observation Systems of Systems (WWP)
GEWEX	Global Energy and Water-Balance Experiment
GFDL	Geophysical Fluid Dynamics Laboratory (NOAA/ERL)
GHCN	Global Historical Climatology Network
G-IPPA	Government-Industry Project Performance Agreement (FAA)
GIN	Geomagnetic Information Nodes (DOI)
GIS	Geographic Information System
GLD	Global Lagrangian Drifters (NOAA/OAR)
GLOFS	Great Lakes Operational Forecast System
GLONASS	Global Navigation Satellite System (NOAA/NESDIS)
GMS	Geostationary Meteorological Satellite-Japan (WWP)
GMSRA	GOES Multi-Spectral Rainfall Algorithms (NOAA/NESDIS)
GMU	George Mason University
GOES	Geostationary Operational Environmental Satellite (NOAA)
GOOS	Global Ocean Observing System
GOS	Global Observing System (WWP)
GOSSP	Global Observing Systems Space Panel (NOAA/NESDIS)
GPCP	Global Precipitation Climatology Program
GPS	Global Positioning System
GPS/MET	GPS for Meteorology
GRIB	Gridded Binary (FM 92-X Ext.)
GRIDS	Ground-based Remote Icing Detection System (NOAA/OAR)
GSFC	Goddard Space Flight Center (NASA)
GSN	GCOS Surface Network (WWP)
GTS	Global Telecommunications System (WWP)
GTSPP	Global Temperature-Salinity Profile Project
GTWAPS	Global Theater Weather Analysis and Prediction System (DOD)
GUAN	GCOS Upper Air Network (WWP)
HAF	Headquarters Air Force (DOD)
HaL	Hurricanes at Landfall (NOAA/OAR)
HAR	Highway Advisory Radio (FHWA)
HARM	Hazardous Atmospheric Release Model (NOAA/OAR)
HAZMET	Hazardous Material (FHWA)
HCRS	Highway Closure and Restriction System (FHWA)
HDB	Hydrologic DataBase (DOI)
HELSTF	High Energy Laser System Test Facility (DOD)
HF	High Frequency
HFRB	High Frequency Regional Broadcast
HIGRAD	Transport and Dispersion Model at LANL (DOE)
HIRS/3	High Resolution Infrared Radiation Sounder (NOAA/NESDIS)
HMI	Hydrologic Modeling Inventory (DOI)
HMSC	Hazardous Materials Spill Center (DOE)
HMMWV	High Mobility Multi-purpose Wheeled Vehicle (DOD)
HPC	Hydrometeorological Prediction Center (NOAA/NCEP)
HPCC	High Performance Computing and Communications
HRAP	Hydrologic Rainfall Analysis Project (DOI)
HRD	Hurricane Research Division (NOAA/ERL)
HRPT	High Resolution Picture Transmission (NOAA/NESDIS)

HS	Health Safety and Security
HSA	Hydrologic Service Area (NOAA/NWS)
HSM	Heat Stress Monitor (DOD)
HYDROMET	A network of automated hydrologic and meteorologic monitoring stations located throughout the Pacific Northwest (DOI)
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory (NOAA/OAR)
HUD	Head-up display (NASA)
IA	Interagency Agreement
IAMS	Initial Attack Management System (DOI)
IAS	International Airspace System (NOAA/NWS)
IAV	Interim Armored Vehicle (DOD)
IBCT	Interim Brigade Combat Teams (DOD)
ICAO	International Civil Aviation Organization
LCC	Launch Commit Criteria
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research (OFCM)
ICSU	International Council of Scientific Unions
IDCS	International Data Collection System (WWP)
IEW	Intelligence and Electronic Warfare (DOD)
IFEX	Intensity Forecast Experiment
IFFA	Interactive Flash Flood Analyzer (NOAA/NESDIS)
IGBP	International Geosphere Biosphere Programme (WWP)
IHC	Interdepartmental Hurricane Conference (OFCM)
IIP	International Ice Patrol (USCG)
IMA	Individual Mobilization Augmentee (DOD)
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IMDES	Interdepartmental Meteorological Data Exchange System
IMETS	Integrated Meteorological System (DOD)
	Incident Meteorologists (NOAA/NWS)
IMPROVE	Interagency Monitoring of Protected Visual Environments (DOI)
INEEL	Idaho National Engineering and Environmental Laboratory (DOE)
INL	Idaho National Laboratory
INS	Incidents of National Significance
INSAT	India's National Satellite (WWP)
IOC	Intergovernmental Oceanographic Commission (WWP)
IPB	Intelligence Preparation of the Battlespace (DOD)
IPCC	Intergovernmental Panel on Climate Change (WWP/DOS)
IPEX	Intermountain Precipitation Experiment (NOAA/OAR)
IPO	Integrated Program Office
IR	Infrared
IRCCSI	Institue for research on Climate Change & Its Societal Impacts
IRTSS	Infrared Target Scene Simulation Software (DOD)
ISCCP	International Satellite Cloud Climatology Program (NOAA/NESDIS)
ISES	International Space Environment Service (NOAA/OAR)
ISIS	Integrated Solar Irradiance Study (NOAA/OAR)
ISMS	Integrated Safety Management System (DOE)
ISS	International Space Station
ISTEA	Intermodal Surface Transportation Efficiency Act (FHWA)
IT	Information Technology
ITCT	Intercontinental Transport and Chemical Transformation (NOAA/OAR)
ITCZ	Inter-tropical convergence zone
ITS	Intelligent Transportation System (FHWA)
ITS-JPO	ITS Joint Program Office (FHWA)
IT-RD	Information Technology Research and Development (EPA)
ITWS	Integrated Terminal Weather System (FAA)
IWEDA	Integrated Weather Effects Decision Aid (DOD)
IWGCCST	Interagency Working Group on Climate Change Science and Technology (DOS)

IWRS	Improved Weather Reconnaissance System (OFCM)
IWRPC	Improved Weather Reconnaissance System Program Council (OFCM)
JAAWIN	Joint Air Force-Army Weather Information Network (DOD)
JAG	Joint Action Group
JAG/OCM	Joint Action Group for Operational Community Modeling
JASL	Joint Archive for Sea Level
JAWF	Joint Agricultural Weather Facility (USDA)
JCOMM	Joint Commission for Oceanographic and Marine Meteorology (WWP)
JCS	Joint Chiefs of Staff (DOD)
JCSDA	Joint Center for Satellite Data Assimilation (NOAA/NCEP)
JET	Joint Environmental Toolkit (DOD)
JGOFS	Joint Global Ocean Flux Study
JHT	Joint Hurricane Testbed (NOAA/OAR)
JMDB	Joint METOC Database (DOD)
JMFU	Joint METOC Forecast Unit (DOD)
JMIB	Joint METOC Interoperability Board (DOD)
JMIST	Joint METSAT Imagery, Software, and Terminals (DOD)
JMV	Joint METOC Viewer (DOD)
JPL	Jet Propulsion Laboratory (NASA)
JSAT	Joint Safety Analysis Team (FAA)
JSIT	Joint Safety Implementation Team (FAA)
JSC	Johnson Space Center (NASA)
JSCP	Joint Strategic Capabilities Plan (DOD)
JTWC	Joint Typhoon Warning Center (DOD)
JWIS	Joint Weather Impacts System (DOD)
KAO	Kirtland Area Office
KDFOC	LLNL Fallout Model
KLC	Kodiak Launch Center (NASA)
KM	Kilometer
KSC	Kennedy Space Center (NASA)
KVERT	Kamchatka Volcanic Eruption Response Team (DOI)
LAAS	Local Area Augmentation System (FAA)
LAC	Local Area Coverage
LAN	Local Area Network
LANL	Los Alamos National Laboratory (DOE)
LAPS	Local Analysis and Prediction System (NOAA/FSL)
LBNL	Lawrence Berkley National Laboratory
LDAR	Lightning Detection and Ranging
LDCM	Landsat Data Continuity Mission (NASA)
LDIS	Local Data Integration System (NASA)
LEO	Low Earth Orbit
LLCC	Lightning Launch Commit Criteria (NASA)
LLNL	Lawrence Livermore National Laboratory (DOE)
LLWAS	Low Level Wind Shear Alert System (FAA)
LLWAS-RS	LLWAS-Relocation/Sustainment (FAA)
LODI	Transport and Dispersion Model at LLNL (DOE)
LRGS	Local Readout Ground Stations (DOI)
LSD	Laboratory Services Division
LSM	Land Surface Model (DOD)
LV	Launch Vehicle
LWS	Living With A Star (NASA)
M2M	Machine-to-Machine
MACOM	Major Army Command

MAGTF	Marine Air Ground Task Force
MAJCOM	Major Command (DOD)
MAW	Marine Aircraft Wing
MB	Millibars
MC	Meteorological Codes
MCAF	Marine Corps Air Facilities
MCAS	Marine Corps Air Station
MCCDC	Marine Corps Combat Development Command (DOD)
MCD	Mesoscale Discussions (NOAA/NWS)
MCO	Maintenance and Construction Operations (FHWA)
MCS	Mesoscale Convective System (NOAA/OAR)
MCSP	Meteorological and Climate Services Project
MCWP	Marine Corps Warfighting Publication (DOD)
MDIFF	Transport and Dispersion Code at INEEL (DOE)
MDCRS	Meteorological Data Communications and Reporting System (WWP)
MDSS	Maintenance Decision Support System (FHWA)
MeaPRS	MCS Electrification and Polarimetric Radar Study (NOAA/OAR)
MEDA	Meteorological Data System
MEF	Mission Execution Forecast (DOD)
MEPED	Medium Energy Proton and Electron Detector (NOAA/NESDIS)
MES	Marine Environmental Services (OFCM)
MET	Mobile Environmental Teams (DOD)
	Meteorological Teams (DOD)
METMF	Meteorological Mobile Facility (DOD)
METOC	Meteorological and Oceanographic (DOD)
METSAT	Meteorological Satellite
MHS	Microwave Humidity Sounder (NOAA/NESDIS)
MHz	Megahertz
MIMS	Multimedia Integrated Modeling System (EPA)
MM5	Mesoscale Meteorological Model-Version 5.0 (DOD)
MME	Mobile Meteorological Equipment (OFCM)
MMS	Meteorological Measuring System (DOD)
	Mineral Management Service (DOI)
	Modular Modeling System (DOI)
MMS-P	Meteorological Measuring System-Profiler (DOD)
MOA	Memorandum of Agreement
MOBY	Marine Optical Buoy (NOAA/NESDIS)
MOCE	Marine Optical Characterization Experiment (NOAA/NESDIS)
MODIS	Moderate Resolution Imaging Spectrometer (NASA)
MOS	Model Output Statistics
MP	Mission Planning (DOD)
MPA	Magnetospheric Plasma Analyzer (DOE)
MPC	Marine Prediction Center (NOAA/NCEP)
MS	Monitoring the Stratosphere (OFCM)
MSFC	Marshall Space Flight Center (NASA)
MSL	Mean Sea Level
MSS	Meteorological Sounding System (NASA)
MST	Meteorological Support Teams (DOD)
MSU	Microwave Sounding Unit (NOAA/NESDIS)
MTI	Multi-spectal Thermal Imager
MTN	Main Telecommunications Network (WWP)
MTOE	Modified Table of Organization and Equipment (DOD)
MTPE	Mission to Planet Earth (NASA)
MTSAT	Multi-functional Transport Satellite
MWSS	Marine Wing Support Squadron
MW	Microwave

N511	National 511-Traveler Information Service (FHWA)
NADIN	National Airspace Data Interchange Network (FAA)
NAF	Numbered Air Force
NAME	North American Monsoon Experiment
NAMIS	NATO Automated Meteorological Information System (DOD)
NMAO	NOAA Marine and Aviation Operations
NAP	Non-insured Crop Disaster Assistance Program (USDA)
NAPP	National Aerial Photography Program (USDA)
NAOS	North American Atmospheric Observing System (NOAA)
NARAC	National Atmospheric Release Advisory Center (DOE)
NARSTO	North American Research Strategy for Tropospheric Ozone (EPA)
NAS	National Airspace System (FAA)
	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NASS	National Agricultural Statistics Service (USDA)
NATCOM	National Communications Center (FAA)
NATO	North Atlantic Treaty Organization (DOD, EPA)
NAVICECEN	Naval Ice Center
NAVOCEANO	Naval Oceanographic Office
NAVLANTMETOCCEN	Naval Atlantic Meteorology and Oceanography Center, Norfolk, Virginia
NAVMETOCCOM	Naval Meteorology and Oceanography Command
NAVPACMETOCCEN	Naval Pacific Meteorology and Oceanography Center, Pearl Harbor, Hawaii
NAWPC	National Aviation Weather Program Council (OFCM)
NBC	Nuclear, Biological, and Chemical (DOD)
NC	NOAA Corps
NCA	National Command Authority (DOD)
NCAR	National Center for Atmospheric Research
NCAS	NOAA Center for Atmospheric Sciences
NCDC	National Climatic Data Center (NOAA/NESDIS)
NCEP	National Centers for Environmental Prediction (NOAA/NWS)
NCO	NCEP Central Operations (NOAA/NCEP)
	Non-commissioned officer (DOD)
NDBC	National Data Buoy Center (NOAA/NWS)
NDGPS	Nationwide Differiential Global Positioning System
NDI	Non-developmental item
NDOP	National Digital Orthoquad Program (USDA)
NDRI	Natural Disaster Reduction Initiative (NOAA)
NDVI	Normalized Difference Vegetation Index (NOAA/NESDIS)
NEAQS	New England Air Quality Study
NEMP	Non-radiological Environmental Monitoring Program
NEPA	National Environmental Policy Act
NERON	NOAA's Environmental Real-Time Observation Network
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NESHAP	*National Emission Standards for Hazardous Air Pollutants* (DOE)
NESS	National Environmental Satellite Service (NOAA)
NEST	Nuclear Emergency Search Team (DOE)
NETRAD	Networked Radars
NEXRAD	Next Generation Weather Radar (WSR-88D)
NFIP	National Flood Insurance Program (FEMA)
NFDRS	National Fire Danger Rating System (DOI/BLM)
NGDC	National Geophysical Data Center (NOAA/NESDIS)
NGIC	National Geomagnetic Information Center (DOI)
NGST	Northrup Grumman Space Technology
NHC	National Hurricane Center (NOAA/NCEP)
NHI	National Highway Institute (FHWA)
NHOP	National Hurricane Operations Plan (OFCM)

NIC	National Ice Center (DOT/USCG)
	National Intelligence Community (DOD)
NIFC	National Interagency Fire Center (DOI)
NIPRNET	Non-secure Internet Protocol Router Network (DOD)
NIRT	Nuclear Incident Response Team
NIST	National Institute of Standards and Technology (DOC)
NITES	Navy Integrated Tactical Environmental Subsystem
NLDN	National Lightning Detection Network (FAA)
NMC	National Meteorological Center(s) (WWP)
NMHS	National Meteorological and Hydrological Services (WWP)
NMOC	Naval Meteorology and Oceanography Command
NMP	New Millennium Program (NASA)
NMS	National Military Strategy (DOD)
NMTN	National Meteorological Telecommunications Network (WWP)
NNDC	NOAA National Data Center (NOAA/NESDIS)
NNSA	National Nuclear Security Administration (DOE)
NNSA/NSO	National Nuclear Security Administration/Nevada Site Office (DOE)
NOAA	National Oceanic and Atmospheric Administration
NOCMP	National Operational Coastal Modeling Program
NODC	National Oceanographic Data Center (NOAA/NESDIS)
NODDS	Navy Oceanographic Data Distribution System
NOGAPS	Navy Operational Global Atmospheric Prediction System
NOHRSC	National Operational Hydrologic Remote Sensing Center
NOS	National Ocean Service (NOAA)
NOTAMS	Notices to Airmen (FAA)
NOWS	NVG Operations Weather Software (DOD)
NPDES	National Pollutant Discharge Elimination System (DOE)
NPN	NOAA Profiler Network (NOAA/OAR)
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Program (NASA)
NPS	National Park Service (DOI)
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service (USDA)
NRI	National Research Initiative (USDA)
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office (DOD)
NRP	National Response Plan
NRVR	New Generation Runway Visual Range (FAA)
NSC	National Security Complex
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center (NOAA)
NSO	Nevada Site Office (DOE)
NSS	National Security Strategy (DOD)
NSSE	National Special Security Events
NSSL	National Severe Storms Laboratory (NOAA)
NSTC	National Science and Technology Council
NSTEP	National Strategic Training and Education Plan (NOAA/NWS)
NSWP	National Space Weather Program (OFCM)
NTCIP	National Transportation Communications for ITS Protocol (FHWA)
N-TFS	New Tactical Forecast System (DOD)
NTIS	National Technical Information Service
NTS	Nevada Test Site (DOE)
NTSB	National Transportation Safety Board
NV	Nevada Operations Office (DOE)
NVG	Night Vision Goggles (DOD)
NVOO	Nevada Operations Office
NWA	National Wilderness Area (DOI)

NWCC	National Water & Climate Center (USDA)
NWCG	National Wildfire Coordinating Group (USDA)
NWIS	National Water Information System (DOI)
NWLON	National Water-Level Observation Network (NOAA/NOS)
NWP	Numerical Weather Prediction
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast Service (NOAA/NWS)
NWSTC	National Weather Service Training Center (NOAA/NWS)
NXDP	National Xeriscape Demonstration Program (DOI)
O&C	Oregon and California Railroad Land Grants (DOI)
OAR	Office of Oceanic and Atmospheric Research (NOAA)
OASIS	Operational and Supportability Implementation System (FAA)
OB	Operational Build
OCAP	Operating Consortium of ASDAR Participants (WWP)
OCE	Office of the Chief Economist (USDA)
OCRWM	Office of Civilian Radioactive Waste Management
OCWWS	Office of Climate, Water, and Weather Services (NOAA/NWS)
OEH	Office of Emergancy Management
OFCM	Office of the Federal Coordinator for Meteorology
OGP	Office of Global Programs (NOAA)
OMB	Office of Management and Budget
OMEGA	Operational Medicine Environmental Grid Application (DOD)
OMPS	Ozone Mapping and Profiler Suite
ONR	Office of Naval Research
OOR	Object Oriented Redesign
OPAREA	Fleet Operational Area (DOD)
OPARS	Optimum Path Aircraft Routing System (DOD)
OPC	Operational Processing Centers
OPS-II	Operational Weather Squadron Production System, Phase II
OPUP	Open Principal User Processor
OR&F	Operations, Research, and Facilities (NOAA/NWS)
ORA	Office of Research and Applications (NOAA/NESDIS)
ORAU	Oak Ridge Associated Universities (DOE)
ORD	Operational Requirements Documents (DOD)
ORISE	Oak Ridge Institute for Science and Education (DOE)
ORNL	Oak Ridge National Laboratory (DOE)
OROO	Oak Ridge Operations Office (DOE)
ORPG	Open Systems Radar Product Generator (NOAA/OAR)
ORR	Oak Ridge Reservation (DOE)
ORS	Optical Remote Sensing
OS	Office of Science, South Carolina
OS-21	Observing System 21st Century (DOD)
OSC	On-Scene Commander (DOE)
OSDPD	Office of Satellite Data Processing and Distribution (NOAA/NESDIS)
OSE	Observing System Experiments (WWP)
OSEI	Operational Significant Event Imagery (NOAA/NESDIS)
OSHA	Occupational Safety and Health Administration
OSO	Office of Satellite Operations (NOAA/NESDIS)
OSSE	Observing System Simulation Experiments (WWP)
OSTEP	Ocean Systems Test and Evaluation Program (NOAA/NOS)
OSTP	Office of Science and Technology Policy
OTC	Operational Test Centers
OTH	Over the horizon (NOAA/OAR)
OTSR	Optimum Track Ship Routing (DOD)
OWF	Operational Weather Flight (DOD)
OWS	Operational Weather Squadron (DOD)

OWSE	Operational World Weather Watch Systems Evaluation (WWP)
PAA	Precipitation Accumulation Algorithm (DOI)
PAC	Procurement, Acquisition, and Construction (NOAA/NWS)
PACS	Polar Acquisition and Control Subsystem (NOAA/NESDIS)
PAR	Phased Array Radar
PATMOS	Pathfinder Atmosphere (NOAA/NESDIS)
PAWRP	Phased Array Weather Radar Project
PBL	Planetary Boundary Layer (DOE)
PC	Program Council (OFCM)
	Personal Computer (DOE)
PCB	Polychlorinated Biphenyl
PCMDI	Program for Climate Model Diagnosis and Intercomparison (DOE)
PD	Program Director (DOD)
PDD	Presidential Decision Directive
PDT	Product Development Team
PECAD	Production Estimates and Crop Assessment Division (USDA)
PIBAL	Pilot Balloon
PIPS	Polar Ice Prediction System (NOAA/NESDIS)
PIRATA	Pilot Research Moored Array in the Tropical Atlantic (NOAA/OAR)
PIREP	Pilot Report
PMC	Project Management Coordinator (DOE)
PMEL	Pacific Marine Environmental Laboratory (NOAA/ERL)
PNNL	Pacific Northwest National Laboratory (DOE)
PNT	Position, Navigation, and Timing (USCG)
POES	Polar-orbiting Operational Environmental Satellite (NOAA)
POP	Parallel Ocean Program (DOE)
POPS	Primary Oceanographic Prediction System (DOD)
PORTS	Physical Oceanographic Real-Time System (NOAA/NOS)
ppm	Part per Million (DOE)
PSDA	Post-Storm Data Acquisition (OFCM)
PSR	Polarimetric Scanning Radiometer (NOAA/OAR)
PSS	Plant Shift Superintendent
PUP	Principal User Processor
QPF	Quantitative Precipitation Forecast (NOAA/NCEP)
QuikSCAT	Quick Scatterometer
R&A	Research and Analysis
R&D	Research and Development
RAFC	Regional Area Forecast Center (WWP)
RAMS	Regional Atmospheric Modeling System (DOE)
RAMSDIS	RAMM Branch Advanced Meteorological Satellite Demonstration and Interpretation System (NOAA/NESDIS)
RAP	Radiological Assistance Program (DOE)
	Remedial Action Plan (DOE)
RARC	Regional Atmospheric Response Center (DOE)
RASS	Radio Acoustic Sounding System (NOAA/OAR and DOE)
RATS	Radio Automatic Theodolite System (NASA)
RAWS	Remote Automatic Weather Station (USDA/DOI)
RBCN	Regional Basic Climate Network (WWP)
RC	Reserve Component (DOD)
RCC	Regional Climate Center (NOAA/NESDIS)
RCTM	Road Condition and Treatment Module (FHWA)
RDA	Radar Data Acquisition
RDEC	Research Development and Engineering Center (DOD)
RDTE	Research, Development, Test and Evaluation (DOD)

REIP	Reengineered Enterprise Infrastructure Program (DOD)
RF	Radio Frequency
RFETS	Rocky Flats Environmental Technology Site (DOE)
RFO	Rocky Flats Office (DOE)
RFC	River Forecast Center (NOAA/NWS)
RMTN	Regional Meteorological Telecommunications Network (WWP)
ROC	Radar Operations Center (NOAA/NWS)
RPC	Rapid Prototype Center (NOAA/SEC)
RSA	Range Standardization and Automation (NASA)
RSAC	Transport and Dispersion Code at INEEL (DOE)
RSFWSU	Remote Sensing/Fire Weather Support Unit (DOI)
RSL	Remote Sensing Laboratory
RSMC	Regional/Specialized Meteorological Centers (WWP)
RSS	Receiving Set Satellite (DOD)
RTH	Regional Telecommunications Hub (WWP)
RUC	Rapid Update Cycle (NOAA/OAR)
RVR	Runway Visual Range (FAA)
RWIS	Road Weather Information System (FHWA)
SAA	Satellite Active Archive
	Snow Accumulation Algorithm (DOI/BLM)
SAFETEA	Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (FHWA)
SALEX	Saharan Air Layer Experiment
SAMS	Stochastic Analysis, Modeling, and Simulation (DOI)
SAP	Special Access Program
SAR	Synthetic Aperture Radar (NOAA/NESDIS)
SARSAT	Search and Rescue Satellite Aided Tracking
SATCOM	Satellite Communications
SATS	Small Aircraft Transportation System (NASA)
SAWS	Stand Alone Weather Sensor (FAA)
SBIR	Small Business Innovation Research Program
SBUV	Solar Backscatter Ultra-violet Instrument (NOAA/NESDIS)
SCAN	Soil Climate Analysis Network (USDA)
SCAPA	Subcommittee for Consequence Assessment and Protective Actions
SCI	Sensitive Compartmented Information (DOD)
SDHS	Satellite Data Handling System (DOD)
SeaWiFS	Sea-viewing Wide Field Scanner (NASA)
SEC	Space Environment Center (NOAA/NCEP)
	Sun Earth Connection (NASA)
SEM	Space Environment Monitor (NOAA)
SEMSIM	Southeastern Michigan Snow and Ice Management (FHWA)
SEON	Solar Electro-optical Observing Network (DOD)
SESS	Space Environmental Sensor Suite
SFMR	Stepped Frequency Microwave Radiometer
SGP	Southern Great Plains (DOE)
SHEBA	Surface Heat Budget of the Arctic Ocean (DOE)
SHEP	State Highway Emergency Patrol (FHWA)
SHRP	Strategic Highway Research Program (FHWA)
SIGRID	Sea Ice in Gridded Format (NOAA/NESDIS)
SLF	Shuttle Landing Facility
SLRS-C	Spacelift Range System Contract (NASA)
SMC	Space and Missile Systems Center (DOD)
SMDC	Space and Missile Defense Command (DOE)
SMG	Spaceflight Meteorology Group (NASA)
SNDR	Subcommittee on Natural Disaster Reduction
SNL	Sandia National Laboratory (DOE)
SNODEP	SNOw DEPth

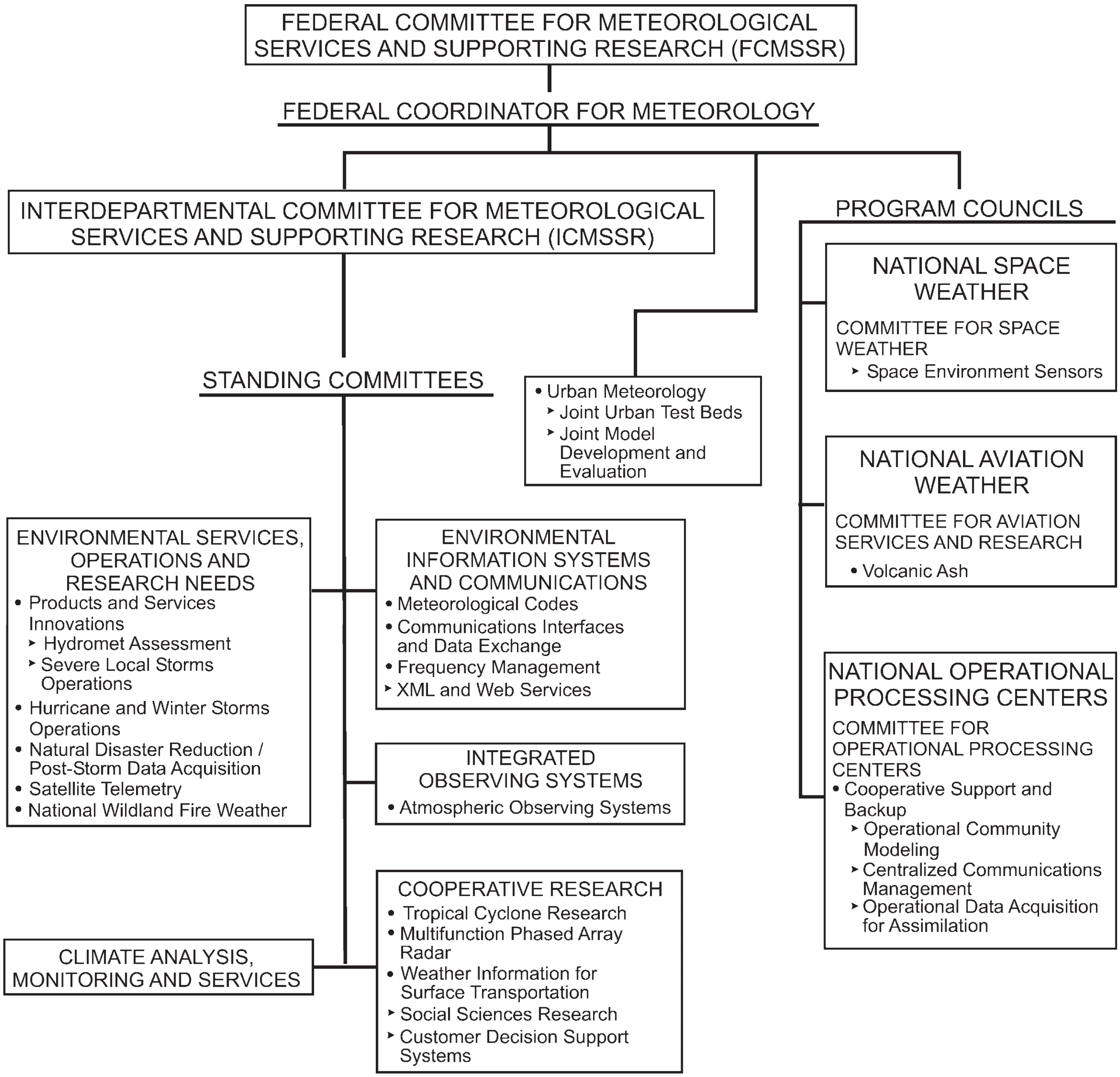
SNOTEL	Snow Pack Telemetry (USDA)
SOCC	Satellite Operations Control Center (NOAA/NESDIS)
SODAR	Sound Detection and Ranging (DOE)
SODAR/RASS	Sound Detection and Ranging/Radio Acoustic Sounding System (DOE)
SOF	Special Operations Forces (DOD)
SOLAS	International Convention for Safety of Life at Sea (NOAA/NCEP, DHS/USCG)
SOPA	Synchronous Orbit Plasma Analyzer (DOE)
SORD	Special Operations and Research Division (NOAA/ARL)
SPLASH	Hydrologic Code at LANL (DOE)
SPAWARSYSCOM	Space and Naval Warfare Systems Command
SPC	Storm Prediction Center (NOAA/NCEP)
SPO	System Program Office (DOD)
SPP	Shared Processing Program
SQA	Software Quality Assurance
SR	Savannah River (DOE)
SRB	Solid Rocket Booster
SRNL	Savannah River National Laboratory (DOE)
SROO	Savannah River Operations Office
SRS	Savannah River Site
SRTC	Savannah River Technology Center (DOE)
SS&WSF	Snow Survey & Water Supply Forecasting (USDA)
SSIES	Special Sensor for Ions and Electrons (DOD)
SSJ	Special Sensor Precipitating Elecron and Ion Spectrometer (DOD)
SSM	Special Sensor Magnetometer (DOD)
SSM/I	Special Sensor Microwave/Imager (DOC, DOD, DOI)
SSM/T	Special Sensor Microwave/Temperature (DOD)
SSOB	Special Support Operations Branch (DOD)
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit (NOAA)
SSUSI	Special Sensor Ultraviolet Spectrographic Imager (DOD)
STAR	Weather Data Format used at Pantex (DOE)
STIWG	Satellite Telemetry Interagency Working Group (OFCM)
STP	Solar-Terrestrial Physics
STS	Special Tactics Squadron (DOD)
STWDSR	Surface Transportation Weather Decision Support Requirements (FHWA)
SURFRAD	Surface Radiation Budget Station at NTS (DOE)
SVS	Synthetic Vision System (NASA)
SWA	Southwest Asia (DOD)
SWAFS	Space Weather Analysis and Forecasting System (DOD)
SWE	Snow Water Equivalent (DOI/BUREC)
SWO	Staff Weather Officer (DOD)
	Space Weather Operations (NOAA/OAR)
SWR	Supplemental Weather Radar (DOD)
SWSI	Surface Water Supply Index (USDA)
SXI	Solar X-Ray Imager (DOD)
T2	Technology transfer
TAF	Terminal Aerodrome Forecast
TAL	Transatlantic Abort Landing (NASA)
TAMDAR	Troposphere Airborne Meteorological Data Reports (WWP)
TAO	Tropical Atmosphere Ocean
TAWS	Target Acquisition Weather Software (DOD)
TCP	Transformation Campaign Plan (DOD)
TDA	Tactical Decision Aid (DOD)
TDWR	Terminal Doppler Weather Radar (FAA)
TEA-21	Transportation Equity Act for the 21st Century (FHWA)
TEC	Topographic Engineering Center (DOD)
	Total Electron Content (DOE)

TED	Total Energy Detector (NOAA/NESDIS)
TEDS	Tactical Environmental Data Server (DOD)
TESS	Tactical Environmental Support System (DOD)
THORPEX	The Observing System Research and Predictability Experiment (WWP)
TIMEX	Thunderstorm Initiation Mobile Experiment (NOAA/OAR)
TIROS	Television Infrared Observation Satellite (NOAA/NESDIS)
TOC	Tactical Operations Center (DOD)
TOE	Table of Organization and Equipment (DOD)
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS-N Operational Vertical Sounder (NOAA/NESDIS)
TNT	Trinitrotoluene (DOE)
TPAWS	Turbulence Prediction and Warning System
TPC	Tropical Prediction Center (NOAA/NCEP)
TPW	Total Precipitable Water (NOAA/NESDIS)
TRACON	Terminal Radar Approach Control (FAA)
TRADOC	Training and Doctrine Command (DOD)
TRB	Transportation Research Board (FHWA)
TRITON	Triangle Trans-Ocean buoy Network (NOAA/OAR)
TRMM	Tropical Rainfall Measuring Mission (NASA)
TRU	Transuric (DOE)
TSIS	Total Solar Irradiance Sensor
TUAN	Tactical Unmanned Aerial Vehicle (DOD)
TWC	The Weather Channel
TWIP	Terminal Weather Information for Pilots (FAA)
TWP	Tropical Western Pacific (DOE)
TWR	Tactical Weather Radar (DOD)
UAV	Unmanned Aerial Vehicle (DOD)
UC	University of Chicago or California
UCAN	Unified Climate Access Network (USDA)
UCAR	University Corporation for Atmospheric Research
UHF	Ultra High Frequency
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization (WWP)
UNLV	University of Nevada at Las Vegas (DOE)
UPOS	University Partnering for Operational Support (DOD)
USA	U.S. Army
USACE	U.S. Army Corps of Engineers
USAES	U.S. Army Engineer School
USAF	U.S. Air Force
USAFE	U.S. Air Forces in Europe
USAFAS	U.S. Army Field Artillery School
USAIC&FH	U.S. Army Intelligence Center and Fort Huachuca
USAR	U.S. Army Reserve
USARAK	U.S. Army Alaska
USARC	U.S. Army Reserve Command
USAREUR	U.S. Army Europe
USARHAW	U.S. Army Hawaii
USARIEM	U.S. Army Research Institute of Environmental Medicine
USARJ	U.S. Army Japan
USARPAC	U.S. Army Pacific
USASMDC	U.S. Army Space and Missile Defense Command
USASOC	U.S. Army Special Operations Command
USCENTCOM	U.S. Central Command
USCG	U.S. Coast Guard

USDA	U.S. Department of Agriculture
USGCRP	U.S. Global Change Research Program
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USHCN	U.S. Historical Climatology Network
USIABP	U.S. Interagency Arctic Buoy Program (NOAA/NESDIS)
USMC	U.S. Marine Corps
USMCC	U.S. SARSAT Mission Control Center (NOAA/NESDIS)
USN	U.S. Navy
USSOCOM	U.S. Special Operations Command (DOD)
USWRP	U.S. Weather Research Program
UT	University of Tennessee
UTC	Universal Time Coordinated (Zulu)
UV	Ultra-violet
VA	Volcanic Ash
VAAC	Volcanic Ash Advisory Center (NOAA/NESDIS)
VAS	VISSR Atmospheric Sounder
VCP	Voluntary Cooperation Program (WWP)
VII	Vehicle Infrastructure Integration (FHWA)
VIIRS	Visible/Infrared Imager/Radiometer Suite
VIN	Vegetative Index Number (USDA)
VIRS	Visible and Infrared Scanner (NASA)
VISSR	Visible and Infrared Spin Scan Radiometer
VOC	Volatile organic compound
VISTAS	Visibility Improvement State and Tribal Association of the Southeast (DOI)
VORTEX	Verification of the Origins of Rotation in Tornadoes Experiment (NOAA/OAR)
VOS	Voluntary Observing Ship (WWP)
VPR	Vertical Profile of Reflectivity (DOI)
VSAT	Very Small Aperture Terminal (DOD)
VSL	Variable Speed Limit (FHWA)
VTMX	Vertical Transport and Mixing Experiment (DOE)
VTS	Vessel Traffic System (NOAA/NOS)
WAAS	Wide Area Augmentation System (FAA)
WAFC	World Area Forecast Center (WWP)
WAFS	World Area Forecast System (WWP)
WAMIS	World Agrometeorological Information Service (USDA)
WAOB	World Agricultural Outlook Board (USDA)
WARP	Weather and Radar Processor (FAA)
WaRSMP	Watershed and River System Management Program (DOI)
WCT	Wind Chill Temperature (OFCM)
WDA	Weather Data Analysis (DOD)
WEFAX	Weather Facsimile (WWP)
WETM	Weather Team (DOD)
WFAS	Wildland Fire Assessment System (DOI)
WFMIS	Wildland Fire Management Information Site (DOI)
WFO	Weather Forecast Office (NOAA/NWS)
WG	Working Group
WG/VA	Working Group for Volcanic Ash (DOI)
WG/PSDA	Working Group for Post-Storm Data Acquisition (FEMA)
WGCV	Working Group on Calibration and Validation (NOAA/NESDIS)
WINCOM	Weather Information Communications (NASA)
WIMS	Weather Information Management System (USDA)
WIND	Weather Information and Display (DOE)
WIPP	Waste Isolation Pilot Plant (DOE)
WIS	WMO Information System(WWP)

WIST	Weather Information for Surface Transportation
WMC	World Meteorological Center(s) (WWP)
WMO	World Meteorological Organization
WMSCR	Weather Message Switching Center-Replacement (FAA)
WOCE	World Ocean Circulation Experiment
WPDN	Wind Profile Demonstration Network (NOAA)
WPSM	Warfighter Physiological Status Monitoring (DOD)
WRD	Water Resources Division (DOI/USGS)
WRF	Weather Research and Forecast (DOC, DOD)
WRS	Weather Reconnaissance Squadron (DOD)
WRTC	Weather Readiness Training Center (DOD)
WSDDM	Weather Support to Deicing Decision Making (FAA)
WSP	Weather Systems Processor (FAA)
WSR-88D	Weather Surveillance Radar-1988 Doppler (NEXRAD)
WSRC	Westinghouse Savannah River Company (DOE)
WSSRAP	Weldon Springs Site Remedial Action Project (DOE)
WST	Weather Specialty Team (DOD)
WTS	Washington TURU Solutions
WWCB	Weekly Weather and Crop Bulletin (USDA)
WWP	World Weather Program
WWW	World Weather Watch (WMO)
	World Wide Web
XOW	Air Force Director of Weather (DOD)
YMP	Yucca Mountain Project (DOE)

FEDERAL METEOROLOGICAL COORDINATING INFRASTRUCTURE



September 2007

LEGEND:
- • Designates a Working Group
- ‣ Designates a Joint Action Group