DEPARTMENT OF THE INTERIOR WEATHER PROGRAMS

The Department of the Interior (DOI), is the nation's principal conservation agency, charged with the mission "*to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.*" The following operational and research programs contribute to the Federal Meteorological Plan.

UNITED STATES GEOLOGICAL SURVEY (USGS)

WATER DATA

The USGS's Water Resources Discipline (WRD) collects streamflow, precipitation, water quality, ground-water level, and other water resources and climatological data as part of a national network and for a number of projects concerning rainfall-runoff, water quality and hydrologic processes. Currently, the USGS collects continuous hydrologic and meteorological data at about 8,900 surface water sites, 2,700 ground water level sites, and 1,600 water quality sites. Periodic records are collected at approximately 1,500 additional surface water sites, 20,200 ground water sites, and 10,300 water quality sites. Precipitation records are collected at about 800 sites.

Data collected at most continuous-record USGS sites are transmitted from remote Data Collection Platforms (DCPs) to Wallops Island, Virginia via a Geostationary Operational Environmental Satellite (GOES). From the Wallops Island facility, data are rebroadcast to a domestic communication satellite (DOMSAT). Data are received from the DOMSAT by local readout ground stations (LRGS) procured by USGS. The USGS currently operates 21 LRGS which provide near-real-time data to the USGS's computerized National Water Information System (NWIS). Near-real-time streamflow data and ancillary information are provided to National Weather Service River Forecast Centers for river forecast points (Figure 3-DOI-1). Additional historical and real-time water resources data are available from the USGS database at NWIS Web (http://waterdata.usgs.gov/nwis/).

The USGS also collects precipitation samples at a number of sites to determine the atmospheric contribution of chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment.

CLIMATOLOGICAL RESEARCH

USGS carries out research in climate change, regional hydrology, the carbon cycle, coastal erosion, and glaciology. The Water, Energy, and Biogeochemical Budgets (WEBB) program is studying processes controlling water, energy, and biogeochemical fluxes at five small research watersheds in the U.S. This program includes research on the effects of atmospheric and climatic variables on watershed processes. There are also a number of ongoing studies to characterize trends in hydrologic data and to relate these trends to climatic variables. Researchers are also using global and regional climate models to enhance understanding of the potential effects of climate change and climate variability on U.S. land and water resources.

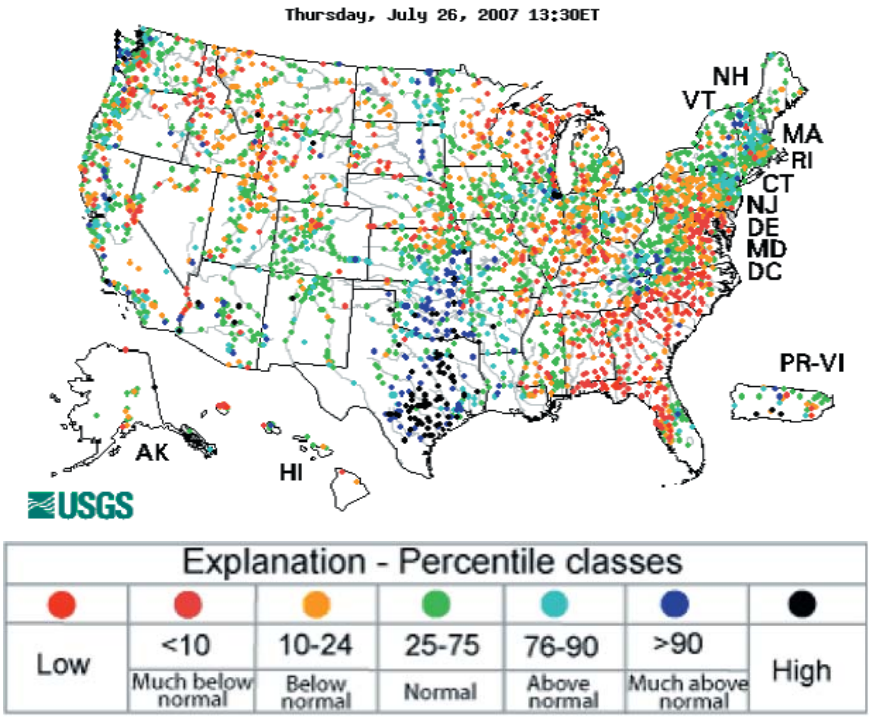


Figure 3-DOI-1. Sample USGS Water Watch map of real-time streamflow compared to historical streamflow for the day of the year. Source: USGS Website (http://water.usgs.gov/waterwatch)

As part of its glaciology program, the USGS maintains an observation program on three benchmark glaciers representative of different climatic zones of the western United States, one in Washington, one on the south coast of Alaska, and one in the interior of Alaska. At each glacier, the program measures the winter snow accumulation, summer snow and ice ablation, air temperature, and runoff in the glacier basin. Beginning in 1959, this is the longest such record in North America. Analysis of this record is providing a greater understanding of the climate variability and its effects on water resources of the western United States. The record clearly shows the effects of changing winter precipitation patterns associated with atmospheric conditions in the northeast Pacific Ocean, including El Niño - La Niña events and the Pacific Decadal Oscillation.

To augment its glacier monitoring efforts, the USGS is using National Systems data to measure fluctuations of glaciers in Alaska, Washington, and Montana. Mountain glaciers are ideal subjects for these systems because they are remote, have an appropriate space scale, and require infrequent but repetitive observations. The observations have established a baseline of regional glacial conditions. The resulting and on-going archive of observations is now 5 years long and is being used to determine recent trends in glacier size and terminus location. In addition, techniques have been developed to generate derived products that provide critical glacial parameters, including DEMs, equilibrium line altitudes, and ablation rates. These products are being incorporated into a glacial runoff model of the South Cascade Glacier, Washington, where they are proving to be a valuable source of otherwise unavailable data.

SNOW AND ICE STUDIES

USGS scientists are cooperating with scientists at the University of Washington, Seattle, to improve hydrologic runoff modeling of the snow pack in the Pacific Northwest through the application of data assimilation techniques. The assimilation uses passive microwave observations from the Advanced Microwave Scanning Radiometer, AMSR-E, and numerical integration of Maxwell's equations constrained by a snow pack model to determine the distribution of snow water equivalent across select drainage basins. Then the UW Variable Infiltration Capacity (VIC) model calculates the subsequent runoff, which is compared to USGS discharge measurements. If the calculated runoff is not within a specified amount of the measured runoff, the assimilation technique adjusts the snowpack characteristics and another iteration is carried out.

USGS, in cooperation with BLM, is using a variety of remote sensing data to monitor the rapid wastage of the piedmont lobe of Bering Glacier, Alaska. Landsat, Radarsat, ICESat, and Ikonos observations show that Bering Glacier is retreating rapidly and thinning in an accelerating retreat from an advanced position that resulted from a major glacial surge in 1993-95. The satellite data and ground-based observations have been combined to determine the surface flow velocities and calving rates of the glacier, and to monitor the expansion of Vitus Lake and Berg Lake, two large lakes whose boundaries include the glacier terminus. The rapid change in glaciation is having a large impact on nearby terrestrial and aquatic ecosystems.

GEOMAGNETIC DATA

The Geomagnetism Program (http://geomag.usgs.gov) of the USGS Central Region Geohazards Team provides real-time, ground-based measurements of the Earth's magnetic field, which are an important contribution to the diagnosis of conditions in the near-Earth space environment of the sun, the solar wind, the magnetosphere, the ionosphere, and the thermosphere. During geomagnetic storms, brought about by the complex interaction of the Earth's magnetic field with that of the Sun's, both high- and low-frequency radio communications can be difficult or impossible, global positioning systems (GPS) can be degraded, satellite electronics can be damaged, satellite drag can be increased, and astronauts and high-altitude pilots can be subjected to enhanced levels of radiation.

Ground-based geomagnetic observatory data are complementary to those collected by space-based satellites; indeed, most of the hazardous effects on technological systems brought about by magnetic storms occur at or near the Earth's surface. Therefore, the Geomagnetism Group monitors the surficial magnetic field by operating 14 magnetic observatories in the United States and its Territories. The data from these observatories, plus 15 foreign observatories, are transmitted to the Group's headquarters in Golden, Colorado, where they are processed and analyzed. Data are then transmitted to the Space Environment Center (SEC) of the National Oceanic and Atmospheric Administration (NOAA) and to the U.S. Air Force's (USAF) Weather Agency at Offutt Air Force Base, Nebraska.

USGS observatories are operated in cooperation with Intermagnet (www.intermagnet.org), an international consortium overseeing the operation of nearly 100 geomagnetic observatories distributed around the globe. The USGS Geomagnetism Program is also an integral part of the National Space Weather Program (http://nswp.gsfc.nasa.gov).

VOLCANOLOGY AND VOLCANIC ASH PLUMES

Through its Volcanic Hazards Program, the USGS is responsible for monitoring volcanoes in the United States and issuing eruption forecasts and notifications. The USGS partici-

pates in the Working Group for Volcanic Ash (WG/VA) of the OFCM. This working group is preparing a National Volcanic Ash Operating Plan for Aviation. The purpose of the plan is to provide operational guidance by documenting the required procedures and information products of the government agencies responsible for ensuring safety of flight operations when volcanic ash has been erupted into the atmosphere. The agencies involved are the USGS, Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Air Force. Timeline for completion of the plan is FY08.

The OFCM helps to administer funding from the FAA to the USGS to improve aviation safety through expanded volcano monitoring in Alaska, where many historically active volcanoes underlie the heavily traveled air routes of the North Pacific region. Over the past decade, with FAA support, the USGS's Alaska Volcano Observatory (AVO) has installed seismic networks at approximately two dozen volcanoes in the Aleutian Islands, bringing to 31 the number of Alaska's volcanoes under continuous real-time geophysical surveillance. Data and information from the AVO monitoring activities are integrated directly into the regional operational activities of the FAA, DOD, and NOAA/NWS to provide warnings for pilots and aircraft operators in the Alaskan region.

The U.S. has experienced significant levels of volcanic activity recently. Augustine Volcano, located near Anchorage, Alaska, erupted from January to April 2006, finally settling back into quiescence that summer. AVO mounted a 24/7 monitoring response to characterize ash-cloud hazards to aviation and worked closely with the National Weather Service to provide ash-fall information to the public. AVO also has continued to closely monitor Cleveland volcano in Alaska, which has been erupting intermittently since 2001. Mount St. Helens, Washington, reawakened in September 2004 from 18 years of quiescence. The eruption has largely consisted of the extrusion of lava with activity confined to the summit area. However, occasional explosions have erupted ash to heights as great as 30,000 feet above sea level. USGS, NWS, and FAA have worked together to develop procedures and protocols to handle an erupting volcano situated between two major metropolitan centers.

Recognizing that many potentially dangerous U.S. volcanoes have inadequate or no ground-based monitoring, the USGS recently evaluated U.S. volcano-monitoring capabilities and published *An Assessment of Volcanic Threat and Monitoring Capabilities in the United States: Framework for a National Volcano Early Warning System (NVEWS)* (http://pubs.usgs.gov/of/2005/1164/). Results of the NVEWS volcanic threat and monitoring assessment are being used to guide long-term improvements to the national volcano-monitoring infrastructure operated by the USGS and affiliated groups.

The most threatening volcanoes, those near communities and transportation infrastructure (ground and air) and with a history of frequent and violent eruptions, need to be well monitored in real time with an extensive suite of instrument types to detect the earliest symptoms of unrest and to reliably forecast behavior of the volcano. Waiting until unrest escalates to augment monitoring capabilities at these high-threat volcanoes puts people (including scientists in the field) and property at undue risk. Remote, isolated, or less frequently erupting volcanoes that nevertheless can pose hazards to air-traffic corridors require sufficient monitoring capability with ground-based instruments to detect and track unrest in real-time so that other agencies responsible for enroute flight safety can be kept apprised of the potential for explosive, ash-cloud-forming eruptions.

The Volcano Hazards Program has posted pages on its website devoted to practical guidance for dealing with ash hazards to transportation, communications, agriculture, water supplies, etc. See http://volcanoes.usgs.gov/ash.

BUREAU OF LAND MANAGEMENT (BLM)

The BLM is one of five Federal Land Management agencies which have centralized Wildland fire weather operations at the National Interagency Fire Center (NIFC), in Boise, Idaho. The BLM's Initial Attack Management System (IAMS) was designed in the mid-1980's to provide real-time data access and modeling for the fire management organization. The IAMS required a considerable dedicated telecommunications network for data distribution. In an effort to reduce these inherent telecommunications costs, the BLM has moved into a "web server" environment. Many of the capabilities that were centrally located in the old IAMS have been moved to other web sites.

FIRE WEATHER WEB SITES

The principal Wildland Fire Management Information System (WFMIS) inputs remain the same with Remote Automatic Weather Station (RAWS) and National Lightning Detection Network (NLDN) information (Figure 3-DOI-2). BLM's new server system is called the BLM Wildland Fire Management Information Site (www.nifc.blm.gov). Additional fire management information is summarized and made available at the Desert Research Institute (wrcc.dri.edu and cefa.dri.edu) and the United States Forest Service Wildland Fire Assessment System (//svinet2.fs.fed.us/land/wfas/). Additionally, the BLM has utilized the Desert Research Insti-

tute's capabilities to respond quickly for website support.

AUTOMATED WEATHER STATIONS

The BLM's RAWS Program primarily collects meteorological data for fire weather forecasting. However, use of BLM's RAWS data set by other non-fire users has generated sufficient funding to permit year-round operation of the entire network. The BLM's Resource Management and Oregon O&C (West-Side) also operate RAWS networks which are much smaller and have specific program requirements that differ from fire management.

LIGHTNING DETECTION

In 1997, the BLM began contracting with a private vendor via the National Weather Service for lightning location data. Data are received at the NIFC in Boise, Idaho, and placed on the BLM WFMIS for qualified user access. Current plans are to continue the operation of the Alaska Automatic Lightning Detection System as an independent government-owed and operated system.

FIRE WEATHER SUPPORT

The BLM's Remote Sensing / Fire Weather Support Unit (RSFWSU) at NIFC provides the full range of program management, equipment dispatch, field and depot maintenance, support and data services for the BLM and numerous other government agencies. This interagency-staffed and funded facility performs work under long term agreements with those agencies within the government having similar equipment and requirements.

CLIMATE MONITORING

In addition to the meteorological monitoring BLM conducts primarily to support wildland fire management activities, the BLM also conducts site-specific climate monitoring at over 200 manual weather station locations on the public lands in the 11 western states and Alaska. The operation of these sites ranges from seasonal to annual, taking measurements of precipitation, temperature, soil moisture, and other meteorological parameters necessary to assess local climactic influences. These data are primarily used for natural resources management and planning at the local level.

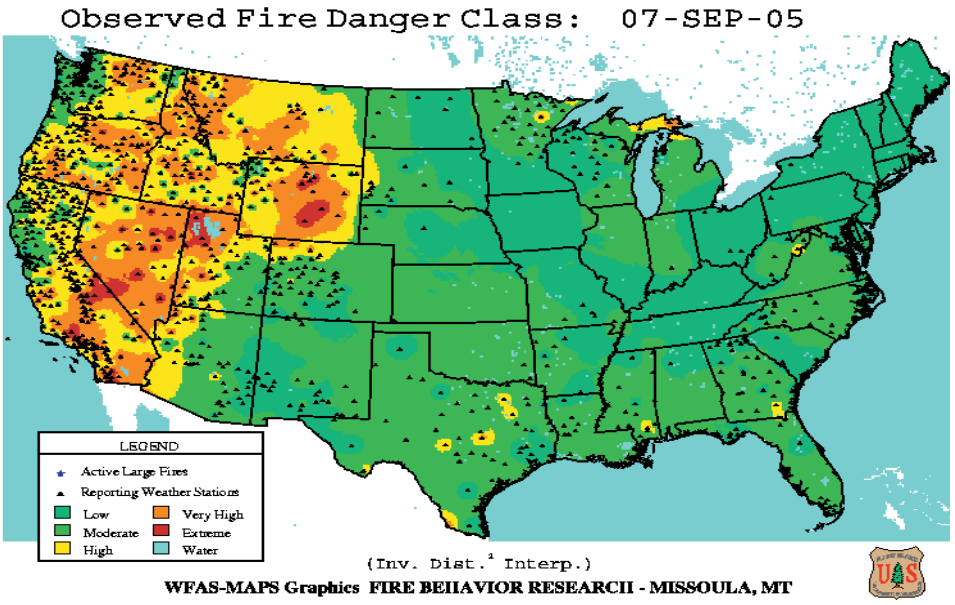


Figure 3-DOI-2. A National Interagency Coordination Center (NICC) graphic of Observed Fire Danger Class for the lower 48 states.

PORTABLE WEATHER STATIONS

During the 1999 fire season, the Remote Sensing/Fire Weather Support Unit began a 2-year "proof of concept" effort with a portable weather station referred to as the Fire RAWS (FRWS). FRWS are intended for use on or near a fire line and can be rapidly relocated to points desired by Fire Behavior Analysts for real-time weather data. Due to the extreme fire season in both 1999 and 2000, the FRWS was used extensively and was found to be a valuable asset for firefighter safety and fire weather forecasting. Fire managers have also increased the use of FRWS to monitor intentionally-initiated prescribed burns.

Currently, 42 FRWS systems are cached at NIFC. FRWS collect, store, and forward data by interrogated voice radio with new data available every fifteen minutes. Satellite data can be retrieved from multiple websites, and hourly satellite data is available to Fire Weather Forecasting Staff for spot forecasts and fire support from all central locations (Geographic Area Coordination Centers, NIFC, etc.).

ALL RISKS SUPPORT

After the terrorist attack on September 11th, 2001, the RSFWSU was tasked to provide near real-time meteorological data collection at the World Trade Center (Figure 3-DOI-3). This effort was in direct support of the Environmental Protection Agency's task of monitoring air quality in the vicinity of the collapsed towers. The unit also provided remote meteorological support for the Columbia Shuttle accident investigation and Hurricane Katrina recovery efforts. Using the personnel and resources available at the RSFWSU, the BLM offers a rapid meteorological support capability that is unique across the Federal government.

BUREAU OF INDIAN AFFAIRS (BIA)

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the

Figure 3-DOI-3. Remote Sensing/Fire Weather Support Unit providing near-real-time meteorological data collection at the World Trade Center.

Southwest. The Bureau also collects and shares fire weather data with other Federal agencies while participating in fire management activities for local and interagency use.

Currently, BIA operates the following instrumentation:

- 69 fire weather RAWS stations (permanent stations)
- 5 "manual" weather stations
- 13 portable RAWS stations used for Prescribed Fire
- 10 RAWS deployed on emergency stabilization projects.

MINERALS MANAGEMENT SERVICE (MMS)

The Minerals Management Service (MMS) gathers offshore meteorological data for use in the management of offshore oil and gas resources and sources of alternative energy. The data are used in air quality and oil-spill modeling, model development, and other research projects.

MMS operates a radar wind profiler (RWP) at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, Louisiana (Figure 3-DOI-4). Data collected at this site may be accessed at http://weather.lumcon.edu/weatherdata/doppler. The data will be applied to regional models for evaluating impacts from emission sources on ozone, fine particulate matter, and regional haze. The Service, in a cooperative agreement with The University of Houston (UH), operates an RWP at the UH Coastal Research Center (UHCRC) near Galveston, TX. The profiler will collect data for three years through FY 09.

The MMS has completed a meteorological and air quality modeling analysis in and around the Breton National Wilderness Area (NWA), which is a PSD Class I area located off southeastern Louisiana. MMS is currently sponsoring the operation of a visibility monitoring station near the Breton NWA IMPROVE site. The objective is to study the relationships between visibility, haze, ozone, PM2.5, dew point depression, and mixing height and to determine the source region(s) for haze, haze precursors, resulting is low visibility conditions near the Breton Island NWA. The study will utilize two additional visibility monitors operated by the Coastal Marine Institute (CMI) at Louisiana State University (LSU). Satellite data will be collected to measure optical depth and to determine source regions of atmospheric pollutants. This project should be completed sometime in FY 08.

Other ongoing studies in the Gulf of Mexico include (1) an effort to evaluate the effects of ozone deposition/chemical mechanism enhancements on air quality model performance over the coastal marine environment and (2) a study to evaluate of the effects of satellite data assimilation on meteorological/air quality model performance. Copies of all final reports in past meteorological and air quality studies in the Gulf of Mexico may be found at http://www.gomr.mms.gov/homepg/regulate/environ/techsumm/rec_pubs.html.

A meteorological data collection effort was conducted by MMS along the Beaufort Sea shoreline in Alaska; five meteorological stations collected data starting in 2001 (see http://www.resdat.com/mms/). Four of these stations will still be operating in FY 08 through an interagency cooperative program. The Service is analyz-

Figure 3-DOI-4. The MMS Profiler at LUMCON facility in Cocodrie, Louisiana.

ing the data gathered by these stations and will develop a mesoscale meteorological model for predicting ocean and ice circulation.

Another ongoing study in Alaska is an effort to develop an atmospheric modeling capability for the Cook Inlet/Shelikof region suitable for nowcast/forecast and research purposes. Among the objectives of this project is to develop an understanding of the mechanisms which drive low-level wind jets in the region, describe the vertical and thermal structure of wind jets, and study the cloud fields and precipitation associated with high wind events in the region. For more information on the MMS Alaska Region Studies Program see http://www.mms.gov/alaska/ess/index.htm.

NATIONAL PARK SERVICE (NPS) AND FISH AND WILDLIFE SERVICE (FWS)

The National Park Service monitors air quality and visibility in a number of national parks and monuments. Gaseous pollutant data are collected on continuous and integrated (24-hour to weekly) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four-hour-average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured every third day. Atmospheric light extinction is measured continuously and relayed to a central location for analyses.

MODELING

The NPS also conducts and contracts research to develop and test air quality models to assess long-range transport, chemical transformation, and deposition of air pollutants. These models are used to estimate source contributions to, and to identify source regions responsible for, observed pollutant loadings.

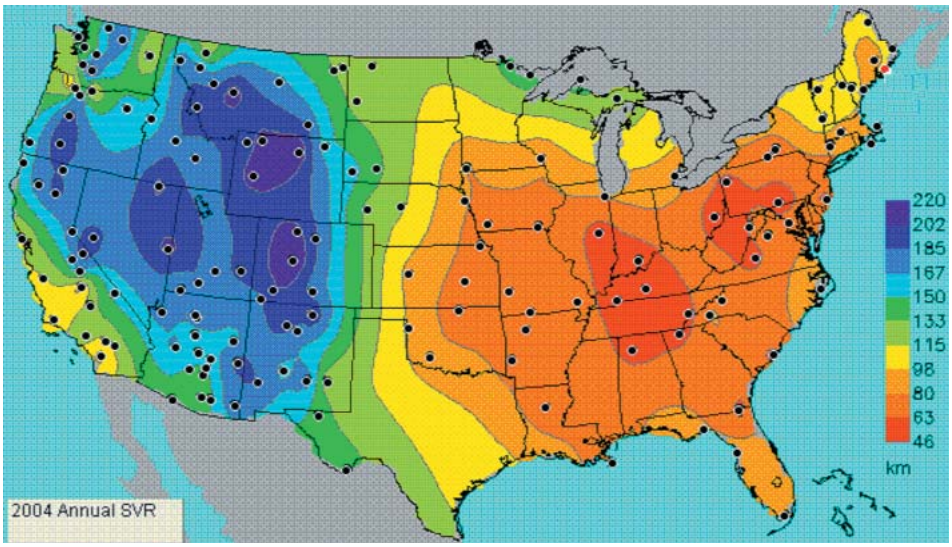


Figure 3-DOI-5. Map of annual average standard visual range (SVR), in kilometers, calculated from IMPROVE particle concentrations. Also shown are the locations of most of the IMPROVE and IMPROVE protocol sites. (http://vista.circa.colostate.edu/views).

JOINT MONITORING AND RESEARCH

The Fish and Wildlife Service Air Quality Branch and the NPS Air Resources Division operate under an interagency agreement and are collocated in Lakewood, Colorado. Expertise from both agencies is pooled to address the air quality issues that are the responsibility of the Assistant Secretary of the Interior for Fish and Wildlife and Parks.

The NPS oversees the operation of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the IMPROVE Protocol network in cooperation with the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the United States Forest Service (USFS), the FWS, the BLM, and various State organizations. Currently, the network has about 170 sites, mostly funded by the EPA in support of their regional haze regulations and through other cooperators. The enhanced network allows a better characterization of visibility and fine particle concentrations throughout rural and remote areas of the country (Figure 3-DOI-5).

BUREAU OF RECLAMATION

The Bureau of Reclamation (Reclamation) activities requiring the collection and use of meteorological data include water supply forecasting, snowpack water equivalent assessment, river system management, reservoir operations, irrigation scheduling, drought status assessment, flood hydrology, and projects related to hydroelectric energy resources. One example of such an ongoing activity is the Watershed and River System Management Program (WaRSMP), which is being developed in partnership with the USGS. Information on WaRSMP is at http://www.usbr.gov/pmts/rivers/rsmgwtrmg.htm.

Other key players in this effort include TVA, the Corps of Engineers, NOAA, NASA, NRCS, the University of Colorado and Colorado State University. This program provides a data-centered framework for science-based water resources decision making. Major components are:

- Hydrologic Database (HDB),

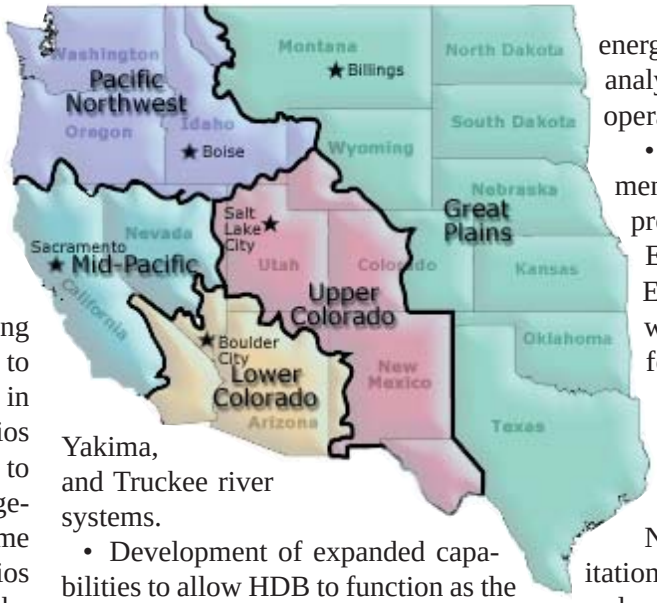
• Modular Modeling System (MMS),

• RiverWare river system modeling framework,

• Stochastic Analysis, Modeling and Simulation (SAMS) system,

• Agricultural WAter Resources Decision Support (AWARDS) and

• Evapotranspiration Toolbox (ET Toolbox) system.



HYDROLOGIC MODELING

The SAMS hydrologic modeling system is being used in WaRSMP to assist water resource managers in developing likely hydrologic scenarios for water supplies. It allows users to test various water resources management strategies, including extreme drought and high-flow scenarios which haven't been encountered in the historical period of record.

The RiverWare and HDB data-centered decision support system enables water managers to examine a variety of observed and forecast hydrologic scenarios using hourly, daily, or monthly data within the legal and physical constraints on operations of the river system. This model provides a holistic management tool for watershed and river systems, in order to meet a variety of competing demands for water.

Each new river system requires considerable development work (2-3 years) for RiverWare and HDB implementation. However, such a system can provide for efficient water operations management, and is especially useful during periods of drought and surplus - as demonstrated by the recent *Colorado River Interim Surplus Criteria: Final Environmental Impact Statement*.

Current Reclamation projects under WaRSMP include:

• Planning and developing HDB, MMS and RiverWare systems for the Gunnison, San Juan, Rio Grande, Yakima, and Truckee river systems.

• Development of expanded capabilities to allow HDB to function as the Database of Record which will document management decisions and the data used to make them for Reclamation's Upper and Lower Colorado regions as well as other participating offices.

• SAMS integration and testing for the lower Colorado and Truckee River Basins.

• Implementing AWARDS systems to improve the efficiency of water management and irrigation scheduling for the Tualatin Project, Upper Columbia project areas, and Lower Colorado area.

• Developing the AWARDS/ET Toolbox system in the Middle Rio Grande and providing 24-hour water use estimates for input, via the Corps of Engineers' Hydrologic Engineering Center Decision Support System or a new HDB, to the Rio Grande RiverWare.

• Implementing similar AWARDS/ET Toolbox systems with input to local HDBs and RiverWare systems in the Upper Columbia, Lower Colorado, and possibly the Truckee-Carson areas.

• Integration and testing of emerging Land Surface Modeling Products from NASA's Global Land Data Assimilation Systems for snow mapping, surface energy and water budgets and ET analysis and prediction for water operations management.

• Testing and development of weather and climate products from the Global Energy and Water Cycle Experiment (GEWEX) for water supply and demand forecasting.

INSTRUMENTATION AND DATA ACQUISITION

NEXRAD estimates of precipitation are used for water supply and water delivery decision-making. Water managers can view the distribution of precipitation over watersheds that supply water to storage facilities, and examine the detailed spatial distributions of precipitation over the irrigated areas along with estimates of soil moisture, and evapotranspiration from crops and riparian vegetation.

The Watershed and River Systems Management Program focuses on integrating multi-disciplinary science into decision support systems that enable water managers to make the best deliveries of water to stakeholders.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in real-time through GOES to Reclamation's DRGS in Boise, Idaho. AGRIMET is another network of 60 DCPs dedicated to analysis of crop water use and water conservation in the Pacific Northwest.

Data collected and products created in Boise are electronically transferred to other BLM, Federal and state offices. Reclamation's primary real-

time hydrometeorological information from the NWS, USGS, NASA, and other agencies is displayed on the AWARDS / NEXRAD / ET Toolbox web site: http://www.usbr.gov /pmts/rivers/awards/index.html

Water supply information from cumulative precipitation estimates from radar is also provided in areas where snowfall is an important source of water. Links directly to USDA Natural Resources Conservation Service and NOAA/National Centers for Environmental Prediction analysis and forecasting web sites are provided to further document the latest information.

TECHNICAL INFORMATION

The National Xeriscape Demonstration Program (NXDP) is nearing an end. The NXDP was initiated by Reclamation to estimate the benefits of water conserving landscaping. In partnerships with States, field demonstration projects were conducted in Fargo ND, Austin TX, the Colorado Front Range, Phoenix AZ, and southern Nevada. Water savings ranged from 18 to over 50 percent in the demonstration projects, strongly suggesting water planners should consider this water conservation alternative as a supply development option.

SNOWPACK ASSESSMENT

Snowmelt represents about 80 percent of reservoir storage in Colorado and is largely responsible for spring flooding events in the state. Therefore it is highly desirable to know snowpack characteristics, such as its snow water equivalent (SWE), its spatial and elevation distribution, and its evolution with time during the water year. With support of the Colorado Water Conservation Board (CWCB), Reclamation has adapted the Snow Data Assimilation System (SNODAS) for enhanced snowpack assessment in the state of Colorado. The SNODAS was developed by the National Operational Hydrologic Remote Sensing Center (NOHRSC), a National Weather Service unit, and data are acquired through the National Snow and Ice Data Center.

SNODAS consists of a spatially distributed snow energy and mass balance model, coupled with an assimilation of all available SWE, snow depth, and snow cover data (from surface, aircraft, radar, satellite). Model outputs are at 1 km resolution and include SWE, snow depth, snowmelt, pack temperature, and sublimation. Comparison with data from Snow Telemetry (SNOTEL) sites and satellite imagery shows faithful representation of SWE and snow cover, respectively. Basin average SWE is substantially reduced over that of SNOTEL because the former is a basin-wide spatial average instead of an arithmetic average of a few high-elevation points. This difference is important hydrologically and holds the promise of coupling snowmelt with a hydrologic model to produce streamflow hydrographs. Such hydrographs would be extremely useful to the decision support systems of water management agencies such as the CWCB and Reclamation, with the ultimate aim of improved forecasting of water supplies and flooding. Colorado SNODAS products have been posted daily at http://www.usbr.gov/pmts/rivers/awards/SNODAS/SNODAS_CO_hist.html since October 2003. Future work will consist of verification of SNODAS outputs, improvement of precipitation inputs, and coupling to a hydrologic model. An example of such an online product is given by Figure 3-DOI-6.

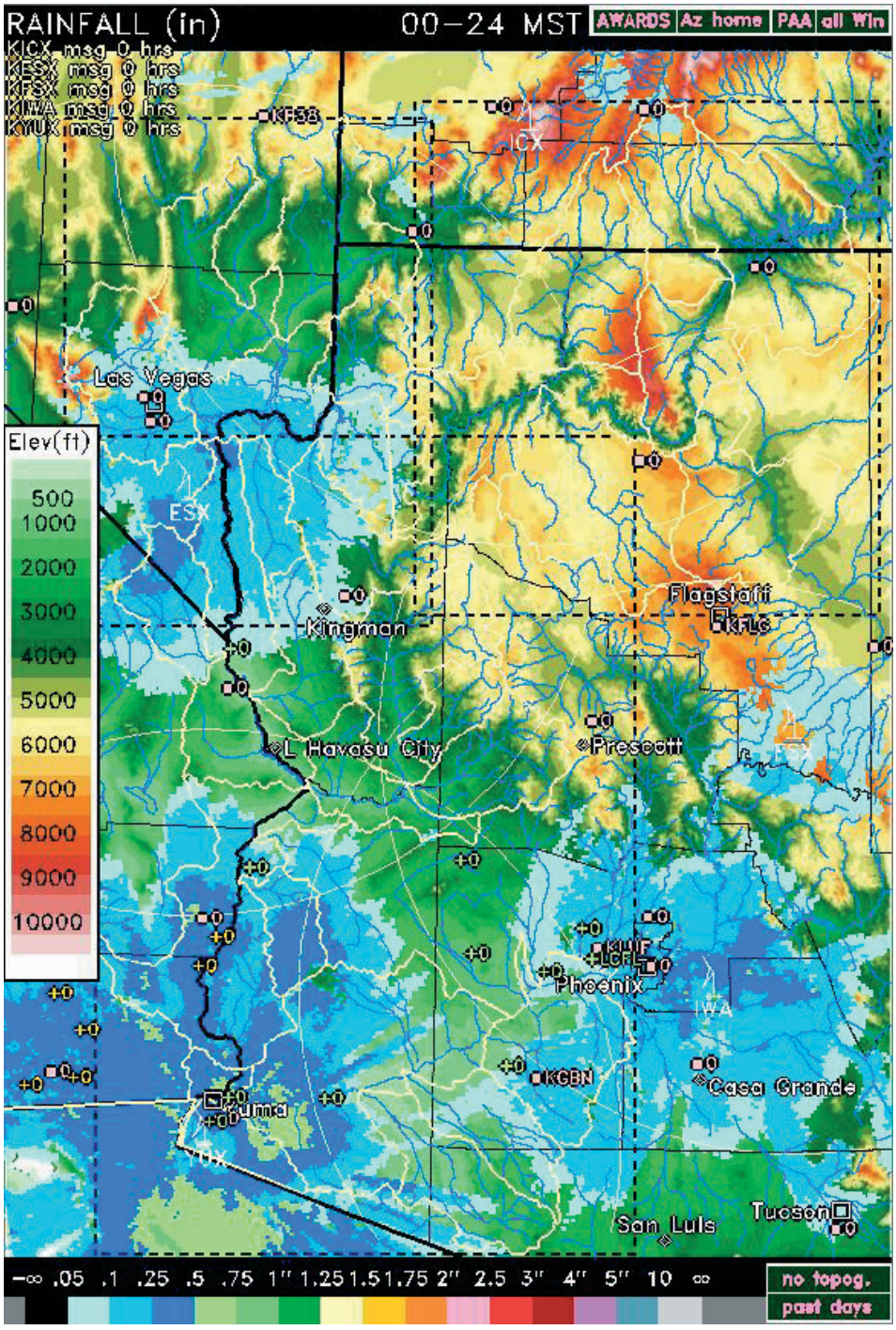


Figure 3-DOI-6. Agricultural Water Resources Decision-Support (AWARDS)/ET Toolbox example for the Lower Colorado River basin. AWARDS merges the precipitation accumulation algorithm (PAA) estimates from five WSR-88D (or NEXRAD) radars into a 2x2km grid.