The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1995

OFCM
OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY

FCM P1-1994

U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

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FEDERAL COORDINATOR
FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

8455 Colesville Road, Suite 1500
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PREFACE

This Federal Plan, the 30th in the series that began in 1965, continues the tradition of summarizing the meteorological services and supporting research activities of all agencies of the Federal Government. As in the past, the Plan provides the Congress and the Executive Branch with a coordinated, overall plan for Government meteorological services and for those research and development programs that directly support and improve meteorological services. The Plan covers the meteorological programs of all agencies for FY 1994 and FY 1995.

The first section of the Plan provides an overview and general summary of the entire document. Essential budget information is provided in graphic formats which summarize the significant aspects of the budget tables included in Section 3. Section 2 highlights interagency cooperation that is essential to meet the needs for meteorological services. Section 3 contains a discussion of resources requested in the President's budget for FY 1995 as compared to appropriated resources for FY 1994. The emphasis is on changes in resources and the related changes in programs. Fiscal data are current as of the end of February 1994. Section 4 provides a review article on "Data Continuity in the Climatological Record". The appendices contain descriptions of agencies' weather activities, a description of the World Weather Program, and a list of acronyms.

This Plan does not include information on basic research in the atmospheric sciences. By long-standing agreement, the more fundamental research activities have been coordinated and reported in the past by the Subcommittee on Atmospheric Research (SAR) of the Committee on Earth and Environmental Sciences. The new Committee on the Environment and Natural Resources (CENR) of the National Science and Technology Council (NSTC) is now reviewing the future course of action. A SAR report for FY 1987-1990 was distributed in 1993. The SAR report is retrospective and serves a very different purpose from that of this Federal Plan, but there are similarities. Representatives of the Office of the Federal Coordinator for Meteorology and the SAR have coordinated approaches to these two reports; however, the distinctions between "supporting" research and "basic" research are sometimes debatable. Some duplications, some omissions, and some double reporting of funding are therefore possible, in spite of efforts to minimize these occurrences.

The principal task of coordinating weather activities is accomplished by the interagency committees shown on the inside front cover. These committees and the organizations shown on the inside of the back cover conduct systematic and continuous reviews of requirements for basic and specialized meteorological services and for supporting research according to guidelines set forth in the Office of Management and Budget Circular A-62.

Julian M. Wright, Jr.
Federal Coordinator for Meteorological
Services and Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH, FISCAL YEAR 1995

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SECTION 1

EXECUTIVE SUMMARY

The President's Budget for FY 1995 requests $2.443 billion for meteorological services and supporting research. This is a 2.8 percent increase over funds appropriated for FY 1994. As in previous years, about 91 percent of the total is requested for three Departments -- Commerce, Defense, and Transportation. The increased funding is primarily associated with the transition to the modernized weather services -- new observing, forecasting, and satellite systems. Major programs initiated in previous years continue to be funded and the groundwork for new programs is being coordinated within the infrastructure of the Office of the Federal Coordinator for Meteorology (OFCM) by the various program councils, committees, and working groups. Budget support for Federal meteorological activities reflects the cooperative efforts and the substantial progress of meteorological science and technology in recent years. This level of support is needed to fully exploit advancements in both observing systems and forecasting procedures during this decade.

Major Programs of DOC, DOD and DOT

The Federal Government continues support for major weather observation, data integration, and communications programs in the budget requests for FY 1995.

The Next Generation Weather Radar (NEXRAD) Program is supported by the Departments of Commerce (DOC), Defense (DOD) and Transportation (DOT). The NEXRAD Program Council, chaired by the Federal Coordinator, continues to provide policy guidance and oversight for the procurement, installation, and operation of the WSR-88D Doppler radars. For FY 1994, 51 systems will be delivered. Of these, 22 had been delivered by the end of February 1994 bringing total deliveries to 69 and total acceptances to 61. The schedule for FY 1995 calls for 51 WSR-88D deliveries. The final unit is scheduled for delivery in January 1996. Implementation of the radars is resulting in markedly higher quality and quantities of storm and wind data at the new sites resulting in more timely and accurate warnings of severe weather. The Operational Support Facility at Norman, OK provides most of the operational support for the operating network.

The Automated Surface Observing System (ASOS) is under the policy guidance of the Joint Automated Weather Observations Program Council chaired by the Federal Coordinator. This program is progressing on schedule -- a contract was awarded by the Department of Commerce in February 1991 for up to 1,700 units to be installed during the next 5 years. More than 337 units have been accepted, and 22 are commissioned.

New automated weather information systems are being installed by DOD and FAA. The National Weather Service is testing an upgrade to the current system while the next generation Advanced Weather Interactive Processing System (AWIPS) is in the design and development stage. These systems facilitate data collection, processing, and interpretation that result in more timely and improved weather forecasts. An additional feature is the rapid distribution of information and products to users. The Air Force has completed a system of 164 units to modernize their base weather station operations. A program council, a committee, and several working groups within the OFCM structure provide coordination for various aspects of the agencies' programs. Funding for the DOC, DOT, and DOD programs is in the FY 1995 budget request.

Other Agency Programs

The Department of Agriculture will continue its weather-related activities for FY 1995 at essentially the same level of funding ($25.18 million) as FY 1994. These include observations taken by the Forest Service and research on the interactions of climate with plant and animal production. The Department of the Interior request is $870,000. The Environmental Protection Agency request of $8.5 million for FY 1995 is a small increase from the $8.1 million for FY 1994.

The National Aeronautics and Space Administration budget request of $174.77 million is virtually all for supporting research, as in previous years. This will include support for meteorology-related activities within the Earth Observing System (EOS), Earth Probes, and for the Upper Atmosphere Research Satellite (UARS). The Nuclear Regulatory Commission (NRC) request of $270,000 is for weather-related activities that emphasize public safety and health in connection with the operation of nuclear facilities. A detailed summary of each agency's meteorological program is given in the Appendices.

Federal Coordination Activities

President Clinton signed a Presidential Decision Directive in May 1994, directing the Department of Defense to merge the Defense Meteorological Satellite Program (DMSP) follow-on acquisition efforts with the Department of Commerce's Polar-orbiting Operational Environmental Satellite system follow-on acquisition team. An Integrated Program Office (IPO) will be established by October 1994 to develop and manage the next generation of polar-orbiting operational environmental satellites planned for the year 2004. The IPO staff will be selected from the Departments of Defense and Commerce, and NASA. Discussions with the European meteorological satellite organization are underway for inclusion of their spacecraft into the final satellite configuration.

In February 1994, the Office of the Federal Coordinator for Meteorology hosted the 48th Interdepartmental Hurricane Conference (IHC) in Miami, Florida. Representatives from DOC, DOD, and DOT reviewed the 1993 hurricane season and operations in the Atlantic, East and West Pacific, and Indian Ocean. The representatives proposed IHC action items and changes to the ***National Hurricane Operations Plan*** (NHOP). Changes that were agreed upon have been incorporated into the Plan; the 1994 NHOP was published in April.

In response to Public Law 102-567, the National Oceanic and Atmospheric Administration (NOAA) Authorization Act of 1992, Section 107, the Office of the Federal Coordinator for Meteorology developed a 5-year management plan to document a joint Department of Commerce (DOC) and Department of Defense (DOD) hurricane reconnaissance program. The plan documented joint efforts to collect operational and reconnaissance data, conduct research, and analyze data on tropical cyclones to assist forecast and warning programs and to increase the understanding of the causes and behavior of tropical cyclones. In January 1994, coordination on the management plan package was completed, and the package was sent to Congress.

The ***National Aviation Weather Program Plan*** was published in September 1992. It incorporates the cooperative efforts of six agencies and addresses the full suite of requirements for Aviation Weather products and services. The Plan identifies requirements that can be met by current capabilities, and by the projected capabilities of currently funded programs. The Plan focuses on the requirements that will necessitate special efforts around the year 2000 and beyond.

Federal Meteorological Handbooks (FMH) are prepared and updated under the guidance of the various OFCM committees and working groups. Revisions have been completed and published for the ***Surface Synoptic Codes*** (FMH-2), ***Meteorological Rocket Observations*** (FMH-10), and ***Doppler Radar*** (FMH-11) which consists of four volumes. Drafts of ***Surface Aviation Observations*** (FMH-1) and ***Upper Air Observations*** (FMH-3) are being reviewed.

The Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) formed an Advisory Panel for Climate Services. This was done to provide the current status and updated information on climate services to the Federal Committee for Meteorological Services and Supporting Research. The panel held a 2-day working session in November 1993 and produced a report in which the panel identified a number of current problem areas such as data continuity and data redundancy. The panel strongly recommended the formation of a Working Group for Climate Services within OFCM to provide a forum for the Federal agencies to coordinate and discuss climate services issues. The Working Group was approved by ICMSSR and is being established.

The Federal Coordinator served as Team Leader for the Disaster Survey Report for the Superstorm of

March 1993. Many of the findings, recommendations and lessons learned from this storm system, and other significant weather events of recent years, are being addressed by NOAA and appropriate OFCM organizational activities.

Resources

The FY 1995 resources requested for Federal meteorological operations and supporting research are $2.443 billion, representing a 2.8 percent increase from the $2.377 billion appropriated in FY 1994. Of the total, about $2.034 billion will be for operations and $409 million for supporting research. The FY 1995 budget, by agency, is shown in Table 1.1.

Figure 1.1 shows each agency's proportion of the total FY 1995 proposed Federal spending for meteorological operations and supporting research. Each agency's proportion of the proposed Federal spending for meteorological operations is shown in Figure 1.2; as in previous years, the Departments of Commerce, Defense, and Transportation account for approximately 99 percent of the Federal budget for meteorological operations. Each agency's proportion of the proposed Federal spending for supporting research is shown in Figure 1.3.

The agencies expect that 16,928 personnel (full-time-equivalent) will be employed in Federal meteorological operations in FY 1995; this is a decrease of 1.5 percent from the 17,191 personnel employed in FY 1994.

Table 1.1. Federal Budget for Meteorological Operations and Supporting Research, FY 1995 (in thousands of dollars)

Agency	Operations	% of TOTAL	Supporting Research	% of TOTAL	TOTAL	% of TOTAL
Agriculture	$11,936	0.6	$13,239	3.2	$25,175	1.0
Commerce	1,105,147	54.3	84,373	20.6	1,189,520	48.7
Defense	488,422	24.0	109,422	26.8	597,844	24.5
Interior	870	0.0	0	0.0	870	0.0
Transportation	418,677	20.6	27,189	6.6	445,866	18.3
EPA	0	0.0	8,500	2.1	8,500	0.3
NASA	8,476	0.4	166,300	40.7	174,776	7.2
Nuclear Reg. Comm.	270	0.0	0	0.0	270	0.0
TOTAL	2,033,798	100.0	409,023	100.0	2,442,821	100.0

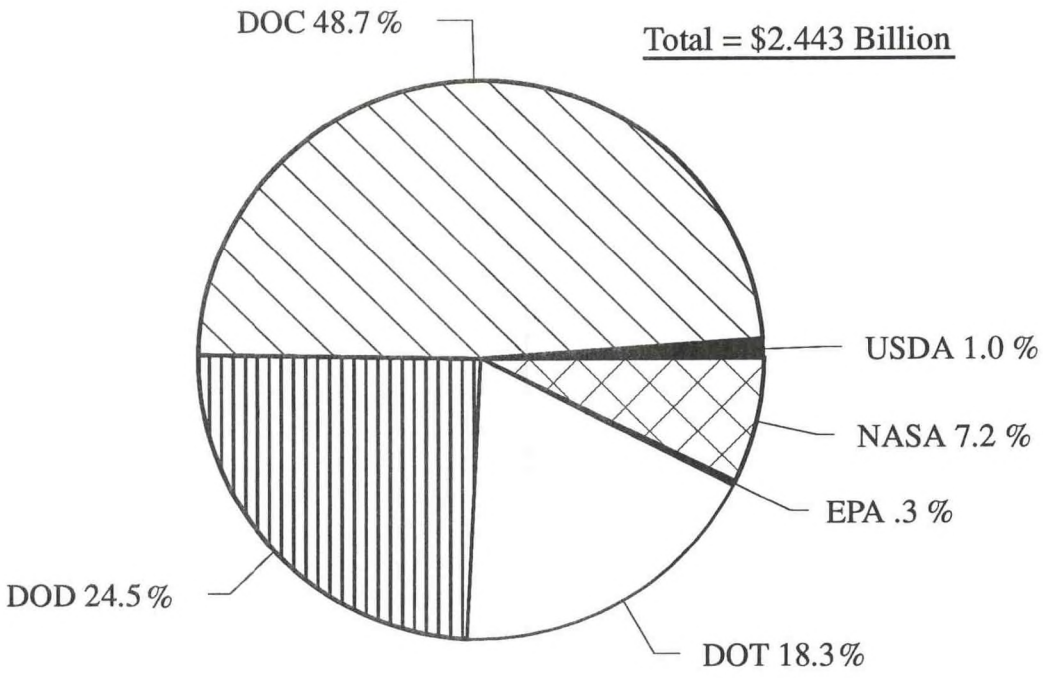

Figure 1.1 Agency Percent of Total Federal Budget for Meteorological Operations and Supporting Research, FY 1995

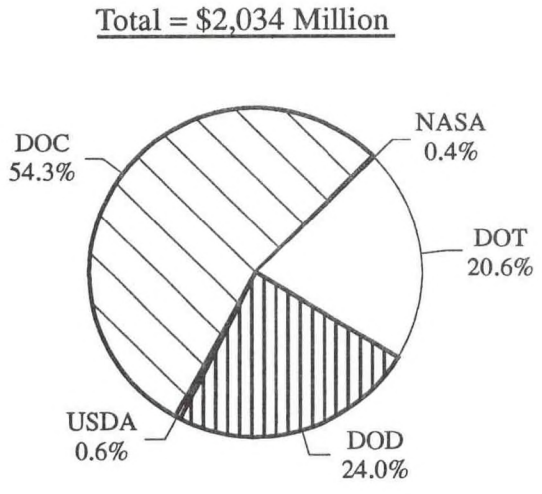

Figure 1.2 Agency Percent of Federal Budget for Meteorological Operations, FY 1995

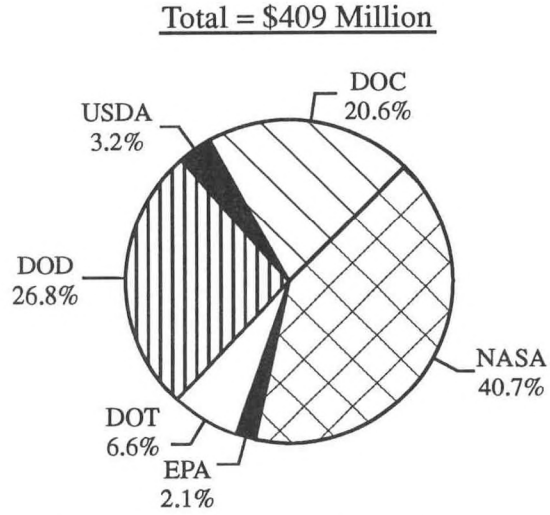

Figure 1.3 Agency Percent of Federal Budget for Supporting Research, FY 1995

SECTION 2

FEDERAL COORDINATION AND PLANNING

In 1963, activities in meteorology gave rise to concern in Congress and the Executive Office of the President about the adequacy of coordination of Federal meteorological activities. This concern was given expression by the Congress in Section 304 of Public Law 87-843, the Appropriations Act for State, Justice, Commerce, and related agencies. Congress directed that the Bureau of the Budget prepare an annual horizontal budget for all meteorological programs in the Federal agencies.

The Bureau of the Budget (now the Office of Management and Budget) issued a report entitled "Survey of Federal Meteorological Activities" (1963). It described each agency's program in some detail, particularly its operational services, and spelled out the relationship between the programs of the various agencies. The report revealed close cooperation but little evidence of systematic coordination. As a result of this study and the concern of Congress, the Director of the Bureau of the Budget issued Circular A-62. The Circular provided the ground rules to be followed in the coordination process. It established a general philosophy for assignment and assessment of agency roles in the field of meteorology and set certain goals to be achieved by the coordination process. The Circular left the task of establishing the coordinating mechanism to the Department of Commerce (DOC), in concert with the other Federal agencies. The Circular reaffirmed the concept of having a central agency, the Department of Commerce, responsible for providing common meteorological facilities and services and clarified the responsibilities of other agencies for providing meteorological services specific to their own needs.

The implementation of Circular A-62 by the Department of Commerce led to creation of the Office of the Federal Coordinator for Meteorology (OFCM). The Office operates with policy guidance from the Federal Committee for Meteorological Services and Supporting Research. The principal work in the coordination of meteorological activities and in the preparation and maintenance of Federal plans is done by the staff of the Federal Coordinator with the advice and assistance of the Interdepartmental Committee for Meteorological Services and Supporting Research, several program councils, committees, and working groups. The organizational relationships are shown on the inside of the back cover of this document.

MISSION AND STAFFING OF THE OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY (OFCM)

The mission of the OFCM is to promote coordination and cooperation among those Federal agencies having weather-related activities so that the most effective and best possible weather information and user services are provided for the funds made available by the Government. To discharge its mission, the OFCM objectives are meshed with the objectives of those agencies which provide the services and perform the research. The objectives are to:

- Document agency programs and activities in a series of national plans and reports that enable agencies to revise or adjust their individual ongoing programs and provide a means for communicating new ideas and approaches to fulfill requirements;
- Provide a structure and program to promote continuity in the development and coordination of plans and procedures for interagency meteorological service operations and supporting research activities;
- Perform analyses, summaries, or evaluations of agency meteorological programs and plans that provide a factual basis for the Executive and Legislative branches to make appropriate decisions related to the allocation of funds;
- Review Federal weather programs and Federal requirements for meteorological services and supporting research. This review may suggest additions or revisions to current or proposed programs or identify opportunities for improved efficiency, reliability, or cost avoidance through coordinated actions or integrated programs.

In 1979, a General Accounting Office (GAO) report, "The Federal Weather Program Must Have Stronger Central Direction," LCD-80-10, recommended stronger centralized planning and direction for Federal weather activities. Pursuant to GAO's recommendation, the DOC increased the permanent professional staff from one to seven and assigned an additional professional as Department representative; DOC also provides administrative support to the OFCM. DOC provides approximately one-half of the office operating budget. The Department of Defense (DOD) currently provides two staff officers (one Air Force Colonel and one Navy Lieutenant Commander) and contributes approximately one-fourth of the OFCM annual operating budget. DOT/FAA provides one professional staff member and also contributes approximately one-fourth of the OFCM annual operating budget. The four regularly assigned agency representatives are designated Assistant Federal Coordinators for liaison to their respective agencies. Based on the current staffing plan, there are ten professionals and five full time administrative support personnel within the OFCM. Approximately one-half of these resources is required for the direct support of the Committee structure and preparation of recurring plans (national operations plans and the annual Federal Plan). The remaining staff time is required for responding to special inquiries, investigations, and studies.

COORDINATION OF MULTIAGENCY PROGRAMS

The Federal Committee for Meteorological Services and Supporting Research was established in 1964 with high-level agency representation to provide policy guidance to the Federal Coordinator and to resolve agency differences that arise during the coordination of meteorological activities and the preparation of Federal plans in general. The Committee is chaired by the Under Secretary of Commerce for Oceans and Atmosphere, who is also the Administrator of the National Oceanic and Atmospheric Administration.

Thirteen Governmental agencies that engage in meteorological activities, or that have a need for meteorological services, are represented on the Committee. These include the Departments of Commerce, Agriculture, Defense, Energy, Interior, State, and Transportation as well as the Environmental Protection Agency, Federal Emergency Management Agency, National Aeronautics and Space Administration, National Science Foundation, National Transportation Safety Board, and the U.S. Nuclear Regulatory Commission. In addition, the Office of Management and Budget is represented.

The Office of Management and Budget (OMB) and the Federal Committee provide guidance at the policy level to the Federal Coordinator. Guidance from the agencies is provided at the program management level by the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR). Under ICMSSR, there are six standing committees: Basic Services, Operational Processing Centers, Automated Weather Information Systems, Aviation Services, Operational Environmental Satellites, and Space Environment Forecasting.

Six Program Councils are established within the OFCM structure to coordinate specific interagency cooperative programs. These are: Joint Automated Weather Observations, Automated Weather Information Systems, Aircraft Icing, Aviation Weather, Next Generation Weather Radar, and Improved Weather Reconnaissance System. Each of the Councils is comprised of decision-level representatives of the agencies directly concerned with the specific program area; the Federal Coordinator serves as chairperson for all the Councils.

Next Generation Weather Radar (NEXRAD)

Official commissioning of the Weather Surveillance Radar-1988 Doppler (WSR-88D) began during 1994. Delivery of new systems continues with agency procurement schedules consistent with budget related restructuring of weather programs. The WSR-88D is a computerized Doppler weather radar developed to meet the needs of the Departments of Commerce, Defense, and Transportation for improved ability to detect and maintain surveillance of hazardous weather. This need was defined by the three Departments, through an OFCM-sponsored study, in the late 1970's. It led, in 1979, to the establishment of a Joint System Program Office to develop and procure

the new Doppler radar under policy guidance and oversight of a tri-agency NEXRAD Program Council chaired by the Federal Coordinator.

The WSR-88D system's advanced technology provides automated Doppler signal processing, computerized processing of data by sophisticated meteorological software algorithms, state-of-the-art ergonomically designed operator workstations, and a high-capacity, processor-driven communications capability. The system is modular in design, upgradeable, has a long life-cycle expectancy, and its advanced weather radar products meet the needs of the three Departments for accurate information on the location, severity, and movement of hazardous weather.

The Department of Commerce's National Weather Service (NWS) uses the WSR-88D for more than forecasts and warnings of severe weather. NWS also uses the WSR-88D rainfall analysis capability to improve its river stage and flood forecasts and to provide data to the Nation in support of effective management of water resources. This advance in water resources management reaches beyond flood control to impact areas such as river navigation, drinking water supplies, pollution management, and water-based recreation -- all with beneficial economic consequences. The Department of Defense will use NEXRAD data to support military operations and protect defense assets in the United States, the Azores, and at key Pacific locations. The Department of Transportation's Federal Aviation Administration uses the data to improve flight safety and to manage traffic more efficiently within the National Airspace System.

The NEXRAD program procurement followed the competitive bidding procedures established in Office of Management and Budget Circular A-109. The acquisition progressed through the System Definition Phase and Validation Phase design and development efforts, to selection of a system contractor and award of Limited Production and Full Scale Production contracts. Unisys was awarded a Limited Production contract for 10 NEXRAD units in December of 1987. In 1989, the WSR-88D prototype unit was given a rigorous independent examination during Initial Operational Test and Evaluation Part 2. The WSR-88D proved that it could significantly improve the timeliness and accuracy of forecasts of severe weather occurrences. Unisys was awarded the Full Scale Production option in January 1990 for 165 additional Doppler radars. The current program requirement is for a total of 162 radar systems to be procured and fielded at 116 NWS sites in the contiguous 48 states, 29 DOD operational sites in the U.S. and overseas, and 13 FAA systems in Alaska, Hawaii, and the Caribbean.

WSR-88D deployment and implementation is proceeding smoothly. As of the end of February 1994, a total of 69 systems have been delivered for all purposes which includes training and maintenance activities as well as field operations; 61 WSR-88D units have been accepted and one commissioned. Accepted systems are available for use by the Government, commissioned systems are fully operational and provide official Government radar data to users. With the program now in full scale production, the Government accepts two to four new systems a month. Final delivery of the last system is scheduled for early 1996. In FY 1994, a total of 51 systems will be delivered, and 51 systems are also scheduled for delivery in FY 1995. Major developments in hardware and software capabilities are underway for product improvement. Current broad-scale activities in support of deployment include depot repair facility preparations, implementation of system support capability, establishment of spare parts inventory, and preparations for system commissioning.

The Operational Support Facility (OSF), established in 1988 at Norman, Oklahoma, provides 24-hour-a-day operational support to WSR-88D field units. The OSF manages the WSR-88D operator training program for all agencies and, in conjunction with the NWS Office of Systems Operations, is completing preparations for the management and coordination of the life-cycle system support program for the NEXRAD system. The DOD maintenance training facility at Keesler AFB, Mississippi, is in operation, and will also provide maintenance training for the DOT. The transition of DOD operator training to Keesler AFB has been completed.

Archiving of the NEXRAD Level III data, which are advanced weather radar products, was begun in 1992 by DOC/NOAA at the National Climatic Data Center (NCDC). The plan to archive the higher resolution data (Level II) from which the products are generated is now being implemented.

Automated Surface Weather Observations

Historically, each agency has independently developed an operational weather system capability in pursuit of its mission. In 1983, the Joint Automated Weather Observation Program (JAWOP) was established by the Departments of Commerce, Defense, and Transportation/FAA. The JAWOP Council, chaired by the Federal Coordinator, provides policy and oversight for the three Departments' automated surface observation program development efforts.

In 1986, the JAWOP Council agreed to use the NWS Automated Surface Observing System (ASOS) at the FAA's towered airport locations. The Administrators of NOAA and FAA agreed that NOAA will procure, install, operate, and maintain the ASOS to meet FAA requirements for both the towered and most of the non-towered (smaller) airports; this will make ASOS the primary Federal surface observing system. Immediate needs of the FAA for limited weather observations at small non-towered airports was satisfied by 200 off-the-shelf automated weather observing systems (AWOS) as an interim capability system until the fielding of ASOS, which is now underway, is completed.

The results of field tests of the ASOS preproduction systems were reviewed by an independent interagency Test Review Board (TRB) that recommended proceeding to the production phase. In February 1991, the ASOS production and implementation contract was awarded to AAI Corporation for as many as 1700 units over the next 5 years. Production was initiated, and the early systems were fielded in the central United States during the summer of 1991. The TRB met again in August 1991 and recommended continuation of the production phase. At its March 1992 meeting, the TRB concluded that the risks of proceeding with full system acceptance and commissioning during the summer of 1992 were small and manageable. Commissioning of NWS-sponsored ASOS units began in late summer of 1992 and will provide the official weather observation for associated airports. More than 337 units have been accepted and 36 units have been commissioned as of May 1994.

Improvements in laser ceilometer technology, a critical component of automated observing efforts, were factored into the NWS next generation laser ceilometer procurement. Production delivery has been completed at primary NWS observing locations, and at selected Air Force and Army observing locations. The new ceilometer will be used as part of the ASOS sensor suite at most locations. The FAA will use the NWS-developed Next Generation Ceilometer for replacement purposes. The FAA has acquired 115 ceilometers through the NWS.

The Navy is planning to replace obsolete equipment with ASOS at Navy and Marine Corps air stations. The Navy does not plan to use ASOS as a fully automated station except at remote sites, such as bombing ranges, where surface observations are not presently taken due to manpower limitations. The Navy requires 86 ASOS units (85 operational and one R&D) at 70 continental U.S. sites and 15 overseas sites. The R&D unit was installed in the Spring of 1992 at the Naval Electronics Engineering Center, Charleston, SC. In order to satisfy the requirement for automated shipboard observations, the Navy is developing the Shipboard Meteorological and Oceanographic Observing System (SMOOS).

Air Force activity in automated meteorological sensors is focused on the combat environment. The Tactical Weather Observing System (TWOS), the observing component of the Air Force's Combat Weather System (CWS) program, consists of four ground-based meteorological sensing capabilities: an airfield observing sensor suite, an upper air measurement system, hand-held sensors, and an expendable tactical observing sensor suite. The primary emphasis is for Commercial Off-the-Shelf (COTS) acquisition; new sensor development has been deferred until late in program acquisition.

The U.S. Army Research Laboratory (ARL) has developed and installed the Surface Automated Meteorological System (SAMS) for automated collection and processing of surface weather parameters for supporting the Army's Research, Development, Test, and Evaluation sites. Standard measured parameters are solar radiation, air temperature, humidity, wind speed and direction, barometric pressure, and soil temperature at each data collection package (DCP). The central site, called the Acquisition Control Unit (ACU), directs the DCPs to acquire and transmit data, calculates a variety of derived parameters, and maintains a listing of the acquired data including reports and plots.

Planned activities for FY 1994-1995 include:

- Continue with ASOS full scale production, fielding as many as 15 or more systems per month;
- Continue commissioning of ASOS units;
- NWS, FAA, and DOD (under the auspices of the JAWOP) will continue with selected future sensor enhancement, development, and testing;
- OFCM will publish the ***Federal Meteorological Handbook No. 1 - Surface Observations*** to reflect automated observing procedures; projected publication date is August 1994.
- FAA will continue selective replacement of aging sensors by means of an add-on to the NWS procurement;
- USN will continue replacement of the AN/GMQ-29 semi-automated observing systems ashore with ASOS during the FY 1993-1996 timeframe;
- USN's technical evaluation of the Shipboard Meteorological and Oceanographic Observing System was completed in 1992 and production began in 1993.

Automated Weather Information Systems

Automated Weather Information Systems (AWIS) are required by a number of Federal agencies. The AWIS are being procured to provide an automated, high-speed, user-friendly man/machine interface for access and processing of a large volume of sophisticated meteorological data. The AWIS supports the timely production of accurate and geographically precise warnings, forecasts and special tailored products; it also provides the communications capability for expeditious product distribution. Major agency systems classified as AWISs are NOAA's Advanced Weather Interactive Processing System (AWIPS), the Federal Aviation Administration's Central Weather Processor (CWP), the U.S. Air Force's Automated Weather Distribution System (AWDS), and the Naval Oceanographic Data Distribution and Expansion System (NODDES). The systems include communications to collect and distribute raw data, information, and processed products. Excluded from AWIS are the observation subsystems and the supercomputers at the major centers. The U.S. Air Force has completed a system of 164 AWDS at military weather stations located in the continental U.S and overseas.

The AWIS Program Council, which consists of high-level representatives from the Departments of Commerce, Defense, and Transportation, was established in 1986 in response to a 1985 recommendation by the Inspectors General of these agencies. The goals of the Council included: identify major items that needed coordination; determine what commonalities existed among the systems; and produce a Federal plan for the coordination of AWIS programs. To pursue these goals, the AWIS Program Council uses the Committee for Automated Weather Information Systems (CAWIS) and its Working Groups for Communications Interfaces and Data Exchange (WG/CIDE), AWIS Meteorological Applications (WG/AMA), and NOAAPORT Liaison (WG/NPL).

CAWIS published the ***Federal Plan for the Coordination of AWIS Programs*** in May 1988. WG/CIDE publishes standards documents relating to formats and telecommunications procedures; the most recent version of the ***Standard Formats for Weather Data Exchange Among Automated Weather Information Systems*** was published in May 1990; the most recent ***Standard Telecommunication Procedures for Weather Data Exchange*** was published in October 1991. This latter standard is based upon the Federal Information Processing Standard 100 which is compatible with a similar document produced by the International Standards Organization. The thrust of the WG/CIDE's effort is to adopt Federal, American, and international standards and, where necessary, to develop standards, procedures, and guidelines that are unique to weather information systems. WG/CIDE designed the Interdepartmental Meteorological Data Exchange System (IMDES). The most recent progress report on the implementation of IMDES was published in July 1991.

WG/AMA is preparing an inventory of meteorological applications programs and techniques and provides a forum for coordination of developments in new or improved meteorological applications. WG/NPL provides an interdepartmental forum for the discussion of plans regarding the implementation of NOAAPORT. NOAAPORT is the name given to the service for broadcasting meteorological data and products to AWIPS and other environmental data systems.

Improved Weather Reconnaissance System (IWRS)

- The Improved Weather Reconnaissance Program

Council (IWRPC) was formed to manage the acquisition of the IWRS equipment. The Air Force Reserve's 53rd Weather Reconnaissance Squadron (53 WRS), as of the end of FY 1994, will operate 10 WC-130 aircraft that are equipped with the IWRS, which provides an automated, high-density, high-accuracy data gathering capability in support of tropical cyclone and winter storm forecasting operations. In fact, the 53 WRS has a Congressionally mandated charter to provide hurricane reconnaissance in support of the National Weather Service's National Hurricane Center. With the successful completion of the IWRS program, the IWRPC continues to meet at least once a year to evaluate the operational effectiveness of the IWRS and to evaluate/approve proposals for IWRS improvements and upgrades. The IWRPC met in February 1994, in conjunction with the 48th Interdeparmental Hurricane Conference, to review the status of on-going projects and enhancements.

The IWRPC-funded project to convert four later-model C-130E aircraft to WC-130H's, by adding the IWRS and an internal fuel tank, was successfully completed on schedule and has significantly enhanced the operational capability of the WC-130 fleet. The development of the new lightweight OMEGA digital dropwindsonde (LOD2) was completed, and procurement of the LOD2 by the Air Force is underway. The 53 WRS plans to take delivery of their first LOD2's in June 1994. Development of the next-generation stepped frequency microwave radiometer (SFMR), which will provide improved surface wind speeds around tropical storms and hurricanes, is on track. The next step is to flight test the new antenna design on NOAA's WP-3D this summer. The development of the LOD2 and the SFMR project were both approved by the IWRPC and financed with IWRS funds.

PLANNING, COMMITTEE ACTIVITIES, AND PUBLICATIONS

Interdepartmental Hurricane Conference

In February 1994, the Office of the Federal Coordinator for Meteorology hosted the 48th Interdepartmental Hurricane Conference (IHC) in Miami, Florida. On the first day, the research community's presentations covered on-going research, experiments, and performance of numerical models. During the rest of the conference, representatives from DOC, DOD, and DOT reviewed the 1993 hurricane season and operations in the Atlantic, Pacific, and Indian Oceans. The 120 representatives proposed IHC action items and changes to the ***National Hurricane Operations Plan*** (NHOP). Changes that were agreed upon have been incorporated into the plan; the 1994 NHOP was published in April. Two other groups met in conjunction with the 48th IHC -- the Improved Weather Reconnaissance Program Council (IWRPC) and the Ad Hoc Group for Tropical Cyclone Research (AHG/TCR).

Climate Services

Climate services in the Federal agencies was selected as an agenda item for a meeting of the Federal Committee for Meteorological Services and Supporting Research (FCMSSR). To provide background information for this subject, the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) formed an Advisory Panel for Climate Services. The panel held a 2-day working session in November 1993 and produced a report in which the panel identified a number of current problem areas such as data continuity and data redundancy. The panel strongly recommended the formation of a Working Group for Climate Services within OFCM to provide a forum for the Federal agencies to coordinate and discuss climate services issues. The Working Group was approved by ICMSSR and is being established.

Federal Meteorological Handbooks

At the direction of the ICMSSR, the OFCM has undertaken a revitalization of the Federal Meteorological Handbooks (FMH) using the existing interdepartmental coordination infrastructure of committees and working groups. The FMH series includes observing and reporting practices for surface, upper air, radar, and meteorological rocket observations. The titles of eleven existing handbooks are: ***Surface Observations***, ***Surface Synoptic Codes***, ***Radiosonde Observations***, ***Radiosonde Code***, ***Winds-Aloft Observations***, ***Upper Wind Code***, ***Weather Radar Observations***, ***Manual on Barometry***, ***Aviation Weather Observations***, ***Meteorological Rocket Observations***, and ***Doppler Radar Meteorological Observations***. The OFCM is reevaluating the status of the FMH series and revising each handbook, as

required, to:

- highlight the responsibility for preparation and maintenance;
- develop a mechanism to ensure that the FMHs remain current and complete;
- assure the merging of information from new or automated technology;
- meet requirements for utility of the primary users;
- reinforce the status of each handbook as the Federal standard for observing and reporting the meteorological phenomena and parameters by which the atmosphere is usually described.

Many OFCM working groups of the Committee for Basic Services are participating in this task. To date, revisions were completed for the ***Surface Synoptic Codes*** (FMH-2) and ***Meteorological Rocket Observations*** (FMH-10) handbooks. Additionally, the four-part ***Doppler Radar Meteorological Observations*** (FMH-11) was completed and published. These parts are: Part A - ***System Concepts, Responsibilities, and Procedures***, Part B - ***Doppler Radar Theory and Meteorology***, Part C - ***WSR-88D Products and Algorithms***, and Part D - ***WSR-88D Unit Description and Operational Analysis***. A final draft of ***Surface Observations*** (FMH-1) has been prepared; the projected publication date is August 1994. Federal agencies are reviewing a preliminary draft of the ***Manual on Codes -- U.S. Supplement*** (FMH-12). This manual will include, along with other codes to be determined, the Pilot Report (PIREP) code form that was included in an earlier version of FMH-1. The new FMH-1 to be issued in August will no longer include the PIREP code. Federal agencies are also reviewing a preliminary draft of ***Upper Air Observations*** (FMH-3).

New versions of all handbooks are available to private-sector users through the Customer Services at the National Climatic Data Center, Asheville, NC. Federal agencies may request copies from the OFCM.

Meteorological Codes

The use of meteorological codes is of fundamental importance for the collection, exchange, and distribution of meteorological information. The Working Group for Meteorological Codes (WG/MC) is the principal means, within the OFCM, for coordinating the employment of these codes by concerned Federal agencies.

A major effort undertaken during 1993-94 by the WG/MC was the implementation of WMO's METAR, SPECI, and TAF codes. Conversion to the new code forms was effected in July 1993 with minimal impacts to operations within the Departments of Commerce, Defense, and Transportation. Currently, the WG/MC is soliciting proposals to enhance the METAR/SPECI/TAF codes and will prepare recommendations for WMO consideration. The WG/MC is also preparing exceptions for filing with WMO for Upper Air as well as Buoy codes.

Over the course of the next several months, the WG/MC plans to prepare and distribute a Manual on Codes patterned after the WMO No. 306, ***Manual on Codes***. The US version will be a collective of U.S.-only forms for which there is no extensive documentation elsewhere within the Federal meteorological community. The tentative distribution date for this publication is mid-1995.

Satellite Telemetry

The Satellite Telemetry Interagency Working Group (STIWG) is co-chartered by the Federal Coordinator for Meteorological Services and Supporting Research and the Chief, Office of Water Data Coordination. The STIWG reports to the Coordinators through the Committee for Basic Services and the Hydrology Subcommittee in the respective coordinating infrastructures. The STIWG is comprised of representatives of agencies which collect data from remote Data Collection Platforms (DCP) through the GOES Data Collection System (DCS). Some of the agencies participating in STIWG activities are: Bureau of Land Management, Bureau of Reclamation, National Weather Service, National Ocean Service, U.S. Army Corps of Engineers, U.S. Geological Survey, Environmental Protection Agency, U.S. Forest Service, National Data Buoy Center, Nuclear Regulatory Commission, and others. The National Environmental Satellite, Data, and Information Service (NESDIS), as the GOES DCS operator, meets with the STIWG for coordination of users' needs, system procedures and status, policy, funding, and troubleshooting.

DCPs owned by the user agencies sense and collect a variety of data at remotely located positions. Among those types of data are rainfall, stream flow, water levels in lakes and reservoirs, seismic stress and vibration, wind direction and speed, atmospheric

pressure, soil moisture, air/soil temperature, sea surface temperatures, and relative humidity.

A major concern of the STIWG and NESDIS has been the growing numbers of DCPs and the possibility of system saturation. NESDIS, in response to this growing concern, has taken steps to increase the efficiency of bandwidth use in the satellite and to increase the throughput at the ground processing system at the Command and Data Acquisition Station. The STIWG member agencies have funded additional demodulations for the ground receiving system and a domestic communications satellite channel to disseminate the collected data to users. They funded studies to evaluate the advantages and impacts of higher baud rate equipment. Based on the results, STIWG agencies have jointly funded the development of 300 and 1200 baud transmitters, demodulators, and test sets. Prototypes are expected in mid-FY 1995.

National Aviation Weather Program

A program council was formed in late 1989 and a supporting Joint Action Group (JAG) in 1990 to address aviation weather issues and provide guidance in the preparation of a national aviation weather program plan. The membership consists of the Departments of Agriculture, Commerce, Defense, Transportation, NASA, and the National Transportation Safety Board. The Program Council, assisted by the JAG, produced the ***National Aviation Weather Program Plan*** (FCM-P27-1992) in September 1992.

The JAG worked closely with users of aviation weather data and services; users from the Federal sector, private meteorologists, the air carriers, and general aviation. The users assisted in developing a list of user needs that identified seven categories that still need improvement:

- Surface and terminal observations;
- Surface and terminal forecasts;
- Upper air and enroute reports;
- Upper air and enroute forecasts;
- Automation;
- Information access and dissemination;
- User education.

The users determined that User Education was the highest priority category to keep them abreast of the modernizations of the National Weather Service and the National Airspace System by FAA. The FAA has continued close coordination with the users while developing new policies related to the modernized environment and technologies. The JAG work to develop interagency action plans to address the remaining needs is pending.

National Aircraft Icing Program

In late 1983, a subgroup of the Federal Committee for Meteorological Services and Supporting Research and other high-level officials in DOD, FAA, and NASA agreed to promote greater coordination in aircraft icing detection and to form a National Aircraft Icing Program Council. The Council was established in 1984.

The Council's Working Group for Aircraft Icing prepared the initial ***National Aircraft Icing Technology Plan***, published in 1986. The planned program has dual objectives: 1) improving aircraft icing detection technologies for the current generation of aircraft, and 2) promoting advances in aircraft icing detection technology that will be needed by 1995 to meet national aeronautical goals for new generations of aircraft.

One section of the technology Plan, "Detecting, Monitoring, and Forecasting" is addressed in detail in the follow-on ***National Plan to Improve Aircraft Icing Forecasts***, which was prepared by an ad hoc group for the Committee for Aviation Services, and published in 1986.

The FAA established a 6-year funding schedule beginning in FY 1990 to achieve the goals set forth in the icing forecasting plan. The principal work has been performed at the National Center for Atmospheric Research through field data collection exercises; subsequent analyses will develop an icing index. Although there has been funding interruption, a modest effort is programmed for FY 1995.

An extension of the program is investigating the use of Doppler radar observations of snowfall location and movement in conjunction with wind and temperature data to provide estimates of icing on the ground at air terminals. This part of the program may provide short-term forecasts for the onset, duration, and severity of snow showers and the icing severity at airports.

Post-Storm Data Acquistion

A Working Group for Post-Storm Data Acquisition (WG/PSDA) was established by the Interdepartmental Committee for Meteorological Services and Supporting Research to prepare an interagency plan for scientific and engineering data acquisition, especially highly perishable data, after coastal storms, tornadoes, tsunamis, and lake storms. Active participants are from the U.S. Army Corps of Engineers, National Weather Service, Federal Emergency Management Agency, U.S. Geological Survey, NOAA Coastal Oceans Program, National Institute for Standards and Technology, and the U.S. Department of Agriculture's Soil Conservation Service. The group met in January 1994 to review the response to Hurricane Emily and to continue work on the Federal plan, which is designed to improve coordination among the Federal agencies and reduce duplication of effort. The goal is to complete the plan in 1994.

Volcanic Ash Reporting and Warning

At the request of the Federal agencies in 1993, the ICMSSR established the Ad Hoc Group for Volcanic Ash (AHG/VA) to develop a National Plan for Volcanic Ash Reporting and Warning. The Plan will identify responsibilities of the Federal agencies to report and collect data on volcanic disturbances and eruptions, and to develop forecasts and warnings of locations and movement of ash plumes or clouds. The initial meeting was attended by members from FAA, Air Resources Laboratory, NWS, NESDIS, USGS, and OFCM. AHG/VA discussed the scope of their work, addressed the Terms of Reference, standardized some terminology, and prepared a preliminary outline of the Plan.

Operational Processing Centers

The Committee for Operational Processing Centers (COPC) comprises the Nation's four operational processing centers (OPCs) -- NOAA's National Meteorological Center (NMC), the Air Force Global Weather Central (AFGWC), and the Navy's Fleet Numerical Meteorology and Oceanography Center (FLENUMMETOCCEN) and Naval Oceanographic Office (NAVOCEANO). The directors of the four OPCs meet on a semi-annual basis to review data issues, modeling activities, and cooperative efforts. The 1993 meetings were hosted by FLENUMMETOCCEN and AFGWC and included a detailed review of each site's activities. Discussions also focused on the status of the Navy-Air Force cooperative efforts with regards to impacts on the OPCs and on Navy/NOAA Cooperation Team efforts in the oceanography arena. A key project underway is the development of a strategic plan for the OPCs which continues to be refined at each meeting.

Meteorological Information Management

The development of new, higher-resolution atmospheric observational systems, the operational deployment of large-scale graphic and alphanumeric communications and display systems, and the transition from traditional paper and film displays for graphical and satellite imagery to automated digital displays, mean that a virtual explosion of meteorological information is occurring and will continue for the foreseeable future. The tremendous volume and complexity of new information threatens to overwhelm present-day archival systems and lead to confusion and serious inefficiencies in the application of retrospective data to scientific and operational needs.

At the same time, the explosion of data is coupled to a growing demand for retrospective meteorological data to support research initiatives, such as analysis of global change, and operational uses such as military planning and environmental and engineering studies. These factors have led to a proliferation of retrospective databases and the real possibility of significant duplication of effort and development of incompatible databases by Federal agencies, other producers, and users.

Recognition of this growing problem led ICMSSR to establish the Working Group for Meteorological Information Management. The aims of this Group are to review current agency plans and requirements, develop guidelines for new data systems, develop a national reference system for retrospective databases, and devise a coordination mechanism to ensure, (1) that user needs are considered, and (2) that duplication of effort is eliminated to the extent possible. In 1991, the Working Group published the ***Federal Plan for Meteorological Information Management***. The document outlines Federal agency requirements for retrospective meteorological data, recommends interagency data management and coordination actions, and describes a proposed national reference system for federally-owned, retrospective, meteorological

databases. The Working Group is continuing to implement appropriate portions of the plan.

National Program for Lightning Detection Systems

The Working Group for Lightning Detection Systems (WG/LDS) has compiled agency requirements for lightning detection and developed a set of standards for lightning detection systems. These documents formed the foundation for a National Weather Service procurement of operational lightning data from a commercial source and a Request for Proposal was issued in February 1991. Proposals were received and evaluated. Contract award took place in August 1992. The data are used routinely in NWS field operations. Meanwhile, various other agencies are arranging to make use of lightning data to meet their requirements.

No-GOES Contingency Plan

NOAA has refined its No-GOES Contingency Plan in the event that an interruption occurs in GOES-7 imaging operations prior to GOES-8 achieving operational status -- planned for October 1994. To date five national tests have been conducted by NOAA, the latest performed in December 1993.

These operational tests have served as a mechanism to further improve products and communication procedures to ensure the timeliness, quality, and utility of the No-GOES imagery. After each test, feedback from the user community assists NOAA in establishing an optimum suite of No-GOES products. Data from NOAA and DOD polar orbiting satellites and from the EUMETSAT/European Space Agency's (ESA) Meteosat-3 satellite have been enhanced to present these data in the most useful format for operational meteorological users.

When GOES-8 becomes fully operational in October 1994, NOAA will have a nominal two-GOES operation. Meteosat-3 will be placed in a backup mode until the successful launch and checkout of GOES-J, or the failure of GOES-7. A nominal two-GOES operation will greatly diminish the need for No-GOES product contingencies.

Hydrometeorology

The Working Group for Hydrometeorology (WG/HM) has been addressing areas for mutual cooperation and coordination in hydrometeorology. One of its first tasks has been the development of a handbook for automated flood warning systems, a task still in progress. The group also recommended the workshop held in late 1991 that was sponsored jointly by OFCM and the Department of the Interior's Office of Water Data Coordination. The workshop addressed three particular items:

- the archiving of the NEXRAD precipitation data;
- the rain gage networks to calibrate the Doppler radars;
- the dissemination of information to users of radar data.

A report summarizing the results of the workshop was issued in January 1992, and the complete proceedings were published in September 1992.

Atmospheric Transport and Diffusion

The Working Group for Atmospheric Transport and Diffusion (WG/ATD) published the first ***Directory of Atmospheric Transport and Diffusion Models, Equipment, and Projects*** in March 1991. A new directory was published in April 1993.

Space Environment Services and Supporting Research

The National Space Environment Forecast and Warning Program provides Federal agencies and public users real-time space environment data, forecasts of the time of terrestrial impact of significant solar output variations, and warnings of solar events threatening human life or effective and economic operation of modern technical systems. The common needs of the participating agencies have led to a program of shared resources and responsibilities that extend to observations and to operation of forecast centers that provide standard services to meet those needs.

Observations of solar activity with optical and radio telescopes are provided by the Department of Defense (DOD). Solar and near-Earth space environment observations are provided by complementary sensors on DOD and Department of Commerce (DOC)/NOAA environmental satellites. Research data, also useful for the forecast and warning services, are obtained from other agencies and shared through real-time communications networks and jointly operated databases. Research data from experiments sponsored by the National Science Foundation (NSF) was made available through these data sharing

arrangements. Provision for real-time access to data from National Aeronautics and Space Administration satellites has been made for missions where the data are shown to have operational use and where logistical arrangements for data reception can be worked out. The Departments of Energy (DOE) and Interior (DOI) make space-based and ground-based data available through similar arrangements. The Department of Transportation (DOT) operates radio navigation systems that also provide information on the state of solar-terrestrial disturbances. Universities and private foundations engaged in solar-terrestrial research contribute to the pool of observations. Finally, real-time exchange of data with other countries through the International Ursigram and World Days Service fills gaps in the U.S. observing system. A Japanese satellite equipped with a special U.S. sensor provides X-ray imaging of the Sun. Most of the data gathered in this program are archived in data centers for use in future studies.

The data gathered in the space environmental monitoring program need to be reduced to a set of standardized indices and warnings and used to make forecasts of future levels of activity. A Space Environment Services Center to provide the forecasts and warnings and databases to the agencies is operated jointly by DOD and DOC/NOAA in Boulder, CO to meet common needs. Some agencies, such as DOD's Air Force Space Forecast Center (AFSFC) at Falcon Air Force Base, CO, also operate dedicated centers to meet specific agency needs beyond those provided by the common service. Most of the data gathered in the operational portion of the space environment program are archived in the National Geophysical Data Center.

The role and responsibilities of agencies participating in the space environment program are detailed in the ***National Plan for Space Environment Services and Supporting Research, 1993-1997*** (FCM-P10-1993), which was prepared by the OFCM Committee for Space Environment Forecasting and published in 1993.

Monitoring the Stratosphere

There is considerable public concern and political debate about the possible man-made effects and influences on the ozone layer. Similarly, there are concerns about possible changes in the Earth's global climate. To measure these effects and changes, if any, long-term monitoring of the ozone and other stratospheric trace gases and temperatures is necessary. The data obtained from this stratospheric monitoring are used to support long-term global studies that can be regarded as "basic" research. However, the stratospheric monitoring is an operational activity that is an extension of atmospheric monitoring for weather and climate. As a result, it is included in this Plan.

In 1982, OFCM published ***The National Plan for Stratospheric Ozone Monitoring and Early Detection of Change, 1981-1986***. The plan developed a program of transition from a reliance on a ground-based network to a combined satellite and ground-based program providing global coverage of ozone and temperature.

The more recent ***National Plan for Stratospheric Monitoring, 1988-1997*** (FCM-P17-89) published in 1989 builds on the previous effort and, in particular, stresses that the problem is not simply one of detecting ozone change. The complex interactions of chemistry, radiation, and dynamics require that meteorological parameters and many chemical species be monitored. Moreover, experience has shown that monitoring, per se, is not a simple engineering problem of taking observations at a station. The stratospheric changes being sought are relatively small, thus monitoring should be considered as a combination of theory, laboratory measurements, field measurements, and interpretation. Sections in the plan give detailed attention to monitoring ozone, meteorology (temperature and winds), solar irradiance, source gases, and trace gases. The agencies' programs and plans for monitoring are described.

Operational measurement programs for the source gases and the satellite measurements of ozone and temperature continue. In addition, the international Network for Detection of Stratospheric Change (NDSC) initiated operations in 1992 and continues further development. Also, the Upper Atmosphere Research Satellite (UARS) launched in September 1991 will play an important role in evaluation of other monitoring products.

In addition, NOAA/NESDIS is considering plans to incorporate high-altitude microwave channels (sensing above 40 km) as part of the next-generation

satellite system. The lack of this information was identified in the National Plan as a major deficiency of the monitoring program. Unfortunately, these high-altitude channels can not be included until the late 1990's. Fortunately, the DOD is planning to include a somewhat different version of the high-altitude microwave channels on their operational SSM/I satellite beginning in about 1996. These data would fill the gap in coverage and the Working Group for Monitoring the Stratosphere has recommended that these data be included within the NOAA operational temperature processing system.

Committee and Working Group Changes

A schematic of the Federal Committee structure for meteorological coordination is found on the back inside cover of this Plan. In the past year, ICMSSR established the Working Group for Climate Services which will report directly to ICMSSR. (See page 2-6.) ICMSSR also disestablished the Ad Hoc Group for Emergency Weather Support; the Group had completed the work for which it had been established.

Meteorological Publications of OFCM

The preparation of Federal plans is a major responsibility of the Federal Coordinator and requires extensive planning and coordination. Generally, Federal plans are prepared for each of the specialized meteorological services and for meteorological programs common to two or more agencies. The Federal coordinating committees and working groups compile information from the involved agencies and proposes a unified plan for consideration. Current publications of the Federal Coordinator for Meteorology are listed in Table 2.1. In general, single copies are available upon request to OFCM.

RELATED FEDERAL METEOROLOGICAL COORDINATION

The focus of OFCM and of this report is on Federal operational meteorological programs and *supporting* research that directly supports the operational programs. Brief descriptions are given below of Federal coordination activities that are not specifically a part of OFCM activities.

Convergence of DOD and DOC Operational Polar-Orbiting Satellite Programs

President Clinton signed a Presidential Decision Directive (PDD) in May 1994, directing the Department of Defense to merge DMSP follow-on acquisition efforts with the Department of Commerce's Polar-orbiting Operational Environmental Satellite system follow-on acquisition team. An Integrated Program Office (IPO) will be established by October 1994 to develop and manage the next generation of polar-orbiting operational environmental satellites planned for the year 2004. The IPO staff will be selected from the Departments of Defense and Commerce, and NASA. The "converged" system will be tentatively identified as the National Polar-orbiting Operational Environmental Satellite System (NPOESS). International participation in the NPOESS was encouraged in the Presidential directive, and discussions with the European meteorological satellite organization are underway for inclusion of their spacecraft into the final satellite configuration.

Atmospheric Research

The Subcommittee for Atmospheric Research (SAR) has been the principal mechanism for coordination of research in atmospheric sciences within the Federal Government (i.e., broad research that does not directly support operational meteorological programs). SAR was a subcommittee under the former Committee on Earth and Environmental Sciences (CEES) which was under the former Federal Coordinating Council for Science, Engineering and Technology (FCCSET). In 1993, the FCCSET, along with its committee structure, was replaced by the National Science and Technology Council (NSTC). The NSTC established the Committee on Environment and Natural Resources (CENR). The status of SAR is currently under review.

The primary goal of SAR has been to improve the planning and coordination of atmospheric research activities among the agencies involved. Agencies represented on SAR have been the U.S. Departments of Agriculture, Commerce, Defense (Army, Navy, Air Force), Energy, Interior, State, and Transportation.

The Environmental Protection Agency, National Aeronautics and Space Administration, and National Science Foundation are also represented. Observers from several other agencies such as the Office of the Federal Coordinator for Meteorology, the Office of Science and Technology Policy, the Office of Management and Budget, and the National Academy of Sciences/National Research Council complete the SAR.

SAR publishes a biennial report of the ***National Atmospheric Sciences Program*** that is distributed widely. The latest report distributed in 1993 highlights 1987-1990 activities and budgets.

To ensure close coordination with the new CENR organization, OFCM has established representatives on the four atmospheric-science related subcommittees: Global Change Research, Air Quality Research, Water Resources/Coastal & Marine Environments Research, and the Natural Disasters Reduction Subcommittee.

World Weather Program

Some Federal agencies participate in international activities relating to meteorological services and data exchange. These activities are carried out under the World Weather Program of the World Meteorological Organization which is a specialized agency of the United Nations. The World Weather Program is described in Appendix E.

Table 2.1 Current Publications of OFCM

Publication Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 1995	May 1994	FCM-P1-1994
National Plan for Space Environment Services and Supporting Research: 1993-1997	August 1993	FCM-P10-1993
National Severe Local Storms Operations Plan	April 1994	FCM-P11-1994
National Hurricane Operations Plan	May 1994	FCM-P12-1994
National Winter Storms Operations Plan	October 1993	FCM-P13-1993
Federal Plans for Mutual Support and Cooperative Backup Among Operational Processing Centers	March 1985	FCM-P14-1985
National Plan for Stratospheric Monitoring, 1988-1997	July 1989	FCM-P17-1989
National Aircraft Icing Technology Plan	April 1986	FCM-P20-1986
Preliminary National Plan for Lightning Detection Systems	June 1988	FCM-P22-1988
Federal Plan for the Coordination of Automated Weather Information System Programs	May 1988	FCM-P23-1988
Federal Plan for Meteorological Information Management	July 1991	FCM-P24-1991
National Plan for Tropical Cyclone Research Change 1 (update inserts)	July 1992 March 1993	FCM-P25-1992
National Aviation Weather Program Plan	September 1992	FCM-P27-1992
Federal Meteorological Handbook No. 1 - Surface Observations	August 1994	FCM-H1-1994
Federal Meteorological Handbook No. 2 - Surface Synoptic Codes Surface Synoptic Code Tables (Update)	December 1988 July 1990	FCM-H2-1988 FCM-T1-1990
Federal Meteorological Handbook No. 10 - Rocketsonde Observations	December 1988	FCM-H10-1988
Federal Meteorological Handbook No. 11 - Doppler Radar Meteorological Observations		
Part A - System Concepts, Responsibilities and Procedures	June 1991	FCM-H11A-1991
Part B - Doppler Radar Theory and Meteorology	June 1990	FCM-H11B-1990
Part C - WSR-88D Products and Algorithms	February 1991	FCM-H11C-1991
Part D - WSR-88D Unit Description and Operational Analysis	April 1992	FCM-H11D-1992
Directory of Atmospheric Transport and Diffusion Models, Equipment, and Projects	April 1993	FCM-I3-1993
Federal Directory of Mobile Meteorological Equipment and Capabilities	March 1993	FCM-I5-1993
Tropical Cyclone Studies Tropical Cyclone Studies Supplement	December 1988 August 1989	FCM-R11-1988 FCM-R11-1988 S
Interdepartmental Meteorological Data Exchange System Report, IMDES	July 1991	FCM-R12-1991
Federal Meteorological Requirements 2000	October 1990	FCM-R13-1990
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	May 1990	FCM-S2-1990
Standard Telecommunication Procedures for Weather Data Exchange	October 1991	FCM-S3-1991
Federal Standard for Siting Meteorological Sensors at Airports	August 1994	FCM-S4-1994
48th Interdepartmental Hurricane Conference (Minutes)	February 1994	None

SECTION 3

RESOURCE INFORMATION AND AGENCY PROGRAM UPDATES

Budget requests for meteorological services and supporting research total $2.443 billion for FY 1995. This is an increase of 2.8 percent from the $2.377 billion appropriated for FY 1994. Of the total, the Department of Commerce budget represents 48.7 percent, Department of Defense represents 24.5 percent, and Department of Transportation represents 18.3 percent, with the remaining 8.5 percent for other agencies.

The tables in this section summarize fiscal information of the Federal Government for the fiscal years 1994 and 1995. The funds shown are those used to provide meteorological services and associated supporting research that has as its immediate objective the improvement of these services. Fiscal data are current as of the end of February 1994 and are subject to later changes. The data for FY 1995 do not have legislative approval and do not constitute a commitment by the U.S. Government. The budget data are prepared in compliance with Section 304 of Public Law 87-843, in which Congress directed that an annual horizontal budget for meteorological programs in the Federal agencies be prepared.

AGENCY OBLIGATIONS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

The fiscal information in Table 3.1 is presented, by agency, for meteorological operations and supporting research and shows the funding level for FY 1994 based on Congressional appropriations, the budget request for FY 1995, the percent change, and the individual agencies' percent of the total Federal funding for FY 1994 and FY 1995.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 1995 is $25.18 million for operations and supporting research. This is a decrease from the planned funding level of $27.30 million for FY 1994. The FY 1995 request for meteorological operations ($11.94 million) permits USDA to assist the Department of Commerce in determining farmers' needs for weather information and in disseminating such information to them. Major USDA activities related to weather observations include the need to complete incremental modernization of the snow telemetry (SNOTEL) system operated by the Soil Conservation Service and the replacement of manual fire rating stations with remote automated weather stations (RAWS) by the Forest Service. The SNOTEL and RAWS networks provide cooperative data for NOAA's river forecast activities, the irrigation water supply estimates, and Bureau of Land Management operations. The modernization of the RAWS entered the testing for acceptance phase in FY 1993.

The supporting research component of the USDA request ($13.24 million) focuses on understanding the interactions of weather and climate with plant and animal production and water resources management. The mission of the supporting research is to develop and disseminate information and techniques to ensure an abundance of high-quality agricultural commodities and products while minimizing adverse effects of agriculture on the environment. The research budget does not include the coordinated effort with EPA on ultraviolet radiation. The Forest Service program, initiated in 1988, supports a research program for a long-term monitoring network to assess potential effects of global climate change and variability on forest health and productivity. Work continues in the forestry ecological systems modeling. In FY 1995, Agriculture Research Service will continue hydrologic work on a regional scale. The special grant of $400,000 in FY 1994 for the North Dakota Agricultural Weather program was not continued in FY 1995. Other reductions include $2.0 million in the climate and forestry research effort for FY 1995.

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 1995 total congressional request of $1,190 million for meteorological programs is 1.8 percent more than the FY 1994 appropriated funds. Changes in NOAA's operations and supporting research for FY 1995 are presented below, subdivided by activities.

Weather Services. Increases for FY 1995 include 179 positions and $45.5 million for the NWS transition

TABLE 3.1 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS*, BY AGENCY

(Thousands of Dollars)

	Operations			% of FY95	Supporting Research			% of FY95	Total			% of FY94	% of FY95
AGENCY	FY94	FY95	%CHG	TOTAL	FY94	FY95	%CHG	TOTAL	FY94	FY95	%CHG	TOTAL	TOTAL
Agriculture	11890	11936	0.4	0.6	15409	13239	-14.1	3.2	27299	25175	-7.8	1.1	1.0
Commerce/NOAA	1090130	1105147	1.4	54.3	78502	84373	7.5	20.6	1168632	1189520	1.8	49.2	48.7
Defense(Subtot)	506249	488422	-3.5	24.0	98875	109422	10.7	26.8	605124	597844	-1.2	25.5	24.5
Air Force	302688	278506	-8.0	13.7	35661	52616	47.5	12.9	338349	331122	-2.1	14.2	13.6
DMSP**	76390	80100	4.9	3.9	31953	28600	-10.5	7.0	108343	108700	0.3	4.6	4.4
Navy	87481	87768	0.3	4.3	6375	6840	7.3	1.7	93856	94608	0.8	3.9	3.9
Army	39690	42048	5.9	2.1	24886	21366	-14.1	5.2	64576	63414	-1.8	2.7	2.6
Interior/BLM	870	870	0.0	0.0	0	0	0.0	0.0	870	870	0.0	0.0	0.0
Transportation/CG	6522	6522	0.0	0.3	0	0	0.0	0.0	6522	6522	0.0	0.3	0.3
Transportation/FAA	360344	412155	14.4	20.3	25840	27189	5.2	6.6	386184	439344	13.8	16.2	18.0
EPA	0	0	0.0	0.0	8100	8500	4.9	2.1	8100	8500	4.9	0.3	0.3
NASA	7907	8476	7.2	0.4	166200	166300	0.1	40.7	174107	174776	0.4	7.3	7.2
NRC	257	270	5.1	0.0	0	0	0.0	0.0	257	270	5.1	0.0	0.0
TOTAL	1984169	2033798	2.5	100.0	392926	409023	4.1	100.0	2377095	2442821	2.8	100.0	100.0
% of FY TOTAL	83.5%	83.3%			16.5%	16.7%			100.0%	100.0%			

* The FY 1994 funding reflects Congressionally appropriated funds; the FY 1995 funding reflects the amount requested in the President's FY 1995 budget submission to Congress.

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

to a modernized weather service (MARDI). This increase will fund the staffing required to operate the new NEXRAD units, prepare for the multi-site operational demonstration, provide required training on the new technologies, and prepare for the nationwide NWS modernization. Recent delays in the transition to modernized operations make it critical now to expedite the field staffing transition; complete scheduled Weather Forecast Office/River Forecast Center relocations; continue with NOAA Weather Radio Console Replacement and other system developments; and continue the certification process as required by Public Law 102-567.

An increase of $7.2 million and 5 FTE for the ASOS program will allow the full-scale production and installation phase of ASOS to continue and support the procurement of back-up sensors, additional ASOS systems, and Planned Product Improvement. An increase of $10.0 million and 18 FTE will support continued AWIPS/NOAAPORT development phase activities that were initiated in December 1992, pre-MARD preparation and risk reduction activities, equipping a limited number of sites, and Operational Test and Evaluation activities to be conducted in FY 1994. And finally, NOAA proposes an increase of $6 million for the NOAA Central Computer Facility. The requested funding level will be used to fully implement the Class VII system (installed in FY 1993), continue the existing Cray YMP 8/32 computer system, and maintain both systems.

DOC funding for the NEXRAD program will decrease by $26.7 million. The remaining funds will support the DOC share of the tri-agency NEXRAD program, including an increase of 9 FTE, the hardware production contract, logistical support for system deliveries in FY 1995 and 1996, and depot and logistics supply support for fielded radar systems. A decrease of $200,000 will result from the proposed termination of repairs to the American Samoa Weather Service Office in FY 1995.

Environmental Satellite, Data, and Information Services. Proposed funding for FY 1995 includes an increase in the polar-orbiting satellite program of $20.1 million and an increase in the geostationary satellite program of $14.3 million. These changes will allow for continuation of procurements to provide the spacecraft and instruments, launch services, and ground systems necessary to assure continuity of environmental satellite coverage. The FY 1995 budget request will maintain a system of polar-orbiting satellites that obtains global data and a system of geostationary satellites that provides near continuous observations of the Earth's western hemisphere.

An increase of $3.1 million is also included to maintain basic mission services including maintenance and operation of satellite ground facilities; provision of satellite-derived products; and conduct of research to improve the use of satellite data. An increase of $2.4 million is requested to restore base levels for archiving and dissemination of climatic, oceanographic and geophysical data.

Weather Research. Requested funding for FY 1995 of this activity, which includes Solar Environmental Research, is $39.5 million -- a decrease of about 8.3 percent from FY 1994. Critical increases are requested for base programs in weather research and space-environment forecasts. An increase of $2.1 million is requested to maintain key weather research components essential to the success of the weather service modernization. An increase of $0.5 million is requested to improve solar forecast data handling and processing capabilities. Total decreases of about $7.7 million are proposed. Although the value of wind profiler data to operational forecasting was demonstrated, the recently completed Wind Profiler Demonstration Network is proposed for termination because of budget constraints. Federal funding for the cooperative five-state Weather Modification Research Program is proposed for termination. This Program supports studies of the physical mechanisms of cloud and precipitation formation. Finally, funding for the new Southeastern U.S. storm research program is also proposed for termination.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 1995 is $597.8 million which is 1.2 percent less than the total funding level for FY 1994. Highlights are given below.

U.S. Air Force

U.S. Air Force resources for meteorological support fall under four categories: general operations, general supporting research, Defense Meteorological Satellite Program (DMSP) operations, and DMSP supporting research.

General Operations. The operations portion of the FY 1995 budget request is $278.5 million, and represents a large portion of the environmental support to the DOD. These funds will pay for weather and space environmental support to the USAF (both active duty and reserve components), the U.S. Army, nine unified commands, and other agencies as directed by the Chief of Staff of the Air Force. Over 4,500 people conduct these activities at over 230 worldwide locations; these people include active duty military, Air Force reservists, Air National Guard weather flight personnel, weather communications and computer specialists, and civilians. General operations funds pay the salaries of the people providing weather support, and the day-to-day operations and maintenance costs for the support they provide.

The FY 1995 request includes $30.2 million for procurement of Air Force standard weather systems needed to sustain and improve on current environmental support capabilities. Acquisition of pre-planned product improvements (P3I) for the Automated Weather Distribution System (AWDS) continues. AWDS P3I retrofits AWDS with enhancements that were either beyond the scope of the original program or beyond the state of the art. Improvements will include ingest of GOES satellite data and weather radar data. Other procurement funding goes to the Weather Information Processing System (WIPS). This computer hardware system upgrade will enable AFGWC to provide meteorological data to DOD command and control systems. It will also process and store new DMSP weather sensor data used by AFGWC's Cloud Depiction and Forecasting System (CDFS), which produces worldwide cloud analysis and forecast products.

General Supporting Research. The FY 1995 budget request for Air Force supporting research is $52.6 million. The Air Force continues R&D efforts in the AWDS P3I area, as well as for the Combat Weather System (CWS), a small, lightweight, modular tactical weather observing and forecast system, for support of Air Force and Army combat operations. In addition, R&D efforts begin in FY 1995 for CDFS II. CDFS II will expand the computer processing capability of the current CDFS at AFGWC, and build a high-resolution, worldwide cloud database by enabling the ingest and exploitation of polar and geostationary weather satellite and sensor data received at AFGWC. A variety of other research efforts will investigate electrodynamics of the Sun and Earth's magnetosphere, ionospheric dynamics, mesoscale meteorology, visible and infrared properties of the environment, and cloud parameterization and prediction.

DMSP Operations. Though funding for DMSP comes from the Air Force, this system is the major source of space-borne meteorological data for the military services and other high-priority DOD programs. Through the shared processing program, the DOD provides environmental data from DMSP sensors to the National Weather Service via the network hub at the National Environmental Satellite, Data, and Information Service, and to the Navy via the network hubs at the Fleet Numerical Meteorology and Oceanography Center and the Naval Oceanographic Office.

The operations portion of the budget request is $80.1 million. The major portion of this funding is for on-orbit operations, tactical terminal procurement, and satellite sensor integration. These funds also pay operations costs for two dedicated command and control facilities. DMSP funds for 400 military and civilian personnel associated with the operation of, and to a much smaller extent, the procurement of the DMSP system.

DMSP Supporting Research. The FY 1995 budget request for DMSP research and development is $28.6 million. The 1994 Congressional Authorization and Appropriations Conferences directed that future DMSP Block 6 funding be used only for studies of a joint DOD/NOAA weather satellite program. Accordingly, FY 1995 funds are for concept studies for the next generation civil/military satellite system, which is scheduled to replace the Block 5D-3 production spacecraft in 2004. This system will offer improved avionics and will exploit advanced hardware and software technologies to produce a more reliable, longer-lived spacecraft with greater mission capability. The remaining funds are for continued calibration and validation efforts for new and modified sensors and modification of data application algorithms.

U.S. Navy

The U.S. Navy FY 1995 funding request for meteorological programs is $94.61 million. The

request includes $87.77 million for operational programs and $6.84 million for supporting research.

Operations Support. Operations support for the Navy and Marine Corps includes the day-to-day provision of meteorological and oceanographic (METOC) products and services. Significant changes continue with a fundamental shift in operational focus to expeditionary war-fighting support. Reliable and timely METOC information is critical to identifying operational limits imposed by the maritime and littoral environments on war fighting forces, sensors and platform performance.

Navy provides specific and unique services such as acoustic propagation models/products and global ice analysis and forecast products to all components; Navy also provides METOC-sensitive tactical decision aids. Primary program direction for FY 1995 continues to improve data collection and processing capabilities for METOC support in littoral areas. Plans include upgrades to the Primary Oceanographic Prediction System (POPS) super computing site at Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA. This system will ultimately assume the global and regional numerical meteorological prediction responsibilities for the Department of Defense (DOD).

Systems Acquisition. Major systems undergoing procurement in FY 1994 and FY 1995 include:

- Tactical Environmental Support System (TESS(3))
  - Naval Integrated Tactical Environmental Sub-System (NITES);
- Primary Oceanographic Prediction System (POPS)
  - Oceanographic and Atmospheric Support Information System (OASIS);
- SMQ-ll Environmental Satellite Receiver /Recorder;
- Automated Surface Observing System (ASOS);
- Shipboard Meteorological and Oceanographic Observation System (SMOOS);
- NEXRAD Principal User Processors (PUP) Supplemental Radar;
- Meteorological Mobile Facility (Marine Corps);
- GEOSAT Follow-On (GFO) Project.

Research and Development. This area is generally not system-specific, but may have applications to one or more meteorological, oceanographic or tactical system. Navy's tabulation of these data includes R&D funding for demonstration, validation, engineering, and manufacturing initiatives.

The U.S. Navy and Marine Corps' initiatives, under sponsorship of the Oceanographer of the Navy, transition work started under exploratory development to operational Navy systems. Work in this area includes upgrades to the Navy's numerical METOC forecasting capability; improvements in communications including data compression techniques; and development/improvement of models to better predict METOC parameters in littoral regions as well as the impact these parameters have on sensors, weapon systems, and platform performance.

U.S. Army

The U.S. Army is requesting $42.0 million for operational support and $21.4 million in Research and Development in FY 1995. Operations show a decrease from FY 1994 by about $3.5 million caused by reduction in forces or facilities. The salaries and equipment costs continue to increase but the decrease in force structure and some training cost has resulted in a decrease in total cost of operational support. Cost associated with the USAF weather teams supporting Army units remain about the same.

Acquisition cost associated with the Field Artillery Meteorological Measuring System (MMS) and the Meteorological Hydrogen Generator (MHG) remained on track in FY 1994 with $10.7 million to complete the MMS acquisition and $6.8 million programmed in FY 1995 for the MHG. The Integrated Meteorological System (IMETS) was approved for Low Rate Initial Production in FY 1994 and has $7.6 million programmed for FY 1995. Within U.S. Army Europe (USAREUR) and Forces Command (FORSCOM) equipment costs are associated with maintaining software and hardware for existing tactical weather systems until IMETS is fielded or for procuring light weight portable computers for contingency weather support.

Army Materiel Command (AMC) funding of $7.8 million in FY 1995 for Test and Evaluation Command (TECOM) Meteorological (Met) Teams was a decrease

TABLE 3.2 AGENCY OPERATIONAL COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

AGENCY	Operations Support		Systems Acquisition		Special Programs		Total			% of FY95 TOTAL
	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	%CHG	
Agriculture	11318	11298	0	0	572	638	11890	11936	0.4	0.6
Commerce/NOAA	632079	641544	452445	457724	5606	5879	1090130	1105147	1.4	54.3
Defense(Subtot)	414937	415782	91296	72545	16	95	506249	488422	-3.5	24.0
Air Force	252618	248317	50070	30189	0	0	302688	278506	-8.0	13.7
DMSP*	52800	57600	23590	22500	0	0	76390	80100	4.9	3.9
Navy	83913	84452	3568	3316	0	0	87481	87768	0.3	4.3
Army	25606	25413	14068	16540	16	95	39690	42048	5.9	2.1
Interior/BLM	870	870	0	0	0	0	870	870	0.0	0.0
Transportation/CG	6522	6522	0	0	0	0	6522	6522	0.0	0.3
Transportation/FAA	250109	252719	108740	157816	1495	1620	360344	412155	14.4	20.3
EPA	------ Not Applicable ------									
NASA	5854	6071	1090	1403	963	1002	7907	8476	7.2	0.4
NRC	257	270	0	0	0	0	257	270	5.1	0.0
TOTAL	1321946	1335076	653571	689488	8652	9234	1984169	2033798	2.5	100.0
% of FY TOTAL	66.6%	65.6%	32.9%	33.9%	0.4%	0.5%	100.0%	100.0%		

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

of 7 percent from FY 1994 funding of 8.25 million. Since FY 1990, the Met Team budget has lost 50 percent in funding and 22 percent in personnel authorizations. Consequently, the Met Teams will provide only the basic weather support to operations with 11 teams for 12 Army Research, Development, Test and Evaluation (RDTE) ranges and sites. Reductions in this program are expected to limit training and decrease parts inventories and personnel and strength.

In Research and Development, Army Research Laboratory, Battlefield Environment Directorate (ARL/BED) funding in applied research (6.5) was cut by $5.1 million from $9.55 million to $4.45 million and is programmed to be eliminated in FY 1996. Basic research is expected to remain about the same in FY 1995. Potential future funding in air pollution research will be investigated in FY 1995. Communication and Electronic Command, and the Research Institute of Environmental Medicine budgets remain about the same in FY 1994 and FY 1995 at about $800,000 for each organization. Army Research Office remains level funded except for an increase of $1.25 million for a Congressionally mandated program.

DEPARTMENT OF THE INTERIOR (DOI)

The DOI funding request of $870,000 for FY 1995 is for meteorological operations within the Bureau of Land Management (BLM). In 1987, the funding and implementation for the Bureau-wide Initial Attack Management System (IAMS) and the Remote Automated Weather Station (RAWS) programs were re-emphasized and the program was completed in 1992. This emphasis increased the operational and maintenance (O&M) funding required and the procurement funding needed to complete the total system. Annual increases in program costs are attributed to the increased requirements of personnel, travel, and operations to cover the added stations and network expansion to full implementation. After full implementation is reached, procurement costs will be reduced to systems life cycle change-out and O&M costs will normally plateau.

DEPARTMENT OF TRANSPORTATION (DOT)

The meteorological programs for the U.S. Coast Guard and the Federal Aviation Administration for FY 1994 and FY 1995 are described below.

U.S. Coast Guard (USCG)

All of USCG's funding for meteorological programs is for operations support. In FY 1995, the requested funding level is $6.52 million --the same as FY 1994. There has been no basic change in the meteorological services provided by the Coast Guard. Among the Coast Guard's activities is the collection and dissemination of meteorological information for the benefit of the marine community. The Coast Guard provides coastal and marine weather observations to NOAA's National Weather Service (NWS), transmits NWS products to marine users and provides engineering expertise and buoy support facilities to the National Data Buoy Center.

Federal Aviation Administration (FAA)

The total FAA request for aviation weather in FY 1995 is $439.3 million for both operations and supporting research; the FAA funding for FY 1994 for aviation weather was $386.2 million. The increase in the budget is principally in operations which will rise from the appropriated $360.3 million to the requested $412.2 million. Funding for Supporting Research will increase about 5.2 percent to $27.2 million.

The FAA involvement in meteorological programs is principally concerned with aviation weather. The FAA role is limited to the observation and dissemination of aviation weather information and to short range automated warnings and forecasts (see Appendix C). FAA's aviation weather programs are directed to improve the timeliness and accuracy of weather information to the aviation user when and where it is needed. The FAA also supports research in those areas that involve improvements to the observation, data dissemination, and forecasting of aviation weather; the end user of the resulting products include pilots, dispatchers, and air traffic controllers.

The FY 1995 increases are in Systems Acquisition (see Table 3.2) as FAA continues to increase its capabilities to monitor and disseminate aviation weather to pilots, dispatchers, and controllers. Individual system acquisition and operational programs with increases greater than $2 million are listed below:

TABLE 3.3 AGENCY SUPPORTING RESEARCH COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

AGENCY	Research & Development		Systems Development		Special Programs		Total			% of FY95
	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	%CHG	TOTAL
Agriculture	15409	13239	0	0	0	0	15409	13239	-14.1	3.2
Commerce/NOAA	50371	54864	20781	29509	7350	0	78502	84373	7.5	20.6
Defense(Subtot)	88540	87122	10335	22300	0	0	98875	109422	10.7	26.8
Air Force	26571	31626	9090	20990	0	0	35661	52616	47.5	12.9
DMSP*	31953	28600	0	0	0	0	31953	28600	-10.5	7.0
Navy	6375	6840	0	0	0	0	6375	6840	7.3	1.7
Army	23641	20056	1245	1310	0	0	24886	21366	-14.1	5.2
Interior/BLM					------ Not Applicable ------					
Transportation/CG					------ Not Applicable ------					
Transportation/FAA	2140	260	23700	26929	0	0	25840	27189	5.2	6.6
EPA	8100	8500	0	0	0	0	8100	8500	4.9	2.1
NASA	108500	108900	57700	57400	0	0	166200	166300	0.1	40.7
NRC					------ Not Applicable ------					
TOTAL	273060	272885	112516	136138	7350	0	392926	409023	4.1	100.0
% of FY TOTAL	69.5%	66.7%	28.6%	33.3%	1.9%	0.0%	100.0%	100.0%		

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

Program	Increase ($millions)
Operations Support:	
Flight Service Stations Operations	$3.1
Systems Acquisition:	
Automated Surface Observing System	23.3
Graphic Weather Display System	3.1
Weather and Radar Processor	2.8
Terminal Doppler Weather Radar	19.2
Aeronautical Data Link	4.8
FSAS OPS Support Implementation Sys.	4.6

In FY 1995 there will be slight decreases in the Acquisition funding for AWOS and the ASOS Data Acquisition System (ADAS); plus, the Digital Altimeter Setting Indicator and the Weather Message Switching Center Replacement funding will be moved to the Operational Support Category.

The FY 1995 budget for Operational Support is nearly level with the increases in FSS operations being offset by reductions in man-hours due to a reevaluation of maintenance resource allocation to weather equipment. The phaseout of the old Weather Message Switching Center and its communications (NATCOM) are somewhat balanced by the WMSCR and its communications (NADIN). The Worldwide Aeronautical Forecast System will become operational in early 1995.

The supporting research funding increases from $26.5 million in FY 1994 to $28.0 million in FY 1995. The more significant increases are $2.5 million for the Aviation Weather Products Generator and $1.7 million for the Integrated Terminal Weather System. Decreases offsetting those increases occur in programs for Airborne Meteorological Sensors and the Airborne Wind Shear programs. The definition of supporting research used in this Plan generally incorporates a broader spectrum of activities than is covered by FAA's other research and development programs.

The number of personnel (full-time-equivalent, FTE) expected to be engaged in FAA's FY 1995 aviation weather program is 3050; this is a 3.6 percent decrease from the FY 1994 level. The reduction is primarily related to decreases in personnel required for meteorological equipment maintenance.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of EPA's funding of meteorological programs is for supporting research. The anticipated funding level in FY 1995 is $8.50 million, representing an increase of nearly five percent over the revised FY 1994 level.

Funding for modeling research into visibility degradation and acid deposition will be reduced during FY 1995. These decreases will be more than offset by increases in funding for the North American Research Strategy on Tropospheric Ozone (NARSTO) and for meteorological modeling efforts to determine sources and pathways for investigations into the effects of inhalation of particulate pollution. Congressional appropriations are expected to continue during FY 1995, providing for performance of the Southern Oxidant Study and for field studies and modeling of accidental releases of toxic and/or hazardous materials.

The EPA is continuing its development and validation of air quality dispersion models for air pollutants on all temporal and spatial scales as mandated by the Clean Air Act, as amended. Research will focus on indoor, urban, mesoscale, and regional models which will be used to develop air pollution control and exposure assessment strategies. There will be increased emphasis placed on meteorological research into regional and urban transport of ozone and particulate pollution, while research into acid deposition model development and evaluation decreases. Increased efficiency of computation and interpretation of results are being made possible by means of high performance computing and scientific visualization techniques.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Virtually all of NASA's funding in meteorology is for supporting research. The requested funding for this supporting research in FY 1995 is $166.3 million, which is almost unchanged from the revised FY 1994 level. The FY 1995 level reflects nearly 8 percent reduction in funding for all of the supporting research and analysis programs and a corresponding increase in the meteorology share of the Earth Observing System (EOS) instruments, EOS science, and the EOS Data and Information Systems.

TABLE 3.4 AGENCY OPERATIONAL COSTS, BY SERVICE

(Thousands of Dollars)

	Basic Meteorology		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
AGENCY	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95
Agriculture	0	0	0	0	0	0	11890	11936	0	0	0	0	11890	11936
Commerce/NOAA	957251	1014009	50056	50706	14944	16740	2765	2765	0	0	65114	20927	1090130	1105147
Defense(Subtot)	15134	14921	328789	305833	25334	24408	0	0	132364	138635	4628	4625	506249	488422
Air Force	0	0	302688	278506	0	0	0	0	0	0	0	0	302688	278506
DMSP*	0	0	0	0	0	0	0	0	76390	80100	0	0	76390	80100
Navy	15134	14921	25982	27208	25334	24408	0	0	16403	16606	4628	4625	87481	87768
Army	0	0	119	119	0	0	0	0	39571	41929	0	0	39690	42048
Interior/BLM	0	0	0	0	0	0	0	0	0	0	870	870	870	870
Transportation/CG	5495	5495	0	0	1027	1027	0	0	0	0	0	0	6522	6522
Transportation/FAA	0	0	360344	412155	0	0	0	0	0	0	0	0	360344	412155
EPA	------ Not Applicable ------													
NASA	0	0	0	0	0	0	0	0	0	0	7907	8476	7907	8476
NRC	77	90	0	0	0	0	0	0	0	0	180	180	257	270
TOTAL	977957	1034515	739189	768694	41305	42175	14655	14701	132364	138635	78699	35078	1984169	2033798
% of FY TOTAL	49.3%	50.9%	37.3%	37.8%	2.1%	2.1%	0.7%	0.7%	6.7%	6.8%	4.0%	1.7%	100.0%	100.0%

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

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC requested funding of $270,000 for FY 1995 is for meteorological operations. The FY 1995 request is essentially unchanged from the FY 1994 request.

The meteorological support program in the U.S. Nuclear Regulatory Commission is focused solely on obtaining and analyzing meteorological data and information to be utilized in atmospheric transport and dispersion models used in dose projections, plume pathway characterizations and concentration estimates related to the safe operation of nuclear facilities and the protection of public health and safety and the environment. Obtaining current, accurate and relevant meteorological information on a real-time basis for use during emergencies is the primary consideration. The NRC budget in this area reflects this priority.

AGENCY FUNDING BY BUDGET CATEGORY

Table 3.2 (page 3-6) shows how the agencies plan to obligate their funds for meteorological operations broken down by "budget category." The funding levels for each agency were discussed above.

Table 3.3 shows how the agencies plan to obligate their funds for meteorological supporting research according to the budget categories. The two major categories are "Operations Support" and "Systems Acquisition." To a large degree, these correspond to non-hardware costs (Operations Support) and hardware costs (Systems Acquisition). For agency convenience in identifying small components that do not fit into the above two major categories, a third category, is added, "Special Programs." Programs that provide support to several Government agencies such as the Air Force's Defense Meteorological Satellite Program (DMSP) are listed on a separate line. The agencies' supporting research budgets are subdivided along similar lines -- Research and Development (non-hardware), Systems Development (hardware), and again Special Programs for small items that do not easily fit into the first two categories.

AGENCY FUNDING BY SERVICE CATEGORY

Table 3.4 summarizes how the agencies plan to obligate operational funds for basic and specialized meteorological services; Table 3.5 shows a similiar breakout for supporting research funds. Table 3.4 shows that "basic" services require approximately 51 percent of the total operational costs while aviation services require about 37 percent. The remaining 12 percent is used to support the other specialized services. The definitions of specialized and basic services are provided below.

Basic Services

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

Specialized Meteorological Services

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

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

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

General Military Services. Those services and facilities established to meet the requirements of military user commands and their component elements. Programs and services which are part of Basic, Aviation, Marine, or Other Specialized Services are not included here.

TABLE 3.5 AGENCY SUPPORTING RESEARCH COSTS, BY SERVICE

(Thousands of Dollars)

AGENCY	Basic Meteorology		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95	FY94	FY95
Agriculture	0	0	0	0	0	0	15409	13239	0	0	0	0	15409	13239
Commerce/NOAA	76877	82748	1625	1625	0	0	0	0	0	0	0	0	78502	84373
Defense(Subtot)	0	0	35661	52616	6375	6840	0	0	54735	47012	2104	2954	98875	109422
Air Force	0	0	35661	52616	0	0	0	0	0	0	0	0	35661	52616
DMSP*	0	0	0	0	0	0	0	0	31953	28600	0	0	31953	28600
Navy	0	0	0	0	6375	6840	0	0	0	0	0	0	6375	6840
Army	0	0	0	0	0	0	0	0	22782	18412	2104	2954	24886	21366
Interior/BLM	------ Not Applicable ------													
Transportation/CG	------ Not Applicable ------													
Transportation/FAA	0	0	25840	27189	0	0	0	0	0	0	0	0	25840	27189
EPA	0	0	0	0	0	0	0	0	0	0	8100	8500	8100	8500
NASA	0	0	0	0	0	0	0	0	0	0	166200	166300	166200	166300
NRC	------ Not Applicable ------													
TOTAL	76877	82748	63126	81430	6375	6840	15409	13239	54735	47012	176404	177754	392926	409023
% of FY TOTAL	19.6%	20.2%	16.1%	19.9%	1.6%	1.7%	3.9%	3.2%	13.9%	11.5%	44.9%	43.5%	100.0%	100.0%

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

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

PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 3.6 shows agency staff resources in meteorological operations. Overall, agency staff resources requested for FY 1995 total 16,928, which is a decrease of 1.5 percent from FY 1994.

INTERAGENCY FUND TRANSFERS

Table 3.7 summarizes FY 1994 funds transferred from one agency to another agency to pay for services that the second agency can perform more efficiently and effectively. While specific amounts may vary from year-to-year, depending upon agency needs, the pattern shown in this table is essentially stable and reflects a significant level of interagency cooperation.

Department of Commerce (DOC). The USCG will be reimbursed $1.137 million for support to the National Data Buoy Center; and NASA $60,000 for stratospheric studies, and $256.2 million for procurement and launch of satellites.

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TABLE 3.6 PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS
(Units are Full Time Equivalent Staff Years)*

AGENCY	FY94	FY95	%CHG	% of FY95 TOTAL
Agriculture	98	98	0.0	0.6
Commerce/NOAA	6077	6132	0.9	36.2
Reimbursed**	581	581	0.0	3.4
Defense(Subtotal)	7141	6938	-2.8	41.0
Air Force	4780	4587	-4.0	27.1
DMSP*	370	400	8.1	2.4
Navy	1574	1537	-2.4	9.1
Army	417	414	-0.7	2.4
Interior/BLM	16	16	0.0	0.1
Reimbursed**	4	4	0.0	0.0
Transportation/CG	108	108	0.0	0.6
Transportation/FAA	3165	3050	-3.6	18.0
EPA	0	0	0.0	0.0
NASA	0	0	0.0	0.0
NRC	1	1	0.0	0.0
TOTAL	17191	16928	-1.5	100.0

* Numbers of personnel are rounded to nearest whole number.
** "Reimbursed" are personnel funded by other agencies.

Department of Defense (DOD). The Air Force will reimburse DOC a total of $3.10 million for NEXRAD/OSF support ($2.5million), COMET participation ($400,000), shared processing communications ($100,000), OFCM support ($100,000), and $300,000 supporting research for DMSP data archiving. The Navy will reimburse DOC $805,000 for climatological analysis and forecasting; $41,000 for training in satellite applications and forecasting; and $5.31 million for procurement of NEXRAD radars, and $3.811 million for procurement of Automated Surface Observing Systems (ASOS). The Army reimbursements include: DOC $650,000 for operations to maintain precipitation reporting stations, and $101,000 for supporting research relating to atmospheric profiling, basic research and field support; DOI/USGS $400,000 to monitor and operate limited observing sites; the Army will also reimburse NASA $103,000, and the National Laboratories $174,000 for supporting research.

Department of Transportation (DOT). The FAA will reimburse DOC/NOAA $57.7 million for procurement of WSR-88D Doppler radars and ASOS systems. Additionally, NOAA will receive $21.82 million for operational support -- $4.1 million for maintenance of WSR-88Ds and ASOSs, $8.51 million for aviation weather observations, $7.1 million for the Center Weather Support Units at all Air Route Traffic Control Centers, $1.4 million to establish the World Area Forecast System, $409,000 for meteorological instructors at the FAA Academy, and $300,000 for studies and dissemination.

The FAA will reimburse a total of $21.62 million for supporting research. The National Science Foundation will receive $19.34 million -- $10.34 million for the Aviation Weather Product Generator and $9.0 million for the Integrated Terminal Weather System. NASA will receive $2.29 million -- $1.59 million for Airborne Windshear Technology and training, and $700,000 for work related to the Aeronautical Data Link.

National Aeronautics and Space Administration (NASA). The Air Force will be reimbursed $1.650 million for observations and forecasts and $345,000 for data acquisition; NOAA/NWS will be reimbursed $1.352 million principally for meteorological support to the space shuttle operations; NOAA/NDBC $95,000 for operation of data buoys; and NOAA/NCDC $120,000 for climatological data.

Environmental Protection Agency (EPA). NOAA's Air Resources Laboratory will be reimbursed $4.2 million for development, evaluation, and application of air quality dispersion models; provision of meteorological expertise and guidance for EPA policy development activities.

Department of Energy (DOE). The NOAA/NWS will be reimbursed $2.246 million to support the NWS Nuclear Support Office at the Nevada Nuclear Test Site.

Nuclear Regulatory Commission (NRC). NOAA's Air Resources Laboratory will be reimbursed $50,000 for technical assistance, and DOE $80,000 for technical assistance.

FACILITIES/LOCATIONS for TAKING METEOROLOGICAL OBSERVATIONS

Table 3.8 indicates the number of facilities or platforms at which the Federal agencies carry out (or supervise) the various types of weather observations.

TABLE 3.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 1994 Funds ($K) Estimated or Planned Operations	Supporting Research
Commerce/NOAA	DOT/USCG	1,137	
	NASA Studies	60	
	NASA(Procurement)	256,181	
Defense/Air Force	DOC	3,100	$300
Defense/Navy	DOC/NOAA/NCDC	805	
	DOC/NESDIS	41	
	DOC(NEXRAD procurement)	5,310	
	DOC(ASOS procurement)	3,811	
Defense/Army	DOC/NOAA/NWS	650	101
	DOI/USGS	400	
	NASA/GSFC		103
	National Laboratories		174
Transportation/FAA	DOC/NOAA	21,820	
	DOC/NOAA(Procurement)	57,700	
	NSF		19,335
	NASA		2,289
NASA	DOD/USAF	1,650	
	DOD/USAF	345	
	DOC/NOAA/NWS	1,352	
	DOC/NOAA/NDBC	95	
	DOC/NOAA/NCDC	120	
EPA	DOC/NOAA/ARL		4,200
DOE	DOC/NOAA/NWS	2,246	
NRC	DOC/NOAA/ARL	50	
	DOE	80	

TABLE 3.8 FACILITIES/LOCATIONS for TAKING METEOROLOGICAL OBSERVATIONS

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 1994)
Surface, land	
Commerce (all types)	1195
Defense (U.S.)	185
Defense (Overseas)	57
Transportation (Flight Service Station)	95
Transportation (Limited Aviation Wea. Reporting Sttn)	160
Transportation (FAA Contract Wea. Obs. Station)	116
Transportation (Automated Wea. Obs. Station)	183
Transportation (Autom. Surf. Obs. System, fielded)	291
Transportation (USCG Coastal)	124
Interior	214
Agriculture	1080
NASA	3
Surface, marine	
Commerce (Merchant Ship Coop Program)	1,500
Commerce (Merch Ship Coop - Foreign Assisted)	314
Commerce (SEAS-equipped ships)	120
Commerce (Coastal-Marine Automated Network)	52
Commerce (NOAA/NOS)	126
Commerce (Buoys -- 120 moored, 70 drifting)	275
Commerce (Large Navigation Buoys)	9
Commerce (Water Level Gages)	189
Defense (Ships with met personnel)	21
Defense (Ships without met personnel; based on record archivals during CY 1993)	313
Transportation (USCG Ships)	76
NASA	2
Upper air, balloon	
Commerce (U.S.)	131
Commerce (Foreign, cooperative)	0
Defense, Fixed (U.S. & Overseas)	54
Defense, Mobile (U.S. & Overseas)	79
Defense (Ships)	33
NASA (U.S.)	1

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 1994)
Upper air, rocket	
NASA	1
Defense	2
Doppler weather radar (WSR-88D) sites	
Commerce (NWS)	81
Defense (U.S. and overseas)	17
Transportation	4
Off-site WSR-88D Processors (PUPs)	
Commerce (NWS)	40
Defense (U.S. and overseas)	54
Transportation	20
Airport Terminal Doppler weather radars	
Transportation (Commissioned)	1
Conventional radar (non-Doppler) sites	
Commerce (NWS)	71
Commerce (at FAA sites)	27
Defense, Fixed (U.S. and overseas)	66
Mobile units (USMC)	6
Remote displays (Navy RADIDS)	48
Weather reconnaissance (No. of aircraft)	
Commerce (NOAA)	2
Defense (USAFRES)	12
Geostationary meteorological satellites (No. operating)	
Commerce (planned configuration of 2)	1
Polar meteorological satellites (No. operating)	
Commerce (planned configuration of 2)	2
Defense (planned configuration of 2; 1 satellite is only partially operational)	3

SECTION 4

DATA CONTINUITY IN THE CLIMATOLOGICAL RECORD*

Introduction

Changes and improvements in ground-based and space-based observing systems inevitably become part of maturing environmental monitoring programs. These changes include variations in spatial and temporal sampling, processing algorithms, quality assurance procedures, instrumental accuracy and precision, and representativeness of measurements. Occasionally, these improvements inadvertently cause a discontinuity in the data record and unfavorably impact analysis of long-term trends or product interpretation.

Reliable data are fundamental to understanding the earth system and predicting future events. Data collected in the past and present are used to understand atmospheric and oceanographic processes, to develop and verify prediction techniques from daily to interannual time scales, to assess short- and long-term changes in the environment, and to understand the effects of human endeavor on the environment. ***Data continuity*** *is the compatibility of past, present and future data such that the observational record is free of artificial (non-physical) changes.* Construction and use of data sets depends critically on data continuity.

This article first describes data continuity as a characteristic of an ideal monitoring system. Next, the concept is discussed in terms of the current state of affairs. Examples are given which underscore the impact that discontinuities in the climatological record can have on solving environmental and societal issues. The data problems are summarized, and some recommendations are given to help solve the problems.

Data Continuity in a Successful Monitoring System

An attribute of a successful monitoring system is the delivery of timely and relevant data and information with adequate temporal and spatial resolution. In addition, the data from the system should maintain continuity with previous observations. The system should evolve with changes in technology such that there are improvements in data quality and minimal impacts on the homogeneity of past, present and future measurements. This cannot be accomplished without a sound data management system.

Ideally, measurements of an environmental variable are made with respect to a specific problem or goal. The appropriate temporal and spatial scales of the measurements, the accuracy, precision, continuity, and overall quality of the measurements are determined to meet the defined goals of the system. Databases are assembled over time, and when new observing systems are operated simultaneously with old systems, much is known about the calibration and validation between new and old sensors.

Normally, operational observing systems fulfill multiple goals and uses. Users who were never envisioned by the network designers often become dependent on the observing system. In a dynamic healthy system, this is normal and system operators must recognize that, in any long-term monitoring system, user needs will evolve and change with time. However, care must be taken to ensure these improvements or adjustments do not create bogus data changes that could have a physical interpretation during future analysis.

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* The Federal Plan has traditionally included an article on a topic or special program of general interest to the meteorological community; occasionally, the article highlights a problem area that would benefit from additional attention.

At the request of the Office of the Federal Coordinator for Meteorology (OFCM), initial material for this article was prepared by Dr. Nathaniel B. Guttman, on the staff of NOAA's National Climatic Data Center. Additional material was provided by Mr. Andrew H. Horvitz (Meteorologist, ASOS Program, National Weather Service), and Mr. Arthur L. Booth (Manager, NOAA-EOSDIS Program). Beneficial review comments were provided by Dr. Norman Canfield (Climatologist, University of Maryland), Dr. Vernon Derr (formerly Director, NOAA Environmental Research Laboratories, now retired), and Col. Frank Routhier (Assistant Federal Coordinator for the U.S. Air Force and U.S. Army). The OFCM assumes responsibility for overall review and editing.

Metadata, i.e., *information about the data*, is vital for linking old measurements with new data into homogeneous databases. Metadata relate to all the information necessary to interpret measurements, including, but not limited to, instrumental characteristics (e.g., calibration, sensor response, sensor sensitivity), sensor location, site changes, observation times, processing procedures, data transmission procedures, and data summarization or averaging methodology. A complete information package associated with a database allows the analyst to make the necessary scientifically and statistically based adjustments to the measurements so that the old and new observations can be linked with a high degree of confidence.

Current State of Affairs

Research to understand the environment, to develop forecasting techniques, and to monitor and assess long-term changes in the earth system is now hampered by inadequate attention to past and present observation and data policies. The problems have been recognized for many years. In 1969, the Stratton Commission reported that there is a wealth of data; however, the data are of limited value because the data came from diverse sources that are not compatible. Data management, including the transformation of data into useful information and the documentation of metadata, has been addressed by public law and scientific reports -- including the National Climate Program Act of 1978, the 1979 report by the National Research Council's Board on Atmospheric Sciences and Climate, and the 1985 National Climate Report of the Woods Hole Workshop (sponsored by the National Research Council). More recently, the subject of data continuity has been discussed at the National Oceanic and Atmospheric Administration (NOAA) sponsored 1991 Workshop on the Quality and Continuity of Environmental Data and the 1993 Second NOAA Data Quality and Continuity Workshop. As a result of these latter two workshops, a special National Academy of Sciences panel is being formed to recommend a national policy and actions for improving data continuity. Within NOAA, the Climate Data Continuity Project has placed an agency-wide emphasis on identifying and solving continuity problems. Even with renewed interest, however, it remains difficult to direct attention and resources to these types of problems.

Temperature and precipitation data collected by a nationwide network of several thousand cooperative observers support a myriad of activities that include establishment of the baseline climate, estimation of monthly national agricultural and horticultural production, weekly assessments of anomalous weather, and long-term climate research. The data also support ground-truth for radar data, daily public service reports by the media, National Weather Service forecasts and warnings, and data requests from the construction, energy, transportation, and agriculture sectors of the economy. Long-term data are essential for many of these activities; however, the data collected in this network are fraught with problems concerning continuity:

- there is a substantial number of observers who fail to collect accurate and complete data;
- the network is unstable in that the majority of sites record data for only about 15 years;
- manual instrumentation makes the network dependent on whatever 24-hour time of observation is convenient for each volunteer observer;
- instruments have periodically changed;
- documentation of the instrumentation and observing procedures as well as the site characteristics is often incomplete.

The National Weather Service (NWS) has taken a role in generating accurate climate data and safeguards needed to ensure the long-term quality of the climate record. The NWS developed the Climate Data Continuity Project in 1991, funded by NOAA's Earth Systems Data and Information Management (ESDIM) Program. The Project objectives are a) to determine whether any systematic differences (biases) exist between the climate record as recorded by the Automated Surface Observing System (ASOS) now being installed and the historical climate record at NWS first-order stations, and b) to document those differences for 24-hour accumulated precipitation, maximum and minimum temperature, and wind speed. The change in the observing system with ASOS will mean changes in instrumentation, procedures, data archival, and in some instances relocations. The determination and application of biases to ASOS observational data will provide a basis for maintaining a continuous climate data record upon

which a time series analysis can be performed without fear of data record contamination. The Project commenced at the first 16 ASOS sites. An additional 16 climatological sites have been established and will also be used for the Project.

Because of their continuous global monitoring capabilities, operational satellites such as NOAA's polar-orbiting operational environmental satellite (POES) series provide a long time series of measurements that are useful for climate studies. Since many of these measurements are used in operational weather forecasting, there is immediate feedback on observational problems and data quality. But operational satellites also suffer from deficiencies, such as lack of onboard calibration for visible channels and orbital drift. The visible sensors are not calibrated in-flight and tend to degrade with time. This problem contaminates the generation of long-term land surface variables such as vegetation index and surface albedo. Currently, long-term visible calibration is performed by characterizing the degradation by monitoring surface features (e.g., deserts) and assuming that their albedos are not changing in time, an approximation that deteriorates over long periods.

Changing Use and Users of Data

In the real world, data are often used to study phenomena and to solve problems that are only indirectly connected with the purpose for which the data were originally collected, processed or summarized. Proper scientific decisions and judgments pertaining to data therefore heavily depend upon a precise knowledge of all the metadata. Unfortunately, documentation about data is often lacking or incomplete.

Two examples illustrate the use of data for purposes other than those originally planned. First, the National Weather Service operates a network of stations in which detailed observations of the weather are made for the primary purpose of analyzing and forecasting local atmospheric events. A secondary long-term use of the data is for climatology. Data collected at the network stations over a long period of time are often used to support descriptive and probabilitstic analyses for engineering designs, energy use, water management, agriculture and transportation. The data requirements for this secondary use are often different than those for the primary use.

The second example concerns ocean data. An Ocean Service Global Ocean Observing System currently exists with coordination provided by organizations such as the International Oceanographic Commission and the World Meteorological Organization. Data collected under this program support marine weather forecasting, safety in maritime operations, and some international research programs such as the World Ocean Circulation Experiment and the Tropical Ocean-Global Atmosphere Program. The Ocean Service data are also used to monitor the global oceans for a secondary purpose of evaluating climate change. The monitoring requirements for climate change, however, are not completely met by the Ocean Service System. For example, different instruments are used by different countries to measure the same variable, and the location of observing sites is not sufficiently constant.

Without adequate metadata, the analyst can only assume characteristics about the sensors, instrument siting, processing methodologies, etc. Adjusting data to compensate for biases, calibration errors, sensor moves, and other artificial changes so that a homogeneous data set can be constructed may be imprecise and lead to erroneous analytical and scientific conclusions. Changes in observing systems are often introduced without adequate monitoring overlap that would permit an accurate comparison between new and old systems. The long-term uses of many data sets are jeopardized as a result.

Need for Data Continuity

Long-term, homogeneous data are critical to studying the environment. The results of these studies, when applied to solving practical problems, invariably improve the welfare of society. Some examples touching many areas of environmental sciences illustrate the need for data continuity.

Floods and Droughts. The staggering costs and human suffering of aperiodic floods in the U.S., such as the 1993 Midwest floods, are well documented. At the other end of the scale, extreme droughts cause major impacts in agriculture, water resources, transportation, recreation/tourism, wildlife, and other

elements of the Nation's environmental and economic infrastructure. The frequency, duration and amount of rain and snow falling upon the earth is vital to life. The temporal and spatial variability of precipitation and the inherent difficulties of its measurement contribute to our current inability to anticipate unusual events. High quality, continuous and consistent precipitation records are critical for evaluating the potential for floods and droughts; for efficient design and operation of irrigation systems, dams, and other structures; for providing "ground truth" for remotely-sensed (radar and satellite) precipitation estimates; and for estimating future changes in global and regional precipitation.

Water Supply. The extent of snow cover represents a primary control over energy changes at the Earth's surface. It is also a major component of the surface hydrologic cycle, affecting freshwater runoff and the local water storage. Long-term changes in the snow cover regime could have a significant impact on water supplies for human consumption and agricultural use. Understanding the role of snow cover in the climate system depends upon a knowledge of past conditions. However, there is no long-term, comprehensive database of snow cover and its variability. A number of databases exist, but they are in different formats, in many separate locations, and under the control of several agencies (e.g., NOAA, USDA, U.S. Army, DOI, state offices, and universities). Many different data sets are available with varying temporal and spatial intervals resulting from numerous measurement techniques. Areal coverage extends from surface point measurements to large-scale area integrations from satellite sensors. Measurement frequency varies from hourly to monthly to seasonally to annually. Not having a long-term, comprehensive data set hampers research on the sensitivity of the climate system to snow cover, which in turn hampers climate modeling and prediction efforts in many time and space scales.

Climate Change. Temperature, wind, and moisture measurements are routinely taken at various altitudes throughout the atmosphere. These upper air observations are used operationally in the development of weather forecasts for periods of several days to several weeks. Historical upper air data have been analyzed by many scientists to determine the extent of climate change, if any. This has resulted in different interpretations and different conclusions. Although upper air measurements have been routinely taken for about 50 years, there have been several changes in sensors as well as in processing algorithms and methodologies. Documentation of these changes is often inadequate. As a result, the existing data set is not homogeneous, and not enough metadata are available to reliably adjust the observations so that a homogeneous data set can be constructed. Resolution of the climate change issue would benefit greatly from a substantially homogeneous upper air data set spanning several decades.

Marine Resources. Utilization and conservation of living marine resources involves the ecologically significant aspects of the environment that support the reproduction, development, growth, and survival of a species. These include physical factors (temperature, salinity, and water depth); chemical factors; biological factors such as parasites, pathogens, symbionts, competitors, and predators; and factors such as coastal wetlands, sea grass beds, and soft sediment substrates. Some of the common mechanisms of habitat degradation are physical loss of habitat; low oxygen levels caused by massive die-offs of phytoplankton blooms; changes in freshwater availability to estuaries caused by water diversion projects and dredge spoil dispersal; and contamination by toxic chemicals or biotoxins. Almost all human activity in the coastal environment affects the living marine resources. Data are needed for damage assessment and restoration, Endangered Species Act concerns, issuing permits under the National Pollution Discharge Elimination System, marine mammal/fisheries interactions, and the impact of aquaculture on the coastal environment quality. Long-term compatible data are needed for properly assessing impacts and for making predictions.

Greenhouse Gases. In order to predict, and possibly manage, future impacts of increased concentrations of greenhouse gases, a better (e.g., more uniform, four-dimensional, multi-scale) understanding of their concentrations, sources, and sinks is critical. Variations, both in time and space, are taking place in the mixing ratios of the gases. Learning more about their cycles and feedback mechanisms is difficult. Measurements demand very

careful standardization over a long time and among different laboratories because atmospheric mixing is vigorous and chemical lifetimes are variable. This requires the establishment and maintenance of very accurate standards for measuring greenhouse gas concentrations on a global scale.

The above examples are only a few of the hundreds that could be given. Homogeneity of data in time and space is rarely inherent in the data used by scientists and planners. Coupled with the lack of homogeneity is the often incomplete metadata about the measurements. As a result, an analyst must resort to making many -- possibly erroneous -- assumptions when using the data. Even with modern computer technology and sophisticated methodologies, extensive time and financial resources are often needed to construct an adequate homogeneous record upon which to base a scientific analysis.

Summarizing the Problems

As environmental issues increase in importance, accurate and thorough documentation of the past and present environmental conditions is vital for making responsible assessments. Increased emphasis therefore is being placed on the Nation's responsibilities to monitor the oceanic, atmospheric, and space environment and to predict its future state.

Over the years much of the environmental data has been acquired from operational networks, satellite systems, and episodic experiments. Ground-based instruments, platforms and locations have been subject to frequent changes for a variety of scientific, administrative, budgetary and convenience reasons. These changes have not always been sufficiently documented, nor have comparisons or calibrations always been made to ensure the integrity of the data. Modifications to operational monitoring of the environment have often been made to benefit an operational mission, but may or may not have been suitable for other scientific studies, and indeed may have introduced discontinuities that are deleterious or disruptive.

Long-term satellite observation databases are affected by uncertain instrumental drifts, small changes in the filter functions of flight models of the same instrument on successive satellites, changes in instrumentation that improve the derived products while introducing systematic changes in the time series, orbital drift, and changes in the operational processing system used to generate the satellite products. All of these problems affect the continuity of satellite-derived products.

Although there is substantial communication among environmental scientists in different programs, and there exist many committees, panels and coordinators, there has been very little agreement within the scientific community for standards and processes that could ensure data continuity. Individual program managers are not always aware of the needs for data archival and data continuity that can support still other programs; nor do they place a significant priority on the measurement needs of other programs. This narrow outlook may, in part, be traced to the technical, organizational, and budgetary compartmentalization of the various disciplines.

Recognizing that much information about past data may be permanently lost, it is incumbent upon all principal investigators, program managers, system and instrument designers, data managers, and data users to protect the existing information against further deterioration and to make the information more accessible. Also recognizing that the diversity of measurement purposes and methodologies will continue and that future uses of the data are sometimes unforeseen, it is imperative that the metadata associated with a data set be permanently documented and made available. In the future, data sets may be combined and reconstructed with confidence only if the complete metadata is recorded.

Solving the Problems

The problems of data continuity are the responsibility of all government agencies monitoring the environment, of private sector environmental scientists, and indeed of the other countries of the world. The current situation could be improved if:

a) Standard procedures are established and followed for collecting overlapping measurements (i.e., comparisons) for all significant changes made in space-based and ground-based instrumentation, observing practices, and sensor siting.

b) Detailed documentation of the procedures, rationale, testing, assumptions, and known problems involved in the construction of the data set from the measurements is made available.

c) Routine assessments are made of ongoing calibration, maintenance, and homogeneity problems for the purpose of taking corrective actions when necessary.

d) Open communication channels among the sensor developers, network designers and managers, data collectors, researchers, data users, and archivists are established to provide feedback mechanisms for recognizing and correcting data problems.

e) The advocacy of adequate budgets to solve these problems is made a joint responsibility of all users of the data. The long-term retrospective users must not assume that the operational users are prepared to support unilaterally all prospective needs, nor should the operational users assume that retrospective users are prepared to support unilaterally all archival needs.

Once the interdisciplinary data requirements are established, the infrastructure must be constructed to collect, process, archive, and produce homogeneous time series of data that meet the environmental requirements. The data collection and management efforts could be organized institutionally (specific to an agency or institution) or disciplinarily (specific to a subject area). The form of the infrastructure is not important as long as all the data continuity requirements are met.

Conclusion

Environmental data have been and are being collected for a multitude of purposes, by a variety of individuals and agencies, and by a myriad of techniques. Metadata (information about the data) are often incomplete. The situation has led to a plethora of inhomogeneous data that cannot be reliably combined into homogeneous data sets. This current state of affairs hampers research on furthering the understanding of the environment because the necessary data sets are not available. The impact on society is that many predictions of future environmental events, and the effects of these events on mankind's endeavors, cannot be made with confidence. As a result, important far-reaching national policies may be developed based on faulty conclusions derived from inconsistent data.

Data sets of integrity will reduce the risk of potentially catastrophic errors in our national environmental policies.

APPENDIX A

DEPARTMENT OF COMMERCE WEATHER PROGRAMS

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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

NATIONAL WEATHER SERVICE

MISSION

The National Weather Service (NWS) has the principal responsibility for the plans and operations of the basic weather services and certain specific applied services. The primary mission of NWS is to help ensure the safety and welfare of the general public with respect to the effects of weather and to further the conduct of governmental and commercial activities which are affected by weather. In support of this mission, NWS:

- Issues warnings and forecasts of weather, flood, and ocean conditions;
- Observes and reports the weather and the river and ocean conditions of the United States and its possessions;
- Develops and operates national meteorological, hydrological, and oceanic service systems;
- Performs applied meteorological and hydrological research;
- Assists in developing community awareness and educational materials concerning weather related natural disasters;
- Participates in international hydrometeorological activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of hydrometeorological equipment and systems overseas under the Voluntary Cooperation Program.

ENABLING LEGISLATION

The basic enabling legislation and authority for weather services are listed below:

- Organic Act of 1890 created the U.S. Weather Bureau in the Department of Agriculture;
- Enabling Act of 1919 allowed the U.S. Weather Bureau to enter into cooperative agreements for providing agriculture weather services;
- Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control; on July 1, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce;
- Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for provision of weather observations and services to aviation;
- Reorganization Plan 2 of 1965 placed the "National Weather Service" (NWS) in the newly created Environmental Science Services Administration (ESSA);
- Reorganization Plan 4 of 1970 made the NWS a part of the newly created National Oceanic and Atmospheric Administration (NOAA).

SERVICES

NOAA provides around-the-clock weather and flood warning and forecast services to the public for the protection of life and property and to meet the needs of all segments of the economy. Weather services are provided by a nationwide network of offices that collect

data, prepare state and local warnings and forecasts, and disseminate information to the population both directly and indirectly through the mass media. Data, analyses, forecasts, and outlooks used by field forecasters to prepare local forecasts are centrally processed by the National Meteorological Center (NMC). The NWS core mission also depends on the study, development, and testing of new methods for improving basic warning and forecast capabilities through research.

Local Warnings and Forecasts

Local weather services are provided through a national network of 52 Weather Service Forecast Offices (WSFOs), 222 more localized Weather Service Offices (WSOs) and 13 River Forecast Centers (RFCs).

Weather Warnings and Forecasts. Both WSFOs and WSOs issue local warnings of severe weather such as hurricanes, tornadoes, severe thunderstorms, flash floods, and extreme winter weather. WSFOs prepare forecasts for zones which are comprised of typically one or more counties that experience similar weather. Each WSFO has forecast responsibility for several zones which, together, comprise an area the size of an average state. WSFOs issue zone forecasts 4 times daily for a period out to 48 hours and a generalized statewide forecast twice daily, including an extended 5-day forecast on a daily basis. WSFOs also provide the main field forecast support for the marine and aviation programs as well as guidance for the fire weather program.

All counties in the United States are assigned to specific WSOs or WSFOs for warning purposes. These offices issue and distribute local warnings of severe weather for their assigned counties. WSOs adapt generalized weather forecasts to local areas and issue severe weather and flash flood warnings.

In preparing local warnings and forecasts, WSFOs use forecast guidance prepared by the National Meteorological Center (NMC) that is based on worldwide meteorological observations. The National Severe Storms Forecast Center (NSSFC) and the National Hurricane Center (NHC) also provide central support for the local warning program.

Weather Service Meteorological Observatories (WSMOs) are additional sources of data for surface observations, upper air observations, and/or radar data. These observations are also used in the NMC database for generating guidance products used by field forecasters.

River and Flood Warnings and Forecasts. RFCs prepare guidance used by WSFOs, and WSOs to issue flash flood watches, warnings, and river forecasts. RFCs provide forecasts of river stage and flow and related products and services for use by water resources managers and other users. Most WSFOs and WSOs support the RFCs by collecting and relaying hydrologic data. NMC provides central support to RFCs by forecasting the movement of large storms that are causing significant precipitation.

Marine Weather Services. Using weather analyses and forecast guidance provided by NMC, marine weather forecasters at coastal and Great Lakes WSFOs issue wind, wave, weather, and ice warnings, forecasts, and other information for the population living and working along the sea coast, off-shore, on the Great Lakes, and on the high seas. Principal products include small craft advisories, gale, storm, tropical cyclone, and storm surge warnings; coastal, off-shore, and high seas forecasts; sea and swell forecasts; sea and lake advisories; and special weather forecasts to aid in the containment and clean up of oil spills and other hazardous substances in the marine environment. In support of Marine Weather Services, the NWS operates the National Data Buoy Center (NDBC). This Center provides real-time operations, data acquisition and data processing, and distribution of meteorological and oceanographic data from moored and drifting buoys and automated observing stations at selected coastal locations. The NDBC also provides systems integration, deployment, maintenance and repair, and redeployment of data buoys and coastal stations. The NWS, through its Port Meteorological Officer Program, also coordinates and manages data acquisition from cooperative merchant ships under the international Voluntary Observing Ship program sponsored by the World Meteorological Organization.

Agricultural Weather Services. NWS provides the Nation with generalized agricultural weather services, including observations, and forecasts that improve agricultural efficiency, conserve energy, and protect the environment. At the direction of Congress, NWS issues warnings of low temperatures injurious to winter

and spring crops, particularly in citrus and deciduous fruit-growing areas as well as specialized forecasts.

Fire Weather Services. Designated NWS offices provide weather warning, forecast, and advisory services to Federal, state, and local wildland management agencies to support wildfire control and suppression activities. Localized weather forecasts are issued, as required, during a fire. NWS offices also provide site-specific forecasts and advisories to Federal natural resource agencies for prescribed burning and smoke management, insect and disease control, planting and cultivating new growth, preservation of watersheds, and promotion of wildlife habitat and recreational facilities.

Tsunami Warnings. Tsunami watches and warnings for Pacific Ocean areas and Alaska are prepared and issued by the Tsunami Warning Center at Ewa Beach, Hawaii, and the regional center at Palmer, Alaska. NWS collects and analyzes observational data from an international network of seismological observatories and sea level observing stations which operate on a cooperative basis. The centers use the data to prepare watches and warnings covering all U.S. territories and states bordering on the Pacific Ocean and disseminate them to WSFOs, Federal and state disaster agencies, military organizations, private broadcast media, and other facilities that furnish warning information to the public.

Central Forecast Guidance

Over the last several decades, NWS has made major improvements in forecasting synoptic-scale (large-scale, slowly evolving) weather.

General Weather Guidance. The National Meteorological Center (NMC) provides centralized processing of data, analyses, forecasts, and outlooks required by field forecasters as a basis for local forecasting. The Center, using numerical forecasting techniques run on large computers, provides the NWS, other Government agencies, private industry, and foreign users with forecast guidance covering periods out to 10 days. When needed, the NMC provides guidance in tracking hurricanes (to 72 hours) and in forecasting the movement of large storms that cause significant precipitation.

In the course of its 24-hour-per-day, year-round operation, NMC receives approximately 50,000 surface observation reports daily from land stations, 3,000 reports from ships, 4,100 upper air observations, and 8,000-10,000 reports from aircraft. Weather satellites provide cloud imagery, cloud-drift wind data, atmospheric temperature soundings, and sea-surface temperatures. Ocean buoys provide additional information on sea temperatures, ocean currents, and air-sea interactions. These data are processed, catalogued, used in the various forecast guidance model runs, and distributed widely to field offices, other Government agencies, private subscribers, and overseas users.

NOAA will continue to incorporate improvements in general weather guidance by:

- Implementing the first national domain mesoscale analysis and forecasting model with significantly higher resolution and improved physics to forecast severe thunderstorms, heavy rain, and snow more accurately;
- Implementing second generation hurricane models to predict the development and movement of hurricanes more accurately;
- Continuing improvements in 1 to 2 day and 3 to 10 day forecasts as much as possible pending the availability of increased computer capacity to handle state-of-the-science physics and analysis procedures, increasing resolution, and ensemble forecasting procedures.

Severe Storm Guidance. The National Severe Storms Forecast Center (NSSFC), Kansas City, MO, prepares and releases messages of expected severe local storms, including tornadoes. These messages, called Tornado or Severe Thunderstorm Watches, include information for public use and aviation services. NSSFC meteorologists continuously monitor weather developments and issue watches when needed. NOAA will continue to develop systems application programs designed to streamline use of the satellite and numerical weather prediction data by forecasters to improve severe storm guidance.

Hurricane Guidance. Two Hurricane Forecast Centers forecast the path and intensity of hurricanes, other tropical disturbances, and associated sea conditions. These two centers are the National Hurricane Center (NHC) in Miami, FL, and the

Central Pacific Hurricane Center (CPHC) in Honolulu, HI. A portion of NHC's responsibility for public warnings rests with the Hurricane Warning Office at San Juan, PR. NMC provides forecast guidance on the track and intensity of hurricanes based on numerical models.

Special hurricane forecasting staff at NHC base their predictions, advisories, and warnings on subjective and objective methods. The hurricane forecasting functions at the NHC and CPHC are integrated with the regular forecasting functions of the Weather Service Forecast Offices where these Centers are located. NOAA will continue to improve hurricane guidance through development of techniques and programs that maximize use of satellite data and through implementation and calibration of storm surge models.

Climate Guidance. The Climate Analysis Center (CAC) prepares monthly and seasonal (90-day) outlooks and collects and analyzes data to depict current anomalies of climate. To improve the accuracy of climate outlooks, the Center develops predictive techniques, performs diagnostic studies of large-scale climate anomalies, and conducts stratospheric research. CAC will continue to incorporate improvements developed by NOAA research laboratories into long-range climate guidance.

Atmospheric and Hydrological Research

NWS conducts applied research, building upon the more basic research conducted by NOAA laboratories and the academic community. Applied meteorological and hydrological research is integral to providing more timely and accurate weather and flood warning and forecast services to the U.S. public.

Meteorological Research. NWS conducts meteorological research to develop, test, evaluate, and improve numerical models and analysis/forecast techniques used in weather and climate prediction including:

- Techniques for predicting mesoscale phenomena (e.g., heavy precipitation, tornadoes, and severe thunderstorms). These techniques will be developed and improved to use digital data from new observing systems such as NEXRAD (Next Generation Weather Radar) with Doppler capability, and GOES-NEXT (geostationary satellites with higher resolution);
- Models to improve hurricane tracking, hurricane probability estimates, and tropical analyses;
- Storm surge models to assist in developing hurricane evacuation plans for additional coastal basins.

Hydrological Research. NWS develops improved hydrologic and hydrometeorological models and procedures in support of the national flood forecasting and water resources forecasting programs including:

- Improvements to the Extended Streamflow Prediction model and its complementary models in the National Weather Service River Forecast System;
- Specialized flood and flash flood forecasting procedures using linked hydrological and meteorological models;
- Algorithms to combine NEXRAD precipitation estimates with data from satellites and other ground-based observation systems.

MODERNIZATION

A Strategic Plan for the Modernization and Associated Restructuring of the National Weather Service was submitted to Congress in 1989. Implementation of the plan will optimize efficiency and effectiveness of the mesoscale warning and forecast program and will include an operational demonstration and evaluation program as required by Public Law 102-567 to refine operational procedures and resolve implementation issues best addressed through actual field experience. Continued improvements in larger scale, centrally prepared weather guidance products for day 2 and beyond through advanced forecasting models and the requested increased computer processing capability are essential to successful implementation of mesoscale forecasting in NWS field operation, where field forecasters will concentrate on the small-scale, short-lived processes that occur in the zero to 36 hour time-scale.

The National Implementation Plan, will provide, on a regular basis, a planning framework and general strategies for accomplishing the transition, as well as advanced notification of when implementation activities

are scheduled to occur at each site. The interrelationships of all of the activities -- facilities preparation, staffing augmentation, training, commissioning of systems, and realigning operations and services--have begun so that the demonstration can begin in 1996. In addition to preparations for the demonstration, nationwide planning and implementation have begun; facilities construction is on-going; training for field personnel is being conducted with necessary backup personnel to cover operational shifts; software development continues; new communications are being established; and all NWS offices have developed and are updating detailed site plans for the transition. The NWS modernization effort is a complex mix of internal NWS activities and multiple contractor efforts. Internal activities provide land, facilities, software, training, staffing, and new operational procedures.

Modernization and Associated Restructuring. The NWS has begun this process of change prompted by two factors: the need to apply advances in hydrometeorological science and technology to operational forecasting, and the need to replace obsolete and increasingly unreliable equipment.

These factors offer the opportunity to improve severe weather warnings, flood warnings, and forecasts through the acquisition of the following new technologically advanced systems:

- Automated Surface Observation System (ASOS) to reduce time-consuming manual observations, provide continuous weather watch, and permit increased productivity of staff;
- Next Generation Weather Radar (NEXRAD) with Doppler capability and sophisticated software to provide nationwide coverage for timely and accurate detection of severe weather and floods;
- Advanced Weather Interactive Processing System (AWIPS) to enable local forecasters to integrate, process, and transmit high-volume radar, satellite, upper air, surface observation data and guidance information;
- Class VII computer power at the NOAA Central Computer facility to accommodate advanced numerical weather prediction models and increased data to improve accuracy of forecast guidance.

These systems upgrades, coupled with observations from planned, advanced geostationary and polar-orbiting satellites and newly developed mesoscale forecasting techniques, will greatly improve the timeliness and accuracy of severe weather and flood warnings to the U.S. public. Improved capability to detect and predict the small-scale, short-lived (mesoscale) phenomena which cause the most destructive weather events will increase warning lead times for severe thunderstorms, tornadoes, high winds, and flash floods, as well as reduce false warnings.

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

The National Environmental Satellite, Data, and Information Service (NESDIS) manages U.S. civil operational environmental satellite systems, as well as global databases for meteorology, oceanography, solid-earth geophysics, and solar-terrestrial sciences. From these sources it develops and distributes environmental data and information products and services critical to the protection of life and property, the national economy, energy development and distribution, global food supplies, and development and management of environmental resources.

An agency of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), NESDIS was established December 1, 1982. It was formed by the merger of the former National Environmental Satellite Service (NESS) and Environmental Data and Information Service (EDIS).

NESDIS operates polar-orbiting satellites in sun-synchronous orbits with equatorial crossing times in the early morning (circa 7:30 a.m. LST) and early afternoon (circa 1:40 p.m. LST). These satellites collect global data four times per day that provide atmospheric and surface measurements in support of short-term weather forecasting and longer term global climate change research. An agreement to be signed in 1995 with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) will give EUMETSAT responsibility for the morning segment of the polar environmental mission, with U.S.-provided payload instruments and sensors, beginning early in the next decade.

NESDIS is also responsible for operating two geostationary environmental satellites: one that monitors the Atlantic Ocean, the U.S. East and Gulf Coasts, and the U.S. Midwest; and one that monitors the Pacific Ocean and West Coast. However, on January 21, 1989, the Western satellite, GOES-6 failed. The Eastern satellite, GOES-7, was moved to a centralized location on February 21, 1989. Its location was adjusted between 108°W and 98°W to provide maximum coverage during the Pacific and Atlantic storm seasons. On April 23, 1992, GOES-7 was maneuvered to 112°W following agreement between the United States and EUMETSAT for the movement of a European geostationary satellite, Meteosat-3, to a position of 50°W to cover the Americas and the Atlantic Ocean. This permitted the movement of GOES-7 to its new position to enhance coverage of the Pacific Ocean. Meteosat-3 was then moved to 75°W on February 19, 1993 after Meteosat-compatible ground equipment was installed at the Wallops, Virginia, Command and Data Acquisition (CDA) Station. This new ground station allows Wallops to acquire and route raw satellite transmissions from Meteosat-3, including telemetry (orbit and attitude) data, to the European Space Operations Centre in Germany. The image data are then processed and routed through Wallops for retransmission via the Meteosat-3 satellite.

The first of a new series of NOAA geostationary satellites, GOES-I, was successfully launched on April 13, 1994. Renamed GOES-8 once in orbit, the new spacecraft was positioned over 90°W prior to a six-month operational checkout. Meteosat-3 can be moved as far west as 115°W, if GOES-7 or GOES-8 fails, to provide U.S. coverage before the successful checkout of GOES-8. On August 20, 1993, NOAA and EUMETSAT signed a long-term agreement for mutual backup of their geostationary satellites.

Environmental Satellite Service

SATELLITE OFFICES

The Office of Satellite Operations directs the operation of NOAA's environmental satellites and the acquisition of remotely sensed environmental data. It manages the Satellite Operations Control Center (SOCC) and Command and Data Acquisition Stations (CDA) which command and control, track, and acquire data from these environmental satellites.

The Office of Satellite Data Processing and Distribution (OSDPD) directs the operations of NESDIS' central ground data processing facilities. It processes and distributes current weather satellite data and derived products to the National Weather Service and other domestic and foreign users. A system for the display and animation of satellite imagery from the GOES-TAP system has been installed in all Weather Service Forecast Offices (WSFOs). The system, called the Satellite Weather Information System (SWIS), automatically acquires, stores, displays, and animates GOES imagery and superimposes guidance products from the National Meteorological Center with the imagery. WEFAX (Weather Facsimile) direct readout systems on NOAA's weather satellites enable users to receive, on relatively low- cost equipment, images and weather charts directly from the satellites.

National Weather Service's Satellite Field Distribution Facilities (SFDFs) distribute processed geostationary satellite products to regional National Weather Service offices and other Federal agencies. The products also are made available to private groups at their expense. SFDFs are located in Washington, D.C.; Miami, Florida; Kansas City, Missouri; Honolulu, Hawaii; San Francisco, California; and Anchorage, Alaska. The Anchorage, Washington, San Francisco, and Honolulu SFDFs redistribute data from both the polar-orbiting and geostationary systems. The San Francisco, Anchorage, and Honolulu SFDFs also have the capability of receiving data broadcast directly from the polar orbiting satellites via the HRPT Image Processing System (see "Polar Orbiting Systems" below.)

The Office of Research and Applications provides guidance and direction for NESDIS research and applications activities. It coordinates the efforts of the Satellite Research Laboratory and Satellite Applications Laboratory. These laboratories conduct studies on the use of satellite data to monitor environmental characteristics and change and develop algorithms to analyze these data for applications to operational weather prediction. Further, the Office of Research and Applications participates in the development of new spacecraft and sensors for future systems. It also carries out a vigorous program to calibrate and validate satellite data to ensure its quality for long term studies. Staff from these laboratories also conduct a strong technology transfer program through scientific

presentations, technical reports, and training workshops at domestic and international sites.

POLAR ORBITING SYSTEMS

These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. Currently, the primary operational spacecraft are NOAA-11 and NOAA-12. NOAA-13 was launched August 9, 1993 to replace NOAA-11 as the primary afternoon spacecraft, but failed 12 days later. All attempts to re-establish communications with NOAA-13 have failed. The next satellite in this series (NOAA-J) is planned to be launched in November 1994. It will be designated NOAA-14 after successful launch. NOAA-9 and NOAA-10 also provide data from operational sensors. NOAA polar satellites carry instruments to provide atmospheric temperature and moisture profiles. They also provide multi-channel images and carry a data collection and platform location system, and a satellite-aided search and rescue (SAR) subsystem. SAR transponders are used to improve the detection and location of distress signals. They are used by the Cospas-Search and Rescue Satellite Aided Tracking (SARSAT) Program, the international program for satellite-aided search and rescue. Russia, the United States, France, and Canada provide Cospas-SARSAT's space segment and related ground segment. Additionally, nearly twenty other countries are formally associated with Cospas-SARSAT as ground segment providers and user states. NOAA operates and maintains the U.S. SARSAT Mission Control Center and seven ground stations. The ground stations receive Doppler signals directly from the satellites and process the information to provide the location of distress transmissions.

During the lifetime of the NOAA system, new instruments may be added or substituted for others. NOAA-9 carries sensors to measure the Earth's radiation budget and ozone. The projected launch schedule and associated instruments for polar-orbiting satellites are shown in Table A.1.

NOAA spacecraft are five-sided, box-like structures that are 3.71 m long, 1.88 m in diameter, and 1,409 kg in weight, including expendables. NOAA-12, NOAA-11, NOAA-10, and NOAA-9 operate in near-polar, sun-synchronous orbits and provide environmental observations of the entire Earth eight times each day. NOAA-12 crosses the Equator in a southward direction at 0715 local standard time; NOAA-11 crosses the Equator in a northward direction at 1715 local standard time; NOAA-10 crosses the Equator in a southward direction at 0557 local standard time; and NOAA-9 crosses the Equator in a southward direction at 0910 local standard time. The orbital period of the satellites ranges from 101.12 to 101.97 minutes which produces approximately 14.2 orbits per day.

The NOAA series satellites carry four primary instrument systems. The Advanced Very High Resolution Radiometer (AVHRR) provides data for real-time transmission to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. The AVHRR instrument provides stored and direct readout radiometer data for day and night cloud cover, sea-surface temperatures, vegetation indices, and snow and ice mapping. AVHRR read-out is accomplished by the following:

- Direct readout to ground stations of the APT class worldwide, at 4-km resolution, of the visible and infrared data; panoramic distortion is removed;
- Direct readout to ground stations of the HRPT class worldwide, at 1.1-km resolution, of all spectral channels;
- Global onboard recording of 4-km resolution data from all spectral channels; global area coverage (GAC) for commanded readout for processing in the NOAA central computer facility at Suitland, MD;
- Onboard recording of data from selected portions of each orbit at 1.1-km resolution of all spectral channels, with local area coverage (LAC) for central processing and sea-surface temperature measurements.

The TIROS Operational Vertical Sounder (TOVS) system combines data from several complementary sounding instruments on the spacecraft. These instruments are the High Resolution Infrared Sounder (HIRS/2), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). The primary instrument providing tropospheric data, HIRS/2, is sensitive to energy from the visible to the carbon

dioxide absorption region of the infrared spectrum. This instrument is designed to provide data that permit calculation of temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere, and total ozone content. The SSU instrument, which is sensitive to energy in the carbon dioxide absorption portion of the infrared spectrum, provides temperature information from the stratosphere. This instrument is provided by the Meteorological Office of the United Kingdom. The third instrument, the MSU, is sensitive to energy in the oxygen absorption region of the microwave spectrum and is used in conjunction with the two IR instruments. The microwave data permit computations to be made in the presence of clouds.

The Data Collection System (DCS) is provided by the Centre National d'Etudes Spatiales of France and is called the ARGOS DCS. The ARGOS DCS provides a means to locate and collect data from fixed and moving platforms. It provides two services not available in the geostationary meteorological satellite data collection system. First, it has the capability to determine platform location, using an inverse Doppler technique. Second, it is able to acquire data from any place in the world, but more particularly in the polar regions, beyond transmission range of the geostationary satellites.

The Space Environment Monitor (SEM) measures solar proton flux, alpha particle and electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitude. The two sensors included within this instrument are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED), in addition to a common data processing unit. This instrument augments the measurements made by NOAA's geostationary satellites. The data from the SEM are processed at Suitland, MD, and transmitted over a dedicated data link to NOAA's Space Environment Laboratory at Boulder, CO, within one hour of the spacecraft readout. Space environment data from the NOAA satellites, as well as the geostationary data, are used to monitor the state of solar activity, which has a significant effect on terrestrial communications, electrical power distribution, and high-altitude aircraft flight. SEM data are archived and disseminated to other Government agencies, industry, and the public by the National Geophysical Data Center.

In addition to the four primary instrument systems, the "afternoon" NOAA series spacecraft carry the Solar Backscatter Ultraviolet Radiometer. The Solar Backscatter Ultraviolet Radiometer (SBUV/2) is a non-scanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 nanometers to 400 nanometers. Data obtained from the instrument are used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth.

The ground system required to receive large volumes of digital data from NOAA satellites consists of two major subsystems -- the Polar Acquisition and Control Subsystem (PACS) and the Central Environmental Satellite Computer System (CEMSCS). The PACS includes components at the Wallops, Virginia, and Fairbanks, Alaska, Command and Data Acquisition (CDA) stations; and the Satellite Operations Control Center (SOCC) at Suitland, Maryland. All the CEMSCS components are in the NOAA facility at Suitland.

PACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the CEMSCS processing and data handling facility. The delivery of NOAA system data from the CDAs to Suitland is accomplished by using the General Electric American Communications, Inc. commercial satellite communications network. This system, which includes Earth stations at Suitland, Wallops and Fairbanks, delivers the data to SOCC. These data are immediately passed on to the CEMSCS for processing. The CEMSCS ingests the raw satellite data and pre-processes and stores them along with appended auxiliary information, such as Earth location and quality control parameters. The data processed by the CEMSCS are used for environmental products and operational weather predictions which are disseminated to users throughout the world.

GEOSTATIONARY SATELLITE PROGRAM

GOES-I, launched April 13, 1994, is currently positioned at 90°W. The spacecraft was renamed GOES-8 in May 1994 and was expected to go through rigorous testing of all of its sub-systems before being declared operational in October 1994. GOES-7, launched February 26, 1987, is currently positioned at 112°W. If still operational, Meteosat-3's future

movement and location depends upon the functionality of either GOES-7 or GOES-8. If EUMETSAT resources allow, NOAA will be furnished with a back-up geostationary satellite in a one-GOES scenario. This will assure optimum and extensive coverage of the development and movement of significant weather systems, such as thunderstorms, hurricanes and major mid-latitude storms over much of North and South America and adjacent oceans. The projected launch schedule and associated instruments for geostationary satellites are shown in Table A.1.

The VISSR Atmospheric Sounder (VAS) is the principal instrument on GOES-7, the current operational GOES. The VAS has both imaging and sounding capability. The VAS provides near-continuous cloud viewing with nominal resolutions of 1 km in the visible wavelengths and 8 km in the infrared wavelength. Full Earth disc pictures are available at regular intervals throughout the day and night; partial disc pictures can be obtained at more frequent intervals to meet special requirements such as viewing development and movement of severe storms.

GOES-Next

The launch of GOES-8 in April 1994 represents a new technological era for GOES satellites. Unlike the current VAS on GOES-7 which timeshares imaging and sounding functions, GOES-8 has independent imager and sounder platforms. Simultaneous broadcast of imager and sounder data yields a significant increase in data volume without schedule conflicts. GOES-8's three-axis stabilized platform has the capability to take continuous views of the U.S. and adjacent waters by scanning east to west while stepping north to south.

The GOES-8 spacecraft hosts an imager capable of detecting atmospheric temperature and moisture measurements in five spectral bands, including the new 3.9 micron and 12.0 micron wavelengths. Unlike GOES-7, GOES-8 also has the feature of transmitting these five spectral bands simultaneously, affording the user community continuous views of atmospheric measurements in various wavelengths, each with its own meteorological and hydrological application. The GOES-8 spacecraft was also designed for flexible scanning of the earth; any variation of scan or sector coverage at regular time intervals can be scheduled in a 30-minute time frame. The five channels and respective resolutions are as follows:

Channel 1 (Visible, .55 to .75 microns) -- 1 km
Channel 2 (Infrared, 3.8 to 4.0 microns) -- 4 km
Channel 3 (Water Vapor, 6.5 to 7.0 microns) -- 8 km
Channel 4 (Infrared, 10.2 to 11.2 microns) -- 4 km
Channel 5 (Infrared, 11.5 to 12.5 microns) -- 4 km

The new GOES-8 satellite will be capable of providing hourly atmospheric sounder coverage over the continental United States operationally for input to weather forecast models and other near-real time analyses. A totally new ground processing system will generate and distribute temperature and moisture sounding fields, as well as derived products for forecast operations.

The GOES-8 sounder, consisting of 19 spectral channels (GOES-7 has 12 spectral channels), is used for measurements of atmospheric temperature and moisture profiles, surface and cloud top temperature, and ozone distribution. Products derived from the sounder include precipitable water and lifted index, a measurement of atmospheric stability. Comparable to the imager, the sounder is capable of providing various scan coverage such as full earth imagery, sectorized imagery, and local imagery. An independent sounder platform, governed under its own schedule, leads to an expansion of sounder data coverage and an increase in the frequency of transmissions.

The GOES also carry a Data Collection System (DCS) which is used to collect and relay environmental data observed by a variety of remotely located platforms, such as river and tide gages, seismometers, buoys, ships, and automatic weather stations. GOES satellites rebroadcast imagery, meteorological analyses, and other environmental data to remote locations using the weather facsimile (WEFAX) system. Data are collected for warnings of solar activity using the Space Environment Monitor (SEM). This block of instruments is more extensive than on the polar spacecraft. The GOES SEM instruments include X-Ray monitors that detect solar flares, energetic particle sensors, and three-component vector magnetometers to measure changes in the ambient magnetic field. Real-time SEM data are used to support operational NOAA and DOD space environment forecasts and alerts. Data from GOES SEM sensors are archived by the National Geophysical Data Center, and provided to retrospective users on-line via Internet and on a variety of computer media.

A system similar technically to the DCS, but used for a different purpose, is the Search and Rescue Satellite Aided Tracking (SARSAT) transponder. The SARSAT transponder on GOES-7 is capable of providing an early alert that a ship or airplane is in distress. While the present system is incapable of providing location of the distress signal, it provides advance warning to the SARSAT Mission Operations Control Center which then begins preparations to act when the signal location is received from the NOAA satellite SARSAT transponder/processor. The transponder on GOES-7 is considered pre-operational, but beginning with GOES-I the transponder will be operational.

In calendar year 1991, NESDIS began sending a limited set of remapped GOES image data products to the first two National Weather Service modernization "risk reduction" sites. Weather Service Forecast Offices at Norman, Oklahoma, and Denver, Colorado, were equipped with work stations to capture satellite images and other NOAA data, emulating modernized Weather Service capabilities. This dedicated-line transmission of remapped GOES data will be upgraded to a point-to-multipoint broadcast service with the initial deployment of AWIPS. After acceptance, this service will be used to distribute other NOAA environmental data and satellite products to various users.

AWIPS compliant imagery generated from GOES-8 are now being transmitted to the OAR Forecast Systems Laboratory (FSL) in Boulder, Colorado, to test network configurations and product validation. After the evaluation period is completed, information gained will be used to deploy AWIPS data to the NWS Risk Reduction Sites in Norman, Oklahoma, and Denver, Colorado.

Prior to full deployment of AWIPS products via the communication avenue NOAAPORT, a point to multi-point broadcast, NOAA will conduct experimental transmissions of digital GOES-8 products to selected NWS Weather Forecast Offices. The display medium, RAMSDIS, will be used to ingest digital GOES-8 data from terrestrial networks and enable the user to perform a myriad of operations including designed overlays, local remapping, looping, and temperature retrievals. RAMSDIS emulates an AWIPS type workstation; this will afford the user a preview of, and familiarization with, digital satellite data.

SATELLITE COMMUNICATIONS SYSTEM (SATCOM)

The NESDIS Telecommunications System is a complex network of voice, teletype, and data grade transmissions sent via satellites, microwave, and terrestrial cable services. A major component of the system is the Office of Satellite Operations which consists of the Satellite Operations Control Center (SOCC) and two CDA stations at Wallops, Virginia and Fairbanks, Alaska. The Office of Satellite Operations is responsible for the operation and safety of NOAA polar and geostationary satellites and for providing satellite data to the Office of Satellite Data Processing and Distribution in Suitland, Maryland.

Another major component is the Environmental Satellite Distribution/Interactive Processing Center (ESD/IPC) in Camp Springs, Maryland. The ESD/IPC is connected in turn with the Fairbanks and Wallops CDA stations, and the six SFDFs.

A third major component, being developed by OSDPD, is the NOAA Operational Satellite Active Archive for satellite data and metadata access, display, and electronic transfer. The client/server prototype implementation, which focuses on AVHRR Level 1b data sets, began operations in April 1994 and is available for general use through the Internet. Developed as a collaborative effort between OSDPD and NOAA's National Climatic Data Center, the prototype offers the user a wide range of capabilities including: data catalog and inventory search; AVHRR image browse; on-line data selection and FTP transfer; and off-line data selection and delivery. On-line system documentation, data guides, and help files will assist the novice user and provide valuable time saving tips to all users. While developed as an independent system, the SAA serves as NOAA's initial interoperable interface to the NASA Earth Observing System Data and Information System (EOSDIS). OSDPD also intends to provide NOAA atmospheric Pathfinder derived data sets as the first major enhancement to the SAA by the end of FY 1994.

TABLE A.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA J	CY 1994
NOAA K	CY 1996
NOAA L	CY 1997
NOAA M	CY 1999
NOAA N	CY 2000

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES J	CY 1995
GOES K	CY 1999
GOES L	CY 2000
GOES M	CY 2004

Instruments for Advanced TIROS N Series

AVHRR	Advanced Very High Resolution Radiometer
SEM	Space Environment Monitor
SBUV	Solar Backscatter Ultraviolet Radiometer
HIRS	High Resolution Infrared Sounder
SSU	Stratospheric Sounding Unit (NOAA J only)
MSU	Microwave Sounding Unit (NOAA J only)
SAR	Search and Rescue System (Antenna)
DCS	ARGOS Data Collection System
AMSU-A	Advanced Microwave Sounding Unit-A (NOAA K,L,M,N only)
AMSU-B	Advanced Microwave Sounding Unit-B (NOAA K,L,M,N only)

Instruments for GOES-Next Series

Imager	
Sounder	
SEM	Space Environment Monitor
SXI	Solar X-Ray Imager (GOES L or M)
SAR	Search and Rescue
DCS	Data Collection System

*Launch date depends on performance of prior spacecraft.

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SUPPORTING RESEARCH PROGRAM

The requirements and goals addressed by NESDIS supporting research in FY 1995 include:

- NOAA's role in the National effort on the study of climate and global change (as detailed in the interagency report of the Committee on Earth and Space Sciences);
- NWS's effort in modernization (including strengthening the environmental observing and prediction systems and improving the application and dissemination of products and services) (per P.L. 100-685);
- Improvement in monitoring of the global ocean and in managing the resources in the coastal zone;
- The management of data that will be needed to support the above;
- The development, evaluation, validation, and implementation of new products and services from GOES-8; these will support NWS modernization;
- The continuation and improvement of products and services from the polar orbiting satellite system.

Research and development of applications of environmental satellite data are devoted to the improvement and development of improved techniques for quantitative and qualitative products and services. These serve national and international programs in weather analysis and forecasting; climate diagnosis; volcanic aerosol detection; programs for agriculture, fisheries, coastal zone management, and energy; and other weather, land and environmental applications. The data from current NOAA operational satellites in both polar and geostationary orbits, and research satellites operated by other nations and by NASA and

DOD, are used to develop improved techniques and algorithms for the definition of the global, three-dimensional structure of the atmosphere (winds, temperature, and moisture structure) that is essential for numerical weather analysis and forecasting.

The geostationary environmental satellites provide nearly continuous imagery and multi-spectral data in the visible and infrared (window and water vapor wavelengths) for study and applications. These studies lead to the understanding of the genesis and life cycles of severe storms (from thunderstorms to hurricanes and winter snow storms) and the morphology and evolution of the mesoscale systems (small time and space scales) in which they form. This research leads to the direct application of data from GOES-Next; analysis of the data also leads to applications with the other modernization tools that include NEXRAD, Profilers (wind and temperature), ASOS and AWIPS.

The GOES-Next satellites will provide higher resolution, enhanced multispectral imaging and separate sounding systems. Ongoing research will focus on new applications and products from this new sensor suite. Hourly soundings will be produced for the continental United States and adjacent waters. These will be tested in current and developmental numerical models to support NWS modernization initiatives. Special products, such as precipitable water and atmospheric stability, will be evaluated. These products together with wind, temperature, and moisture profiles, and ASOS will improve the temporal and spatial observations, particularly in coastal and mountainous soundings areas, complementing the improvements expected in the global polar soundings.

The new GOES infrared spectral bands available from the imager will assist scientists in observing low cloud/fog trends for nighttime applications. Accurate fog trends are extremely important for the aviation and marine communities. Higher resolution, 10-bit data, and better signal to noise ratios in all channels from the GOES-8 imager provide greater detail or sharpness in the data. This results in significant improvements to the quantitative and qualitative analysis and forecast products relayed to the user community, including severe weather analysis, cloud height measurements, cloud motion winds, low level water vapor identification, sea surface temperatures, volcanic ash detection, and tropical cyclone analysis.

Improvement in the methods for estimating precipitation from satellite data is critical for the prediction of flash floods on the local scale. On the global scale, precipitation estimation is important to the understanding of the effects of the release of latent heat of condensation in both numerical forecasts and in numerical climate models. Before making landfall, a satellite derived estimate of wind speeds and rainfall is attained for tropical systems and disseminated, both domestically and overseas. Other measurements from satellites requiring continued study and improvements are solar insolation, the "vegetation index" of biomass concentration, and the "soil wetness index", used to monitor the areal extent of flooding. These contribute to understanding of the hydrologic and biogeochemical cycles. In addition, winds, derived from cloud motions, are an essential source of data input to the National Meteorological Center's numerical forecast models.

Climate analysis, diagnosis and monitoring performed by the National Meteorological Center's Climate Analysis Center depend upon global satellite observations of the incoming and outgoing radiation. Knowledge of this "heat" or "radiation-budget" of the earth-atmosphere system is essential to the national and international research on the Earth's climate and environment. Research with satellite data is the key to understanding the effects of clouds as regulators of incoming and outgoing radiation that may lead to long term net warming of the globe. Applications research continues to improve estimates of the global distribution of atmospheric aerosols, their effect on climate, and on other satellite measurements. Satellites provide the only global measurement of ozone. Monitoring its distribution and concentration is critical to understanding the fate of this important atmospheric compound.

Monitoring sea surface temperature with satellites will continue to be a focus of research for climate diagnosis and other applications. The passive microwave and other multispectral data from DOD's meteorological satellites and international satellites contribute to improvements in the measurement of this important parameter. Research and development on the use of satellite data in coastal marine areas continues. This includes algorithms for estimating temperature, turbidity, and productivity for bays and estuaries. These satellite observations combined with aircraft and

in-situ oceanic data contribute to development of dynamic models of coastal processes.

The scientists at NESDIS continue to provide expertise and advice for the specification of sensors, processing systems, and technical requirements for the development of future satellite systems.

Environmental Data Bases

NATIONAL CLIMATIC DATA CENTER

The National Climatic Data Center has the principal responsibility to manage the national climatological data program, including data and information services. To meet this responsibility, the Center:

- Performs all data management functions regarding retrospective meteorological data, including data from in-situ and remote sensing sources (satellites, radars, etc.). Such functions include data acquisition, archiving, retrieval, indexing, quality assessments, evaluation, synthesis, dissemination, and publication of data collected by global and national observation networks or systems that have enduring value to the Nation and are sufficient to describe the climate;
- Operates as a designated Agency Records Center, for processing, storage, and servicing of retrospective meteorological records;
- Prepares and provides special products and services to users as required as a basis for regulatory standards and policy decisions;
- Maintains national and global databases for analyses of long-term climate trends and for monitoring global change;
- Provides facilities, data processing support, data exchange, and expertise, as required, to meet U.S. commitments to foreign nations, international organizations, and to the World Meteorological Organization's (WMO) programs. NCDC is the archive for meteorological data sets from WMO World Climate Research Program and WMO World Climate Data Program Projects such as the Tropical Ocean-Global Atmosphere (TOGA) Program, the Global Precipitation Climatology Program (GPCP), International Satellite Cloud Climatology Program (ISCCP), etc. In this capacity, NCDC operates the World Data Center-A for Meteorology under the auspices of the International Council of Scientific Unions.

The modernization of observing networks with the use of new technology and the increased concern for global climate change throughout the world have increased the challenge of managing climate data and serving the research community. To meet this challenge, NCDC is focusing on the development and implementation of new data processing systems for data from new observing equipment and new satellite systems, and to prepare and structure baseline data sets to meet the national and global needs for monitoring climate change. A Global Climate Perspectives System will be available for comparing current climate observations with long-term trends to put current observations into perspective. Researchers will be able to access data, perform analyses and inter-compare parameters.

Climate Data Management

The management of retrospective meteorological data for climate purposes has become increasingly complex as new automated and remote sensing high volume observing systems replace traditional manual systems. First, these new systems have necessitated a change in the concept of processing data for the climate database. New automated observing systems have made it possible to effectively quality control data for random errors on site, leaving the more complex quality control to identify systematic errors and biases to the NCDC. Second, the data from the new systems (both in-situ and satellite) must be integrated with the historical data, and third, the requirements for accurate homogeneous long-series data sets on a national, regional and global scale are placing an additional demand on data management and user services that may require the reprocessing of entire long-series databases.

In FY 1995, the NCDC plans to:

- Continue technology upgrade (i.e., computers, workstations, on-line storage and access, communication, etc.) to meet data management and services through the 1990's. High Density Storage Systems will be expanded to meet the demand for on-line access;
- Implement new processing systems to ingest the new data streams as the weather modernization

program is being phased in. Substantially more data (Level III products and Level II data) from an increased number of NEXRAD sites will be available to users;

- Issue a comparative study of the characteristics of data collected with automated systems versus manually observed data, as a result of the Weather Modernization Program;
- Working with the World Meteorological Organization, continue the preparation of a high priority global data set to monitor climate change;
- Prepare climate perspectives studies to place contemporary climate into historical perspective;
- Reanalyze and/or reprocess long-series data sets and produce global/regional baseline data sets;
- Enhance the operation of the World Data Center to concentrate on the collection and exchange of international historic climate data needed to complete long series data sets;
- Participate in NOAA data management programs as required to support the U.S. Climate and Global Change Program and the U.S. Global Change Data and Information System;
- Continue the development of CD-ROM based systems to describe the climate of the United States and to present data and information from around the world;
- Acquire, service and archive foreign meteorological satellite data (i.e. European Meteosat, etc.).

Climate Data Services

The demand for basic climatic data and information services has been increasing annually. NCDC now services over 140,000 requests for data and information annually. Due to a particularly large increase in requests from the research community, NCDC has formed the Research Customer Service Group, which specializes in providing data services support for both domestic and foreign climate research institutions. NCDC has information about its data and services integrated into the NOAA Master Directory as well as on the NCDC On-line Access and Service Information System. The popularity of on-line data continues to grow, and NCDC will expand its services to meet that demand. An increased number of in-situ data sets will be made available via on-line access. Extensive use will be made of the state-of-the-art telecommunications and Internet (World Wide Web, mosaic, home page) to improve on-line browse and access for in-situ and remotely sensed (NESDIS Satellite Active Archive) data. In FY 95, NCDC and NESDIS/OSDPD plan to implement the operational Satellite Active Archive, an expanded version of the prototype demonstrated in FY 94, making near-real time satellite data available on-line for browsing images and/or accessing and ordering data. Data can be transferred computer to computer or ordered for off-line delivery.

NATIONAL OCEANOGRAPHIC DATA CENTER

The National Oceanographic Data Center (NODC) supports climatic services and research through its data management and data services activities. The NODC provides data management for major climate-related studies such as the Tropical Ocean-Global Atmosphere (TOGA) program, the World Ocean Circulation Experiment (WOCE), and the Joint Global Ocean Flux Study (JGOFS). The NODC also provides data products and services individually to researchers as well as to members of the operational marine community (e.g., the Navy, Coast Guard, shipping industry).

Data Management

The NODC is working closely with the academic community to provide data management for global change research programs. Three joint centers have been established with university groups to focus on different aspects of data management for global change:

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

The JEDA Center is providing management of subsurface thermal data in support of TOGA. This activity is now part of a larger, global effort called the Global Temperature-Salinity Pilot Project (GTSPP). A cooperative international project, the GTSPP was initiated to improve the quality, volume, and

accessibility of global ocean temperature and salinity data.

NODC is participating in the Joint Archive for Sea Level by assisting researchers at the University of Hawaii in the acquisition, processing, quality assurance, archiving, and dissemination of sea level data from a network of island-based and coastal tide gages. The network consists of 137 stations in the Pacific Ocean Sea Level Network originally established as part of the North Pacific Experiment (NORPEX).

An initial project of JCRMOD was the establishment and operation of a data information unit (DIU) in support of WOCE. An online information system called Oceanic provides WOCE program information to principal investigators and other researchers. Using the successful WOCE DIU as a model, a DIU is being created for the TOGA Coupled Ocean-Atmosphere Response Experiment (COARE). In addition to an oceanographic component TOGA/COARE also includes atmospheric and ocean-atmosphere interface components and will thus extend the types of data to be tracked beyond those for WOCE. An information system for TOGA/COARE analogous to Oceanic is also operational.

To promote efforts to locate and preserve older, historical ocean data, the NODC has organized the Global Oceanographic Data Archaeology and Rescue (GODAR) Project. In support of this project the NODC in October 1992 published the *NODC Inventory of Physical Oceanographic Profiles: Global Distributions by Year for All Countries*. This publication is the first in a planned series of data inventory publications that provide data distribution plots and summaries of the NODC's data holdings. This information will help the worldwide oceanographic community to identify data not yet included in the NODC's digital data archives. In March 1993, the GODAR project was endorsed by the Intergovernmental Oceanographic Commission (IOC), and the U.S. NODC/WDC-A, Oceanography, was designated as the project leader. The success of initial GODAR activities has already resulted in the submission to the NODC of an additional 960,000 temperature-salinity profiles from nine countries.

NODC's research group has published a series of scientific papers described by decadal-scale variability of the North Atlantic Ocean as determined from the analysis of historical data. In particular, time-series data from Ocean Weather Stations "C" and "5", and a 7-volume ocean atlas providing objective analyses of major ocean parameters, have been published or are in press.

Data Services

During FY 1993, the NODC filled 12,245 user requests and disseminated 462 gigabytes of digital data to customers. CD-ROM continues to be an increasingly important medium on which to disseminate large ocean data sets. At the end of FY 1994, NODC will have released about 60 individual disks holding several major ocean data sets and other ocean data products. In early FY 1994, NODC established Gopher and Mosaic servers on the Internet. These servers contain information about NODC, its products, and services. These servers will also enable basic data browse and electronic data ordering services.

The NODC has management responsibility for the NOAA Library and Information Network (NLIN) consisting of:

- the NOAA Central Library in Silver Spring, MD;
- regional libraries at major NOAA facilities in Miami, FL, and Seattle, WA;
- more than 30 field libraries and information centers at other NOAA locations throughout the United States.

The NOAA Central Library has moved to the new NOAA building complex in Silver Spring, MD. The new and expanded facility enables the library to offer improved information services to users including climate and global change researchers.

Technology Enhancements

In FY 1994, NODC completed the conversion of its computer system from an older configuration based on a cluster of DC VAX computers to a modern client-server architecture based on advanced UNIX workstations. An upgraded Ethernet local area network (LAN) links the distributed computing resources at NODC's headquarters offices. Silicon Graphics workstations function as distributed servers to support NODC database operations, user services, and data communications. Peripheral devices include magnetic

tape drives (9-track, 8 mm, IBM 3480 cartridge), an optical disk drive, and an optical "Jukebox" that provides over 300 gigabytes of mass storage. The Ethernet LAN operates with TCP/IP protocol and supports about 90 nodes, including both high speed workstations sand PC-class computers.

NATIONAL GEOPHYSICAL DATA CENTER

Program Description

The National Geophysical Data Center (NGDC) carries out a number of programs which provide data for research in meteorology and climatology. Of particular interest is NGDC's program to assemble global information on paleoclimate and cooperate in research projects to employ the combined global paleoclimate database for climate model verification and climate change studies. Support for this program from the NOAA Climate and Global Change Program (CGCP) is continuing.

NGDC has actively sought and acquired many paleoclimate databases derived from tree-rings, pollen and macrofossils, lake and bog sediments, marine sediments, ice cores, and other geological and biological sources. Digital data sets have been enhanced with custom display and search capabilities. These research tools are currently being distributed to the paleoclimate community. Objectives of the program are to cooperate with researchers from NOAA, other agencies, and academia to describe the global patterns of decade to millenial scale climate change; to identify and understand the causes of this climate change; improve the ability of separating man-induced climate change from the natural variability, and to validate the models that are being used to predict global climate change the next several centuries.

Long-term, global records of solar variability archived at NGDC are the principal databases available to support research into the impact of changing solar energy output affecting Earth and changing climate or other global systems. Older ways of observing solar activity continue to be used today and their results are archived at NGDC. They provide continuity between the past and modern observations using new technology deployed on the Earth and in space. They offer a means to calibrate new observations and, by proxy, extend them back into the past. Drawings and counts of sunspots from visual observations exist since the early 17th century, and show the persistence of the well-known 11-year solar cycle. These have been used since the mid-19th century to produce the sunspot number index of solar activity. Efforts to correlate these numbers with weather and climatic conditions have intrigued scientists at least since the beginning of the 19th century (almost 50 years before 11 year sunspot cycle was discovered). From early in the 20th century, systematic telescopic observations were made of solar flares in visible light and other wavelengths.

NGDC holds Space Environment Monitor data from NOAA geostationary satellites since the early 1970s, including X-ray flare records made above the shield of Earth's atmosphere. For the past 11 years, satellites have carried instruments above the atmosphere and recorded significant changes in the total solar irradiance, the "solar constant," the total luminosity of the Sun. These data may be studied at NGDC, combined with complementary geomagnetic and ionospheric databases and with records about auroral occurrences. They already are made available to the research community in publications and on magnetic tapes, floppy diskettes, and Compact Disc-Read Only Memory (CD-ROM) media for computer analysis. With joint DOD (USAF) and NASA support, NGDC operates a special archive for the Defense Meteorological Satellite Program that collects imagery and special sensor data from polar orbiting satellites in raw form and processes them into archival format. Selected data are available on-line and all are available on various computer media.

The National Snow and Ice Data Center (NSIDC) at the University of Colorado and associated with NGDC, maintains several cryosphere-related data sets of interest to meteorology and climatology. These include a collection of historical photographs of glaciers; temperature, pressure, and position data from satellite-queried drifting buoys placed on the central Arctic pack ice; and data from the DOD-NOAA sea ice chart digitizing programs. NSIDC provides data management services for the Second Greenland Ice Sheet Program (GISP II) and the National Science Foundation-funded Arctic System Science Ocean-Atmosphere-Ice Interaction (ARCSS) research programs. In addition, NSIDC has developed gridded sea ice products (sea ice concentration and multi-year ice fraction) based upon passive microwave data

collected by the Scanning Multi-channel Microwave Radiometer on Nimbus 7 and the DMSP Special Sensor Microwave Imager. The passive microwave data sets are being distributed on CD-ROMs. Under NOAA ESDIM funding, NSIDC is acquiring snow cover, glacier, and sea ice records from former Soviet Union scientists and institutes.

NGDC is integrating multi-thematic global and continental data for intercomparison and analysis related to studies of global change. Various elements of this program include: (a) Global Ecosystems Database, an integrated multi-disciplinary environmental CD-ROM database structured for Geographic Information Systems and designed to support global characterization and modelling research; (b) Africa Global Change Database, initially constructed as a pilot database for the IGBP (predecessor to the Global Ecosystems Database), and now an educational product being made available to the teaching and research communities; (c) regional integrated databases for China, North America and South America. Additions to the Ecosystems database are released annually. The 1992 release included global data sets of topography; AVHRR derived monthly vegetation indices; vegetation, ecosystems, and land-cover classifications; methane emissions; soil classes and properties; long-term average monthly temperature; precipitation; cloudiness; and geographic boundaries. The 1994 release added new global and regional data sets and model-derived outputs.

In addition to integrated database products distributed on CD-ROM, NGDC also maintains and improves individual disciplinary data sets related to this mission, including: Generalized Monthly Global Vegetation Index, Experimental Calibrated bi-weekly Global Vegetation Index, Tateishi Monthly Global Vegetation Index and derived land-cover class, Olson World Ecosystems, Varlyguln/Basllevitch above-ground phytomass, CZCS marine pytoplankton pigment concentrations, global and continental topography, global geographic boundaries, numerous geophysical data sets, and an operational archive of DMSP satellite meteorological data. In support of these databases, graphic browse and visualization software is being developed. These databases and the associated supportive access software will play an important role in the NOAA CGCP.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

Environmental Research Laboratories

Environmental Research Laboratories (ERL) R&D programs support NOAA meteorological and space services and are oriented toward providing, understanding, and developing techniques and technologies to form the basis for improvements in the Nation's weather services. These important functions encompass the missions of several ERL laboratories.

Special emphasis is placed on improving severe weather and hurricane forecasts and warnings. Severe weather includes any major natural hazard such as flash floods, strong winds, thunderstorms (including tornadoes, lightning and hail), heavy snowstorms, extreme cold or drought. ERL laboratories will continue to conduct both inhouse and cooperative research with other NOAA components, joint institutes, and universities.

Observing Technology

The Environmental Technology Laboratory (ETL), formerly the Wave Propagation Laboratory, develops and experimentally evaluates new environmental remote sensing concepts and systems. ETL also improves the Nation's atmospheric research and forecasting and warning services through the transfer of remote sensing technology.

As an outcome of ETL research, ERL's Forecast Systems Laboratory is operating 29 wind profiling Doppler radars that make up the Wind Profiler Demonstration Network. This network, located in the central United States, is providing hourly winds aloft data to weather forecasters and is helping improve weather forecasts and warnings. The operation of this network is continuing in FY 1994.

During FY 1995, ETL will continue development of atmospheric profiling systems to remotely and continuously measure vertical profiles of wind speed and direction, temperature, and humidity. Specific efforts include the development and integration of the radio-acoustic sounding system (RASS) into wind

profilers to augment their capability with temperature profiles and, continuing development of techniques that can integrate the data from ground-based and satellite-borne profiling systems for more effective use of this data in forecasts.

ETL will also continue development of Lidars and infrared Doppler multifrequency radars as research tools to improve our knowledge of atmospheric winds, turbulence, and moisture processes. Development of dual-polarization Doppler and multifrequency radars and passive radiometers will also be undertaken to study convective storms and their precursors, including in-cloud and entrainment processes. ETL will also continue research in the area of ocean remote sensing including theoretical and experimental studies of rough surface scattering processes.

Tropical Atmospheric Research

The Tropical Dynamics and Climate Program of the Aeronomy Laboratory is using a network of remote sensing wind profilers in a long-term study of tropical circulation and its impact on global climate, in support of the Tropical Ocean Global Atmosphere (TOGA) program. The Trans Pacific Profiler Network (TPPN) consists of an array of wind profilers and Integrated Sounding Systems which make continuous measurements of atmospheric winds and other parameters in the tropical Pacific. In addition to 50 MHz wind profilers, the network is incorporating 915 MHz lower tropospheric wind profilers recently developed at the Aeronomy Laboratory. The observations, which extend from the boundary layer to the lower stratosphere, reveal the relationship between atmospheric vertical motions and convective systems in the tropics. Precipitation measurements can be made with sufficient vertical resolution to categorize precipitation in deep and shallow convective systems and in stratiform conditions. The network will: 1) provide valuable improvements to the boundary layer and convective parameterization schemes used in general circulation models, and 2) contribute to climate forecasting by furthering the understanding of the coupled ocean-atmosphere dynamics that governs the El Niño-Southern Oscillation phenomenon, the dominant component of interannual climate change. Installation of the network follows the Aeronomy Laboratory participation in the 1992-93 field phase of the TOGA Coupled Ocean Atmosphere Response Experiment (COARE).

Routine wind observations are made at Christmas Island using a 50 MHz wind profiler, and surface and upper air observations are made at Manus Island, Papua New Guinea using an Integrated Sounding System installed by the Aeronomy Laboratory. Data from these systems are used by the National Meteorological Center and the European Center for Medium Range Weather Forecasting in their operational analysis and forecast products. Monthly summaries of the Christmas Island winds are published in the NOAA/NWS/NMC Climate Diagnostics Bulletin.

Severe Weather Analysis and Forecasting Research

The National Severe Storms Laboratory (NSSL) in Norman, OK, focuses its research to understand and forecast severe weather systems and their associated hazards such as tornadoes, hail, high winds, heavy rain and snow, lightning, and ice storms. The parameters of storm development and intensification are identified and studied by incorporating observations from Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning location networks. In FY 1995, work is being expanded to include assessment and improvement of numerical models to forecast severe weather systems. NSSL provides significant technical and scientific support, including research and development, for the NOAA/USAF/FAA NEXRAD program.

In FY 1995, NSSL will continue to develop techniques, in cooperation with the National Weather Service, to forecast and warn of weather hazards to aviation and the general public. Immediate technology transfer will be effected by close association with National Weather Service Forecast Offices, particularly those in Norman, OK and Phoenix, AZ. The NSSL also works closely with NSSFC to improve severe storm forecast procedures.

Also, ERL will continue to transfer knowledge of Doppler radar applications, severe weather systems and heavy rainfall events; much of the transfer is through courses at the NWS training center. Visits and interactions with NWS centers, regional headquarters, and forecast offices continue and FSL and NSSL are participating directly in new training programs such as the Cooperative program for Operational Meteorology, Education and Training (COMET) in Boulder and the NEXRAD Operational Support Facility in Norman.

Improvement of short-range (1-12 hour) forecasting will be accomplished by the development and evaluation of new local data system technologies and techniques, many of which can be incorporated into operational weather forecasting in the near term. The Program for Regional Observing and Forecasting Services (PROFS) provides a tested prototype to evaluate workstations for laboratory and forecast office environments. Specifically, PROFS has and will continue to develop capabilities to allow the forecaster to integrate, view, and manipulate observations from current and planned meteorological sensing systems using computer-assisted data display and synthesis techniques. By maintaining state-of-the-art capability for use in research and development of operational techniques, it has provided a mechanism to evaluate weather service requirements for the Advanced Weather Interactive Processing System (AWIPS).

PROFS will continue its emphasis on data application from the GOES VISSR Atmospheric Sounder (VAS), Doppler radar, Aeronautical Radio Incorporated (ARINC) Communications Addressing and Reporting System (ACARS), and the WPDN as inputs to its quantitative mesoscale analysis and prediction model, thus expanding service improvement efforts to include nonsevere as well as severe weather, to assist NWS modernization and restructuring, and to upgrade National Meteorological Center operations.

A multi-year program of coastal meteorology research was begun in FY 1994 at the Pacific Marine Environmental Laboratory (PMEL). This program also involves WPL and NSSL, the NWS Forecast Office in Seattle, NCAR, and the University of Washington; support for the program is also being provided by the Office of Naval Research and NSF. This research is intended to improve the understanding of the effects of prominent terrain on U.S. West Coast weather, with the ultimate goal of providing improved forecasts of coastal winds, sea state, and storm surges. The early emphasis has been on the upstream effects of the coastal terrain in the storm environment, when the background forcing is strong and the coastal forecasts are most critical. The approach being taken involves a combination of special field observations and diagnostic studies using experimental NWP simulations. Recently completed field work featuring a NOAA P-3 research aircraft yielded meteorological data for the Pacific Northwest coast during low-level winds of up to 85 knots, and in the vicinity of two of the strongest cold fronts ever observed in detail over the ocean. The case studies from this work will provide immediate insights on the influences of the coastal terrain on landfalling storms, and high-quality data sets for NWP initialization and validation.

Mesometeorology and Precipitation Forecasting and Warning Research

NSSL and FSL develop techniques to improve short-term forecasts of significant weather events. Through detailed case studies and regional climatologies, scientists from these two laboratories have developed diagnostic tools and aids for operationally forecasting thunderstorms, lightning, flash floods, and large mesoscale convective storms complexes. Activities underway include studies of the precipitation structure of mesoscale convective systems, of interactions between mesoconvective systems and the larger environment, of satellites to infer storm development and rainfall, and of winter storm forecasting procedures. In FY 1995, NSSL will be using polarization information to improve radar procedures for rain estimation.

Midlatitude Mesoscale Meteorology Research

At the Aeronomy Laboratory, the Atmospheric Dynamics Program combines observational and theoretical studies of mesoscale high-frequency atmospheric processes, focusing on internal gravity waves and vertical air motion. By improving the understanding of these dynamical processes, the research contributes to improvements in weather forecasting and the transfer of advanced meteorological measurement technology to operational use. Data for the studies is obtained from the 50 and 915 MHz wind-profiler radars at the Flatland Meteorological Observatory, which make continuous horizontal and vertical wind measurements in the very flat terrain near Champaign-Urbana, Illinois. The Observatory also includes a 915 MHz Radio Acoustic Sounding System which measures temperature, an array of 24 digital barometers spread over Illinois, and standard surface and balloon-borne instruments. The research has shown that all enhancements of gravity-wave energy are associated with meteorological events, such as fronts, convection, or jet streams, and that such events always cause enhancements.

Hurricane Analysis and Prediction Research

The Hurricane Research Division (HRD) of the Atlantic Oceanographic and Meteorological Laboratory (AOML) performs research to improve operational hurricane forecasts and warnings. HRD's hurricane field program uses highly instrumented NOAA P-3 research aircraft to acquire unique data which are analyzed to describe and understand the dynamics and energetics of the hurricane's inner intense core.

More specifically, HRD is engaged in a research strategy that consists of three areas: increasing data density in tropical cyclones and their surrounding environments, understanding storm dynamics and energetics, and improving forecast models. These elements are crucial for improved tropical cyclone track and intensity forecasts which will save lives and money.

In addition to the HRD research, the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton, NJ, models the genesis, development, and decay of tropical storms, including small-scale features within hurricane systems, using multi-nested models of the storm system and its environment.

Numerical Analysis and Prediction Modeling

GFDL conducts long lead-time research to understand the predictability of weather on both large and small scales and carries out experimental applications of this understanding to NOAA missions. Two main areas of weather research are covered by the GFDL program -- Experimental Prediction and Mesoscale Dynamics. Experimental prediction research is carried out with the National Meteorological Center to determine the predictability of global atmospheric circulation on extended time scales. Mesoscale dynamics research seeks to understand the practical limits of mesoscale predictability and the interaction of mesoscale phenomena with the larger and smaller scales.

ARL's Atmospheric Sciences Modeling Division (Research Triangle Park, NC) conducts intramural and extramural research programs to develop predictive models on local, regional, and global scales for assessing changes in air quality and air pollutant exposures, as affected by changes in ecosystem management and regulatory decisions. The Division provides technical guidance on applying and evaluating air quality simulation models that are used to assess, develop, or revise air pollution control strategies for attainment/maintenance of ambient air quality standards.

Air Quality Research

The Air Resources Laboratory (ARL) carries out research on processes that affect the quality of the atmosphere, primarily in the context of air pollution, deposition, and emergency preparedness. Various field divisions of ARL focus on specific issues related to the development of predictive models. The Atmospheric Turbulence and Diffusion Division (Oak Ridge, TN) carries out an integrated program of theoretical and experimental research on atmospheric turbulence and diffusion in the lower atmosphere. This includes dispersion and planetary boundary layer studies in non-stationary and non-homogeneous conditions, air-surface exchanges of properties and trace gases (especially over and within vegetation canopies), and emergency preparedness efforts.

ARL's Field Research Division (Idaho Falls, ID) conducts research on the transport, dispersion and removal of those materials in the atmosphere usually regarded as pollutants. Progress toward this goal is sought by studies of the mean and turbulent atmospheric flow characteristics on all scales of motion and by studies of the history of a wide variety of tracers accidentally or purposefully introduced into the atmosphere.

The Aeronomy Laboratory conducts research on air quality as part of its tropospheric chemistry program. A primary focus is on understanding the processes of near-surface ozone formation in rural regions. Field experiments, laboratory work, and numerical modeling studies assess the relative roles of natural hydrocarbons (emitted from vegetation), anthropogenic hydrocarbons, and nitrogen oxides in controlling ozone production. A series of field experiments have been conducted in recent years in the southeastern United States, a heavily vegetated region which frequently experiences elevated levels of ozone. Analysis of the data has linked ozone production most strongly to anthropogenic nitrogen oxides and natural, but not manmade, hydrocarbons. These results have implications for regulatory approaches to controlling air quality in the region.

Ozone production on the global scale was studied by the Aeronomy Laboratory in a recent field campaign, the North Atlantic Regional Experiment (NARE). The study was undertaken in response to the growing concern that long-range ozone transport may influence air quality on an interhemispheric scale. Comprehensive chemical and dynamical measurements, both ground-based and from airborne platforms, tracked the changing composition of air masses containing pollutants from eastern North America as these air masses were carried into the North Atlantic. Results indicated that the quantity of ozone generated photochemically from anthropogenic emissions on the North American continent exceeded that injected from the stratosphere. This conclusion supports the contention that ozone derived from anthropogenic pollution has a hemisphere-wide effect at northern temperate latitudes.

The Environmental Technology Laboratory uses its suite of remote sensors, including a mobile profiler network, airborne and ground-based ozone lidars, Doppler lidar, and supporting turbulence instrumentation, to understand and better model the transport, transformation, and fate of primary and secondary pollutants in both rural and urban environments as well as in complex orography.

Space Environment Services

The National Oceanic and Atmospheric Administration and the USAF Air Weather Service jointly operate the National Space Environment Services Center in the Space Environment Laboratory (SEL) in Boulder, CO. The Center provides forecasts, alerts, indices, and summaries of disturbances occurring on the Sun, in space, in the geomagnetic environment, and in the upper atmosphere. The services are used by DOD, DOT, DOC, DOI, DOE, NASA, NSF, commercial users, and the research community: (1) to optimize the operation of technical systems that are adversely affected by disturbances in the space environment, and (2) to carry out research in the solar-terrestrial environment. Examples of the adverse effects include loss or reduced efficiency of communication systems, radiation hazards to personnel and systems on high-altitude aircraft and in space, degradation of surveillance and monitoring systems for defense, errors in navigation systems, perturbations of satellite orbits, and disruptions in power distribution networks.

The Center serves as the International World Warning Agency for the solar-terrestrial environment. It collects international data (on sunspots, corona, x-rays, magnetic, etc.) in real time and from this data, provides Ursigram and World Days Service, and meets additional specific needs of other Government agencies. The Center distributes data to other countries and issues a consensus set of daily forecasts for international use.

The Center operates with observations received from agencies that make their data available in real time and, in return, receive the services to meet their own needs. Agencies making major contributions of data include DOD, NASA, DOC, NSF, DOE, and DOI. The Space Environment Laboratory cooperates directly with NOAA/NESDIS to receive solar x-ray, particle, in situ magnetic field, and plasma data from the Space Environment Monitors on GOES and the polar-orbiting NOAA satellites.

Data are collected, stored, and displayed for analysis and products are distributed through the Space Environment Laboratory Data Acquisition and Display System (SELDADS II). Services are distributed via teletype and digital data links (primarily operated by other agencies), via the SELDADS, by radio broadcast (WWV), by mail, by recorded telephone messages available to commercial dial-up users, and by low-cost commercial satellite broadcast service.

NATIONAL OCEAN SERVICE

The National Ocean Service (NOS) develops, implements, and manages programs in physical, biological, chemical, and geological oceanography and establishes a scientific information base on which to support development of national policy for the oceans and their users. NOS efforts are coordinated with marine programs administered by other components of NOAA. Products and services provided by NOS encompass the full range of NOAA marine activities. Operational ocean observing activities administered by NOS include: Voluntary Observing Ship (VOS) programs; moored/drifting buoy programs; water level programs, and satellite observation programs.

Voluntary Observing Ship (VOS) Program. NOS operates a global VOS Program that provides real-time meteorological and oceanographic data from selected vessels. Data are collected with the Shipboard Environmental data Acquisition System (SEAS), which transmits the information to NOAA via the GOES system. The information is then disseminated nationally and internationally using existing data networks. Presently there are over 120 vessels in the program, that record and transmit surface meteorological information four times per day at synoptic hour. Of these vessels, about 80 also are equipped to collect expendable bathythermograph (XBT) data.

Southern Hemisphere Drifting Buoy (SHDB) Program. In support of the Global Climate Observing System requirements, NOS, in cooperation with the NWS, NOAA Office of Global Programs (OGP) and Scripps Institution of Oceanography, maintains a network of 100 meteorological drifting buoys in the Southern Hemisphere. The buoys measure sea level atmospheric pressure, air temperature, and sea water temperature. Observations are obtained through the ARGOS data collection and platform location system on-board the NOAA polar orbiting satellites.

Tropical Atmosphere Ocean (TAO) Moored Array. NOS is a partner, with OAR and OGP, in the implementation of the TAO moored buoy array. TAO is a basin-wide array of moored ATLAS buoys in the tropical Pacific that report surface wind, air temperature, sea surface temperature, ten subsurface temperatures to a maximum depth of 500m and two subsurface pressures in real-time via the ARGOS system. There will be 70 buoys deployed by the end of FY 1994. The array is operated by the TAO Project Office located at NOAA's Pacific Marine Environmental Laboratory in Seattle, WA where NOS has responsibility for management of project operations and logistics. While the principle objective of the project is to support research objectives, the real-time availability of the data makes it extremely valuable to the operational meteorological centers.

Arctic Drifting Buoy Program. The U.S. Interagency Arctic Buoy Program (USIABP) was established in 1992 to provide the management structure and coordination necessary to maintain a baseline network of drifting buoys. Buoys within the array provide sufficient spatial resolution to define surface synoptic scale atmospheric pressure, air temperature, and sea ice drift fields. Emphasis has been placed on the accurate measurement of ambient air temperature. Data are used in real-time for operational weather and ice forecasting and for research in the Global Climate Change Program. The USIABP is a collaborative program that draws operating funds and services from the collective contributions of eight Government agencies and/or programs. The organizations include: NOAA's NOS, Office of Oceanic and Atmospheric Research, and Office of Global Programs; the Office of Naval Research; the Naval Oceanographic Office (NAVOCEANO); the National Aeronautics and Space Administration; and the National Science Foundation. By the end of FY 1994, the USIABP will have a network of 45 buoys.

National Water Level Observation Network (NWLON). NOS operates and maintains the NWLON for the collection of water level data, as well as other oceanographic and meteorological data. The NWLON consists of 189 stations located in U.S. coastal areas and the Great Lakes. Through its strategic locations and data dissemination capabilities, NWLON supports a number of NOAA and other Federal Programs, such as: the NOS Tide Prediction Program; NWS Tsunami Warning System and storm surge warning/forecast activities; Climate and Global Change Program; and the U.S. Army Corps of Engineers lake level regulation, dredging operations, and coastal construction efforts.

Physical Oceanographic Real-Time System (PORTS). PORTS is a data acquisition and dissemination system which integrates a number of important meteorological and oceanographic parameters, including currents, water levels, and marine winds. Traditional NOAA tide and current prediction tables provide only the astronomical tides and currents and do not always meet the needs of users who must also consider the non-tidal effects of river flow, winds and other meteorological forces. PORTS measures and integrates these important data and provides a data dissemination system that includes telephone voice response, as well as modem access.

NOS also provides operational marine analyses and forecast guidance material, as required by NOAA's mission responsibilities. Analyses, interactive guidance products, and numerical model output are produced at,

and disseminated from, two National Centers: 1) the NOAA Ocean Products Center (Camp Springs, MD) which provides marine weather and physical oceanographic products; and 2) the Navy/NOAA Joint Ice Center (Suitland, MD) which provides analyses/forecasts of hazardous ice conditions for the Great Lakes and Polar regions. Additionally, the NOS Ocean Applications Branch (Monterey, CA) provides dial-in access to numerical oceanographic and marine weather products produced by the Navy's Fleet Numerical Meteorology and Oceanography Center, as well as satellite data and synoptic weather and oceanographic observations from a variety of sources.

OFFICE OF NOAA CORPS OPERATIONS
AIRCRAFT OPERATIONS CENTER

The Aircraft Operations Center (AOC) supports several NOAA missions, in particular, it operates a fleet of aircraft which are used to support NOAA's research and development programs to improve weather, marine, and climate services. It also provides weather reconnaissance support to NOAA programs, other Federal agencies and international programs approved by the Aircraft Allocation Council. Light aircraft provide aerial photography for nautical and aeronautical charting and living marine resources surveys.

AOC was established in October 1983 to consolidate the management of all aircraft used by NOAA. Fourteen aircraft located throughout the United States are managed by AOC located at MacDill Air Force Base in Tampa, Florida.

NOAA's atmospheric and oceanographic research and reconnaissance operations are supported by two fully instrumented WP-3D aircraft which carry state-of-the-art environmental research equipment. The aircraft research and navigation systems provide detailed spatial and temporal observations of a wide range of atmospheric and oceanic parameters. AOC develops and calibrates specialized instruments, integrates user-supplied instruments into the automated systems, and processes and analyzes data sets obtained from various field programs.

AOC aircraft provide high density/accuracy hurricane data to the National Hurricane Center in near real-time. Storm data are transmitted via the aircraft satellite data link to upgrade forecasting models of hurricane track/intensity. The AOC aircraft have primary responsibility for reconnaissance of tropical storms and hurricanes over foreign airspace that may be restricted for U.S. military flights. AOC augments USAF operational aircraft reconnaissance with high-density, high-accuracy data when storms are within 24 hours of landfall of the continental United States and whenever DOC needs exceed DOD resources. AOC also provides a quick response capability for investigation of storm activity east of 80°W longitude from August 1 through September 30 each year.

APPENDIX B

DEPARTMENT OF DEFENSE WEATHER PROGRAMS

The Department of Defense (DOD) operates a military environmental service system to provide specialized worldwide meteorological and oceanographic analysis and prediction services in support of military forces. This system directly supports all phases of military operations, from strategic planning to tactical operations. While the Army and Marine Corps each have a small specialized weather support capability, the Naval Meteorology and Oceanography Command and the Air Force Weather System are the primary sources of military weather products. 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 special observing capabilities such as the Defense Meteorological Satellite and Global Weather Intercept Programs to meet unique military requirements. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES AIR FORCE

METEOROLOGICAL SERVICES

The functional manager for Air Force meteorological services is the Director of Weather (HQ USAF/XOW), within the HQ USAF, Deputy Chief of Staff for Plans and Operations. HQ USAF/XOW oversees the development and implementation of weather support concepts, doctrine, policies, plans, and programs to ensure effective weather support for the Air Force, Army, and other agencies as directed by the Chief of Staff, USAF. The AF also provides support to DOD joint operations as directed by the Joint Chiefs of Staff under the Unified Action Armed Forces (JCS Publication 0-2) document. Another role of HQ USAF/XOW is to interface with other Military Departments, Federal Agencies, and international organizations concerning coordination, cooperation, standardization, and interoperability of weather services.

Air Weather Service (AWS) is a Field Operating Agency (FOA) reporting to HQ USAF/XOW. AWS currently provides centralized weather and space environmental support to designated users through three centralized support organizations: Air Force Global Weather Central (AFGWC), the USAF Environmental Technical Applications Center (USAFETAC), and the Air Force Space Forecast Center (AFSFC).

In November 1993, the Chief of Staff of the Air Force approved a restructure of Air Weather Service. FY 1994-1995 restructure actions include:

- Transfer of the AFSFC to AF Space Command by October 1, 1994.
- Detachments (Det) and Operating Locations (OL) which report directly to AWS will be deleted by October 1, 1995 (Details on the realignment of current Det and OL functions are still being coordinated).
- Scale back operation of the USAFETAC facility to 80 hours per week.

Observations

Meteorological observations are classified as surface, upper air, radar, or satellite observations. Observation and sensing of the space environment are discussed in the Space Environmental Services section.

Surface observations are taken by Air Force personnel in support of military operations and analysis and forecasting. Observations from both Air Force and Army locations (fixed and tactical) are made available to local users and are also collected by the Automated Weather Network (AWN) for transmission to AFGWC and to other military and civil locations throughout the world. There are 125 Air Force operated surface observing locations or facilities in the continental United States (CONUS) and overseas.

Upper air observations provide a major input for numerical analysis and forecasting. Most of this information comes from U.S. and foreign rawinsonde

sources and military and civilian satellite-derived data. Additional upper air information from data-void areas is obtained from in-flight pilot reports from both military and civil aircraft.

Weather radar is a principal source of information for making short-term warnings of severe weather. The Air Force operates 75 fixed weather radar sets (20 at overseas locations) and 5 tactical weather radar sets. Two of the CONUS sets are a part of the U.S. basic weather radar network; nine are used in a backup capacity. Also, 15 of the Air Force weather radars are used to support the National Hurricane Operations Plan. The tactical weather radar sets are used to support contingency operations. The Air Force will operate 30 WSR-88D (NEXRAD) radars when the system installation is completed in FY 1996, and have access terminals at 195 Air Force bases and Army posts.

The Air Force manages the Defense Meteorological Satellite Program (DMSP), which provides a large volume of cloud, upper air, and space environmental data, and is the most important single source of global weather data used for combat support. On-board sensors provide AFGWC and the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC) with visible, infrared, and microwave imagery of the entire globe; temperature and moisture sounding data; auroral electron counts; and other specialized space environment data. DMSP also supplies direct, real-time readout of regional image and mission sensor data to selected land-based and ship-borne terminals located worldwide.

The present DMSP satellite series (Block 5D-2) uses an Operational Linescan System (OLS). Beginning with the fourth (Block 5D-1) series satellite the infrared spectral window was narrowed to 10.5 to 12.5 micrometers to reduce the amount of absorption by ozone and water vapor. The visible detectors were selected to optimize distinction among clouds, ground, snow, and water. It uses both stellar and inertial references, together with on-board processors, to maintain stability and pointing accuracy. The DMSP also flies a microwave temperature sounder (SSM/T) which provides vertical temperature and height profiles of the atmosphere. Satellite F-8, launched in June 1987, carried the first microwave imager (SSM/I) providing new capabilities to observe rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data.

President Clinton signed a Presidential Decision Directive (PDD) in May 1994, directing the Department of Defense to merge DMSP follow-on acquisition efforts with the Department of Commerce's Polar-orbiting Operational Environmental Satellite system follow-on acquisition team. This "converged" system, tentatively identified as the National Polar-orbiting Operational Environmental Satellite System (NPOESS), will establish an Integrated Program Office (IPO) by October 1994. The IPO will contain selected members from the Departments of Defense and Commerce, and NASA. Focused on creating the next generation of polar-orbiting operational environmental satellite, the IPO will manage the system from cradle to grave. The first NOPESS spacecraft is scheduled to be available by 2004. International participation in the NPOESS was encouraged in the PDD, and discussions with the European meteorological satellite organization are underway for inclusion of their spacecraft into the final NPOESS constellation.

Communications

The utility of observations of meteorological elements depends on an effective communications network. The USAF global weather communications system provides for the collection of alphanumeric meteorological data, delivers these data to weather centrals and forecast facilities, and distributes centrally produced products to the user. The Air Force communications system consists of conventional weather teletype networks; high-speed automated digital facilities; long-haul, point-to-point teletype data circuits; facsimile networks; and radio and teletype intercept facilities.

The Air Force-operated Automated Weather Network (AWN) is the backbone of military weather communications. High-speed computers interconnected with 2400 baud to 56 kilobaud circuitry deliver foreign and domestic weather data to designated users. Weather intercept sites in key overseas areas obtain World Meteorological Organization weather broadcasts, as well as non-WMO broadcasts, for AWN delivery to AFGWC. The AWN also delivers these data to the Navy and to NOAA's National Meteorological Center.

Overseas collection and dissemination networks deliver data to, and exchange data with, the AWN Automatic Digital Weather Switch (ADWS) at Hickam AFB, HI, and RAF Croughton, UK. In the continental US (CONUS), the ADWS at Tinker AFB, OK drives the Automated Weather Distribution System (AWDS), the CONUS Meteorological Data System (COMEDS), and other special teletype systems, and provides direct support to AWDS in the collection and dissemination of weather information. These circuits also collect and disseminate military Notice to Airman (NOTAM) message traffic to all DOD CONUS users.

The Communications Front-End Processor (CFEP) at Offutt AFB, NE, is the hub of all communications at AFGWC. It drives dedicated circuits, the Interdepartmental Meteorological Data Exchange System (IMDES), the weather chart facsimile system which provides graphic data to worldwide military users, and interfaces with the AWN. CFEP also drives separate graphics networks serving the CONUS, Alaska, Europe, Central America, and the Pacific.

Preparation of Analyses and Forecasts

The primary center for providing weather analyses and forecasts for Air Force and Army operations is AFGWC at Offutt AFB, NE. AFGWC uses a networked computer system and an interactive graphics and imagery system to implement a "build-and-apply" concept. Worldwide weather data are relayed to AFGWC and blended with civil and military meteorological satellite data to construct a real time, integrated environmental database. Computer programs further digest the data to construct models of the atmosphere and to forecast its future behavior. Manual tailoring of the data is critical for application to the specific needs of the warfighters. The interaction between forecaster and machine is accomplished with the Satellite Data Handling System (SDHS). SDHS consists of approximately 35 interactive workstations capable of high-speed interaction with satellite and conventional meteorological data to prepare forecasts and other environmental products. SDHS employs interactive workstations capable of high-speed interactions with satellite and conventional meteorological data to prepare tailored environmental products. The Federal Plan for Mutual Support and Cooperative Backup Among Operational Processing Centers designates AFGWC as backup for the NWS facsimile network, the NWS Automation of Field Operations and Services (AFOS) products, and the National Severe Storms Forecast Center.

In support of DOD combat operations, the Air Force weather system operates centralized units consisting of AFGWC, USAFETAC, AFSFC, fixed theater Forecast Units (FUs), fixed Weather Support Units (WSUs), and provides personnel to deployed Joint Meteorological/Oceanographic (METOC) Forecast Units (JMFUs). Normally weather support is a mix of centrally and locally produced meteorological products. AFGWC is generally responsible for forecaster aids (analyses and prognoses) and tailored guidance products for meteorologists who apply the information to specific areas or missions. Theater FUs are specifically named units, e.g., the Korean Forecast Unit, designated to provide forecast services and products from a fixed location for a specific geographical area, tactical operation, or exercise. A JMFU provides the same services as a theater FU; however, it is deployed to support a specific combat operation or exercise which is not or cannot be supported by theater FU. AFGWC directly supports Air Force, Army, and joint forces whenever the theater FU lacks support capabilities, when a JMFU is not established, or during the period when the deployed JMFU is not yet operational.

Dissemination of Forecasts and Warnings

The Air Force and Army require worldwide meteorological services for specific operational and planning activities. Military users require meteorological information directed to the needs of weapon systems being developed or used; command and control systems; Army firing units; research, development and evaluation; training and deployment of military forces; and contingency operations.

The Air Force Weather System enhances the unique global capability of military aviation while indirectly assisting civil aviation. Air Force personnel provide flight weather briefings, air/ground radio services, and tailored observations, forecasts, watches, and warnings for military operations.

A special aspect of the military weather mission is the need to provide adequate decision-assistance to commanders and resource managers. To fulfill this requirement, designated Air Force weather personnel serve as part of the working staff of operational Air Force, Army, and joint force units. In this capacity,

Air Force weather personnel identify all weather sensitive areas of the operation, monitor the weather service provided in these areas, and provide expert advice to mitigate weather impacts on training or combat operations. This effort helps ensure that Air Force, Army, and joint force units fulfill their missions regardless of the weather and results in efficient use of weather resources by gearing them to mission needs.

Deployed weather teams are the basic units providing weather support in a combat theater. These teams provide surface and upper air observations, staff weather officer services, and forecasts. The Combat Weather System, Tactical Weather Radar, tactical meteorological satellite direct readout terminals, and tactical communications terminals provide the means to acquire vital meteorological data within a theater. A high frequency radio broadcast system is used to transmit alphanumeric and facsimile products to the theater weather force. This system consists of regional broadcast stations at Anderson AFB, Guam; Elmendorf AFB, AK; Elkhorn, NE; and Croughton, England.

Specialized Support

The USAF Environmental Technical Applications Center (USAFETAC), Scott AFB, IL, provides environmental data and specialized studies to support the Air Force, Army, and other Government agencies. Typical support satisfies requirements for assessments of natural environmental effects on military plans, weapon systems, facilities, and intelligence activities. USAFETAC collects environmental data from AFGWC and then sorts, checks, stores and employs these data to produce tailored products. USAFETAC also operates a facility, collocated with the National Climatic Data Center in Asheville, NC, that exchanges data and shares some facilities with that civil agency. USAFETAC typically collects, quality assures, and applies worldwide surface and upper air observations; a three-dimensional cloud analysis extracted from meteorological satellite imagery (Real-time Nephanalysis); a global analysis of snow cover; solar, geomagnetic, and space observations and indices; and many other specialized environmental data sets. As already noted in the Air Force-directed restructure of AWS, operating hours for USAFETAC will be reduced to 80 hours per week.

In addition to the specialized products provided by USAFETAC, the Air Force supports an array of specialized requirements of the Air Force and Army. Some of these are described below.

The Air Force integrates Army weather mission into its overall mission concept. The Army trains and educates Air Force personnel about Army organizations, concepts of operations, and the weather sensitivities of Army operations and equipment. Air Force weather units are aligned and integrated with the Army intelligence organization. Weather products are in a form which is directly usable and understandable by Army personnel and are integrated into Army communications systems. Mobile and fixed meteorological equipment is programmed by the Air Force. In a tactical environment, weather personnel serve with echelon-above-corps, corps, divisions, separate brigades, regiments, aviation brigades, armored cavalry regiments, ranger regiments, and special forces groups (as well as subordinate battalions deployed at forward operating bases). Observer support is provided to all levels identified above.

The Air Force provides meteorological products to the Nation's space and missile programs. This includes a wide range of weather observing services at the Air Force Eastern Space and Missile Center and the Kennedy Space Center. The Air Force also provides launch forecasting service for NASA's manned and unmanned launches and for commercial launches from the Kennedy Space Center.

The Air Force provides specialized meteorological services for the Air Force Western Space and Missile Center at Vandenberg AFB, CA, and the Pacific Missile Range which includes Pt. Mugu and San Nicholas Island, CA, and Barking Sands, HI. The Air Force also supports the White Sands Missile Range, NM, the Kwajalein Missile Range, and other DOD research and test facilities.

The Air Force and the Navy operate the Joint Typhoon Warning Center on Guam under the Naval Pacific Meteorology and Oceanography Center West, Guam. The Center provides tropical cyclone warning services to DOD units and other US subscribers in the area west of 180 degrees to the east coast of Africa in both hemispheres.

The Air Force directly supports DOD Special Strategic Programs, the National Command Authority,

the National Military Command System, and the National Security Agency. Tailored environmental support products are disseminated to these customers worldwide.

The Air Force and NOAA operate the Joint USAF/NOAA Space Environment Services Center at Boulder, CO. The center provides space environmental data, products, services, and solar forecasts to a wide variety of customers.

The Air Force also provides Agro-meteorological output to the USDA's Foreign Agricultural Service and other national customers. The output provided includes diagnostic soil hydrology and other meteorological output pertinent to crop growth and yield estimation.

Air National Guard

There are two distinct functions within the Air National Guard (ANG) weather program. The traditional ANG weather program consists of approximately 30 weather flights, ranging in size from 13 to 25 personnel. The flights provide support to US Army units, mostly those of the Army National Guard (ARNG). The flights meet monthly to train for their wartime missions. The ANG is also responsible for peacetime weather support to its flying units. Civil Service employees of the ANG provide weather support at six National Guard Bureau (NGB) locations, and additionally, there is contractor-provided weather support at six ANG locations.

Planned Enhancements

Air Force, Army, and joint force operational requirements for environmental support are the basis for all Air Force actions to improve existing or acquire new capabilities. The Air Force assesses these requirements and attempts to satisfy them through either hardware acquisitions or technique development.

Air Weather Service and the Naval Meteorology and Oceanography Command are working on initiatives to improve environmental support to joint, inter-service, and service operations. They focus on the strengths of each of the services and build on existing cooperative efforts. ~~As part of this cooperative effort, four of the initiatives designate AFGWC as the primary DOD meteorological satellite center, the primary DOD cloud analysis and forecast center, and the primary DOD theater METOC center; FLENUMMETOCCEN is designated as the primary DOD global numerical weather prediction center.~~

Deleted, Per Julian M. Wright, Jr. Federal Coordinator

The Air Force is modernizing and improving its base-level weather systems. This includes the Automated Weather Distribution System (AWDS) Pre-Planned Product Improvements (P3I) and Next Generation Weather Radar (NEXRAD) programs. NEXRAD installations are in progress. AWDS installations were completed in Spring 1994.

To enhance AWDS in base weather stations and to expand forecasting capabilities, the AWDS Pre-Planned Product Improvement (P3I) program consists of the following phases:

Phase I. Interoperability with other command, control, communications, computer, and information (C4I) systems;

Phase II. Improvement of processor speed of all workstations;

Phase III. A remote briefing capability, an intra-AWDS product preparation capability, and improved meteorological satellite ingest capability.

The Concept for Weather Support to Air Force Theater Operations 1995-2005 (CONOPS), describes the means to produce and apply environmental information to enhance the employment of military assets. The Combat Weather System (CWS) Operational Requirements Document, describes the approach to implement the CONOPS by supporting military forces from initial deployment through sustained theater operations.

The goal of the CWS is to interface highly capable automated weather observing and forecasting systems with combat planning and execution systems. The CWS will enhance the effectiveness of combat operations by improving the capability of deployed weather forces to produce comprehensive and timely weather decision products for battlefield commanders and aircrews. The observing components of the CWS will provide accurate automated surface and upper air observations and quickly distribute these data to weather forecast systems. The forecasting portion of the CWS will in turn rapidly transmit the surface observations to the automated theater battle management C4I systems for further dissemination to

operational customers. The forecasting system will also integrate all observations for quick generation of tailored forecasts for distribution.

The NEXRAD radar, WSR-88D, is being procured under the auspices of the NEXRAD Joint System Program Office. The WSR-88D is an automated, digitized, S-band Doppler system that was jointly developed and procured. It will be operated and maintained by DOD, NOAA, and FAA within the CONUS and by the Air Force and Navy overseas. The system incorporates the latest technological advances in Doppler radar, data processing, communications, and display. The CONUS NEXRAD network will satisfy weather radar requirements in support of the general public, the military, and the entire spectrum of the aviation community. Installations of the WSR-88D are in progress and are expected to be completed by 1996.

The Centralized Data Management System (CDMS) transition is a related series of distinct acquisition, development, and integration efforts to transition AFGWC from a database-dependent applications environment to a centralized database management system. Under the CDMS transition, AFGWC centralized the management of a number of key databases on one computer for both unclassified and classified production. This acquisition will be integrated with improved AFGWC hardware/software systems and will transition to the centralized database management environment under planned programmed steps with major AFGWC hardware upgrades and related software modernization efforts. CDMS transition reached initial operational capability in 1992 with operational support to the Global Applications Database. Final operational capability is currently scheduled for FY 2002 in conjunction with the AFGWC Satellite Data Handling System replacement.

The Cloud Depiction and Forecasting System (CDFS) II will make major software and hardware modifications at AFGWC to upgrade the weather satellite data processing, cloud depiction and forecasting, and classified weather support functions to meet customer-stated support requirements. CDFS II will also incorporate weather satellite data, cloud depiction and forecast data, and supporting data bases into the AFGWC CDMS.

The Advanced Computer Flight Plan (ACFP) System will replace a leased optimized computer flight plan system and the existing Air Force-owned flight simulation model. The ACFP system will be Government-owned and will satisfy requirements beyond the capabilities of current systems with enhanced flight planning and optimization features and increased responsiveness to customer needs.

The MARK IVB Direct Readout program will procure satellite receiver terminals to replace the aging MARK IIIs, and some MARK IVs. In addition to providing high resolution satellite imagery from polar and geosynchronous weather satellites, the MARK IVB terminals will be able to accept and use data from the DMSP microwave imager and sounders and the TIROS microwave sounding units A and B. The MARK IVB will produce both uniform gridded data fields and traditional meteorological products.

The Small Tactical Terminal (STT) program will procure small, lightweight, ruggedized, modularized, interoperable first-in satellite receive terminals that will receive data transmitted by geostationary and polar orbiting (Automatic Picture Transmission) meteorological satellites. Full-scale production is scheduled to begin in FY 1995.

In January 1988, the Air Force awarded four competitive concept study contracts for Block 6, the follow-on to the Block 5D-2/5D-3 satellites. In July 1992, two contractors were selected to proceed with the risk reduction phase. The objectives include lowering DMSP system life cycle cost and assessing cost effective options for increased survivability, interoperability, and remote sensing capability. The Navy (oceanography) and Army (tactical support) are participating in the Block 6 studies. In FY 1994, the Block 6 efforts were redirected to accommodate a combined civil/military program.

SPACE ENVIRONMENTAL SERVICES

Many DOD systems operate in, or are affected by, conditions above 50 kilometers. The space environment includes the thermosphere, ionosphere, and magnetosphere, as well as the regions that influence them such as the sun and interplanetary space. The AFSFC provides basic and specialized space environmental support to military electromagnetic communications, surveillance, and warning systems which operate in this environment. AFSFC provides

space environment forecasting and specialized services for:

- ionospheric conditions;
- energetic particle fluxes at satellite orbits;
- solar flare, solar particle, and geomagnetic storm events;
- upper atmospheric density variations by providing geomagnetic and solar indices;
- high frequency (HF) radio wave propagation;
- detailed post-analysis studies of operational system problems to determine if the space environment was a contributing factor.

The effects of the space environment on DOD systems are many and varied. The magnetosphere affects satellite operations through such phenomena as Single Event Upsets (SEUs) and spacecraft charging. Manned spaceflights are vulnerable to intense radiation from large solar flares and geomagnetic storms, particularly for high inclination orbits. Ionospheric conditions have a profound effect on the propagation of radio waves and radar signals, leading to communications blackouts and erroneous radar returns. Variations in the neutral atmosphere affect satellites orbiting at relatively low altitudes.

The focal point for space environmental support is the AFSFC. The AFSFC also participates with NOAA in the joint operation of the Space Environment Services Center (SESC) in Boulder, CO. Under existing agreements, SESC and AFSFC provide limited back-up for each other during contingencies.

Data Sources

Solar Data. AFSFC operates a network of solar optical and radio telescopes. Solar Electro-Optical Network (SEON) observatories are located at Sagamore Hill, MA; Ramey, Puerto Rico; Holloman AFB, NM; Palehua, HI; San Vito, Italy; and Learmonth, Australia.

AFSFC receives real-time solar X-ray and energetic particle data from the Geostationary Operational Environmental Satellites (GOES). DMSP polar and DOD geostationary satellites provide additional energetic particle data.

Ionospheric Data. A world-wide (primarily northern hemisphere) network of ionosondes and polarimeters provides ionospheric data. AWS is currently deploying the automated Digital Ionospheric Sounding System (DISS) to replace older instruments and provide improved ionospheric coverage. Of the 19 DISS sites programmed, 14 are operational, and the remaining 5 will be installed in the next few years.

Geomagnetic Index. AFSFC monitors variations of the geomagnetic field using ground-based magnetometers through a cooperative agreement with US. Geological Survey (USGS), computes a real-time geomagnetic index, and transmits the derived index to users for use in density models.

Magnetospheric Data. AFSFC has a limited in-situ magnetospheric monitoring capability by using real-time energetic particle data from operational NOAA and DOD spacecraft in low Earth and geosynchronous orbits.

AFSFC Warning and Forecast Services

In near real time, AFSFC provides operators advance warning of conditions that could degrade performance of their systems. Notifications include:

- solar X-ray events which can disrupt high frequency (HF) communications on sunlit paths;
- solar radio bursts which can disrupt communications systems and interfere with radar systems;
- solar proton events which can produce radiation hazards to spacecraft and absorption of transpolar HF radio waves;
- ionospheric disturbances which can degrade HF and satellite communications systems;
- geomagnetic disturbances which can affect the orbital parameters of low altitude satellites, cause spacecraft charging and/or physical damage, disrupt HF radio wave propagation, or interfere with radar systems.

Future Improvements in AFSFC Support

The AFSFC is enhancing its ability to observe the space environment, analyze data, and model the near-Earth environment.

Transionospheric Sensing System (TISS). The TISS is a planned replacement for the current polarimeter network. The TISS, using signals from Global Positioning System (GPS) satellites, will measure total electron content. The initial purchase and deployment of five TISS units is in progress.

SEON Upgrade. The SEON upgrade will improve the capabilities of the SEON observatories. Efforts to upgrade obsolete and unsupportable equipment to maintain current capability are in progress.

Solar X-Ray Imager. A Solar X-Ray Imager (SXI) will be flown on the GOES-Next series of satellites. The SXI will monitor solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum. These data will be down linked to the SESC and transmitted to AFSFC in real time.

Solar Wind Interplanetary Measurements (SWIM). SWIM is an Air Force Phillips Laboratory experiment scheduled to fly on NASA's WIND research satellite in November 1994 and will provide 2 hours of real-time interplanetary solar wind data to AFSFC each day. Additionally, there will be two campaigns a year during which real-time data will be provided 8 hours a day. The expected life of SWIM/WIND is 5 to 7 years.

Space Environmental Technology Transition (SETT) Models. The SETT program transitions state-of-the-art space environmental models to operational use at AFSFC. These models will specify and forecast the space environment from the Sun to the Earth's upper atmosphere. The output of these models will drive specific application programs tailored to customer needs. The transition of the SETT models to the AFSFC will be complete by 1999. Follow-on model development will focus on improving model accuracies and will replace surrogate parameters (as model inputs) with direct measurements wherever possible.

a. Magnetospheric Models. The Magnetospheric Specification Model (MSM) provides specification of magnetospheric particle fluxes at geostationary altitudes and precipitating particle fluxes in the auroral zone. An upgrade to this model, the Magnetospheric Specification and Forecast Model (MSFM), is under development and will provide forecast capability and increase the MSM coverage area. One application of MSM output will be as input for satellite anomaly programs.

b. Ionospheric Models. The Parameterized Real-Time Ionospheric Specification Model (PRISM) specifies global electron density. A second ionospheric model, the Ionospheric Forecast Model (IFM) is still under development and will be based on a model developed by Utah State University. When completed in 1995, the IFM will provide an ionospheric forecasting capability. Ionospheric model output will be used as input for space track radar correction and HF radio wave propagation programs. Another variant of ionospheric models, the Wide-Band Model (WBMOD), will provide estimates of ionospheric scintillation severity between two endpoints.

c. Neutral Atmosphere Model. The Vector Spherical Harmonic Model (VSH), under development by the University of Michigan and scheduled for completion in 1996, will specify global neutral particle densities, winds, and temperatures from 90 to 1500 km in the atmosphere. VSH output will be used as input for satellite drag programs and input for ionospheric models.

d. Integrated Space Environmental Models (ISEM). The Interplanetary Shock Propagation Model (ISP) to propagate discontinuities in the solar wind from the Sun to the Earth's upper atmosphere. This will provide a 1-3 day warning of geomagnetic storms resulting from solar flares. A coupling model and executive system will be developed to integrate the models into a single system sharing input and output data. ISEM will provide a single framework to coordinate and facilitate the execution of all other SETT models using scientific expertise and decision making capability within the program which will increase consistency of the outputs, optimize run times, and decrease forecaster workload.

SUPPORTING RESEARCH

The objective of the Air Force meteorological research program is to provide a new, detailed knowledge of the atmosphere, how it works, how it limits system performance, and how it can be used to the advantage of the Air Force as a force multiplier. Improved measurement and prediction techniques, together with an early evaluation of weather effects on new systems, can make a significant difference and bring the Air Force, Army, and joint forces closer to their goal of conducting operations in all kinds of weather. Requirements for research and technology in meteorology are expressed in Mission Areas Analyses and Mission Need Statements. In addition, the Air Weather Service provides guidance in the form of documented geophysical requirements.

The Phillips Laboratory, Geophysics Directorate (PL/GP) at Hanscom AFB MA, has the mission responsibility within the Air Force to conduct both in-house and contractual basic research, exploratory development, and advanced technology development in the environmental sciences, including meteorology. Its exploratory development program in meteorology emphasizes moisture and cloud numerical weather prediction, satellite remote sensing, climatological studies, weather simulation, atmospheric density measurement and prediction, and battlefield weather observing and forecasting. Research and development for the Defense Meteorological Satellite Program (DMSP) are also conducted. The entire Air Force atmospheric sciences R & D program is being carefully coordinated with similar efforts in the Army and Navy.

Weather Prediction

Research in weather prediction techniques and models is focused on mesoscale or battlefield domains. Particular emphasis is placed on cloud processes in the atmospheric boundary layer and studies of their formation, evolution and dissipation. Procedures to better account in NWP models for surface exchange processes and for representing surface characteristics in model data bases will be stressed. These include: soil type, vegetation type and growth stage, soil moisture and temperature, and snow cover and depth. On-going studies of the sensitivity of boundary layer cloud processes to the representation of surface characteristics will be translated into model algorithms for test and evaluation. Mesoscale model data impact studies will focus on both ground-based (profiler and surface sensors) and satellite (imagery and sounding) sources. Tactical wartime data denial experiments will also be conducted as part of these studies. The use of massively parallel computing architectures for mesoscale applications will be assessed. Theater-scale analysis and forecasting models will be developed for use in a workstation environment. The development of an artificial intelligence-based regional terminal forecast model will be completed and a test and evaluation program will be started. The development of precipitation diagnostic algorithms (from non-radar sources) for use in wartime will be completed.

Research to support the increasing needs for a global cloud prediction capability at Air Force Global Weather Central (AFGWC) will be concentrating on two approaches. Multivariate diagnostic algorithms to infer cloud characteristics (total cloud and layered amounts, bases, tops) from global and regional-scale NWP models will be evaluated for prediction intervals ranging upward from 12 hours. Short-range cloud prediction (0-12 hr) techniques will seek to exploit new global cloud analysis capabilities to be available at AFGWC through the Cloud Depiction and Forecast System II hardware/software upgrade. Here imagery extrapolation methods will be augmented by simple physical models to account for short-term cloud growth and decay and by highly resolved (in space and time) cloud climatology statistics.

Research to improve hazardous weather warning capabilities at air bases from WSR-88D Doppler weather radars will be focusing on better tornado, hail, and severe storm structure algorithms due to the use of a new mesocyclone detection model which will be developed in FY 1994. The development of algorithms to define fine line features (such as gust fronts and synoptic-scale frontal boundaries) will be completed. Studies to identify lightning precursors in WSR-88D data for air mass thunderstorms will be initiated. Studies of the atmospheric electric field distribution aloft and its relationship to aerospace vehicle-triggered lightning will be completed. These studies will focus on measurements taken with electric field sounding rockets in field programs conducted in FY 1994.

Satellite Remote Sensing

To enhance Air Force, Army, and joint force operations, a major effort is directed toward using satellites to determine temperature and water vapor vertical profiles and horizontal fields. Research efforts also include effectiveness studies for active satellite sensors, such as satellite-borne lidars and radars, for determining the profiles of wind and other weather variables with very high vertical resolution for initialization and assimilation into weather prediction models.

Techniques will be developed to incorporate microwave imagery data into the cloud analysis programs at AFGWC. The present level of support will continue for this research to develop new analytical methods in satellite meteorology. The ultimate goal is to more accurately specify cloud characteristics; e.g., cloud height, cloud physical thickness, optical depth, particle size, cloud phase, and rain areas. The design of satellite sensors in terms of wavelength, resolution,

and bandwidth and the calibration of deployed satellite measurement systems, such as the DMSP SSM/T-2 water vapor sounder, will continue primarily in support of DMSP. Research on integration of the environmental information from a number of satellite measurement platforms and sensors is underway.

Characterization of cloudiness on the operational theater scale, based on direct readout of satellite weather data, is being implemented in support of tactical operations. A package of satellite cloud analysis algorithms, called TACNEPH, has been developed and will be implemented in the MARK IV-B DMSP ground terminal and the more portable small satellite tactical terminals.

Climatology Studies

Support of Environmental Requirements Cloud Analysis and Archive (SERCAA) is the new global cloud analysis program for use in determining the radiative and hydrological effects of clouds on climate and global change. SERCAA is the prototype of the next-generation real-time automated cloud analysis model. The first phase of SERCAA directly supports the Cloud Depiction and Forecast System II. An archive of these quality cloud products which will be useful in environmental monitoring and climate change research is planned.

In climatological technique development, weather simulation models are being developed to replicate numerically typical weather sequences for operational applications. Research in modeling clouds and visibility is being expanded to include additional atmospheric elements, specifically a mesoscale environmental simulation package to provide a realistic sequence of weather events at any given location. This model will allow environmental factors to be considered in the design stage of weapon systems and for application to war games.

Research into specifying the probability of simultaneous cloud-free viewing from multiple sites under various cloud conditions is ongoing. Simulation of time evolution of 3-D scenes of weather elements will initially concentrate on cloud scenes. Whole-sky imagery data and concomitant satellite imagery will provide the basis for developing algorithms for ground-based and satellite (or aircraft)-based viewing scenarios. Weather simulation computer models for conceptual design and studies and analysis applications will continue.

The first of two Defense Modeling & Simulation Office (DMSO) projects will focus on developing techniques for simulating Environmental Effects for Distributed Interactive Simulation (E2DIS) and to conduct related requirements and capabilities surveys. The second is to implement into DIS format the 3-D cloud scene model developed in the first project.

Two programs are in progress to develop a more complete understanding of atmospheric effects on laser propagation. In the first of these programs, supporting the Airborne Laser Program, the effects of atmospheric phenomena near the tropopause on laser propagation is the key issue. Modeling and measurements in support of a more complete understanding of turbulence, aerosols, and cirrus clouds on such propagation are the focus. In the second of these programs, investigations are underway to evaluate the ability to measure winds with a Doppler LIDAR in support of weapon targeting (the so-called ballistic wind problem). Actual measurements are being conducted together with supporting meteorological observations and analyses.

The CHANCES program (Climatological and Historical Analysis of Clouds for Environmental Simulations) was initiated in FY 1994 and will continue through FY 1995. The goal of this program is to develop one complete year of global total cloud climatology with very high spatial and temporal resolution. The prime data will be obtained from four geosynchronous and four polar satellites. They include GOES-7, GMS and METEOSAT 3/4 geosynchronous satellites and four DMSP and NOAA polar satellites. Ancillary data include topography, surface albedo, snow/ice, and global temperatures. The data analysis will use ISCCP algorithms (International Satellite Cloud Climatology Program) modified to handle the required one hour temporal and 5km spatial resolution. Cloud-top temperature and height, cloud type (daytime 7 types and nighttime 3 types) and total cloud cover will be provided. The products will have applications to operations planning anywhere in the world, and surveillance and intelligence from satellites or high altitude aircraft.

Atmospheric Density

The objective of the atmospheric density work is

to develop very accurate methods to measure and predict the density of the neutral atmosphere in the altitude range of 90 to 1500 kilometers. Current density models do not achieve the levels of accuracy required by the Air Force; so new measurements of density will be made using recently developed, well calibrated, and highly accurate instruments. These new measurements will be the basis for an upper atmospheric global circulation model that incorporates the current physical understanding of the processes that drive the upper atmosphere. Models will be used to calculate accurate trajectories of satellites, reentry vehicles, and space debris.

Battlefield Weather Observing and Forecasting

The battlefield weather program completed development of the electro-optical tactical decision aid (EOTDA) in FY 1994. This software is used on microcomputers in base weather stations and host command and control computer systems using an AFGWC-provided data base. This automated forecasting aid is used to predict acquisition and lock-on ranges for precision guided weapons used by the Air Force and the Army.

The Tactical Weather Observation System (TWOS) program is selecting and testing meteorological sensors and techniques suitable for use in an automated tactical mode. The automation of weather observations is needed in the three problem areas of clouds, visibility, and present weather. TWOS will be implemented as part of the Combat Weather System.

The Air Combat Targeting/EO Simulation (ACT/EOS) effort in the Weather Impact Decision Aids (WIDA) program is in progress. It will combine global terrain and features, target structure, and meteorological and operational planning data through target contrast and EO sensor performance models to provide commanders and air crews complete in-theater environmental situational awareness. Another WIDA program is the development of Night Vision Goggle (NVG) Operations Weather Software (NOWS) for planning operations using NVGs.

UNITED STATES NAVY

Overview/Organization

Within the U.S. Navy, meteorological and oceanographic (METOC) products and services are provided globally to DOD units based ashore and at sea. U.S. Naval METOC personnel and resources are assigned to naval shore and afloat staffs, U.S. Marine Corps aviation weather units, test stations and ranges, shipboard weather offices, and activities of the Naval Meteorology and Oceanography Command. Personnel and resources from the naval research, development, logistic, and training components and Naval Systems Commands, laboratories, research facilities, and training commands constitute various additional support components.

Primary services are provided by activities and detachments assigned to the Naval Meteorology and Oceanography Command. Shore field activities within the Naval Meteorology and Oceanography Command (NAVMETOCCOM) include the Fleet Numerical Meteorology and Oceanography Center, the Naval Oceanographic Office, the Naval Ice Center, four theater Naval Meteorology and Oceanography Centers (Atlantic, European, Pacific, and Western Pacific), four NAVMETOCCOM Facilities, 42 NAVMETOCCOM Detachments, and eleven component offices.

The Fleet Numerical Meteorology and Oceanography Center (FLENUMMETOCCEN) in Monterey, CA is the Naval Meteorology and Oceanography Command's processing center dedicated to running state-of-the-art, operational, global, and high resolution regional atmospheric and oceanographic analysis and forecast models. Through linkage with DOD and NOAA environmental satellite and data distribution systems, FLENUMMETOCCEN acquires global coverage of environmental data. Numerically generated METOC products are made available for distribution on Navy and joint command, control, communications, computers, and intelligence (C4I) systems via the Navy Theater METOC Centers which additionally produce products and services tailored to specific military operations or exercises. The Navy Oceanographic Data Distribution System (NODDS) permits worldwide, dial-in access to FLENUMMETOCCEN products. NODDS technology and access to unclassified FLENUMMETOCCEN products is provided to

NOAA for use in the civil sector under a recently signed Annex to the NAVY-NOAA Memorandum of Agreement (MOA). FLENUMMETOCCEN is uniquely capable of providing high resolution meteorological products on short notice, for any location, worldwide, in support of contingency military and humanitarian operations. Products available from FLENUMMETOCCEN include atmospheric and oceanographic observations, data extracts, and analysis and forecast fields of METOC parameters required to support joint military operations.

The Naval Oceanographic Office (NAVOCEANO), located at Stennis Space Center, MS is the Naval Meteorology and Oceanography Command's center responsible for collecting, processing, and distributing hydrographic, oceanographic and other geophysical data and derivative products. This is in response to long term national and strategic requirements as well as emergent, short term requirements in support of contingency operations. To accomplish this, NAVOCEANO has a fleet of eight survey ships, a sophisticated satellite and ocean buoy processing facility, and access to oceanographic survey aircraft. NAVOCEANO's Warfighting Support Center, using the large scale computer facility at NAVOCEANO, operates interactive ocean models for littoral (coastal) regions and special automated ocean models which may be required on a non-routine basis such as ocean drift or oil spill models. Products available from NAVOCEANO include ocean fronts and eddies analyses, and surface and three-dimensional ocean thermal fields which are distributed through the Navy Theater METOC Centers via joint and Navy C4I systems. As a node on the Special Operations Command Research, Analysis, Threat Evaluation System (SOCRATES), NAVOCEANO provides products in support of special operations in the littoral regions. NAVOCEANO is also the Navy's primary NOAA TIROS data processing facility.

The Naval Ice Center, Suitland, MD (formerly the Naval Polar Oceanography Center) in cooperation with the NOAA and the U.S. Coast Guard provides ice analysis and forecasting services to DOD and allied activities either directly or through the theater NAVMETOCCOM centers.

The four theater Naval Meteorology and Oceanography Centers are hubs for the dissemination of METOC data; providing full spectrum meteorological and oceanographic services to Navy and joint forces operating within their respective area of responsibility. The Naval Pacific Meteorology and Oceanography Center (NAVPACMETOCCEN), Pearl Harbor, HI, assisted by its subordinate NAVPACMETOCCEN West, Guam, is responsible for the Pacific and Indian Oceans, Red Sea, and Persian Gulf areas. Additionally, NAVPACMETOCCEN West operates the Joint Typhoon Warning Center with the U.S. Air Force to provide tropical cyclone warnings to DOD and U.S. interests in the Western Pacific and Indian Oceans. The Naval Atlantic Meteorology and Oceanography Center, Norfolk, VA is responsible for the Atlantic Ocean, and the Greenland, Norwegian, and Barents Seas; and the Naval European Meteorology and Oceanography Center, Rota, Spain, for the Mediterranean, Black, and Baltic Sea areas. The Atlantic and Pacific centers have assumed METOC product and service support for the Arctic and Antarctic areas formerly managed by the Naval Ice Center. Aligned with specific Navy Component Commanders, familiar with operations within theater, theater METOC centers manage and prioritize the dissemination of basic numerical METOC products from FLENUMMETOCCEN and NAVOCEANO, and add tailored services specifically focused on theater requirements. Products are transmitted to the operating forces via AUTODIN, the High Speed Fleet Broadcast, high-frequency facsimile broadcasts, and via linkage to joint and Navy C4I systems. They provide global and high resolution theater analysis and forecast fields of METOC parameters required for shipboard and other deployed mobile METOC processing systems. Other products and services include depictions of significant weather, tropical cyclone advisories, high wind and seas warnings, ship route weather forecasts and routing, aviation forecasts, and a variety of special meteorological and oceanographic forecasts produced as needed to meet the situational requirements of the Navy and Joint Force Commander. In addition, they act as staging centers for Navy Mobile Environmental Team (MET) services. Because of their in-theater presence and focus, NAVMETOCCOM centers are ideally suited to serve as Joint Force METOC Forecast Units (JMFU) in support of theater joint operations.

The four Naval Meteorology and Oceanography Command Facilities at Jacksonville, FL; San Diego, CA; Pensacola, FL; and Yokosuka, Japan; provide limited area, local and aviation environmental forecast services, as well as services to aircraft, ship, and submarine staffs. Meteorological forecast guidance from the theater oceanography centers and the Fleet Numerical Meteorology and Oceanography Center is used by all facilities. Those facilities located overseas augment this guidance with data from local sources.

There are 42 Naval Meteorology and Oceanography Command Detachments located worldwide. Although primarily situated at Naval Air Stations, several are located at Naval Stations in support of sea-going units. Each detachment is established under an Officer or Chief Petty Officer in Charge, who reports to one of the Naval Meteorology and Oceanography theater centers or facilities. These detachments provide areal, aviation meteorological and oceanographic forecasting and warning services to DOD and allied units within their local and functional areas of responsibility. Detachments within the contiguous states use the basic and applied meteorological numerical products from both the Fleet Numerical Meteorology and Oceanography Center and the National Meteorological Center in providing services. Overseas detachments use available U.S. Air Force and foreign products in addition to Fleet Numerical Meteorology and Oceanography Center numerical products. Two detachments are oriented to provide specific technical services; one coordinates the Navy's climatological program, which is an element of the Federal Climate Complex at the National Climatic Data Center, Asheville, NC; the other involves circuit management of the USAF Automated Weather Network (AWN) at Tinker AFB, OK.

On-Scene Support

The primary sources of on-scene Navy METOC support for forces afloat and those in-theater ashore are provided by permanently embarked Navy METOC personnel (OA Divisions) and/or by deployable assets (Mobile Environmental Teams). METOC products and services provided to the operating forces are tailored in accordance with the requirements of the Fleet and/or Joint Force Commanders and Fleet units. This support consists primarily of METOC information and forecasts for current operational use, forecast tactical indices for weapon and sensor system employment and tactical decision making, and climatological information for long-range planning and design purposes.

The Navy's permanent afloat METOC organic assets are their OA Divisions which are embarked aboard major aviation-capable combatants and command ships (CV/CVN, LHD, LHA, LPH, LCC). These units, staffed with officer and enlisted personnel and equipped in accordance with their designated functions, are integral to the command to which they are assigned. Their primary METOC support objectives are safety, optimum tactical METOC services to all Warfare Commanders, and tailored on-scene METOC products and services to the assigned Task Force/Group and allied units in national or coalition military and humanitarian operations. The primary system of the OA Division's suite of METOC equipment is the Tactical Environmental Support System (TESS) 3. TESS 3 is a computer-based, interactive, METOC data receiving, storing, processing, display, and communications system. The TESS units receive data from four major sources: global and theater METOC data fields from FLENUMMETOCCEN and NAVOCEANO via the Navy's Theater Centers, remotely sensed satellite data and imagery from the onboard AN/SMQ-11 satellite data receiver/recorder, alpha-numeric data via the High Speed Fleet Broadcast, and local conventional data from the Shipboard Meteorological and Oceanographic Observing System (SMOOS). TESS 3's data base and applications software is provided from the Oceanographic and Atmospheric Master Library (OAML) and the Geophysical Fleet Mission Program Library (GFMPL). The AN/SMQ-11 provides for the acquisition of high resolution DMSP, NOAA/TIROS, and geostationary imagery. Upper air sounding information is made available from the permanently installed Miniature Radiosonde System (MRS - AN/UMQ-12). The division is also equipped with Alden Marine Facsimile Recorders and a PC-based facsimile system (PCGRAFAX). Standard CD-ROM based climatology products, the Naval Oceanographic Data Distribution System (NODDS), and the PC Imaging Communications Systems (PICS) software programs are part of their inventory.

The Navy's deployable assets are their Mobile Environmental Teams (MET) located at the theater

Naval Meteorology and Oceanography Command Centers in Norfolk, VA; Rota, Spain; and Pearl Harbor, HI and at their Facilities in Jacksonville, FL; San Diego, CA; and Yokosuka, Japan. MET provide short-term, on-scene METOC services to units and activities without organic METOC personnel within the DOD, other government agencies, and elements of the armed forces of allied nations. They also deploy with organic METOC personnel as part of the U.S. Naval component required for Joint/Combined METOC support structures. The MET have their own portable sensing and display equipments, the heart of which is the Mobile Oceanography Support System (MOSS). MOSS operates on a 386 TEMPEST personal computer and is capable of interfacing with two additional laptops to provide communication and satellite capabilities to receive and display APT satellite transmissions and various radio alphanumeric broadcasts, and run tactical forecasting application programs from the GFMPL accessing the OAML databases. MOSS includes a CD-ROM for the display of CD climatology. The MET also deploy with the portable MRS system and the Alden Marine Facsimile TR-4 Recorder. If the situation warrants, they have the capability to set up a Navy Automated Weather Station at remote sites. These units sense temperature, humidity, pressure, and wind and are capable of direct readout and/or transmission of the data via NOAA polar orbiting meteorological satellites. There are additional portable equipments, personal computer based systems, and software programs that a MET may deploy. The Geostationary Imaging Display System (GSIDS) receives, displays, and manipulates any low resolution geostationary meteorological satellite image. The NODDS can provide the MET with the latest gridded data fields available from FLENUMMETOCCEN's numerical model analyses and forecasts. The PICS adds the capability for receipt of enhanced oceanic satellite imagery available from NAVOCEANO.

U.S. Marine Corps

U.S. Marine Corps (USMC) garrison aviation weather units are staffed with USMC meteorological personnel. They function and are supported in a manner similar to Naval Meteorology and Oceanography Command Detachments but under USMC management. These weather units are integral to Marine Corps aviation activities and provide services to assigned activities and organizations which include nine major air stations in the contiguous United States, one in Hawaii, and two in Japan.

The Fleet Marine Force aviation units, also staffed with meteorological personnel, are indigenous to each of the twelve Marine Wing Support Squadrons. They operate and maintain meteorological mobile facilities to provide environmental support during tactical operations. The units are task organized to respond to the commander's requirements according to the mission, functioning independently as required. While in garrison, the weather personnel and equipment augment and support the host activity's weather unit.

METEOROLOGICAL AND OCEANOGRAPHIC (METOC) SERVICES

Significant changes continue within the Navy in response to the fundamental shift in operational focus to Expeditionary Warfare. Reliable and timely meteorological and oceanographic information is critical to identifying operational barriers and limits imposed by expected weather and the maritime environment. The FY 1995 program continues to improve data collection and processing capabilities for METOC support in littoral areas (i.e., an operating area extending from the high seas adjacent to a coast across the coastline and inland). A commitment to enhanced operational safety for personnel, ships, and aircraft continues as a cornerstone of the Navy and Marine Corps program. Efforts in the FY 1995 program address both system acquisition and operational support needs.

Battlespace Management Systems

Tactical Environmental Support System (TESS). TESS is a modular, computer-based support system designed to provide Navy decision-makers with meteorological/oceanographic assessments and forecasts and to integrate air/ocean data with sensor/weapon platform parameters to assess system performance. Initial operational deployment of TESS 3 began during FY 1992. TESS 3 functions as the operational, resident air/ocean data base. Data sources will include in-situ sensors, meteorological and oceanographic satellites, U.S. and foreign radio weather broadcasts and data fields prepared ashore, principally at the theater oceanography centers which provided value added products to the fleet units in

addition to the numerical prediction guidance generated by the Fleet Numerical Meteorology and Oceanography Center. Its applications and capabilities extend well beyond those of an automated weather information system because of the extensive ocean acoustic analysis and prediction capabilities, and data bases containing sensor and weapon system parameters for use in tactical decision aids hosted in the system.

Navy Integrated Tactical Environmental Sub-system (NITES). NITES is an open-systems compliant application that will reside within the Navy C4I architecture onboard all ships and at all major Navy/Marine Corps commands and staffs, both ashore and afloat. NITES is designed to integrate TESS derived products into the principle command and control decision aids for use with strategic and tactical computer systems. NITES open-system design potentially makes it inter-operable with other DOD, Federal, and Allied command and control systems that are based on the Operational Support System (OSS) architecture.

Primary Oceanographic Prediction System (POPS). The POPS program was initiated in order to install large scale computers, associated software and peripheral hardware at the Naval Meteorology and Oceanography Command's two operational computer centers. The contract was awarded to Grumman Data Systems in April 1990, and a Cray Y-MP8/8128 was installed at the Naval Oceanographic Office at Stennis Space Center, MS in October 1990. A Cray Y-MP 2E was then installed at FLENUMMETOCCEN in November 1991. This smaller Cray operates the database management system for the much larger and much more powerful Cray Y-MP C90, which was installed at FLENUMMETOCCEN in September 1992. The C90 provides the number crunching capability to automatically run large oceanographic and atmospheric models, both globally and regionally. The supercomputer configuration is surrounded by several workstations which operate a variety of functions for the operational runs, including graphics support, software maintenance and communications. This system of computers is assuming the functions of the obsolescent Control Data Corporation Cyber 205, which had been in use since 1982. The Oceanographic models to be run on the new Cray system represent a significantly improved capability for the Navy. Previously, running global scale ocean models has been constrained by computer memory size and processor speed. Today, for the first time, the Navy has the requisite computer technology to operate a skillful global and regional ocean prediction system. As the system evolves, Navy scientists will move toward numerical models which fully couple the ocean and the atmosphere. Under the Navy-Air Force (NAVAF) cooperation agreements, this computer suite will assume numerical modeling responsibilities for all of DOD. Further, the Navy's unique ocean model output is made available to NOAA through memoranda of agreement between Navy and NOAA.

Satellite Data Receiver/Recorder, AN/SMQ-11. The AN/SMQ-11 has been developed as the next generation satellite receiving-recording system for use aboard major afloat combatants and at selected sites ashore. It is replacing a variety of existing Navy satellite reception systems. The SMQ-11 is composed of a dual-planar array antenna system and two equipment cabinets for data processing. It has the capability to process encrypted transmissions from the Defense Meteorological Satellite Program (DMSP) as well as imagery from national civil satellite systems (TIROS, GOES, WEFAX). Satellite information from this system can be provided to the Tactical Environmental Support System (TESS) for additional processing and applications. Additional planning is underway to exploit data from other satellite systems (foreign and domestic) projected for the late 1990's. Production of the AN/SMQ-11 commenced in FY 1987. A total inventory of 74 units is programmed.

Naval Oceanographic Data Distribution and Expansion System (NODDES). NODDES is the primary data distribution system for the Naval Oceanographic and Meteorological Support System. NODDES expands previous capabilities for the transfer of meteorological and oceanographic data from Naval Meteorology and Oceanography Command primary data production centers to theater command centers while providing increased automation of routine operations and enhancing on-site interactive capabilities for finished product preparation and distribution. NODDES redistributes applications data processing functions to theater centers, thereby decentralizing processing functions, improving flexibility and responsiveness and reducing

potential single points of failure. It also upgraded capabilities for data assimilation, data distribution and product generation at all of the command's centers and increased command wide operational availability of environmental support via distributed systems, data bases and state-of-technology communications.

Operational Products and Services

Optimum Track Ship Routing (OTSR) is an advisory service whose primary mission is safety. Originally designed as an enroute time and fuel saving service, OTSR has evolved into the primary tool for ships to minimize the risk of damage from extra-tropical and tropical storms, high seas and sea ice. In addition, OTSR will assist port authorities and/or ships inport to avoid damage from tropical cyclones by issuing sortie recommendations to the Senior Officer Present Afloat (SOPA). These recommendations assist the SOPA in choosing a time to depart and direction/location to sortie ships. To maximize fuel economy, OTSR provides recommendations for Ocean Current Assistance/Avoidance Routes in the vicinity of strong ocean currents. OTSR takes into consideration individual ship characteristics, cargo limitations as well as specific operations enroute.

Optimum Path Aircraft Routing System (OPARS) at FLENUMMETOCCEN is one of the most successful and cost efficient programs in the Navy. A computerized flight planning network capable of forecasting the most fuel efficient altitude and flight path for a given mission, OPARS can be tailored to meet the individual user's particular mission requirements. Among its many options, OPARS can calculate the fuel load needed to arrive with a specific reserve; maximum cargo for a particular flight; in-flight refueling requirements; maximum time on-station; mandatory over water reporting positions; and fuel usage for specific routes and/or altitudes.

To receive a flight plan, a requester provides his local weather briefing office basic information about his aircraft and mission. The weather office then formats his request and forwards by direct telephone link to FLENUMMETOCCEN. Here OPARS incorporates four data bases: environmental; air route structure; aircraft performance characteristics; and prohibited air space, to determine the optimum route for the aircraft. This custom tailored flight plan is zipped back to the originator within minutes.

Navy Oceanographic Data Distribution System (NODDS) was first developed in 1982 to make FLENUMMETOCCEN numerical products available to front line users. NODDS has grown in use as product support has expanded; it provides a unique approach to environmental data communications. Once a user has defined products desired for a specific area, an automatic process of acquiring data is initiated. Using a commercial "off the shelf" licensed communications software package, the system calls FLENUMMETOCCEN and requests the data fields from a security shell in a host mainframe computer. The required data is extracted from one of the global data bases as a compacted ASCII transmission which is generated for each field/product. By transmitting field data and limiting the area of extraction, the transmissions are small and communications efficient. Once the raw data is received by the user's NODDS system, the required contouring, streamlining, shading, etc. is performed automatically until products are in a ready to display format. All standard meteorological fields available from FLENUMMETOCCEN can be displayed along with a wide number of oceanographic, acoustic and satellite products. NODDS also has the ability to overlay up to three different fields, or display individual sequence loops. Fields may be automated or zoomed for more detail, and sent to a graphics capable printer.

NODDS is now available to the Federal Government and others in the civilian community through an agreement between Navy and the National Oceanic and Atmospheric Administration (NOAA). This version, referred to as NOAA NODDS to distinguish it from the Navy version, allows real time weather and ocean analyses and forecasts generated at FLENUMMETOCCEN to be made available to NOAA's National Ocean Service Ocean Applications Branch (OAB) in Monterey, CA. Civilian customers will be able to access this data using NOAA NODDS software modules.

The Warfare Support Center (WSC) was established at NAVOCEANO to provide near real-time, tailored products to support operational commands via COMNAVMETOCCOM activities. Currently the WSC's products are being produced from the Satellite Analysis and Data Fusion Branch, the Multichannel Sea-Surface Temperature (MCSST) Branch, the Altimetry Data Fusion Center (ADFC),

Classified Services Branch and the WSC's Models Branch. The WSC is the only organization within DOD to produce global ocean front and eddy analysis. Primarily using infrared imagery obtained from NOAA polar orbiting satellites, an analysis is made of temperature gradients for over 80 ocean fronts. These analyses are processed on a HP835 mini-computer and sent to theater centers and the fleet via DDN or the Personal Computer Image Communication System (PICS). Additionally, these data are used in the Navy's ocean modeling efforts.

NAVOCEANO has been named the National Center of Expertise for MCSST. As of May 1994, the WSC assumed total operational responsibility for the production of MCSST observations from AVHRR Global Area Coverage data. Processed data is sent to AFGWC, NOAA, FLENUMMETOCCEN and is also available to authorized users via PICS. The MCSST Branch uses the Cray Supercomputer, the Concurrent 3280/3280E computer system as well as a multitude of smaller computers to monitor the system. The ADFC is the newest addition to the WSC. ADFC processes satellite altimetry and scatterometry data from ERS-1 and TOPEX satellites. These satellites provide information such as sea-surface height, significant wave height, ice edge data as well as wind speed and direction from scatterometry. In the future ADFC will gain additional altimetry and scatterometry coverage from the GEOSAT follow-on satellite. ERS-1 data is processed internally, while TOPEX data is initially processed at the Jet Propulsion Laboratory in Pasadena, CA before further processing at the WSC. The WSC's models Branch is responsible for High-Resolution ocean models in support of fleet operations. Responsible for the implementation, maintenance and daily operations of all NAVOCEANO numerical ocean models, the WSC also tailors model output to meet user requirements. Model standardization is coordinated with FLENUMMETOCCEN. Special Operation Forces (SOF) support can be provided by the WSC Classified Services Branch. The WSC handles request from United States Special Operations Command (USSOCOM) for operational METOC data. Mission specific, rapid response, all-source, ocean environmental support packages developed by experts within the WSC are tailored to the minimum volume and classification necessary to allow SOF personnel to effectively evaluate environmental considerations.

SUPPORTING RESEARCH

The Navy administers a diverse research and development (R&D) program as an adjunct to METOC support observations. The program ranges from software development to the engineering of sensors, interfaces, processing, display and distribution devices. Leveraging of R&D activities of the other services, as well as those of non-DOD agencies, is always considered. In addition, the use of non-developmental (i.e., government and commercial off-the-shelf) items is vigorously pursued. Several efforts are ongoing to enhance the quantity, quality, and optimum utilization of observational data.

Atmospheric Modeling

The Navy is a world leader in the field of numerical weather prediction. The primary goal of this effort is to improve fleet readiness and safety of ships and aircraft, and to enhance weapons system performance through the application of new numerical modeling technology. Significant efforts are continuing to optimize the use of satellite data in Navy numerical modeling. This is made possible by ongoing R&D efforts at the Naval Research Laboratory (NRL) which keep the Navy Operational Global Atmospheric Prediction System (NOGAPS) and its companion Regional Atmospheric System (NORAPS) at the leading edge of technology. Upgrades to NOGAPS and NORAPS spectral models are planned, incorporating asynoptic and remotely-sensed data in the model initialization process. The relocatable, high-resolution (40-45 km) NORAPS model is now used routinely for operational contingency support, and a triple nested version, with grids of 45, 15, and 5 km are planned for FY 1995.

In the future, NORAPS will be replaced with the Coupled Oceanographic and Atmospheric Mesoscale Prediction System (COAMPS) model. The atmospheric component of COAMPS will feature triplynested grids down to resolutions of a few kilometers, non- hydrostatic physics, explicit moisture physics and aerosols and improved data assimilation. The underlying and fully coupled oceanographic component of COAMPS will combine the capabilities of the Optimum Thermal Interpolation System (OTIS), the third generation Wave Model (WAM) and the Princeton Ocean Model (POM) to provide for fully interactive two-way coupling between ocean and

atmosphere. With lateral boundary conditions provided by FLENUMMETOCCEN global models, COAMPS will provide the high-resolution, relocatable and fully integrated METOC prediction capability required for seamless support of sea-air-land operations required by joint littoral warfare.

R&D in the area of satellite remote sensing is also a major element of the Navy's program. Sensors aboard existing satellites are being exploited to the greatest extent possible, and a robust plan is in place to anticipate, prepare for, and capitalize on new capabilities as they are introduced. Because many of these satellite processing algorithms are designed for use in tactical systems such as TESS(3) and NITES, expert/rule bases schema are employed wherever possible to reduce manpower-intensive interpretation procedures. The principal focus of the Navy R&D program in remote sensing is emphasizing the development of techniques to extract tactically significant information in the littoral regions of the world.

Upgraded data assimilation, quality control, and data management techniques round out the R&D efforts undertaken in support of these models. A major new thrust has been initiated in the area of numerical weather prediction R&D to develop a shipboard tactical atmospheric forecast capability. This model, intended for use in TESS(3), will deliver high resolution (5 km), limited area (100s of km), short range (12-24 hr) atmospheric predictions and will assimilate locally acquired data in real time.

Sensor Development

The shipboard Meteorological and Oceanographic Observing System (SMOOS), currently being fielded, was developed as part of the Navy R&D program in sensor development. As a follow-on to SMOOS, advanced and engineering development of new sensors and related technologies is underway. Some of these include:

- LIDAR atmospheric profiling sound sensor
- Autonomous drifting buoys which automatically provide surface and subsurface data
- Autonomous sensor suites for all Navy ships (SMOOS is installed on major combatant ships only)
- Aerosol measurement sensors
- METOC data compression techniques to facilitate communications

Expendable drifting buoy development program. One key development is the AN/WSQ-6 (series) satellite reporting expendable drifting buoy development program sponsored by the Oceanographer of the Navy. These buoys will be capable of measuring and reporting air temperature, sea surface temperature, barometric pressure, sub-surface ocean temperature versus depth at various intervals down to 300 meters, omni-directional ambient noise, wind speed and direction, directional wave spectra, optical parameters, and other properties of the near-surface air/sea environment. The buoys sample and report hourly observations via Service ARGOS reporting. As other communications networks become available such as Low Earth Orbiting satellites, they will be explored. Near real-time data reception is available via Local User Terminals and the Tactical Environmental Support System (TESS). The data are computer formatted and available locally or remotely transmitted to other fleet units as inputs to various environmentally supported Tactical Decision Aids. Day-to-day monitoring, archival of the drifting buoy data and forwarding to NOAA's data bases are done by the Naval Oceanographic Office. The first in the series of fleet certified buoys measuring barometric pressure, air temperature, and sea-surface temperature will begin transition in FY 95. As funding and testing permit, new sensors will be added to the buoy platform. Multi-parameter, long life, expendable instrumentation such as the AN/WSQ-6 buoys are a vital key to success of the U.S. Navy's contribution to a global ocean observing capability.

Laser Bathymetric Systems (LABS). The Navy is also evaluating several methods to modernize and improve the Navy's bathymetric data collection capability in shallow water and littoral regions. One such technique is by use of airborne LABS using fixed- and rotor-wing aircraft. Under a Navy International Program Sponsored Foreign Comparative Testing (FCT) program, an Australian laser bathymetry system is being upgraded and refitted into a P-3 bombay-mounted configuration. Testing will be completed by February 1996. Additionally, helicopter mounted systems such as the Army's SHOALS system and the SWEDISH

HAWKEYE system are being evaluated for a Navy LABS capability. A Canadian sponsored semi-submersible bathymetry collection system (DOLPHIN) has also been evaluated for Navy hydrographic surveys and mine countermeasures evaluations. Two Navy SEA_LIONS with capabilities similar to DOLPHIN semi-submersibles are being retrofitted with swath bathymetry and other oceanographic sensors for test and evaluation.

Mini-Rawinsonde (MRS). Procurement of a portable mini- rawinsonde system began in FY 1988 and was completed in FY 1992. The system consists of a surface receiver/processor and lightweight balloon-borne expendable sensor package capable of measurements of pressure, temperature, humidity, and wind speed and direction. During FY 1994 and FY 1995 the Navy will be investigating the transition to a GPS-based mini-rawindsonde system.

Automated Surface Observing System (ASOS). Development efforts undertaken by the NOAA/National Weather Service have been leveraged in Navy's selection of the NWS Automated Surface Observing System (ASOS) for Navy and Marine Corps use ashore. Acquisition and installation of ASOS systems continue at Navy and Marine Corps stations worldwide in support of aviation and local area forecasting requirements to replace equipment beyond their maintenance life cycles. Designed use will assist Meteorological Technicians in assimilating field meteorological parameters and improve efficient entry of surface aviation observations and synoptic weather reports into the Automated Weather Network (AWN).

Next Generation Weather Radar (NEXRAD). Principle User Processing Stations (PUPS) associated with NEXRAD will provide significant improvements in radar analysis of meteorological features and severe weather over the United States. Navy is participating in the NEXRAD program, and will draw upon NEXRAD radars for coverage over Navy forecast areas. In some cases, Navy property was made available for the installation of the radar. NEXRAD PUPS installed during FY 1993 and 1994 will display imagery from NEXRAD systems covering areas of routine military operations and training.

Supplemental Weather Radar. The Navy and Marine Corps has established a Mission Needs Statement for procurement of a Supplementary Weather Radar to provide radar coverage at selected sites (many overseas) not scheduled to receive a NEXRAD pup. This system will replace the obsolete AN/FPS-106 weather radar now in use.

GEOSAT Follow-On (GFO). Launched in 1985, the GEOSAT-A spacecraft provided ocean topography data until its failure in 1990. In FY 1991, the Navy began development of a follow-on capability to acquire ocean topography data. In FY 1992, a contract was awarded to Ball Aerospace and Communications Group for the development of the first GFO satellite to be launched in FY 1996. The contract has options for two additional satellites.

Other sensor developments. Other developments include miniaturization of an Acoustic Doppler Current Profiler in a swimmer-board configuration to allow collection of bathymetry, currents, and bottom tracking for underwater swimmer navigation. This technology and other sensor developments will be used on a variety of autonomous underwater vehicles to enhance the Navy's oceanographic data collection capabilities. As miniaturization of sensors and associated electronics become commercially available, the Navy intends to pursue more expendable, low-power, low-cost sensor systems. The goal is to get data "From the Sea" and quickly into the hands of fleet operators whose safety, sensors, and systems are influenced by it.

INTERAGENCY COOPERATION

Memorandum of Agreement (MOA)

Navy and NOAA now operate under a new umbrella MOA, signed in 1993, that will incorporate all previous agreements as annexes. Significant weather/equipment related aspects include:

- Cooperative relationships between FLENUMMETOCCEN and NMC;
- Navy/NOAA operational imagery signal agreements;
- NAVMETOCCOM/NWS agreement on provision of Navy meteorological services to Micronesia;
- Navy/NOAA Joint Ice Center operations;
- Navy/NOAA/AWS agreement on shared processing of satellite data;

- Navy/NOAA agreement on the procurement, installation, maintenance, and operation of ASOS; and
- Navy/NOAA Oceanographic Data Distribution System.

MOAs exist between the Department of Commerce, Department of Transportation, and the Department of Defense concerning production and operation of the NEXRAD system. One MOA (June 1989) addresses allocation of program costs in the production phase of NEXRAD. A second MOA (September 1990) addresses interagency operations of the WSR-88D weather surveillance Doppler radar.

SUMMARY

The impact of these programs on fleet readiness and operational capabilities is significant. By the end of FY 1995, a logical framework will be in place to ensure that a survivable, responsive and layered network can provide in-situ and shore-based METOC services to the operating forces of the U.S. Navy and Marine Corps engaged in expeditionary warfare operations "From the Sea" in the littoral regions of the world using the best "C4I for the Warrior" architecture available to all DOD units.

UNITED STATES ARMY

ARMY OPERATIONAL SUPPORT

Overview of Operational Equipment and Support Missions

The U.S. Army provides two kinds of direct weather support to the Army missions. These are upper air observations for artillery fire support missions and limited surface weather observations to support Army weapon systems forward of Division tactical operations centers. The Air Force Major Commands (MAJCOMs) provide operational weather services to active Army forces in combat, contingencies, and peacetime training under law and according to Army-Air Force agreements. U.S. Army Forces Command (FORSCOM), U.S. Army Europe (USAREUR), U.S. Army Pacific (USARPAC), U.S. Army South (USARSO), Eighth U.S. Army (EUSA), U.S. Army Training and Doctrine Command (TRADOC) are Major Army Commands (MACOMs) with Air Force weather personnel providing installation and tactical support and Army Artillery Meteorological crews providing direct support. The Air National Guard (ANG) provides operational weather support to the Reserve Component (RC), the Army Reserve, and the Army National Guard (ARNG) during peacetime training and activation, and augments the active forces for exercises. The ANG acts like an Air Force MAJCOM in providing support to the RC.

The Army also provides operational weather support to Army Research, Development, Test, and Evaluation (RDTE) ranges, centers, and research and other facilities through the Test and Evaluation Command (TECOM) Meteorological Teams (Met Teams) and U.S. Army Space and Strategic Defense Command (SSDC) contractors. TECOM operational support is described as part of Army Materiel Command in the RDTE section. SSDC provides operational support to the Kwajalein Atoll range through a Meteorological Environmental Test Support contractor.

Army provides the tactical field equipment and communications equipment to the USAF personnel for tactical operations. MACOMs have purchased off-the-shelf, non-developmental items (NDI) to provide interim Army tactical communications equipment until the Integrated Meteorological System (IMETS), AN/TMQ-40, is fully fielded. IMETS is an automated mobile weather support and communications system. The Project Director (PD) for IMETS is under the direction of the Program Executive Officer for Command and Control Systems (PEO, CCS). The Communications and Electronics Command (CECOM) and Army Research Laboratory (ARL) provide appropriate technical assistance to PD, IMETS, and to artillery meteorological programs. Initial deliveries of IMETS will begin in FY 1995.

Interim, NDI systems presently providing operational communications support include the USAREUR Automated Weather System (UAWS) and the FORSCOM GOLDWING System. UAWS is a tactical secure radio system, mounted in a 5-ton truck with shelter, used for receiving and transmitting weather information and downlinking civil weather satellite imagery. UAWS will be phased out as new systems become available. GOLDWING performs

similar functions, but is lighter weight and transportable in boxes by two men. GOLDWING will continue to be used in conjunction with IMETS at locations where funding constraints does not allow IMETS to be fielded. UAWS and GOLDWING will be replaced, or upgraded for use in tactical exercises and contingencies by USAF Weather Teams (WETMs) and ANG Weather Flights supporting active Army and Reserve forces. IMETS will communicate with UAWS and GOLDWING over HF radio until they are replaced.

Artillery Meteorological 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 Artillery units during tactical training exercises, at permanent Army Artillery Ranges, or during the full range of combat missions. Artillery Meteorological Crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

Artillery Meteorological Crews use the Meteorological Data System (MDS), AN/TMQ-31, to take upper air observations during tactical operations. It is a mobile upper air sounding system on a 5-ton truck and trailer. The MDS sends upper air data to the Field Artillery Tactical Data System for use in adjusting artillery fire, to the USAF WETMs, and to the Chemical Officer for use in smoke operations and nuclear, biological, and chemical (NBC) defense operations. In order to meet increased mobility requirements, the Army will continue to develop the Meteorological Measuring System (MMS), AN/TMQ-41, during FY 1995 with fielding scheduled for FY 1996. The MMS will be deployable on a small vehicle, and the required size of the Artillery Meteorological Crews will be reduced. MDS will be refurbished and issued to the RC as it is replaced by the MMS. The Meteorological Hydrogen Generator (MHG) will start development in FY 1995 to provide a more mobile source of gas for artillery upper air balloons in a combat environment. In FY 1995, the MMS and MHG programs will be managed by the Intelligence and Electronic Warfare (IEW) Directorate, Communications and Electronics Command (CECOM), Research, Development, and Engineering Center (RDEC), Fort Monmouth, NJ. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK developed the requirement documents and is the combat developer for artillery meteorological equipment.

Army Intelligence personnel in the forward combat areas take aperiodic, limited surface weather observations at the brigade and battalion command posts with tactical observing equipment, when directed by the Intelligence Officer (S2).

Headquarters, Department of the Army, Office of the Deputy Chief of Staff for Intelligence (ODCSINT) is responsible for Army weather support policy. Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS) is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements.

Army Operational Support provided by the Air Force

The Air Force provides tactical and fixed-installation weather support to the Army. This support includes tactical forecasting and observing support during field exercises, contingencies and wartime; and peacetime weather support services at Army airfield weather stations. Although peacetime Air Force WETM support is primarily for aviation training from Army airfields, USAF WETMs directly support Army maneuver, intelligence, and other staff elements during exercises and training. They also provide supplemental information to artillery met crews in areas beyond artillery direct observations capabilities. Under current agreements, the Army and Air Force share responsibility for fixed and tactical support equipment. The Air Force installs, operates, and maintains standard AF meteorological forecasting and observing equipment at Army airfields. The Air Force provides the personnel, tactical observing and forecasting equipment and software in the field, while the Army provides and maintains the tactical communications, field equipment, and vehicles to support the USAF WETMS deployed in tactical exercises, contingencies, or combat.

U.S. Army Space and Strategic Defense Command (SSDC)

SSDC provides operational support to test facilities. The U.S. Army Kwajalein Atoll (USAKA) Meteorological Test Support (METS) contractor performs meteorological functions in support of missile operations and for synoptic purposes including surface,

upper air, and meteorological satellite observations, and the preparation of daily and special weather forecasts for the Kwajalein Range.

The U.S. Army Space Command (ARSPACE) is a subcommand of SSDC and runs the Army Space Exploitation Demonstration to demonstrate off-the-shelf solutions to warfighters needs. One of the areas investigated in FY 1994 and continuing into FY 1995 is in the area of the high resolution weather satellite receiver (HRWSR). The HRWSR acquires and processes the full telemetry stream of civilian and military weather satellites. The imagery and data is then used by the Staff Weather Officer in preparation of tailored products and forecasts for use on the battlefield. The system is also available for use in exercises or contingencies and demonstrates capabilities expected to be available in the IMETS, Block II and III in the FY 1997-1999 time frame.

Army Corps of Engineers (COE) Civil Operational Activities

The Corps of Engineers (COE) (dams and civil works) operates a network of about 8000 gauges of which 2200 are land-based limited meteorological observing sites. The remainder are hydrologic in nature. The meteorological observing sites measure precipitation and other data in the United States to provide information for regulating 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 1573 of these sites. Similarly, COE transfers funds to the Geological Survey to collect and maintain precipitation information from 423 of these sites. The remainder are maintained by the COE. Data from many of these sites are automatically telemetered using satellite microwave, landlines, radio, etc. to provide for real-time use of data. Although the COE finances the network, data are made available to all other Federal agencies.

Training and Doctrine Command (TRADOC)

TRADOC manages and develops training programs, writes both Army and Joint weather support doctrine, and establishes the weather requirements documents for Army tactical weather support equipment. The U.S. Army Intelligence Center (USAIC), Fort Huachuca, AZ is the proponent and user representative for the tactical weather support in wartime, contingencies, and peacetime tactical training. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK is the proponent for upper air meteorological support. The Engineer School, Fort Leonard Wood, MO coordinates weather support requirements in Terrain Analysis and Topographic Engineering. TRADOC schools submit requirements for weather support to HQ TRADOC for approval.

USAIC is the TRADOC functional proponent for tactical Army weather support. The Center's Weather Support Team writes tactical weather support concepts and doctrine; identifies deficiencies and baseline weather support requirements; provides weather support training to intelligence personnel and USAF personnel supporting the Army; and establishes requirements documents for weather support equipment. The Intelligence Center sponsors the Joint Army/Air Force tactical weather concept, which embraces the "Owning the Weather" concept of the Army Research Laboratory. These concepts describe how weather support to the future Army will be provided. The concepts describe the employment of IMETS, with its capability to integrate surface and upper air information from national and indigenous sources with battlefield weather data collected by the Automatic Meteorological Sensor System (AMSS), the Unmanned Aerial Vehicle (UAV) meteorological sensor systems, Field Artillery Profilers, weather satellite, and other sources to provide a 3-dimensional display of weather and environmental effects on and above the battlefield.

IMETS is a mobile, automated system that receives, integrates, models, and processes weather data from multiple national, indigenous, and tactical sources, as well as from civil and military weather satellites. It provides near real-time weather observations and forecasts, including digital displays to other tactical users and produces tactical decision aids (TDAs) and other tailored weather effects information. TDAs help determine the impact of adverse weather conditions on Army weapons systems and operations. IMETS integrates Air Force weather processing software with Army communications hardware in a vehicle-mounted standard shelter. IMETS will depend on the AMSS as one source of high density observations.

AMSS is a future lightweight man portable or vehicle-mounted system which automatically collects and transmits surface weather information and soil conditions to the brigade or battalion Intelligence Officer (S2) and the USAF weather team. The WETM uses the information to help to support the Intelligence Preparation of the Battlefield (IPB), to tailor support to battlefield operating systems, to produce weather effects decision aids, and to develop map overlays and matrices supporting targeting, nuclear, biological and chemical (NBC) defense operations.

USAFAS trains all Field Artillery Meteorological Crew members with a staff of approximately 35 military and civilian instructors. USAFAS also has the role of developing requirements documents for new upper air observing systems and writing operational support concepts, doctrine, and procedures to be taught in the classroom and executed in the field.

The Aviation Center, Chemical School, and Engineer School incorporate weather support procedures into training programs in their mission areas. The Engineer School develops evaluation procedures integrating the effects of weather conditions into terrain analysis, mobility, and counter-mobility doctrine, training, and planning. The Aviation Center has unique operational requirements for weather support to remote training locations requiring direct USAF support. Therefore, it maintains additional Army communications equipment to relay weather information to these sites in conjunction with USAF weather support at Army airfields.

Headquarters, TRADOC is the TRADOC approval authority for weather hardware requirements and policy.

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

Army Meteorological Research, Development, Test, and Evaluation

Under Army-Air Force agreement, the Army has responsibility for weather support for Army RDTE. The Corps of Engineers (COE) and the Army Materiel Command (AMC) are the major contributors to weather research. However, the Medical Research and Development Command also does research related to soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations.

Corps of Engineers (COE). The COE is responsible for reviewing all emerging Army systems for environmental effects, as stated in Army Regulation 70-1. The COE also manages the Technology Demonstration (TD 08) program. TDAs are developed for this program by three COE laboratories: Topographic Engineering Center (TEC), Cold Regions Research and Engineering Laboratory (CRREL), Waterways Experiment Station (WES). WES develops TDAs supporting the terrain analysis. TDAs interpret the impact of weather and terrain conditions on Army systems and operations. They are based on weather and terrain limitations, known as critical values. Critical values are determined from design criteria, operational testing, or other evaluations of Army capabilities in adverse weather. Technology Demonstrations are currently being transitioned to the terrain and weather systems such as the Integrated Meteorological System (IMETS), the Digital Topographic Support System (DTSS), and the Army Tactical Command and Control System (ATCCS).

Topographic Engineering Center (TEC). The TEC (Fort Belvoir, VA) provides applied environmental support to Army research and development programs and coordinates the development of TDAs relating to environmental effects on combat systems and operations. This includes the development of environmental effects data bases and models that are relevant to the military plans, operations, and material acquisition communities. TEC is also responsible for developing integrated software modules that are designed to be exploited in the synthetic environment arena. TEC also contributes to the development of policies and procedures for the consideration of realistic natural environmental conditions in the materiel acquisition process. Within this capacity, TEC is responsible for reviewing all emerging systems for environmental effects, as outlined in AR 70-1.

Cold Regions Research and Engineering Laboratory (CRREL). Under the military engineering portion of its civil and military support mission, the CRREL (Hanover, NH) provides weather support to Army weapon systems RDTE, combat, and combat support mission areas, and develops climatological studies on the effects of winter environment on Army operations. A work unit entitled "Winter Distributed Interactive Simulation" has been implemented and will be integrated into the synthetic environment program. CRREL develops data bases and models predicting

infrared and millimeter wave (MMW) weapon system performance, and capability of technology to enhance military operations in cold environments. Under a Memorandum of Understanding (MOU), the U.S. Army Test and Evaluation Command (TECOM) provides operational observing, weather instrumentation, and forecasting services for CRREL's RDTE efforts through a Met Team located at CRREL.

Army Materiel Command (AMC). AMC is responsible for the design, development, test, and evaluation of new systems and equipment. Part of this responsibility is to satisfy performance requirements in representative meteorological conditions. AMC also provides climatological support to RDTE projects involving electro-optics and obscurants. It is also responsible for determining weather effects critical threshold values and environmental sensitivities of battlefield systems. AMC has several subcommands and elements carrying out weather research and development responsibilities.

Test and Evaluation Command (TECOM). TECOM is a subcommand of AMC with responsibility to provide operational support to 12 test/evaluation ranges and research/development sites with 11 Meteorological (Met) Teams. TECOM Met Teams provide atmospheric data collection, analysis, consultation, and warning and forecast services for Army and DOD RDTE efforts. TECOM invested a small amount in the development and evaluation of a GPS-based upper air system allowing balloon-borne, dropsonde or rocketsonde sampling capabilities in FY 1994 and 1995. This Global Positioning System (GPS) upgrade potentially increases tropospheric spatial sampling resolution and provides validation of other meteorological sensors. To support meteorological modeling requirements of Dugway Proving Ground (DPG), TECOM funded modeling, simulation, and testing in FY 1994 for range surety and DOD chemical/biological defense programs. This will remain limited in FY 1995 to the small FY 1994 fixed resources available.

Meteorological instrumentation will be acquired through Army technical development resources or through direct funding from RDTE projects for test-specific or unique requirements. Applied research funds in FY 1995 are split between TECOM Met Teams and the Army Research Laboratory (ARL).

Army Research Laboratory (ARL). The Battlefield Environment Directorate (BED) of the ARL supports the Chief of Staff, U.S. Army's (CSA) five modernization objectives through the "Owning the Weather" (OTW) initiative. Battlefield environmental effects impact each of the CSA objectives:

- Protect and sustain the force;
- Project the force;
- Win the information war;
- Conduct precision strikes throughout the battlefield;
- Dominate the maneuver battle.

Under the DOD Project Reliance taxonomy, BED is the lead agency for multi-service programs in transport and diffusion modeling and mobile atmospheric profiling. In addition, the Directorate is an active partner in the Project Reliance sub-sub-areas of the theater data fusion and prediction, boundary layer process and interaction, and atmospheric effects assessments. BED has single agency responsibility for battlefield environmental effects. The Directorate's history as the former U.S. Army Atmospheric Sciences Laboratory reveals a long distinguished record of supporting live-fire tests of weapons systems at the Army's ranges. The R&D world is replete with many examples such as the early Copperhead munitions, which were pressed into production without adequate environmental testing, with resulting mission failure. The advent of simulation and visualization technology will enable new systems to be environmentally tested by simulation/visualization techniques before expensive prototypes or production models are procured. Although this accelerates the decline of the historical BED applied research (6.5) mission, it also provides the opportunity to intensify Tech Base efforts to insert real world atmospheric effects into new simulation techniques for system design and testing.

In this regard, most prominent of the Directorates technology thrusts for FY 1995 will be small scale atmospheric simulations; atmospheric electro-optics and acoustics; artillery meteorology; weather intelligence; propagation environment; model validation; atmospheric susceptibility; chemical/biological aerosols; and boundary layer processes.

The Directorate benefits from direct access to an unparalleled, division-sized outdoor instrumented laboratory at its White Sands, NM site. BED

researchers have access to both automated and manned data collection points across the 40x140 mile range. Data sources include 20 automated surface observations stations, 11 permanent Rawinsonde/PIBAL sites for upper air data, a meteorological rocket launch complex, two 500 foot instrumented meteorological towers, and an advanced atmospheric profiler complex for high resolution vertical profiles of wind, wind shear, optical turbulence and virtual temperature. These sources are supplemented by surface instrumentation at various launch sites, a doppler weather radar, and other special purpose sensors.

The present and future programs of the Directorate are driven by a combination of scientific, customer, and mission requirements. Key program elements are (1) development of the "Owning the Weather " Initiative; (2) maintaining a viable and technically superior atmospheric research team; (3) fulfillment of mission obligations to the Army's RDECs; (4) support to the DOD Science and Technology Strategies, Project Reliance, and the Army Science and Technology Master Plan; (5) cultivation of the partnering opportunities with other ARL directorates and sister government laboratories; (6) continuation of close ties with the TRADOC community and participation in the Battle Laboratories and the Louisiana Maneuvers programs; (7) maintenance of strong ties to the terrain-related programs of the Army Corps of Engineers; and (8) leveraging of national and international environmental science programs and sponsorship of dual-use/defense conversion technologies.

Army Research Office (ARO). The ARO (Research Triangle Park, NC) manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with atmospheric dynamics at small scales, propagation of electromagnetic radiation through natural and induced obscurants, and boundary layer atmospheric physics.

The basic research program is conducted in two funding lines: the individual investigator program and the University Research Initiative (URI). In both programs, the focus of the research is on the atmospheric processes and effects in the atmospheric boundary layer where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding of atmospheric effects on soldiers, materials, and weapons systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on air flow, and the development of natural obscuration. 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 to resolve turbulence time scales. One URI center concentrates on boundary layer processes, especially near the ground. The second center is developing remote sensing of boundary layer wind fields at time and space scales of atmospheric dispersion.

Two areas of special funding are also managed. The Augmentation Awards for Science and Engineering Research and Training (AASERT) program provides funding for additional graduate and undergraduate students working under existing sponsored research programs. The other area is in Congressionally mandated funding to academic institutions. This office will managed one such program beginning late in FY 1994 and extending for seven years.

Communications and Electronics Command (CECOM). The CECOM Intelligence and Electronic Warfare (IEW) Directorate, Fort Monmouth, NJ is conducting research or development on the Meteorological Measuring System (MMS), Meteorological Hydrogen Generator (MHG), the Target Area Meteorological Sensor System (TAMSS), and the Integrated Meteorological System (IMETS) for the program directors.

The MMS is a light version of the Meteorological Data System (MDS), upper air sounder. MMS will be fielded to light divisions and will eventually replace all MDSs. It is an upper air meteorological data collection, processing and dissemination system that will provide data to the field artillery and target acquisition users. This meets light forces requirements for roll-on/roll-off capability during assault. The system, a non-developmental item, is currently under contract.

The MHG is a highly mobile, tactical hydrogen generating system to be used to rapidly inflate meteorological balloons in the field in support of the field artillery sections. The MHG will be skid mounted and transportable on a Highly Mobile Multi-wheeled

Vehicle (HMMWV). It will provide a steady flow of hydrogen gas in sufficient quantity to satisfy the requirements of the field artillery using a chemical reaction of methanol and distilled water.

The TAMSS research is part of the Field Artillery's (FA) Met Improvement Plan. This program includes a suite of sensors and systems contributing to the acquisition of meteorological data in the Target Area. This suite will include parallel development of sensors and equipment in both the Intelligence and FA areas. The FA portion of this program will include the development of a Global Positioning System (GPS) sonde, Radiometric and Interferometric meteorological profilers and dropsondes. TAMSS is in early development and will be fielded after the end of the decade.

The IEW Directorate provides matrix support to the development of IMETS. IMETS will employ standard Army Tactical Command and Control System (ATCCS) hardware and Air Force Tactical Automated Weather Distribution System software and upgrades that follow. IEW Directorate will support IMETS through initial fielding and further development.

Medical Research and Development Command

U.S. Army Research Institute of Environmental Medicine (USARIEM). The USARIEM, Natick MA conducts research on the effects of temperature, altitude, work, and nutrition on the health and performance of individual soldiers or combat crews operating Army systems. Applied research efforts in thermal physiology and biophysical modeling are directed toward improving soldier performance and minimizing health risks in climatic extremes. The sensitivity of the soldier to weather parameters (primarily ambient air temperature, dew point temperature, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The goals of applied research efforts are to develop methods to assess and extend the boundaries of the envelope in an operational setting. On-going research efforts include: 1) laboratory and field studies on soldiers to support validation requirements for thermal strain predictive models; 2) laboratory and field studies on soldiers, to quantify psychological and task performance decrements associated with weather extremes; and 3) laboratory and field studies to support evaluation of satellite Remote Sensing (RS) and Geographic Information System (GIS) technology for use in heat stress/heat injury assessment.

APPENDIX C

DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

FEDERAL AVIATION ADMINISTRATION

RESPONSIBILITIES FOR AVIATION WEATHER

The Federal Aviation Administration (FAA) is responsible for the safety and separation of aircraft and the efficiency of flight operations. The adequacy of aviation weather information contributes significantly toward fulfilling these responsibilities. FAA makes recommendations to the U.S. Department of Commerce on civil aviation meteorological services, provides specialized equipment at certain airfields, observes and reports the weather at about 360 airports, distributes weather data over civil communications systems, and provides the principal means for disseminating weather advisories and information to pilots.

Weather information for pilots is made available through Flight Service Stations (FSS), recorded messages broadcast over navigational aids, special weather broadcasts, telephone answering systems, and by the Direct User Access Terminal (DUAT) system provided by private vendors. Air Route Traffic Control Centers have weather service units manned by National Weather Service (NWS) meteorologists to assure that vital weather information is available to controllers and pilots.

FAA maintains a continuing research program to improve aviation weather service to the users of the National Airspace System (NAS). FAA also engages in engineering efforts to improve weather observations and communications related to aviation.

The Aviation Weather Program is aimed at progressively improving the timeliness and accuracy of weather information provided to aircrews, dispatchers and the Air Traffic Control (ATC) system to reduce the number of weather related accidents and incidents and to increase both system capacity and fuel savings by reducing weather related delays. Wherever practical, the objectives of this program are accomplished by enhancing existing and planned air traffic control operations and procedures by providing improved aviation weather information services. Facets of the program are conducted in close cooperation with the NWS.

PROGRAMS FOR AVIATION WEATHER

En Route Weather Radar Program

This program supports the definition, development, and implementation of the Next Generation Weather Radar (NEXRAD) for enroute applications. NEXRAD will provide accurate aviation-oriented products concerning reflectivity, wind velocity, and hazardous storms.

Improved weather data from NEXRAD provided to ATC through the Weather and Radar Processor (WARP) will increase aviation safety and fuel efficiency. In addition to the benefits to be gained in today's system, future automated ATC functions and improved traffic-flow management require reliable and accurate weather data so that projected maximum fuel savings and manpower productivity gains based on these improvements can be realized.

Implementation costs associated with NEXRAD are being funded jointly by the Department of Commerce, the Department of Defense, and the Federal Aviation Administration. The program is being managed within the Department of Commerce, and is being developed and acquired under the auspices of the NEXRAD Program Council within the Office of the Federal Coordinator.

NEXRAD implementation in the field began in 1990 and is expected to be completed in 1996. The number of NEXRAD units to be acquired is being determined by the participating agencies. FAA is emphasizing the development of algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms, and that provide new or improved aviation-oriented products.

To improve hazardous weather detection, reduce flight delays, and improve flight planning services, the joint NEXRAD program provides several aviation weather products related to wind, wind shear, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones-tornadoes.

Terminal Doppler Weather Radar (TDWR)

This program consists of the procurement and installation of a new terminal weather radar based on Doppler techniques. TDWR units will be located to optimize the detection of microbursts and wind shear at selected high activity airports. In addition, it will have the capability to identify areas of precipitation, and thunderstorm location. TDWR's will be integrated with the existing Low Level Wind Shear Alert System (LLWAS) at many airports.

Microbursts are weather phenomenon that consist of an intense down draft with strong surface outflows. They are particularly dangerous to aircraft that are landing or departing. The TDWR scanning strategy will be optimized for microburst/wind shear detection. The radar will be located on or near the airport operating areas.

Algorithms for the automatic detection of microbursts, wind shear, and gust fronts are further being refined and tested by the FAA. Data collected with FAA's transportable Doppler weather radar facility (at Memphis, TN; Huntsville, AL; Denver, CO; Kansas City, MO, and Orlando, FL) provided the primary basis for development and validation of the algorithms. This facility was used to evaluate the operational aspects of TDWR and will continue to support the enhancement and development of wind shear algorithms at Orlando and Denver.

A contract was awarded in November 1988 for 47 turnkey TDWR installations at sites specified by FAA, of which 45 are operational units and two are support units for training and testing. Field implementation will occur in the 1992 to 1994 time frame. The alphanumeric display and the situation displays will be located in the tower cab and the Terminal Radar Approach Control (TRACON). The displays have been tested operationally in 1988, 1989, 1990, 1991, and 1992, at Denver Stapleton, Kansas City, and Orlando International Airports. The production displays have been utilized at Orlando.

In FY 1992, a TDWR software upgrade package was initiated. This package integrates TDWR and LLWAS, and will implement changes identified during the operational demonstrations.

Other Weather Radar Programs

Air Route Surveillance Radars. The present Air Route Surveillance Radars provide weather data for the Air Route Traffic Control Centers (ARTCC) out to 200 nautical miles. A new Air Route Surveillance Radar (ARSR-4) will provide the ARTCC's with accurate multiple weather levels out to 200 nautical miles. This will be the first en route radar with the ability to accurately report targets in weather. The ARSR-4 will be used to provide weather information until NEXRAD is operational in the Rocky Mountain area. Even after NEXRAD is in place, ARSR-4 will provide supplemental weather information for some areas.

The ARSR-4 is a joint Federal Aviation Administration/United States Air Force (FAA/USAF) funded project. Forty joint FAA/USAF radar sites will receive the new ARSR-4 radar during the 1992-1994 period.

Airport Surveillance Radar-9 (ASR-9) Weather Modular Enhancement. The Weather Modular Enhancement will be an add-on modification to the existing ASR-9 radars and will provide air traffic controllers information on low level wind shear associated with microbursts in the vicinity of the ASR-9 radars. Presently, the ASR-9 weather data that are available consist of the six intensity levels as defined by the National Weather Service. In addition, gust front detection capability will be provided.

New Generation Runway Visual Range (RVR)

The runway visual range program provides for a new generation RVR sub-element of the NAS. The RVR provides runway visual range information to controllers and users in support of precision landing and takeoff operations. The new generation RVR incorporates state-of-the-art sensor technology and imbedded remote maintenance monitoring. New generation RVRs will be procured for all new qualifying locations and will replace many existing RVRs in the NAS inventory.

The RVR provides for near real-time measurement of visibility condition along a runway (up to three points along the runway can be measured - touchdown, midpoint and rollout) and reports these visibility conditions to air traffic controllers and other users.

The system automatically collects and formats data from three sensors: a visibility sensor, using forward scatter meters replacing the transmissometers currently in use; a runway light intensity monitor of both runway edges and center line lights; and an ambient light sensor controlling computer calculations using a day or night algorithm. The data processing unit calculates RVR products and distributes the products to controllers and other users.

A total of 529 RVR visibility sensors will be deployed at 264 airport locations beginning late CY 1993. Enhancements are planned to interface with the Tower Control Computer Complex (TCCC) and the NWS's Automated Surface Observation System (ASOS) by 1996.

Low Level Wind Shear Alert System (LLWAS)

LLWAS provides pilots with information on hazardous windshear conditions that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The basic system consists of a wind sensor located at center field and five sensors near the periphery of the airport. A computer processes the sensor information and displays wind shear conditions to air traffic controllers for relay to pilots.

The LLWAS-Network Expansion (LLWAS-NE) is the first step in the FAA's efforts to upgrade National Airspace Systems' capability to detect windshear. Earlier, six-sensor LLWASs have provided adequate protection for microbursts; however, testing at Denver Stapleton Airport and recently at Orlando International Airport have resulted in the development of two more sophisticated windshear detection systems. One of these systems is the LLWAS-NE. The LLWAS-NE will include expanding the network of sensors, improved sensor siting, and runway-oriented alerts.

The airports scheduled for LLWAS-NE installation in late 1992 and early 1993 are: Orlando, Washington National, Chicago O'Hare, Atlanta, Dallas-Ft. Worth, Tampa, St. Louis, and the new Denver Airport. Long-term modifications of LLWAS will lead to the implementation of an enhanced LLWAS.

The improvement phase referred to as LLWAS-3 will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new information/alert displays which enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. Initially, 83 airports were identified to receive LLWAS-3. Funding for LLWAS-3 was programmed to begin in 1992. LLWAS-3 is scheduled to be fully deployed by 2001.

In the future, LLWAS-3 and TDWR will work in conjunction providing a synchronous alarm of wind shear to the air traffic. Studies have been conducted on how these systems can be integrated into a single wind shear display for the air traffic controller. Development of a system is underway that will integrate the information from these two systems into a single wind shear display for the air traffic controller. Investigation is also underway on how integrated wind shear information can best be communicated or displayed to the pilot. Also, studies will be conducted to evaluate other sensors for the airport approach and departure corridors. These sensors are intended to provide wind shear detection out to three miles from the touchdown zone.

Automated Surface Weather Observing Program

The FAA is acquiring automated surface weather observing systems; acquiring related data acquisition systems; and development, test, and evaluation of weather sensors in cooperation with the National Weather Service.

AWOS/ASOS Acquisition. Automated surface weather observations will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, precipitation type, occurrence and accumulation) through the use of automated sensors. It will process these data, and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

The FAA has deployed Automated Weather Observing Systems (AWOS) at 200 airports to provide the basic aviation weather products directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to enhance aviation safety and the efficiency of flight

operations by providing real-time weather data at airports that previously did not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations, and are available off-the-shelf as a commercial product.

The FAA has negotiated with the National Oceanic and Atmospheric Administration (NOAA) to procure, install, operate, and maintain Automated Surface Observing Systems (ASOS) at the remaining airports where the FAA provides observations and at additional non-towered airports without weather reporting capabilities. A production contract was awarded in February 1991. The FAA will be sponsoring, as part of a reimbursable agreement with NOAA, 537 systems with an option for 228 additional systems. The first FAA-sponsored systems were installed in August 1991 and will continue to be installed into 1995.

Automated Weather Observing Systems (AWOS) for Non-Federal Applications. Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement, as well as the funding for the regular maintenance. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on Non-Federal Automated Weather Observing Systems.

There are currently five versions of the non-Federal AWOS. An AWOS-A provides only altimeter setting. The AWOS I system contains sensors to measure wind speed and direction, ambient and dew point temperature, altimeter setting, and density altitude. The AWOS II contains the AWOS I sensors plus a visibility sensor, and an AWOS III adds a cloud height sensor to an AWOS II. An AWOS IV will include AWOS III plus the option for precipitation identification, thunderstorm detection and runway surface condition. Most important, all versions are required to have the capability to broadcast a minute-by-minute update of the current weather to the pilot by radio, using a computer generated voice output. AWOS III also enables the pilot (or other user) to call the AWOS on a telephone and obtain the current weather observation during his preflight activities. In addition, the observation may be transmitted to the database within the national weather network.

By the begining of FY 1994, there were more than 275 non-Federal AWOSs. Some of these are capable of reporting through a geostationary communications satellite and many more will reach that capability during the year. These observations will be entered into the national network for use in support of the National Airspace System and the national weather system.

AWOS/ASOS Data Acquisition System (ADAS). ADAS will function primarily as a message concentrator collecting weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each air traffic control center's area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to WARP and the Data Link Processor (DLP) (via NADIN) within the center in which it is installed. It will also distribute AWOS data to the National Airspace Data Interchange Network (NADIN) which will forward the data to WMSCR for further distribution. This DLP via Mode S makes weather data available to pilots and air traffic controllers on a timely basis within the "local" area and other users. Field implementation of ADAS has started and will be completed in 1995.

Weather Sensor Development, Test and Evaluation. This activity (1) evaluates new systems and techniques for the measurement of surface weather parameters, (2) tests the capabilities of improved weather sensors, and (3) supports research studies on weather conditions that are hazardous to flight operations.

Because of the importance of reliable, complete and timely surface observations for aviation safety, and the need to reduce the cost of obtaining these observations, the FAA supports advanced weather sensor development activities. The work is conducted primarily by the NWS and NOAA's Environmental Research Laboratory. Technologies being investigated include sensors for: (1) improved visibility detection; 2) current type and amount of precipitation; 3) lightning detection systems; 4) runway surface conditions; and 5) sensors that can detect freezing rain.

Integrated Terminal Weather System (ITWS)

This project will develop a system to integrate weather data from sensors in the terminal area to provide and display compatible, consistent, real-time products that require no additional interpretation by controllers or pilots. ITWS will use data from AWOS, NEXRAD, TDWR and NWS data and products to forecast aviation impact parameters such as visibility, icing and windshears, including downbursts. Initial capabilities will include sensors available in the mid-to-late 1990's.

Flight Service Automation System (FSAS)

This program will improve user access to weather and Notice to Airmen (NOTAM) information, simplify flight plan filing, and provide a FSAS that will meet the projected increases in demand for flight services without proportional increases in staff. Automation is being implemented through installation of a Model 1 Full Capacity (M1FC) system at each of 61 Automated Flight Service Stations.

The first Model 1 System was commissioned in 1986; it was not until August 1991 that the full capacity was achieved. As of April 1993, all Model 1 Systems had been replaced by M1FC, which were operating in 50 Automated Flight Service Stations (AFSS) and 14 Flight Service Data Processing Systems (FSDPSs). All 61 AFSSs will be commissioned by June 1994, and all 21 FSDPSs will be installed by September 1994. M1FC will provide sufficient hardware and software to drive all of the terminals in the 61 AFSSs.

The Direct User Access Terminal (DUAT) system has been operational since February 1990. Pilot users are able to access Weather and NOTAMs and file their IFR and/or VFR flight plans from their home or office personal computer through DUATS.

Graphics Weather Display Systems (GWDS) in the AFSSs consist of a variety of different vendor systems. These systems will be maintained as interim systems until replaced by a standardized graphics functionality.

Weather Message Switching Center Replacement (WMSCR)

WMSCR replaces the weather message switching center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, MO, with state-of-the-art technology. It will perform all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of Notices to Airmen (NOTAM). It will rely on FAA's National Airspace Data Interchange Network (NADIN) for a majority of its communications support. The system will accommodate graphic data and function as the primary FAA gateway to the National Meteorological Center (NMC) and, therefore, will be the principle source of NWS products for the National Airspace System (NAS).

To provide for geographic redundancy, the system will have nodes in the NADIN buildings in Atlanta, GA, and Salt Lake City, UT. Each node will support approximately one-half of the United States and continuously exchange information with the other to ensure that both have identical national databases. In the event of a nodal failure, the surviving one will assume responsibility for the entire network. The implementation of WMSCR will allow the closing of NATCOM. The system is expected to be operational by early 1995. The WMSC system may be rehosted in Atlanta pending the start-up of WMSCR.

Aeronautical Data Link Program (ADLP)

The ADLP will implement the Data Link Processor (DLP) to support weather services for aircraft utilizing the discreetly addressed data link capability of the FAA's Mode Surveillance (MODE S) system. It will receive down link requests for weather products from aircraft, formulate replies and return them to the pilot via the data link. This will improve air-ground communications services by expanding the pilot's ability to access desired weather information while operating on the airport surface or in flight. It will also reduce the workload of flight service specialists and air traffic controllers who currently provide the only means of such access.

Initially, the data link services to be implemented will be those for which automated databases currently exist, or are planned to be operational in the near term. These include alphanumeric products such as SIGMET, AIRMET, surface observations, terminal forecasts, winds aloft, pilot reports and alphanumeric radar summary information. Installation of this system began in 1991 and is continuing as programmed. The ADLP will be enhanced in 1996 to support additional weather (including wind-shear advisories) and ATC tower applications (including digital ATIS) and to provide expanded data link communications functions in support of ATC data link services.

National Airspace Data Interchange Network (NADIN)

The NADIN II Packet Switched Network is being implemented to serve as the primary interfacility data communications resource for a large community of NAS computer subsystems. The network design incorporates state-of-the-art packet switching technology into a highly connected backbone network in order to provide extremely high data flow capacity and efficiency to the network users. NADIN II will consist of operational switching nodes at each Area Control Facility and two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City and Atlanta. It will interface directly to such systems as the WMSCR, Weather and Radar Processor (WARP), Meteorologist's Weather Processor (MWP), ADLP, AWOS/ASOS Data Acquisition System (ADAS), Traffic Management System (TMS), Consolidated NOTAM System (CNS), and Area Control Computer Complex (ACCC), and may be used as the intrafacility communications system between these (collocated) users during transition to end-state.

Worldwide Aeronautical Forecast System (WAFS).

The WAFS is a satellite based system for disseminating aviation weather information and products to international aviation offices and aircraft in flight. The information and products are prepared at two designated offices-one in Washington, D.C. and one at Bracknell, U.K. The U.S. part of WAFS is a joint project of FAA and NOAA/NWS to meet requirements of the member states of the International Civil Aviation Organization.

Central Weather Processor (CWP)

CWP will improve the dissemination of weather information throughout the National Airspace System (NAS), to pilots, air traffic controllers, flight service specialists, traffic management specialists, and NWS meteorologists assigned to weather service units in the air traffic control centers and the central flow control facility. It will provide specialized automated tools to these meteorologists to enhance their ability to summarize hazardous weather information and ensure that the latest and best information is disseminated to all users. CWP will also provide for a near-real-time, area mosaic of weather radar information (NEXRAD) for subsequent distribution to controller displays. These improvements are necessary to help reduce the high percentage of accidents and delays directly related to weather.

The CWP is composed of two elements. The first is a commercially-available Meteorologist's Weather Processor (MWP) which has been procured through a series of 5-year leases. This provides current meteorological data for the preparation of short-term aviation forecasts and severe weather advisories by the NWS meteorologists assigned to the FAA centers. The second element is a Weather and Radar Processor (WARP) which will automatically create unique NEXRAD-based mosaic products. The WARP will send these products, along with other time-critical weather information to controllers through the Advanced Automation System (AAS) and to pilots via the enhanced Weather Communications Processor and Mode S data link.

The deployment of MWP was completed in 1992. The MWP leased in the second 5-year period will interface with the WARP which should become operational in 1998. The MWP will also interface with NWS offices to permit a rapid flow of weather information to and from each FAA center. Future leases of the MWP will consider the possibility of utilizing services available from AWIPS-90 (Advanced Weather Interactive Processing System) sponsored by the National Weather Service.

Requirements for the CWP and other agencies' automated weather information systems are being coordinated through the Committee for Automated Weather Information Systems (CAWIS) working under the auspices of the AWIS Program Council. The intent of this activity is to avoid unnecessary duplication of development effort and to assure the sharing of information and products in the operational phase.

Weather Processing

The Committee for Automated Weather Information Systems, under the direction of the Program Council within the Office of the Federal Coordinator, developed a National Plan which integrates requirements, development and implementation activities associated with AWIS programs and projects of the Departments of Commerce, Defense, and Transportation. Under this Plan, the Departments are cooperating in the review, clarification, and allocation of requirements to the various specialized elements of the planned national AWIS. New interface requirements are being defined and plans for product sharing are being developed. In addition, new interfaces with elements of the NAS will

be developed to support the CWP weather information dissemination function. Included is an interface with the DLP to provide NEXRAD mosaics for communication to the pilot and receive Pilot Weather Reports from aircraft in flight.

This project translates these new interface requirements into verified interface designs and product specifications which, when they are approved for implementation, will be included in the CWP program.

Centralized Weather Information Processing

This project will develop an integrated weather database for generating route-oriented, alphanumeric, and graphic products that are consistent and machine readable. Activities include the identification of weather-information sources appropriate for a centralized database, development of a suitable structure for this database, specification of machine-readable output products, and development of a rigorous set of algorithms for the generation of these products.

Aviation Weather Products Generator (AWPG)

The AWPG will capitalize on significant advances in atmospheric sciences and computer technology to develop small scale products of weather phenomena of major importance to aviation. Data inputs will come from the NWS four-dimensional database of the Aviation Gridded Forecast System (AGFS) and ITWS, providing the most accurate, high spatial and temporal resolution of current and forecast variables available. It will automatically generate timely regional and national aviation weather products for immediate use by non-meteorological personnel, such as pilots, air controllers, traffic management personnel, and flight service specialists. The products will be available on the aeronautical data link. Implementation is expected in the late 1990's.

Airborne Wind Shear Detection and Avoidance

This project will develop requirements for airborne wind shear devices that provide the flight crew with the ability to reliably detect hazardous wind shear along the intended flight path, with sufficient time to avoid it.

In 1987, the FAA and NASA entered into a Memorandum of Agreement through which NASA will provide unique national resources for the study, analysis, and verification of requirements for "forward-looking" sensors such as Doppler radar and Doppler lidar. These resources include NASA's Aircraft Landing Dynamics Facility to evaluate the full-scale effects of heavy rain, aircraft simulation capabilities, the ability to perform four-dimensional microscale atmospheric modeling, and instrumented flight-test facilities. The two agencies will develop the functional and performance requirements for airborne wind shear detection and avoidance, and will transfer the results of this effort to manufacturers to accelerate their development and certification programs.

In FY 1989, the effort focused on full-scale simulation tests of candidate system configurations of sensors, flight controls and cockpit displays. FY 1990 was the first opportunity to perform flight tests of candidate airborne wind shear detection and avoidance concepts based upon the previous year's analysis and experiments.

It is projected that airborne remote detection technology and onboard processing of ground-based data will be developed, evaluated and flight tested.

Improved Aircraft Icing Forecasts

This initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as recommended in the, "National Plan to Improve Aircraft Icing Forecasts." This Plan was jointly developed under the aegis of the Federal Coordinator for Meteorology by the Department of Transportation, Department of Defense, Department of Commerce, National Aeronautics and Space Administration, and the National Science Foundation to provide the National Weather Service with an improved aircraft icing forecast capability. The objectives of this Plan are to develop an icing severity index, develop icing guidance models, and to develop a better comprehension of synoptic and mesoscale conditions leading to icing. The end result of this effort will be improved icing forecasting capability, to be operational in 1996. Pilots will be provided with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

UNITED STATES COAST GUARD

Among the Coast Guard's (CG) activities are: marine and coastal weather observations by ocean going cutters and at shore stations; collection and transmission to the National Weather Service (NWS) of marine weather observations received from ships at sea by Coast Guard Communications Stations; broadcast of NWS marine weather forecasts, weather warnings and weather facsimile charts to marine users; monitoring the seasonal iceberg threat to the North Atlantic shipping lanes off the Grand Banks of Newfoundland and the transmission of warning messages defining the iceberg limits; providing facilities and ship support to maintain the National Data Buoy Center (NDBC) network of automated environmental monitoring platforms; and operation of long-range radio navigation systems (OMEGA and LORAN-C) which are used by the meteorological sounding instruments essential to observational networks.

Coast Guard seagoing cutters and coastal stations provide weather observations to the NWS. Coast Guard Communications Stations broadcast NWS marine forecasts, weather warnings and weather facsimile charts and collect weather observations from commercial shipping for the NWS. Coast Guard Groups broadcast NWS marine forecasts and weather warnings. The Coast Guard conducts the International Ice Patrol (IIP) which uses radar equipped aircraft to patrol the area of the Grand Banks of Newfoundland during the iceberg season. IIP determines the geographic limits of the iceberg hazard broadcasting twice-daily iceberg warning bulletins and daily ice facsimile charts depicting the limits of all known ice to the marine community during the period of iceberg danger. IIP operates an Iceberg Drift and Deterioration Model to predict iceberg distribution between IIP reconnaissance flights. IIP annually archives iceberg data reflecting all targets (both known icebergs and unidentified radar targets) merged into the Drift and Deterioration Model. The data is forwarded to the National Snow and Ice Data Center. The listing contains iceberg sighting data along with the last model predicted position.

Various Coast Guard facilities support the National Data Buoy Center (NDBC). NDBC's automated network of environmental monitoring platforms in the deep ocean and coastal regions provide accurate and reliable data for NWS and other users. Fifteen Coast Guard personnel fill key technical and operating positions within NDBC; the senior Coast Guard officer assigned serves as the Deputy Director. Coast Guard cutters provide the deployment and retrieval of data buoys and service visits to both buoys and coastal stations, expending up to 280 cutter days annually. Coast Guard aircraft, boat, and shore facilities also provide NDBC support.

The Coast Guard operates navigation stations providing OMEGA and LORAN-C radio-navigation signals for the aviation and navigation communities. These signals also support the operation of meteorological sounding instruments essential to observation networks.

Coast Guard Marine Science Technicians receive basic training in meteorology as a major part of the training for their specialty.

Meteorological activities are coordinated by the Ice Operations Division of the Office of Navigation Safety and Waterways Services at Coast Guard Headquarters. The Coast Guard NDBC operation is managed at Coast Guard Headquarters by the Short Range Aids to Navigation Division of the Office of Navigation Safety and Waterways Services. Field management of the meteorological activities is a collateral function of the Coast Guard district and area staffs.

No Coast Guard unit is dedicated solely to meteorology; all facilities perform a variety of missions. No capital investments in meteorological facilities are planned or contemplated.

APPENDIX D

WEATHER PROGRAMS OF OTHER AGENCIES

DEPARTMENT OF AGRICULTURE

Weather is the most important factor influencing the Nation's variability in crop yields and related production. The Nation's food and fiber products are a critical resource impacting our domestic and international economic position and have taken on new dimensions in foreign affairs and national security. The recent expansion in export markets has reduced stocks and benefitted our farm sectors as global consumption of total grains has exceeded production in two of the last three years. The U.S. Department of Agriculture (USDA) conducts supporting research that focuses on understanding the interactions of weather and climate with plants, animals, forests and forest ecological systems and assists the Department of Commerce in determining farmers' needs for the weather information and in disseminating such information to them.

The World Agricultural Outlook Board (WAOB), in cooperation with the National Weather Service's Climate Analysis Center monitors the daily weather patterns around the world. The WAOB agricultural meteorologists convert the weather data into information to assess crop development and yield potential for all major commodity crops in major producing areas of the world. Special weekly briefings are provided to the Secretary of Agriculture and the economics and commodity analysts of USDA. The Senate and House Agricultural Committees also requested periodic briefings on crop relating drought effects in 1988 and 1989.

Historically, the Forest Service (FS) has collected meteorological data to assist in the control of forest fires and the management of smoke from prescribed burning. However, other FS activities also need weather data to ensure sound management decisions. Therefore, a national weather program was establish to coordinate all FS meteorological activities and to meet the increasing need for diverse weather information: The major objectives of the program are to: improve quality control of weather data, improve the design and operation of data collection networks, increase data recovery from the weather stations, and upgrade station maintenance. Meteorological data collected by manual weather stations and Remote Automated Weather Stations (RAWS) support research of weather effects on forestry management, forest fires, smoke management, visibility protection in wilderness areas, and atmospheric deposition. A weather information management system and a library to archive all FS weather data are being developed in cooperation with the Regional Climate Centers of the National Climate Program. The Forest Service monitoring network will provide essential data for use in Global Change work.

The Forest Service currently operates more than 300 RAWS, mostly in the western United States. Air temperature, relative humidity, soil moisture, wind direction, speed, and precipitation are transmitted via GOES telemetry. These data are received via a direct readout ground site in Boise, ID, operated by the Bureau of Land Management. The main use of the data is in the calculation of the fire danger rating for the Forest Service and cooperating agencies. These data are also used by other resource managers such as road engineers, wildlife biologists, and hydrologists who monitor precipitation, silviculturalists who are attempting to maximize tree planting opportunities, ecologists, and soil specialists and fisheries biologists monitoring the effects of runoff. The main secondary user of these RAWS data is NOAA National Weather Service for fire weather forecasting and flood warnings.

The Soil Conservation Service (SCS) operates a network of 1400 manual snow courses and over 550 automated data collection sites in conjunction with a snow telemetry project (SNOTEL) for the western United States and Alaska. The primary objective of the project is to forecast streamflow for the coming spring runoff season. These measurements are made in cooperation with other Federal, state and local agencies, power companies, irrigation companies, and the provincial Government of British Columbia.

Water supply forecasts help irrigators make the most effective use of available streamflow for achieving their agricultural production goals. Farmers who collectively irrigate more than 10 million acres of land in the western United States benefit from water supply forecasts. Other Federal agencies and private organizations also use water supply forecast information to help them carry out their missions. These forecasts

also help the Federal Government in administering international water treaties.

Beginning in FY 1987, SCS implemented a new initiative to upgrade the SNOTEL data collection system at a total cost of $5 million. This effort continues and includes upgrading 510 data collection sites in the existing SNOTEL system with new state-of-the-art equipment and adding about 40 additional sites. The data collection site upgrade will include replacement of snow pillows, transducers, damaged precipitation gages, antennas, towers, solar panels, battery temperature sensors, and deteriorated shelter houses.

Supporting Research

The mission of the USDA supporting research program is to develop and disseminate information and techniques to ensure an abundance of high-quality commodities and products while minimizing any adverse effects of agriculture in the environment.

The research efforts of the Agricultural Research Service (ARS) relate directly to the effects of climate on agricultural production and the natural resource base. They are directed toward developing technologies and systems for: 1) managing precipitation and solar energy for optimum crop production; 2) improving our understanding of water-plant-atmosphere interactions; 3) optimizing the use of energy, water, and agricultural chemicals; 4) reducing plant and livestock losses from pests and environmental stress; 5) developing improved techniques for irrigation and drainage; and 6) minimizing the adverse effects of climate and weather, including atmospheric contaminants, on atmospheric production and the environment.

The Cooperative State Research Service (CSRS) coordinates research programs in the state agricultural experiment stations, the 1890 Land Grant Distributions, and cooperating forestry schools. These institutions conduct a wide variety for research applicable to agriculture and forestry. Meteorological research in these institutions is practically all climatological. A proportion of each state's program is consolidated into broad Regional Research Projects. Animals and plants are subjected to many climatic stresses and are therefore the focal point of much of this research. Work begun in FY 1990 to evaluate plant response to changes in levels of ultraviolet radiation as part of the Global Change Research Program will be significantly expanded through the CSRS competitive grants program in FY 1994. The work is coordinated with EPA's ultraviolet radiation program and will support assessment efforts to develop related national policy on environment.

Forest Service research includes efforts to: understand and control forest fire initiation by lightning; improve the translation of mid-range forecast elements to describe forestry conditions, incorporate drought information into management decision-making and better describe how regional climatic variability affects the use of daily weather information by foresters. The FS long term monitoring network will provide critical data for use in the Global Change research work.

Investigations by the National Agricultural Statistics Service (NASS) support domestic crop estimating programs for major commodities. Promising studies are underway to develop models relating weather parameters and associated variables to corn ear weight and wheat head weight. Results from previous efforts to develop models for short term forecasting have had only limited success. Research will continue in this area with the expectation that the relationships between weather variables and crop yield will improve as better plant process models become available.

The NASS program to explore the use of satellite and weather data for assessing crop conditions is continuing. A preliminary investigation of polar orbiting meteorological satellite data showed a good relationship between crop condition and reflectance data as determined by the agreement between measured and forecast final corn and soybean yields. The crop conditions assessment procedures, based on meteorological satellite data, are being automated and near real-time applications are being explored.

DEPARTMENT OF THE INTERIOR

Specific financial data for the Department of the Interior's (DOI) Atmospheric Science Research Programs are reported through the Subcommittee for Atmospheric Research; however, operational program budgets are reported in the Federal Plan. The narrative below describes the full range of meteorological activity in the Interior Department.

The Bureau of Reclamation activities requiring the collection and use of meteorological data include water scheduling, flood hydrology, irrigation project management, and reservoir operations, as well as projects related to the development of wind and solar energy resources. Multi-agency work is also proceeding in projecting potential effects of climate change on western water resources and Bureau operations. Bureau of Reclamation's weather modification research program has not been funded since 1989 except for reimbursable work.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in the "real-time" through the NOAA's Geostationary Operational Environmental Satellite (GOES) to the Bureau's Direct Readout Ground Stations (DRGS) in Boise, Idaho. AGRIMET is a subset of 36 HYDROMET DCPs dedicated to analysis of crop water use and water conservation. Data collected and products created in Boise are immediately transferred to other bureau, Federal and state offices.

The Geological Survey's Water Resources Division collects precipitation, streamflow, and other climatological data for a number of projects concerning rainfall/runoff, water quality and hydrologic processes. Currently, the Geological Survey collects hydrometeorological data from approximately 3,500 GOES DCPs through six DRGS units. In September 1992, the Survey awarded a contract to procure direct readout terminals (DROTs) to receive domestic satellite (DOMSAT) retransmission of all data collected on NOAA's GOES data collection system. These compact DROT systems are proving to be much more efficient and economical data sources than the conventional DRGS receivers.

The Survey is continuing a joint research program with NASA to map snowpack water equivalent using satellite passive microwave techniques. Comparison of data collected by the Department of Agriculture's Soil Conservation Service Snow Telemetry (SNOTEL) sites, by Survey field teams, and through instrumentation by other agencies is being made to test the feasibility of making assessments of snowpack from space.

The Survey also researches past climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology. It collects precipitation and dryfall atmospheric deposition samples in a number of studies for determination of atmospheric contribution to the chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment.

The Bureau of Land Management's (BLM) Initial Attack Management System (IAMS) provides real-time data access and modeling for the fire management organization. The system enables rapid evaluation, assessment, and decision making capabilities for the BLM's wildfire responsibilities. The principal inputs are Remote Automatic Weather Station (RAWS) meteorological data, Automatic Lightning Detection System (ALDS) information, vegetation, slope, elevation, and terrain data. These real-time data sources are coupled to advanced fire modeling capabilities to facilitate the BLM's fire and resource management objectives.

The BLM's RAWS Program collects meteorological data from a network of stations located throughout twelve western states including Alaska. This network is comprised of three classes of systems placed at strategic remote locations. All data are recovered via the GOES system by the BLM's DRGS located at the Boise Interagency Fire Center (BIFC) in Boise, Idaho. The Bureau presently owns 359 systems with about 300 of these being fielded. The network is planned to ultimately reach 359 fielded systems.

The BLM's RAWS Support Facility at BIFC provides a full range of management, maintenance, data, and support services for the BLM and numerous other Government agencies. This work is performed under long-term interagency agreements with those agencies having similar equipment and requirements.

The BLM's Automatic Lightning Detection System (ALDS) covers the eleven western states and Alaska. The western U.S. ALDS is comprised of 36 direction finders (DF) providing high detection efficiency coverage of cloud-to-ground activity for 95 percent of the western United States. The system provides data via a satellite telecommunications system for BLM's IAMS. Data are also supplied to the National Weather Service, State University of New York (SUNY), New Mexico Institute of Mining and Technology, and several Department of Defense installations. The Alaska ALDS is comprised of nine DFs providing the required coverage for Alaska Fire Service's needs.

In addition to the meteorological monitoring to support fire management activities, the BLM also conducts site-specific climate monitoring at over 200 locations on the Public Lands in the eleven western states and Alaska. The operation of these sites ranges from seasonal to annual measurements of precipitation, temperature, soil moisture, and other meteorological parameters required to assess local climatic influences. These data are primarily used for natural resource management and planning at the local level.

In 1991, the BLM Global Change Research Program established five monitoring sites in BLM wilderness and wilderness study arm to establish baseline conditions for assessment of long term ecosystem trends. A total of 20 sites are planned to be established over the initial 5-year period. A standardized monitoring platform will be operated at these sites to include measurements of climate and atmospheric chemistry.

The Minerals Management Service's Environmental Studies Program gathers offshore environmental data in support of mineral leasing responsibilities. Currently, the Service supports eight data buoys which transmit via NOAA satellites from off the Pacific Coast. Wind data are used in the Service's Oil Spill Risk Analysis Model to predict effects of potential spills.

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

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

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the Southwest. The Bureau also shares fire weather data with other Federal agencies while participating in fire weather forecasting at the Boise Interagency Fire Center.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OPERATIONS

The National Aeronautics and Space Administration (NASA) Headquarters Weather Support Office has continued to improve NASA weather support capabilities for both manned and unmanned launch vehicles. It is expected that these improvements will strengthen and enhance the information provided to the ground-based decision makers and astronaut observers to insure that NASA achieves the best operational posture for the space shuttle launches and landings. The goal of the operations program is to provide the specialized meteorological data needed by operational forecasters at the NASA/Kennedy Space Center and Johnson Space Center to support the Space Shuttle Program.

Improved weather information begins with improved observing systems and includes efforts to provide better communications, integrated data management systems and displays, an automated

network of observing stations/systems, and improved forecasting techniques and methods.

The goal of the Advanced Development Program has been to develop techniques and systems that aid in prediction of and avoidance of the weather impacts associated with mesoscale weather phenomena in a subtropical coastal environment. Summer thunderstorms are frequent in this environment; many hazardous ground and launch operations are carried out during shuttle processing that are especially endangered by mesosoale weather events such as thunderstorms. The project addresses predicting the development of convective clouds, the extent of threat of lightning associated with thunderstorms and electrified clouds, and the initiation of lightning. Attention is being given to improved prediction models.

The elements comprising the operations program are intended to provide the specialized meteorological data that are needed for the support of both manned and unmanned launch vehicles. Mesoscale weather events have a strong impact on shuttle ground processing operations, launch, and landing operations. The long range goal of the program is to provide support that uses the latest technological developments. The Applied Meteorology Unit, collocated with the AF Cape Canaveral Forecast Facility, provides a facility in which recent technological development can be verified and older technology may be reexamined and improved for the purpose of transitioning useful procedures, techniques, and models into the operational forecasting arena. Applications likely to provide near term benefits to launch and landing operations and to ground processing are emphasized. Four major programs will be certified in FY 1994: the advanced ground-based field mill system, the new mesoscale tower system, the 50 MHz Doppler radar wind profiler, and the lightning detection and ranging system. A major FY 1995 initiative under study is to replace the meteorological data display, analysis, and distribution system.

RESEARCH -- PHYSICAL CLIMATE

NASA sponsored research and analysis activities are geared towards addressing the scientific needs of a complex multidisciplinary program designed to fulfill NASA's responsibilities in the U.S. Global Change Research Program. These responsibilities pertain to developing an understanding of the processes that may affect climate change. The climate variables which are commonly studied are concerned mainly with the lower atmosphere. But, in considering the climate system we cannot look at the atmosphere alone. Processes in the lower atmosphere are strongly coupled to the land surface, the oceans, the cryosphere, the biosphere and the stratosphere. The NASA/Mission to Planet Earth Science Division is responsible for planning, implementing, and managing broad based studies of the atmospheric, oceanic, and land surface processes that govern the atmospheric and oceanic circulations, energy budget, water cycle, and the associated distributions of temperature, moisture, clouds, and precipitation over the surface of the Earth. These include studies of the biosphere, stratosphere and Earth system modeling. Meteorology related research is mostly sponsored by the Science Division's Physical Climate Branch.

The physical climate and hydrologic system have preferred modes of variability on a number of time scales, and the ultimate effects of man's alterations of the atmosphere and surface will be strongly modulated by the natural characteristics of the system. An accurate prediction of the magnitude and timing of a change in climate (changes in the patterns of temperature, precipitation, and severe weather) is limited because of a significant number of uncertainties in the understanding of the physical climate system, including: a) how clouds modulate the Earth's radiative balance and, conversely, how their distribution may respond to a change in the radiative forcing or aerosol loading of the atmosphere; b) how the exchange of energy between the ocean and the atmosphere may change, especially if the circulation patterns of the ocean change; c) how the exchange of energy and water will be impacted by changes in terrestrial vegetation and albedo (due to changes in land cover and the extent of sea ice, glaciers, and snow cover); d) how climate and land surface hydrology interact; and e) how water is exchanged between ice sheets and the ocean and the effect of this exchange on sea level.

In order to carry out the physical climate program, it is necessary to monitor the critical physical variables that characterize the state of the atmosphere, land surface, oceans, and the cryosphere. It is also necessary to study the interaction of many dynamic and thermodynamic processes within these components of the climate system (i.e. the atmosphere, land surface, oceans and the cryosphere), as well as those processes that govern the interactions and feedbacks between

these components. These are mainly the fluxes of heat, momentum and water.

Discipline Oriented Research

To implement the Physical Climate Program, the Branch is organized into five discipline oriented programs. The objectives and major research priorities for each of these programs are provided below.

The objective of the Atmospheric Dynamics Program is to develop an improved understanding of the physical processes important in determining the circulation of the atmosphere on all scales, ranging from the mesoscale to the global scale.

This includes not only a comprehensive understanding of the distributions and cycles of mass, energy, momentum and water vapor in the troposphere, but also a complete understanding of the coupling between the dynamical and thermodynamical processes with the hydrological and radiative processes. Many different kinds and scales of motion are involved. The way in which small-scale atmospheric processes, (e.g., convection and mesoscale systems) affect large-scale circulation is inadequately known. Conversely, the influence of large-scale processes on small-scale events is crucial to understanding climate change and requires substantial research. Understanding of these scale interactive processes and how they affect the generation, maintenance and dissipation of convective systems, frontal circulations and cyclonic storms is a key focus of this research activity. Much remains to be determined about the effects of topographic and thermal forcing on large-scale and mesoscale flows, the details of monsoons, and the teleconnections that result in a response in remote regions of the globe. Diurnal variations of the atmospheric structure, boundary layer processes, and generation of the fronts at the surface, and in the free atmosphere, are other important processes within the troposphere that are inadequately understood.

The key contribution that this program provides to the atmospheric sciences is the development of improved remote sensing instruments and data inversion techniques to measure important meteorological parameters necessary for characterizing the state of the lower atmosphere and its interaction with other components of the physical climate system. Progress is being made in the development and refinement of: ground and airborne lidars for the measurement of temperature, moisture and pressure; airborne radars for measurement of precipitation and cloud properties; airborne microwave radiometers for surface imaging and measuring moisture, temperature, precipitation and cirrus cloud properties; airborne lidars for the measurement of aerosol and cloud backscatter properties and wind velocity profiles; and, balloon and airborne infrared radiometers for improved sea surface temperature measurements. All these measurement activities are closely related to the development of the Office of Mission to Planet Earth (MTPE) flight sensors/missions such as TRMM (Tropical Rainfall Measuring Mission), AIRS (Atmospheric Infrared Sounder), AMSU (Advanced Microwave Sounding Unit), MHS (Microwave Humidity Sounder), MIMR (Multifrequency Imaging Microwave Radiometer), and LAWS (Laser Atmospheric Wind Sounder).

The objectives of the Radiation Processes Program are to advance the understanding of radiative exchange processes in the sun-earth-atmosphere system, to develop improved radiation models and parameterizations for Earth system models, and to improve space observational capabilities for radiation parameters and processes. The approach is to conduct observational and theoretical investigations of major radiative forcing parameters, field experiments and modeling studies of major radiative feedback mechanisms, and analysis and validation of space observations for radiative processes.

Elements of the program include radiative forcing and feedback studies involving clouds, aerosols, and solar irradiance; diagnostic studies and algorithm improvement relating to surface radiation and radiation-dynamical interactions; and remote sensing studies for retrieval algorithm improvement data validation and measurement calibration. The priorities of the program have been driven by global change research issues so that clouds and radiation have been emphasized. Research support for cloud and radiation studies has been closely coordinated with programs in other agencies through the First ISCCP Regional Experiment (FIRE) Project. Due to the recent emergence of aerosol radiative forcing as a global change issue having large potential impact but substantial uncertainty, aerosol and aerosol-cloud interaction processes are being elevated in priority. A number of investigations supported by the Radiation

Processes Program are closely integrated with the MTPE flight sensors such as LITE (Lidar In-space Technology Experiment), CERES (Clouds and Earth's Radiant Energy System), MISR (Multi-angle Imaging SpectroRadiometer), ACRIM (Active Cavity Radiometer Irradiance Monitor) and EOSP (Earth Observing Scanning Polarimeter).

The objective of the Water Cycle Processes Program is to understand the role of water in land-atmosphere interaction by promoting new or improved techniques for measuring hydrologic variables; developing processes models for describing mesoscale coupling of atmospheric motion and the exchange water, energy and momentum at the land surface; and formulating new theories about the role of large-scale land-atmosphere interaction in regional and global climate.

Major research priorities of the program include: a) characterization of spatial and temporal variability of land surface moisture state and its relation to the partitioning of net radiative energy into latent and sensible heat exchange with the atmosphere, as well as the partitioning of precipitation (or irrigation) into infiltration and runoff, including techniques of aggregation and disaggregation of surface moisture, precipitation, and evaporation transfer fluxes; b) study of feedback in atmospheric motion, including the boundary layer, owing to changes in land surface hydrology, and vice versa, including variations with season and geography; c) developing an understanding of the coupling of radiation balance over large areas of snow and ice and atmospheric dynamics and role of timing and rate of snowmelt in large-scale hydrology and land-atmosphere interaction. Efforts are underway to define an L-band large aperture microwave radiometer capable of measuring the water content of the top few centimeters of bare soil.

The Physical Oceanography Program primarily focuses on ocean circulation research and air/sea interaction studies. These studies are supported by an active program of aircraft and spacecraft-borne instrumentation development/validation and a research program dedicated to providing a better fundamental understanding of the interaction between electromagnetic radiation and the ocean surface.

An understanding of heat and momentum fluxes between the ocean and atmosphere on basin-scales remain important to issues of climate and global change. The measurement of these fluxes from space on large scales requires better spacecraft-borne estimates of surface wind speed, sea surface temperature, and near surface humidity. Currently, studies are funded to improve existing space-borne sea surface temperature algorithms.

With the recent successful launch of the TOPEX/POSEIDON mission in August 1992, financial resources used to support basic altimeter research, such as, precision orbit determination studies, electromagnetic bias studies, and ionosphere correction studies have been reduced in size to accommodate basic scatterometer research. These new studies are needed to support scatterometer algorithm development for NSCAT (NASA Scatterometer), which will be launched aboard the Japanese ADEOS satellite in 1996. The retrieval of geophysical parameters from scatterometers and altimeters depends on a thorough understanding of the interaction between microwave radiation and the ocean surface. These studies continue to represent an important element of this program. The vitality of the Physical Oceanography program is strongly dependent on data from the existing TOPEX/POSEIDON mission and future data from NSCAT, SIR-C (Shuttle Imaging Radar-C), MIMR, MODIS (MODerate-Resolution Imaging Spectroradiometer), and AIRS.

Long-term goals of the Polar Processes Program are: a) improved understanding of polar processes through analysis of satellite and in situ data and by model simulations; b) significant improvement in our ability to represent high-latitude processes in models of global climate and climate change; and c) development of the ability to monitor important high-latitude phenomena that are likely to respond to climate change.

The program priorities include: a) derivation, from satellite data, of long-term, reliable time series of snow cover on land and sea-ice extent, concentration, motion, surface temperature, albedo, and atmospheric characteristics above the sea ice; b) estimation, using these time series together with in situ measurements from data buoys, of fluxes of energy, salt, and water at the ocean/ice/atmosphere interfaces; c) investigation of the impact of these fluxes on the overlying atmosphere and cloud cover, on ocean density structure, and on high-latitude ocean circulation; d) measurement, using

satellite and aircraft data, of the mass balance of the Greenland and Antarctic ice sheets, and of some of the factors affecting it - snow accumulation, summer melting, and ice discharge down glaciers and ice streams; and, e) improved understanding of what determines snow-accumulation rates and summer melting rates on the ice sheets.

Extensive data sets from past and existing passive microwave, radar-altimeter, SAR and vis/ir satellite sensors contribute to this effort. Future MTPE sensors of interest include MIMR, NSCAT, MODIS, AIRS, AMSU, MHS, ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometers), ALT (ALTimeter) and GLAS (Geoscience Laser Altimeter System).

Research Supporting Major Programs

In addition to the above disciplines, a major research effort in support of the TRMM (Tropical Rainfall Measuring Mission) is ongoing in the Physical Climate branch. The objective of this research is to develop an improved capability to observe rainfall from space in order to understand the role of rainfall in the global energy and water cycles in climate and climate change. TRMM is being developed jointly by the U.S. and Japan and is scheduled for launch in 1997.

Major priorities of this TRMM related effort include: a) development of an improved understanding of the physics involved in the remote sensing of rainfall from space; b) development of improved 3-D, time-dependent models of precipitating cloud systems including their dynamical, microphysical and radiative characteristics; c) acquisition and analysis of long-term radar and gauge observations of rainfall to improve understanding of the variability of rainfall statistics in order to derive more accurate total rainfall values from TRMM and other satellite observations; d) development of algorithms for the retrieval of rainfall rates from the TRMM sensors; e) development of standards for the improved measurement of rainfall and a means to validate and calibrate rainfall observing systems; and f) development of advanced remote sensing techniques to observe rainfall.

The Physical Climate Program participates with other U.S. (and sometimes international) agencies in coordinated field experiments to obtain comprehensive data sets. A good example is the recent participation in the international Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) in the western tropical Pacific Ocean during 1992 to 1993, with a comprehensive field campaign in early 1993. NASA aircraft and instruments participated in well coordinated operations involving NOAA and NCAR aircraft and measured convective activity and tropical cirrus properties in a variety of situations ranging from dissipating systems to actively building and large mature systems. Tropical Cyclone Oliver near the North East Coast of Australia was visited three times. Most NASA convection, radiation, precipitation (TRMM), air-sea interaction and oceanography objectives were realized.

Planning for the international Global Energy and Water Cycle Experiment (GEWEX) is ongoing. The first phase of GEWEX initiative -- the Continental-Scale Experiment over the Mississippi Basin-- is slated to be initiated in the 1994-95 time period. GEWEX will observe and model the global hydrological cycle, in order to predict variations of global and regional hydrologic processes and water resources, and their response to environmental change.

The Upper Atmosphere Research Satellite (UARS) launched in September 1991 continues to provide valuable data for studying the coupling of chemical, radiative, and dynamic processes in the stratosphere.

Development of the Earth Observing System (EOS) is continuing. The primary objective of the EOS is to document global climate change and to observe regional-to-global scale processes. Utilizing several satellites, EOS will document global climate change over a fifteen-year period to provide long-term, consistent data for use in modeling and understanding global processes. The first EOS platform is scheduled for launch in 1998.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for working with state, local, and other Federal Government agencies to provide user-appropriate and scientifically credible air quality meteorological programs to support regulatory applications. Applied research and meteorological support is furnished primarily by EPA's Atmospheric Research and Exposure Assessment Laboratory in Research Triangle Park, NC, through an interagency agreement with the National Oceanic and Atmospheric Administration (NOAA), which provides approximately 55 research meteorologists to the EPA. Meteorological support to the EPA Office of Research and Development, the EPA Office of Air and Radiation, the EPA Regional Offices, and to state and local agencies includes: development and application of air quality dispersion models for pollution control, and for direct and indirect exposure assessment strategies; preparation and performance of dispersion studies and air quality model evaluations; and review of meteorological aspects of environmental impact statements, state implementation plans, and variance requests. Meteorological expertise and guidance are also provided for the air quality standard, modeling guideline, and policy development activities of the EPA.

In light of the latest changes to the Clean Air Act, air quality models and the manner in which they are used are expected to evolve considerably over the next few years. In the area of pollutant deposition, the evaluation of nitrogen and oxidant chemistry in addition to sulfur chemistry will elucidate the role of model formulation, radiative transfer, and surface/vertical exchange in the air quality model predictions, along with development of a better understanding of model predictions relative to control strategy assessment. Further development and evaluation of existing air quality models will take place to accommodate the inter-pollutant effects resulting from the variety of control programs that are now or will be in place. These inter-pollutant effects include trade-offs among controls on oxidant, ozone, sulfur oxides, nitrogen oxides, and volatile organic compounds as well as developing predictable methods of forecasting the impacts on various measures of air quality.

With respect to inhalable particulate model development, dispersion models will be enhanced to accurately predict aerosol growth from precursors over regional and local transport distances. To assist in the evaluation of the contribution of various sources to regional air degradation, inert tracer and tagged species numerical models are being developed. These models will introduce separate calculations for inert or reactive chemical species emitted from a particular source or region. The calculations will proceed to simulate transport and transformation to a receptor point, where the contribution of the particular source could be isolated.

With respect to oxidant air quality modeling, the role of biogenic volatile organic compounds, rural nitrogen oxides, and vertical transport will be elucidated along with the development of a better understanding of the fundamental aspects of the ozone nonattainment problem such as differences in urban and rural photochemical production and their interaction through transport. Much of this research will be performed under the new program entitled North American Research Strategy on Tropospheric Ozone (NARSTO).

Atmospheric research in the areas of climate and climate change includes ozone distribution in the global troposphere, the relationship between that ozone distribution and climate (including temporal and spatial aspects), and regional climate studies addressing the interaction of climate with the biosphere. The climatology program involves both analytical and statistical climatology as well as support for regional-scale climate model development. Climate change issues and their feedbacks with the biosphere will be stressed.

In addition to these three major areas, dispersion models for inert, reactive, and toxic pollutants are under development and evaluation on all temporal and spatial scales, e.g., indoor, urban, complex terrain, mesoscale, and regional. Other efforts include construction and application of air pollution climatologies; determination and description of pollutant effects on atmospheric parameters; and conversely, determination of meteorological effects on air quality. Measurement data obtained during field programs and from wind tunnel and water channel/towing tank experiments will be used to continue development and evaluation of these models in the FY 1994-95 period. EPA participation in the interagency High Performance Computing and Communications (HPCC) Program is enabling increased efficiency in air quality meteorological modeling, with the subsequent transfer of these achieved efficiencies to the user community.

The EPA is also an active participant in the U.S. Weather Research Program (USWRP), mainly by providing research-in-kind in the area of meteorological simulation modeling on local, meso-, and regional spatial scales of pollutants from fossil-fueled power plants, vehicle exhausts, and other emissions sources.

The detailed understanding and modeling of the mesoscale circulations that control the atmospheric dispersal of these pollutants will also be applied to coping with accidental releases of toxic or radioactive materials.

DEPARTMENT OF STATE

The Department of State plays an active role in international climate/meteorological policy making as a result of the growing worldwide concern with global environmental issues, including the depletion of the stratospheric ozone layer and global warming. The Department's role has principally revolved around preparation and negotiation of the U.S. position in three fora: (1) the Conference of the Parties to the Vienna Convention and its Montreal Protocol on Substances that Deplete the Ozone Layer, (2) the Intergovernmental Panel on Climate Change (IPCC); and (3) the Intergovernmental Negotiating Committee (INC) for a framework Convention on Climate Change.

Stratospheric ozone depletion has been recognized as a critical health and environmental problem for more than a decade. Under the leadership of the Department of State, the United States worked to negotiate international agreements to phase-out ozone-depleting substances, which should lead to a recovery of the ozone layer in the next century. To date, these treaties have been signed and ratified by more than 130 countries (including the United States), representing 99 percent of the world's production of ozone depleting substances.

The IPCC, which is jointly sponsored by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), held its first session in 1988. This organization serves as a government forum to assess the state of scientific, technical and economic information regarding climate change. The IPCC is currently organized in three working groups, examining: (1) the state of the science; (2) impacts and possible response strategies, including mitigation and adaptation; and (3) economics and other cross-cutting issues. The IPCC released its first assessment report in 1990, and a supplementary report in 1992. It is currently developing an interim assessment of the science, to be published in late 1994, and a full second assessment report from each of the working groups, scheduled for publication in 1995.

The INC was responsible for negotiating the Framework Convention on Climate Change. Negotiations began in February 1991, hosted by the United States in Washington, D.C.; the convention was open for signature in Rio de Janeiro at the Earth Summit in June 1992. As of August 1994, it had been ratified by 84 countries, including the United States. The INC is now working to prepare for the first meeting of the Conference of the Parties to the Convention, scheduled to be held in Berlin in late March 1995. The Convention calls for countries to develop inventories of their emissions and sinks of greenhouse gases, and calls upon developed countries to aim to return these emissions to their 1990 levels by the year 2000.

In addition to its primary role in the fora listed above, the State Department is active on the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council (NSTC). The CENR was established in 1993 to coordinate scientific domestic programs. Furthermore, while the emphasis on global environmental issues is a key new component of the Department's focus, traditional State Department responsibilities, set forth in earlier Federal Plans, continue. These include but are not limited to international aspects of food policy, disaster warnings and assistance, WMO and UNEP activities, and international meteorological programs.

NUCLEAR REGULATORY COMMISSION

The U.S. Nuclear Regulatory Commission (NRC) licenses and regulates all nuclear facilities subject to the Atomic Energy Act of 1954 as amended. The licensing and operation of these nuclear facilities require the identification of meteorological and climatological conditions that can affect the safe operation of the facility, and that provide input to the assessment of the radiological impacts of any airborne releases from the facility.

Within the NRC, reviews of facility siting, design, construction and operation are conducted by the Office of Nuclear Reactor Regulation and the Office of Nuclear Material Safety and Safeguards. These reviews include consideration of meteorological factors. The NRC Office for Analysis and Evaluation of Operational Data and the NRC Regional Offices assure that commitments by NRC applicants, permittees and licensees are carried out, and also conduct NRC responses to nuclear facility emergencies. The Office of Nuclear Regulatory Research develops regulations, guides, criteria, and other standards related to the protection of public health and safety and the environment in the licensing and operation of nuclear facilities. This Office also develops and conducts confirmatory research programs in support of activities of the other Offices and in support of rulemaking and standards activities.

The two primary meteorological areas in which the NRC will have an interest during FY 1995 and beyond are 1) improvements in the meteorological capabilities of the NRC and the operators of nuclear facilities to cope with emergencies involving the unplanned releases of radioactive materials, and 2) paleoclimatic reconstruction and long-term climate change models for applications in the assessment of geologic high-level radioactive waste repositories. The NRC also maintains an interest in the transport and dispersion of airborne, hazardous non-radioactive materials and their potential effects on the safe operation of nuclear facilities.

DEPARTMENT OF ENERGY

The Department of Energy (DOE) supports meteorological services at nine of its laboratories and at the Nevada Test Site. Services include climatological summaries, general weather forecasts, and items specifically in support of laboratory operations such as environmental monitoring, atmospheric sciences research, and hazardous material release assessments. The National Weather Service Nuclear Support Office at the Nevada Test Site provides continuing meteorological services required by the safety and technical programs associated with all forms of nuclear and non-nuclear experiments conducted at the test site and other locations.

FEDERAL EMERGENCY MANAGEMENT AGENCY

Under direction of the President, the mission of the Federal Emergency Management Agency (FEMA) is to plan for and coordinate the protection of the civilian population and resources of the Nation, and to include planning for the continuity of constitutional government in time of emergency. FEMA replaced five former agencies, integrating a number of emergency activities which include development of community awareness for meteorological emergencies and coordination of all emergency warnings to the public.

FEMA's principal involvement with meteorology results from the coordinating role of FEMA in support of preparedness for national security emergencies, and for carrying out statutory disaster relief responsibilities involved with the extremes of meteorologically-related phenomena. These responsibilities have been listed in Executive Order 12656 which forms the basis for FEMA's continuing relationship with the Executive line agencies.

In carrying out its role, FEMA works with all of the agencies to assure that the delivery of meteorological and climatological-related information is conducted in keeping with established preparedness goals and objectives. As administrator of the National Flood Insurance Program, FEMA publishes a system of

Flood Insurance Rate Maps (FIRM) which serve as the official demarcation for flood insurance risk. FEMA was given responsibility by the 100th Congress for coordinating the preparation of a national coastal erosion and flood plain database.

FEMA's priority interests with the Office of the Federal Coordinator are in promoting standards and procedures which will enhance the ability of the Nation to mitigate and recover from national security emergencies, and to coordinate its statutory responsibilities by enhancing integrated services under off-standard conditions. These interests extend to national standards for geographic information systems used for delivery of meteorological services by other agencies. For meteorologically-related matters, the National Preparedness Directorate is the principal contact point within FEMA. Developments involving flooding and erosion impacts are coordinated within the Insurance Administration offices of FEMA.

APPENDIX E

WORLD WEATHER PROGRAM

The Department of Commerce (DOC) was designated by the President, following Senate Concurrent Resolution 67 (1968), to be the lead agency in coordinating the U. S. participation in the World Weather Program (WWP). Previous to 1983, DOC published a separate report on WWP Plans. Beginning with the 1983 edition of the Federal Plan for Meteorological Services and Supporting Research, a section on the WWP has been included and has obviated the need for a separate report. Included at the end of this Appendix are bilateral and regional international cooperative activities not under the WWP. While not exhaustive, most Government programs are included. This Appendix was prepared by the Working Group for World Weather Program of the Committee for Basic Services within the Federal meteorological coordination mechanism.

GOALS AND ORGANIZATION OF THE WORLD WEATHER PROGRAM

The goals of the WWP are to extend the time, accuracy, range, and scope of weather prediction and to understand the physical basis of climate and of climatic changes. The ability of the United States and other nations to use their existing scientific capability to understand the climate and to increase their weather predicting skills is limited by the lack of global weather data. Available weather data are barely adequate over 20 percent of the Earth while the remaining 80 percent, mostly over the oceans, remain inadequately observed.

Development of the technology and the systems to obtain these observations, especially over the oceans, presents formidable problems. However, with the use of satellites, aircraft, ships, radar, anchored and drifting buoys, and balloons, a system can be developed that will be able to observe and collect comprehensive daily data about the atmosphere of the entire globe. This system is too complex to be implemented by a single nation. This has been clearly recognized by the leaders of many nations whose international cooperation in meteorology has been a tradition for more than a century. The continuing need for international cooperation prompted the President of the United States to propose to the United Nations (UN) in 1961 the establishment of an international effort in weather prediction. The United Nations responded by calling upon the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) to develop measures to improve weather forecasting capabilities and to advance knowledge of the basic physical forces that determine climate.

The WMO, with 167 members, is a specialized agency created by the UN to facilitate international cooperation in the fields of meteorology and hydrology. The WMO responded to the UN request with the concept of the World Weather Watch (WWW), an operational system to bring the global atmosphere under improved surveillance and to provide for the rapid collection and exchange of weather data as well as for the dissemination of weather products from centralized processing centers.

More recently the WMO, through its commission structure, is working towards the design and implementation of improved observations for a Global Climate Observing System (GCOS) through enhancements to the Global Observing System (GOS) and other appropriate measures. These efforts are expected to yield an enhanced GOS for both operational and research purposes; they are part of the effort to strengthen WMO's commitment to improve understanding of climate and related environmental matters, as articulated by the Second World Climate Conference in 1990 and repeated at the United Nations Conference on the Environment and Development (UNCED).

The responsibilities of U. S. Federal agencies in the WWP follow:

Department of Commerce (DOC): Represents the U. S. at WMO and provides the focal point (NOAA) to coordinate our Nation's efforts in these international programs, implements those service improvements in the existing international weather system for which the U. S. accepts responsibility, and develops new technology as related to its responsibilities.

Department of State (DOS): Maintains relations with developing nations and through the WMO assists developing nations in improving their national weather

services and develops appropriate multilateral and bilateral arrangements to further international participation.

National Science Foundation (NSF): Stimulates and supports basic research by non-Government scientists on atmospheric and ocean circulations and modeling. It also promotes the education and training of atmospheric and ocean scientists at universities.

Department of Defense (DOD): Although the mission of the Department of Defense (DOD) weather services is basically internal, the nature of DOD's operations is global. As such, the observation, telecommunication and data processing programs of the military weather services provide significant indirect support to the WWW through DOD's interface with NOAA's National Weather Service (NWS). Information from the research and development activities of these services is exchanged routinely with other similar national agencies and is often presented at national forums.

Department of Transportation (DOT): Through the U. S. Coast Guard, provides personnel to support NOAA's National Data Buoy Center (NDBC) in developing, operating, and evaluating data buoy systems. Coast Guard cutters and aircraft provide operational support to deploy, service, and retrieve buoys built for test or operational purposes. The observation and telecommunication programs of the Department of Transportation (DOT) also provide significant indirect support to the WWW through DOT's interaction with NOAA's National Weather Service.

National Aeronautics and Space Administration (NASA): Performs research and develops space technology required for an effective global weather system.

THE WORLD WEATHER WATCH

The World Weather Watch (WWW) is an integrated system which functions on three levels: global, regional, and national. The WWW is divided into three essential elements that are closely linked and interdependent: Global Observing System (GOS), Global Data Processing System (GDPS), and Global Telecommunication System (GTS).

These elements are coordinated and closely integrated through three WWW support functions. The Data Management function coordinates, monitors, and manages the flow of data and products within the WWW system to assure their quality and timely delivery. It also includes the definition and use of code forms for data exchange. The Systems Support Activity provides guidance, technical and scientific information, and training to those involved in the planning, development, and operation of WWW components. The Implementation Coordination function assures the timely completion of the WWW implementation and effective support and maintenance of the WWW system.

Global Observing System (GOS)

The GOS is a coordinated system of methods, techniques, and facilities for making weather observations on a worldwide scale. It is a composite system containing surface-based and space-based (satellite) subsystems. The main elements of the surface-based subsystem are:

- Regional basic synoptic networks, manned and automatic, for both surface and upper-air observations.
- Fixed sea stations, composed of ocean weather stations, fixed and anchored platform stations, island and coastal stations.
- Mobile sea stations, including moving ships and drifting buoys.
- Aircraft Meteorological Stations, including automated aircraft reporting systems.

Other elements are:

Aeronautical Meteorological Stations
Research and Special Purpose Vessels
Climatological Stations
Agricultural Meteorological Stations
Weather Radar Stations
Meteorological Reconnaissance Aircraft
Solar Radiation Stations
Atmospheric Detection Stations
Meteorological Rocket Stations
Ozone Stations
Background Pollution Stations
Tide Gage Stations
Wind Profilers

The space-based (satellite) subsystem provides vital support for meteorological and hydrological predictions and warnings. The use of satellites enables the routine collection of environmental observations from even the

most remote locales. Two categories of satellites are used: those in near-polar orbits and those in geostationary orbits.

Satellites in near-polar orbits provide global coverage twice a day (in daylight and darkness) by circling from pole to pole as Earth rotates beneath. They usually orbit at altitudes under 1000 km. They are equipped with instruments to collect precise radiance measurements for numerical analysis and prediction applications, as well as instruments/systems for other applications. Typical products derived from their primary instruments are: atmospheric temperature and water vapor soundings; sea surface temperatures; radiation fluxes; cloud cover information; and ice/snow extent. Additionally, they are used to monitor, among others, ozone, volcanic eruptions, global vegetation greenness, and the distribution of energetic particles in the upper atmosphere. Systems aboard these satellites may include those to collect and relay data from both fixed and drifting in-situ platforms and to provide the detection and tracking of signals from emergency transmitters used in Search and Rescue programs.

Presently, operational meteorological satellites in polar orbits are operated by the Commonwealth of Independent States (the Meteor-3 series) and the United States (the NOAA series). NOAA currently launches satellites, alternately, into afternoon and morning orbits on a planning schedule of 15 1/2 months between launches. China has been operating a polar orbiter, FY1B, since September 3, 1990. This experimental satellite has been working intermittently since August 1991. The current operational NOAA polar orbiting satellites are NOAA-11 (launched in an afternoon orbit in September 1988) and NOAA-12 (launched in a morning orbit in May 1991). NOAA-9 (launched in December 1984) and NOAA-10 (launched in September 1986), although not in full service, continue to provide ozone and radiation budget measurements. NOAA-J (which will become NOAA-14 when operational) is currently scheduled for launch in November 1994.

On May 10, 1994, President Clinton signed a directive to converge the Nation's civilian and military polar orbiting operational environmental satellites. A team of experts from NOAA, NASA, and the Department of Defense are in the process of evaluating a management strategy for the new integrated office. The first converged satellite is expected to be launched no earlier than 2004.

Operational geostationary meteorological satellites provide the repetitive, day and night observations of the Earth-disk in their fields of view that are needed to provide a "continuous weather watch." From their geostationary altitude (36,000 km) over the Equator, and with orbital speed matched to Earth's rotation rate, each remains fixed above its assigned equatorial subpoint on Earth. They monitor the Earth scene below in the visible and the infrared bands and, by providing observations of an area every few minutes, are well-suited to tracking the progress of mesoscale and/or short-lived environmental events. In addition to imagery, products derived from geostationary satellite data include surface temperature fields and atmospheric winds (from cloud displacements over time). Some geostationary weather satellites are equipped to provide atmospheric temperature and water vapor soundings, image atmospheric water vapor distributions and transport, and monitor solar particle flux, (including solar x-rays), at the spacecraft. Systems for collecting and relaying data from automatic sensor platforms are included in the payload, a Search and Rescue Satellite-Aided Tracking capability may be aboard, and communications functions are provided to support users. Data from these satellites are proving increasingly important in climatic monitoring and research.

Presently, operational geostationary weather satellites are operated by Japan, India, EUMETSAT (Europe), and the United States. Japan's Geostationary Meteorological Satellite (GMS) is positioned at 140°E; India's Indian National Satellite (INSAT) is at 74°E; and EUMETSAT's METEOSAT is at 0°. EUMETSAT is currently operating a second METEOSAT at 75°W providing supplementary Atlantic data coverage. The United States normally operates two Geostationary Operational Environmental Satellites (GOES); one at 75°W, the other at 135°W. An earlier launch failure resulted in GOES-7 (launched in February 1987) becoming the sole operational GOES when GOES-6 failed in 1989. GOES-7 is now positioned at 112°W. NOAA has launched the next satellite in this series (GOES-I which was renamed GOES-8 after it was in orbit). GOES-8 is scheduled to be operational in October 1994.

Faced with an aging, single GOES, the United States has developed two plans to ensure data continuity in both the short and long term. First, NOAA has developed and successfully tested a No-GOES

Contingency Plan. This plan, which is ready for implementation if and when needed, utilizes a combination of data from the U.S. Polar Orbiting Environmental Satellite (POES) system, the DOD DMSP, and the European METEOSAT series of satellites. These various data types are acquired by NOAA and disseminated to the normal recipients of GOES-7 data. Second, NOAA has entered into agreement with the European Space Agency (ESA) and EUMETSAT for the "loan" of the METEOSAT-3 spacecraft, which has been moved to a position at 75°W longitude. The Europeans will continue to operate this satellite through a "bent-pipe" communications link from Darmstadt, Germany to Wallops Island, Virginia, to the satellite. A long-term mutual back-up agreement was signed in August 1993.

The United States intends to operate the GOES-8 spacecraft at the 75°W position and GOES-7 at the 135°W position by early 1995. Further use of the METEOSAT spacecraft will depend on the operability of GOES-7 and GOES-8. The NOAA-EUMETSAT agreement provides for moving METEOSAT as far west as 115°W if either GOES-7 or GOES-8 fails to provide United States coverage until the launch of the next U.S. geostationary satellite, GOES-J, in 1995.

Both the NOAA and the GOES series of U.S. satellites broadcast their data directly to any properly equipped ground station within line of sight. Reception of these broadcasts is unrestricted and does not require any pre-notification. The United States, through NOAA, develops information and products from these data for further distribution over the Global Telecommunications System (GTS).

The WWW is a flexible system which can be adapted to changing technology and operational conditions. The latest technological and scientific developments in observations, data processing, and telecommunications are under constant review with an eye towards improving the GOS, GDPS and GTS.

Over the last few years, several systems intended to improve the operation of the GOS have continued to undergo development and deployment. Among these systems is the family of automated aircraft reporting systems known as the Automated Meteorological Data and Reporting (AMDAR) systems. This family of systems includes the Aircraft to Satellite Data Relay (ASDAR) System and the ARINC Communications Addressing and Reporting System (ACARS). ARINC is Aeronautical Radio Incorporated -- a wholly owned subsidiary of the airlines.

To date some twenty ASDAR systems have been purchased, with two being identified as spare units. Currently, thirteen operational ASDAR Systems have been installed aboard aircraft. Ten systems are installed aboard British Airways aircraft. Two of these systems are owned by Switzerland; another is owned by Australia. The Netherlands, Saudi Arabia, and Germany each have a unit installed. The US plans to operationally support two units which were originally fielded aboard B-747 and DC-10 aircraft that were operated by Continental Airlines; arrangements are currently being sought for carriage of these units on another international airline with operations in the Caribbean. Other systems awaiting installation are expected to be flown by Spain and a southern hemisphere carrier.

A cooperative effort among Aeronautical Radio Inc (ARINC), NWS and the FAA began operating to provide thousands of automated meteorological reports from ACARS equipped aircraft flying over the U.S. The ARINC Meteorological Data Collection and Reporting System collects, organizes and disseminates automated position/weather reports to the NWS. The standardized weather data is being sent to the NWS in the Binary Universal Format Representation (BUFR) code. Twelve thousand reports a day in varied formats and internal codes are received by ARINC and the quantity is expected to increase to 150,000 (mostly automated ACARS) reports by the late 1990's. Efforts are underway to assure operational availability.

Large quantities of weather reports, particularly over oceanic and other data sparse areas, will be realized via satellite communication and navigation systems. This source of data was the primary subject by the U.S. and other members of the International Civil Aviation Organization (ICAO) and the WMO's Automatic Air Reporting study group. The group developed amendments to the ICAO Technical Regulations and made substantial progress toward standardizing meteorlogical down-link codes (automatic binary, automatic character, manual routine, and special air-reports).

In addition to these aircraft-based systems, others are also being deployed to improve the GOS. The

Automated Shipboard Aerological Program (ASAP) has, for example, about 12 systems reporting regularly. During the same period there has also been deployment of substantial numbers of drifting buoys. A number of nations including the U.S. are implementing test networks or single sites of ground based Doppler radars called wind profilers to provide nearly continuous soundings of wind. During the past year there were approximately 88 systems in use world-wide. A demonstration network of 29 wind profilers is being operated principally in the central part of the U.S. to assess the utility of the data in operational and research meteorological analysis and prediction. A report on the multi-year meteorological and engineering assessment will be available in the fall of 1994. The data has been made available on the GTS to those countries requesting it.

The concept of the Operational World Weather Watch Systems Evaluation (OWSE) has also been developed as a framework for regional implementation. The OWSE-Africa, which was created to evaluate the very extensive use of a geostationary meteorological satellite (operated by the European operational satellite consortium, EUMETSAT) to improve telecommunications and data availability in Africa, has been completed. It was designed to implement and test the data collection system for receipt of meteorological observations from various countries in Africa. Thus far, approximately 100 data collection platforms have been installed in Kenya, Ethiopia, Ghana, Sudan, Nigeria, Sierra Leone, Zaire, Egypt, Madagascar, St. Helena, Guinea, and Cape Verde. Evaluations have been carried out to gage the improvement of observations, and preliminary results show that when systems are operating, high receipt rates are achieved. Results indicate that high receipt rates may be achieved for data originating in Africa, but infrastructure and maintenance issues remain for full operational deployment to be successful.

Efforts are underway to design and implement a Global Climate Observing System (GCOS) building upon the WWW, Global Atmospheric Watch (GAW), Integrated Global Ocean Services System (IGOSS), and other existing systems to further knowledge and understanding of climate and the prediction of climate and climate change. Initial efforts are focused upon establishing planning groups to address needs and requirements for data over the atmosphere, ocean, and land surfaces. Currently, upper air and surface observing networks are being defined to provide basic measurements for the GCOS. Links to existing organizational structures are being established and a high priority has been set on making observational enhancements.

Global Data Processing System (GDPS)

The purpose of the GDPS is to make available all processed information required for both real-time and non-real-time applications. The GDPS produces products and processed information, based on recent advances in atmospheric science, using powerful numerical computer methods. Members have real-time access through the GTS to GDPS products which allow all countries to benefit from their participation in the WWW.

The GDPS is organized as a three-level system. It consists of World Meteorological Centers (WMCs), Regional/Specialized Meteorological Centers (RSMCs) together with National Meteorological Centers (NMCs) which carry out GDPS functions at the national level. In general, real-time functions of the system involve preprocessing of data including real time quality control, analysis and prognosis, including derivation of appropriate meteorological parameters. The non-real-time functions include data collection and archival, additional quality control, storage and retrieval, as well as cataloging of observational data and processed information for operational and special applications, and for research.

WMCs are located in Melbourne, Moscow and Washington; they provide products used for general short, medium and long-range weather forecasts on a global scale. Melbourne specializes in forecast products for the Southern Hemisphere.

The RSMCs are located at Algiers, Algeria; Antananarivo, Malagasy; Beijing, People's Republic of China; Bracknell, England; Brasilia, Brazil; Buenos Aires, Argentina; Cairo, Egypt; Dakar, Senegal; Darwin, Australia; Jeddah, Saudi Arabia; Khabarovsk, CIS; Lagos, Nigeria; Melbourne, Australia; Miami, USA; Montreal, Canada; Moscow, CIS; Nairobi, Kenya; New Delhi, India; Novosibirsk, CIS; Offenbach, Germany; Rome, Italy; Tashkent, CIS; Tokyo, Japan; Tunis, Tunisia; Washington, USA, and Wellington, New Zealand. The European Center for Medium Range Forecasting is also an RSMC. These centers provide regional products used for short and

medium-range forecasting of small, meso-, and large-scale meteorological systems by WMCs. Products of RSMCs can be used by members at the national level for further processing or interpretation to provide assistance or service to users.

In the World Area Forecast System (WAFS), two centers (Washington and London) are designated by the ICAO as World Area Forecast Centers (WAFCs). They issue upper wind and temperature forecasts with global coverage to associated Regional Area Forecast Centers (RAFCs). The regional centers also prepare and distribute forecasts of weather elements defined by ICAO as significant weather.

In the planned implementation of the final phase, the two world centers would prepare and issue computer-based wind and temperature forecasts as they now do. In addition, those centers will automate all of the significant weather elements. While some of these elements are now prepared automatically, others may begin to be realized in the near future through forecaster initiated graphic interaction.

The dissemination of aeronautical information via global satellite broadcast will begin in early 1995. The U.S. will provide the links to two of the three satellites specified in the system.

Global Telecommunication System (GTS)

The GTS provides communication services for the collection, exchange and distribution of observational data and processed information among the WMCs, RSMCs and NMCs of the WWW, to meet the needs of Members for operational and research purposes which involve real-time or quasi-real-time exchange of information. The GTS also supports other WMO programs, joint programs with other international organizations, and environmental programs as decided by the WMO Congress.

The GTS is organized on three levels:

- The Main Telecommunication Network (MTN);
- The Regional Meteorological Telecommunication Networks (RMTN);
- The National Meteorological Telecommunication Networks (NMTN).

The GTS is supported by telecommunication functions of the WMCs, Regional Telecommunications Hubs (RTHs), RSMCs, and NMCs.

The MTN links the WMCs at Melbourne, Moscow, and Washington with the RTHs at Algiers, Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Maracay, Nairobi, New Delhi, Norrkoping, Offenbach, Prague, Rome, Sofia, Tokyo, Toulouse and Wellington. It ensures the rapid and reliable exchange of observational data and processed information required by the Members.

The RMTNs consist of an integrated system of links which interconnects RTHs, NMCs, and RSMCs to WMCs. The RMTNs provide for the collection of observational data and the selective distribution of meteorological information to Members.

In summary, the GTS enables the NMCs to receive and distribute observational data and meteorological information to meet the requirements of Members. Planned WWW activities for FY 1994-1995 include:

- GTS network redesign to take into consideration new technical opportunities such as Internet-like services;
- Improvement of the capacity of MTN links and inclusion of graphics (e.g., Washington-Brasilia, Washington-Buenos Aires);
- Implementation of upgraded regional networks;
- Continued implementation of satellite serviced data collection platforms to enhance the collection of meteorological data from upper air and surface observing sites;
- Continued implementation of satellite direct readout stations that are compatible with polar orbiting satellites and the WEFAX (weather facsimile) component of the geostationary satellites.

Voluntary Co-operation Program (VCP)

From the beginning of WWW, it was clear that all countries need better weather observations and improved communication systems. To help remedy deficiencies and to fully implement the WWW, the WMO established a Voluntary Assistance Program

(VAP) in 1967. The name of the program was changed to Voluntary Co-operation Program (VCP) in 1979.

The WMO-VCP helps the developing countries to implement the WWW program by providing equipment, services, and long and short-term study fellowships. Since the inception of the VCP, the U.S. has provided short-term fellowships in electronics, communications, operation and maintenance of weather data collection systems, electrolytic hydrogen generators, tropical meteorology, and river flood forecasting to students from more than 50 countries. Long-term fellowships, through which the students receive baccalaureate or advanced degrees, have been completed by candidates from over 48 countries. Highest priorities are given to those facilities needed to support the global aspects of WWW. The goal of VCP is to eliminate deficiencies in global observations and communications and to establish ground-readout stations for Automatic Picture Transmission (APT) reception so that the countries may benefit more fully from weather satellite services.

The U.S. has contributed annually from $1.5 million to $2.3 million to VCP since 1969. Other nations contribute a total of approximately $2.0 million annually and this continues to increase. Contributions are in three categories; equipment and services (80 percent), financial contributions (about 10 percent), education and training (about 10 percent).

The Department of State (DOS) provides funding for VCP projects with NOAA administering and carrying out programs designed to aid meteorological/hydrological and climate projects in recipient countries. In FY 1993, DOS funding for WWW/VCP programs was $2.25 million. In FY 1994, $2.25 million was approved, and in FY 1995, $2.25 million has been requested.

The Climate Computing (CLICOM) project of the WMO's World Climate Program has become a major and very successful WMO project in which the U.S. has played a leading role. Each CLICOM unit consists of a small network of 1 to 6 personal computers, peripherals and resident data management software which together provides developing countries with the capability to digitize and better use their climatological data. The resulting climate information can be used for better management of each country's agricultural, hydrologic and other natural resources. It is also important in determining the potential impact of the changing global climate. The U.S. VCP has provided major funding for the original development of the data management software and also funded hardware and training for installation of CLICOM in countries in Africa, Central and South America. The system has been installed in 100 countries with funding coming from France, Finland, the United Kingdom, the United States and the United Nations Development Program. Fifteen instructors have been trained and nearly 150 systems are in use.

Planned VCP activities for FY 1995 include:

- Continued support for data collection and telecommunications capabilities in Africa;
- Implementation and updating of surface and upper-air observational programs in the tropics, the Southern Hemisphere, and Africa as resources and priorities permit;
- Support for first year operating costs and equipment for WAFS/RA-IV WWW satellite communications;
- Provision of user terminals for WAFS/RA-IV WWW communications to several Caribbean nations;
- Continued support for the implementation of VCP projects in Latin America and the Caribbean areas in support of the hurricane and tropical storm programs;
- Maintenance of the CLICOM software for the WMO.

BILATERAL AND REGIONAL INTERNATIONAL COOPERATIVE PROGRAMS

United States - Peoples Republic of China (PRC) Protocol in Atmospheric Sciences

This US - PRC Protocol has provided a broad diversity of both research and operational activities over more than a decade. Program areas include monsoon studies, techniques for forecasting torrential rains, climate studies, mesoscale meteorology, Tropical Ocean Global Atmosphere (TOGA) research, satellite

meteorology, and the training and participation program. More details are given below.

Scientific Experiments and Research on Monsoons -- one expert spent a year at Florida State University studying radiation and precipitation measurements.

Climate Studies -- one expert spent a year at UCLA on a coupled climate system while two others spent three months working at the University of Arizona on tree ring analyses. Another expert spent a year at the State University of New York at Albany on high resolution global models while three additional experts visited the NWS Climate Analysis Center on developing management plans for establishing their own climate center.

Mesoscale Meteorology -- a dozen experts attended the fourth workshop on mesoscale meteorology.

Satellite Meteorology and Meteorological Satellites -- a Chinese expert has spent a year at the National Climate Data Center incorporating PRC data sets into existing NCDC Comprehensive Aerological Reference Data Set. An expert has spent a year with NESDIS on improvements to vegetation indices.

Atmospheric Chemistry -- an expert worked on analyses of Waliguanshan Baseline Observatory samples while a second spent a year at the University of Iowa examining the Asian dust role in the photochemical oxidant cycle.

TOGA -- one expert spent six months on an analysis TOGA COARE data while another spent a year at Columbia on coupled ocean-atmosphere modeling and ENSO prediction.

Training and Participation -- five trainees spent one year at the Forecast System Laboratory working on interactive systems; three at the Techniques Development Laboratory on MOS forecasts and computer-worded forecasts while three trainees worked in various areas at NESDIS.

APPENDIX F

SELECTED ACRONYMS AND ABBREVIATIONS

ADAS	AWOS/ASOS Data Acquisition System (FAA)
ADLP	Aeronautical Data Link Program (FAA)
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services (NOAA/NWS)
AFRES	Air Force Reserve
AFS	Air Force Station
AFSFC	Air Force Space Forecast Center
AFSS	Automated Flight Service Station (FAA)
AI	Artificial Intelligence
AIP	Airport Improvement Program (FAA)
ALBE	AirLand Battlefield Environment (Army)
AOC	Aircraft Operations Center (NOAA)
AMC	Army Materiel Command
AMR	Aircraft Microwave Refractometer
ANG	Air National Guard (Army)
ARGOS	French Satellite Data Collection System
ARL	Army Research Laboratory
ARSR	Air Route Surveillance Radar (FAA)
ARTCC	Air Route Traffic Control Center (FAA)
ASL	Atmospheric Sciences Laboratory (Army)
ASOS	Automated Surface Observing System (NOAA)
ASR	Airport Surveillance Radar (FAA)
ATC	Air Traffic Control (FAA)
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
AWDS	Automated Weather Distribution System (USAF)
AWIPS	Advanced Weather Interactive Processing Systems (NOAA)
AWIS	Automated Weather Information Systems
AWOS	Automated Weather Observing System (FAA)
AWN	Automated Weather Network
AWS	Air Weather Service (USAF)
BED	Battlefield Environment Directorate
CAC	Climate Analysis Center (NOAA/NWS)
CAS	Committee for Aviation Services (OFCM)
CAT	Clear Air Turbulence
CAWIS	Committee for Automated Weather Information Systems (OFCM)
CBL	Computer-Based Learning
CBS	Committee for Basic Services (OFCM)
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CECOM	Communications and Electronics Command (Army)
COE	Corps of Engineers
COES	Committee for Operational Environmental Satellites (OFCM)
COMET	Cooperative Program for Operational Meteorology, Education and Training
CONUS	Continental United States

CSEF	Committee for Space Environment Forecasting (OFCM)
CWP	Central Weather Processor (FAA)
CWSU	Center Weather Service Unit (FAA)
DACS	Data Acquisition and Control Subsystem (NOAA/NESDIS)
DCPLS	Data Collection and Platform Location System (NOAA/NESDIS)
DCS	Data Collection System (NOAA/NESDIS)
DDN	Defense Data Network (DOD)
DIFAS	Digital Ice Forecasting and Analysis System (USN)
DLP	Data Link Processor (FAA)
DMSP	Defense Meteorological Satellite Program (DOD)
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOS	Department of State
DOT	Department of Transportation
DPSS	Data Processing and Services Subsystem (NOAA/NESDIS)
DUAT	Direct User Access Terminal (FAA)
EO	Electro-Optical
EOSAEL	Electro-Optical Systems Atmospheric Effects Library
EPA	Environmental Protection Agency
ERBE	Earth Radiation Budget Experiment (NOAA/NESDIS)
ERL	Environmental Research Laboratories (NOAA)
FAA	Federal Aviation Administration
FCMSSR	Federal Committee for Meteorological Services and Supporting Research
FEMA	Federal Emergency Management Agency
FORSCOM	U.S. Army Forces Command
FNMOC	Fleet Numerical Meteorology and Oceanography Center (USN)
FSAS	Flight Service Automation System (FAA)
FY	Fiscal Year
GARP	Global Atmospheric Research Program
GDPS	Global Data Processing System (WWP)
GOES	Geostationary Operational Environmental Satellite (NOAA)
GOS	Global Observing System (WWP)
GPS	Global Positioning System (Army)
GSFC	Goddard Space Flight Center (NASA)
GTS	Global Telecommunications System (WWP)
GWDS	Graphics Weather Displays Systems (FAA)
HIRS/2	Modified High-resolution Infrared Sounder (NOAA)
HRPT	High Resolution Picture Transmission (NOAA)
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
ICSU	International Council of Scientific Unions
IEW	Intelligence and Electronic Warfare
IMETS	Integrated Meteorological System (Army)
IR	Infrared
ITOS	Improved TIROS Operational Satellite (NOAA)
IWRS	Improved Weather Reconnaissance Systems

JAWOP	Joint Automated Weather Observation Program
JTWC	Joint Typhoon Warning Center (USAF/USN)
LLWAS	Low Level Wind Shear Alert System (FAA)
M	Million
McIDAS	Man-computer Interactive Data Access System
MET	Mobile Environmental Teams (USN)
METOC	Meteorological/Oceanographic (USN/USAF)
MMS	Meteorological Measuring System (Army)
MOA	Memorandum of Agreement
MSU	Microwave Sounding Unit
MWP	Meteorological Weather Processor (FAA)
NADIN	National Airspace Data Interchange Network (FAA)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NBC	Nuclear, Biological, and Chemical (Army)
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center (NOAA)
NDBC	National Data Buoy Center (NOAA)
NEDN	Naval Environmental Data Network (USN)
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NEXRAD	Next Generation Weather Radar Program (WSR-88D)
NGDC	National Geophysical Data Center (NOAA)
NHC	National Hurricane Center (NOAA)
NMC	National Meteorological Center (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NOC	Naval Oceanography Command (USN)
NODC	National Oceanographic Data Center (NOAA)
NODDES	Naval Oceanographic Data Distribution and Expansion System (USN)
NOGAPS	Navy Operational Global Atmospheric Prediction System
NOMSS	Naval Oceanographic and Meteorological Support System (USN)
NORAPS	Navy Operational Regional Atmospheric Prediction System
NOTAM	Notice to Airmen
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center (NOAA)
NSSL	National Severe Storms Laboratory (NOAA)
NTSB	National Transportation Safety Board
NWR	NOAA Weather Radio
NWS	National Weather Service
OFCM	Office of the Federal Coordinator for Meteorology
OMB	Office of Management and Budget
OPARS	Optimum Path Aircraft Routing System (USN)
PATWAS	Pilot Automatic Telephone Weather Service (FAA)
PIBAL	Pilot Balloon
PL/GP	Phillips Laboratory, Geophysics Directorate (DOD/AFSC)
POPS	Primary Oceanographic Prediction System (USN)
PROFS	Program for Regional Observing and Forecasting Service (NOAA/ERL)
PUP	Principal User Processor (NEXRAD)

R&D	Research and Development
RDEC	Research, Development, and Engineering Center (Army)
RDTE	Research and Development, Test and Evaluation (Army)
RFC	River Forecast Center (NOAA/NWS)
RVR	Runway Visual Range (FAA)
RWP	Real-time Weather Processor (FAA)
SATCOM	Satellite Communications System (NOAA)
SBUV	Solar Backscatter Ultraviolet Instrument (NOAA)
SDHS	Satellite Data Handling System (DOD/USAF)
SEM	Space Environment Monitor (NOAA)
SFDF	Satellite Field Distribution Facility (NOAA/NWS)
SMOOS	Shipboard Meteorological and Oceanographic Observing Sensor (USN)
SOCC	Satellite Operations Control Center (NOAA/NESDIS)
SSU	Stratospheric Sounding Unit (NOAA)
STIWG	Satellite Telemetry Interagency Working Group (OFCM)
SWIS	Satellite Weather Information System (NOAA/NWS)
TDWR	Terminal Doppler Weather Radar
TDA	Tactical Decision Aid (Army)
TESS	Tactical Environmental Support System (USN)
TIROS	Television Infrared Observation Satellite (NOAA)
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS N Operational Vertical Sounder (NOAA)
TRADOC	Training and Doctrine Command (Army)
UAV	Unmanned Aerial Vehicles (Army)
UN	United Nations
USAF	U.S. Air Force
USAFETAC	USAF Environmental Technical Applications Center
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USN	U.S. Navy
UTC	Universal Coordinated Time (US usage)
VAS	VISSR Atmospheric Sounder
VHF	Very High Frequency
VHRR	Very High Resolution Radiometer
VISSR	Visible and Infrared Spin Scan Radiometer
VRS	Voice Response System
WEFAX	Weather Facsimile
WETM	Weather Team (Army)
WMC	World Meteorological Center(s)
WMO	World Meteorological Organization
WMSCR	Weather Message Switching Center Replacement (FAA)
WRP	Weather Research Program (NOAA)
WSCMO	Weather Service Contract Meteorological Office (NOAA/NWS)
WSFO	Weather Service Forecast Office (NOAA/NWS)
WSMO	Weather Service Meteorological Office (NOAA/NWS)
WSO	Weather Service Office (NOAA/NWS)
WSR-88D	Weather Surveillance Radar (NEXRAD)
WWP	World Weather Program
WWW	World Weather Watch

FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (FCMSSR)

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (ICMSSR)

- Working Group for Climate Services
- Working Group for Post-Storm Data Acquisition
- Working Group for Meteorological Information Management

STANDING COMMITTEES

AUTOMATED WEATHER INFORMATION SYSTEMS
- Working Group for Communications Interfaces and Data Exchange
- Working Group for AWIS Meteorological Applications
- Working Group for NOAAPORT Liaison

OPERATIONAL PROCESSING CENTERS
- Working Group for Cooperative Support and Backup

OPERATIONAL ENVIRONMENTAL SATELLITES

AVIATION SERVICES
- ▸ Volcanic Ash

SPACE ENVIRONMENT FORECASTING

PROGRAM COUNCILS

- AUTOMATED WEATHER INFORMATION SYSTEMS
- JOINT AUTOMATED WEATHER OBSERVATIONS
- NATIONAL AIRCRAFT ICING
- NATIONAL AVIATION WEATHER
  - Joint Action Group
- NEXT GENERATION WEATHER RADAR
- IMPROVED WEATHER RECONNAISSANCE

COMMITTEE FOR BASIC SERVICES
- ▸ Mobile Meteorological Equipment

Working Groups

- Atmospheric Transport and Diffusion
- Doppler Radar Meteorological Observations
- Hurricane and Winter Storms Operations
  - ▸ Tropical Cyclone Research
- Hydrometeorology
- Lightning Detection Systems
- Marine Environmental Services
- Meteorological Codes
- Monitoring the Stratosphere
- Profiler Systems
- Radar Meteorological Observations
- Satellite Telemetry
- Severe Local Storms Operations
- Surface Observations
  - ▸ Federal Meteorological Handbook No. 1
  - ▸ Surface Instrumentation Standards
- Upper Air Observations
  - ▸ Federal Meteorological Handbook No. 3
- World Weather Program

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LEGEND:
- • Designates a Working Group
- ▸ Designates an Ad Hoc Group or a Task Group