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 standalone 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.

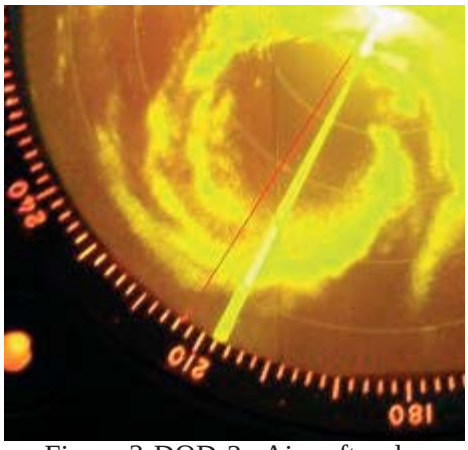

Figure 3-DOD-2. Aircraft radar shows the eye of Hurricane Claudette is 25 nautical miles wide and the wall cloud is weakest in the northeast quadrant (53 WRS website)

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 Multifunctional 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).

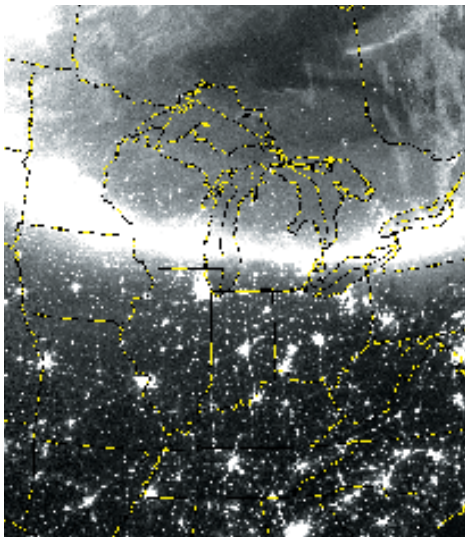
Figure 3-DOD-3. DMSP captures Aurora Borealis, over the Midwest; the aurora was pushed toward the equator by a November 4, 2003, geomagnetic storm. (AF Weather website)

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

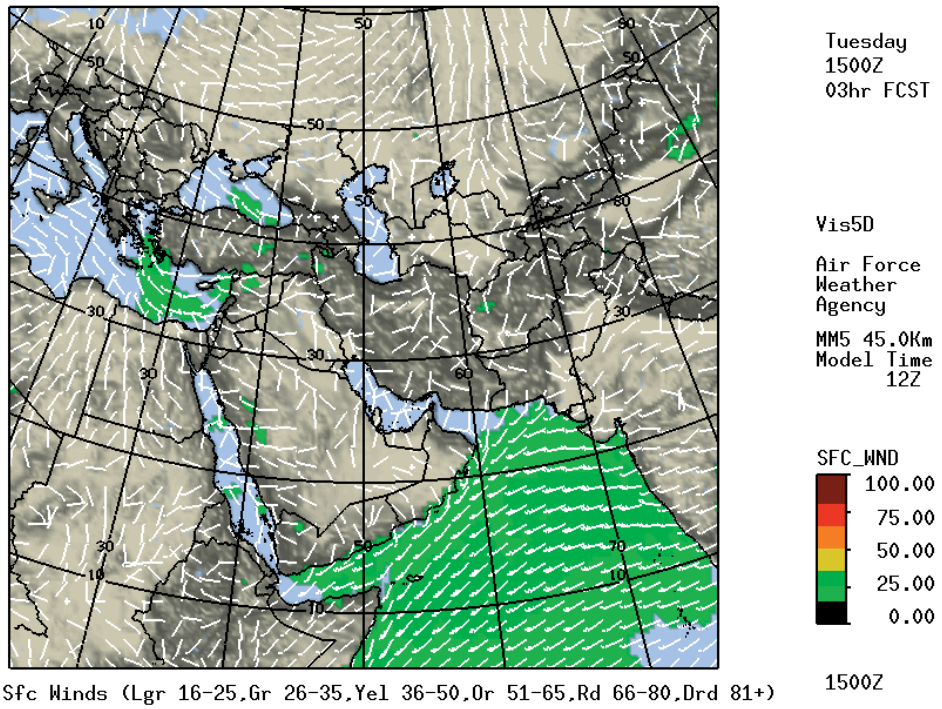

Figure 3-DOD-5. Joint Air Force and Army Weather Information Network (JAAWIN) provide reachback capability for deployed weather forces. This 3-hour forecast of surface winds over Southwest Asia was generated from AFWA's 45-km MM5 (AFWA Website)

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 pre-

diction 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. Analysts 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

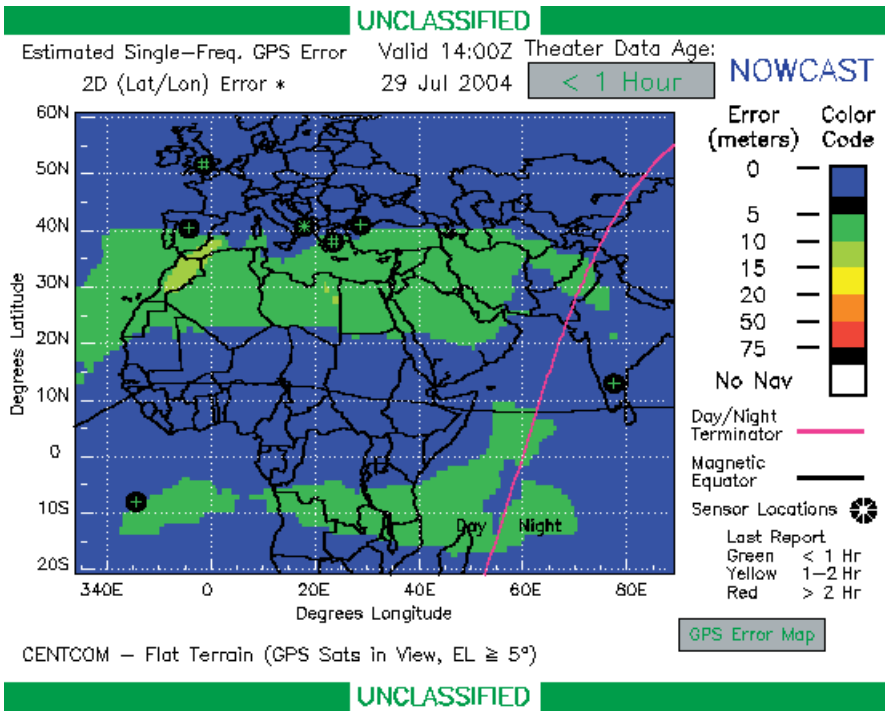

Figure 3-DOD-6. Single-Frequency GPS Receiver Error Map (visualization by HQ AFWA)

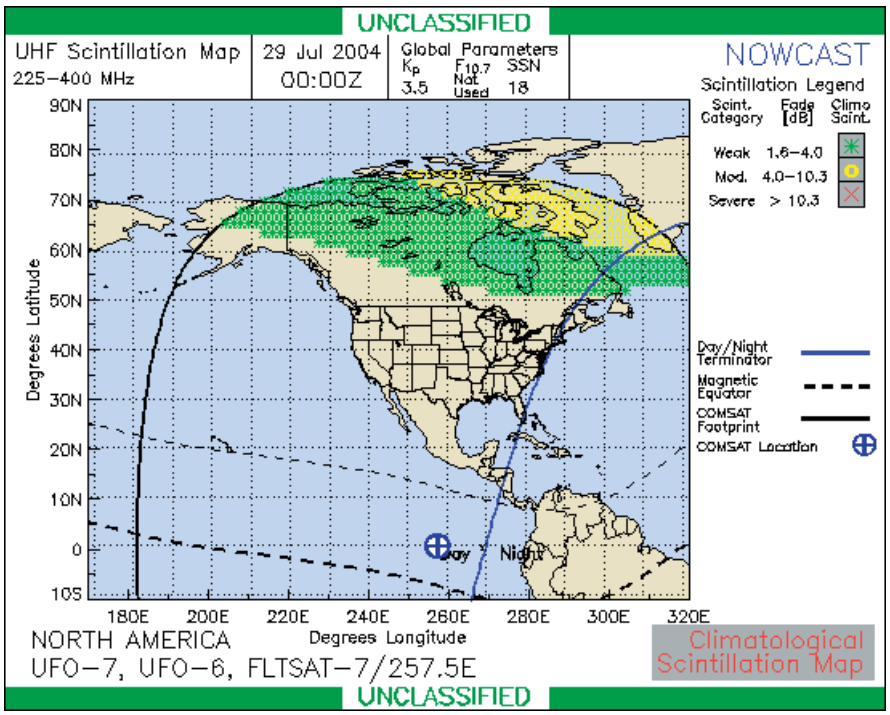

Figure 3-DOD-7. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

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.

Provide Actionable Environmental Impacts Information to Decision Makers

To provide actionable environmental impacts, AF weather forces continually improve the core processes of tailoring and integration.

Tailoring. Once centralized weather units create a depiction of the past, current, and future state of the natural

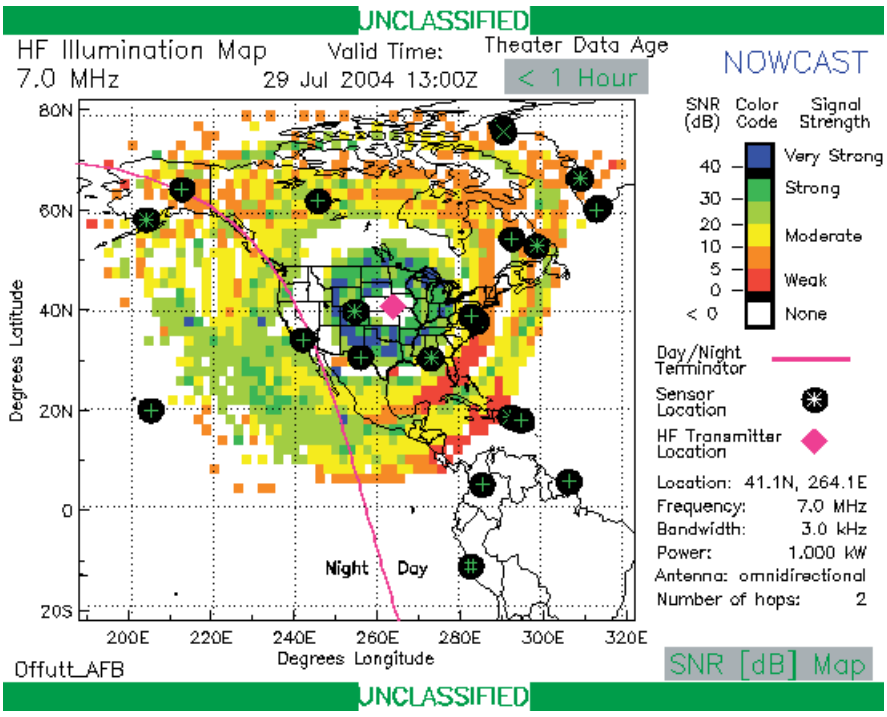

Figure 3-DOD-8. HF Illumination Map (visualization by HQ AFWA).

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-

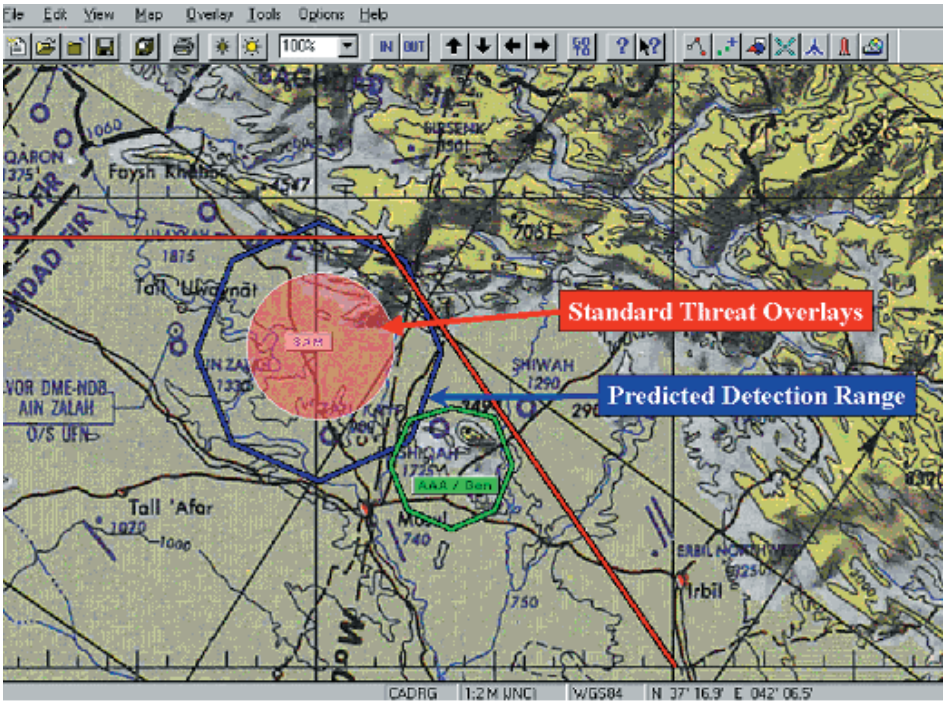

Figure 3-DOD-9. Target Acquisition Weapon Software (TAWS) integrates meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution. (US Air Force Released)

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.

Integration. 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 bul-

letins, 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

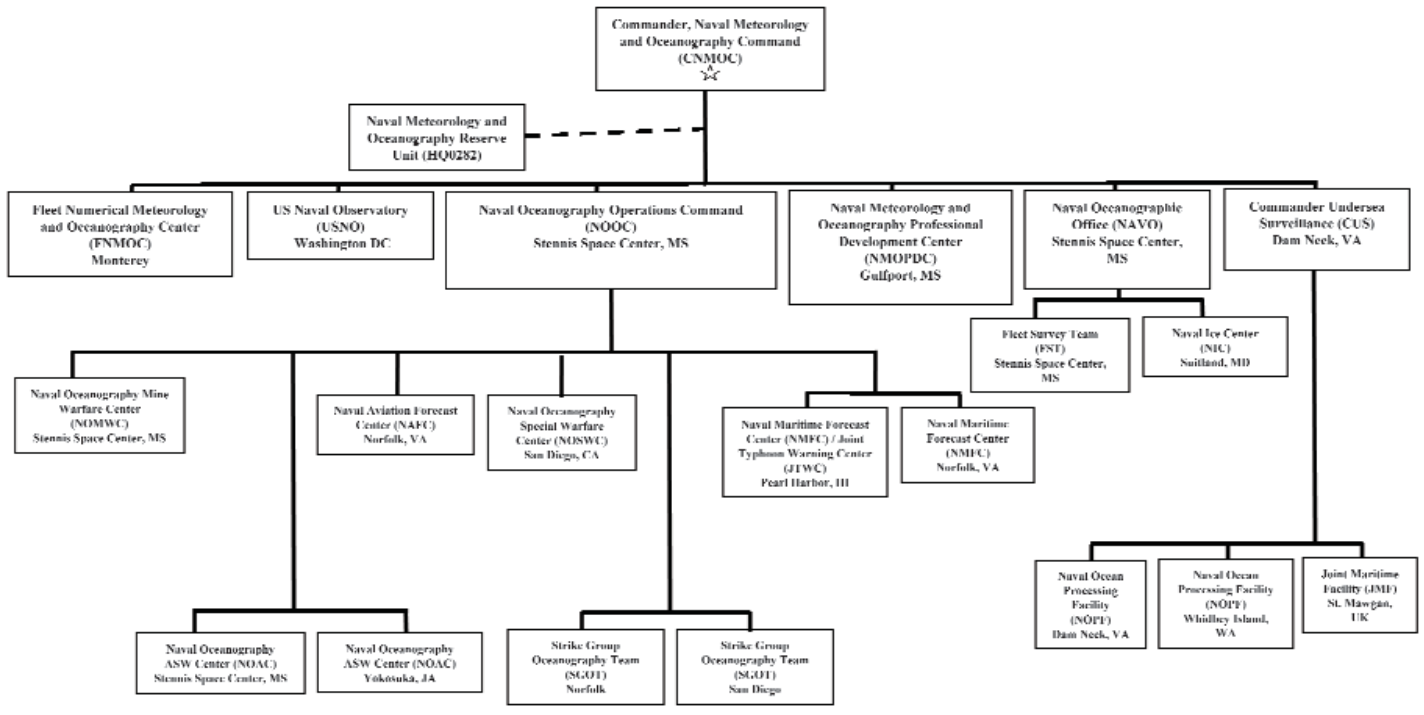

Figure 3-DOD-10. Naval Meteorology and Oceanography Command Organizational Chart (US Navy Released)

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.

Training and Doctrine Command Programs

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 Com-

bined 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 perform-

ance. 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.