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 small weather operations capabilities, 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

USAF METEOROLOGICAL AND SPACE ENVIRONMENTAL SERVICES

OVERVIEW

Air Force weather forces provide high-quality, mission-tailored terrestrial and space environment observations, forecasts, and services to the U.S. Air Force (USAF), U.S. Army (USA), and a variety of U.S. Government (USG) departments and agencies. Air Force weather enables Joint Warfighters to anticipate and exploit the weather...for air, space, cyberspace, and ground operations

ORGANIZATION

AF weather is functionally organized under the Director of Weather (AF/A3O-W), Directorate of Operations (AF/A3O), Deputy Chief of Staff, Operations, Plans, and Requirements (AF/A3/A5), Headquarters Air Force. The Director of Weather oversees Air Force-wide training, organizing, and equipping of AF weather organizations to include the following functions:

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

Figure 3-DOD-1: Air Force Weather Mission Statement

Figure 3-DOD-2. AF Weather Agency's "Lt Gen Thomas S Moorman" Building, opened April, 2008.

equipment to support worldwide training and combat operations

AF weather operations provide a Total Force capability employing over 4,100 Active Duty (AD) and Reserve Component (RC) military and civilian personnel supporting Air Force 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.

AF weather is organized in a 3-tier structure to maximize capabilities that can be accomplished in the rear area via "reachback" technology. This minimizes forward presence on the battlefield, making a "light and lean" presence consistent with the overall USAF vision for contingency operations in the 21st century.

AIR FORCE WEATHER AGENCY (AFWA)

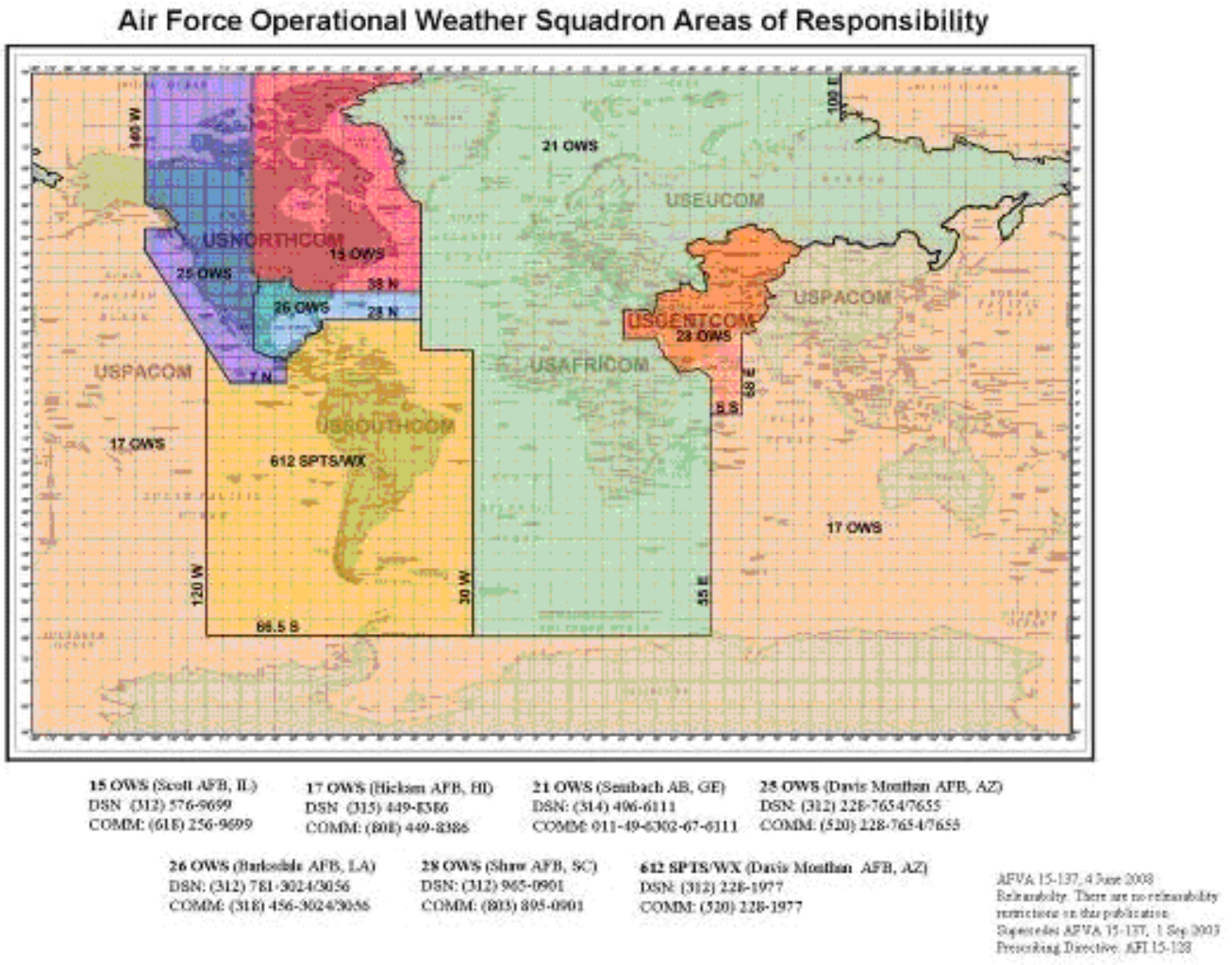
The centerpiece of global-scale collection and production is the Air Force Weather Agency (AFWA), Offutt AFB, NE, a field operating agency reporting directly to the Air Force Director of Weather. AFWA performs two distinct functions for AF weather. As part of its Lead Command responsibilities, AFWA plans, programs, and fields standard weather systems. At the same time, AFWA has a strategic-level operations and production function. Specifically, AFWA is charged with collecting, analyzing, predicting, tailoring, and integrating weather data at all operational levels.

Through the execution of the second function, 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 operates a satellite data processing center and a centralized climatology center with the largest military archive of meteorological data in the world. The agency runs numerical weather prediction models, conducts global cloud and snow analyses, and runs cloud analysis and forecast models. AFWA also maintains a global meteorological database, and provides dedicated support to the Intelligence Community (IC).

AFWA consists of a functional management headquarters; the 1st Weather Group (1 WXG) with three subordinate CONUS operational weather squadrons (OWS); the 2nd Weather Group (2 WXG), which operates three squadrons, two at Offutt and one at Asheville, NC; the Air Force Combat Weather Center at Hurlburt Field, FL, which supports the Combat Weather Flights and Battlefield Weather Teams through investigation, development, integration, exploitation, and training across new and existing systems and processes; as well as five detachments and operating locations. The 1 WXG commands three operational weather squadrons that conduct weather operations in support of Total Force Army and Air Force operations in the CONUS: the 15th Operational Weather Squadron (15 OWS) at Scott AFB, IL, the 26th Operational Squadron (26 OWS) at Barksdale AFB, LA, and the 25th Operational Weather Squadron (25 OWS) at Davis-Monthan AFB, AZ.

The 2 WXG, collocated with HQ AFWA at Offutt AFB, NE, consists of the 2nd Systems Operations Squadron (2 SYOS) which provides automated weather characterization on a global scale, the 2nd Weather Squadron (2 WS) which provides global coverage of forecaster-in-the-loop products to exploit the weather as well a backup for two national weather centers (Space Weather Prediction Center and the Washington-Volcanic Ash Advisory Center), and the 14th Weather Squadron (14 WS) at Asheville, NC, which provides centralized climatological database services, produces specialized weather-impact information for the Department of

DOD Figure 3: Air Force Operational Weather Squadron (OWS) areas of responsibility (AORs) overlaid on geographic combatant commander AORs.



Defense and allied nations, and warehouses and distributes atmospheric science-related technical information.

OPERATIONAL WEATHER SQUADRONS

Six operational weather squadrons (OWSs) form the backbone of regionally focused, "reachback" weather operations, providing a variety of weather forecast products and support to units assigned to and/or deployed into their Area of Responsibility (AOR). OWSs support AF, Army, Navy, Marine, Guard, Reserve and regional Combatant Commanders, providing operational weather support, such as graphical analyses, aviation terminal aerodrome forecasts and aviation hazard forecasts, operational level planning and mission execution products, such as the Joint Operations Area Forecast, severe weather watches/warnings and advisories, and other products using the OWS Production System Phase II (OPS II). The AF will replace OPS II with the Joint Environmental Toolkit (JET), which began fielding began in summer 2008 and will be complete in the fall of 2009. OWSs also provide theater-scale, tailored environmental information to guide development of mission execution forecasts by Active Component (AC) and Reserve Component (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. In addition, OWSs are charged with providing forecaster training for our new recruits.

WEATHER FLIGHT/DETACHMENTS

At AF bases and Army posts, AF weather forces focus on their warfighter's mission requirements. These units provide and disseminate observations and develop tailored mission execution forecasts based on centrally produced guidance. Personnel in these units also act as "eyes forward" for their supporting OWS. Weather personnel supporting conventional AF operations typically deploy with a New Tactical Forecast System (N-TFS), (currently being upgraded to the Joint Environmental Toolkit), the TMQ-53 tactical observing system for semi-permanent sites, and hand-held Kestrel observing kits for back-up operations. This equipment, coupled with robust communications to receive weather data including satellite imagery, provides the essential capability required for deployed weather forces to meet operational requirements. Currently, AF weather has 130+ weather organizations supporting USAF or US Army units at the wing, corps, division, or brigade level, and leverage communications "reachback" to OWSs & to AFWA.

For AF operations, these weather professionals are normally assigned to a flight under an operations support squadron in an AF flying wing; however, individuals from the weather flight are integrated into flying squadron mission planning and execution processes. In this capacity, they infuse critical weather information at key points in the decision cycle to help aircrews maximize wartime capabilities, enhance flight safety, and optimize training effectiveness. Weather experts are also assigned to weather specialty teams in air and space operations centers. This cross-cutting team integrates 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.

Likewise, Army weather requirements are incorporated into the AF's overall weather operations concept. AF weather forces are integrated with Army intelligence staffs. The Army trains and educates Air Force personnel on Army organizations, concepts of operations, and the weather sensitivities. AF weather forces are currently habitually aligned with echelons above corps, corps, divisions, separate brigades, aviation brigades, armored cavalry regiments, ranger regiments, and Special Forces groups (as well as subordinate battalions deployed at forward operating bases). Over the next few years, AF weather 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.

OPERATION IRAQI FREEDOM/OPERATION ENDURING (OIF/OEF) FREEDOM SUPPORT

AF weather units are fully engaged in contingency operations in Iraq and Afghanistan, and play an integral part in support of OIF/OEF AF and Army missions and operations. Currently, 198 AF weather personnel are deployed to 33 locations around the world. The success of reachback communications and support between AFWA/OWSs and forward deployed weather units has decreased the AF weather forward "footprint" 40% since DESERT STORM, despite a much higher operations tempo at these locations. In terms of customers supported, about 50% of AF weather deployed personnel are supporting AF operations, 40% are supporting US Army operations, and 10% are supporting Special Operations Forces operations.

As an example of its focus on the OIF/OEF missions, AF weather has procured "Weather Pod" observing systems that are being fielded as remote expendable observing systems in support of AF and Army operations in the OEF/OIF theaters. They will be used to take observations at locations where AF weather personnel are deployed as well as at locations where there are typically no weather personnel, such as forward operating bases and forward air refueling ports. The Weather Pods may also be placed along select flight routes and other locations of particular weather interest.

RESERVE COMPONENT

The Reserve Component (RC) is composed of the Air Force Reserve Command (AFRC) and the Air National Guard (ANG). AF weather continues to integrate these forces to more closely align with AC weather force operations. Air Force RC weather personnel augment the AC at all levels. In some cases,

Figure 3-DOD-4. 53 WRS "Hurricane Hunter" WC-130J aircraft on-board radar (53 WRS Web site)

the RC provides very unique weather related services not duplicated in the AC force, such as AFRC's 53d Weather Reconnaissance Squadron (53 WRS) and the ANG's Weather Readiness Training Center (WRTC).

To augment OWS operations, AFRC organized two operational weather flights (OWF), each staffed by AFR weather personnel, capable of augmenting an OWS either in the CONUS or overseas. Additional AFR weather personnel serve as individual mobilization augmentees (IMAs) assigned to various active AF weather organizations at all echelons, typically in staff, forecasting, or scientific roles. There are also AFR weather personnel in Air Reserve Technician positions, i.e., combined full-time Civil Service/AFR military positions, employed by the 53d WRS as Airborne Weather Reconnaissance Officers. Lastly, AFRC contract weather personnel provide weather services at AFRC-operated bases in the CONUS.

The AFRC's 53 WRS, also known as the "Hurricane Hunters," provides another means of collecting vital meteorological data, especially in and around tropical cyclones. Their specially equipped WC-130J aircraft collect temperature, moisture, wind, pressure, and visually observed information at the aircraft location as well as vertical profiles of the atmosphere collected by dropsondes. Hurricane Hunter aircraft penetrate the eyes of tropical cyclones to provide the National Hurricane Center a very accurate center fix location as well as other meteorological parameters, including sea level pressure. 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 ANG traditional program consists of 27 numbered weather flights, ranging in size from 13 to 25 personnel, who meet monthly to train for their wartime mission. These flights provide weather support to ANG and Army National Guard units. ACC-gained ANG wings also have up to four traditional weather positions to provide weather operations for each wing's flying mission. In addition, there are traditional weather positions in two ANG Special Tactics Squadrons (AF Special Operations Command), and four ANG UAV units (Predator). The ANG also has 7 contract and 4 civil service locations where they are responsible for providing peacetime weather support to airfield operations.

AIR FORCE RESEARCH LABORATORY (AFRL)

The AF Research Laboratory (AFRL) supports AFWA by executing research conducted by external agencies and by conducting in-house research on 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. In space weather research, AFRL programs focus on ionospheric impacts to radio frequency systems, charged particle specification and forecasts, solar disturbance prediction, and neutral density effects on Low-Earth Orbit spacecraft. Working closely with the DMSP System Program Office at the Space and Missile Systems Center, under a Memorandum of Agreement, AFRL supports the development and upgrading of operational space weather sensors, models, and software products to include: space environment sensors on the DMSP spacecraft; state-of-the-art ground-based scintillation detectors; total electron content sensors; DISS/NEXION; SEON; and the Operationalized Space Environment Network Display suite of web-based products.

EDUCATION/TRAINING

AF weather officers are all university graduates with a bachelor's degree in meteorology; many

of these go on to obtain a master's degree in meteorology or related subjects through the AF Institute of Technology advance degree program.

After completing Basic Military Training, AF enlisted forecasters receive technical training in aviation meteorological observing, analysis and forecasting through the 335th Training Squadron's (335 TRS) weather schoolhouse at Keesler AFB, MS.

Both officer and enlisted AF weather personnel receive additional training in areas of tropical weather analysis and forecasting, weather satellite imagery interpretation, Doppler weather radar operation and interpretation weather effects on electro-optics weapon systems, through in-residence and on-line courses offered by the 335 TRS.

SPACE ENVIRONMENTAL

SPACE ENVIRONMENTAL INFORMATION

Space environmental information is obtained through a combination of ground- and space-based systems. For the near-Earth environment, i.e., ionosphere, ground-based systems provide highly accurate point source verification and specification, whereas space-based systems enable global coverage and theater-wide situational awareness. For solar data, ground-based systems provide reliable observations of the sun in optical and radio frequencies, and space-based observations measure frequencies unobtainable from the ground. Space-based systems provide in situ measurements of the space environment, i.e., solar wind, magnetosphere. AF weather has outlined plans to modernize ground-based space sensing in a space weather implementation plan and is collaborating with U.S. and Allied government and civilian agencies to achieve a robust space sensing capability.

Figure 3-DOD-5. Solar optical and radio telescopes at Learmonth, Australia. (US Air Force Released)

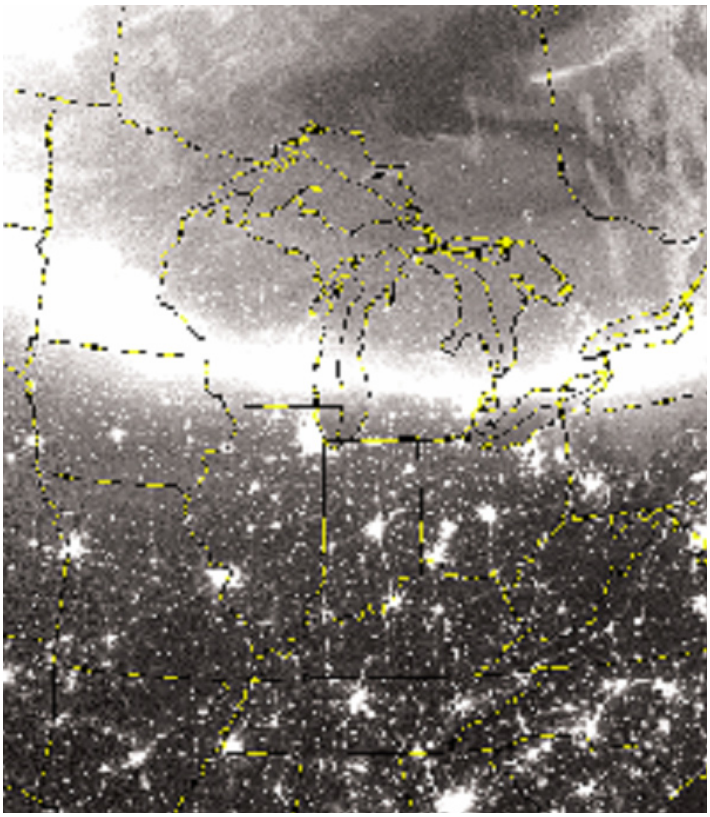
AFWA's 2 WXG operates the Solar Electro-optical Observing Network (SEON), a system of ground-based telescopes at Sagamore Hill, MA, Holloman AFB, NM, Palehua, HI, San Vito, Italy, and Learmonth, Australia. This network provides 24-hour observations of solar phenomena at optical and radio wavelengths. A worldwide network of ground-based ionosondes and other sensors provide ionospheric data. The AF manages 14 automated Digital Ionospheric Sounding Systems (DISS) to measure electron density profiles in the ionosphere. The DISS network is undergoing modernization as part of Next-generation Ionosonde (NEXION) fielding started in summer of 2009. AFWA funds a 27 International Ionosonde site database at the National Geophysical Data Center (NGDC) in Boulder, CO. NASA's Jet Propulsion Laboratory operates a complementary global network of over 125 sensors deriving ionospheric line-of-sight total electron content from global positioning system (GPS) signals and provides these data to AFWA's 2 WS Space Weather Flight. In addition, the U.S. Geological Survey operates a network of ground-based magnetometers, primarily in the northern hemisphere, which provides the Space Weather Flight with critical measurements of the geomagnetic field and its variances. The Air Force Research Laboratory at Hanscom AFB, MA, provides ionospheric scintillation data from a global network of 22 UHF and L-Band receivers, supporting AF C2 satellite systems and strategic long-range radar systems.

From space, the GOES satellites provide real-time solar X-ray, charged energetic particle, and geomagnetic data through the Space Weather Prediction Center (SWPC). The Solar X-Ray Imager, aboard GOES-12, monitors solar emissions in the X-ray portions of the solar spectrum and provides near real-time display at AFWA and the SWPC. DMSP, NOAA, and other DOD satellites provide charged energetic particle data in low-Earth and geosynchronous orbits. Additionally, the AF leverages space-based data from NASA and other agencies.

DEFENSE METEOROLOGICAL SATELLITE PROGRAM

The Defense Meteorological Satellite Pro-

DOD Figure 6: DMSP captures Aurora Borealis, over the Midwest; the aurora was pushed toward the equator by a 4 November 2003 geomagnetic storm. (AFWA Web site)



gram (DMSP), which provides cloud, upper air, and space environmental data, is a vital source of global weather data used to support combat operations. Onboard sensors provide AFWA and the Navy's Fleet Numerical Meteorology and Oceanography Center with visible, infrared, and microwave imagery, temperature and moisture sounding data, electrically charged particle fluxes, and other specialized space environment data. The DMSP also supplies direct, real-time readouts of regional imagery and mission-sensor data to DOD land-based and shipboard terminals located worldwide. In addition to DMSP polar-orbiting data, AFWA receives stored data from the DOC's Polar-orbiting Operational Environmental Satellite constellation and real-time high-resolution data from the DOC's Geostationary Operational Environmental Satellite (GOES) East and West; EUMETSAT's Meteosat-7, -8, and -9 geostationary satellites and METOP polar orbiters; as well as the Japanese Multifunctional Transport Satellite (MTSAT). AFWA currently receives data from MODIS, 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-Unclassified (DATMS-U).

NPOESS

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) will replace the existing DMSP and NOAA polar-orbiting satellite programs beginning in FY 2014 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 and planned operational use of data from the NPOESS Preparatory Project, planned for launch in 2011. In January 2006, the program was expected to exceed its approved program baseline by 25 percent. This required the Department of Defense to recertify the program to Congress in accordance with the Nunn-McCurdy Amendment of the 1982 Defense Authorization Act. AF weather provided information on operations and requirements to Integrated Product Team 2 (IPT-2). IPT-2 was charged with assessing alternatives for the program. The certification resulted in a reduced configuration. One of three orbits was eliminated and will be augmented by the polar-orbiting constellation of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). The number of satellites was reduced from six to four. Some non-Key Performance Parameter sensors were removed and the Conical Microwave Imager/Sounder was terminated and will be reworked.

SPACE LAUNCH SUPPORT

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

as directed.

AIR AND SPACE NATURAL ENVIRONMENT MODELING AND SIMULATION

The Air Force Director of Weather carries out the DOD Air and Space Natural Environment Modeling and Simulation Executive Agent (ASNE MSEA) responsibilities of managing, coordinating, and implementing all aspects of modeling and simulation relating to the Air and Space Natural Environment domain to include, but not limited to, planning, programming, monitoring, and reporting across all DOD components in accordance with the Under Secretary of Defense for Acquisition, Technology, and Logistics Memorandum to the Secretary of the Air Force, designating the Department of the Air Force as the MSEA for air and space natural environment representations. The DOD ASNE MSEA ensures DOD communities who use simulations for their training, acquisition, testing, planning, experimentation, and analysis have the right tools, infrastructure, and databases necessary to represent the air and space natural environment and its effects.

RESEARCH INITIATIVES

The overarching objective of the Air Force meteorological and space environmental technology transition program is to provide capability designers, operational weather personnel, and weather information users the technology and tools to gain and maintain the advantage over a potential adversary. Air Force weather's capability needs in the atmospheric and space environment sciences are articulated in the Meteorological and Oceanographic (METOC) Environment and the Ionospheric Effects Characterization (IEC) Initial Capabilities Documents (ICDs), Capability Review assessments, the AFW and AFWA Strategic Plans, the AFW Operations Functional Concept and Enabling Concepts (Characterize the Environment, Exploit Environmental Information, and Net-Centric Operations), and supporting concept and implementation plans. AF weather also strives toward improvements through cooperative development and testing agreements both with other governmental agencies and laboratories, as well as for-profit companies. Additionally, both AFIT and the Naval Postgraduate School offer AF graduate students in the atmospheric and space environmental sciences an opportunity to research topics of immediate operational interest to the Service.

CLOUD FORECASTING

In applied meteorological R&D, the AF is improving cloud forecasting techniques by doubling the resolution, using a new cloud interpretation/typing 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.

WEATHER FORECAST MODELING FOR AF AND ARMY OPERATIONS

The Weather Research and Forecasting (WRF) model is the next generation community model and is another area of AFWA participation in research and development in collaboration with 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. AFWA initially implemented WRF operationally in 2006 and will continue with sponsorship and funding of development at NCAR and ESRL, test and evaluation of real-time runs of the WRF prototype. The Land Information System (LIS) analyzes the current state of the land surface to provide information to DOD and civilian agencies, and through coupling with WRF, will improve forecasting performance in the low levels of the atmosphere. This allows AF weather forces to provide better forecasts for low-level aircraft operations, the dispersion of aerosol contaminants, and the employment of precision-guided munitions. It also allows for assessment of trafficability for ground forces.

AFWA is in the process of identifying a future capability called the Ensemble Prediction System (EPS). EPS output will help AF Weather personnel to provide better forecasts for the warfighter with increased confidence, particularly at the tactical level. The ongoing Joint Ensemble Forecast System (JEFS) prototype effort is laying the groundwork to

construct an operational EPS and the first non-operational JEFS products are being produced daily at AFWA as part of the JEFS test in the U.S. Pacific Command (USPACOM) and U.S. Central Command (USCENTCOM) AORs.

TACTICAL DECISION AIDS

AF weather collaborates in the development of several tactical decision aids, to include the Target Acquisition Weapons Software (TAWS), the Infrared Target Scene Simulator (IRTSS), and Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA).

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 multi-spectral imagery with TAWS weather inputs to generate forecast target scene images for mission rehearsal.

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 modular programs as part of the Tri-Service Integrated Weather Effects Decision Aid (T-IWED+A) initiative. The T-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 T-IWEDA integrate environmental impacts into the mission execution forecasts for C2 and mission planning (MP) systems throughout the military planning and execution cycle. The TDA program continues adding weapons systems and targets at the request of users from the Services.

RESEARCH PARTNERING INITIATIVES

AF weather is partnering with the NWS and the Navy in the National Unified Operational Prediction Capability (NUOPC) project. This partnership exists to enable a Tri-Agency joint global atmospheric ensemble forecast system. NUOPC is an integration of ongoing efforts coordinated by a Tri-agency management organization. The NUOPC vision is a National NWP system with interoperable components built on common standards and framework (Earth System Modeling Framework (ESMF)) with managed operational ensemble diversity and a national global NWP research agenda to accelerate science and technology infusion.

OVERVIEW

The U. S. Navy's Oceanography and Meteorology Program (NOP) provides global meteorology, oceanographic, Maritime Geospatial-Environmental Information & Services and ocean surveillance critical for safe and effective operations of the Navy and Marine Corps and the Department of Defense. Its mission is to protect the Fleet, shape the battlespace and maximize warfighting capability. The program includes oceanography, bathymetry, hydrography, meteorology, acoustics, geophysics, astrometry, geospatial information and precise time.

Naval METOC underpins every aspect of naval operations and warfare. It provides an affordable and sustainable competitive advantage to the Nation and protects the substantial National investment in both afloat and ashore force structure.

The NOP, which is supported by ocean engineering, operational supercomputing and operations research, in recent years reinvented itself to meet the warfighting needs of the operators and the fiscal needs of today's Navy.

Increasingly, costs are leveraged in the Joint, interagency and international arenas to deliver capabilities at a shared cost. The NOP is the Department of Defense's global Numerical Weather Forecasting Capability and it partners with Air Force weather in the areas of flight weather forecasting, Joint operations, information management and acquisition programs. It also has strong relationships with all five directorates in NOAA.

ORGANIZATION

OCEANOGRAPHER OF THE NAVY

The Oceanographer of the Navy (OPNAV N84) represents the Naval Oceanography Program on the staff of the Chief of Naval Operations. His staff works closely with the staff of Commander Naval Meteorology and Oceanography Command (CNMOC), the operational arm of the Naval Oceanography Program, to ensure the proper resources are available to meet mission requirements, to act as a liaison between CNMOC and the Chief of Naval Operations, and to represent the Naval Oceanography Program in interagency and international forums.

In April 2009, the Oceanographer of the Navy and Commander, Naval Meteorology and

Figure 3-DOD-7. USS Annapolis (USN 760) is seen on the surface of the Arctic Ocean after breaking through three feet of ice during ICEX 2009 (U.S. Navy photo)

Figure 3-DOD-8. Aerographer's Mate 2nd Class Derron Gee, from East Hampton, N.Y., runs a satellite loop computer program used to predict weather patterns in the metrological shop aboard the aircraft carrier USS John C. Stennis (CVN 74). (U.S. Navy photo by Mass Communication Specialist 3rd Class Kenneth Abbate)

Oceanography Command signed into effect Naval Oceanography 2025, a strategic vision of the future of the Naval Oceanography Program. Incorporating inputs and perspectives from a wide array of stakeholders, this document will be used to guide investments in research and development, acquisition, work force structure, and future operational concepts based on realistic expectations of future changes, and community-wide support.

In May 2009, the Chief of Naval Operations appointed the Oceanographer of the Navy to head Task Force Climate Change (TFCC). TFCC will address the emerging Navy need to develop a comprehensive approach about the Arctic to guide its future public, policy, and strategy discussions. TFCC will recommend policy, strategy, roadmaps, and investments for the Navy regarding the Arctic and Climate Change that are consistent with existing National, Joint, and Naval guidance, including National Security Presidential Directive/ Homeland Security Presidential Directive (NSPD-66/HSPD-25), Joint Vision 2020, Sea Power 21, and a Cooperative Strategy for 21st Century Seapower. The initial focus for TFCC will be the Arctic, and the primary deliverable will be a holistic, chronological science-based roadmap for future Navy action with respect to the Arctic between now and 2040.

In addition, Navy weather is partnering with the NWS and the Air Force in the National Unified Operational Prediction Capability (NUOPC) project. This partnership exists to enable a Tri-Agency joint global atmospheric ensemble forecast system. NUOPC is an integration of ongoing efforts coordinated by a Tri-agency management organization. The NUOPC vision is a National NWP system with interoperable components built on common standards and framework (Earth System Modeling Framework (ESMF)) with managed operational ensemble diversity and a national global NWP research agenda to accelerate science and technology infusion.

NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

The Naval Meteorology and Oceanography Command serves as the operational arm of the Naval Oceanography Program. Headquartered at the Stennis Space Center in Mississippi, CNMOC is a third echelon command reporting to United States Fleet Forces (USFF). CNMOC's claimancy is globally distributed, with assets located on larger ships (aircraft carriers, amphibious ships, and command and control ships), shore facilities at fleet concentration areas, and larger production centers in the U.S.

CNMOC is focused on protecting the Fleet from destructive weather and providing critical environmental knowledge to the warfighting disciplines of Anti-Submarine Warfare; Naval Special Warfare; Mine Warfare; Intelligence, Surveillance and Reconnaissance; and Fleet Operations (Strike and Expeditionary), supported by core capabilities of Maritime Safety Operations, Aviation Safety Operations, Navigation, Precise Time, and Astrometry.

Major activities and additional subordinates within the command currently include:

- Naval Oceanography Operations Command, Stennis Space Center, MS
- Naval Aviation Forecast Center, Norfolk, VA and detachments
- Naval Maritime Forecast Center, Pearl Harbor, HI
- Naval Maritime Forecast Center, Norfolk, VA
- Strike Group Oceanography Teams in Norfolk, VA; San Diego, CA; and Fallon, NV; (with subordinate mobile environmental teams)

Figure 3-DOD-9. A Navy E-2C Hawkeye approached for an arrested landing on the flight deck of the aircraft carrier USS Harry S. Truman (CVN 75). The Hawkeye is the Navy's all-weather, carrier-based tactical battle management airborne early warning, command and control aircraft. (U.S. Navy photo)

- Naval Special Warfare Oceanography Center in San Diego, CA (with components and detachments in Stuttgart, Germany, Norfolk and Pearl Harbor)
- Naval Oceanography ASW Centers in Yokosuka, Japan and Stennis Space Center, MS (with subordinate detachments)
- Naval Oceanographic Office, Stennis Space Center, MS
- Fleet Survey Team, Stennis Space Center MS
- Naval Ice Center, Suitland, MD
- Fleet Numerical Meteorology and Oceanography Center, Monterey, CA
- U.S. Naval Observatory, Washington, DC
- Naval Meteorology and Oceanography Professional Development Center, Gulfport, MS

NAVAL OCEANOGRAPHY OPERATIONS COMMAND (NAVOCEANOPSCOM)

The NAVOCEANOPSCOM, headed by the Commander, Oceanographic Operations, serves as the principal operational organization of CNMOC and coordinates and manages efforts among field activities under the Operational Oceanography Program to optimize warfighting resources, support safe operations and enhance dominance of the battlespace through superior understanding and exploitation of the environment. The Command encompasses the nine warfighting and enabling directorates. Each directorate determines how that directorate's services are delivered globally. Each directorate reports to a single Navy Captain who functions as Naval Oceanography's Chief Operating Officer.

The Commander, Oceanographic Operations supports the combatant commanders and national missions, U.S. interagency and international partners. The major NAVMETOCCOM production centers (NAVOCEANO, FLENUMMETOCEN, NAVOBSY) support the Commander, Oceanographic Operations.

The command's operational model is based on standardizing services for each directorate, automating everything that can be automated and coupling situational awareness and a small on-scene presence, supported by a significant 24/7 reachback production capability at the major production centers.

Dangerous weather and safe navigation are the top two Fleet concerns.

Aviation Forecasting

Many environmental conditions severely impact flight operations and mission accomplishment. These include: wind speed and direction, cloud ceiling, precipitation, turbulence, visibility, icing and severe weather such as thunderstorms. An accurate forecast is often the deciding factor in mission success and for the safety of the pilot and their aircraft.

Navy Meteorologists and forecasters analyze current physical environmental conditions and use state of the art computer models to forecast atmospheric and oceanographic phenomena impacting naval flight operations.

Meteorologists are assigned to Aviation Forecasting hubs in the United States and overseas locations.

Core aviation weather services include flight route weather briefings via an internet-based flight weather briefer, severe weather warnings and advisories for Navy airfields and terminal aerodrome fore-casts for Navy airfields.

Fleet Operations

The Naval Meteorology and Oceanography Command are actively engaged with Fleet forces to provide valuable physical environmental knowledge to aid warfighting decision making. Personnel are integrated with the Fleet, where they provide in situ observations, run tactical decision aids and interpret environmental data to provide decision support to Fleet commanders.

The onboard personnel work with reachback cells to analyze and forecast environmental conditions from launch point to target and to determine optimum Fleet maneuvers, ingress and egress routes, amphibious landing points and times, flight operations, weapons load-outs and target selection.

Deploying personnel are highly trained meteorology and oceanography specialists for support planning and operations. Reachback teams work with onboard personnel to refine data, develop models, conduct forecast analyses and deliver high-quality information to Fleet commands.

Tailored Strike Group Oceanography Team

Figure 3-DOD10. Aerographer's Mate Airman Jonathan Salgado launches a weather balloon from the fantail of the aircraft carrier USS Theodore Roosevelt (CVN 71) to gather atmospheric data. (U.S. Navy Photo by Mass Communication Specialist Seaman Andrew Skipworth)

(SGOT) Detachments train, work-up and deploy with carrier and expeditionary strike groups through each phase of the Fleet Readiness Training Program. Each SGOT detachment includes a team who forecast for the aircraft carriers, amphibious assault ships and other vessels making up the strike group. In addition to flight deck weather, they forecast en route and target area METOC conditions which may vary greatly considering the tremendous reach of Naval Aviation along the world's dynamic coastlines.

Maritime Weather Operations

Navy meteorologists and forecasters are assigned to Maritime Forecasting Centers in Hawaii and Virginia. Core maritime weather services include Optimum Track Ship Routing (OTSR), a weather forecasting service to support transoceanic voyages and coastal operations. OTSR services:

- Provide hazardous ocean and weather advisories and divert recommendations to ship Commanding Officers and Masters at sea.
- Include sortie recommendations for potentially damaging weather conditions in port.
- Provide preliminary climatologic outlooks for transit and mission planning.
- Routine ship weather forecasts (WEAX) and aviation weather forecasts for ship-based helicopters (AVWX) include high wind and seas warnings and local area warnings for Fleet Concentration Areas.

The Joint Typhoon Warning Center (JTWC), established by the U.S. Pacific Command, is jointly

Figure 3-DOD-11. Marines from the 22nd Marine Expeditionary Unit (22 MEU) gather on a port-side weather deck aboard the amphibious dock landing ship USS Fort McHenry (LSD 43) to watch as the amphibious assault ship USS Bataan (LHD 5) closes in for a refueling at sea. (U.S. Navy photo by Mass Communication Specialist 2nd Class Kristopher Wilson)

manned with U.S. Air Force personnel. JTWC services include tropical cyclone forecasts, warnings and other products for Department of Defense warfighters operating in the Pacific and Indian Oceans. JTWC, located in Pearl Harbor, Hawaii, is an internationally recognized tropical cyclone forecasting center.

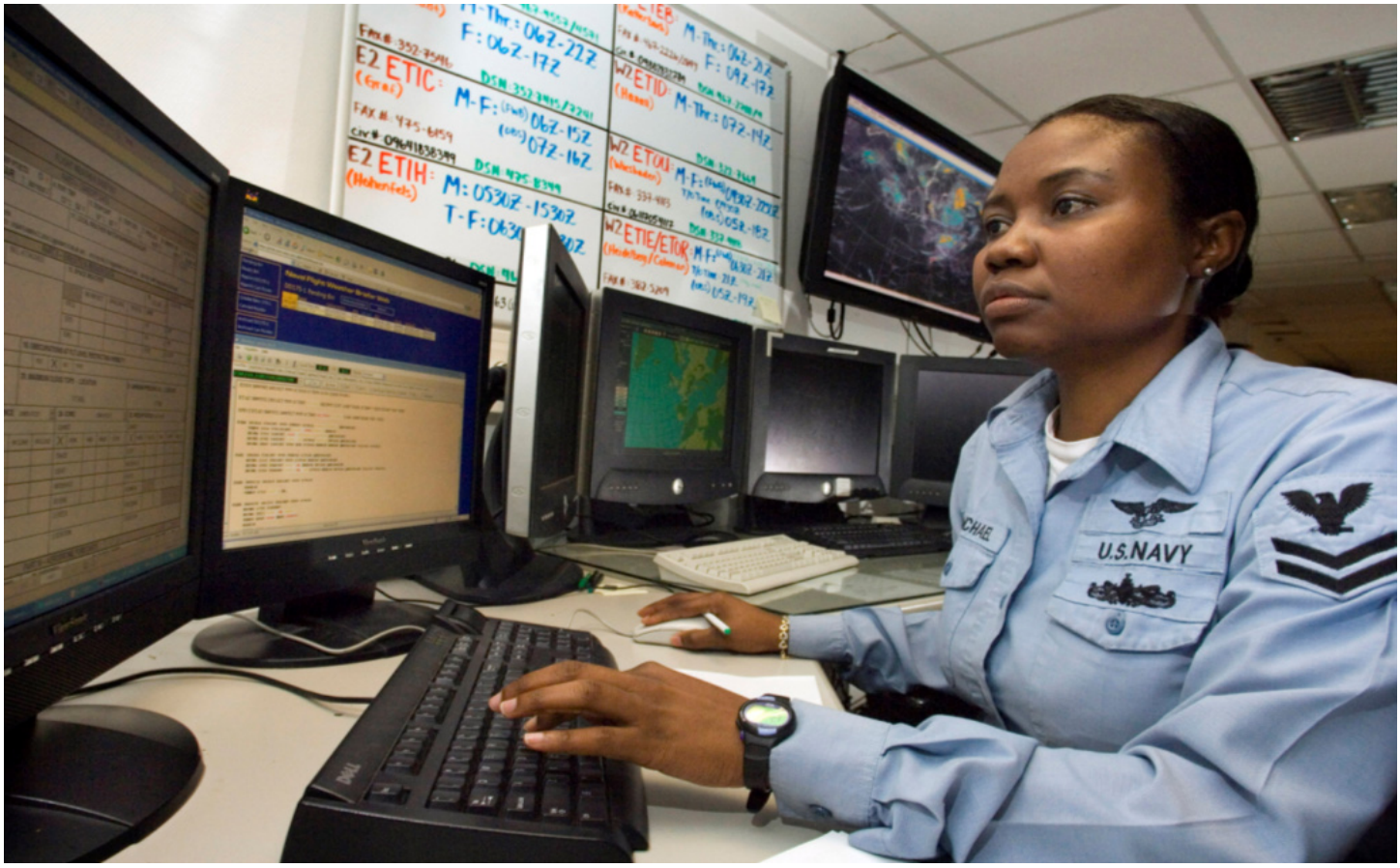
FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER

The Fleet Numerical Meteorology and Oceanography Center (FLENUMMETOCEN, FNMOC) an Echelon four activity reporting to the Commander, Naval Meteorology and Oceanography Command, is the NOP's production center for meteorology. The center plays a significant role in the National capability for operational weather and ocean prediction through its operation of sophisticated global and regional meteorological and oceanographic models, extending from the top of the atmosphere to the bottom of the ocean. Through close collaboration with the Naval Oceanographic Office (NAVOCEANO), FLENUMMETOCEN is a key component in the Navy's operational weather and ocean prediction program. This program provides information that helps give Naval forces an asymmetric advantage in speed, access and persistence in any combat operation for which they may be called upon.

FLENUMMETOCEN is well known for its long and productive history of implementing, evaluating, operating, maintaining and improving complex Numerical Weather Prediction (NWP) system 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, FLENUMMETOCEN acquires and processes over six mil-lion 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, FLENUMMETOCEN is designated as the DOD center for global Numerical Weather Prediction. FLENUMMETOCEN 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.

FLENUMMETOCEN 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 FLENUMMETOCEN models and applications in some fashion, and forms the basis for the FLENUMMETOCEN global Ensemble Forecast System (EFS). COAMPS is a high-resolution, non-hydrostatic regional model, multiply nested within NOGAPS, that has proven to be particularly valuable for forecasting weather and ocean conditions in highly complex coastal areas. GFDN is a moving-nest tropical cyclone (TC) model, nested within NOGAPS, that is used to forecast TC tracks globally. WW3 is a spectral ocean wave model that is employed both globally (driven by NOGAPS) and regionally (driven by COAMPS) in support of a wide variety of naval operations. Other models support and supplement the main models with predictions of ocean thermal structure, ocean currents and other data. All of the models are conDOD Figured, scheduled and operated under the central control of FLENUMETOCCEN Operations. COAMPS, however, can also be conDOD Figured, scheduled and operated remotely by users in the field as an on-demand modeling service. This is done over the Web via the FLENUMMETOCEN Centralized Atmospheric Analysis and Prediction System (CAAPS). In general, FLNUMMETOCEN 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-

Figure 3-DOD-12. Aerographers Mate 2nd Class Evelyn Michael prepares weather briefs for aircrews throughout Europe from Sembach Air Base, Germany. Petty Office Michael is one of the Navy weather forecasters at Sembach's 20th Operational Weather Squadron. (U.S. Air Force photo/Master Sgt. John Lasky)



ocean interface.

FLENUMMETOCEN'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 FLENUMMETOCEN 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 FLENUMMETOCEN models feed directly into applications models, tactical decision aids and other products that provide direct support to various weather-sensitive activities associated with the warfighting directorates identified above. These include optimum path aircraft routing, optimum track ship routing, issuance of high-winds and high-seas warnings, hurricane/typhoon sortie decisions, covert ingress/egress of 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.

FLENUMMETOCEN also provides a wide-range of meteorological and oceanographic observations and satellite imagery to complement its models and applications products. These include on-demand extracts from its global observational database, a full range of Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager products, ERS and QuikScat scatterometer wind products, a comprehensive view of tropical cyclones via the FLENUMMETOCEN 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).

FLENUMMETOCEN also hosts the USGODAE Monterey Data Server in support of the Global Ocean Data Assimilation Experiment. This system serves as a one-stop shop for meteorological and oceanographic data and model products required to support global ocean modeling R&D. It also functions as one of two Argo Global Data Assembly Centers, hosting the complete collection of quality-controlled Argo temperature/salinity profiling float data.

Many of FLENUMMETOCEN'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, FLENUMMETOCEN provides a Web-based capability called WxMap (i.e., "Weather Map"). WxMap, requiring only a Web browser for access, allows the user to select and quickly display predicted meteorological and oceanographic fields for any user-defined geographical area.

All of FLENUMMETOCEN'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 FLENUMMETOCEN 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, FLENUMMETOCEN also plays a key role in the U.S. national program for weather prediction. In this regard, FLENUMMETOCEN'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.

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

NAVAL OCEANOGRAPHIC OFFICE

The Naval Oceanographic Office (NAVOCEANO, NAVO) is the NOP's production center for oceanography.

Since atmospheric conditions are inherently coupled to oceanographic conditions, the Navy's program in meteorology is closely linked with oceanography, which is the focus of the NAVOCEANO, Stennis Space Center, Mississippi. NAVOCEANO primary responsibilities include the collection, processing, and distribution of oceanographic, hydrographic, and other geophysical data and products. NAVOCEANO runs and disseminates products from the world's first operational global ocean model, NRL Layered Ocean Model (NLOM), as well as a number of regional and coastal circulation and wave models. NAVOCEANO also runs the Polar Ice Prediction System (PIPS) ice model and provides the output to the National Ice Center for product generation. A key ingredient to ocean model performance is real-time data for assimilation and evaluation. NAVOCEANO is the Navy's primary processing facility for NOAA polar-orbiting satellite data and is nationally recognized for satellite-derived sea-surface temperature and satellite altimeter-derived sea surface topography and wave height. NAVOCEANO's global sea surface temperature is 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 scalable, supercomputing architecture and facilitating transition from R&D to operational use.

UNITED STATES NAVAL OBSERVATORY

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

The NAVOBSY performs an essential scientific role for the United States, the Navy and the Department of Defense. Its mission includes determining the positions and motions of the Earth, Sun, Moon, planets, stars and other celestial objects, providing astronomical data; determining precise time; measuring the Earth's rotation; and maintaining the Master Clock for the United States. Observatory astronomers formulate the theories and conduct the relevant research necessary to improve these mission goals. This astronomical and timing data, essential for accurate navigation and the support of communication on Earth and in space, is vital to the Navy and Department of Defense. It is also used extensively by other government agencies and the public at large.

EDUCATION/TRAINING

Navy Officer (meteorologists/ oceanographers) are all university graduates in meteorology, oceanography or other earth sciences, with most attaining dual meteorology and oceanography advanced graduate degrees.

Enlisted forecaster and/or briefers are trained in meteorological analysis and forecasting at military schools. Enlisted observers receive training at military schools.

The enlisted Aerographer's "A" (observer) and "C" (forecaster) schools are located at the Naval Technical Training Unit collocated with Air Force and Marine weather training at Kessler Air Force Base, MS.

Ongoing professional development for both officer and enlisted personnel is offered through the Naval Meteorology and Oceanography Professional Development Center in Gulfport, MS (with Pacific and Atlantic detachments). The center offers directorate training as well as training on oceanographic knowledge continuum.

PROGRAM ALIGNMENT

The Naval Oceanography Program is changing

Figure 3-DOD-13. The 13th Marine Expeditionary Unit's weather Marines, prove that weather forecasting and observation is more than blue screens and good looks. (U.S. Marine Corps photo)

focus from an acquisition-based program to "in stride" technology transition that rapidly transitions R&D and influences the Navy's S&T investments. Emerging R&D technologies will be tested in computational and operational environments and transitioned after an appropriate collaborative period.

UNITED STATES MARINE CORPS (USMC)

The mission of the Marine Corps METOC Service is to provide meteorological, oceanographic, and space environmental information, products, and services required to support Marine Corps and other military operations. The Marine Corps METOC support infrastructure is designed to readily deploy and operate in austere expeditionary environments. It is capable of providing sustained, comprehensive, and relevant METOC support to all elements of a Marine Air Ground Task Force (MAGTF), as well as bases and stations of the supporting establishment.

ORGANIZATION

The Deputy Commandant for Aviation, Headquarters U.S. Marine Corps (Code APX-33), 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), Facilities (MCAF), Auxiliary landing Fields (AUX), and Strategic Expeditionary Landing Fields (SELF). These activities are manned and equipped to provide direct aviation METOC support and services to host and tenant units at seven major air stations in the continental United States, one in Hawaii, and two in Japan.

Within the FMF, Marines deploy as scalable, tailored, combined-arms teams known as MAGTFs. There are three sizes of MAGTFs. They are the Marine Expeditionary Unit (MEU), Marine Expeditionary Brigade (MEB), and Marine Expeditionary Force (MEF) with the latter being the largest. Additionally, Special Purpose MAGTFs may be formed to support operationally unique situations and/or requirements. All MAGTFs, regardless of size, share four organizational elements that vary in size and composition according to the mission: Command Element (CE), Ground Combat Element (GCE), Aviation Combat Element (ACE), and Combat Service Support Element (CSSE).

FMF METOC activities are organized, trained, and equipped to provide tailored support products and services to all combat elements of the MAGTF. METOC support is focused towards impacts on expeditionary maneuver warfare operations, particularly operational maneuver from the Sea. FMF METOC activities are fully interoperable within joint force operations as part of a Service or functional component command. When directed to stand-up as part of a Joint Task Force headquarters (JTF HQ), they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from pre-crisis state to full operational capability in a distant theater to provide on-scene support to MAGTF, combined, joint, allied, and coalition operations and other military operations as may be directed. FMF METOC assets are permanently assigned to MEF headquarters, intelligence battalions, Marine Wing Support Group (MWSG), and Marine Wing Support Squadron (MWSS). There are three MEFs strategically positioned for global response. I MEF, based in southern California and III MEF, forward based in Okinawa, Mainland Japan, and Hawaii fall under the control of the Commander, Marine Forces Pacific. II MEF, located at bases in North and South Carolina, falls under the Commander Marine Forces Command. MEF METOC personnel serve as special staff to the Commanding General and are under the direction and cognizance of the intelligence division (G-2).

The three intelligence battalions in the Marine Corps are co-located with respective MEF headquarters. These battalions directly support the MEF G-2 and serve as MAGTF intelligence centers during operations. METOC is a vital part of the intelligence estimate and is an essential element that supports the Marine Corps Rapid Response Planning Process. METOC personnel assigned to these commands provide expertise, products, and services that directly support the intelligence preparation of the battlespace (IPB) process by helping intelligence analysts to effectively evaluate,

integrate, and synchronize METOC effects for both enemy and friendly courses of action.

Additionally, METOC Marines are assigned to MAGTF units other than the ACE and are task organized and equipped to provide a limited level of METOC support to combat elements. These elements include but are not limited to the MAGTF Command Element (CE), Ground Combat Element (GCE), the Logistics Command Element (LCE), and the MEU in support of specialized operations. Personnel and their equipment are 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. These Marines can be assigned to augment a Joint Meteorological Coordination Cell (JMCC) during joint operations, Marines deploy with rugged, ancillary environmental collection and data processing equipment. During operations they organically collect METOC products, data, and information from the nearest deployed METMF(R), Navy METOC OA Division afloat, host nation, or other METOC support organizations and agencies to satisfy METOC information requirements.

The Marine Aircraft Wing (MAW) 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 MWSS. 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 Meteorological Mobile Facility (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 Coordination Cell (JMCC) during joint operations and exercises.

The METMF(R) NextGen is a mobile system that provides tactical meteorological support to the Marine Air Ground Task Force This system will replace the legacy MetMF(R) with current and emerging state-of-the-art technologies offering a smaller overall size and increased mobility. These advancements will significantly enhance the meteorological capabilities of the Marine Corps Expeditionary Forces.

Specialized METOC Support

The Marine Corps' Chemical Biological Incident Response Force (CBIRF) was established in 1996, as a result of Presidential Decision Directive 39 to manage the consequences of NBC materials or weapons used by terrorists. This national-level asset is part of II MEF, located at Indian Head, MD. It is comprised of specially trained and equipped Navy, Marine, and civilian personnel who can rapidly be forward deployed and/or respond to a credible threat of a 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, permanently assigned METOC forecasters provide specialized NBC dispersion forecast products and services that aid mission accomplishment of this organization.

EDUCATION/TRAINING

Marine Officers (METOC personnel) are all trained at appropriate service level schools.

Many Marine (METOC Officers possess university degrees in various disciplines to include natural science. Several possess graduate degrees in science related disciplines. Enlisted forecasters or briefers are trained in meteorological analysis and forecasting at military schools. The enlisted METOC Analyst/Forecaster school is located at the Naval Technical Training Unit collocated with Air Force and Navy weather training at Keesler Air Force Base, MS. Ongoing professional development for both officer and enlisted personnel is offered through the Naval Meteorology and Oceanography Professional Development Center in Gulfport, MS. The center offers directorate training as well as training on oceanographic knowledge continuum.

The U.S. Army continues its 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. The Army and Air Force are working together to determine the optimal weather team sizing, equipment, and communications capabilities required to support the new modular Army forces.

OPERATIONAL EQUIPMENT AND SUPPORT MISSIONS

Although it is transforming to a modular force, the existing weather support structure within the 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 (ACOMs) 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. Air Force (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 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 the Army National Guard (ARNG), collectively designated the Reserve Component (RC). In addition, during exercises and contingencies, the ANG may augment the active Army as weather personnel.

The Army also provides the operational weather support to Army Research Development, Test and Evaluation (RDT&E) 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 personnel for tactical operations. The Distributed Common Ground System – Army (DCGS-A) provides 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.

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.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff, G-2, is responsible for Army weather 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 SYSTEMS

The Meteorological Measurement Set-Profiler (MMS-P) is a major improvement over the MMS. The Profiler design will support the new generation of artillery weapons. Profiler provides highly accurate MET data to adjust artillery fire and achieve first round hits and fires for effect. The system provides

MET data on demand with data staleness of less than 30 minutes. The system will include frequent and update meteorological messages that enhances the meteorological validity within a larger battle space over the current equipment. The MMS-P uses the MM5 mesoscale meteorological model to assimilate data from a variety of sources to provide the best meteorological messages to the user in a timely fashion. The system receives data from ground-based sources, radiosondes, and satellite-based sources, (such as boundary data from communications satellites and, in a future program block improvement, polar orbiting meteorological satellites) through onboard satellite receiving capability. The data affects the operation of the mesoscale meteorological model and for post-processing of the data in order to generate meteorological messages. Finally, an operator interface, in conjunction with the message generation and formatting software, facilitates communication between the MMS-P and all other systems that require interoperability with the MMS-P. The Profiler Program successfully executed a development and testing program culminating in an Initial Operational Test and Evaluation (IOTE) 1Q FY05. Four System Design and Development (SDD) models have been converted to a Low Rate Production configuration with 13 additional LRIP system produced. Full Rate Production (FRP) was approved at a FRP Decision in FY05. Profiler Block I reached its Army Acquisition Objective of 120 systems with the FY08 award. As Block I systems continue to be fielded in FY10, Profiler Block II program begins.

The Integrated Meteorological System (IMETS) is a state-of-the-art Army meteorological decision-aid support system that is being integrated into DCGS-A. A key component of IMETS is the Integrated Weather Decision Aid (IWEDA) application, which allows warfighters to display the effects of weather phenomena on personnel and operations for mission planning. The Army is responsible for integrating the Air Force's Joint Environmental Toolkit (JET) into DCGS-A and providing web-centric weather support for Army intelligence and command/control systems. DCGS-A will field weather software capabilities, including JET, on common Army hardware systems. The IMETS Program Office transitioned to the Program Executive Office - Intelligence, Electronic Warfare & Sensors (PEO-IEW&S) as part of the Distributed Common Ground System-Army (DCGS-A) program in FY08. Initial fielding of DCGS-A weather services will occur as part of the ISR Surge software builds for DCGS-A V3.1 in FY10. Over time (FY10-12), remaining IMETS systems will be displaced with the fielding of weather services on DCGS-A V3.1. Integration work continues providing similar weather services for the DCGS-A Mobile Basic.

ARMY OPERATIONAL SUPPORT PROVIDED BY THE AIR FORCE

Under AR 115-10/AFJI 15-157, the AF provides the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical, installation and airfield Active Army and reserve component support requirements. Weather manpower requirements for Army support are sourced from AF active and reserve component weather personnel. The AF assigns AF weather personnel to the warfighting Army Commands and ASCCs at Army Service Component Commands, Corps, Divisions, Combat Aviation Brigades (CAB), Brigade Combat Teams (BCT), Armored Cavalry Regiments, Special Forces Groups, Ranger Regiments, and Special Operations Aviation Regiments (SOAR) to provide direct, on-site weather support. AF Operational Weather Squadrons (OWSs) and post-level weather organizations provide installation 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 installation and garrison activities include supporting flying operations at Army Airfields and severe weather watch, warning, and advisory services for aircraft and installation 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 provides other tactical equipment to AF Personnel through an Army Table of Organizations and Equipment (TOE). The following paragraphs describe weather activities within Army Commands and Army Service Compo-

nent Commands.

U.S. ARMY FORCES COMMAND (FORSCOM)

Weather support to the U.S. Army Forces Command is diverse and demanding. FORSCOM, the Army's largest major command, requires and uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations.

Weather support to FORSCOM's units comes from dedicated AF weather personnel aligned under three Air Support Operations Groups (ASOGs) within Air Combat Command (ACC) and Pacific Air Forces (PACAF): 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 AF personnel aligned as a weather detachment at their respective installations. Corps and division weather personnel are authorized personnel and equipment to support a variety of missions at the various Army echelons. Weather support at each Army echelon is conducted according to Army Field Manual 34-81. Currently, there are nearly 350 authorizations supporting various echelons across FORSCOM. These personnel, enabled by an operational weather squadron, provide installation and tactical weather warning, observing, mission execution forecast, special support, and SWO services during peacetime, combat, contingency, exercise, or armistice operations.

ACC and PACAF weather organizations provide direct, on-site support at 22 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 AF weather personnel 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 FY05 due to modularity. These 6-person sections, comprised of Army weather personnel, collect upper air observations for direct use by field artillery units.

The New Tactical Forecast System (N-TFS) is the primary in-garrison and tactical weather equipment for receiving graphics and alphanumeric data. The Joint Environmental Toolkit (JET) is currently replacing the N-TFS to perform those functions. Data is received Non-Secure Internet Protocol Router Network, and Secure Internet Protocol Router Network. Nineteen IMETS and 15 IMETS-Lights 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.

Figure 3-DOD-14. Soldiers and equipment are constantly exposed to the elements, as evidenced by this dust covered HMMWV. US Army photo by Sgt. Igor Paustovski. (US Army Released)

Training and Doctrine Command (TRADOC) Programs

Headquarters, TRADOC is responsible for leading the Army in development of Army-Air Force inter-Service weather operations and services concepts and doctrine required to conduct Army operations, developing and managing of Army weather training programs, documenting standard Army equipment for use by Air Force weather personnel in the Table of Organization and Equipment (TOE), recommending Modification TOE (MTOE) and Common Table of Allowances to DCS, G-3/5/7 for validation, processing tactical Army weather support requirements and identifying deficiencies in Army doctrine pertaining to weather, weather impacts, weather operations and weather services.

Key mission areas for the next few years will be to assist the Air Force to develop and implement a new weather support concept to meet the needs of the Army's modular force including brigade combat teams; to update weather support doctrine, policy, organization, concepts, and tactics, techniques, and procedures; to ensure weather effects to Army operations are documented and communicated to soldiers and Air Force weather support personnel; and to ensure Army weather support processes and procedures are trained across the TRADOC schools and centers. These mission areas are accomplished in coordination with the Air Force Staff Weather Officers (SWOs) and the Department of the Army Civilian (DAC) assigned within TRADOC; one SWO assigned to Headquarters, TRADOC at Fort Monroe, VA, one SWO assigned to the Combine Arms Center at Fort Leavenworth, KS, two SWOs and one DAC assigned to the US Army Intelligence Center at Fort Huachuca, AZ.

The TRADOC Schools/Centers

The US Army Intelligence Center and Fort Huachuca (USAIC&FH) is the functional proponent for Army tactical weather support. USAIC&FH represents the Army warfighter by processing weather support requirements and developing solutions to satisfy those requirements when they are the responsibility of the Army. In the past year, USAIC&FH hired a Department of the Army Civilian (DAC) to head the Army Weather Proponent Office. This DAC heads USAIC&FH weather proponent efforts in Joint Capabilities Integration and Development (JCIDS) and DOTMLPF work. This JCIDS and DOTMLPF work occurs within USAIC&FH and in conjunction with other Army Centers of Excellence, research, and experimentation organizations. Scheduled for FY10, the DAC will head an Army-wide Weather Capabilities Based Assessment to determine capability requirements, gaps, and possible solutions. The Air Force has also assigned two active duty Air Force weather personnel and contracted one civilian to USAIC&FH. The contract civilian, which will be converted to a Department of the AF Civilian (DAFC) 1 Oct 09, is responsible for assisting the 304th MI BN conduct the Battlefield Weather Course (BWC). The Air Force weather personnel assist in overseeing the BWC, assist with the JCIDS and DOTMLPF work, and are the primary AFW interfaces with USAIC&FH Force

Figure 3-DOD-15. Reliable weather forecasts and observations are necessary to ensure safety during flight operations. (U.S. Army photo)

Design who develop Tables of Organization and Equipment (TOEs) for Military Intelligence (MI) organizations. These TOEs document the equipment the Army is required to provide AFW personnel per AR 115-10/AFJI 15-157. The TRADOC Capability Manager for Sensor Processing (TCM-SP) employs one DAC to serve as the interface between the proponent (USAIC&FH) and material developer to ensure as many requirements as possible are met by the developed solution. Currently, most of this work is directed towards PM DCGS-A.

The Air Force SWO at the Army's Combined Arms Center (CAC) located at Fort Leavenworth, KS is the primary overseer of the TOE and Modified Tables of Organization and Equipment (MTOE) for Air Force weather teams supporting Army operations. The CAC SWO is the Air Force weather point of contact for implementing MTOE structure changes for support to Modular Forces in the Transformed Army. The CAC SWO also arranges for or provides environmental data, concepts of operation, and weather subject matter expertise for programs, projects, documents, and studies conducted by 1) the TRADOC System Manager - Army Battle Command System, 2) the Battle Command Battle Lab-Leavenworth, 3) the Center for Army Lessons Learned, 4) the Combined Arms Doctrine Directorate, 5) the TRADOC Assistant Deputy Chief of Staff for Intelligence –Threats, the Foreign Military Studies Office, and 6) the TRADOC Analysis Center-Leavenworth. Other key CAC SWO tasks are to develop weather/weather effects scripts and climatology packages to support modeling and simulation efforts of the Battle Command Training Program (BCTP) and the National Simulation Center, to make available Army weather support instruction at the Command and General Staff College (CGSC), to provide climate expertise to all units assigned or attached to Fort Leavenworth and to be the Staff Weather Officer to the U.S. Army Aviation Center of Excellence (USAACE) at Fort Rucker, AL.

The U.S. Army Aviation Center of Excellence (USAACE) at Fort Rucker, AL, incorporates weather instruction and procedures into rotary-wing training programs in their mission areas. The USAACE is the proponent for all Army aviation, including Unmanned Aerial Vehicle Systems (UAVS). The USAACE has requirements for weather observations and USAF forecast support at Cairns Army Airfield, Troy Municipal Airport (MAP), AL, and Andalusia MAP, AL. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites.

Figure 3-DOD-16. Students at the U.S. Army Field Artillery School prepare to launch a balloon. (U.S. Army Photo)

The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK, is the proponent for artillery and ballistic meteorological support to the Army. The AN/TMQ-41 Meteorological Measuring Set (MMS) and AN/TMQ-52A Meteorological Measuring Set-Profiler (MMS-P) are utilized to conduct surface and upper air observations. The MMS and MMS-P provides weather data to the Field Artillery Tactical Data System for ballistic calculations; to USAF weather forces for weather forecasting; and to the Chemi-

cal Officer for obscurant deployment, and Nuclear, Biological, Chemical (NBC) defense operations. Efforts are ongoing to ensure these observations are sent back to military weather centrals where they can be ingested into numerical meteorological analysis and forecasting models. Active unit's MMSs will eventually be replaced by the AN/TMQ-52A Meteorological Measuring Set Profiler (MMS-P). The MMS-P is currently being fielded and is scheduled for completion of fielding by FY11. The MMS-P is a suite of meteorological sensors and associated software/models which will provide the Field Artillery with current and/or expected weather conditions at a point where the weapon munitions is expected to engage a target (Target Area Met). Currently, the MMS is trained to all Advanced Individual Training Marines and Allied Soldiers. The MMS-P is trained to all Advanced Individual Training Soldiers attending the Field Artillery Meteorology Course.

Air Combat Command (ACC) contracts day-to-day operational weather support to aviation operations at Fort Rucker (Cairns Army Airfield, Troy Municipal Airport, and Andalusia Municipal Airport). ACC, through the same contract, also provides installation airfield weather services (observing and/or forecasting) at Fort Belvoir, Fort Benning, Fort Knox, Fort Leonard Wood, Fort Huachuca, and Fort Sill.

Eighth U.S. Army

The Eighth United States Army (EUSA) uses Army resources to measure surface and upper air meteorological data for ARTYMET support. Second Infantry Division's (2 ID) First Heavy Brigade Combat Team (1 HBCT) and 210th Fires Brigade use the newly fielded AN/TMQ-52 Profiler System to collect upper air data for direct use by field artillery units.

Air Force weather personnel assigned to the 607th Weather Squadron (607 WS) provide operational weather support to EUSA units. The 607 WS provides installation 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 weather teams at four installations to provide direct weather support to HQ Eighth Army, HQ 2 ID, the 2nd Combat Aviation Brigade (2 CAB) and its aviation battalions. In FY09, the 607 WS has 63 assigned weather personnel to support the Army mission. IAW AR 115-10/AFJI 15-157, the EUSA provides installation facilities, tactical equipment (MTOE and CTA) and an operating budget.

United States Army Europe

U.S. Army Europe (USAREUR) and 7th Army (7A) 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 AF's 7th Weather Squadron (7WS) provides USAREUR/7th Army installation and tactical weather intelligence and support. This includes observing services for installation and garrison operations, contingency and exercise operations, staff weather officer (SWO) services, and specialized support. The 21st 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. Weather teams located at V Corps and its aviation assets, 1st Armored Division and its aviation brigade, Southern European Task Force, and 7th Army Training Command, as well as 7WS supporting 7th Army, evaluate and tailor these forecast products to enhance 7A Staff situational awareness and produce mission execution forecasts when needed.

The 7WS mission, with its 5 detachments and operating locations, provides 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 provide or arrange deploying weather force structure to match missions USAREUR, or its subordinate elements, is called upon to execute. 7WS will tailor the permanently assigned weather force to meet requirements of the 7A structure and utilize "reach-back" capabilities to the maximum extent possible to minimize the fielded footprint without compromising

Figure 3-DOD-17. Soldiers from U.S. Army Europe prepare shelters to provide protection from the cold during a four-week U.S.-Italian winter survival training course in the Dolomite Mountains of northern Italy. (U.S. Army photo by Staff Sgt. David Hopkins).

weather operations.

Three IMETS and five IMETS Lights are fielded within USAREUR (V Corps, two divisions and their aviation brigades, and two separate brigades). IMETS is geared to interface as a module of the Army Battlespace Control System to inject decision-quality weather products into the common operating picture for Army commanders.

USAREUR provides supporting USAF weather teams with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four 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 limited observations at forward areas in the battlespace. USAREUR G-2 funds 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. This data provides critical information that benefits flight safety as well as the theater weather sensing strategy without having to forward deploy more people to austere locations.

7WS also provides combat skills training to weather forecasters to increase their ability to be assets in combat, should the need arise. Some training and equipment are supplied by Joint Multinational Training Center HHC.

United States Army Pacific (USARPAC)

U.S. Army Pacific (USARPAC) uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating surface weather observations to support tactical units and operations.

USARPAC provides supporting USAF units with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operations and maintenance funds. There are three subordinate commands within USARPAC: U.S. Army, Hawaii (USARHAW), U.S. Army, Alaska (USARAK), and U.S. Army, Japan (USARJ).

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 NIPRNET and SIPRNET conduits.

The 17th Operational Weather Squadron (17 OWS) at Hickam AFB, HI, provides HQ USARPAC ASCC with installation and tactical weather warnings, forecasts, and special support. USARPAC and JTF-HD direct support (DS) Staff Weather Office (SWO) services are provided by Detachment 1 of the 1st Weather Squadron. Additional AF personnel provide DS weather support to the 25th ID (L), 25th CAB, and the 1-25 Stryker BCT. USAF also provides weather support, though not in a DS role, to U.S. Army Japan (USARJ), U.S. Army Hawaii (USARHAW), 4-25 IBCT, and U.S. Army Alaska (USARAK). DS AF personnel deploy with their supported operational organizations, providing tailored battlefield observations and forecasts. 17 OWS provides regional weather support, allowing forward-deployed AF personnel to focus on specific area and target forecasts.

The 17 OWS provides tactical- and operational-level forecast products for the PACOM AORs, to include all USARJ, Korean Theater of Operations,

Figure 3-DOD-18. Accurate wind forecasts are essential to deliver airdropped supplies to the precise location. (U.S. Army photo)

and Alaska. 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 1st Weather Squadron located at Ft Lewis, WA. The OL on-site at Camp Zama provides weather observation services and produces mission execution forecasts ISO support aviation operations.

The 17OWS provides strategic and theater level weather support and services to all DOD units stationed or operating in Alaska. At the tactical-level, Det 3, 1WS is collocated with the 1-25 SCBT at Fort Wainwright, AK. They provide weather support for both tactical and installation operations, observe the atmosphere and evaluate and tailor forecast products to produce Mission Execution Forecasts and staff briefings. Det 3 also supports 1-25 SCBT tactical unmanned aerial vehicle (T-UAV) operations. The Alaska Army National Guard operates the Bryant Army Airfield at Fort Richardson.

The 1st Weather Squadron out of Ft Lewis, WA is collocated with and provides DS to I Corps.

U.S. Army Special Operations Command (USASOC)

Routinely deployed in over three dozen countries, USASOC's forces have demanding missions spanning the globe and all levels of warfare. Special Operations Forces (SOF) missions are often carefully managed, high-risk scenarios operating at the edge of equipment capabilities, frequently at night and in adverse weather; these mission profiles routinely create great demands for precise weather information. SOF meteorological and oceanographic (METOC) operations with USASOC forces enable commanders to improve efficiency, effectiveness and safety of operations. Air Force Special Operations Command (AFSOC) Special Operations Weather Teams (SOWTs) and AFSOC-gained Air National Guard (ANG) weather personnel provide direct support to USASOC units. Active component SOWTs are assigned to AFSOC's 10th Combat Weather Squadron (CWS), Hurlburt Field, FL; 320th Special Tactics Squadron (STS), Kadena AB, Japan; and 321st STS, Mildenhall AB, UK. ANG personnel providing direct support to Army SOF (ARSOF), when activated, are assigned to the 107th Weather Flight (MIANG), 146th Weather Flight (PAANG), and the 181st Weather Flight (TXANG). These SOWTs employ specialized AFSOC-provided tactical METOC kits to conduct environmental reconnaissance and provide METOC observations from data-sparse areas in permissive and uncertain environments for planning and executing U.S. military operations. At the deployed team level, 10th CWS SOWTs collect environmental data that are used by SOF commanders and staffs and forwarded to strategic METOC centers to improve meteorological models & forecasts. Additionally, SOWTs operate with the USASOC's seven Special Forces Groups (SFG); the 75th Ranger Regiment; the 160th Special Operations Aviation Regiment; all SFG and regimental subordinate battalions, and Psychological Operations Groups. AFSOC SOWTs provide the DOD's sole source for high-fidelity METOC environmental data collection from austere, denied, hostile, or semi-permissive areas of the battlespace. In addition, full-spectrum METOC operations include climatology, solar/lunar illumination and geometry analyses and atmospheric effects studies; feasibility analyses, courses of action and mission impact assessments; surface, upper-air and tactical radar observations; weather watch/warnings; highly-resolved mission execution forecasts that demand fully-integrated and highly-qualified SOF METOC forces, including flight

weather briefings & flight following and drop/landing zone forecasts; training ARSOF and host nation and indigenous forces on conducting limited METOC observations; and foreign internal defense analyses, surveys, and training.

USASOC is also responsible for ARSOF training beyond conventional Army-provided basic training. This is accomplished primarily through the John F. Kennedy Special Warfare Center and School (SWCS) at Fort Bragg, NC. SWCS trains over 14,000 students a year including Special Forces assessment and qualification; and Civil Affairs and Psychological Operations courses. SWCS' North Carolina "local" training area for Special Forces includes a 15-county area (bounded roughly by Interstate Highways I-85, I-40, I-95 and the South Carolina state line, approximately the area of Connecticut, Rhode Island, and Delaware) known as Pineland, home to a free-play unconventional warfare exercise. SWCS' training for military free-fall (MFF) parachutists is at Ft Bragg and at Yuma, AZ; and combat dive (SCUBA) training is at Key West, FL. In addition, the 160th Special Operations Aviation Regiment's training at Fort Campbell, KY, includes a rigorous assessment and selection process followed by a comprehensive and demanding training regimen for the unforgiving special operations aviation mission set. Weather support for this diverse array of training operations is derived from a combination of NOAA/National Weather Service, Air Force Weather Agency, regional & functional operational weather squadrons, and US Navy products.

USASOC plans and expends resources for some operational and administrative support to SOWTs operating with USASOC components. USASOC provides funding for office and deployable automation systems and connectivity to local networks; operations and maintenance/sustainment to support USASOC requirements. Additionally, USASOC provides for some tactical items such as NBC and some communications equipment; electrical power, vehicles, life support equipment necessary for accomplishing AFSOC's ARSOF weather operations; and maintenance and supplies for USASOC-provided equipment. USASOC also provides funding for facilities, telephones, office space, and real property to house supporting special operations weather units, as well as secure storage of required equipment.

DOD Figure 19. A 10th Special Forces Group (Airborne) Mountaineer climbs out of an Alaskan glacier. (U.S. Army Photo)

USASOC and AFSOC are cooperating to integrate the Joint Environmental Toolkit (JET) into the DCGS-A and suite of SOF operational capabilities. Currently, two AFSOC meteorological liaison personnel are assigned to OL-D, AFSOC/A3 and are located at HQ USASOC to coordinate AFSOC-USASOC METOC operations, logistics, and related requirements.

Army Corps of Engineers

In its civil operational activities, the Corps of Engineers (COE) uses a network of about 10,850 land-based gages. About 55 percent of these sites collect meteorological data, 35 percent collect a combination of hydrologic and meteorological data, and 10 percent collect hydrologic or water quality data. The COE funds or partially funds nearly 50 percent 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 876 of meteorological

sites. The COE also transfers annual funds to NWS for hydro-meteorological studies such as development of NOAA ATLAS 14. Similarly, COE transfers funds to the U.S. Geological Survey (USGS) to maintain hydro-meteorological data collection services for 2479 sites, while the COE maintains the rest. Services performed by USGS will vary based on the type of equipment and sensing at each site, consequentially, the cost can also vary as much as $2000 - $20,000 per site per year. Services can include site visits, maintenance of equipment, replacement of damaged equipment, field measurements for verification of data and continuous monitoring of data results. About 90 percent of all COE sites provide real-time data via satellite, microwaves, meterbursts, landlines, or radio. Data from COE gage sites are available to other federal, state and local agencies. All COE data are made available to the National Weather Service.

United States Army Space and Missile Defense Command (USASMDC)

The High Energy Laser Systems Test Facility (HELSTF), an USASMDC directorate located on White Sands Missile Range, is an Army element of the DOD Major Range and Test Facility Base with the mission of high-energy laser (HEL) test and evaluation for future Army and sister Service HEL weapons. In addition to HEL systems test and evaluation, extensive use has been made of on-site laser systems to perform damage and vulnerability testing on laser-hardened materials, missile and aircraft components, and assorted battlefield equipment. The atmospheric sciences/meteorological mission is to support HEL testing by providing measurements of atmospheric conditions that are extremely important to propagation of any HEL beam thru the atmosphere. Many unique meteorological instruments are maintained to support this critical data collection for HEL testing. The HELSTF meteorological team also supports critical safety analysis of atmospheric dispersion for the very toxic laser fuels used. Efforts for FY 10 include work required to modernize the atmospheric measurements and data collection/analysis capabilities needed to support new laser testing activities.

U.S. 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 meteorological services support contractor provides meteorological support for range activities including missile operations, remote island missile launches including Wake Island, intra-atoll transportation (marine and aircraft), and emergency operations support.

Figure 3-DOD-20. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll. (US Army Released)

A full suite of surface and upper air observing equipment is available for support of these operations. Two fixed upper air sounding systems (1680 MHz) utilizing GPS radiosondes are located on Kwajalein and Roi-Namur. One portable GPS upper air system (403 MHz) is available in providing sounding for remote locations. A dual-polarized Doppler S-band weather radar provides weather surveillance from Kwajalein Island, and Doppler C-band weather radar is available for operations at Wake Island. Both radars are volume scanning radars that also are used to predict the threat of lightning events. Two POES satellite receivers (one mobile) both having McIDAS display and management systems, and two geostationary satellite receivers (one transportable) provide access to satellite imagery, circus cloud detection and cloud height, and data processing and analysis. An intra-atoll mesonet and lightning detection network round out the sensors available to RTS forecasters at Kwajalein. Lightning prediction and detection at Wake Island is supported by a thunderstorm sensor that includes a field mill.

In cooperation with NASA/GSFC, RTS weather continues to support global climate studies through the Tropical Rainfall Measurements Mission and the follow-on program of Global Precipitation Measurement. Solar-earth radiation flux monitoring with a suit of radiation measurements systems has been conducted for NOAA/ESRL since 1989.

WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDT&E)

The Army has responsibility for weather support for research, development, test, and evaluation (RDT&E) to support Army ground combat missions as specified in AR 115-10/AFJI 15-157. The Corps of Engineers (COE) and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations. The Army Test and Evaluation Command (ATEC) is responsible for operational meteorological support to Army RDT&E.

Army Corps of Engineers

The Corps of Engineers (COE) is responsible for reviewing all emerging Army systems for environmental effects, as stated in Army Regulation 70-1. Within the COE Engineer Research and Development Center (ERDC), the Topographic Engineering Center (TEC) and the Cold Regions Research and Engineering Laboratory (CRREL) develop Tactical Decision Aids (TDAs) to interpret the impact of weather on terrain to enhance Army operations. TDAs are transitioned to the Digital Topographic Support System (DTSS) and the Commercial Joint Mapping Tool Kit (CJMTK).

Under its military mission, CRREL 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. In partnership with TEC, these products transition to various research and engineering programs including advanced technology demonstrations and specific programs of record such as DTSS and CJMTK.

Army Materiel Command (AMC)

The Army Materiel Command (AMC) is responsible for the research, design, development, test, and evaluation of equipment to satisfy the Army's requirements for meteorological support. AMC provides climatology 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 of the ARL Computational and Information Sciences Directorate (CISD) develops environmental knowledge and technology for the warfighter through a robust R&D program characterizing and modeling the lower atmosphere and its effects on Army systems and personnel at very high spatial and temporal resolution. Current R&D includes basic research and experimental characterization of urban wind flow and atmospheric turbulence for its effects on systems, the investigation of battlefield aerosols and hazards relevant to soldier health, and development of remote sensing capabilities to gather critical data. Numerical modeling includes assimilation of battlefield meteorological observations into diagnostic and prognostic numerical weather models that address fine scale terrain and urban domain effects. This includes the fusion of forward area observations into short-term forecasts called "nowcasts." The applications and products

developed from these efforts are often in the form of weather decision aids that compute weather effects and impacts on systems, sensors, personnel and operations and include recommended course of action planning such as optimizing mission flight profiles that avoid weather hazards and enhance the probability of mission success.

The ARL BE Division consists of three Branches located at ARL Headquarters in Adelphi, MD, and at White Sands Missile Range, New Mexico. The Division also administers congressionally-funded research programs at Colorado State University and at the University of Alaska at Fairbanks. It provides a liaison to the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integration Program Office to coordinate on Army satellite data and information requirements. The division works closely with the U.S. Air Force Weather Agency to provide new DOD-relevant weather products for evaluation and operational hosting on the Joint Army Air-Force Weather Information Network. These products include the Tri-Service Integrated Weather Effects Decision Aid (T-IWEDA), the Weather Running Estimate-Nowcast (WRE-N) and the urban 3D Wind Field Model (3DWF). These and other related products are transitioned as well to the Weather Services capabilities being developed by DCGS-A. The BE program addresses needs for both the current and future force as well as coordinating with other agencies such as the FAA and Department of Homeland Security.

The Atmospheric Modeling Applications Branch addresses the development of the next generation mission execution forecast model (very short term forecasts), web-enabled tactical decision aids, and aviation weather route planners for manned and unmanned systems applicable for DOD, DHS and civilian missions.

Meteorological forecast model applications are focused on the WRE-N and Meso-/micro-scale Numerical Weather Prediction development, improvements, and evaluation. The WRE-N is a combined analysis and "nowcast" model system that will provide the DCGS-A with a capability to satisfy the stated nowcasting requirement. The WRE-N system will produce locally-updated high resolution meteorological data in 3-hour forecast blocks, tailored for execution-level planning and decision making applications. As battlefield weather conditions change, the WRE-N will produce rapid and continuous "local corrections" to regional scale mission planning operational forecasts, retain consistency with theater-wide operational forecast guidance from Air Force and joint DOD weather centers, and insure effective assimilation and fusion of local battlefield weather observations into each WRE-N modeling cycle. Such fine-scale battlefield weather modeling work leverages ARL's DOD Supercomputing Resource Center's capabilities to facilitate examination of the applicability of new atmospheric prediction models for Army scales, that is, at horizontal coverage of hundreds of kilometers and grid spacing of one kilometer or less. DSRC resources also allow for the testing of new boundary layer closures and data assimilation methodologies for potential Army applications.

Warfighter Decision Aids developed in the branch utilize meteorological model gridded output to provide the commander a tactical advantage with validated and verified, web-enabled, tactical decision aids and associated databases that describe the impacts expected and the resulting performance degradation due to weather for both friendly and threat systems, allowing for analysis and adjustments in tactics and weapon system selection before enemy engagement. Decision aids play an important role in the mission planning process associated with both man in the loop and autonomous command and control systems.

Work to develop manned and unmanned aircraft system applications has focused on the Aviation Weather Routing Tool (AWRT) as the primary end product. It addresses a major operational flying mission shortfall by providing accurate weather impacts information to aircraft mission commanders. The AWRT may be considered as a sophisticated tactical decision aid that will generate a highly-intuitive, 4-D graphical "fly through" display of adverse weather effects on aircraft systems. Perhaps more significantly the AWRT will employ a computationally efficient automated search algorithm to identify optimum routes to minimize adverse weather impacts along the flight path.

The BE Atmospheric Dynamics Branch addresses basic research, atmospheric measurements, numerical modeling and application development focused on fine scale, high resolution dynamics of the

boundary layer atmosphere that impact the Soldier and systems. Projects and capabilities in the branch include:

Development and verification of the 3D Wind Field (3DWF) model for wind flow in urban and complex terrain. This efficient and fast-running model provides near real time diagnostic analysis of the average wind flow over a broad range of scales from tens of km down to garrison and forward operating base (FOB) scales. The 3DWF model has also been used to zoom in to model mean wind flow around barriers and individual buildings. The 3DWF model is the core model used in the BED development of a 24/7 operational capability called the Local Rapid Assessment of Environmental Conditions (L-REAC) system. This system is designed to give immediate information following airborne hazard events to garrison and emergency operations center commanders for evacuation, shelter in place and first responder routing decisions.

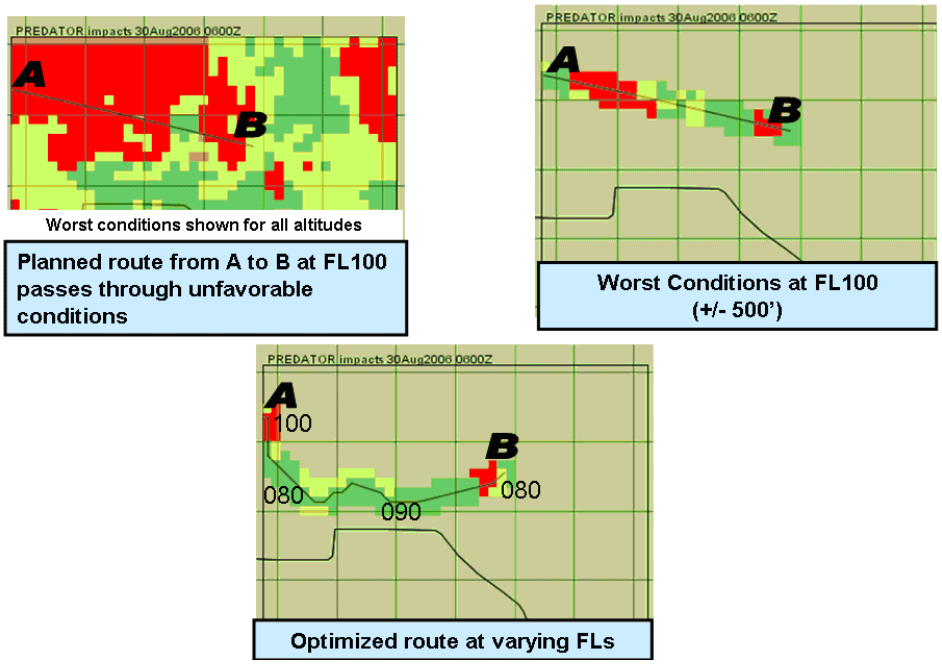


Figure 3-DOD-21. The Aviation Weather Routing Tool can optimize the flight path of a manned or unmanned system. (U.S. Army graphic)

Basic research in the Atmospheric Dynamics Branch includes planning, execution and analysis of field experiments on urban meteorology and boundary layer turbulence. Data from highly instrumented experiments around buildings are used to verify and improve 3DWF. Field experiments using 2D arrays of sonic anemometers investigate small scale dynamics and the transition from isotropic to non isotropic turbulence near the surface. These data are also valuable to the development of BED capabilities to model the statistics of boundary layer turbulence and water vapor fluctuations for applications such as characterizing the environment of micro air vehicles in urban atmospheres and the performance of active infrared and terahertz surveillance systems in a range of realistic environments.

Applied research efforts address the need for better environmental awareness to protect autonomous and semi-autonomous systems. BE Division is looking at various approaches including biomimetic and biologically inspired methods to sense and react to the local environment and avoid or warn of hazards to platforms and sensors. A number of applications are also being investigated to exploit wideband acoustic signals, including the full ultrasonic spectrum, for local environmental sensing of the atmosphere, identification and location of man-made and natural signatures, and data communication.

The BE Atmospheric Sensing Branch develops sensing technologies for scientific and operational sensing of the state of the atmosphere, acoustic propagation, and aerosols. Recent work has focused on the development of ultra-compact Doppler Lidar systems; experimental and theoretical developments to better understand acoustic propagation in urban environments; and aerosol measurement programs.

Models and codes under development will provide valuable tools for the investigation of environmental effects on acoustic sensor performance. They will enable more detailed studies of the effects of urban structures, turbulence, vegetation, and ground surfaces on sound propagation and the resulting effects on acoustic sensors. This is accomplished by defining what aspects of a structure are important to the acoustic propagation and thus reducing the complexity of the problem resulting in more efficient propagation models. The decision aid models created from these new propagation models

will be used to determine the impact of the environment on acoustic sensor systems and the detectability of acoustic signals on various military platforms.

Remote sensing of the battlefield environment, either through active LIDAR (laser radar), passive infrared imaging or passive spectral radiometric systems have significant importance for Intelligence, Surveillance and Reconnaissance (ISR) operations. Development of advanced remote sensing technologies include: system engineering of next-generation LIDAR sensors, algorithm development to enhance ISR products from remotely- sensed data as well as developing an operational methodology for field deployment of LIDAR systems.

Aerosol research focuses on the ubiquitous, but relatively unknown, fraction of organic carbon aerosols (OCA) and natural biological aerosols (BA) in the atmospheric boundary layer. This elusive aerosol fraction, which contains partially volatile organic and biological molecules, is the primary interferant to BW/CW aerosol agent detection. OCA and BA also affect atmospheric visibility, atmospheric radiative balance, and human health. Research to further develop and employ ultraviolet-laser induced fluorescence (UV-LIF) and two-dimensional angular optical scattering (TAOS) techniques will improve the understanding of OCA as well as BA in natural atmospheric aerosols.

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 over land, where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding, modeling, and quantifying of atmospheric effects on soldiers, materials, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on airflow, and the development of natural obscurations throughout the diurnal cycle. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture of the boundary layer at turbulence time scales. Special funding areas are also managed. The Defense University Research and Instrumentation Program (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. Funding for programs is expected to decrease in FY10 because of national budget considerations, meaning that fewer new programs will be initiated. 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 high resolution modeling of conditions for initiation, development and maintenance of turbulence in strongly stratified atmospheric boundary layers.

Army Test and Evaluation Command (ATEC)

The Developmental Test Command (DTC), a subordinate command of United States Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to Army research, development, test and evaluation (RDT&E). Under responsibilities established in AR 115-10/ AFJI 15-157, the DTC meteorological units provide meteorological data collection and analysis, consultation, and weather forecast and warning services to support Army and other DOD RDT&E activities at eight Army installations.

The Army RDT&E Meteorology Program is continuing to collaborate with the National Center for Atmospheric Research (NCAR) on enhancements to the ATEC Four-Dimensional Weather (4DWX) System, which is the backbone of the meteorological support infrastructure at the Army test ranges. ATEC 4DWX modeling capabilities include Weather Research and Forecasting (WRF)-based real-time

four-dimensional data assimilation (RT-FDDA) at seven Army test ranges, and Global Meteorology on Demand (GMOD), a globally-relocatable mesoscale modeling system to support Army RDT&E (including DTC distributed and virtual testing) at locations other than the Army ranges. Output from the 4DWX mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results. Major 4DWX system components include a central data archival/retrieval system for all range and external meteorological and model data, the WRF high-resolution mesoscale meteorological model, an innovative real-time data assimilation system, and a variety of user-configurable displays. The DOD High Performance Computing Modernization Office provided the 4DWX program with a high performance computer (HPC) which enables operational mesoscale ensemble forecasts to support major DTC test operations. The ensemble system uses both the Mesoscale Model Version 5 (MM5) and the WRF model as members of the ensemble set, which typically uses 30 members with varying physics packages, boundary or initial conditions, and model type. System enhancements during FY09 included improvements to the WRF model's capability for deterministic numerical weather prediction at the test ranges, and continued development of ensemble and probabilistic techniques. System enhancements during FY10 will include WRF and data assimilation development focused on forecasting improvements at each range, in addition to advances which apply generally to all WRF applications, including assimilation of new types of data, and development of a prototype next-generation data assimilation approach. In addition, work will begin on extending the AutoNowcaster thunderstorm prediction system to additional ranges, where radar data necessary for AutoNowcaster operations are available.

The Chief of the Meteorology Division at Dugway Proving Ground's West Desert Test Center serves as the DTC Program Manager for Meteorological Support to Army RDT&E. Specialized services provided by the Division include: (1) technical assistance to the DTC operational meteorological teams/branches; (2) atmospheric model verification and validation, including algorithm evaluation and the generation of validation data sets; and (3) technical assistance to the DOD CB defense modeling community in the development of new CB hazard assessment models. Division employees also serve on various national and international committees addressing issues related to meteorological measurements, atmospheric dispersion modeling, and CB hazard assessment.

Army Medical Research and Materiel Command

The 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. The resolution scales are meters to kilometers and minutes to several days. USARIEM is working through an MOA with the ARL Battlefield Environment Division to implement thermal models on the DCGS-A.

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 physiological status monitoring (PSM) work effort, 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.