# 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 (AFW) 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 AFW support to the Army.

AIR FORCE WEATHER (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 (HAF). The Director of Weather oversees AF-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 AF 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,

6. Advocating and fielding standardized weather equipment.

AFW oversees operations that provide a Total Force capability employing over 4,200 Active and Reserve Component (AC and RC) military and civilian personnel supporting AF and Army conventional and special operations forces (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, Nebraska, a field operating agency (FOA) reporting directly to the AF 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 global processing center collocated with a functional management headquarters, the 1st Weather Group (1 WXG) with four subordinate CONUS Operational Weather Squadrons (OWS), two subordinate centers (the Air Force Combat Climatology Center (AFCCC) and the Air Force Combat Weather Center (AFCWC)), and 11 detachments and operating locations. AFWA also provides backup support to five national weather centers.

The 1 WXG commands four OWSs 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. AFCCC, Asheville, North Carolina, provides centralized climatological database services, produces specialized weather-impact information for DOD and allied nations, and warehouses and distributes atmospheric science-related technical information. From Hurlburt Field, Florida, AFCWC transitions technology to support tactical-level weather operations while developing operational concepts, tactics, techniques, and procedures.

Eight OWSs 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 area of responsibility (AOR). These AORs are currently under revision to better align with the recently activated 1 WXG. The A3O-W proposed AORs are depicted in Figure 3-DOD-1. OWSs produce and disseminate terminal aerodrome forecasts (TAFs), weather watches, warnings, and advisories, planning and execution area forecasts, and other products using the OWS Pro-

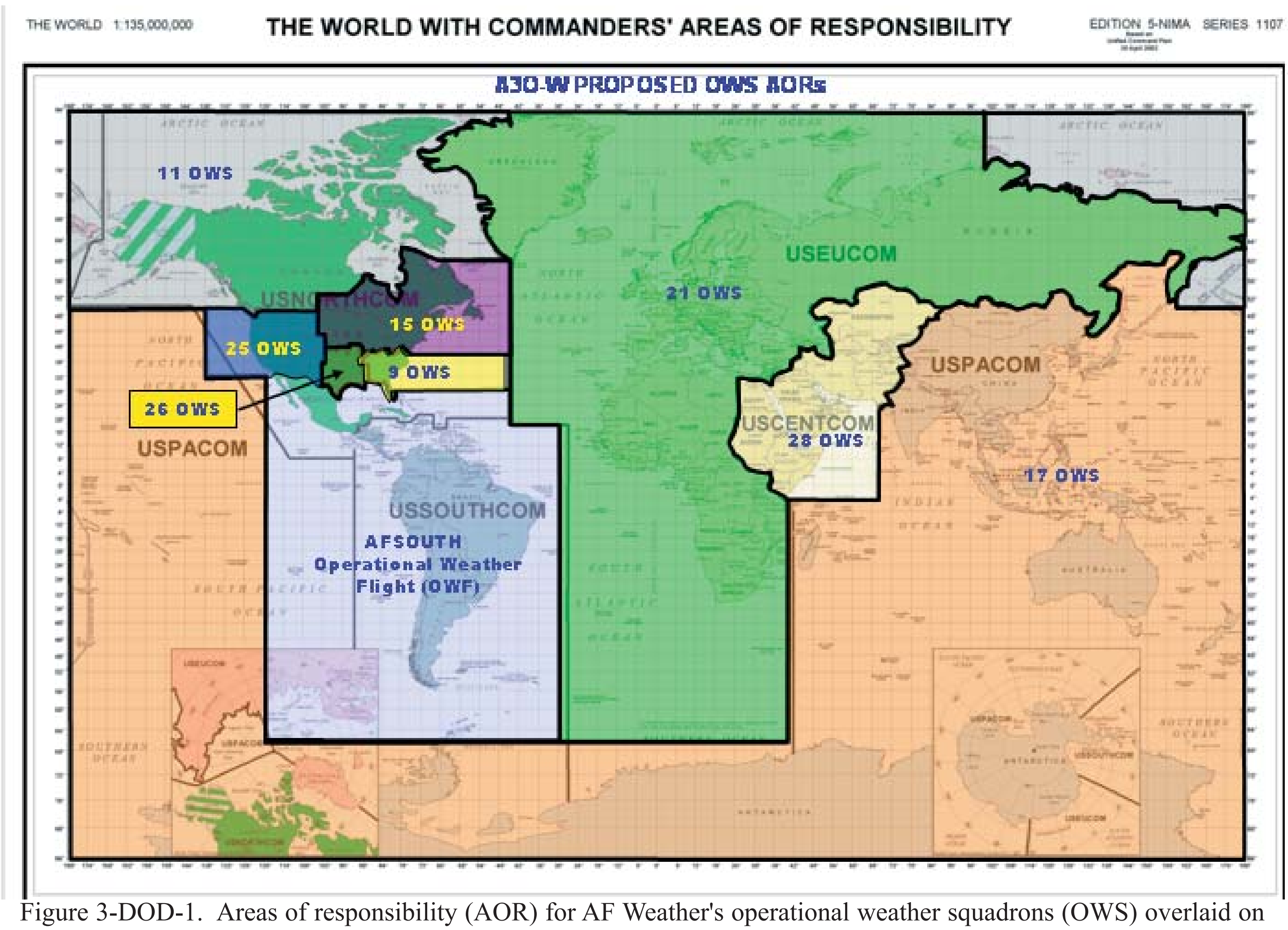


Figure 3-DOD-1. Areas of responsibility (AOR) for AF Weather's operational weather squadrons (OWS) overlaid on geographic combatant commander AORs.

duction System Phase II (OPS II). OWSs also provide theater-scale, tailored environmental information to guide development of mission execution forecasts (MEF) 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, AFW forces take and disseminate local observations and develop tailored MEFs based on centrally produced guidance. These personnel also act as "eyes forward" for OWSs. 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 (AFR) and the Air National Guard (ANG), and AFW continues to reengineer these forces to more closely align with AC weather operations. AF reservists augment the AC at all levels. To augment OWSs, AF Reserve Command recently organized two operational weather flights (OWF), each with just 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 1 day each month and for an additional 2 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 Army National Guard and U.S. Army Reserve units. Many ANG flying wings also have up to five personnel to provide weather support for each wing's flying mission. The ANG also provides peacetime weather support at locations where the ANG is responsible for airfield support. The Weather Readiness Training Center (WRTC) at Camp Blanding, near Starke, Florida, is also operated by the ANG to provide weather support operations training.

## CHARACTERIZE THE ENVIRONMENT

To characterize the environment across the globe, AFW forces continually improve the core processes of collection, analysis, and prediction.

### Collection

AFW 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, indigenous environmental data may be insufficient; consequently, the AF maintains a capability to deploy in-theater to establish an environmental data collection network.

AFW personnel take observations essential for effective military operations and for weather analysis and forecasting. Weather personnel at both AF and Army locations (garrison and deployed) make observations available to local users and transmit them to military and civil locations throughout the world. U.S. and foreign rawinsonde reports are primary sources of upper air observations and 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 AF 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 (WMO) channels.

The Observing System 21st Century (OS-21) program will provide a much-needed, state-of-the-art life-cycle replacement for AF observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. The manual configuration is intended for tactical operations and continues the improvements begun under the AFW 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 2007. 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 Federal Aviation Administration (FAA), and Department of Commerce (DOC)/National Weather Service (NWS) operate and maintain WSR-88Ds within the Continental United States (CONUS), and the AF operates and maintains several WSR-88Ds overseas. The AF transitioned to the open architecture Open Principal User Processors (OPUPs) at installations with stand-alone legacy PUPs and at all CONUS and PACAF OWSs, 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 (TWR) provide fixed Doppler radar coverage for major overseas installations not covered by the WSR-88D. Ellason weather radars (EWR) provide a deployable weather radar capability for worldwide military contingency operations. Weather radar data extracted from air surveillance radars (ASR) and displayed using the Digital Weather Intelligence Data (DWID) system supplement primary weather radar data and provide data from areas without primary weather radar coverage.

The AF Reserve Command'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-130 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 NWS's 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.

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 (FNMOC) with visible, infrared, and microwave imagery, temperature and moisture sounding data, electrically charged particle fluxes, and other

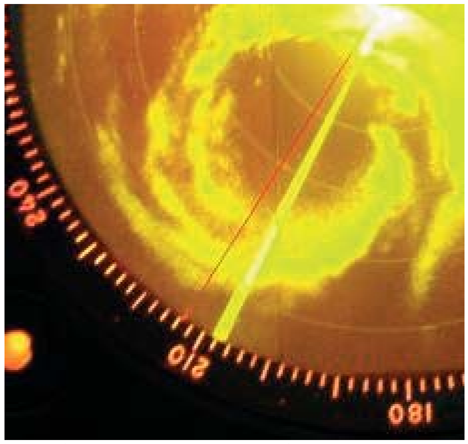

Figure 3-DOD-2. Aircraft radar shows the eye of Hurricane Claudette is 25 nautical miles wide and the wall cloud is weakest in the northeast quadrant (53 WRS website)

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 (OLS) 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 2010. (Note: In January 2006, the program was expected to exceed its approved program baseline by 25 percent. This required the DOD to recertify the program to Congress in accordance with the Nunn-McCurdy Amendment of the 1982 Defense

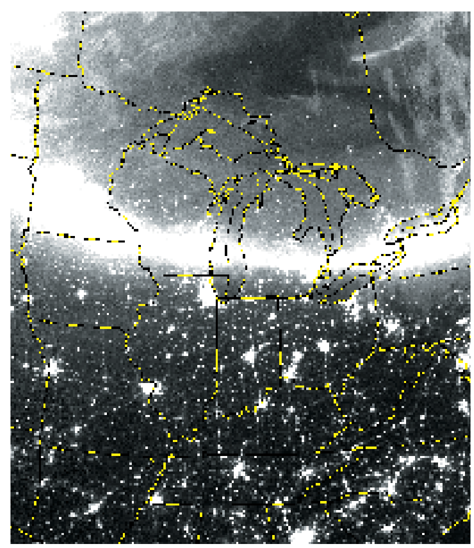

Figure 3-DOD-3. DMSP captures Aurora Borealis, over the midwest; the aurora was pushed toward the equator by a November 4, 2003 geomagnetic storm. (AF Weather website)

Authorization Act. AFWA hosted and provided information on operations and requirements to Integrated Product Team 2 (IPT-2). IPT-2 is charged with assessing alternatives for the program. The final program configuration, including the number of platforms and sensors, is yet to be determined.)

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; the European Union's Meteosat-5, -7, -8 and -9 geostationary satellites; and the Japanese Multi-functional Transport Satellite (MTSAT). AFWA currently receives data from NASA's Tropical Rainfall Measuring Mission (TRMM), Quick Scatterometer (QuikSCAT), and AQUA Advanced Microwave Scanning Radiometer-E (AMSR-E) via Direct Asynchronous Transfer Mode (ATM) System-Unclass (DATMS-U). Moderate Resolution Imaging Spectroradiometer (MODIS) data is currently received via the Defense Research Engineering Network (DREN).

AFW implemented the Joint METSAT Imagery, Software, and Terminals (JMIST) capability to receive real-time visible, infrared, and microwave imagery and other non-imagery weather data from both polar-orbiting and geostationary satellites. JMIST employs network and satellite communications, MARK NB and Receiving Set Satellite (RSS) direct read-out terminals, and client applications to provide ready access and manipulation capabilities for advanced low-orbiting satellite imagery to numerous agencies, to include the U.S. Air Force, U.S. Navy, U.S. Army, U.S. Marines, NOAA and NASA. JMIST also provides a stand-alone geostationary METSAT Direct Readout Terminal (DRT) and a Direct Readout Satellite Receiver (DRSR) for mobile units with insufficient network communications to employ reach-back methods.

Next generation satellite programs, in particular NPOESS and GOES-R, require AFWA to reengineer the way it receives, stores, and processes METSAT data, as well as how it exposes and delivers that data to internal and external users. AFWA is partnering with Electronic Systems Command (ESC) in 2006, to initiate the NPOESS Data Exploitation Study. The primary outputs of the study will include a way ahead for processing and storing NPOESS data at AFWA, a way ahead for exposing and delivering METSAT data including NPOESS to command and control (C2) and other users, an analysis of alternatives for the "to be" enterprise software and system architecture for exploitation of data from current and programmed satellites, and a recommended phased approach necessary for AFWA to modify systems to meet the "to be" software and system architecture for exploitation of data from current and programmed satellites. The study is scheduled to begin in the summer of 2006, and last for nine months.

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, Massachusetts; Holloman AFB, New Mexico; Palehua, Hawaii; 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 (JPL) operates a complementary global network of over 125 sensors deriving ionospheric line-of-sight Total Electron Content (TEC) from GPS signals and provides these data to AFWA's Space Weather Branch. In addition, the United States Geological Survey (USGS) 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. AF Research Laboratory at Hanscom AFB, MA, provides ionospheric scintillation data from a global network of 15 UHF and L-Band receivers, supporting AF command and control 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 NOAA’s Space Environment Center (SEC). The Solar X-Ray Imager (SXI), which became operational January 30, 2003, aboard GOES-12, monitors solar emissions in the X-ray portions of the solar spec-

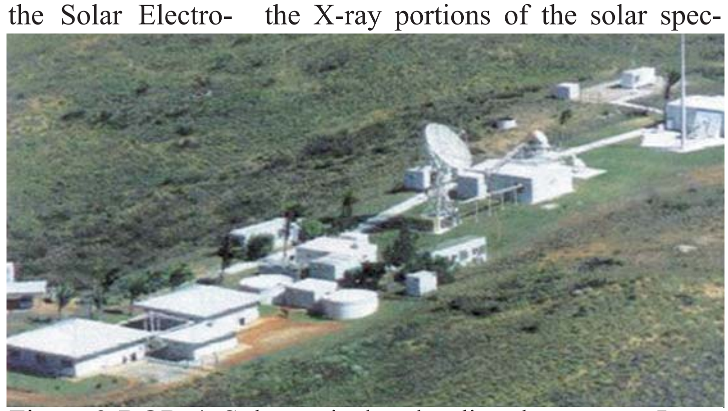
Figure 3-DOD-4. Solar optical and radio telescopes at Learmonth, Australia.

trum and provides near real-time display at AFWA and the SEC. 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 (ACE) satellite provides real-time solar wind data critical for forecasting geomagnetic disturbances and their impact to warfighter communications.

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 Global Weather Center Division is the AF's main production capability for global space and terrestrial weather analyses and forecasts. Worldwide conventional weather data are relayed to AFWA 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 Satellite Data Handling System (SDHS) facilitates the interaction between forecaster and machine.

The Division's Meteorological Satellite (METSAT) Applications Branch analyzes imagery, develops techniques, inserts technology, and recommends improvements to METSAT products. The branch produces rapid response, tailored METSAT imagery and evaluation for DOD contingency operations and generates automated METSAT imagery products for web-based distribution to DOD users. The branch also tracks and classifies tropical cyclones for the DOD Joint Typhoon Warning Center (JTWC) and NOAA's National Hurricane Center; serves as the DOD focal point for volcanic ash plume detection, advisories, and trajectory forecasts; and provides back up for both JTWC satellite operations and the DOC's Washington Volcanic Ash Advisory Center. In addition, the METSAT Applications Branch 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, branch 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 branch also develops new capabilities to display and visualize satellite imagery on workstations and infuses state-of-the-art techniques into improved imagery analysis.

The Division's Space Weather Branch employs a suite of state-of-the-art space weather models to specify current solar and global characteristics, extrapolate space weather phenomenon to areas of the globe where observations are not currently available, and to forecast future conditions. These models use available observations and include both climatology-based and physics-based algorithms. Some of the more significant models employed include the following:

- A Kp analysis and prediction algorithm provides real-time analysis of Kp and a one and four hour prediction.
- A Dust prediction algorithm provides a one 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.
- Scintillation forecasts are provided by the climatology-based WIDEBAND model.
- The Magnetospheric Specification and Forecast Model specifys and predicts (for 3 hours) the lower energy particle environment.
- The newly implemented Radiation Belt Environments (RBE) model provides specification of the higher energy particle environment.
- A 27 day prediction of relativistic electron behavior at geostationary altitude is provided by the relativistic Electron Prediction (REP) model.
- 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 (CME's).
- Several other applications are also employed to calculate other important space weather related parameters.

The Global Theater Weather Analysis and Prediction System (GTWAPS) is the 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, Mesoscale Model version 5 (MM5), which provides fine-scale forecasts (Figure 3-DOD-5 on next page). 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 global war on terrorism. MM5 is routinely provided by AFWA to NOAA's National Centers for Environmental Prediction (NCEP),

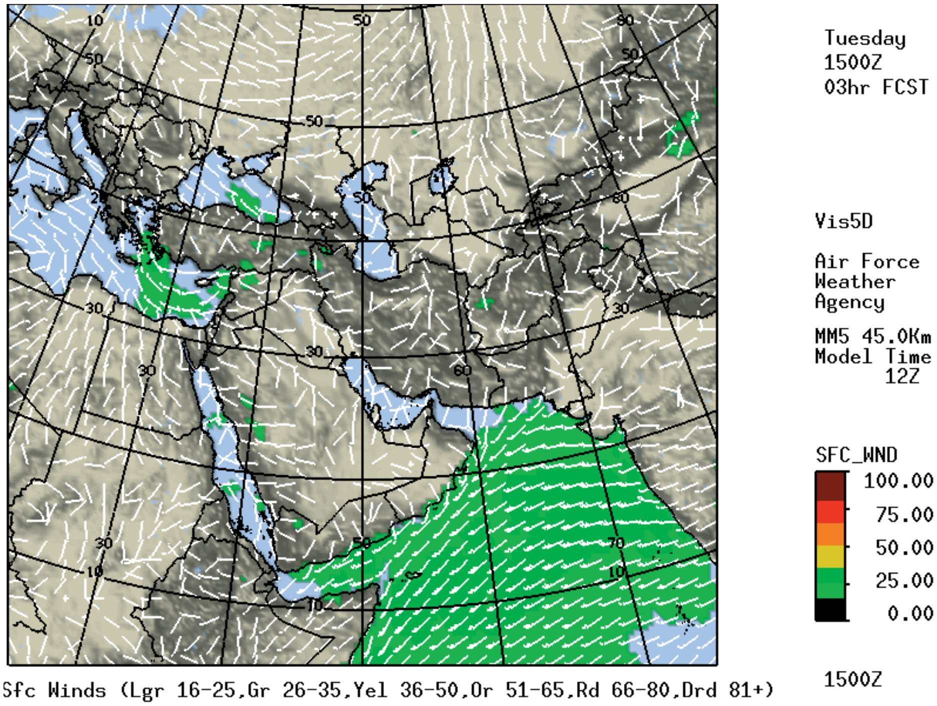


Figure 3-DOD-5. Joint Air Force and Army Weather Information Network (JAAWIN) provide reachback capability for deployed weather forces. This 3-hour forecast of surface winds over Southwest Asia was generated from AFWA's 45-km MM5 (AFWA Website)

where it is a backup to their Eta model.

The future replacement of MM5 will be the Weather Research and Forecast (WRF) model. 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 reengineered 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 METOC database segments, promoting interoperability among data sharers. WDAC, through the use of the Joint METOC segments and the Joint METOC Broker Language (JMBL) for web services, will improve the interoperability with DOD command and control (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.

The Air Force Combat Climatology Center (AFCCC) is collocated with NOAA's 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 (PAlS) to produce vertical profiles for any point on Earth for any time from 1985 to the present.

The AF Director of Weather is the DOD Air and Space Natural Environment Modeling and Simulation Executive Agent (ASNE MSEA). The Director executes this responsibility through the ASNE MSEA office, a division within AFCCC (AFCCC/SM). The executive agent is responsible for ensuring modeling and simulation developers and users have the tools, infrastructure, and databases necessary to represent the air and space natural environment. AFCCC/SM sponsors research and development and fields technology at AFCCC, the designated center providing tailored atmospheric data for modeling and simulation. AFCCC fielded the Environmental Scenario Generator (ESG) capability in 2005, to support modeling and simulation. In cooperation with the National Geophysical Data Center (NGDC) and the Defense Modeling and Simulation Office (DMSO), AFCCC/SM also sponsors ongoing research to develop a similar capability to provide tailored on-demand representations of the space environment.

AFW's OWSs are regional/theater analysis and forecast centers for AF and Army operations. OWSs 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 AF and Army installations within their AOR. OPS II, a component of the Forecasting System 21st Century (FS-21i) 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 environment, AFW 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 operational, C2, and support forces worldwide. Additionally, N-TFS ingests data from AF and indigenous observing sources, which then are forwarded to OWSs/AFWA for further dissemination and incorporation into centrally produced models.

AFW is currently working toward a single workstation that will eliminate redundancies/inefficiencies and ultimately extend, consolidate and/or replace the OPS II, 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 (METOC) Database (VJMDB) via common-user-communications. Additionally, JET will integrate with joint and coalition command and control 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. The JET contract was awarded to Raytheon on 28 Mar 2006, after a 20 month source selection process. Fielding of the first increment is expected to begin in Jan 2007, with an 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 command and control systems (e.g., mission planning systems), include Target Acquisition Weapon Software (TAWS) (Figure 3-DOD-6 on next page), Infrared Target Scene Simulation (IRTSS), and Tn-Service Integrated Weather Effects Decision Aid (TS-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 TS-IWEDA uses environmental 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 TSIWEDA integrate environmental impacts into the mission execution forecasts for C2 and MP systems throughout the military planning and

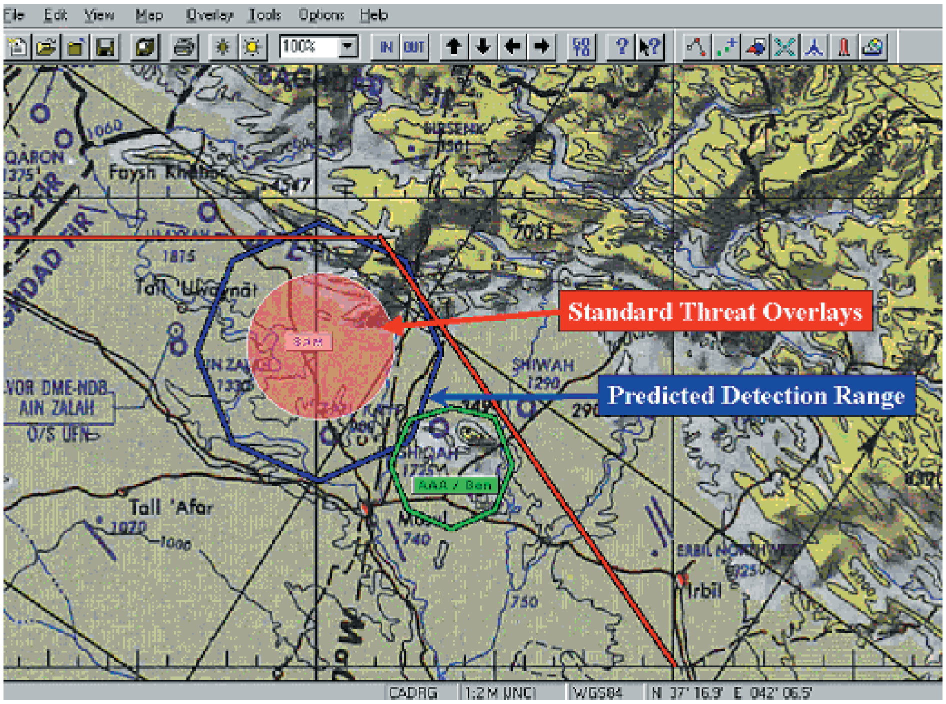


Figure 3-DOD-6. Target Acquisition Weapon Software (TAWS) integrate meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution.

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 (ADA) to support ABL development and operations and a common radio frequency (RF) system performance prediction capability based on U.S. Navy software.

AFWA's Special Support Operations Branch (SSOB) 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 U.S. Special Operations Command (USSOCOM), Service component special operations commands, and theater special operations commands. The SSOB is continually involved in global military operations, including Operations ENDURING FREEDOM and IRAQI FREEDOM. Additionally, the SSOB 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 (DOD) and Department of State personnel and family members stationed overseas.

AFWA's IC Weather Branch provides detailed global cloud analyses and forecasts to the intelligence community. 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 DOD and IC regarding weather services and the exploitation of weather information.

As the sole source of DOD space

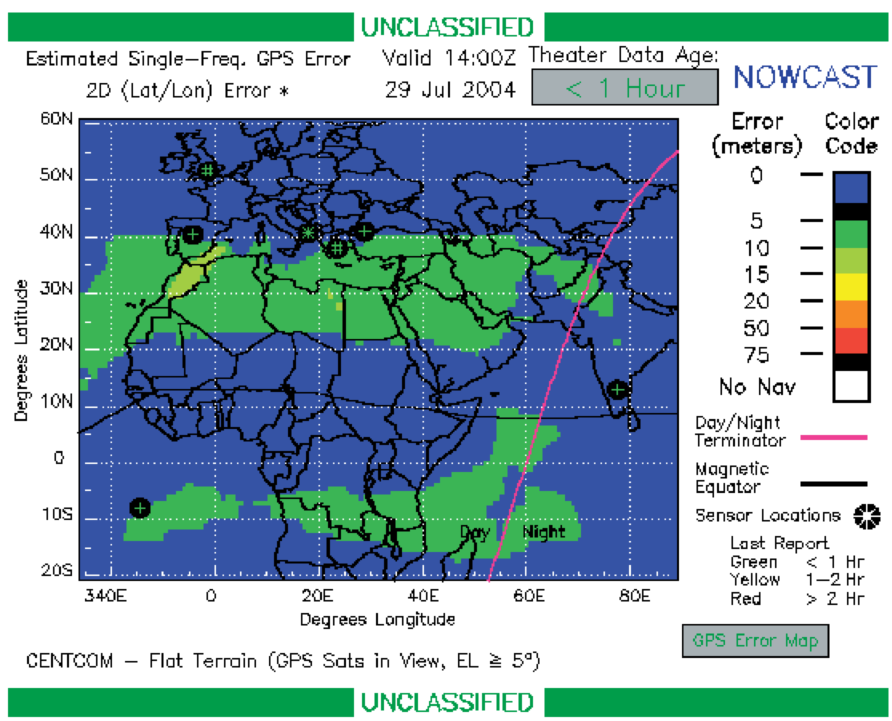


Figure 3-DOD-7. Single-Frequency GPS Receiver Error Map (visualized by HQ AFWA)

environmental information, AFWA partners with NOAA's Space Environment Center to meet the nation's military and civilian space weather needs. AFWA's Space Weather Branch 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 (SATCOM) links provide valuable planning information to improve command and control capabilities. Further examples of model output informational products include Single-Frequency GPS Receiver Error maps (Figure 3-DOD-7 on previous page), UHF Satellite Communication Scintillation maps (Figure 3-DOD-8), HF Illumination maps (Figure 3-DOD-9), 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.

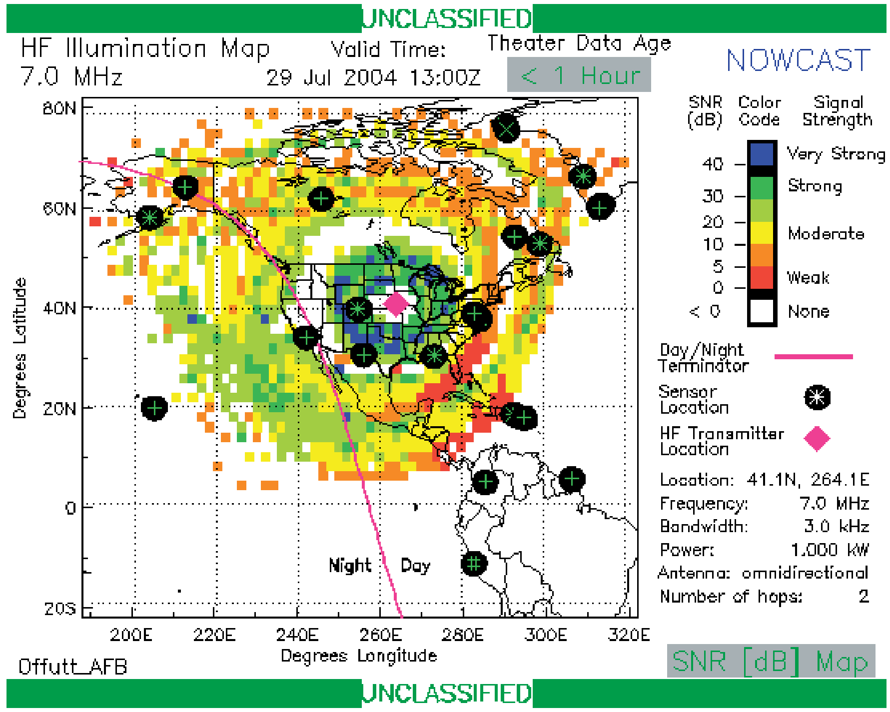


Figure 3-DOD-9. HF Illumination Map (visualized by HQ AFWA).

The AF provides meteorological and space weather products to the nation's space and missile programs, including a wide range of weather observing services at the AF Eastern Range and the Kennedy Space Center (KSC). The AF also provides tailored forecasting for NASA's manned and unmanned launches and for commercial launches from KSC. In addition, the AF provides specialized meteorological information for the AF Western Range at Vandenberg AFB, California; the Pacific Missile Range, which includes Point Mugu and San Nicholas Island, California, and Barking Sands, Hawaii; White Sands Missile Range, New Mexico; Kwajalein Missile Range, Republic of the Marshall Islands; and other DOD research and test facilities as directed.

The AF also provides agro-meteorological support to the U.S. 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

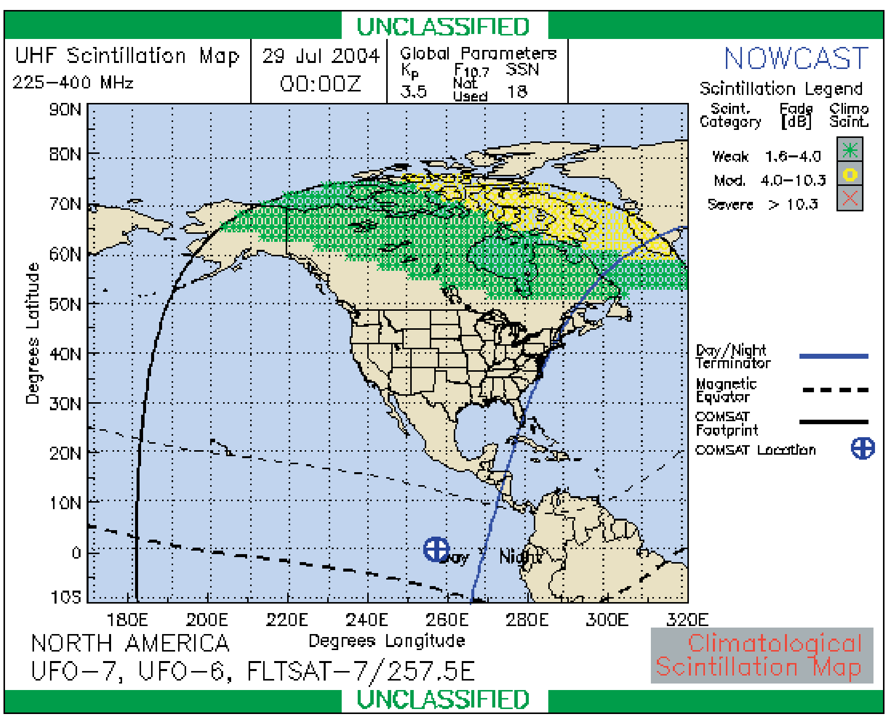


Figure 3-DOD-8. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

the information/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 interfaces, and personnel embedded at the right echelons with decision-makers, to integrate accurate, relevant, and consistent weather and weather impacts information into decision-making processes. Since timeliness is critical to effective integration; AFW 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 OWSs.

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 Non-Secure Internet Protocol Router Network (NIPRNET) and Secure Internet Protocol Router Network (SIPRNET). Alphanumeric data, including surface, upper-air, space weather, and pilot reports, are also collected and distributed via the Automated Weather Network (AWN), Very Small Aperture Terminal (VSAT) satellite communications system, and the NIPRNET. The AWN, consisting of data collection, message creation, and dissemination software, is a global communications network used for alphanumeric terrestrial and space weather data. The AWN supports DOD as well as federal and foreign meteorological, space, and aviation centers.

AFWA 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 (FITL) products, and text bulletins, and includes links to all OWS websites. Additional products are available to classified users via JAAWIN-Secret (JAAWIN-S) and JAAWIN-Sensitive Compartmented Information (JAAWINSCI).

JWIS offers another means of making tailored weather information available to DOD users. JWIS provides a link to weather information from both AF and Navy sources for exploitation by command and control systems and applications. AFW successfully demonstrated a JWIS-based machine-to-machine (M2M) weather information transfer to command and control 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 AFW personnel serve on the staffs of operational AF, 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 (WST) in air and space operations centers (AOCs). 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, AFW experts are integrated into a variety of other unique mission areas, such as space launch support and research, development, test, and evaluation (RDTE) 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 RDTE 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. AFW forces are integrated with Army intelligence staffs, and the Army trains and educates AF personnel on Army organizations, concepts of operations, and their weather sensitivities. AFW forces are currently 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). 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 emerging operational environment (post-Cold War, 9-1l, and Global War on Terror) 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 machine-to-machine (M2M) information exchanges. The challenge to AFW 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, accurate, and relevant environmental information, accessible via a common web-services interface from anywhere on the Global Information Grid (GIG). 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 2006, increment three will deliver JMCAT (weather data catalog) and Gridded CDC (subscription capability for data from JMGRID). For FY 2007, 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 AF meteorological and space environmental research and development (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 AF 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 Global Assimilation of Ionospheric Measurements (GAIM) model. AFW continues to work with USU toward the fielding of a full physics version of the GAIM model sometime in FY 2008-2009. In addition, AFW will be working during FY 2007 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.

<u>Mesoscale Modeling for AF and Army Operations</u>

The Weather Research and Forecasting (WRF) model is the next generation community model expected to replace 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 is preparing to initially implement WRF operationally in 2005, 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 both DOD and civilian agencies, and through coupling with WRF, will improve forecasting performance in the low levels of the atmosphere. This allows AFW 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.

Through a joint AF-Navy effort, AFWA and FNMOC were awarded a $4.2 million grant from the DOD High Performance Computing Modernization Office in 2004, to establish an operational test and evaluation center for the WRF modeling framework. Additionally, each organization gained status as a DOD High Performance Computing Distributed Center. The WRF Operational Test Center (OTC) will greatly enhance DOD's ability to efficiently incorporate state-of-the-science modeling technologies into operations. The end result will be never-before-seen predictive accuracy of fine-scale weather features crucial to DOD operations. A cutting-edge IBM supercomputer suite, split into two identical subsystems, was installed at each weather center. The distributed WRF OTC subsystems will be virtually integrated using high-speed communications networks, allowing operational simulations with real-time weather data from each center. After rigorous test and evaluation, the specialized WRF configurations that perform optimally for DOD and Service-unique mission needs will be implemented at AFWA.

Over the next several years, AFWA will transform its mesoscale 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 2008.

<u>Atmospheric Optical Turbulence</u>

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 AF 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.

<u>United States Weather Research Program (USWRP)</u>

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.

<u>Air Force Research Laboratory (AFRL)</u>

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 (LEO) spacecraft. Working closely with the DMSP System Program Office (SPO) at the Space and Missile Systems Center (SMC) 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 (CCMC), 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 (COSMIC).

In conclusion, through a continuous process of review and definition, the AF 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.

**METEOROLOGICAL SERVICES**

The United States Navy Oceanography Community (officer and enlisted personnel) are required to assess both meteorological and oceanographic (METOC) impacts on naval, joint, and combined operations. METOC support begins with intelligence preparation of the environment (IPE), or measuring the physical environment, and culminates with exploitation of the environment by employing sensors and weapons in a manner that result in more effective force protection and offensive strike operations. The generation of METOC forecasts and determination of potential environmental impacts on platforms, sensors, and weapons systems requires the collection of METOC data through a variety of tactical and dedicated sensors (including satellites), the fusion and analysis of atmospheric and oceanographic conditions, and the integration of METOC knowledge into decision aids/mission planning systems.

The Office of the Oceanographer/Navigator of the Navy was recently realigned under the Chief of Naval Operations (CNO), Integration of Capabilities and Resources (N8) and CNO, Warfare Integration (N8F), and is now designated as CNO (N84). The Commander, Naval Meteorology and Oceanography Command (COMNAVMETOCCOM), is an Echelon III command and reports directly to the Commander, U.S. Fleet Forces Command (COMUSFLTFORCOM) for meteorological and oceanographic (METOC) operational support. While operational requirements are coordinated through COMUSFLTFORCOM, the CNO, through the Office of the Oceanographer of the Navy (N84), sponsors the development of future capabilities with related research and development (R&D) and acquisition to support prioritized requirements. The Navy METOC organization provides meteorological support services for Navy and joint forces, meteorological products to the uniformed services and other Government agencies, and oceanographic support to all elements of DOD.

Research and development is conducted by warfare centers, laboratories, and systems commands, through sponsorship by the Chief of Naval Research and the Oceanographer/ Navigator of the Navy. To ensure that all research and development supported by the Oceanographer is in direct support of the Naval Mission as established by formal Navy Doctrine, the Oceanographer has developed and implemented a comprehensive framework to transition research to operations. The Naval Research Laboratory (NRL) and the Program Executive Office (PEO), C41 and Space are the primary activities that manage naval research and transition to operations, and are supplemented by various universities, industry partners, and organizations under Navy contract. NRL detachments are collocated with the Fleet Numerical Meteorology and Oceanography Center in Monterey, California and with the Naval Oceanographic Office at Stennis Space Center, Mississippi. The PEO C41 and Space Program Office (PMW-l80) is Navy's single program manager for METOC system development and acquisition. The Naval Oceanography Community is moving towards increased automation and more "machine to machine (M2M)" operations using a service oriented architecture and web-based services in the future.

In 2006, the Naval Meteorology and Oceanography Command continued its realignment and transformation from a geo-centric to knowledge-centric organization designed to directly and measurably enhance warfighting capabilities.

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,

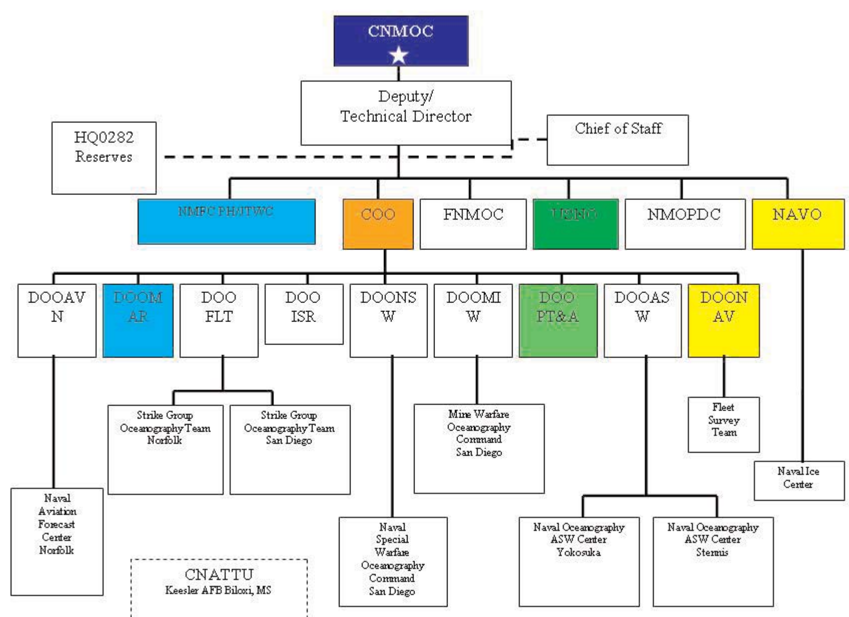


Figure 3-DOD-10. Naval Meteorology and Oceanography Organization. (COO - Commander, Oceanography Operations and DOO - Director, Oceanography Operations)

• Naval Maritime Forecast Center/ Joint Typhoon Warning Center, Pearl Harbor, HI,
• U.S. Naval Observatory, Washington, DC, and
• Naval Meteorology and Oceanography Professional Development Center, Gulfport, MS.

Additional subordinate commands include:
• The Naval Aviation Forecast Center, Norfolk, VA,
• Strike Group Oceanography Teams in Norfolk, VA and San Diego, CA,
• Mine Warfare Oceanography Command, San Diego, CA,
• Naval Special Warfare Oceanography Center in San Diego, CA,
• Naval Oceanography ASW Centers in Yokosuka, Japan and Stennis Space Center, MS,
• Fleet Survey Team, Stennis Space Center MS, and
• Naval Ice Center, Suitland, MD.


Figure 3-DOD-1l. Forecasters at the Naval Maritime Forecast Activity (NMFA) Norfolk monitor current weather conditions within the SECOND FLEET area of responsibility. The Naval Meteorological Center is currently preparing for the upcoming hurricane season predicted to be as or more severe than last year. (U.S. Navy Released)

NAVAL OCEANOGRAPHY OPERATIONS COMMAND

The Naval Oceanography Operations Command (NAVOCEANOPSCOM), Stennis Space Center, MS, was established in early 2006, as an Echelon IV command reporting to Commander, Naval Meteorology and Oceanography Command. 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.

NAVOCEANOPSCOM encompasses nine separate directorates:
• Anti-Submarine Warfare (ASW);
• Mine Warfare (MIW);
• Naval Special Warfare (NSW);
• Navigation (NAV);
• Precise Time and Astronomy (PTA);
• Intelligence, Surveillance and Reconnaissance (ISR);
• Maritime (MAR) Operations;
• Fleet (FLT) Operations (Strike and Expeditionary); and
• Aviation (AVN) Operations.

The Commander, Oceanography Operations supports the combatant commanders and national missions, U.S. interagency and international partners. The other NAVMETOCCOM production centers (NAVOCEANO, FLENUMETOCCEN, NMPOC/JTWC, etc.) 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. Aviation and maritime operations have also been centralized and are now organized under the aviation and maritime directorates of the NAVOCEANOPSCOM.

Aviation Forecasting

Aviation forecasting is now conducted at CONUS and OCONUS aviation forecasting hubs which provide flight route weather briefings, point weather warnings for Navy airfields, Terminal Aerodrome Forecasts provided every 6 hours and Forecast advisories for aircraft. Forecasting for the Atlantic is conducted by the Naval Aviation Forecast Center in Norfolk, VA. A Naval Aviation Forecast Component will also be established in San Diego, CA to provide aviation meteorology products to military assets. Routine aviation and installation weather for NATO and the U.S. European AOR is provided by the Naval Aviation Forecast Activity (NAFC)/21st Operational Weather Squadron in Sembach, Germany.

Systems used in aviation forecasting include:
• Flight Weather Briefer, a DOD-developed automated web-based system used to request, produce and disseminate flight route weather briefings.
• Leading Environmental Analysis and Display System (LEADS) Avia-

tion Forecasting System. The primary display and analysis tool used by our forecasters.

• Automated Surface Observing System (ASOS). The Navy's primary airfield environmental observing system, standardized with Federal Aviation Administration and National Weather Service.

Fleet Operations

The Naval Meteorology and Oceanography Command is actively engaged with Fleet forces to provide valuable environmental knowledge to aid warfighting decision making. Skilled 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 that 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 face of the FRTP and deployment. Each SOOT Detachment includes a trained cadre of meteorologists and oceanographers who forecast for the CVNs/LHDs/LHAs. In addition to flight deck weather, they forecast the target area METOC that varies greatly considering the tremendous reach of Naval Aviation along the world's dynamic coastlines. Naval Strike Group Oceanography Teams are located in Norfolk, VA, and San Diego, CA. Support in the European AOR is provided by the Naval Strike Group Oceanography Team, collocated with Naval Aviation Forecast Center in Norfolk, VA.

US Marine Corps landing forces receive METOC support from Marine METOC Support teams and METOC divisions on amphibious capable ships.

Maritime Operations

The Maritime Directorate is located at the Naval Maritime Forecast Center in Pearl Harbor, HI. There is also a Naval Maritime Forecast Activity (NMFA) collocated with the Naval Aviation Forecast Center in Norfolk, VA. NMFA Norfolk supports Optimum Track Ship Routing and en route weather for the Atlantic, Mediterranean, waters surrounding Western and Southern Africa, and the Black and Baltic Seas.

Key components of the maritime operations mission are ship routing, forecasts and warnings and support for ice operations. Significant contributions to maritime safety and efficiency include:

• Optimum Track Ship Routing (OTSR), an enroute weather forecasting service to support trans-oceanic transits and coastal operations of the Navy and naval support ships. OTSR services also include sortie recommendations for potentially damaging weather conditions in port. Additionally, OTSR provides climatologic outlooks for preliminary transit and mission planning.

• Delivery of tropical cyclone forecasts, warnings and other products.

• Ship weather forecasts (WEAX).

• Aviation weather forecasts for ship-based helicopters.

• High wind and seas warnings, special weather advisories and local area warnings.

• Ice analysis and forecasting by the National Ice Center, a joint operations of the Naval Ice Center, U.S. Coast Guard and NOAA.

• Joint Operational Area Forecasts for Commanders operating in littoral regions.

Figure 3-DOD-12. The Military Sealift Command (MSC) underway replenishment oiler USNS JOHN ERICSSON (T-AO 194), breaks away from the NIMITZ-class aircraft carrier USS RONALD REAGAN (CVN 76) after a refueling at sea in foggy weather.(U.S. Navy Released)

FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER

The U.S. Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC; see https://www.fnmoc.navy.mil/), an Echelon IV activity reporting to the Commander, Naval Meteorology and Oceanography Command, 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), FNMOC is a key component in the

Figure 3-DOD-13. An F/A-18F Super Hornet assigned to the "Fighting Vigilantes" of Strike Fighter Squadron One Five One (VFA- 151) launches from the flight deck of the NIMITZ class aircraft carrier USS ABRAHAM LINCOLN (CVN 72) during a snowstorm. (U.S. Navy Released)

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. Users of FNMOC's products include all branches of the Department of Defense (DOD), the intelligence community (IC), other government organizations (e.g., National Weather Service), private companies, a number of colleges and universities, and the general public.

FNMOC 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 U.S. 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, FNMOC 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, FNMOC is designated as the DOD center for global Numerical Weather Prediction. FNMOC 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.

FNMOC 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 FNMOC models and applications in some fashion, and forms the basis for the FNMOC global Ensemble Forecast System (EFS).

COAMPS is a high-resolution, nonhydrostatic 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 FNMOC 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 FNMOC Centralized Atmospheric Analysis and Prediction System (CAAPS). In general, FNMOC 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.

FNMOC'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 FNMOC 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 anti-submarine 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 FNMOC models feed directly into applications models, tactical decision aids and other products that provide direct support to various weather-sensitive activities associated with the Business Lines 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 Special Operations Forces, 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.

FNMOC 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 (SSM/I) products, ERS and QuikScat scatterometer wind products, a comprehensive view of tropical cyclones via the FNMOC 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). FNMOC also hosts the USGODAE Monterey Data Server in support of the Global Ocean Data Assimilation Experiment (GODAE). 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 (GDACs), hosting the complete collection of quality-controlled Argo temperature/salinity profiling float data.

Many of FNMOC'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, FNMOC provides a Web-based capability called MyWxMap (i.e., "My Weather Map"). MyWxMap, 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 FNMOC'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 FNMOC also hosts a DOD High Performance Computing Modernization Program (HPCMP) Distributed Center, which are integrated closely with POPS.

In addition to its primary role of focused support to the warfighter, FNMOC also plays a key role in the U.S. national program for weather prediction. In this regard, FNMOC'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. FNMOC 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). In addition, FNMOC serves as the Alternate Joint Typhoon Warning Center (AJTWC), providing the backup for the JTWC located in Pearl Harbor, Hawaii. And finally, FNMOC makes a subset of its products available to the general public via the Internet.

FNMOC 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. FNMOC 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 FNMOC, is the optimum arrangement for transitioning R&D quickly and cost-effectively into new and improved operational weather prediction capabilities.

## NAVAL OCEANOGRAPHIC OFFICE

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) at the Stennis Space Center in 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 - Naval Research Laboratory (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 scaleable, supercomputing architecture and facilitating transition from R&D to operational use. The NAVOCEANO web site for information is https://www.navo.navy.mil.

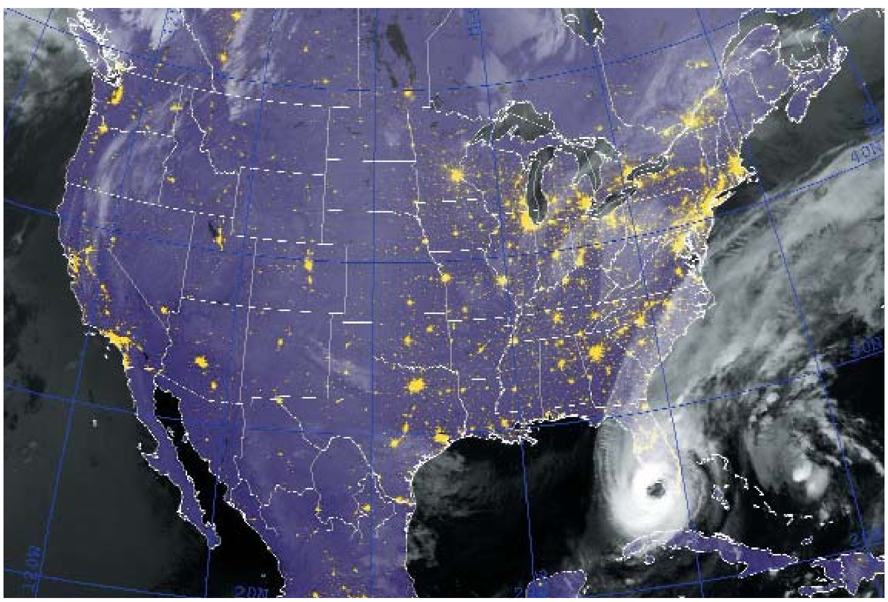

Figure 3-DOD-14. GOES E/W Satellite composite image provided by the U.S. Naval Research Laboratory, Monterey, Calif., showing Hurricane Wilma at 4:00 am EST. Wilma, a dangerous category three hurricane on the Saffir-Simpson Hurricane scale, has maximum sustained winds near 125 mph with higher gusts at this time. (U.S. Navy Released)

NAVAL MARITIME FORECAST CENTER/JOINT TYPHOON WARNING CENTER

Located at Pearl Harbor, Hawaii, the Naval Maritime Forecast Center, an Echelon V activity reporting to the Commander, Naval Meteorology and Oceanography Command, hosts the Command's Maritime Directorate and is collocated with the Joint Typhoon Warning Center (JTWC). The JTWC is the U.S. Department of Defense agency responsible for issuing tropical cyclone warnings for the Pacific and Indian Oceans.

Official JTWC support is provided to all branches of the U.S. Department of Defense and other U.S. government departments and their agencies such as the State Department (U.S. Embassies and Consulates), and the Department of Commerce, (U.S. National Weather Service). JTWC products are intended for use by operational units in making decisions regarding ship movements, aircraft sorties and operational planning and by other government agencies in their respective support and international cooperation roles.

As an example, the U.S. National Weather Service, in close cooperation with JTWC, utilizes JTWC tropical cyclone warnings to provide local scale forecasts for the various political entities known as Micronesia. Though not an official member or participant in the United Nations World Meteorological Organization (WMO), JTWC continually attempts to maintain cordial relations with WMO tropical cyclone forecast centers to minimize the issuance of conflicting information. JTWC tropical cyclone warning support is conducted on a 365 days/year, 24 hours/day basis. JTWC monitors, analyzes and forecasts tropical cyclone genesis, development and movement across more than 100 million square miles of the Pacific and Indian Oceans from the west Coast of the Americas to the east Coast of Africa. This area of responsibility encompasses more than 90 percent of the world's tropical cyclone activity.

Manned by U.S. Air Force and Navy personnel, JTWC uses a vast array of data sources and computational resources in fulfillment of the stated mission. These sources include numerous meteorological satellite systems and sensors, radar data, surface and upper level synoptic data and numerical atmospheric models.

U.S. NAVAL OBSERVATORY

The U.S. Naval Observatory in

Washington, D.C., is one of the oldest scientific agencies in the country. Established in 1830 as the Depot of Charts and Instruments, the U.S. 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 U.S. Naval Observatory serves as the official source of time for the Department of Defense and the standard of time for the U.S.. The atomic clock timescale of the Observatory is based on an ensemble of cesium-beam frequency standards and hydrogen masers.

The U.S. Naval Observatory performs an essential scientific role for the U.S., 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 U.S.. 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.

EDUCATION/TRAINING

Navy Oceanography Officers are all university graduates in meteorology, oceanography or other earth sciences, with most attaining dual meteorology and oceanography advanced graduate degrees.

Enlisted forecasters/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, Mississippi.

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.

UNITED STATES MARINE CORPS (USMC)

The mission of the Marine Corps (Meteorology and Oceanography (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 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.

<u>Organization</u>

The Deputy Commandant for Aviation, Headquarters United States Marine Corps (Code ASL37), is the responsible office for Marine Corps METOC requirements and support. The Marine Corps METOC organization consists of two operational chains 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 U.S., one in Hawaii, and two in Japan.

Within the FMF, Marines deploy and employ as scalable, tailored, combined-arms teams known as Marine Air Ground Task Forces. There are three sizes of MAGTFs. They are the Marine Expeditionary Unit (MEU), Marine Expeditionary Brigade (MEB), and Marine Expeditionary Force (MEF) with the latter being the largest. Additionally, Special Purpose MAGTFs (SPMAGTFs) 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 (EMW) operations, particularly Operational Maneuver from the Sea (OMFTS). 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 (JTF HQ), they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from precrisis 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 Marine Expeditionary Force Headquarters (MEF HQ), Intelligence Battalions, Marine

Figure 3-DOD- 15. 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)

Wing Support Groups (MWSGs), and Marine Wing Support Squadrons (MWSSs). There are three Marine Expeditionary Forces 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 (CG) 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 Marine Expeditionary Force 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.

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 (FOB) 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 (ACM). 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

Figure 3-DOD-l6. 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 information requirements.

Specialized METOC Support

The Marine Corps' Chemical Biological Incident Response Force (CBIRF) was established in 1996, as a result of Presidential Decision Directive (PDD) 39 to manage the consequences of Nuclear, Biological, and Chemical (NBC) materials or weapons used by terrorists. This national level asset is part of the re-activated 4th Marine Expeditionary Brigade - Anti-Terrorism (MEBAT) located at Indian Head, Maryland. 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 Chemical, Biological, Radiological, Nuclear, or High Yield Explosive (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 (MCWP) 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 (MCCDC), Doctrine Division web site at https://www.doctrine.guantico.usmc.mil/.

**ARMY TRANSFORMATION**

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 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 AF 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 U.S. 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 U.S. 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 U.S. 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. AF Major Commands (MAJCOMs) provide operational weather services to war fighting ASCCs in combat, contingencies, and peacetime training. U.S. Army Forces Command (FORSCOM), U.S. Army Europe (USAREUR), U.S. Army Pacific (USARPAC), U.S. Army Special Operations Command (USASOC), Eighth U.S. Army (EUSA), and U.S. Army Training and Doctrine Command (TRADOC) have AF Weather (AFW) personnel providing daily installation and tactical weather support. Army Artillery Meteorological (ARTYMET) Crews provide direct upper air observation support to artillery units in the same ASCC. During peacetime training and activation, the Air National Guard (ANG) provides AF operational weather support to the U.S. Army Reserve (USAR) and Army National Guard (ARNG), collectively designated the Reserve Component (RC). In addition, during exercises and contingencies, the ANG may augment the active Army Battlefield Weather forces.

The Army also provides the operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges, centers, and other research facilities using the Developmental Test Command's (DTC) Meteorological Teams (MET Teams) and U.S. 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 U.S. 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 (EAC) to aviation battalions. The Communications and Electronics Command (CECOM) and Army Research Laboratory (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 Active Component (AC) 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, to USAF Battlefield Weather Teams (BWTs), and to the Chemical Officer for use in smoke and in Nuclear, Biological and Chemical (NBC) defense operations (Figure 3-DOD-17). The U.S. 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 1 15-l0/AFJI 15-157, the

Figure 3-DOD-17. Accurate wind profiles are essential for the Artillery to engage their targets. Photo courtesy U.S. Army.

AF provides the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical and garrison active component and reserve component support requirements. Army support manpower requirements are sourced from 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, aviation brigades, separate brigades, and Special Forces groups/ranger regiments to provide direct, on site weather support.

AF operational weather squadrons (OWSs) 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 (DIICOE) and Joint Technical Architecture - Army (JTA-A) 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.

<u>Eighth U.S. Army</u>

The Eighth United States Army (Eighth Army) requires and uses Army resources to collect upper air data for artillery support. Two artillery meteorological (ARTYMET) crews with the Second Infantry Division (2 ID) use AN/TMQ-41 Meteorological Measuring Sets to collect upper air data for direct use by field artillery units. AFW 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 FY 2006, 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.

<u>United States Army Europe</u>

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

Figure 3-DOD-18. Reliable wind forecasts are necessary to ensure safety during airborne operations.(Photo courtesy U.S. Army).

tactical weather intelligence and support. 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) Operational Weather Squadron (OWS) at Sembach AB, Germany, provides operational-level forecast products for the European Command Area of Responsibility, to include all USAREUR units. BWTs 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 7 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 10 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. During late FY 2006 and early FY 2007, three 7WS detachments will close: Hanau, Giebelstadt, and Wurzburg. These closures follow USAREUR transformation.

Seven IMETS were 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. IMETS Light was fielded in Oct FY 2005 to Aviation Brigade weather teams, and an upgrade (version 6.4) was fielded in FY 2005 (Figure 3-DOD-19).

USAREUR provides supporting USAF weather teams with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four artillery meteorological (ARTYMET) sections collect upper air observations for direct use by field artillery units. The Forward Area Limited Observing Program (FALOP) consists of Army personnel taking lim-

Figure 3-DOD-19. The Integrated Meteorological System - Light (IMETS-L). (Photo courtesy U.S. Army.)

Figure 3-DOD-20. Weather plays an important role in day to day Army operations, such as this bridging operation in South Korea. (Photo courtesy U.S. Army)

ited 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.

U.S. Army Special Operations Command (USASOC)

Weather support to USASOC allows commanders to improve efficiency, effectiveness and safety of operations for USASOC units. Air Force Special Operations Command (AFSOC) and Air National Guard (ANG) weather personnel provide direct support to USASOC units and are assigned to 10th Combat Weather Squadron (CWS); OL-A, 320th Special Tactics Squadron (STS); 321st STS; and OL-A, 353rd Special Operations Group. ANG personnel providing direct support to USASOC when activated are assigned to the 107th MIANG, 146th PAANG, and the 181st TXANG.

SOWT personnel use tactical weather kits to collect limited weather data and provide limited scope meteorological observations from permissive, semi-permissive, and uncertain environments in direct support of Army Special Operations Forces (ARSOF). 10th CWS SOWTs collect weather data at the deployed team level. These observations are passed to operating bases for use by ARSOF commanders and staff and a variety of other weather units and personnel. Specifically, SOWTs provide garrison and tactical support to USASOC units including the U.S. Army Special Forces Command and its seven subordinate Special Forces Groups (SFG); the 75th Ranger Regiment; the 160th Special Operations Aviation Regiment; the United States Army Civil Affairs and Psychological Operations Command (USACAPOC); and all SFG and regimental subordinate battalions and two separate aviation companies. Weather operations include: climatology and solar/lunar illumination tables and studies; courses of action and mission impacts analysis; weather watch/warning services; mission execution forecasts; flight weather briefings; drop/landing zone forecasts; training of ARSOF; training of host nation and indigenous forces on conducting limited observation programs; surface, upper-air and tactical radar observations; and Foreign Internal Defense analysis, surveys, and training. AFSOC SOWTs provide the DOD's sole source for high-fidelity Meteorological and Oceanographic (METOC) intelligence data collection from austere, denied, hostile, or semipermissive areas of the battlespace.

USASOC plans and expends resources for some operational and administrative support to SOWTs providing meteorological service support to USASOC components. USASOC provides funding for office and deployable automation systems and connectivity to local networks; operations and maintenance/sustainment to support USASOC requirements; funding for temporary duty for some USASOC mission needs; and funding for the Army Combat Uniform (ACUs). Additionally, USASOC provides for some tactical items such as NBC and some communications equipment; electrical power, vehicles, life support equipment necessary for accomplishing USASOC weather support missions; and maintenance and supplies for USASOC provided equipment. Fifteen Integrated Meteorological Systems-Light (IMETS-L) have been fielded within USASOC and funding has been secured for thirty-six additional systems. IMETS-L provides AFSOC SOWTs a system to assist with mobile automated weather data receiving, processing, and dissemination. IMETS-L also provides AFSOC SOWTs a system to assist with digital weather support, real-time tailored weather information, forecasts, and weather effects on friendly and hostile weapons systems. USASOC also provides funding for facilities, telephones, office space and furniture, and real property to house supporting special operations weather units, as well as secure storage of required equipment.

United States Army Pacific (USARPAC)

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 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 NTPRNET and SIPRNET conduits. The 25th ASOS weather budget will increase in FY 2007 due to an increase in IMETS funding and the 25ID(L) SWO's operating budget. Approximately $9.4K has been provided for each fielded IMETS-V system, and $ 8.9K for each IMETS-L system. Furthermore, the SWO's operating budget increased from an undeterminably small amount to $25K. The 25th ASOS also supports Bradshaw Army Airfield, for which funding is incorporated into the SWO's operating budget.

The 17th Operational Weather Squadron (17 OWS) at Hickam AFB, HI, provides HQ USARPAC with garrison and tactical weather warnings, forecasts, special support, and Staff Weather Office (SWO) services. Additional BWTs assigned to U.S. Army Japan (USARJ), U.S. Army Hawaii (USARHAW), including the 25th ID (L), and U.S. Army Alaska (USARAK), including 172 SIB, provide direct, on-site support at 5 USARPAC installations. The BWTs also deploy with their customers, 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. The 17 OWS provides regional weather support, allowing the forward deployed forces to focus on specific area and target forecasts. There are three subordinate commands within USARPAC: United States Army, Hawaii (USARHAW), United States Army, Alaska (USARAK), and United States Army, Japan (USARJ). The 17 OWS provides operational-level forecast products for the USFJ and USFK AORs, to include all USFJ and USFK AF 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 Staff Weather Officer (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 BWT assigned to the 374th Operational Support Squadron at Yokota AB. The OL on-site at Camp Zama provides observational support and produces mission execution forecasts to 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, serves as the CG, USARAK's SWO. Additionally, 11 OWS is responsible for 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. The 11 OWS provides flight weather briefing support, as required, to Army, Army Reserve, and Army National Guard aviation assets in theater. An AF BWT (3 ASOS/WE) is collocated with the 172d Infantry Brigade (Separate) (172d Stryker Brigade Combat Team (172 SBCT)) at Fort Wainwright, and the aviation assets of 4th Battalion, 123d Aviation Regiment. The 3 ASOS/WE provides weather support for both tactical and garrison operations, observes the atmosphere and evaluates, then tailors, forecast products to produce Mission Execution Forecasts and staff briefings. The 3 ASOS/WE also supports 172 SBCT tactical unmanned aerial vehicle (T-UAV) operations. The Alaska Army National Guard operates the airfield at Fort Richardson.

U.S. Army Forces Command (FORSCOM)

Weather support to the U.S. Army Forces Command (FORSCOM) 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 Active Army (AA), U.S. Army Reserve (USAR) and Army National Guard (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 U.S. Army is the Army component of U.S. 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 U.S. Southern Command (USSOUTHCOM). USARSO relocated from Fort Buchanan, Puerto Rico, to Fort Sam Houston, Texas, in 2003, and became a FORSCOM major subordinate command October 1st, 2003. FORSCOM also commands three Army Corps: I Corps at Fort Lewis, Washington, III Corps at Fort Hood, Texas, and XVIII Airborne Corps at Fort Bragg, North Carolina. 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 U.S. Armies (CONUSAs), First U.S. Army and Fifth U.S. Army, are responsible for training, mobilization, and deployment support to Reserve Component units in FORSCOM. Another major subordinate command to FORSCOM, the U.S. Army Reserve Command (USARC), commands all U.S. Army Reserve units in the continental U.S. 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.

The Army is in a period of transformation, over the next several years where the Army will transform from its current structure to a structure that has two higher headquarters replacing existing divisions, corps and echelons above corps. This transformation is requiring AFW to retune its service approach to Army units in terms of manpower and functions.

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, Washington; 3 ASOG at Fort Hood, Texas; and 18 ASOG at Pope AFB, North Carolina. A weather squadron under each ASOG supports the Corps. Each Army division normally has dedicated 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, and Air Force Joint Pamphlet 15-127. 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.

Air Combat Command weather organizations provide direct, on-site support at 11 major, Army installations, including the National Training Center at Fort Irwin, California, and the Joint Readiness Training Center at Fort Polk, Louisiana, 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. Six more teams are planned to be added in FY 2006 - FY 2007.

The New Tactical Forecast System (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-L, developed by the Army Research Laboratory, have been fielded within FORSCOM. FORSCOM has also fielded commercial Automated Weather Observing Systems at Yakima Training Center, Washington, Fort Campbell, Kentucky, and Georgetown Bahamas.

<u>Training and Doctrine Command (TRADOC)</u>

Headquarters, TRADOC (HQ TRADOC) is responsible for development and management of weather training programs, Army and Joint weather support doctrine (concepts and field manuals), and the establishment of requirement documents for Army tactical weather support. HQ TRADOC is the approval authority for Army-AF weather doctrine, Army weather system requirements, and weather support policy. Key mission areas for the next few years will be to coordinate weather requirements to the Army's Modular Forces; develop new weather support doctrine, concepts, and tactics, techniques, and procedures; ensure weather, weather effects to operations, and weather support processes/procedures are properly trained across the TRADOC schoolhouses.

The IMETS continues as the state of the art Army weather support system. However, over the next few years its capabilities will be consolidated into the Air Force's Joint Environmental Toolkit (JET) program. The Army will retain research and development efforts related to Army-specific weather support challenges (short-term forecasting in the lowest levels of the atmosphere) and will be responsible for interfacing JET with Army command and command systems. Initial JET fielding is programmed to begin in FY 2007.

The U.S. 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. A key component to providing weather support to the Army is IMETS, fielded by the Army and operated by Air Force Battlefield Weather Teams (BWTs). The USAIC&FH Weather Team assists in advising the Army Research Lab, USAIC&FH, DAMI-PO and AFW on Army weather support issues and helps develop solutions to meet both active and reserve forces' weather requirements. In addition, the USAIC&FH Weather Team conducts and monitors initial weather support training to Army Military Intelligence personnel and AFW personnel supporting the Army. The USAIC&FH Weather Team consists of three active duty AFW personnel that support Army concepts, architecture and requirements initiatives; one civilian contractor that manages the Battlefield Weather (BW) course; and one Army Government Civilian that serves as the assistant TRADOC Capabilities Manager (TCM) for IMETS. This year the USAIC&FH Weather Team drafted the initial Army Weather Functional Area Analysis (FAA) and will continue associated work on weather input to the Intelligence, Surveillance and Reconnaissance (ISR) Concept Capabilities Plan (CCP). Also, the team developed a new TRADOC Staff Weather Officer organizational structure which consolidates most SWOs under one office at Ft Huachuca. This new manning initiative includes the future addition of an Army Weather civilian position, also located at Ft Huachuca. Due to personnel turnover, the BW course hired a new Course Administrator this year. The USAIIC&FH TCM for IMETS has coordinated with DCGS-A to ensure the highest level of integration of IMETS as a Program of Record (POR) in the DCGS-A family of systems while developing a clear migration path towards total integration of capabilities. The TCM participated in the DCGS-A Fusion Working Group documenting each intelligence domain's current fusion architecture and documenting the level of automation currently being provided by POR systems for each level of fusion. The TCM also provided DCGS-A an evaluation of IMETS ability to satisfy the DCGS-A CPD requirements. 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.

The AF SWO at the Army's Combined Arms Center (CAC) is the primary overseer of the Tables of Organization and Equipment (TOE) for BWTs supporting Army operations. 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 the TRADOC System Manager - Army Battle Command System, the Battle Command Battle Lab-Leavenworth, the Center for Army Lessons Learned, the Combined Arms Doctrine Directorate, the TRADOC Assistant Deputy Chief of Staff for Intelligence -Threats, the Foreign Military Studies Office, and 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 Battle Command Training Program (BCTP) and the National Simulation Center, and to make available Army weather support instruction at the Command and General Staff College (CGSC).

The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK is the proponent for upper air meteorological support to the Army. Artillery meteorological crews, Active and Reserve, had used the AN/TMQ-50 to measure surface weather parameters. Tactical reliability issues forced an Army-wide 'STOP-USE' of the AN/TMQ-50 at the end of FY 2003. Artillery meteorological crews currently use manual surface instruments to measure surface weather conditions. The AN/TMQ 55 (TACMET) is being fielded to Artillery Meteorological sections to replace the AN/TMQ 50. The AN/TMQ-41 Meteorological Measuring Set (MMS) and AN/TMQ-52 Meteorological Measuring Set-Profiler (MMS-P) are utilized to take 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 Nuclear, Biological, Chemical (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 our newest numerical meteorological analysis and forecasting models. Active unit's MMSs will eventually be replaced by the AN/TMQ-52 Meteorological Measuring Set Profiler (MMS-P). The MMS-P is scheduled to begin fielding in early FY 2005. 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).

The U.S. Army Engineer School (USAES), Fort Leonard Wood, MO, coordinates weather support requirements for Terrain Analysis and Topographic Engineering. USAES develops methods of measuring and forecasting state of the ground for trafficability assessments using input weather data fields. Their mission also includes identifying, and documenting requirements to interface meteorological and engineer battlefield systems. Due to resource constraints, USAES no longer has a full time civilian meteorologist in the Terrain Visualization Center, DCD, but does have an instructor at the Terrain School at Ft Belvoir , VA, to teach weather effects on cross-country mobility and engineer missions.

The U.S. 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), Alabama, and Andalusia MAP, Alabama. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites. Two active duty positions, aligned under the Directorate of Training and Doctrine (DOTD), are allocated to provide staff support for Army aviation and aviator training weather issues in areas of curriculum, concept development and doctrine. Staff weather personnel review training material and doctrine publications, provide advice to USAAWC staff and monitor developing

Figure 3-DOD-21. Meteorological Measuring Set- Profiler (MMS-P) obtains upper level wind data for artillery fires. (Photo courtesy U.S. Army.)

The USAAWC SWO also supports the U.S. Army Combat Readiness Center, Air Traffic Services Command, and other Fort Rucker tenants. Operational weather support for aircrews and resource protection are provided by Air Force contractors who are functionally aligned under the Directorate of Plans Training Mobilization and Security (DPTMS).

Beginning in FY 2004, ACC contracted 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. ACC, through the same contract with 3D Research Corporation, 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.

<u>Army National Guard (ARNG) Artillery</u>

In FY 2005, the ARNG downsized its Meteorological (MET) Sections assigned to artillery units at Division level, Field Artillery Brigades (DIVARTY), and in Separate Brigades to two 6-soldier teams in the DIVARTY's, except in the Light DIV where there is one team, equaling a total of fifteen 6-soldier teams. In the ARNG "Modular Forces", there is one 6-soldier team per Fires Battalion in the Brigade Combat Team (BCT), providing 34 teams with six soldiers each, for 204 soldiers. In the Fires BDE there are 3 MET teams required per BDE providing 21 teams with 6 soldiers each, for a total of 126 soldiers. However, all Fires BDE TABs have authorizations for only one MET team for a total authorization for 42 soldiers. All together the ARNG has 246 soldiers authorized to Artillery Metrological Teams.

The ARTYMET 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 ARTYMET 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

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 Corps 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/National Weather Service (NWS) to collect and maintain precipitation information from 826 of meteorological sites. Similarly, COE transfers funds to the U.S. Geological Survey to maintain precipitation data collection from about 2000 sites, while the COE maintains the rest. Seventy-five percent of all Corps sites provide real-time data via satellite, microwaves, meterbursts, landlines, or radio. Data from COE gauging sites are available to other Federal, state and local agencies. All Corps data is made available to the National Weather Service. Most of the data is also used by other agencies.

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 (Figure 3-DOD-22). Many unique meteorological instruments are maintained to support this critical data collection for HBL 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-23) 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/BRL.

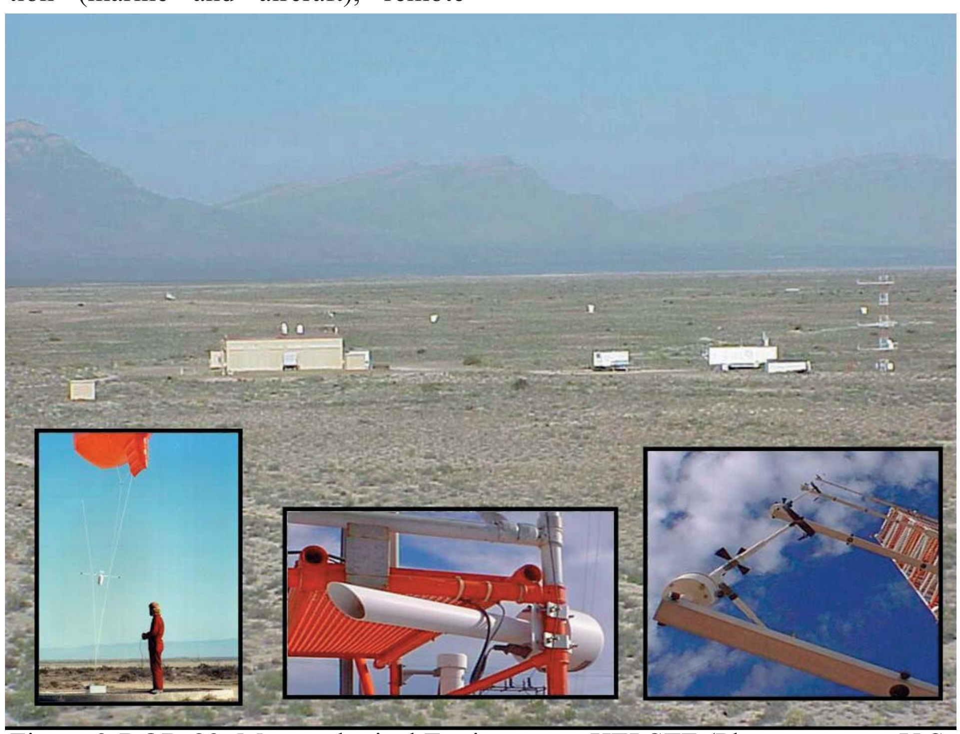

Figure 3-DOD-22. Meteorological Equipment at HELSTF (Photo courtesy U.S. Army.).

Figure 3-DOD-23. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll. Photo courtesy U.S. Army.

WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDTE)

Under Army-AF agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) 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.

Corps of Engineers (COE). 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).

Under its military mission, the Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH, provides support to Army weapon systems RDTE 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. These products transition to various research and engineering programs including advanced technology demonstrations and specific programs of record such as the Commercial Joint Mapping Tool Kit. Recent efforts have included supporting materiel developers to simulate acoustic/seismic systems for the purpose of risk mitigation and trade-off studies.

Army Material Command (AMC). 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 RDTE 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 Army Research Laboratory (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, Maryland and White Sands Missile Range, New Mexico. 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 Command and Control 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 Operational Environmental Satellite System (NPOESS) IPO. These positions focuses on coordinating technology transitioned from the BE Division into Army and AF fielded systems.

The BE Division and the Army Project Director- Integrated Meteorological System (PD-IMETS) office are partnering with AFW in new programs, such as the development of a common Joint Environmental Toolkit (JET). The Army IMETS Battle Command (BC) 6.4 software and several AFW system software baselines are to converge as a single weather forecasting software tool. The Army will add command and control interfaces and weather effects tactical decision aid products such as the Tri-Service Weather Effects Decision Aid (TS-I WEDA). 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 Battle Command and Future Combat Systems (FCS) as DCGSA 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 being performed.

The Atmospheric Effects Branch performs research on the basic characteristics of the atmosphere as they will affect new sensing technologies and systems. The branch designs and executes experiments to verify and improve the new diagnostic and prognostic numerical weather models and atmospheric effects on sensors and systems. Technology is developed to more easily capture forward area environmental data and information in near real-time in a networked environment. The branch also is responsible for producing and verifying tactical decision aids and models to assess 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 Intelligence Preparation Battlefield (IPB) and weather optimization of route planning into mission planning and execution 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, North Carolina, 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 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 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 (DURIP) provides funds for instrumentation needed to support ongoing research activities. The Defense Experimental Program to Stimulate Competitive Research (DEPSCoR) 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 process and studies of stable boundary layers in complex terrains.

Communications Electronics Command (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 (CERDEC), 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 active Army units and National Guard Bureau are equipped with the MMS.

The Meteorological Measuring Set-Profiler (MMS-P) AN/TMQ-52 System. The Meteorological Measurement Set-Profiler (MMS-P) is a major improvement over the MMS. The AN/TMQ-52 design will support the new generation of artillery weapons. 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 MMS 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. Four System Design and Development (SDD) models have been produced. Developmental testing has been successfully completed and Low Rate Initial Production (LRIP) was approved at a MS C decision in FY 2003. The Profiler system has completed Initial Operational Test and Evaluation (IOTE) FY 2005. Full Rate Production (FRP) was approved at a FRP Decision in FY 2005.

The Intelligence and Information Warfare Directorate (I2WD), Communications Electronics Research & Development Engineering Center (CERDEC), Research Development & Engineering (RD&E) Command is providing technical and sustainment support to the Program Director-IMETS.

The IMETS comes in two basic configurations known as the Vehicle Mounted (AN/TMQ40B/C/D) and Light (AN/GMQ-36/36A/36B) groups. The IMETS Vehicle Mounted group has three variants, all with the same function that differ only by vehicle, shelter, and/or generator (Figure 3-DOD-24). The new IMETS-Light (AN/GMQ-36A) provides a transit case version of the IMETS with the same software capabilities as the vehicle version.

Either the IMETS Vehicle Mounted or the IMETS Light configuration can provide the weather component of the Intelligence Electronic Warfare (IEW) sub-element of the Army Battle Command System (ABCS). IMETS has been designated by the DCGS as the Weather Center for DCGS-A weather

Figure 3-DOD-24. IMETS Vehicle Mounted Configuration. (Photo courtesy U.S. Army.)

requirements and is on track to fully support the Future Combat System (FCS) prime. The IMETS at Div and Corps levels provides commanders at all echelons with an automated tactical weather system that receives, processes and disseminates weather observations, forecasts, battlefield visualization, and weather effects decision aids to all Army Tactical Command and Control System (ATCCS) Battlefield Functional Areas (BFAs). IMETS can receive weather information from (either USA, European, Japanese, or Chinese civilian) geostationary satellites depending on the system's location, civilian forecast centers, the Air Force Weather Agency, artillery meteorological sections and remote sensors. IMETS processes and collates forecasts, observations, and climatological data to produce timely and accurate weather products tailored to the specific war-fighters needs. Significant weather and environmental support to war-fighters are the weather applications such as the automated tactical decision aids and contours client. These weather products display the impact of the weather on current or planned operations for both friendly and enemy forces. Weather products can also be overlaid on the Common Operational Picture (COP) or Common Tactical Picture (CTP) accessed by using a browser, and is executed on the users terminal through weather client implementations.

Major test events in FY 2005 include the IMETS Intra-Army Interoperability Certification test, completed during the first quarter of FY 2005, at the Central Test Support Facility (CTSF) and the ABCS 6.4 Good Enough (GE) Operational Evaluation (OPEVAL) completed in second quarter FY 2005. The AN/TMQ-40C Materiel Release is on schedule to occur at the last quarter of FY 2005, and the AN/TMQ-40D for FY 2006. Both of these systems, along with the AN/GMQ-36 are on schedule to field to units. In order to streamline the acquisition process, the IMETS AN/GMQ36A/B has been given permission to go directly to Materiel Release pending the results of Development Testing and skip Milestone C pending on Development Testing results. FY 2005 efforts will focus on the ABCS 6.4 GE Operational Assessment and fielding and the IMETS Light (AN/GMQ-36A/B) Materiel Release and fielding decision, along with finishing the fielding efforts for the AN/GMQ-361 to gaining units including the Stryker Brigade. AN/TMQ40B/C/D systems will also be fielded during FY 2005.

Army Test and Evaluation Command (ATEC)

The Developmental Test Command (DTC), a subordinate command of U.S. Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to eight Army ranges and test sites. 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 research, development, test and evaluation (RDT&E) activities at eight Army installations. Funding for the Army RDT&E Meteorology Program under Program Element 665702 is sufficient to maintain the basic meteorological support infrastructure at Army RDT&E ranges and sites. However, instrumentation needed to support unique or test-specific requirements generally must be funded by test sponsors. Because the majority 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 and technicians to ensure continuity in specialized meteorological support services as senior employees begin to retire.

The Army RDT&E Meteorology Program has entered into a multi-year working relationship with the National Center for Atmospheric Research (NCAR) to enhance "range scale" (mesoscale to microscale) forecast and analysis capabilities at the Army test ranges. The principal product of this relationship is the Four-Dimensional Weather (4DWX) System, which consists of a central data archival/retrieval system for all range and external meteorological and model data, a high-resolution mesoscale meteorological model (MM5), and a variety of user-configurable displays. The MM5 mesoscale model is 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 capabilities include MM5-based real-time four-dimensional data assimilation (RT-FDDA) at the major Army test ranges and 4DWX On the Move (OTM), 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 will continue the transition of its operational mesoscale model from MM5 to the next-generation Weather Research and Forecast (WRF) model. The NCAR/ATEC version of WRF includes the full observation nudging capabilities of the MM5-based RT-FDDA system. Output from 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 Program Manager for Meteorological Support to Army RDT&E. Under Program Element 0605384, the Division's Modeling and Assessment Branch also provides the following specialized services:

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 Material Command

The U.S. Army Research Institute of Environmental Medicine (USARIEM) conducts basic and applied research on the effects of heat, cold, high terrestrial altitude and nutritional status on the health and performance of individual soldiers and combat crews operating Army systems.

Applied research in thermal physiology and biophysical modeling is directed towards improving soldier performance and minimizing health risks in climatic extremes. The sensitivity of the soldier to local weather parameters (primarily ambient temperature, dew point, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The overall goals of USARIEM weather-related research programs are to develop methods to effectively monitor and, where possible, extend the operational envelope for both training and operational scenarios.

Weather-related research efforts include the development and validation of automated methods to integrate thermal strain prediction models with real-time weather information resources relevant to dismounted infantry operations. Temporal and spatial scales of interest are meters to kilometers and minutes to several days. USARIEM is working through an MOA with the Army Research Laboratory Battlefield Environment Division to implement thermal models on Personal Digital Assistant (PDA) devices and the Integrated Weather Effects Decision Aid (IWEDA).

The availability of ground level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. As part of the warfighter physiological status-monitoring (WPSM) program, USARIEM is investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with predictive model processes. The effective fusion of these two real-time data streams will enable near term environmental strain and performance status predictions for individual warfighters.

A miniature weather station developed under a Small Business Innovative Research (SBIR) project has been refined into a 1 kg battery powered unit which may be used to collect meteorological data to support the prediction of thermal stress on the WPSM system. Research efforts in this area are intended to address capabilities identified in the Operational Requirements Document (ORD) for the Army's Land Warrior program.