The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1993

OFCM
OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY

FCM P1-1992

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

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FISCAL YEAR 1993

FEDERAL COORDINATOR
FOR
METEOROLOGY

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Rockville, Maryland 20852

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PREFACE

This Federal Plan, the 28th 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 1992 and FY 1993.

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 1993 as compared to planned resources for FY 1992. The emphasis is on changes in resources and the related changes in programs. Fiscal data are current as of the end of February 1992. Section 4 provides a review article on "Mesoscale Meteorology". 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 by the Subcommittee on Atmospheric Research (SAR) of the Committee on Earth and Environmental Sciences under the Federal Coordinating Council for Science, Engineering and Technology. This division of responsibilities explains the absence in this report of any substantial references to large basic research programs, such as global climate change.

A SAR report for FY 1987-1990 will be published in 1992. 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. This Circular was rescinded in November 1991; a replacement mechanism is under consideration by the Office of Management and Budget.

James A. Almazan
Acting Federal Coordinator for Meteorological
Services and Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH, FISCAL YEAR 1993

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EXECUTIVE SUMMARY

The President's Budget for FY 1993 requests $2.34 billion for meteorological services and supporting research. This is 4.0 percent more than the $2.25 billion appropriated for FY 1992. As in previous years, about 91 percent of the total is requested for three Departments: Commerce, Defense, and Transportation. 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 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 1993. These programs include:

- The Next Generation Weather Radar Program (NEXRAD), 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. The first ten limited production systems are installed and are being thoroughly tested. Preliminary operational testing shows markedly higher quality and quantities of storm and wind data that potentially will allow more timely and accurate warnings of severe weather.

- The automated surface weather observation program, under the policy guidance of an interagency 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 five years. More than 50 units are installed and under review for acceptance.

- The automated weather information systems programs, under development or being installed by several agencies as indicated in the budgets. 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 installed and accepted more than 60 of their new systems which markedly modernize their base weather station operations; a total of 162 systems will be installed. 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 1993 budget request.

Other Agency Programs

The Department of Agriculture will continue its weather related activities in FY 1993 at essentially the same level of funding ($25.18 million) as in FY 1992. 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 requests $8.1 million, an increase of 13 percent, primarily in response to the 1990 Clean-Air Act amendments.

The National Aeronautics and Space Administration budget request of $166.72 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 $145,000 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

A National Aviation Weather Program Council, established in late 1989, provides policy guidance for the preparation of a National Aviation Weather Program Plan. The draft plan incorporates the cooperative efforts of six agencies and is scheduled to be completed in September 1992.

The acquisition and use of lightning data by the Federal agencies has been an area of considerable interest and concern in recent years. An experimental nationwide network proved the value of these data for operations in many agencies. A Request for Proposals for lightning data was issued by the National Weather Service and is under negotiation at this time.

The OFCM coordinates agency standards for weather data collection and reporting. The Federal Meteorological Handbooks (FMHs) are prepared and updated under the guidance of the various OFCM committees and working groups. There are currently ten handbooks in use by Federal agencies and the meteorological community in the U.S. Revisions have been completed and published for the Surface Synoptic Codes (FMH-2) and Meteorological Rocket Observations (FMH-10). The Doppler Radar Handbook (FMH-11) consisting of four parts (Parts A, B, C, and D) have been completed and published. Federal agencies are also reviewing drafts of Surface Observations (FMH-1), and Upper Air Observations (FMH-3).

Resources

The FY 1993 resources requested for Federal meteorological operations and supporting research are $2.343 billion, representing a 4.0 percent increase from the $2.253 billion in FY 1992. Of the total, about $1.993 billion will be for operations and $350 million for supporting research. The FY 1993 budget, by agency, is shown in Table 1.1.

Figure 1.1 shows the proportion of the total request for each agency. Each agency's proportion of the proposed 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. The proportions of each agency's proposed spending for supporting research is shown in Figure 1.3.

The total Federal budgets for the 14 year period 1980-1993 are shown in Figure 1.4; the budgets are presented in terms of actual and constant dollars (i.e., adjusted for the Consumer Price Index).

The agencies expect that 17,904 personnel (full-time-equivalent) will be employed in Federal meteorological operations in FY 1993; 17,892 personnel are currently employed in FY 1992.

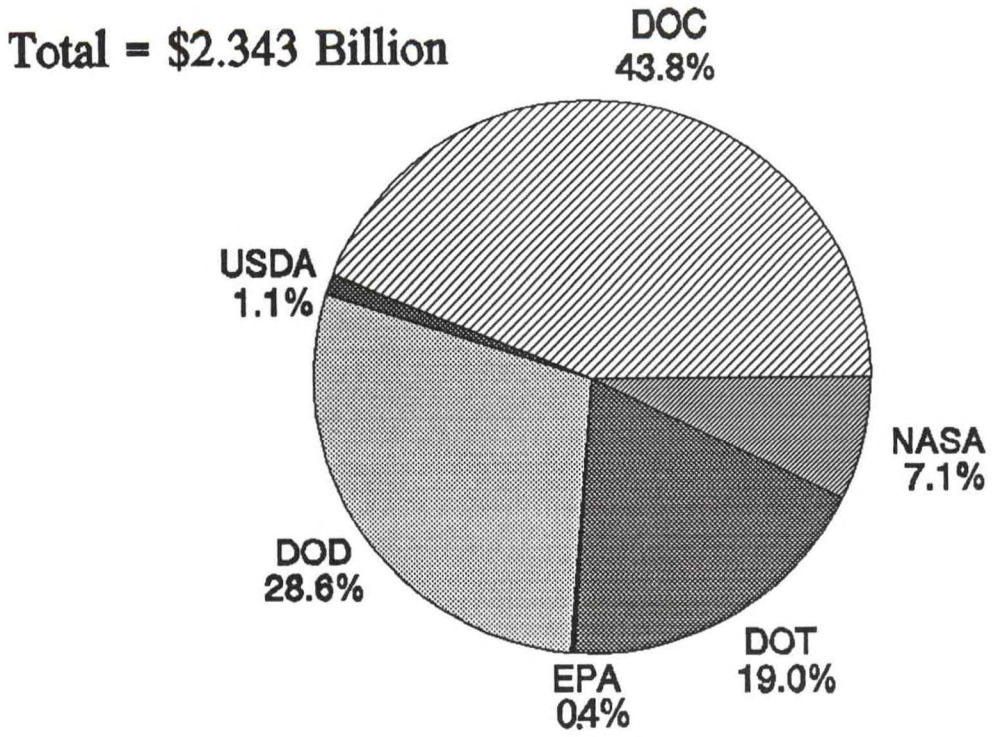

Figure 1.1 Agency Percent of Total Federal Budget for Meteorological Operations and Supporting Research, FY 1993

Table 1.1. Federal Budget for Meteorological Operations and Supporting Research, Fiscal Year 1993 (in thousands of dollars)

Agency	Operations	% of TOTAL	Supporting Research	% of TOTAL	TOTAL	% of TOTAL
Agriculture	$10,741	0.5	$14,443	4.1	$25,184	1.1
Commerce	977,554	49.1	49,476	14.1	1,027,030	43.8
Defense	587,141	29.5	83,375	23.8	670,516	28.6
Interior	870	0.0	0	0.0	870	0.0
Transportation	409,037	20.5	35,565	10.2	444,602	19.0
Envir. Prot. Agency	0	0.0	8,100	2.3	8,100	0.4
NASA	7,619	0.4	159,100	45.5	166,719	7.1
Nuclear Reg. Comm.	145	0.0	0	0.0	145	0.0
TOTAL	1,993,107	100.0	350,059	100.0	2,343,166	100.0

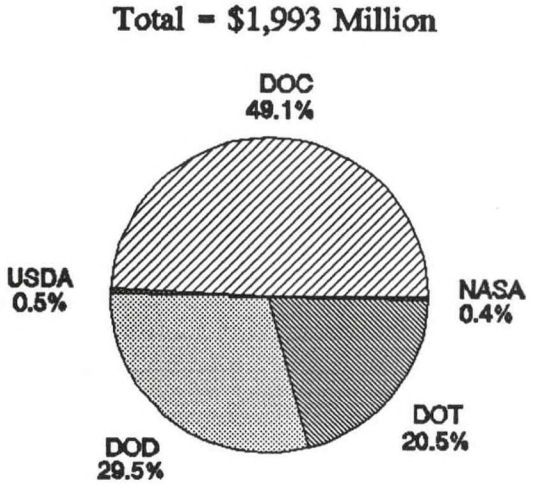

Figure 1.2 Agency Percent of Federal Budget for Meteorological Operations, FY 1993

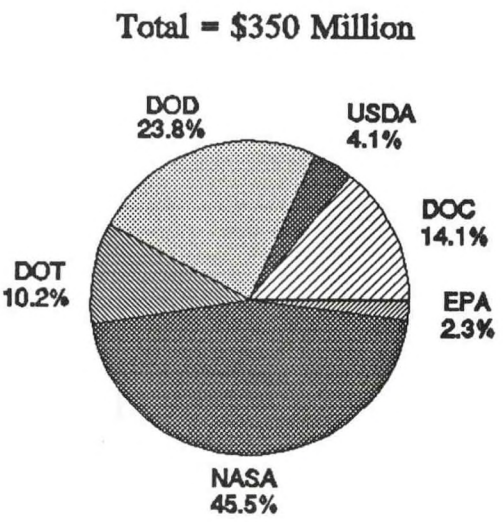

Figure 1.3 Agency Percent of Federal Budget for Supporting Research, FY 1993

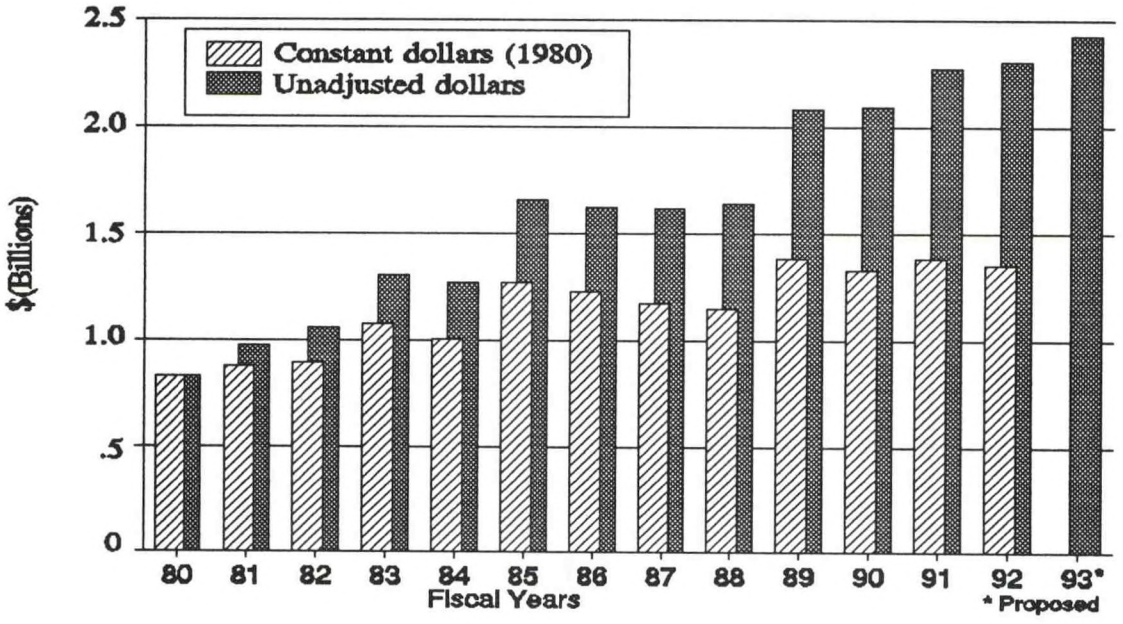

Figure 1.4 Total Federal Budgets for Meteorological Operations and Supporting Research, FY 1980-1993

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. In the past year, OMB has rescinded Circular A-62 and is now reviewing an alternate mechanism that would replace and update Circular A-62.

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:

- 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;
- 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 the satisfaction of requirements;

- 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;
- 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.

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 have been 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. Each of the Councils is comprised of decision-level representatives of the agencies directly concerned with the specific program area.

Next Generation Weather Radar (NEXRAD)

Delivery of the Weather Surveillance Radar (WSR-88D) is proceeding.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 Federal Plan for FY 1991 included a full description of the NEXRAD program.)

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 economic consequences to the United States. The Department of Defense uses NEXRAD data to support military operations and protect defense assets on a worldwide basis. 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 follows 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 (now Paramax) was awarded a Limited Production contract for 10 NEXRAD units in December of 1987. From March to August of 1989 the WSR-88D prototype unit was given a rigorous independent examination during Initial Operational Test and Evaluation Part 2 (IOT&E(2)). The WSR-88D proved that it could significantly improve the timeliness and accuracy of forecasts of severe weather occurrences. Paramax was awarded the Full Scale Production option in January 1990 for 165 additional Doppler radars.

The eight WSR-88Ds near Oklahoma City, Oklahoma; Sterling, Virginia; Melbourne, Florida; Northwest Florida (Eglin AFB); Frederick, Oklahoma (Altus AFB); St. Louis, Missouri; Dodge City, Kansas; and Houston/Galveston, Texas are available for Government experimental use. Current broadscale activities in support of deployment include depot repair facility preparations, integration

of equipment components for shipping, implementation of system support capability, and establishing the spare parts inventory.

The Operational Support Facility (OSF), established in 1988, has begun its role of providing 24-hour-a-day operational support to WSR-88D field units. The OSF is managing the WSR-88D operator training program in Norman, Oklahoma, and is completing preparations for management and coordination of the life-cycle system support program for the NEXRAD system.

The NEXRAD Level III data, which are advanced weather radar products, will be archived by DOC/NOAA at the National Climatic Data Center (NCDC) beginning in 1992. Plans are now being formulated to address archiving the higher resolution data (Level II) from which the products are generated.

Automated Surface Weather Observations

Historically, each agency has independently developed an operational weather system capability in pursuit of its mission; supporting research was frequently carried out jointly. In 1983, in order to coordinate these efforts and in response to an OFCM recommendation, the Joint Automated Weather Observing 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, NWS and FAA sought convergence of their automated surface weather observation programs by closely examining system commonality and revalidating system requirements. This resulted in an agreement in 1986 by the JAWOP Council to use the NWS's 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 airports. Towered airports are the large airports that have a control tower and FAA personnel to control aircraft traffic. Non-towered airports are those smaller airports with no control tower or regular observers for weather conditions. The NWS and FAA application of ASOS will make this system the primary Federal surface observing system. Immediate needs of the FAA for limited weather observations at small non-towered airports will be 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, has been completed.

The ASOS development concluded with preproduction systems qualified through field tests conducted at the Tulsa International Airport (involving the Weather Service Office and the Air Traffic Control Tower), and the NWS Sterling Research and Development Center. The results of these field tests, as well as the overall ASOS test program, were reviewed by an independent interagency Test Review Board. The Board found sound system performance and recommended proceeding to the production phase. In February 1991, the ASOS production and implementation contract was awarded to AAI Corporation and production was initiated with initial systems fielded in the central United States beginning during the summer of 1991. The Testing Review Board (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 the first NWS-sponsored ASOS is expected to take place in late summer of 1992. Once commissioned, ASOS will provide the official weather observation for that airport.

An earlier NWS demonstration contributed to significant improvements in laser ceilometer technology, a critical component of automated observing efforts. These technical improvements were factored into the NWS's next generation laser ceilometer procurement. Production delivery has been completed at primary NWS observing locations. The new ceilometer will be used as part of the ASOS sensor suite at most locations. Both the Air Force and FAA have decided to use the NWS-developed Next Generation Ceilometer for replacement purposes. The Air Force has acquired 287 ceilometers and the FAA has acquired 115 ceilometers through the NWS. The Air Force is also considering use of the NWS-developed ASOS for certain Air Force applications.

The Navy is planning to replace obsolete equipment with the 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).

The Air Force activity in automated sensor development is principally focused on the war fighting environment. The Air Force Tactical Weather Observing System (TWOS) will include surface, airborne, and satellite-based observations. Air Force sensor development is the responsibility of the Phillips Laboratory, Geophysics Directorate. The laboratory will develop tactical sensors while continuing to monitor ASOS. A fixed-base automated observing system based on the tactical sensors and ASOS will be developed in the late 1990s.

The U.S. Army's Atmospheric Sciences Laboratory (ASL) 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 1993 include:

- Continue with ASOS full scale production, fielding as many as 15 or more systems per month.
- Commissioning of additional ASOS units will take place.
- NWS, FAA, and DOD (under the auspices of the JAWOP) will continue with selected future enhancement sensor development and testing.
- OFCM will revise the "Federal Meteorological Handbook No. 1-Surface Observations" to reflect automated observing procedures.
- USAF and FAA will continue selective replacement of aging sensors by means of an add-on to the NWS procurement.
- U.S. Navy will plan for the replacement of the AN/GMQ-29 semi-automated observing systems ashore with ASOS during the FY 1992-1995 timeframe.

- U.S. Navy's technical evaluation of the Shipboard Meteorological and Oceanographic Observing System (SMOOS) is expected to be completed in FY 1992. SMOOS production is expected to begin during FY 1993.

Automated Weather Information Systems (AWIS)

Automated Weather Information Systems (AWIS) are required by a number of Federal agencies. The AWIS are being procured to reduce labor intensive functions; to reduce the time required to process and interpret weather data; to reduce the time to produce forecasts, warnings and special tailored products; and to distribute these products to users expeditiously. Major agency systems classified as AWISs are the Department of Commerce'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 Environmental Data Network (NEDN), which will transition to the Naval Oceanographic Data Distribution and Expansion System (NODDES) during FY 1993. 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 more than 60 of the AWDS installed in military weather stations located in the continental U.S.

The AWIS Program Council, which consists of high-level representatives from the Departments of Commerce, Defense and Transportation, was established during February 1986 as part of the Federal coordination mechanism for meteorology. This was in response to a 1985 recommendation by the Inspectors General of these agencies. The Council decided to identify major items that needed coordination in both the short and long term; to determine if there was redundancy among the systems and, if so, whether it should be eliminated; to determine what commonalities existed among the systems; and to produce a Federal Plan for the Coordination of AWIS Programs.

In order to further its agenda, the AWIS Program Council uses the Committee for Automated Weather Information Systems (CAWIS) and its Working Group for Communications Interfaces and Data Exchange (WG/CIDE), Working Group for AWIS Meteorological Applications (WG/AMA), and Working Group for 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. Its most recent Standard Formats for Weather Data Exchange Among Automated Weather Information Systems was published in May 1990. Its 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 Working Group'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. In addition, 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 distributing

meteorological data and products to AWIPS and other environmental data systems beginning in the NWS modernization era.

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 is responsible for developing and maintaining a technology plan and for providing policy guidance for its execution. 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. This plan presents a comprehensive list of aircraft icing research needs and objectives, describes the efforts now underway, and proposes the areas of need. It recognizes that the scope, definitions, and priorities may change as the National Aircraft Icing Technology Plan is implemented and as the need arises to reflect accomplishments and changes in agency missions and goals.

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

In 1989, the FAA established a 6-year funding schedule, beginning in FY 1990, to achieve the goals set forth in the icing forecasting plan. In FY 1990, funding was provided by the FAA to the National Center for Atmospheric Research (NCAR) to develop and conduct an extensive icing research program. The objectives of this program are to develop and evaluate an icing severity index, and an operational icing forecast for aviation. A third objective is to evaluate sensors appropriate for the detection of icing conditions. NCAR will conduct field data collection exercises during four successive winters: two in the Denver area and two in the central U.S. This effort commenced in January 1990 with a combined ground-based and airborne data collection in the Colorado area. The program is being monitored by the Aircraft Icing Program Council.

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 on the ground.

National Aviation Weather Program Council

This program council was formed in late 1989 and a supporting Joint Action Group 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 principal activity of this program council is, through a joint action group, preparation of a National Aviation Weather Program Plan. This plan will establish user needs and agency responses in the area of aviation weather services for the next decade and beyond. It is expected that the plan will be completed in 1992.

PLANNING, COMMITTEE ACTIVITIES, AND PUBLICATIONS

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

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 ten 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, and Meteorological Rocket Observations. Another, Doppler Radar Meteorological Observations, is under development. 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 have been completed for the Surface Synoptic Codes (FMH-2) and Meteorological Rocket Observations (FMH-10) handbooks. Additionally, the four-part Doppler Radar

Meteorological Observations Handbook (FMH-11) has been 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 of Doppler Radar Meteorological Observations, and Part D - WSR-88D Unit Description and Operational Analysis. Federal agencies are also reviewing and preparing comments to preliminary drafts of Surface Observations (FMH-1) and 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.

Working Group for 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 issue addressed by the WG/MC during its 1991 meetings was the implementation of modifications to existing meteorological codes as proposed by the WMO. Specifically, the Working Group was primarily concerned with the changes proposed to the aviation codes (METAR, SPECI, and TAF). At present, plans call for the NWS to develop software to convert surface aviation observations to METAR observations for approximately 250 airports. These airports primarily serve as ports-of-entry for foreign and domestic air carriers. The projected implementation date is July 1993.

National Program for Lightning Detection Systems

In 1983, the Office of the Inspector General, Department of Commerce, issued a management audit report that indicated the significance of the threat of lightning to life and property, and the need to improve severe weather forecasting. It stated that a number of agencies were active in programs directed toward lightning detection and encouraged the Department of Commerce (NOAA) to determine the action necessary to improve the Nation's lightning detection program.

The Department of Commerce member of the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) requested that the Office of the Federal Coordinator for Meteorology (OFCM) undertake a study to document the Federal agencies' interest in lightning detection and existing and planned programs of the agencies. The study, completed in early 1985, revealed that extensive systems exist for the detection and tracking of cloud-to-ground lightning. These systems are organized in networks operated by various Federal agencies, universities and private industry.

In December 1984, ICMSSR agreed to the need for a National Plan for Lightning Detection Systems. The National Plan should make maximum interagency use of existing systems and coordinate the ongoing lightning programs of the Federal agencies. Preceding the plan, however, a study of the status of the various agency, university and industry lightning programs was conducted. The study revealed agencies were operating with different levels of experience in lightning detection and at different stages in formulating operational requirements. A report entitled "The Status of National Programs for Lightning Detection Systems", published in 1986, identified issues and problems that needed to be resolved in developing a national plan for lightning detection systems.

A field testing program evaluating available lightning detection systems was conducted by the National Severe Storms Laboratory (NSSL). A report by NSSL entitled "An Evaluation of Two Lightning Ground Strike Locating Systems" was published in 1988.

The Working Group for Lightning Detection Systems (WG/LDS) determined that development in several areas had not progressed sufficiently to prepare a final national plan. To further the many efforts in progress, including an interagency experiment in using national lightning data, a Preliminary National Plan for Lightning Detection Systems was published by the OFCM in 1988 to provide a framework for further development. The interagency experiment in using composite national lightning data was successfully concluded in March 1991. The agencies were able to learn a great deal about the performance of lightning detection systems and the uses of the data.

The Working Group 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. The RFP closed in June. Proposals were received and evaluated. As a result of the evaluation, contract award has been delayed, but is expected shortly. Meanwhile, various agencies continue to make use of lightning data to meet their requirements.

Profiler Systems

NOAA formally initiated research in the early 1980's to explore the development of ground-based systems that would supplement, and in some instances provide an alternative to, the radiosondes used over the past 50 years to obtain upper-air meteorological data. The concept of profilers involves combining remote sensors to monitor upper-air winds, temperature, and moisture continuously and automatically.

Wind Profilers. NOAA began installation of its wind profiler demonstration network (WPDN) in 1990 and completed the installation in early 1992. The WPDN consists of 29 profiling radars situated across the central United States with additional profilers located at Maynard, Massachusetts and Homer, Alaska. The WPDN is providing data for assessing the impact of profiler technology on NWS operations and a wide range of atmospheric research problems. This assessment is designed to determine the potential value of a national network and to aid the decision-making process of implementing such a network. Both meteorological and engineering data from the WPDN will be examined for the assessment.

WPDN data are collected at NOAA's Forecast Systems Laboratories (FSL) in Boulder, CO, and distributed in near real-time to the NWS and other agencies and institutions. Each wind profiler samples the atmosphere every six minutes and transmits these data to the profiler "hub" at FSL where an hourly consensus-averaged wind is computed. Quality control of the data is done at each site and at the profiler hub. These quality control checks are designed to "identify and flag" all incorrect wind data prior to transmission of the hourly data to the National Meteorological Center (NMC) and the NWS Telecommunications Gateway. In addition to hourly data, six-minute wind data are sent to the National Climatic Data Center in Asheville, NC for archiving.

From the Gateway, the data are distributed to many NWS forecast offices on AFOS and to selected private sector subscribers to the NWS Family of Services. During the summer of 1992, NWS will send wind profiler data to the Canadian Atmospheric Environment Service for their

evaluation and, by placing the data on the Global Telecommunication Network, to interested international users as well.

Thermodynamic Profiling. Types of temperature and moisture profilers include Radio Acoustic Sounding System (RASS), the correlation radiometer (CORRAD), the High-resolution Interferometric Sounder (HIS), and the Raman and Differential Absorption Lidar (DIAL). Temperature sounding comparisons between radiosondes, RASS, and the microwave radiometer have been conducted with encouraging results. HIS experiments have shown promise but more work is needed.

By operating a thermodynamic profiler in conjunction with a wind profiler, wind, temperature, and moisture profiles can be obtained simultaneously and independently. NWS plans to integrate RASS systems with some of their wind profilers in the WPDN. Temperature data from these integrated systems will extend up to 3-4 Km above the ground for the 404 Mhz systems with the same vertical resolution as that of the lower-level wind data (approximately 250 meter intervals). The Army's Atmospheric Science Laboratory at White Sands Missile Range is integrating RASS systems with their 50, 404 and 924 Mhz wind profilers, and has begun utilizing both RASS and wind data in their research efforts.

Weather Reconnaissance Program

The U.S. Air Force Reserve provides operational weather reconnaissance to support hurricane forecasting. The Air Force Reserve's 815th Airlift Squadron has total responsibility for the Air Force fixed-wing weather reconnaissance missions. The Squadron, part of the 403rd Airlift Wing, Keesler Air Force Base, Mississippi, operates 12 WC-130 aircraft that are configured with a fully automated, high-density data gathering system that provides extensive information about tropical systems and winter storms. These data are used by the National Hurricane Center, the Central Pacific Hurricane Center, and the National Meteorological Center to improve the forecasts and warnings of tropical cyclones and winter storms. The Office of NOAA Corps Operations augments the USAF Reserve operational weather reconnaissance with two fully instrumented WP-3D reconnaissance aircraft. The two NOAA aircraft also support the research requirements of the National Hurricane Center and the National Meteorological Center. OFCM is coordinating development efforts for a new digital dropwindsonde to replace the current dropsondes used by the Air Force and NOAA weather reconnaissance systems.

No-GOES Contingency Plan

Problems with the development of the new GOES-I satellite instruments have delayed the launch to late 1993. NOAA continues to refine its No-GOES Contingency Plan in the event that an interruption occurs in GOES-7 imaging operations.

The Plan has been distributed to agency representatives on the Committee for Operational Environmental Satellites and to other offices having a broad operational interest. As with all plans that have a potential for impacting the critical operational missions of NOAA, the No-GOES plan must be tested. NOAA has created a separate test plan for each test which describes the process by which the Agency No-GOES plans are demonstrated and evaluated. To date, three national tests have been conducted by NOAA. These operational tests have served to highlight needed improvements in the products and communication procedures to ensure the timeliness, quality, and utility of the No-GOES imagery. The goal of these No-GOES tests are to demonstrate the NOAA product

generation and distribution system to supply imagery from non-GOES sources, and to evaluate the utility of the current No-GOES product suite.

As stated in the NOAA No-GOES Contingency Plan, several enhancements are underway to provide additional capabilities to access, process, distribute, and display non-GOES satellite data. Specifically, observations from NOAA and Department of Defense (DOD) polar orbiting satellites and from the European Space Agency's Meteosat-3 satellite are being enhanced to present these data in the most useful format for the operational meteorological users. Enhancements include the addition of U.S. state boundaries on Meteosat-3 imagery, new enhanced polar acquisition stations at selected NWS offices, higher resolution of NOAA polar satellite composites, and various processing/communication arrangements. As additional systems, capabilities, and products are established, they will be demonstrated to the user community and evaluated in subsequent tests.

Hydrometeorology

A relatively new working group 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:

(1) the archiving of the NEXRAD precipitation data;
(2) the rain gage networks to calibrate the Doppler radars;
(3) the dissemination of information to users of radar data.

A report summarizing the results of the workshop is under development.

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. DOD provides ionospheric and geomagnetic field data from terrestrial networks. Research data, also useful for the forecast and warning services, are obtained from other agencies and shared through real-time communication networks and jointly operated data bases. Research data from experiments sponsored by the National Science Foundation (NSF) have been 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 data bases to the agencies is operated jointly by DOD and DOC/NOAA to meet common needs. Some agencies, such as DOD, 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: 1988-1992 (FCM-P10-1988), which was prepared by the OFCM Committee on Space Environment Forecasting and published in 1988. The Committee will publish an updated plan in 1992.

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 is 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.

From the viewpoint of sensors and sensor platforms the great majority of considerations are progressing in a satisfactory manner. 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) is being developed and operations will begin during the next fiscal year. Also, the Upper Atmosphere Research Satellite (UARS) was launched in September 1991. With current assessment of an approximate 9-year lifetime of the satellite (one

cryogen cooled instrument will have a scheduled lifetime of about 20 months), UARS will play an important role in evaluation of other monitoring products.

In addition, NOAA/NESDIS has established 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/IS 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.

Mobile Meteorological Equipment.

In 1991, OFCM sponsored a report entitled "Federal Meteorological Requirements 2000 (FMR 2000)" that was a review of the meteorological requirements of the agencies of the Federal Government through the decade of the 1990s and leading up to the year 2000. The report recommended areas where continued and increased interagency coordination is warranted, thus providing opportunities for further action by OFCM. One of those areas for near-term OFCM involvement was in the area of "Mobile Meteorological Equipment." The viewpoint was that DOD's tactical equipment should be given increased visibility to possibly satisfy other Federal agency needs.

With the approval of the ICMSSR, an ad hoc group was formed to address this issue. At their first meeting it was decided that there was a need for a "directory" that catalogued mobile meteorological equipment held by each of the Federal agencies. Subsequent ad hoc group meetings helped shape the format and content of this directory. The group plans to commence work on the directory in 1992.

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 Ad Hoc Group for Mobile Meteorological Equipment. The purpose of the group is to develop an inventory of pertinent equipment and capabilities that are held by the agencies and determine the potential for sharing among the agencies.

ICMSSR also established the Working Group for Post-Storm Data Acquisition (WG/PSDA). This group will prepare an interagency plan for acquisition of scientific and engineering data after tsunamis, coastal storms (including hurricanes), and lake storms. Reasons for acquiring the data include: determination of the effectiveness and benefits of storm protection and damage reduction measures; assessment and improvement of various forecast models, procedures, and standards used in coastal construction. The data will also assist in the delineation of coastal hazard zones.

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. In most cases, the preparation of Federal plans is facilitated by the existence of individual agency plans for the service or program involved. The Federal Coordinator compiles 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 directly supporting research. While not specifically a part of OFCM activities, brief descriptions are given below of Federal coordination activities that relate to other aspects of meteorology.

Subcommittee for Atmospheric Research

The Subcommittee for Atmospheric Research (SAR) was originally known as the Interdepartmental Committee for Atmospheric Sciences (ICAS). It was established in 1959 by the Federal Council for Science and Technology (FCST) and was the principal mechanism for coordination of research in atmospheric sciences within the Federal Government until 1977. At that time, FCST and its subordinate organizations were abolished and replaced by the Federal Coordinating Council for Science, Engineering and Technology (FCCSET). SAR succeeded ICAS and became a Subcommittee of the FCCSET Committee on Atmosphere and Oceans (CAO). In 1987, the CAO was disestablished and replaced by the Committee on Earth Sciences (CES) which became the Committee on Earth and Environmental Sciences (CEES) in 1990. The SAR is now a subcommittee of the CEES.

The primary goal of SAR is to improve the planning and coordination of atmospheric research activities among the agencies involved. Agencies represented on SAR are 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 published report is for the years 1984-1987. The next SAR report is being prepared for publication in 1992; it will highlight 1987-1990 activities and budgets.

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 1992	April 1992	FCM-P1-1992
National Plan for Space Environment Services and Supporting Research: 1988-1992	July 1988	FCM-P10-1988
National Severe Local Storms Operations Plan	September 1990	FCM-P11-1990
National Hurricane Operations Plan	April 1992	FCM-P12-1992
National Winter Storms Operations Plan	October 1991	FCM-P13-1991
National Plan for Stratospheric Monitoring, 1988-1997	July 1989	FCM-P17-1989
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	December 1990	FCM-P25-1990
Federal Meteorological Handbook No. 1 - Surface Observations	April 1988	FCM-H1-1988
Federal Meteorological Handbook No. 2 - Surface Synoptic Codes	December 1988	FCM-H2-1988
Surface Synoptic Code Tables (Update)	July 1990	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	March 1991	FCM-I3-1991
Tropical Cyclone Studies	December 1988	FCM-R11-1988
Tropical Cyclone Studies Supplement	August 1989	FCM-R11-1988 S
Interdepartmental Meteorological Data Exchange System Report, IMDES	July 1991	FCM-R12-1991
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	May 1987	FCM-S4-1987

SECTION 3

RESOURCE INFORMATION AND AGENCY PROGRAM UPDATES

Resources included in the Federal agencies FY 1993 budget requests for meteorological services and supporting research total $2.343 billion. This is an increase of 4.0 percent from the $2.253 billion appropriated for FY 1992. Of the total, the Department of Commerce budget represents 43.8 percent, Department of Defense 28.6 percent, and Federal Aviation Administration about 18.9 percent with the remaining 8.7 percent for other agencies.

The tables in this section summarize fiscal information of the Federal Government for the fiscal years 1992 and 1993. 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 1992 and are subject to later changes. The data for FY 1993 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 planned (appropriated) funding level for FY 1992, the budget request for FY 1993, the percent change, and the individual agencies' percent of the total Federal funding for FY 1992 and FY 1993.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 1993 is $25.18 million for operations and supporting research. This is an increase of 0.8 percent from the planned funding level of $24.99 million for FY 1992. The FY 1993 request for meteorological operations ($10.74 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 Digital Weather Image Processing System (DWIPS) has enhanced global monitoring of crop conditions by the Joint Agricultural Weather Facility.

The supporting research component of the USDA request ($14.44 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 includes studying plant response to ultraviolet band (UVB) radiation and has been coordinated with the Environmental Protection Agency's UVB program. 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 1993, Agriculture Research Service will continue hydrologic work on a regional scale.

TABLE 3.1 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS, BY AGENCY
(Thousands of Dollars)

AGENCY	Operations FY92	Operations FY93	Operations %CHG	% of FY93 TOTAL	Supporting Research FY92	Supporting Research FY93	Supporting Research %CHG	% of FY93 TOTAL	Total FY92	Total FY93	Total %CHG	% of FY92 TOTAL	% of FY93 TOTAL
Agriculture	10702	10741	0.4	0.5	14290	14443	1.1	8.1	24992	25184	0.8	1.1	1.1
Commerce/NOAA	825833	977554	18.4	49.1	54302	49476	-8.9	12.6	880135	1027030	16.7	39.1	43.8
Defense(Subtot)	664635	587141	-11.7	29.5	88558	83375	-5.9	28.9	753193	670516	-11.0	33.4	28.6
Air Force	363820	370600	1.9	18.6	18212	19981	9.7	4.7	382032	390581	2.2	17.0	16.7
DMSP*	187343	88492	-52.8	4.4	28478	23300	-18.2	7.4	215821	111792	-48.2	9.6	4.8
Navy	86784	92516	6.6	4.6	11185	11399	1.9	8.8	97969	103915	6.1	4.4	4.4
Army	26688	35533	33.1	1.8	30683	28695	-6.5	8.0	57371	64228	12.0	2.6	2.7
Interior/BLM	870	870	0.0	0.0	0	0	0.0	0.0	870	870	0.0	0.0	0.0
Transp/CG	2577	2577	0.0	0.1	0	0	0.0	0.0	2577	2577	0.0	0.1	0.1
Transp/FAA	395906	406460	2.7	20.4	28107	35565	26.5	8.8	424013	442025	4.3	18.8	18.9
EPA	0	0	0.0	0.0	7150	8100	13.3	1.9	7150	8100	13.3	0.3	0.4
NASA	6899	7619	10.4	0.4	153300	159100	3.8	39.8	160199	166719	4.1	7.1	7.1
NRC	130	145	11.5	0.0	0	0	0.0	0.0	130	145	11.5	0.0	0.0
TOTAL	1907552	1993107	4.5	100.0	345707	350059	1.3	100.0	2253259	2343166	4.0	100.0	100.0
% of FY TOTAL	85	85			15	15			100	100			

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

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 1993 total congressional request of $1,027.0 million for meteorological programs is 16.7 percent more than the FY 1992 appropriated funds. Changes in NOAA's operations and supporting research for FY 1993 are presented below, subdivided by activities.

Weather Services. Increases in the subactivity for FY 1993 include the following: NOAA requests an increase of 97 positions and $20.3 million for the NWS Transition (MARDI). This increase will fund the staffing required to operate the new NEXRAD units, prepare for the nationwide NWS modernization, and prepare for and conduct a multi-site operational demonstration. Plans also include a $1.1 million increase to fund the DOC share of the tri-agency NEXRAD program. The funding is necessary for logistic support activities and for the replacement of existing obsolete radars. An increase of $5.2 million will allow the full scale production and installation phase of ASOS to continue.

Proposed FY 1993 decreases include the following: NWS proposes to streamline its management by reconfiguring the current four-region management structure (for the lower 48 states) into a three-region structure, netting a savings of 18 positions and $848,000. A savings of $1.3 million will be achieved by discontinuing maintenance of the four non-essential moored buoys surrounding Hawaii, by discontinuing operations and maintenance of five California data buoys, and by realigning staff and anticipated workload at the NOAA Data Buoy Center. NWS proposes further streamlining measures by consolidating managerial functions of the Pacific Region Headquarters and the Alaska Region Headquarters. The consolidation will net a savings of 11 positions and $381,000. A savings of 37 positions and $2.4 million will result from eliminating the specialized agricultural weather services and fruit frost programs. A decrease of 8 positions and $468,000 will result from reducing the fire weather services program. Discontinuing the operational support for the Susquehanna and Colorado River Basin flood warning systems will save $997,000. A savings of $200,000 will be realized by canceling contract observers at Stampede Pass, Washington; Sexton, Oregon; and Blue Canyon, California. A decrease of $3.1 million has been requested for six Regional Climate Centers located in Illinois, Louisiana, Nebraska, Nevada, New York, and South Carolina.

Plans also include a decrease of $5.5 million for the advanced systems to process weather data and provide necessary communications (AWIPS/NOAAPORT). The requested funding level will allow NOAA to initiate contractor and program activities in the AWIPS Development Phase contract and to continue critical AWIPS pre-MARD preparations and risk reduction activities. And finally, NOAA proposes a decrease of $3.2 million for the NOAA Central Computer Facility. The requested funding level will be used to initiate the acquisition of a Class VII computer system through a lease arrangement, continue the existing Cray YMP8/32 computer system, and maintain the new systems.

Environmental Satellite, Data, and Information Services. Proposed funding for FY 1993 includes an increase in the polar-orbiting satellite program of $86.3 million and an increase in the Geostationary Satellite Program of $10.9 million. These changes will allow for continuation of procurement to provide the spacecraft and instruments, launch services, and ground systems necessary to assure continuity of environmental satellite coverage. The FY 1993 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 $5.6 million in FY 1993 is proposed for the NOAA Earth System Data and Information Management Program (ESDIM), of which $4.0 million is to increase the ongoing data rescue and access effort and $1.6 million is to begin planning to modernize the NOAA-wide data system. This builds on the ESDIM program initiated in FY 1991. ESDIM is a NOAA-wide effort to save critical environmental data from being lost and to improve access to these data. The increase in FY 1993 funds will be used to develop plans and standards for a modern NOAA-wide system to acquire, process, and distribute NOAA's environmental data in the 1990's.

Funds are also included to provide basic mission services including maintenance and operation of satellite ground facilities; provision of satellite-derived products; conduct of research to improve the use of satellite data; and the archiving and dissemination of climatic, oceanographic and geophysical data.

Weather Research. Under the Weather Research line item, including Solar Environmental Research, there will be a net programmatic decrease of $4.942 million due to the reduced funding plan for operation and assessment of the 29-site/16-state Wind Profiler Demonstration Network (WPDN). In addition, the Program for Regional Observing and Forecasting Systems (PROFS) will be decreased. The cooperative five-state Weather Modification Research Program will be terminated. This Program supports studies of the physical mechanisms of cloud and precipitation formation. Finally, funding will be terminated for the new Southeastern U.S. storm research program.

Offsetting these decreases will be an increase of $357,000 to improve solar forecast data handling and processing capabilities.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 1993 is $670.5 million which is 11 percent less than the total funding level for FY 1992. Details are given below.

U.S. Air Force

U.S. Air Force resources for meteorological support fall under two distinct categories: general operations and Defense Meteorological Satellite Program (DMSP) operations.

General Operations. The operations portion of the budget request for FY 1993 is $370.6 million.

Air Force funding represents a large portion of environmental support to the DOD. These funds will pay for weather and space environmental support to the USAF (both active and reserve components), the US Army, seven unified commands, and other agencies as directed by the Chief of Staff of the Air Force. The support is conducted by nearly 5500 people at over 250 worldwide locations; these people include active military, Air Force reservists, Air National Guard, weather flight personnel, weather communications and computer specialists, and civilians. These funds pay the salaries of these people and the day-to-day operations and maintenance costs for the support they provide.

The $370.6 million also includes weather communications. The Automated Weather Network (AWN) communications hub at Carswell AFB processes over 250,000 weather messages per day to and from nearly 10,000 worldwide weather stations over Air Force long-haul circuitry and approximately 1400 leased circuits. This function is required 24 hours a day, year around.

The FY 1993 request includes $74 million for procurement of Air Force standard weather systems ($63 million) and system spares ($11 million) needed to sustain and improve on current environmental support capabilities. FY 1993 is the final year of procurement funding for the Automated Weather Distribution System (AWDS). By the end of FY 1993, nearly all of the planned 162 systems will be installed. AWDS modernizes Air Force weather station operations by allowing weather forecasters to store, process, graphically display, and distribute weather information. Procurement of Pre-planned Product Improvements (P3I) for AWDS gets into full swing in FY 1993. AWDS P3I retrofits AWDS systems with enhancements that were either beyond the scope of the original program or beyond the state of the art. Improvements will include communications connectivity to other DOD systems and ingest of GOES satellite data. Procurement funding of the AF portion of the tri-agency NEXRAD [Weather Surveillance Radar, 1988D (WSR-88D)] continues in FY 1993. Other procurement funding goes to upgrading the Satellite Data Handling System at AF Global Weather Central (AFGWC), continuing the additional buy of the Transportable Cloud Height Detector (TCHD) and the Tactical Meteorological Observation System (TMOS), and for purchasing a new capability for authorized worldwide users to be able to tie in to the AFGWC database using a personal computer and standard telephone lines.

DMSP Operations. DMSP is the primary DOD environmental satellite program. Though funding for DMSP comes from the Air Force, the system is the major source of space-borne meteorological data for the military services and other high priority DOD programs. Through the shared processing network, environmental data from DMSP sensors are also provided outside the DOD to the National Weather Service.

The operations portion of the FY 1993 DMSP budget request is $88.5 million, which reflects FY 1992 being the final year of the Block 5D-3 multi-year procurement (satellites S-19 and S-20). The major portion of this funding is for on-orbit operations, tactical terminal procurement, and satellite sensor integration. Also included in the DMSP line is funding for 355 military and civilian personnel associated with the operation of, and to a much smaller extent, the procurement of the DMSP system. The funds also pay operations costs for two dedicated command and control facilities.

General Supporting Research. The FY 1993 budget request for Air Force supporting research is $19.98 million. The Air Force continues R&D efforts in NEXRAD algorithms refinement, upgrading the Air Force Solar Electro-optical Network (SEON), new computer models to improve atmospheric forecasting, and new automated weather observing sensors. Additionally, the Air Force continues to monitor the Department of Commerce's development of the Automated Surface Observing System.

This program includes the start of new battlefield weather observing and forecasting programs in support of USAF and Army tactical operations as a result of lessons learned from DESERT SHIELD/STORM. New R&D thrusts include a tactical weather observing and forecasting system, development of a transportable AWDS, and further refinement of Electro-Optical Tactical Decision Aids (EOTDAs).

DMSP Supporting Research. The FY 1993 budget request for DMSP research and development is $23.3 million. These funds are for initial development of the next generation satellite system (DMSP Block 6). Block 6 satellites are scheduled to replace the Block 5D-3 production spacecraft in 2005. Block 6 spacecraft will offer improved avionics, and 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/validation efforts for new/modified

sensors, development efforts for a new smaller tactical terminal, and modification of data application algorithms.

U.S. Navy

The U.S. Navy FY 1993 funding request for meteorological programs is $103.92 million. The request includes $92.52 million for operational programs and $11.40 million for supporting research.

Operations Support. Operations support for the Navy and Marine Corps includes the day-to-day provision of meteorological products and services, as it does for other agencies. Navy also provides specific and unique services, such as acoustic propagation models and products, environmentally-sensitive tactical decision aids, and global ice analysis and forecast products to all services. Communication costs are significant for an organization with global responsibilities, and the uniqueness of forces at sea drives requirements for specific products and communications capabilities.

Systems Acquisition. Major systems undergoing procurement in FY 1992 and FY 1993 are identified below (see Appendix B for more detail):

- Tactical Environmental Support System (TESS(3))
- Primary Oceanographic Prediction System (POPS)
- SMQ-11 Environmental Satellite Receiver/Recorder
- Automated Surface Observing System (ASOS)
- Shipboard Meteorological and Oceanographic Observation System (SMOOS)
- NEXRAD Principal User Processors (PUPs)
- Naval Oceanographic Data Distribution and Expansion System (NODDES)

Research and Development. This equates to basic or exploratory research, usually conducted by a Government or university laboratory. This research is not generally system-specific, but may have applications to one or more meteorological, oceanographic or tactical systems. Navy's tabulation of these data includes R&D funding for Exploratory Development initiatives.

Navy's advanced development, under sponsorship of the Oceanographer of the Navy, transitions work started under exploratory development to the operational Navy Systems. Work in this area includes upgrades to the Navy's numerical forecasting capability, improvements in communications, including data compression techniques, to provide better data to ships at sea and development of new models to predict the effect of meteorological parameters on electromagnetic and electro-optic sensors.

U.S. Army

The U.S. Army is requesting $64.23 million in FY 1993 for operations and research and development (R&D). While costs associated with normal operations and R&D decrease, the total costs increased because two new weather support systems are being procured. The Meteorological Measuring System (MMS), a lightweight upper air sounding system for Field Artillery support, continues to be procured for combat units in FY 1993. The Integrated Meteorological Systems (IMETS), a tactical weather support system for aviation and combat commanders with an Air Force weather team, begins initial fielding in FY 1993. MMS and IMETS procurement costs are $14.8 million and account for most of the increase from FY 1992 to FY 1993.

The operational support costs for Operations DESERT SHIELD and DESERT STORM are not shown for FY 1992. For routine training and peacetime operations the trend is for resources to stay about the same with savings made as units with weather support forces are deactivated in the Major Army Commands (MACOMs). Some savings are realized by Field Artillery use of the MMS because it has a smaller crew and lower operational costs than the larger Meteorological Distribution System, which it replaces. The MMS will continue to be procured and fielded at a cost of $8.8 million in FY 1993. In FY 1992, the Army developed the initial IMETS for testing purposes and transitioned to procure the first operational systems in FY 1993. IMETS will require approximately $6 million for procurement of the first systems and another $1 million in continued R&D on software development and integration of software and hardware. Interim MACOM weather support systems will continue to be maintained until IMETS is fielded.

DEPARTMENT OF THE INTERIOR (DOI)

The DOI funding request of $870,000 for FY 1993 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 with a planned FY 1992 program completion. 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)

Within DOT, the U.S. Coast Guard and the Federal Aviation Administration describe their meteorological programs for FY 1992 and FY 1993 below.

U.S. Coast Guard (USCG)

All of USCG's funding for meteorological programs is for operations support. In FY 1993, the requested funding level is $2.58 million. 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 this information to NOAA's National Weather Service and provides use of facilities to the National Data Buoy Center.

Federal Aviation Administration (FAA)

Total FAA funding for aviation weather in FY 1992 is $424.0 million for both operations and supporting research. The FAA's proposed FY 1993 total budget for aviation weather is $442.0 million. The increase in the budget is principally in operations support which will rise from $271.5 million to $290.4 million, an increase of 7 percent. System acquisitions show a marginal decrease of 8 percent from $121.3 million to $112.2 million. Funding for supporting research will increase by 27 percent from $28.1 million to $35.6 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

TABLE 3.2 AGENCY OPERATIONAL COSTS, BY BUDGET CATEGORY
(Thousands of Dollars)

AGENCY	Operations Support		Systems Acquisition		Special Programs		Total			%of FY93
	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	%CHG	TOTAL
Agriculture	10128	10150	0	0	574	591	10702	10741	0.4	0.5
Commerce/NOAA	441611	498483	380323	475070	3899	4001	825833	977554	18.4	49.1
Defense(Subtot)	457557	439413	205874	146618	1204	1110	664635	587141	-11.7	29.5
Air Force	297843	296568	65977	74032	0	0	363820	370600	1.9	18.6
DMSP*	54357	36669	132986	51823	0	0	187343	88492	-52.8	4.4
Navy	84916	87668	1868	4848	0	0	86784	92516	6.6	4.6
Army	20441	18508	5043	15915	1204	1110	26688	35533	33.1	1.8
Interior	870	870	0	0	0	0	870	870	0.0	0.0
Transp/CG	2577	2577	0	0	0	0	2577	2577	0.0	0.1
Transp/FAA	271521	290398	121280	112191	3105	3871	395906	406460	2.7	20.4
EPA	--------- Not Applicable ---------									
NASA	4941	5062	1121	1475	837	1082	6899	7619	10.4	0.4
NRC	130	145	0	0	0	0	130	145	11.5	0.0
TOTAL	1189335	1247098	708598	735354	9619	10655	1907552	1993107	4.5	100.0
% of FY TOTAL	62	63	37	37	1	1	100	100		

*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.

information and to very short range automated warnings and forecasts. FAA's aviation weather programs are directed to improve the timeliness and accuracy of weather information to the aviation user. 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.

Most of the FY 1993 increases are in operations as FAA continues to increase its support 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:

Program	Increase ($millions)
System Acquisition	
Next Generation Weather Radar	$4.2
National Airspace Data Interchange	3.3
Real Time Weather Processor	2.0
Weather Message Switching Center Replacement	2.0
Terminal Doppler Weather Radar	2.0
Operations Support	
Flight Service Stations Operations	7.0
Contract Aviation Weather Observations	5.7
Maintenance of Meteorological Equipment	2.6
Leased Telecommunication Lines	2.6

Partially offsetting these increases in FY 1993 are decreases in system acquisition programs of $11.6 million for Flight Service Station Automation, $6.2 million for the new Denver Airport, $5.0 million for acquisition of ASOS/AWOS/ADAS, and $2.5 million for the Meteorologist Weather Processor.

Funding for supporting research programs increases from $28.0 million in FY 1992 to $34.7 million in FY 1993. The majority of the increased funding is committed to programs that support systems research including development of an Integrated Terminal Weather System and Aviation Weather Product Generator. The FAA is continuing its icing and airborne windshear research programs and is supporting the development of airborne meteorological sensors to monitor humidity to improve icing forecasts. The definition of supporting research used in this report generally incorporates a broader spectrum of activities than is covered by FAA's research and development programs.

The number of personnel (full-time-equivalent, FTE) expected to be engaged in FAA's FY 1993 operational aviation weather program is 4305; this is the same as for FY 1992. The number of FY 1992 personnel reported in last year's Federal plan, was 3829 FTE's. The 12.4 percent increase from 3829 to 4305 results from a change in cost accounting rather than an increase in personnel. A re-evaluation of flight service specialist's workload has shown that a greater proportion of their time is devoted to weather than heretofore allocated. The increase in FTE's is virtually all due to the revised allocation of flight service specialists' workload, not to an overall increase in workload.

TABLE 3.3 AGENCY SUPPORTING RESEARCH COSTS, BY BUDGET CATEGORY
(Thousands of Dollars)

AGENCY	Research & Development		Systems Development		Special Programs		Total			%of FY92 TOTAL
	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	%CHG	
Agriculture	14290	14443	0	0	0	0	14290	14443	1.1	4.1
Commerce/NOAA	44053	46086	2500	1870	7749	1520	54302	49476	-8.9	14.1
Defense(Subtot)	76295	74309	12263	9066	0	0	88558	83375	-5.9	23.8
Air Force	12871	14699	5341	5282	0	0	18212	19981	9.7	5.7
DMSP*	28478	23300	0	0	0	0	28478	23300	-18.2	6.7
Navy	11185	11399	0	0	0	0	11185	11399	1.9	3.3
Army	23761	24911	6922	3784	0	0	30683	28695	-6.5	8.2
Interior	--------- Not Applicable ---------									
Transp/CG	--------- Not Applicable ---------									
Transp/FAA	4437	5396	23670	30169	0	0	28107	35565	26.5	10.2
EPA	7150	8100	0	0	0	0	7150	8100	13.3	2.3
NASA	90300	91600	63000	67500	0	0	153300	159100	3.8	45.5
NRC	0	0	0	0	0	0	0	0	0.0	0.0
TOTAL	236525	239934	101433	108605	7749	1520	345707	350059	1.3	100.0
% of FY TOTAL	68	69	29	31	2	0	100	100		

*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.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of EPA funding of meteorological programs is for supporting research. The requested funding level for FY 1993 is $8.10 million, an increase of 13 percent from the FY 1992 level of $7.15 million. This $950,000 increment was provided to the EPA Office of Research and Development under the 1990 Clean Air Act Amendments in the area of ozone non-attainment. A separate Congressional appropriation providing for performance of the Southern Oxidant Study continues during FY 1993.

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

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 1993 is $159.1 million, an increase of 3.8 percent from the FY 1992 funding level. The FY 1993 level reflects slightly increased funding for meteorology related activities within the Earth Observing System (EOS), no signficant funding change for the supporting research and analysis programs, and a slight decrease in funding for the Earth Probes which include a scatterometer to measure ocean surface winds, a total ozone mapping spectrometer, and a program for tropical rainfall measurement. The Upper Atmosphere Research Satellite (UARS) was launched during FY 1991. The requested funding for its operation during FY 1993 is $35.4 million. Funding level for UARS operation during FY 1992 is $17.2 million. NASA has completed the restructuring of EOS from a program in which the instruments were to be flown on a series of larger platforms to one in which the instruments will fly on intermediate-sized and smaller spacecraft.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC requested FY 1993 funding of $145,000 is for meteorological operations. This is an increase from the $130,000 appropriated for FY 1992.

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

AGENCY FUNDING BY BUDGET CATEGORY

Table 3.2 (page 3-8) 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 (page 3-10) shows how the agencies plan to obligate their funds for meteorological supporting research according to the budget categories.

TABLE 3.4 AGENCY OPERATIONAL COSTS, BY SERVICE
(Thousands of Dollars)

	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
AGENCY	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93
Agriculture	0	0	0	0	0	0	10702	10741	0	0	0	0	10702	10741
Commerce/NOAA	760944	914369	35389	35596	24088	24589	2412	0	0	0	3000	3000	825833	977554
Defense(Subtot)	290598	245523	191569	175899	24865	26461	0	0	125562	111488	32041	27770	664635	587141
Air Force	181910	185300	127337	129710	0	0	0	0	36382	37060	18191	18530	363820	370600
DMSP*	93671	44246	37469	17698	0	0	0	0	46836	22123	9367	4425	187343	88492
Navy	15017	15977	26429	28238	24865	26461	0	0	15990	17025	4483	4815	86784	92516
Army	0	0	334	253	0	0	0	0	26354	35280	0	0	26688	35533
Interior/BLM	0	0	0	0	0	0	0	0	0	0	870	870	870	870
Transp/CG	1777	1777	0	0	800	800	0	0	0	0	0	0	2577	2577
Transp/FAA	0	0	395906	406460	0	0	0	0	0	0	0	0	395906	406460
EPA	--------- Not Applicable ---------													
NASA	0	0	0	0	0	0	0	0	0	0	6899	7619	6899	7619
NRC	60	75	0	0	0	0	0	0	0	0	70	70	130	145
TOTAL	1053379	1161744	622864	617955	49753	51850	13114	10741	125562	111488	42880	39329	1907552	1993107
% of FY TOTAL	55	58	33	31	3	3	1	1	7	6	2	2	100	100

*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.

In earlier years, the agencies' operational budgets were subdivided into "functional" categories-- Observations, Analyses and Forecasts, Communications, Dissemination, and Management Support. Advancing technology and increasing integration of components have blurred the meaning of these functions and have made identification more difficult. The new categories were chosen to align more closely with agency budgets. As a result, the new categories are referred to as "budget categories". The two major new 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". Also for agency convenience, special programs such as the Air Force's Defense Meteorological Satellite Program can be 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 indicates the corresponding data for supporting research. Table 3.4 shows that "basic" services require approximately 58 percent of the total operational costs while aviation services require about 31 percent. The remaining 11 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 and Defense 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)

	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
AGENCY	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93	FY92	FY93
Agriculture	0	0	0	0	0	0	14290	14443	0	0	0	0	14290	14443
Commerce/NOAA	49535	44709	1767	1767	0	0	0	0	0	0	3000	3000	54302	49476
Defense(Subtot)	10821	11706	0	0	11185	11399	0	0	66552	60270	0	0	88558	83375
Air Force	9106	9991	0	0	0	0	0	0	9106	9990	0	0	18212	19981
DMSP*	0	0	0	0	0	0	0	0	28478	23300	0	0	28478	23300
Navy	0	0	0	0	11185	11399	0	0	0	0	0	0	11185	11399
Army	1715	1715	0	0	0	0	0	0	28968	26980	0	0	30683	28695
Interior/BLM						----------	Not Applicable	----------						
Transp/CG						----------	Not Applicable	----------						
Transp/FAA	0	0	28107	35565	0	0	0	0	0	0	0	0	28107	35565
EPA	0		0	0	0	0	0	0	0	0	7150	8100	7150	8100
NASA	0	0	0	0	0	0	0	0	0	0	153300	159100	153300	159100
NRC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	60356	56415	29874	37332	11185	11399	14290	14443	66552	60270	163450	170200	345707	350059
% of FY TOTAL	17	16	9	11	3	3	4	4	19	17	47	49	100	100

*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 requirements of user agencies or groups not included in the preceding categories, such as support to civil and military programs involving space operations and support to Federal, state and local governmental agencies responsible for dealing with urban air pollution.

PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 3.6 shows agency staff resources in meteorological operations. Overall, agency staff resources requested for FY 1993 total 17,904, which is an increase of less than 0.1 percent from FY 1992.

INTERAGENCY FUND TRANSFERS

Table 3.7 summarizes interagency fund transfers for FY 1992 to other agencies to pay for services that the receiving agencies 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.

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

AGENCY	FY92	FY93	%CHG	% of FY93 TOTAL
Agriculture	98	98	0.0	0.5
Commerce/NOAA	4084	4393	7.6	23.7
Reimbursed**	635	635	0.0	3.4
Defense (Total)	8670	8373	-3.4	45.3
Air Force	6210	5993	-3.5	32.4
DMSP	364	355	-2.5	1.9
Navy	1583	1575	-0.5	8.5
Army	513	450	-12.3	2.4
Interior/BLM	16	16	0.0	0.1
Reimbursed**	4	4	0.0	0.0
Transp/CG	79	79	0.0	0.4
Transp/FAA	4305	4305	0.0	24.0
EPA	0	0	0.0	0.0
NASA	0	0	0.0	0.0
NRC	1	1	0.0	0.0
TOTAL	17892	17904	0.1	100.0

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

TABLE 3.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 1992 Funds ($K) Estimated or Planned	
		Operations	Supporting Research
Commerce/NOAA	DOT/FAA	$400	
	DOT/USCG	1,100	
	NASA(Procurement)	217,000	
	NASA/Wallops	125	
Defense/Air Force	DOC	295	
	DOT		$297
	NRL		50
	USGS	176	
Defense/Navy	DOC	855	
Defense/Army	DOC/NOAA	630	320
	USDA		65
	NSF		72
	National Laboratories		143
Transportation/FAA	DOC/NOAA	16,303	2,925
	DOC/NOAA(Procurement)	40,045	
	NSF		16,700
	NASA		3,000
NASA	DOD/USAF	460	
	DOC/NOAA/NWS	1,420	
	DOC/NOAA/NDBC	80	
	DOC/NOAA/NCC	100	
EPA	DOC/NOAA/ARL		4,200
DOE	DOC/NOAA/NWS	2,246	
NRC	DOC/NOAA/ARL	35	
USDA	NSF/SAR/NAS		30

Department of Commerce (DOC). The FAA will be reimbursed $400,000 for facilities support; the USCG $1.1 million for support to the Data Buoy Center; and NASA $217 million for procurement and launch of two satellites, and $125,000 for support at Wallops Island.

Department of Defense (DOD). The Air Force will reimburse DOC a total of $295,000 for climate data ($165,000), and general support ($130,000). The Air Force will transfer $297,000 to DOT to complete a contract helping develop automated observation sensors and $176,000 to USGS for magnetometer data. The Navy will reimburse DOC a total of $855,000 -- for climatological analysis and forecasting ($813,000) and for training in satellite applications and forecasting ($42,000). The Army reimbursements include: DOC $320,000 for supporting research relating to LIDAR development, horizontal path profilers, wind profiler, radio acoustic sounder, radar support, and $630,000 to maintain precipitation reporting stations; to provide supporting research the Army will also reimburse the USDA $65,000, the NSF $72,400, and the National Laboratories $143,000.

Department of Transportation. The FAA will reimburse DOC/NOAA a total of about $16.30 million for operations -- $6.94 million for meteorological support at Center Weather Service Units (located with most Air Route Traffic Control Centers and the National Aviation Weather Unit in Kansas City); $8.42 million for contract weather observations; $100,000 for "AM Weather" broadcast; $18,000 for high altitude facsimile charts; and $825,000 for meteorological instructors at the FAA academy. FAA will also reimburse DOC/NOAA approximately $2.92 million for supporting research. FAA will also reimburse NOAA $40.05 million for procurement of NEXRAD radars and automated surface observing systems. The National Science Foundation will be provided $16.70 million to have the National Center for Atmospheric Research run field tests on terminal doppler weather radar and low level wind shear detection systems (TDWR/LLWAS) and related work. The NASA will be reimbursed $3.0 million for supporting research on airborne windshear technology and training.

National Aeronautics and Space Administration. The Air Force will be reimbursed $460,000 for data acquisition; NOAA/NWS will be reimbursed $1.42 million principally for meteorological support to the space shuttle operations; NOAA/NDBC $80,000 for operation of data buoys; and NOAA/NCC $100,000 for climatological data.

Environmental Protection Agency. NOAA's Air Resources Laboratory will be reimbursed $4.2 million for research related to air quality dispersion models, and guidance for EPA policy development.

Department of Energy. 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. NOAA's Air Resources Laboratory will be reimbursed $35,000 for technical assistance.

Department of Agriculture. NSF/SAR will be reimbursed $30,000 to support studies by the National Academy of Sciences.

LOCATIONS BY TYPE OF OBSERVATION

Table 3.8 indicates the number of locations or platforms at which the Federal agencies carry out (or supervise) the various types of weather observations. Both the type and the number of platforms change little from year to year.

TABLE 3.8 LOCATIONS BY TYPE OF OBSERVATION

Type of Observation	Agency	No. of Locations (FY 1992)
Surface, land	Commerce (WSFO, WSO, WSMO)	233
	Commerce (WSCMO)	27
	Commerce (Marine Reporting/CG Station)	145
	Commerce (AMOS, RAMOS, AUTOB, DARDC)	144
	Commerce (Supplem. Aviation Wea. Reporting Station)	427
	Defense (U.S.)	173
	Defense (Overseas)	90
	Transportation (Flight Service Station)	78
	Transportation (Limited Aviation Wea. Reporting Station)	160
	Transportation (FAA Contract Wea. Obs. Station)	134
	Transportation (Automated Wea. Obs. Station)	158
	Transportation (USCG Coastal)	110
	Interior	214
	Agriculture	840
	NASA	2
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 (Moored Buoy)	50
	Commerce (Large Navigation Buoy)	9
	Defense (Ships with met personnel)	35
	Defense (Ships without met personnel; based on record archivals during CY 1990)	310
	Transportation (USCG Ships)	93
	NASA	2
Upper air, balloon	Commerce (U.S.)	94
	Commerce (Foreign, cooperative)	33
	Defense Fixed (U.S. & Overseas)	69
	Defense (Ships)	33
	Defense Mobile (U.S. & Overseas)	70
	NASA (U.S.)	1
Upper air, rocket	NASA	1
	Defense	2
Weather radar	Commerce (NWS)	129
	Commerce (at FAA Sites)	27
	Defense (U.S. & Overseas)	125
	Defense (Remote displays)	49
	Transportation (Remote displays)	131
	NASA	1
Weather reconn. (No. of aircraft)	Commerce (NOAA)	2
	Defense (USAFRES)	12

SECTION 4

MESOSCALE METEOROLOGY*

INTRODUCTION

Mesoscale meteorology is a topic of much concern to operational meteorologists and the research community, as well as to Government managers and legislators who develop, shape and fund programs. These concerns address not only theoretical and modeling aspects of mesoscale processes but also measurement systems, data assimilation, and display and dissemination of mesoscale information.

Mesoscale processes include weather phenomena with spatial scales of 2-2000 km and time scales of several minutes to twenty-four or more hours. These phenomena encompass most of the weather systems that cause damage or disasters such as severe thunderstorms, tornadoes, flash floods, hurricanes, and significant winter storms.

History is replete with examples of significant weather events that affect human lives and the Nation's economy. Every season brings reminders of destructive and incapacitating weather. In recent years, hurricanes such as "Bob" in New England and "Hugo" in South Carolina caused billions of dollars in damage in addition to causing injuries and some fatalities. Weather is a factor in aircraft accidents and incidents, massive chain reaction highway accidents, etc. Hardly a day goes by without weather or weather effects being in the headlines in some part of the country.

Improvements in the detection and short-range predictions of adverse mesoscale weather would benefit a broad range of economic and social activities. Examples of these include agriculture, ground, air and sea transportation, construction, outdoor recreation, and military operations.

Many panels, committees and working groups have reviewed and studied the requirements for and the progress in mesoscale research. Most have issued reports or statements describing the current status of mesoscale research and have provided recommendations on actions needed to exploit new technology, advance the science and improve forecasts of mesoscale events.

The earlier work of these groups (many under the sponsorship of the National Academy of Sciences) helped focus attention on mesoscale phenomena and stimulated more research and development efforts. A Committee for Mesoscale Processes was organized by the American Meteorological Society during the early 1980s. Since 1983 this committee has sponsored five major conferences on mesoscale processes. Reports from these conferences are available in conference preprints or in conference summary articles published in the Bulletin of the American Meteorological Society. Another very positive outgrowth from the various groups is the cooperative programs among Government agencies to develop, acquire and field new observational measurement systems such as the Next Generation Weather Radar (NEXRAD), automated surface observation systems, aircraft sensors, etc.

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* This section was prepared by Floyd F. Hauth (Colonel, USAF, Retired) under contract to the Office of the Federal Coordinator for Meteorology (OFCM). It includes an abridged version of the Mesoscale Meteorology Plan prepared for the U.S. Weather Research Program. Mr. Hauth represented the U.S. Air Force and the U.S. Army at the OFCM at the time of his retirement in December 1991.

Considering the interest in mesoscale research and the potential benefits from applications of new technology in this area, an abridged version of a report** by the Subcommittee on Atmospheric Research, Committee on Earth and Environmental Sciences provides a summary of recent and current research activities by U.S. Federal agencies and a strategic plan to guide future work in mesoscale meteorology.

Mesoscale Meteorology Plan

Predicting Our Weather: A Strategic Plan for the U.S. Weather Research Program

(Abridged Version for the Federal Plan)

INTRODUCTION

On almost a daily basis, our society discovers new exposures and frailties that demand better weather forecasts. Among the information most critically needed are atmospheric observations at mesoscale resolution -- space and time scales on the order of tens of kilometers and minutes that are too small to be adequately resolved by our existing observing network. To meet this challenge, NOAA, the FAA, and DOD are implementing new weather observing technologies such as NEXRAD, ASOS and GOES-Next, as part of the modernization of the national weather observing network. These systems, together with modern data-handling and computing technology, will enable earlier detection and public warning of severe weather events and will also provide the first continuous observations of previously unresolved mesoscale weather processes. Inherent in these new data is the prediction potential to achieve significant improvements in local and regional weather forecasts.

An effective and well-coordinated national research program is required to develop the understanding, techniques, and systems needed to translate the new observational data into dramatically improved forecasts.

Planning for this program was led by the Committee on Earth and Environmental Sciences (CEES), Subcommittee on Atmospheric Research, in close collaboration with the National Academy of Sciences (NAS). Participating agencies include the Department of Agriculture (USDA), the Department of Commerce (DOC), the Department of Defense (DOD), the Department of Energy (DOE), the Department of the Interior (DOI), the Department of Transportation (DOT), the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF).

Weather Prediction: The National Stakes

The U.S. Weather Research Program will produce benefits in four broad areas: reduced fatalities and injuries due to weather hazards; reduced private, public and industrial property damage; improved efficiency and savings for industry, transportation, and agriculture; and improved flow of more accurate weather forecasts to the public and public officials. The potential annual benefit to the Nation in these areas is hundreds of lives saved, thousands of injuries averted, and billions of dollars conserved. Specific arenas where the U.S. Weather Research Program will decrease our Nation's vulnerability to weather are listed below.

** "Predicting Our Weather: A Strategic Plan for the U.S. Weather Research Program," A Report by the Subcommittee on Atmospheric Research of the Committee on Earth and Environmental Sciences, July 1992.

Natural Disaster Reduction and Public Safety. *Each year, some one thousand Americans die in their homes, or in the course of their daily affairs, because of mesoscale weather events such as thunderstorms, squall lines, hurricanes, winter storms, and the severe phenomena that accompany them: lightning, flash floods, storm surge, tornadoes, strong winds, and blizzards. Thousands more are injured or suffer serious financial loss. Weather is responsible for 85 percent of the U.S. natural disaster areas declared by the President.*

Safe and Efficient Aviation and Other Transportation. *Each year, weather causes or contributes to six thousand fatalities on U.S. highways and eight hundred deaths in aviation accidents. Half of all flight delays are attributable to weather while uncertainties in predictions of flight-level winds add a quarter billion dollars annually to the national aviation fuel bill. Incorrect marine weather forecasts result in significant losses for ocean shippers who use the forecasts to plan the most efficient routes. An urban society is dependent on effective snow prediction and removal for day-to-day operation. Over $750 million per year, a significant fraction of snow removal costs, is spent preparing for forecast snows that never occur!*

Agriculture. *Farming has always been vulnerable to weather. Attempts by the agricultural sector to supplement rainfall with energy-intensive irrigation projects have introduced new weather sensitivities. The drawdown of major aquifers has continued to increase the costs of irrigation. Planting, applying fertilizers, pesticides and herbicides, and harvesting crops could be done more efficiency with improved weather forecasts. More accurate weather forecasts on time scales of hours to many days offer agricultural benefits worth billions of dollars annually.*

Water Resource Management. *Stream flow control, land management, precipitation augmentation and other watershed management methods are used nationally to achieve a variety of goals, including flood control, water conservation, water quality, and hydroelectric power production. Management decisions are weather sensitive, and are based on forecasts out to hours, days, or weeks. In some cases, improved use of weather forecasts can eliminate the need for additional dams. The value of accurate forecasts to the water resource management sector is estimated in the billion-dollar-per-year range.*

Effective Energy Production, Use and Environmental Protection. *Our highly industrialized society depends on a variety of energy sources and production techniques that can adversely affect humans and their environment. For years, pollutants from fossil fuel power plants and vehicle exhausts have produced acid precipitation, as well as ozone in the troposphere, where it is considered a pollutant. The total impacts of these emissions can be assessed meaningfully only with detailed understanding and modeling of the mesoscale circulations that control their atmospheric dispersal. Coping with accidental releases of toxic or radioactive materials requires knowledge of the entire range of weather conditions. Mesoscale circulations also affect the wind-driven trajectory and ultimate impact of oceanic oil spills, such as from the EXXON Valdez.*

Space Flight Operations. *The growing importance of space flight operations for communications, natural resource industries, environmental sciences, planetary sciences, and national defense has combined with international attention to make weather prediction for the Kennedy Space Flight Center one of the most visible, high-stakes weather forecasting operations in the U.S. The Space Shuttles are uniquely vulnerable to high-level winds, wind shear, clouds, precipitation, and atmospheric electricity, and they are launched in the most thunderstorm-prone region of the U.S. Weather remains a significant and costly wild card in scheduling Space Shuttle launches and landings.*

Defense. *Throughout history, weather has determined the success or failure of military enterprises. New technologies have changed the nature of armed conflict and support operations in ways that have increased the impact of weather. The shift on the battlefield from the foot soldier to helicopters, tanks, and mobile artillery creates demand for weather information along planned routes. The introduction of electro-optical weapons and use of obscurants increase the importance of visibility forecasts. The hazards of chemical and biological agents make short-term, localized prediction of transport and diffusion over irregular terrain a necessity. Aircraft carrier protection and electro-optical weapons change the need for weather information at sea. Use of on-board computers and composite materials for light weight and stealth, has made aircraft more vulnerable to dust and atmospheric electricity.*

Related Areas of Earth Science. *A broad range of research efforts across the earth sciences hinges on improved understanding of weather processes, particularly on the mesoscale. To assess the effects of greenhouse gases on global warming there is a need for better understanding of the individual weather events comprising the hydrologic cycle, as well as the feedbacks between clouds, radiation, and the earth's vegetation, land and oceans. Some two thousand thunderstorms that are underway at any moment worldwide inject trace gases and aerosols into the stratosphere, but the importance of this process has yet to be clearly defined. Lightning from these storms is an important but poorly understood natural source of nitrogen oxides. The U.S. Weather Research Program will provide high resolution data sets that are important complements to broad-domain process studies of global change.*

CURRENT RESEARCH ACTIVITIES

Individual agency efforts in mesoscale research reflect their particular missions and build on their respective scientific and technical strengths. In the U.S. Department of Agriculture, the Agriculture Research Service uses hydrologic models to assess how changes in water supplies vary with meteorological conditions. Results from this research will lead to improved management techniques for individual, basin and regional water supplies.

Within the Department of Commerce, NOAA is responsible for monitoring and predicting the atmosphere on all time and space scales and archiving data for use in research. Emphasis in current research includes:

- *developing new techniques to measure atmospheric parameters*
- *increasing basic understanding of meteorological processes*
- *incorporating measurements and conceptual models using integrated numerical weather prediction techniques*
- *developing local, regional and global forecast products*

The Department of Defense mission requires reliable and accurate weather data and forecasts for planning and conducting operations in response to contingencies or large scale conflicts. DOD research and development focuses on data acquisition capabilities and the use of such data in forecasts for tactical and strategic military activities.

The Department of Energy mission requires weather research in support of energy use and production, and emphasizes emergency preparedness; the transport, transformation, and ultimate fate of pollutants; and the effects of pollutants on the environment. Mesoscale circulations, and

boundary-layer processes are an important DOE focus, as most accidental releases of hazardous material occur in the boundary layer, and impacts are felt near or at the earth's surface. Other research relates to precipitation processes that play a major role in chemical reactions, venting of pollutants aloft, horizontal redistributions and atmospheric cleansing.

Within the Department of the Interior, the U.S. Geological Survey (USGS) conducts research on the interactions of atmospheric and hydrologic processes to develop an understanding of the sensitivity of water resources to both climatic and meteorological variations and changes. This effort involves the development of watershed models capable of predicting runoff, sediment yields, and water balance conditions for normal and extreme rainfall and snowmelt on land of varied terrain and usage. It also involves the development of model parameter estimates and their relation to measurable watershed and meteorological characteristics.

The Department of State Bureau of Oceans and International Environmental and Scientific Affairs provides foreign policy/foreign relations insight, guidance and assistance to mission responsible agencies seeking international agreements.

Within the Department of Transportation, the Federal Aviation Administration (FAA) sponsors:

- *research and development directed toward a better understanding of the meteorological phenomena hazardous to aviation, including microbursts and frontal wind shear, aircraft icing conditions, low visibility, hail, turbulence, high intensity rainfall, freezing precipitation, lightning, and strong, sustained winds;*
- *development of mesoscale numerical modeling and numerical weather prediction techniques specifically for the aviation hazards identified above and for short-term forecasts or nowcasts required for these intermittent and short-lived meteorological phenomena;*
- *development of meteorological products tailored for aviation meteorologists, air traffic controllers, and commercial and private pilots;*
- *development or refinement of sensors and software algorithms which detect, measure, or calculate the intensity of meteorological phenomena hazardous to aviation.*

The Environmental Protection Agency mission requires description of the mesometeorological environment to help identify source-receptor relationships and thus establish the basis for effective regulatory policy. EPA is particularly interested in research to enhance descriptions of mesoscale processes through modeling and data assimilation, the role of convective clouds in vertical transport of atmospheric constituents and atmospheric chemistry, and mesoscale processes as they relate to global climate and its regional ecological impacts.

The National Aeronautics and Space Administration is responsible for development and application of satellite technologies to conduct earth-science research from space to improve the understanding of interactive processes that regulate the total climate system. Research emphasis is to better understand:

- *mesoscale processes and their role in the global hydrologic cycle;*
- *related interdisciplinary process studies in atmospheric, oceanographic, and land sciences;*
- *remote sensing instrument development; improvement of algorithms and inversion techniques for deriving useful scientific information from remote observation;*

- *development of data processing and data assimilation techniques, utilization of remote sensing data in numerical models for purposes of model initialization and verification and sensor performance assessment;*
- *testing and developing physical parameterization schemes for models.*

The National Science Foundation is responsible for maintaining the health of basic research in all areas of the atmospheric sciences. The Foundation supports theoretical, observational, and numerical modeling research with the goals of increasing fundamental understanding of mesoscale weather systems and improving mesoscale predictive capability. Research areas of emphasis are:

- *scale interaction field experiments aimed at improved understanding of dynamical and microphysical processes of mesoscale phenomena;*
- *development of advanced numerical mesoscale models;*
- *development of advanced research instrumentation;*
- *limited field experiments to determine characteristics of mesoscale phenomena in different portions of the globe with emphasis on tropical cyclones and impacts of mesoscale systems on the global weather system.*

PLAN DESCRIPTION

Implementation Strategy

Coordination Mechanisms. *Planning and implementing a broad and comprehensive mesoscale weather research program will require collaboration and program coordination among many institutions and agencies. These can be broadly grouped into two communities that are involved with the science of weather research and forecasting:*

National scientific community: *Includes both structured [National Academy of Sciences (NAS), American Meteorological Society (AMS)] and informal mechanisms (scientist to scientist) for planning science activities.*

Government agencies: *Includes individual agencies of the Government that support and conduct weather research and the coordinating bodies for these agencies within governments.*

No single Federal agency encompasses the breadth required by the U.S. Weather Research Program. An effective confederation is required to support and conduct the needed activities. Moreover, the complexity and scope of the research required underscores the advantages of an effective interface with coordinating bodies, including the NAS. It is of paramount importance to establish and maintain these coordinating mechanisms.

Strategic Priorities

The CEES/SAR has developed a multi-level priority-setting framework that can be used to focus and integrate program development and budget proposals. See figure 4-1. The five strategic priorities are:

Increase the national benefits from the substantial dollar investment in weather observation modernization. *The Program will achieve high leverage by building upon the multi-billion-dollar modernization of the national weather observing network that is already underway.*

Improve local and regional weather forecasts. *The Program will achieve quick economic payoffs by realizing the potential of the hardware investment for improved predictions as well as warnings. Effective transfer of new forecasting techniques from research activities to operations will be accomplished through experimental forecast centers and by education and training programs.*

Focus on the multiscale nature of weather. *The Program will achieve quick scientific payoffs by answering research questions that impede progress not only in mesoscale weather but also in related fields of science, including global change, hydrology, and atmospheric chemistry. It is an integrated program designed to understand how weather phenomena on different scales interact to affect each other.*

Coordinate government, university, and private-sector efforts. *The Program will achieve efficiencies by coordinating efforts of Federal agencies, state institutions, the academic research community, and the private sector. Only through cooperation of this type can the key scientific and intellectual resources of our Nation be focused most productively.*

Complement research on global change, water resources, and natural disaster reduction, by addressing critical regional-scale scientific issues. *The Program will characterize local and regional scale precipitation and hydrologic processes that: (1) are critical inputs to climate and global change research, (2) are fundamental to progress in understanding ground water processes and managing water resources, and (3) will allow for earlier predictions and warnings of natural disasters such as floods.*

Integrating Priorities

The U.S. Weather Research Program has four parallel and interrelated priorities, one or more of which must be served by any research project or activity of the Program. These integrating priorities are listed below.

Document the detailed structure and evolution of weather systems. *This will be done by taking the following actions:*

Deploying and assessing observing systems. Measurement of all important physical quantities over the domain of interest (initially the Great Plains, subsequently the United States, and ultimately the entire globe), and resolve in both space and time the multi-scale processes that shape mesoscale weather systems.

The Program will build on capabilities of the modernized national weather observing network, now being implemented by the Departments of Commerce, Defense, and Transportation, which includes new polar-orbiting and geostationary satellites, the NEXt-generation RADar (NEXRAD) system, the Terminal Doppler Weather Radar System (TDWRS), the Automated Surface Observing System (ASOS), a national lightning detection network, and communications and computational capabilities, including the Advanced Weather Information Processing System (AWIPS).

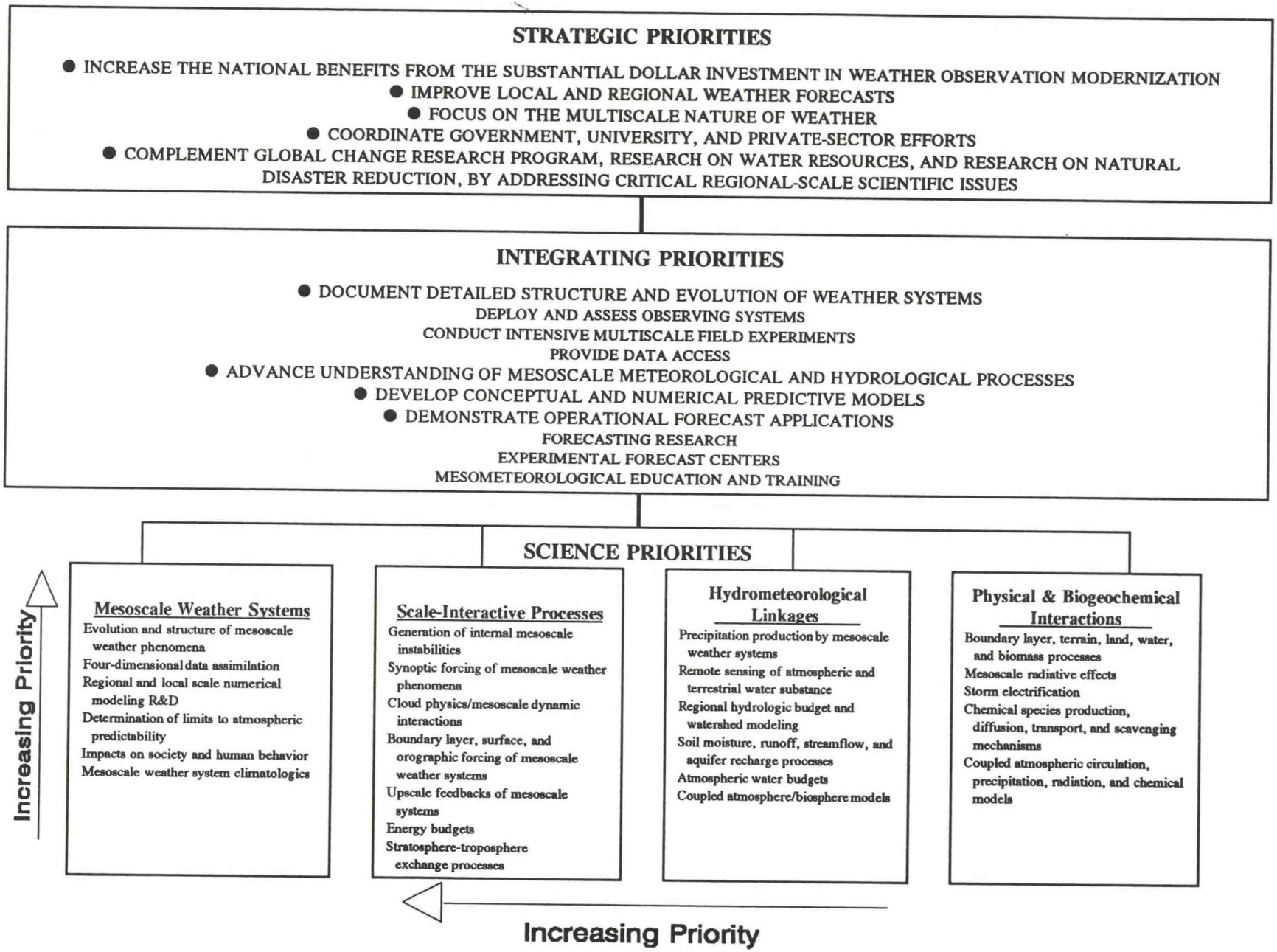

Figure 4.1 U.S. Weather Research Program Priority Framework

To these capabilities, the U.S. Weather Research Program will add wind profilers, expanded reporting of meteorological conditions from commercial aircraft, new satellite instruments such as altimeters, scatterometers, and radiometers, and other research instruments such as lidars, acoustic sounders, and airborne Doppler radars.

Conducting intensive multi-scale field experiments. Optimal use of the new operational data will require using Scale Interaction Experiments of several months' duration, focusing on limited regions, which will provide more detailed observations of winds, temperature, humidity, clouds, precipitation, and boundary-layer conditions. These experiments will provide critical information for the proper interpretation and diagnosis of the operational data.

Providing data access. Of critical importance to the success and impact of the modernization of the national weather observing network is the availability of data to the scientific community and the private sector.

Advance the understanding of mesoscale meteorological and hydrological processes. *Newly available modernized observations will be used to advance the fundamental understanding of mesoscale weather processes and their hydrological interactions, particularly with respect to severe weather development. Major advances are now possible in studies of the genesis, structure, evolution, and scale interactions of both intense winter storms and spring/summer convective systems. These high density data sets will provide a base for improving observing systems and developing new remote sensing capabilities that will allow improved watershed budgets and models to be developed.*

Develop conceptual and numerical predictive models. *This integrating priority includes research and development in mesoscale numerical modeling at a number of U.S. institutions coupled with a numerical weather prediction technology transfer interaction with the National Meteorological Center. Here, the Federal and academic research community will be able to test and evaluate new models and algorithms, prior to their operational implementation.*

Demonstrate operational forecast applications. *This will be done through forecasting research and establishment of experimental facilities described below:*

Forecasting research. Current weather observations, conceptual understandings, and centralized numerical predictions, form the basis for a broad range of weather services and products provided to the Nation by Federal agencies carrying out their respective missions. The advances in understanding and numerical weather prediction that will be achieved by the U.S. Weather Research Program, will allow corresponding changes in the entire Federal product line.

Experimental Forecast Facilities (EFF). To compress the time required to transfer science and technology from years into months, technology testing and transfer mechanisms will be developed between the research and operational communities. To speed this effort, participating Federal agencies will establish several Experimental Forecasting Centers at selected locations, where researchers and operational meteorologists, hydrologists, and chemists from Government agencies and universities will work together. Envisioned activities include:

- *An Experimental Forecast Facility, at NOAA's National Meteorological Center, to speed the improvement of the centralized numerical weather guidance that is the mainstay of most Federal efforts.*
- *An Experimental Forecast Facility, at NOAA's NWS Forecast Office in Norman, Oklahoma, that will concentrate on improving local forecasts and warnings based on centralized numerical weather guidance and high-resolution local observations.*
- *An Experimental Forecast Facility, at NOAA's Forecast Systems Laboratory in Denver/Boulder, Colorado, that will concentrate on improving information systems technology in support of short-range forecasting, and on meteorological conditions in the Front Range of Colorado.*
- *An Experimental River Forecast Facility, at one of NOAA's River Forecast Centers, aimed at improving the use of NEXRAD and other data in river management.*
- *An Experimental Forecast Facility, jointly funded by NOAA and the FAA, located at the National Severe Storms Forecast Center in Kansas City, Missouri. This facility will serve as a Terminal Area Weather Test Bed to develop advanced forecast weather products that are tailored to the needs of the aviation community.*
- *An Experimental Forecast and Technology Transfer Facility, for NASA's Kennedy Space Center, providing products tailored to the needs of spaceflight operations.*
- *Increased coordination between the USDA's Joint Agricultural Weather Facility and the National Meteorological Center of the Department of Commerce. This work will include new product development by NOAA and enhanced evaluation by USDA.*

Meso-meteorological education and training. *Operational forecasters require appropriate education and training to keep pace with the rapid advances in weather observing technologies and the science of mesoscale weather processes. Toward this goal, the NWS has established a program called the Cooperative program for Operational Meteorology, Education and Training (COMET). Through cooperative arrangements with universities and Government agencies, COMET's long term objectives are to: 1) improve operational forecasts and warnings through improved education and training, 2) facilitate the transfer of research results into operational forecasting, 3) serve the needs of the academic and operational communities and help bring them together, and 4) promote education and training through better access to data, improved interactions between forecasters and researchers, and participation of professors and graduate students in COMET activities.*

Science Priorities

Mesoscale Weather Systems. *Studies need to be conducted to improve understanding of the evolution and structure of mesoscale weather phenomena; the optimal spatial and temporal assimilation of the vast amounts of new data that soon will be available; conceptual and numerical models of regional and local weather; possible inherent limits to our ability to predict the weather; the impacts of severe weather and benefits of improved forecasts on society and human behavior; and regions which show climatological preferences for mesoscale weather system development.*

Scale-interactive Processes. *Research is required on the origins of instabilities and initiation of convection in mesoscale systems; influences of larger scale weather patterns on mesoscale processes; interactions of cloud and precipitation processes with mesoscale dynamics; influence of terrain and boundary layer processes on mesoscale weather system evolution; contributions of*

mesoscale systems to global circulation and climate processes; energy budgets associated with mesoscale systems; and mechanisms and processes associated with stratosphere-troposphere exchange.

Hydrometeorological Linkages. *Studies must be conducted to better understand the processes governing development, location, timing, amount and type of precipitation associated with mesoscale systems; techniques that allow remote sensing of atmospheric and terrestrial water substance; the constructs of regional hydrological budgets and watershed models; the mesoscale processes that affect the terrestrial component of the Earth's hydrologic cycle; moisture fluxes, precipitation efficiencies and atmospheric water budgets; and the coupling and modeling of atmospheric and biospheric processes.*

Physical and Biogeochemical Interactions. *Research is required on the influence of boundary layer processes and Earth's surface characteristics on biomass activity; the radiative interactions of mesoscale weather systems with local and regional weather, global circulations and climate; the processes that govern storm electrification in mesoscale weather systems; the production, diffusion, transport, and scavenging mechanisms of chemical species by mesoscale weather systems; and the integration and coupling of atmospheric circulation, precipitation, radiation, and chemical models.*

SUMMARY

The importance of mesoscale weather events is amply demonstrated in the U.S. Weather Research Plan. These events affect nearly every human activity and have cost many lives and hundreds of billions of dollars in damage in this country over the past several decades. As research and technology transitions to operations the payoff from improved detection and forecasting of mesoscale storms has tremendous potential in saving lives and in major benefits to the U.S. economy.

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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 awareness 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 several 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; a generalized statewide forecast twice daily; and a more general, 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 data base 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/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 similiar to those available from the private sector. The FY 1993 budget proposes that users of these specialized services purchase them directly from the private sector.

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. The FY 1993 budget proposes that state and local users of these specialized services purchase them directly from the private sector.

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, NOAA 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 3,000-4,000 reports from aircraft. Weather satellites provide cloud imagery, 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 second generation Regional Analysis and Forecast Systems (RAFS) models with 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-art physics, increasing resolution, and analysis.

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 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. NOAA will continue to incorporate improvements 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 will conduct 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 will develop 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 100-685 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. The interrelationships of all of the activities--facilities preparation, staffing augmentation, training, commissioning of systems, and realigning operations and services--have been planned so that the demonstration can begin in 1995. In addition to preparations for the demonstration, nationwide planning and implementation have begun: facilities preparation is on-going; training schedules for field personnel are being planned with necessary backup personnel to cover operational shifts; software development continues; new communications are being established; and all NWS offices are working on 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 Earth-observing satellite systems, as well as global data bases 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 the development and management of natural 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 that monitor daily weather and surface conditions over the globe. It is also responsible for operating two geostationary environmental satellites -- one that monitors the Atlantic Ocean, 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. The 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 to meet the needs of the National Weather Service. Based on an agreement between the United States and the European meteorological satellite organization (Eumetsat), a European geostationary satellite (Meteosat-3) was moved to a position of 50°W to cover the U.S. East Coast and the Atlantic Ocean. This permitted the movement of GOES-7 to its new position to enhance coverage of the Pacific Ocean. Agreement has also been reached to move a European satellite to a position as far West as 115°W, if necessary in case GOES-7 fails, to provide U.S. coverage until the launch of the next U.S. geostationary satellite.

The second major area of NESDIS' responsibility is environmental data and information management and dissemination. NOAA gathers global data about the oceans, earth, atmosphere, space, and Sun and their interactions to describe and predict the state of the physical environment. Many other agencies, organizations, and individuals, both domestic and foreign, collect similar data for particular uses and missions. Once the original collection purposes have been served, selected data flow to NESDIS data centers, which incorporate them into national environmental data bases that document the physical environment and its processes.

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 (CDA) facilities that command and control, track, and acquire data from these environmental satellites.

The Office of Satellite Data Processing and Distribution 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 (WSFO). 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 Facilites (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, DC; Miami, FL; Kansas City, MO; Honolulu, HI; San Francisco, CA; and Anchorage, AK. The Anchorage, Washington, and San Francisco SFDFs distribute data from both the polar-orbiting and geostationary systems. The San Francisco SFDF also has the capability of receiving data from the polar orbiting satellites.

The Office of Research and Applications provides guidance and direction for NESDIS research and application 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 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

The NOAA series of environmental polar-orbiting satellites replaced the ITOS system in July 1979. TIROS-N, the NASA prototype, was launched on October 13, 1978; and NOAA-6, the first NOAA-funded operational satellite of this series, was launched on June 27, 1979. In the years following, a series of NOAA polar orbiting satellites were launched. Currently, the primary operational spacecraft are NOAA-11 and NOAA-12. NOAA-9 and NOAA-10 also provide data from operational sensors.

NOAA-funded satellites retain the NOAA name and are numbered consecutively beginning with the number immediately following that last used in the ITOS series. These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. They carry advanced instruments to provide improved temperature soundings and microwave channels to facilitate sounding retrieval in cloudy areas. They also provide advanced multi-channel images and carry a data collection and platform location system. During the lifetime of the NOAA system, new instruments may be added or substituted for others. The first Advanced TIROS-N (ATN) satellite, NOAA-8, carried a search and rescue capability in addition to its standard instruments. 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 of 833, 814, 807 and 852 km, respectively, and provide environmental observations of the entire Earth four times each day. NOAA-10 crosses the Equator in a southward direction at 0700 local time. NOAA-11 crosses the Equator in a northward direction at 1354 local time. NOAA-12 crosses the Equator in a southward direction at 0730 local time and NOAA-9 crosses the Equator in a northward direction at 1702 local time. The orbital period of the satellites ranges from 101.23 to 102.2 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. Thus, the AVHRR instrument improves satellite services

in stored and direct readout radiometer data for day and night cloud cover, sea-surface temperatures, and snow 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 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 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 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 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 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 detectors included within this instrument are the Total Energy Detector and the Medium Energy Proton and Electron Detector. 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. The NOAA series data, as well as the geostationary series 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.

In addition to the four primary instrument Systems, the "afternoon" NOAA series spacecraft contain the Solar Backscatter Ultraviolet Radiometer and the Earth Radiation Budget Experiment. 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 micrometers to 400 micrometers. Data obtained from the instrument will be used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth.

The Earth Radiation Budget Experiment (ERBE) has two components. One is a non-scanner instrument with four earth-viewing radiometers, two of which are wide angle (limb to limb of the Earth), while the other two are medium angle (10° Earth central angle). A fifth radiometer is a shuttered, sun-viewing monitor. The wide and medium angle radiometers each have a total channel (0.2 to 50 μm), and a shortwave channel (0.2 to 5 μm). The sun-viewing radiometer measures the total solar spectrum (0.2 to 50 μm). A second component of ERBE is a cross-track scanner instrument with three earth-viewing radiometers having a 3° by 4.5° field-of-view. The spectral intervals of the radiometer are shortwave (0.2 to 5 μm), longwave (5 to 50 μm), and total (0.2 to 50 μm).

NOAA-9 and future polar satellites carry instruments for the operational monitoring of atmospheric ozone (the SBUV/2 is only carried on the afternoon or PM satellite) and will contribute to experimental monitoring of the Earth's radiation budget with the ERBE on NOAA-9 and NOAA-11 only. NOAA-8 and future polar satellites carry search and rescue (SAR) transponders, used to improve the detection and location of distress signals. This project is an international effort committed to global coverage for the search and rescue mission. The United States operates and maintains the SAR Mission Control Center and three ground stations. The ground stations receive Doppler signals directly from the satellite and process the information to provide the location of distress transmissions.

The ground system, required to receive large volumes of digital data from NOAA satellites, consists of two major subsystems -- the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). The DACS includes components at the Wallops, VA, and Fairbanks, AK, Command and Data Acquisition (CDA) stations; the Satellite Operations Control Center (SOCC) at Suitland, MD; and the Western European Station at Lannion, France. All the DPSS components are in the NOAA facility at Suitland.

DACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the DPSS processing and data handling facility. The delivery of NOAA system data from the CDAs to Suitland is accomplished by General Electric using the 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 DPSS for initial processing.

The DPSS 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 new Polar Acquisition and Control System (PACS) will replace DACS by May 1992.

GEOSTATIONARY SATELLITE PROGRAM

The geostationary satellite program began in 1966 as an operational experiment in which the imaging capability and weather broadcast system of the NASA Applications Technology Satellites 1 and 3 were used. This program became an operational reality following the launch of NASA's Synchronous Meteorological Satellites (SMS) 1 and 2 in 1974 and 1975. These satellites were the prototypes for NOAA's Geostationary Operational Environmental Satellites (GOES).

Since GOES-1 was launched on October 16, 1975, six more GOES satellites have been put into orbit. GOES-7, launched in March 1987, is currently positioned at 112°W. The next launch of a geostationary satellite, GOES-I, is currently scheduled for late 1993. NOAA currently plans to locate one spacecraft at 75°W and another at 135°W. As mentioned previously, NOAA will be receiving backup geostationary satellite support through an agreement with the Europeans. This will provide overlapping or concurrent viewing of the development and movement of destructive 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 the geostationary satellites starting with GOES-4. 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 7 km in the infrared wavelength. Full Earth disc pictures are available at 30-minute 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.

The concept of obtaining atmospheric soundings from geostationary satellites is being tested. GOES 6 and 7 are being used in an operational demonstration program to determine the capability of the VAS. Results have been excellent, and an operational demonstration of a ground system to use the VAS data to improve NOAA's operational weather analysis and forecasting programs is underway. The additional capabilities of the VAS are the multi-spectral imaging. The VAS has 12 infrared channels which are used to derive temperature and moisture profiles over selected areas. Sounding from a geostationary satellite affords several advantages over sounding from a polar-orbiting satellite. They are: (1) constant surveillance, (2) constant viewing geometry, (3) better determination of temporal and spatial gradients, (4) easier comparisons with radiosondes, and (5) synoptic large-area coverage. Starting with GOES-I, the systems will be capable of simultaneous imaging and soundings.

The VAS demonstration program has resulted in a VAS Data Utilization Center (VDUC) interconnecting the NWS's three major centers with NESDIS. Future development and direction of operational meso-meteorological systems will be influenced by the outcome of this VAS demonstration. The GOES also carry a Data Collection System 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. These 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. This instrument is similar to the SEM on board the NOAA series S/C and consists of a Magnetometer, an energetic particle monitor and later a Solar X-Ray Telescope.

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, will be equipped with work stations that will 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-90. After acceptance, this service, to be known as NOAAPORT, will be used to distribute other NOAA environmental data and satellite products to various users.

TABLE A.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA I	CY 1992
NOAA J	CY 1993
NOAA K	CY 1995
NOAA L	CY 1996
NOAA M	CY 1997

Instruments for Advanced TIROS N Series

AVHRR	Advanced Very High Resolution Radiometer
SEM	Space Environment Monitor
SBUV	Solar Backscatter Ultraviolet Radiometer
SAR	Search and Rescue System
ERBE	Earth Radiation Budget Experiment
HIRS	High Resolution Infrared Sounder
SSU	Stratospheric Sounding Unit
MSU	Microwave Sounding Unit
DCS	ARGOS Data Collection System

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES I	CY 1993
GOES J	CY 1994
GOES K	CY 1998
GOES L	CY 1999
GOES M	CY 2003

Instruments for GOES Series

VISSR	Visible Infared Spin Scan Radiometer
VAS	VISSR Atmospheric Sounder
SEM	Space Environment Monitor
DCS	Data Collection System
GIS	GOES Imager and Sounder (I-M)
SAR	Search and Rescue

*Launch date depends on performance of prior spacecraft.

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 Command and Data Acquisition Stations at Wallops, VA, and Fairbanks, AK. 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, MD.

Another major component is the Environmental Satellite Distribution/Interactive Processing Center (ESD/IPC) in Camp Springs, MD. The ESD/IPC is connected in turn with the Fairbanks CDA station, and the six Satellite Field Distribution Facilities. The Fairbanks CDA station also relays satellite data by land line and microwave circuits to the Anchorage SFDF and the NWS WSFOs at Anchorage and Fairbanks. The WSFO at Juneau, AK, receives satellite data from the Anchorage SFDF. By the end of FY 1988, SATCOM consisted of over 60 data links required for the operation of the satellite data processing and distribution system.

SUPPORTING RESEARCH PROGRAM FOR FY 1993

The requirements and goals addressed by NESDIS supporting research in FY 1993 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 Environmental Sciences);
- The modernization effort of the National Weather Service (per P.L.100-685);
- The improvement of the monitoring of the global ocean and the management of resources in the coastal zones;
- The management of data that will be needed to support the above;
- The evaluation, validation, and implementation of new products and services from GOES-I; these will support the NWS modernization;
- The continuation of products and services from the polar orbiting satellite system.

Research and the 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; programs for agriculture, fisheries, coastal zone management, 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 (both 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 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-I;

analysis of the data also leads to applications with the other modernization tools that include NEXRAD, Profilers (wind and temperature), ASOS, and AWIPS.

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.

Improvement in the methods for estimating precipitation from satellite data is important for forecasting flash floods on the local scale, and, on the global scale, important to the understanding of the effects of the release of latent heat of condensation in both numerical weather forecasts and in numerical climate models. Other measurements from satellites requiring continued study and improvements are solar insolation, the "vegetation-index" of biomass concentration, and winds derived from cloud motions. These contribute to understanding the hydrologic and biogeochemical cycles.

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;
- As a designated agency Federal Records Center, operates the Center for NOAA 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 data bases 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 programs. 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 on global climate change throughout the world have increased the challenge of managing climate data and serving the research community. To meet this challenge, NCDC will be 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 needs for monitoring climate change.

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 data base. 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 data bases.

In FY 1992, the NCDC plans to:

- Continue technology upgrade (i.e., computers, on-line storage, communication, etc.) to meet the data management and services through the 1990's;
- Implement new processing systems to account for the changed concept in processing data from automated systems and to accept new data streams;
- Study the characteristics of data collected with automated systems versus manually observed data and continue the development of techniques to treat data to form homogeneous long series data bases;
- Working with the World Meteorological Organization, participate in 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 global change;

- Develop CD-ROM based systems to describe the climate of the United States and to present data and information from around the world;

Climate Services

The demand for the basic climatic data and information services has been increasing annually. The recent concern for climate change has placed an increased need to readily identify the availability of data bases and to service large volumes of data. NOAA has implemented a NOAA Master Directory and will be expanding the capabilities of this directory that will help users access data. The NCDC plans to develop an interface between the NCDC data inventory system and the NOAA directory to provide more information to users. An automated system to allow users to browse (review available data products), to order and for cost accounting will be implemented. Expanded on-line access to data bases is planned.

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. As of April 1992, the TOGA tropical Pacific thermal data base assembled by the JEDA Center contained 135,316 temperature profiles. 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 temperature and salinity data. While the JEDA Center at Scripps continues its focus on the Pacific Ocean, the Commonwealth Scientific and Industrial Organization of Australia is providing management and quality control for Indian Ocean data, and NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami is providing management and quality control for data from the Atlantic Ocean. The NODC receives both near-real-time and delayed-mode temperature-salinity data and merges them into a continuously managed global database.

Through the creation of the Joint Archive for Sea Level, the NODC is 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 stations in the Pacific Ocean Sea Level Network originally established as part of the North Pacific Experiment (NORPAX), which began in 1974, as well as stations operated by many national and foreign agencies. The archive of sea level at the NODC included hourly, daily, and monthly sea level values for 94 stations in the Pacific Ocean and 40 stations in the Indian Ocean. Data from the first Atlantic Ocean stations are being reviewed and quality checked at JASL and will be added to the NODC data archive.

An initial project of JCRMOD was the establishment and operation of the 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 under development with operations planned for mid-1992.

To promote efforts to locate and preserve older, historical ocean data, the NODC has organized the Ocean Data Archaeology and Rescue Project. A set of global data location plots showing the geographic distribution by year of NODC's temperature and salinity data holdings has been produced and distributed to other major oceanographic institutions and data centers worldwide to enable researchers and data managers to see what data are available, to determine temporal and spatial gaps in the data coverage, and to identify data that are not in the archives. In the coming years, preservation of ocean data resources in the nations of the former Soviet Union will receive high priority. As one step in this process, the NODC will host visiting scientists from Russia in order to foster cooperative work in ocean data rescue, management, and analysis.

In a related effort, the NODC is supporting the joint NOAA-NASA program to preserve certain large data sets important for climate applications. Designated as "Pathfinder Data Sets," these include Advanced Very High Resolution Radiometer (AVHRR) satellite data that have a current data volume of about 4 terabytes. Using its WORM Optical Disk Autochanger, the NODC is migrating AVHRR satellite data from deteriorating magnetic tapes to optical disk. The NODC recently completed converting the 1987 data consisting of over 220 gigabytes held on 1,750 cartridge tapes to just 35 optical platters. Work is continuing on data from other years.

Data Services

In FY 1991, the NODC fulfilled a total of 10,220 user requests and disseminated a total of over 210 gigabytes of digital data to customers. The NODC has accelerated production of ocean data CD-ROM.

NODC's first prototype CD-ROM contained temperature and salinity profiles for the Pacific Ocean. Accompanied by data access and display software on floppy disk, this CD-ROM was released to selected researchers for testing and evaluation. This first NODC CD-ROM was very successful and prompted many user comments and suggestions. These suggestions were incorporated into a two-volume set of CD-ROMs containing global temperature and salinity data that was released in July 1991. Disc 1 of this set holds 1.62 million temperature and salinity profiles from the Atlantic and Indian Oceans totalling 451 megabytes of data. Disc 2 holds 1.57 million profiles from the Pacific Ocean totaling 474 megabytes.

In cooperation with the NOAA National Ocean Service, the NODC produced a set of six CD-ROMs holding enhanced geophysical data records (GDRs) from the Exact Repeat Mission of the U.S. Navy Geosat (Geodetic Satellite). The data on the CD-ROMs span the period from November 1986 though December 1989. The new Geosat GDRs were prepared by the NOS Satellite and Ocean Dynamics Branch and are based on new satellite orbits that are more precise than the original orbits by an order of magnitude. The recomputed data are referred to as "T2" Geophysical Data Records because the new orbits are based on the GEM-T2 gravity model. In addition, the T2 GDRs contain other new fields that significantly increase the overall accuracy of the Geosat data. The last in this set of six Geosat CD-ROMs was completed in March 1992. It is expected that other Geosat data sets will be released on CD-ROM in the future.

With assistance from WDC-A, Oceanography, NODC has compiled inventories of ocean measurement (oceanographic station data and salinity, temperature, density) programs that have repetitive sampling at the same locations for long time periods. A total of 27 time-series data sets ranging in minimum duration from five years for North Pacific Ocean Weather Stations and related sections to more than 30 years for the CALCOFI sections have been identified and researched. A total of 56 North Atlantic sections have also been fully inventoried. Final manuscript has now been completed for both inventories. A third inventory covering 19 sections from the remainder of the World Oceans has also been completed. These sections are from the Mediterranean, North,Barents, and Tasman Seas, as well as from the South Atlantic. Finally, an inventory and data from the 10 Ocean Weather Stations are now available.

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

- the NOAA Central Library in Rockville, 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 libraries are placing special emphasis on providing information services to climate and global change researchers.

Technology Enhancements

To facilitate production of ocean data CD-ROMs, the NODC installed a CD-ROM premastering workstation that was first used to produce the set of six Geosat CD-ROMs. This workstation allows data to be formatted and written to 8mm Exabytes cartridges in the ISO 9660 standard. The premastered data are then shipped to a commercial production facility that produces the CD-ROMs.

In November 1991, the NODC's in-house computer resources were expanded and upgraded. NODC's VAX 6000/410 was upgraded to a VAX 6000/510 and a VAX 8530 was added to the clustered system. In addition, 29 PC-386s and 40 PC-486s were procured to replace older, outdated units. The new PCs are connected to NODC's Ethernet LAN providing enhanced distributed processing as part of an upgraded ocean data management system.

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 data base 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 data bases derived from tree-rings, 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 researchers 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 record of past conditions that document the impact of changing solar energy output affecting Earth. Continued older types of observation of solar activity provide continuity with the past and provide a means to calibrate new types of measurements made using modern instruments on Earth and in space. 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. This cycle has been correlated with changing climatic conditions. 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 from above the shielding atmosphere. For the past 11 years, satellites have carried absolute instruments above the atmosphere to record significant changes in the "solar constant," the total luminous output of the Sun. These data are studied at NGDC, combined with complementary geomagnetic and ionospheric databases, and made available to the research community in publications and on computer media that include magnetic tapes, floppy diskettes, and Compact Disc-Read Only Memory (CD-ROMs).

NGDC, through its affiliated contract data center, the National Snow and Ice Data Center (NSIDC) maintains several cryosphere-related datasets 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 Coordinated Eastern Arctic Experiment, the Second Greenland Ice Sheet Program (GISP II) and the National Science Foundation-funded Arctic System Science Ocean-Atmosphere-Ice Interaction (ARCSS/OAI) 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 Climate and Global Change Program (CGCP) sponsorship, NSIDC is studying ways to utilize the ingest and output data streams from the Naval Polar Oceanography Center's Digital Ice Forecast and Analysis System for climate research. NSIDC is also developing an improved global snow cover model for the Air Force Global Weather Central.

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 annually revised 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, and now an educational product being made available to the teaching and research communities. In addition to integrated database products distributed on CD-ROM, NGDC also maintains and improves individual disciplinary data sets related to this mission, including: global ecosystem classification, vegetation classes, vegetation indices, land cover, global topography, soils, geographic boundaries, and global phytoplankton pigment concentrations. 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 Profiler Program Office of ERL, located in the Forecast Systems Laboratory, is deploying the wind profilers that will make up the 29 station Wind Profiler Demonstration Network (WPDN) in the central United States. Installation of the systems was completed in early 1992. Wind data from this network will be used to assess the operational impact of this new technology.

The Wave Propagation Laboratory (WPL) continued to operate three automatic tropospheric wind profiling radars and total water (i.e., vapor and precipitation) measuring radiometers in Colorado during FY 1992. Only two of the wind profiling radars are co-located with radiometers. Observations from the systems of WPL and Profiler Program Office contribute to development and test methods for effective use of continuous profiler data to improve NWS short-range, local forecasts. The data will continue to be used in real time by the Denver National Weather Service and surrounding Forecast Offices, and for research by ERL, the National Center for Atmospheric Research, and university researchers.

WPL will continue studies to improve the accuracy and height resolution of wind, temperature, and humidity profiles. Low-altitude vertical temperature profiles comparable to those of the radiosonde are currently being produced by the Radio Acoustic Sounding System (RASS). The altitude is extended by combining the RASS measurements with TIROS N satellite data. Development of both the RASS and the thermodynamic (temperature/moisture) remote sensing profilers will continue in FY 1993. The development of a high resolution interferometric sounder (HIS) began in

FY 1990 and will continue into FY 1993. The remote sounder will provide ground based measurements of atmospheric temperature and humidity profiles and trace constituents.

Profiler radars can also detect precipitation and large cloud particles. From the time-continuous records of Doppler spectra as a function of height, the size distribution of precipitation particles, their temporal evolution, and their change with altitude can be monitored. Several case studies have been conducted that illustrate how the profiler can observe the morphology of drop size distributions in liquid precipitation. This work will continue in 1993.

The technology of infrared Doppler lidar and multifrequency radars will be advanced by continued application to wind, aerosol, and turbulence studies, as well as to convective storms.

Severe Weather Analysis and Forecasting Research

The National Severe Storms Laboratory (NSSL) in Norman, OK, focuses its research to understand and forecast severe convective storms and their associated weather hazards such as hail, high winds, heavy rain, lightning and turbulence. The parameters of storm development and intensification are identified by incorporating observations from Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning location networks. NSSL provides significant technical and scientific support, including research and development, for the NOAA/USAF/FAA NEXRAD program.

NSSL will continue to develop techniques, in cooperation with the National Weather Service, to identify and warn of weather hazards to aviation and the general public. Immediate technology transfer will be effected by close association with the National Weather Service Forecast Office in Norman, OK.

In FY 1992, ERL continued to transfer knowledge of Doppler radar applications, convective 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. This level of activity will be continued in FY 1993.

The Program for Regional Observing and Forecasting Service (PROFS) in Boulder, CO, is continuing to improve the effectiveness of short range, locally specific, weather services. The improvements are achieved through a program of applied forecasting research and development based on new understanding of storm development as determined by the research community. PROFS integrates these advances with emerging technologies, advanced observational systems (such as NEXRAD, VAS, and the WPDN), and conventional data. These quasi-operational systems are specific hardware/software configurations of the highly flexible PROFS Exploratory Development Facility, with extensions into Denver and Norman WSFOs under the NWS AWIPS program. These advanced capabilities will be evaluated to reduce the risks of AWIPS procurement, to improve forecasts and operations, and as a prototype of the NWS forecaster work-station of the 1990s.

PROFS will continue its emphasis on data application from the GOES VISSR Atmospheric Sounder (VAS), Doppler radar, 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.

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, ERL scientists 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.

Hurricane Analysis and Prediction Research

The Hurricane Research Division (HRD) of the Atlantic Oceanographic and Meteorological Laboratory 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.

HRD purchased and installed a computer work station on one of NOAA's P-3 research aircraft. The new work station, together with appropriate software developed by HRD scientists, will enable HRD to conduct airborne real-time processing and analysis of fields such as radar data, omega dropwindsonde data, stepped frequency microwave radiometer data, and in-situ flight level data. The results will be transmitted to the National Hurricane Center in real time via the GOES satellite. The system was subjected to a partial test in Tropical Cyclone Marco during 1990. A similar work station was installed on the other NOAA P-3 and HRD continued development and testing of these systems in FY 1992.

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.

The Wave Propagation Laboratory, through cooperative agreements with the National Center for Atmospheric Research, continues to apply four-dimensional data assimilation modeling techniques to simulate Profiler Network observations. Results have demonstrated the importance of co-locating RASS temperature capabilities with wind profilers and will provide information for determining the necessary density of an operational wind profiler network.

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 contexts 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. The primary focus for air quality is on understanding the processes of surface ozone formation in rural regions and the contribution of natural hydrocarbons to these processes. This work is accomplished through field experiments, laboratory work, and numerical modeling studies.

The Wave Propagation Laboratory uses its remote sensor capabilities (e.g., wind profilers and lidars) to understand the interaction of meteorological processes in air quality.

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 in real time, 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, and support, 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; and water level 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, which record and transmit surface meteorological information four times per day at synoptic hours. Of these vessels, about 80 also are equipped to collect expendable bathythermograph (XBT) data.

TOGA Southern Hemisphere Drifting Buoy (SHDB) Program. In support of the Tropical Ocean and Global Atmospheric (TOGA) Program, NOS maintains a network of thirty 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.

TOGA-Tropical Atmosphere Ocean (TAO) Moored Array. NOS is a partner with OAR in the implementation of the TOGA-TAO moored buoy array. TOGA-TAO is a basin-wide array of moored ATLAS buoys in the tropical Pacific deployed in support of TOGA 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 are presently 27 buoys deployed and plans call for a full implementation of 62 buoys by 1993. The array is operated by the TOGA-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 the research objectives of TOGA, the real-time availability of the data makes it extremely valuable to the national operational meteorological centers.

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.

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 -- the NOAA Ocean Products Center (Camp Springs, MD) which provides marine weather and physical oceanographic products, and the Navy/NOAA Joint Ice Center (Suitland, MD) which provides analyses/forecasts of hazardous ice conditions for the Great Lakes and Polar regions.

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 at Miami International Airport in 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 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 Navy's Naval Oceanography Command and the Air Force Weather support system are the primary sources of military weather support. The military weather services contribute to the national and international weather observing capability by making 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 Program 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 (AF) 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). 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 reporting to HQ USAF/XOW. AWS provides centralized weather and space environmental support to designated users through three centralized support organizations: Air Force Global Weather Central (AFGWC), USAF Environmental Technical Applications Center (USAFETAC), and Air Force Space Forecast Center (AFSFC). Additionally, AWS transitions technology to operational capabilities; manages Air Force-wide weather systems; and provides standardization, interoperability, and effectiveness evaluation of the Air Force weather support system.

The Office of Management and Budget Circular A-62, 13 November 1963, divided meteorological services into two types--basic and specialized. Although involved in both services, Air Force is more heavily oriented toward specialized services, supporting military aviation, combat air and ground operations, and space operations. The general functions involved in providing meteorological services include:

- Observing weather conditions;
- Communicating meteorological data and information;
- Preparing analyses and forecasts;
- Issuing and disseminating forecasts and warnings;
- Providing specialized support.

Observations

Meteorological observations are frequently 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 at both Air Force and Army locations (fixed and tactical) are manually prepared with some atmospheric elements being sensed by instruments and some directly by the observer. These observations 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 162 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 is obtained from U.S. civil and foreign sources, as well as rawinsonde (fixed and mobile) facilities operated by the Air Force. 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 87 fixed weather radar sets (20 at overseas locations) and five 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 DOD meteorological satellite system provides a large volume of cloud, upper air and space environmental data for strategic and tactical support and is the most important single source of global weather data. The Defense Meteorological Satellite Program (DMSP) is the DOD operational environmental satellite system managed by the Air Force to support worldwide military requirements. On-board sensors provide to AFGWC and the Navy's Fleet Numerical Oceanography Center (FNOC) visible and infrared (IR) images of the entire globe, temperature soundings, auroral electron counts, and other specialized environmental data. DMSP also supplies direct, real-time readout of regional cloud-cover information (visible and IR) to selected U.S. military terminals located around the world.

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, 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.

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 AWN is the backbone of military weather communications. High-speed computers interconnected with 2400 baud to 56 Kbps circuitry are used to deliver foreign and domestic weather data to designated users. Weather intercept sites in key overseas areas obtain weather data from foreign weather broadcasts for AWN delivery to AFGWC. The AWN also delivers these data to the Navy's FNOC and to NOAA's National Meteorological Center. Overseas collection and dissemination teletype networks are driven by the AWN Automatic Digital Weather Switch (ADWS) computers at Hickam AFB, HI, and RAF Croughton, UK. In the continental US (CONUS), the AWN at Carswell AFB TX drives the Automated Weather Distribution System (AWDS), the CONUS Meteorological Data System (COMEDS), and other special teletype systems to collect and disseminate 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 the facsimile system, providing graphic data to worldwide military users. CFEP drives the separate networks serving the CONUS, Alaska, Europe, Central America, and the Pacific, using computers to store and forward required products.

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 seven mainframe production computers, a cluster of three super minicomputers for computer flight plan generation, and an interactive graphics and imagery system. The computer-based operation of AFGWC uses a "build-and-apply" concept. Worldwide weather data are relayed to AFGWC via the AWN and blended with civil and military meteorological satellite data to construct a real time, integrated environmental data base. Scientific computer programs further digest the data to construct models of the atmosphere and to forecast its future behavior. Final tailoring of the data is accomplished for application to the specific problem of the decision maker. The interaction between forecaster and machine is accomplished with the Satellite Data Handling System (SDHS). SDHS consists of 35 interactive workstations capable of high-speed interaction with satellite and conventional meteorological data to prepare forecasts and other environmental products. SDHS provides man-machine interactive computer support to virtually all tasks formerly performed manually within AFGWC. The Federal Plan for Mutual Support and Cooperative Backup Among Operational Processing Centers designates AFGWC as backup for the NWS's facsimile network and NWS's National Severe Storms Forecast Center.

In support of combat operations, the Air Force weather support system operates centralized units consisting of AFGWC, USAFETAC, AFSFC fixed theater Forecast Units (FU), deployed Tactical Forecast Units (TFU), and fixed Weather Support Units (WSU). Normally weather support is a mix of centrally and locally produced meteorological products. AFGWC is generally responsible for forecaster aids (analyses and prognoses) and other operational support products for general purpose use by 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 TFU 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 will

directly support deployed weather teams whenever the theater FU lacks support capabilities, a TFU is not established, or during the period when the deployed TFU is not yet operational.

Dissemination of Forecasts and Warnings

The Air Force and Army require worldwide meteorological services to support 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 support system contributes to the unique global needs of military aviation and makes its information available to civil aviation. Air Force personnel provide flight weather briefings, air/ground radio services, and tailored observations, forecasts, watches, and warnings to support military requirements.

An aspect of special emphasis in military weather support is the need to provide adequate decision-assistance to commanders and resource managers. To fulfill this requirement, designated Air Force personnel serve as part of the working staff of supported Air Force and Army units. In this capacity, Air Force identifies all weather sensitive areas of the supported operation, monitors the weather service provided in these areas, and provides expert advice when weather threatens to restrict training or combat operations. This effort helps ensure that Air Force and Army units are able to fulfill their missions in spite of adverse weather, and it results in efficient use of weather resources by gearing them to mission essential support needs.

Deployed weather teams are the basic units supporting customers in a combat theater. These teams provide surface and upper air observations often by using tactical weather observing equipment, staff weather officer services, and forecasting support. The Tactical 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 support force. This system consists of regional broadcast stations at Anderson AFB, Guam; Elmendorf AFB, AK; Elkhorn, NE; Homestead AFB, FL; and Croughton, England.

Specialized Support

The USAF Environmental Technical Applications Center (USAFETAC), Scott AFB, IL, provides environmental data and specialized studies to support the USAF, U.S. 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 analyses extracted from meteorological satellite imagery (Realtime Nephanalysis);a global analysis of snow cover; solar, geomagnetic and space observations and indices; and many other specialized environmental data sets.

In addition to the specialized support 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 support into its overall support concept. The Army trains and orients Air Force personnel about Army organizations, concepts of operations, and the weather sensitivities of Army operations and equipment. Air Force support units are aligned and integrated with the Army intelligence organization. Support 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 for use in Army support is programmed by the Air Force. In a tactical environment, direct forecast support is normally provided down to corps, divisions, separate brigades, regiments, echelon-above-corps, 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 support 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. AWS 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. AWS 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 Oceanography Command Center, 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 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, including AFGWC.

The Air Force also 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.

Air National Guard

There are two distinct functions within the Air National Guard (ANG) weather program. The traditional ANG weather program consists of 34 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

USAF and Army 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.

The Air Force is modernizing its base-level weather support systems. This includes an Automated Weather Distribution System (AWDS) and the Next Generation Weather Radar (NEXRAD). Both of these systems have funds programmed for their R&D and acquisition phases. Installation of both systems is in progress.

The AWDS automates the handling of weather data by incorporating the latest state-of-the-art data processing, communications, and display technologies. The data-handling function will maximize forecaster capability. A modular design permits AWDS to be operated in a fixed or mobile environment and minimize staffing requirements. AWDS receives information from the National Weather Service via the AFOS through AFGWC. (AFOS is the NWS system also known as "Automation of Field Operations and Services").

To enhance AWDS in base weather stations and to expand the capabilities of forecasters in a combat environment, the AWDS Pre-Planned Product Improvement (P^3I) will provide the following capabilities: inter-system interoperability, high frequency radio for transportable AWDS, increased local graphic distribution, multiple software improvements, improved meteorological satellite ingest, and forecaster assistance through advanced processing techniques and command post staff weather officer (SWO) terminals.

The Concept Paper for Weather Support to Air Force Theater Operations 1995-2005 (CONOPS), dated 1 February 1992, describes the means to produce and apply environmental information needed to support the employment of military power. The Combat Weather System (CWS), in part, provides the means to implement the approach described in the CONOPS. The goal of the CWS is to enhance the effectiveness of combat and support forces by providing automated observation and forecast products aligned with customer operations and requirements. These weather support systems will provide quality observations and quickly distribute these data to weather forecast systems and operational customers. In turn, the CWS (which includes a man-machine interface) will be able to integrate these observations and generate higher quality, tailored forecasts quicker and distribute them faster to operational customers through their automated command and control (C2) systems. The first CWSs will be fielded in FY 1996.

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 USAF 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 1994.

The Centralized Data Management System is a related series of distinct acquisition, development and integration efforts to transition AFGWC from a multiple copy data base environment to a centralized data base environment. The system replaced two Sperry computers during FY 1990 with one computer for both unclassified and classified production as well as backup and development capacity. A Centralized Data Base Computer was also acquired in FY 1990 which will be integrated with improved software from the AFGWC Software Improvement Program (ASIP). Additional AFGWC hardware/software systems will not be transitioned to the centralized data base environment until final operational capability is achieved in approximately FY 1997.

The final model developed under AFGWC's Advanced Weather Analysis and Prediction System (AWAPS) is the Relocatable Window Model (RWM), a regional and relocatable analysis and forecast model suite designed for military application. Limited operational use of the RWM has already been made. The model will provide non-cloud fields to the Combat Weather System (CWS).

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

Changes will be made to models and applications at AFGWC to take advantage of the promising, new Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Water Vapor Profiler (SSM/T-2) and a new Upper Atmospheric Sounder associated with the DMSP Special Sensor Microwave Imager and Sounder (SSMIS). The SSMIS Upper Atmospheric Sounder will produce credible temperature soundings to approximately 70 km.

The MARK IVB Tactical Terminal program will procure satellite receive terminals to replace the aging MARK IIAs, IIIs, and IVs. In addition to providing satellite imagery, the MARK IVB terminals will be able to accept and use data from the DMSP Microwave Imager, Microwave Temperature Sounder, Microwave Water Vapor Profiler, and the TIROS Advanced Microwave Sounding Units A and B to produce both uniform gridded data fields and traditional meteorological products. The MARK IVB contract was awarded to Lockheed Corporation in October 1988. MARK IVB IOT&E occurred in the 3rd quarter of FY 1992 with a production decision scheduled for June 1992.

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 rate 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. Initial operational capability for the DMSP follow-on system is FY 2005.

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 heliosphere (solar) and interplanetary space. The AWS provides basic and specialized space environmental support to military electromagnetic communications, surveillance, and warning systems which operate in this environment. AWS provides environmental forecasting and/or specialized services for: (1) ionospheric conditions, (2) energetic particle fluxes at geostationary orbits, (3) solar flare and solar particle events, and (4) upper atmospheric density variations by providing geomagnetic and solar indices to the user.

The current hub of the AWS space environmental forecasting program is the AFGWC Space Environmental Support Branch which provides the only operational space environmental support within the DOD. The AWS is now moving space environmental support functions and manpower positions to a new facility, the Air Force Space Forecast Center (AFSFC). Initial operational capability of the AFSFC occurred in June 1992 with final operational capability planned for October 1992. Ionospheric conditions have a profound effect on radio wave propagation. The AFSFC will have the capability to give real-time reports on ionospheric conditions and the capability to forecast and predict ionospheric disturbances. Ionospheric models under development will be ready for customer use after the AFSFC becomes operational. Magnetospheric and Neutral Atmospheric models are also being developed.

The AWS also participates with NOAA in the joint operation of the National Space Environment Services Center (SESC) in Boulder, CO. The SESC provides basic solar-geophysical analyses and forecasts to AFGWC and serves as a contingency backup for AFGWC and AFSFC space environmental support.

Data Sources

USAF operates and funds a variety of ground-based and space-based solar-geophysical sensors. The Solar Observing Optical Network (SOON) is comprised of AN/FMQ-7 solar optical telescopes located in Puerto Rico, New Mexico, Hawaii, Australia, and Italy. The Radio Solar Telescope Network (RSTN) is comprised of AN/FRR-95 solar radio telescopes in Massachusetts, Hawaii, Australia, and Italy. USAF operates, or provides funding for, numerous other geophysical sensors as shown in Table B.1.

Data Provided

Space environmental support encompasses the present state and/or forecasts for the Sun, the interplanetary medium, the near-Earth space environment, and the ionosphere.

Solar Flares. The SOON (AN/FMQ-7) was specifically designed to provide consistent, rapid flare observations and data for reliable, short-term forecasting of solar flares and their effects. Currently, exploitation of SOON data by applying advanced modeling techniques is being accomplished by the Air Force's Phillips Laboratory, Hanscom AFB, MA, and NOAA's Space Environment Laboratory (SEL) located at Boulder, CO. SOON optical data are complemented by the RSTN's radio frequency measurements which allow limited monitoring of solar disturbances under all weather conditions.

Geomagnetic Index. AFGWC monitors variation of the Earth's magnetic field through the use of ground-based magnetometers. Data from these sensors are processed at AFGWC to develop a geomagnetic index which is transmitted to users for real-time use in density models. Recently, AFGWC expanded its magnetospheric monitoring by using real-time high energy particle data from operational DOD geostationary spacecraft as well as magnetospheric observations from the GOES satellites.

Ionospheric Variability. AFGWC forecasters monitor the state of the ionosphere, the Sun, and the magnetosphere in order to provide notifications and forecasts of ionospheric irregularities. Short term forecasts for high frequency communications systems can be provided in real-time as can specification and forecasts of electron density profiles and total electron content. The primary long-range forecast requirements are for HF radio propagation.

Event Notification. Since the state-of-the-art in accurately forecasting solar and geophysical events is limited, AWS has concentrated on providing rapid notification to system operators of actual solar events which could degrade the performance of their systems. Rapid event notification is provided for decision assistance to all levels within the military chain of command. The Proton Prediction System model upgrade has enhanced AWS forecasts of solar proton events. AFGWC notifications of these events are provided within minutes of detection of a disturbance and are specifically tailored for each system operator.

Planned Enhancements

AWS plans to upgrade the Space Environmental Support System in several areas: ground-based observing, space-based observing, and forecast capability.

The Digital Ionospheric Sounding System (DISS), consisting of 19 programmed digisondes, of which 13 are already installed, will improve and automate ionospheric measurements. The Transionospheric Sensing System (TISS) will consist of 17 units monitoring signals from the Global Positioning System to calculate total electron content and ionospheric scintillation parameters. The existing magnetometer network will be replaced by a new network operated by the US Geological Survey (USGS). The Solar Electro-optical Observing Network (SEON) of optical and radio telescopes will be upgraded and given new capabilities -- an ability to locate solar flares on the Sun by radio

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Table B.1 Geophysical Sensors of Space Environment

Sensor	Purpose	Locations
Polarimeters	Measure total electron content of ionosphere	Eleven, N. Hemisphere
Ionosondes	Measure ionospheric electron density profiles	Eleven, N. Hemisphere
Magnetometers	Measure changes in geomagnetic field	Six, mid-high latitude
Defense Meteorological Satellite Program	Measure precipitating electron flux, ion flux, ion density, electron and ion temperature, and provide optical auroral pictures	Polar orbit
DOD Spacecraft	Measure high-energy and low-energy electrons and protons	Geostationary orbit
Solar X-ray Imager	Locate positions of solar flares, measure solar x-ray and extreme ultraviolet fluxes	Geostationary orbit

wavelength means and enhanced magnetograph capabilities. The SEON will be consolidated from six sites to five sites, and possibly to four if technology permits. New space environment sensors will fly on future Defense Meteorological Satellite Program (DMSP) satellites. A Solar X-Ray Imager (SXI) will be flown on the GOES Next series. The SXI will monitor solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum. These data will be downlinked to the National Space Environment Services Center in Boulder, CO and transmitted to the AFSFC in real time. Initiatives continue to be considered to obtain solar wind and interplanetary magnetic field data from sensors located outside the magnetosphere.

The AFSFC at Falcon AFB, CO, will be the focal point for space environmental support to the DOD. AFSFC will receive real-time space environmental data from DMSP, GOES, and other satellite systems: SEON, DISS, TISS, and the USGS magnetometer network. Input data will support space environmental models, which will be used by forecasting teams to produce alerts, warnings, and other products tailored to user's needs. State-of-the art computer systems will run models, now under development, including: global ionospheric models, the neutral atmospheric model, the magnetospheric model, and integrated space environmental models.

The ionospheric models will consist of a specification and a forecast component. The specification component will be the Parameterized Real-time Ionospheric Specification Model (PRISM) which includes high-latitude and southern hemispheric enhancements and has the capability to use data from the Defense Meteorological Satellite Program space environmental sensors and other real-time data sources. The forecast model is still under development and will be based on the first-principle ionospheric model being developed by Utah State University.

The neutral atmospheric models consist of a parameterized forecast model and a more detailed specification model. The specification model is the University of Michigan Vector Spherical Harmonics (VSH) parameterization of the Thermospheric Ionospheric General Circulation Model (TIGCM). The forecast model will be some derivative of the TIGCM. The neutral atmospheric models will specify and predict global neutral densities, winds, and temperatures from 90 to 1500 km in the atmosphere. The models will incorporate measurements of neutral density, solar extreme ultraviolet radiation, interplanetary magnetic field orientation, and high-latitude ion convection and auroral zone energy measurements from DMSP sensors.

The magnetospheric specification model has completed advanced development and will provide specification of magnetospheric particle fluxes at geostationary altitudes and precipitated particle fluxes into the auroral zone. The model incorporates geomagnetic index inputs, available solar wind and interplanetary measurements, geostationary energetic particle measurements, and ion convection and low-latitude auroral boundary inferences from Defense Meteorological Satellite Program DMSP sensors. An upgrade to this model is underway which will provide a limited forecasting capability based upon ground-based observations. Full forecast capabilities will await a more robust space-based sensor network including a libration point satellite.

The Integrated Space Environmental Models, now in the planning stage, will provide an interplanetary model to carry shocks in the solar wind plasma from the Sun's corona to the Earth's magnetopause. An energy transfer model will be used to convey interplanetary energetics to the Magnetospheric Model and other space environmental models, based on interplanetary magnetic field conditions. A coupling model will be used to provide output fields from one space environmental model as inputs to the other models, and feedbacks will be provided among the models so they act as a single system. Solar models will not be ready for operational use until the year 2000.

SUPPORTING RESEARCH

The objective of the Air Force meteorological research program is to develop equipment and techniques for observing and predicting meteorological conditions that affect military systems and operations. Requirements for research and technology in meteorology are expressed in Air Force Technology Planning Objectives, Mission Area 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, ground-based and satellite remote sensing, climatological studies, boundary layer meteorology, cloud physics, atmospheric density, and battlefield weather observing and forecasting. Research and development for the Defense Meteorological Satellite Program (DMSP) is also conducted.

In the area of moisture and cloud forecasting, research is being conducted on global and regional scales. Research with a mesoscale cloud model focuses on improved boundary conditions and accounting for local forcing. New moisture-to-cloud algorithms are being developed based on a comparison of global model cloud forecast errors with Air Force Global Weather Central (AFGWC) operational cloud forecasts. New physical parameterization schemes for cumulus convection, boundary layer processes, and radiation (including input from satellite sensors) have been developed and are being tested on the global model. The initial regional model was completed and is undergoing testing and modification. Forecaster effectiveness in an automated operational environment, such as the Automated Weather Distribution System (AWDS), is being evaluated using PL/GP's Advanced Interactive Meteorological System (AIMS). More work is planned to evaluate how continuous wind measurements from a vertically pointing very high frequency (VHF) radar will contribute to numerical modeling and real-time monitoring of developing mesoscale weather systems. An assessment of the utility of "expert system" techniques in short-range weather forecasting is being pursued. A new effort called the Advanced Meteorological Processing System (AMPS) is underway. AMPS will incorporate "expert system" techniques and numerically-based approaches to receiving and processing copious amounts of weather data from new observing systems. New procedures will be used to process and combine weather radar and satellite imagery to automatically estimate cloud motions. These motions can then be integrated to allow mapping cloud and precipitation systems in three dimensions. Research efforts will remain constant in this area.

In the ground-based remote sensing area, automated doppler weather radar techniques are being developed for identifying regions of potential hazardous clear air turbulence and aircraft icing. Doppler techniques are also being developed for precise short-term forecasts of thunderstorm precursor phenomena. These techniques will be incorporated into the jointly-procured (DOD, DOC, and DOT) WSR-88D Doppler Weather Radar (also known as NEXRAD). Coherent polarization diversity weather radar techniques to derive hydrometeor characteristics, such as particle size distribution, orientation, and thermodynamic phase, are being tested.

To support satellite meteorological requirements, improved inversion algorithms are being developed to compute more accurate vertical temperature and water vapor profiles from satellite measurements at far-infrared and microwave wavelengths. An additional effort is planned to establish a versatile cloud-truth data field which is essential for evaluating new cloud algorithms that use satellite observations. A study will evaluate the use of microwave imagery information for mapping

meteorological parameters such as rain rate, ocean surface wind speed, and soil moisture. 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 depict cloud characteristics; i.e., cloud height, cloud thickness, phase, and rain areas. Techniques will also be developed to use satellite data to determine tropical storm location, intensity, and thermodynamic structure. A new effort, supported by DMSP, is underway to develop a tactical cloud analysis system using satellite-sensed data and imagery. Support of Environmental Requirements Cloud Analysis and Archive (SERCAA) will be initiated to provide a new global cloud analysis algorithm for use in determining the radiative and hydrological effects of clouds on climate and global change. SERCAA can provide the next-generation real-time cloud analysis model; it will replace the present realtime nephanalysis (RTNEPH) in use at AFGWC.

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. Climatological studies of rainrate duration modelling and analysis of high resolution cloud photographs taken in orbit are nearing conclusion. These studies are used to quantify the distribution of cloud sizes, of clear intervals, and of the variation in apparent cloud cover as viewing angle changes. Climatological studies supporting reentry vehicles will begin and research into methods of predicting triggered lightning strikes to aircraft and launch vehicles will continue.

The major thrust of the cloud physics program is to develop computerized mathematical models for forecasting the microphysical structure of clouds and cloud systems, given macroscopic statements about the nature of the atmosphere. The weather attenuation program will continue extremely high frequency (EHF) data reduction and interpretation and will test the microphysics of the cloud model against available data sets. This program includes simultaneous measurements of EHF attenuation and detailed microphysics of the clouds, rain and snow, and snow in the melting layer.

The objective of the atmospheric density work is to develop very accurate methods to measure and predict 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 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.

The battlefield weather program will emphasize electro-optical tactical decision aids (EOTDAs) which are being developed for use on microcomputers in base weather stations and host command and control computer systems using an AFGWC provided database. 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 present level of support for atmospheric sciences research will continue. In evaluating Air Force needs, it was decided to continue a new program in triggered lightning prediction at a modest level of support. Another initiative will investigate improved techniques for target area climatologies and analytical efforts in satellite meteorology (e.g., lidar) for determining real-time target area weather. These new techniques will support current and next generation reentry vehicle requirements. Successful completion of the weather attenuation experiment and subsequent data analysis has made available the necessary resources for these new efforts and has provided flexibility to start a new project to develop a tactical cloud analysis program.

UNITED STATES NAVY

OVERVIEW/ORGANIZATION

Within the U.S. Navy, meteorological and oceanographic support is provided globally to units based ashore and at sea. These include environmental personnel and resources 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 Oceanography Command. Personnel and resources from the naval research, development, logistic, and training components are also included. Naval Systems Commands, laboratories, research facilities, and training commands constitute various additional components.

Primary support is provided by activities and detachments assigned to the Naval Oceanography Command. Shore field activities within the Naval Oceanography Command having meteorological responsibilities include a primary numerical processing center, three regional Naval Oceanography Centers, two Naval Oceanography Command Centers, seven Naval Oceanography Command Facilities, 46 Naval Oceanography Command Detachments, and two Naval Oceanography Command components.

The Fleet Numerical Oceanography Center (FNOC), Monterey, CA, operates the master computer center and functions as the hub of the Naval Environmental Data Network. The Naval Environmental Data Network (NEDN) is designed for product distribution among the major Naval Oceanography Command activities. Through linkage with DOD and NOAA environmental satellite systems and Air Force and NOAA data distribution centers, FNOC acquires global coverage of environmental data. A joint agreement exists between the Air Force, Navy and NOAA to share processing tasks and environmental product lines of mutual interest to all parties from DMSP, GOES and NOAA TIROS satellites. From these data, basic and applied numerical (computer) products are generated for distribution via the NEDN and other communications systems for use by other activities in producing specific support products and services. During FY 1993, the Navy will transition the distribution of environmental data and products to its regional activities from the NEDN to the Defense Data Network (DDN).

The Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, MS, operates an Operational Oceanography Center (OOC) that is responsible for providing real-time oceanographic support to the fleet.

The three regional Naval Oceanography Centers -- the Naval Western Oceanography Center at Pearl Harbor, HI; the Naval Eastern Oceanography Center at Norfolk, VA; and the Naval Polar Oceanography Center at Suitland, MD -- are assigned broad geographical fleet support services and related matters within their specific areas of responsibility. The Naval Western Oceanography Center is responsible for the Pacific and Indian Ocean areas; Naval Eastern Oceanography Center for the

Atlantic and Mediterranean Sea areas; and the Naval Polar Oceanography Center for the Arctic and Antarctic areas. They utilize numerical products from the FNOC to provide environmental broadcasts and tailored support in response to specific requests from the operating forces.

The two Naval Oceanography Command Centers are located at Rota, Spain, and on the island of Guam. Naval Oceanography Command Center, Rota, assists Naval Eastern Oceanography Center in the Mediterranean Sea area. Naval Oceanography Command Center, Guam, assists the Naval Western Oceanography Center with provision of environmental services in the Western Pacific and the Indian Ocean areas. Both of these centers provide fleet environmental broadcasts and tailored support in a manner similar to the regional centers. Naval Oceanography Command Center, Guam, has an additional responsibility for operation of 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.

Seven Naval Oceanography Command Facilities at Brunswick, ME; Jacksonville, FL; San Diego, CA; Yokosuka, Japan; Republic of the Phillipines; Keflavik, Iceland; and Bermuda provide limited area, local and aviation environmental forecast services, as well as direct support for ship and submarine staffs. Five of these activities command detachments. Primary forecast guidance from Fleet Numerical Oceanography Center is utilized by all facilities; the overseas facilities augment this guidance with data from local sources.

There are 47 Naval Oceanography Command Detachments located worldwide. Although primarily located at Naval Air Stations, several are located at Naval Stations to provide services to sea-going units. Each is established under an Officer-in-Charge or Chief Petty Officer-in-Charge who reports to a designated shore/field activity. The majority of these detachments are oriented to provide direct environmental support, including aviation meteorological and oceanographic services, within their local areas. Detachments within the contiguous states utilize the basic and applied numerical products from both the National Meteorological Center and the Fleet Numerical Oceanography Center to provide meteorological and oceanographic services. Overseas detachments use foreign and Air Weather Service (AWS) products, as available, in addition to Fleet Numerical Oceanography Center numerical products. Three of the detachments are oriented to provide specific technical support; such functions include coordination of the Navy's climatological program at the National Climatic Data Center at Asheville, NC, coordination and circuit management with the USAF Automated Weather Network (AWN) at Carswell AFB, TX, and liaison and coordination with the USAF Global Weather Central at Offutt AFB, NE.

Oceanographic/meteorological units are permanently assigned to 39 aviation-capable U.S. Navy ships. These units, staffed with officer and enlisted personnel and equipped in accordance with their designated support functions, are integral to the command to which they are assigned. Smaller units, termed Mobile Environmental Teams are temporarily assigned to Navy ships upon request to meet short-term support requirements. These METs, available from six Naval Oceanography Command activities (Rota, Jacksonville, Norfolk, San Diego, Yokosuka, and Pearl Harbor) are outfitted with their own portable equipment. Navy ships without dedicated units also contribute by providing vital meteorological and oceanographic observations, frequently from data-sparse oceanic areas. Technical guidance is provided by the Naval Oceanography Command.

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 Oceanography Command Detachments but under USMC management. These weather units are

integral to Marine Corps aviation activities and provide support to assigned activities and tenant organizations thereof, 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.

PROGRAM DESCRIPTION

The Navy's meteorological Operational Support programs are designed to satisfy validated fleet requirements. They include surface and upper atmospheric observations programs, flight forecasting services, Optimum Path Aircraft Routing System (OPARS), tailored forecasts, and optimum track ship routing for naval and naval contract vessels, local and operating area forecasts, tropical cyclone warnings, local severe weather forecasts, high seas and winds forecasts, manual and numerically-derived analyses and prognoses, microcomputer-based product dissemination and display capabilities, statistical and climatological studies, and a wide range of mission-specific and tactical support products to the operating forces of the U.S. Navy.

The FY 1992 budget includes programs that address a total of 86 validated requirements. Efforts are focused in three broad areas: shipboard tactical environmental support; upgrades to Fleet Numerical Oceanography Center, Naval Oceanographic Office and other Naval Oceanography Command centers and their data distribution networks; and enhanced capabilities at Naval Oceanography Command shore-based aviation support activities. Efforts in the FY 1992 program address both the Systems Acquisition and Operations Support categories. They are highlighted below.

Tactical Environmental Support System (TESS). TESS is a modular, computer-based support system designed to provide Navy tactical commanders at selected shore commands and major surface combatants with secure and responsive environmental data support, including assessments of the effects of the environment on specific platforms, sensors, weapon systems and communication. Initial Operational Capability (IOC) was achieved in FY 1992 with installation on the USS Theodore Roosevelt and USS Kitty Hawk. TESS will function as the operational, resident air/ocean data base.

The acquisition strategy for TESS is to build upon an interim capability based on the Navy-Standard Desktop Tactical Support Computer. This interim capability (known as TESS 1 and TESS 2) was implemented as a non-research and development effort, and was completed during FY 1989. A total inventory of 71 units will exist with installations keyed to major fleet combatants and selected shore activities with significant command and control responsibilities. The follow-on system, TESS(3), rehosts the existing TESS 2 capabilities while providing significant new enhancements. A Pre-Planned Product Improvement (P3I) program is planned to provide upgrades to both hardware and software upgrades to TESS(3). TESS(3) utilizes environmental data from:

* Environmental satellites
* Naval Oceanographic Command (NAVOCEANCOM) shore activities
* General Service (GENSER) messages including AUTODIN and Fleet Broadcast
* Direct operator entry
* Local sensor system (BATHY, MRS and AMR)
* Shipboard Meteorological and Oceanographic Observation System

The TESS(3) database management system creates and maintains a current Master Data File (MDF), and tags, stores, retrieves, processes, and assists TESS(3) operators in quality control of this input data. TESS(3) application software draws upon the MDF to derive environmental support products tailored to user requirements. TESS(3) allows users to request and access products through a variety of communications interfaces.

Naval Oceanographic Data Distribution and Expansion System (NODDES). NODDES is an extension of the capabilities inherent in TESS(3). It will perform all of the functions in TESS(3) and will also have communications (DDN, SATCOM, etc.) interfaces which will allow for receipt and transmission of grid field data. NODDES is the primary means by which TESS(3) afloat will receive updated grid fields. NODDES will be located at the seven Naval Oceanography Centers located throughout the world.

Primary Oceanographic Prediction System (POPS). Existing computer systems at the NAVOCEANO and FNOC have reached their limits in computational speed, memory and processing architecture. Further improvements in atmospheric models and the development of global, eddy-resolving ocean models require computational capabilities which exceed those of the current computer systems. Emergent requirements were documented, validated and funded, with the recommendation that the Primary Oceanographic Prediction System (POPS), which will consist of two Class VII supercomputers, be procured beginning in FY 1990. In FY 1991, the first of two POPS Class VII supercomputers (Cray Y-MP8) became operational at NAVOCEANO, Stennis Space Center, MS, to support ocean modeling and other research and development efforts. Replacement of the existing Class VI machine with a Class VII supercomputer at the FNOC, Monterey, CA, is planned during FY 1992. This computer will significantly upgrade the ability to run Navy operational and developmental meteorological and oceanographic models. High speed communications links between these activities will provide backup capabilities.

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 which include the AN/SMQ-6 and the AN/SMQ-10. The SMQ-11 is composed of a 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). Satellite information from this system can be provided to the Tactical Environmental Support System (3) [TESS(3)] for additional processing and applications. Production of the AN/SMQ-11 commenced in FY 1987 and is planned to be completed in FY 1995. A total inventory of 74 units is programmed.

Atmospheric Modeling. Continued upgrades to the Navy's Operational Global Atmospheric Prediction System and the Navy Operational Regional Atmospheric Prediction System (NOGAPS/NORAPS) spectral model continue. These include imporvements in the data assimilation and initialization schemes and boundary layer parameterizations. Significant efforts are underway to optimize the use of satellite data in Navy numerical modeling. A recently developed, relocatable NORAPS model can produce 40 km resolution analyses and forecasts for military applications. Both NOGAPS and NORAPS are installed at FNOC. NORAPS is now being redesigned to include a triple-nested grid to provide a resolution of less than 20 km; a version, tailored to run on TESS(3), is expected in FY 1995 or FY 1996.

Sensor Development. Several efforts are underway to enhance the Navy's quantity, quality and utilization of observational data.

Next Generation Weather Radar (NEXRAD). Principle User Processing Station (PUPS) associated with NEXRAD will provide significant improvements in radar analysis of meteorological features and severe weather over the United States. NEXRAD PUPS are being procured by the Navy to display imagery from NEXRAD systems covering operational areas. In some cases, Navy property was made available for the installation of the radar. NEXRAD PUPS will be procured by Navy during FY 1990 through FY 1995. NEXRAD will not totally replace other meteorological radars for Navy, because a number of locations overseas will not be covered by the NEXRAD system.

Mini-Rawinsonde. Procurement of a portable mini-rawinsonde system to replace the GMD-1 ashore system and the SMQ-1 afloat system began in FY 1989 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.

Supplementary Weather Radar. The U.S. Navy is preparing a Mission Needs Statement for eventual procurement of a Supplementary Weather Radar. These systems will augment NEXRAD PUPs by providing a radar system at selected sites that are not scheduled to receive a PUP, and will replace the obsolete AN/FPS-106 weather radar, now used by Navy and Marine Corps activities.

Light Detection and Ranging (LIDAR). The Navy has begun development of a surface based LIDAR to detect vertical profiles of temperature, humidity and vector wind in the bottom ten kilometers of the atmosphere, including the marine boundary layer. The system is being developed as sensor upgrade for SMOOS and will be installed on Aircraft Carriers and surface combatants.

Shipboard Meteorological and Oceanographic Observation Sensor Suites (SMOOS). The SMOOS is an automated system for improving the timeliness, quality and reliability of meteorological and oceanographic measurements. SMOOS sensor data will be transmitted to TESS(3) via fiber optic cables to provide an additional source of data for processing and display. The SMOOS sensors and associated hardware will be fielded for shipboard versions of TESS(3) only.

Automated Surface Observing System (ASOS). Development efforts for the ASOS undertaken by the National Weather Service have been leveraged by the Navy in selection of the ASOS to replace antiquated ashore observing system. The Navy is procuring approximately eighty five units for installation at sites in the continental United States and overseas.

Digital Ice Forecasting and Analysis System (DIFAS). The DIFAS system of the Joint Ice Center (Navy/NOAA) is a comprehensive workstation-based system which ingests data from a variety of sources, allows for interaction between data sets, and produces ice analysis and forecast products in the form of screen displays, hardcopy charts, alphanumeric messages, and gridded output products. Implemented during FY 1989, but with improvements scheduled for the subsequent three fiscal years, the DIFAS will use the following data for all areas of ice coverage:

- TIROS AVHRR (Advanced Very High Resolution Radiometer) visible, IR and NIR imagery;
- NMC Guidance Products;
- Fleet Numerical Oceanography Center Guidance Products, including ice edge and SSM/I (Special Sensor Microwave Imager) ice parameters;
- Drifting buoy;
- Climatological Summaries and Bathymetry.

Products produced by DIFAS fall into three categories: graphic products, alphanumeric messages, and gridded data in a format chosen for ease of encoding, retrieval, and manipulation.

Summary. The impact of these programs on fleet readiness and operational capabilities is significant. By the end of FY 1992, a logical framework will be in place to ensure that a survivable, responsive and layered network can provide in-situ as well as shore-based support to the operating forces of the U.S. Navy.

UNITED STATES ARMY

OVERVIEW

Army Operational Support

The U.S. Army provides three kinds of direct weather support to the Army combat mission. These are direct reception of weather satellite data at deployed locations, upper air observations for artillery fire support missions and limited surface weather observations to support Army weapon systems. Other supporting services are provided to the Army for training and combat by the Air Force under Law and according to Army-Air Force agreement. The Army also provides operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges and sites through the Test and Evaluation Command (TECOM) Meteorological Teams. The TECOM operational support is described as part of the Army Materiel Command in the Research, Development, Test and Evaluation section.

Army issues tactical equipment and communications equipment to the USAF Weather Teams (WETMs) for tactical operations. Army Major Commands (MACOMs) have purchased off-the-shelf non-developmental items (NDI) to provide interim Army tactical communications equipment until the Integrated Meteorological System (IMETS) is fielded beginning in FY 1993. IMETS will be an automated communications system that receives, integrates, processes, and disseminates weather data from multiple sources including the surface and upper air observing systems, and military and civilian weather satellites. It will provide near-real-time weather information and forecasts to other Army tactical processors for development of tactical decision aids (TDAs). IMETS will be vehicle-mounted in a standard shelter. The IMETS Product Manager is under the Program Executive Officer for Command and Control Systems (PEO, CCS) with technical assistance from Communications and Electronics Command (CECOM). Interim NDI systems presently providing operational support include the US Army Europe Automated Weather System (UAWS) and the FORSCOM GOLDWING System. Both delivered key weather communications support to deployed forces in the Persian Gulf. UAWS is a tactical secure radio system, mounted in a 5-ton truck with shelter, receiving and transmitting weather information. GOLDWING performs similar functions, but is light weight and transportable in boxes by two men. Both systems employ small commercial receivers to tap civil weather satellite imagery. GOLDWING and UAWS will be upgraded until IMETS is fielded to all USAF WETMs supporting the Army. Air National Guard Weather Flights supporting Army Reserve Component forces also use GOLDWING.

Army Artillery Meteorological Crews take upper air observations during tactical training exercises, at permanent Army Artillery Ranges, and in combat in support of Artillery units at division level, Field Artillery Brigades, and Separate Brigades with a direct support Artillery Battallion. They take Artillery Limited Surface Observations (ALSO) as required as a secondary mission.

Army Artillery Meteorological Crews use the Meteorological Data System (MDS), the 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. The Chemical Officer uses atmospheric information to support smoke operations and nuclear, biological, and chemical (NBC) defense operations. In order to meet mobility requirements, the Army will continue in FY 1993 to procure the Meteorological Measuring System (MMS), AN/TMQ-38. The MMS will be easily deployable on a small vehicle and will reduce the size of the team. As the MDS is replaced by the MMS, the MDS will be refurbished and issued to the Reserve Component (RC). The MMS program is managed by the Program Manager for Electronic Warfare/Reconnaissance, Surveillance, and Target Acquisition (EW/RSTA), Fort Monmouth, NJ with technical assistance from Communications and Electronics Command (CECOM) at the same location. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK developed the requirement documents for the MMS.

Army Intelligence personnel in the forward combat areas are tasked to take limited surface weather observations at the brigade and battalion command post as a minimum at sunrise, noon, and sunset. They usually use a Belt Weather Kit (BWK); in Eighth U.S. Army, Korea, they use the Air Force developed TMQ-34. The Automated Meteorological Sensor System (AMSS) is a program for tactical equipment to take automated surface observations and is scheduled to be fielded after FY 1996.

Headquarters, Department of Army, Office of the Deputy Chief of Staff for Intelligence (ODCSINT) is responsible for the Army weather support policy encompassing both tactical operations and peacetime training support. 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 those requirements.

Army Operational Support Provided by the Air Force

The Air Force provides both tactical and garrison weather support to the Army. This support includes forecasting and observing during tactical exercises, contingencies, and wartime; and also includes weather support services at fixed locations, usually Army air fields. Although fixed support is primarily for headquarters staff and aviation training, it also supports maneuver, artillery and other missions. According to the joint agreement, the Air Force provides the personnel and tactical observing equipment for Air Force weather observers, and the Army provides the tactical communications, personnel field equipment, and vehicles to support USAF WETMs.

At a garrison location, Air Force support to the Army is similar to that found on an Air Force base. The Army provides the fixed facilities and on-post communication links to Air Force-provided and maintained standard terminal communications and observing equipment at the Army airfield weather station. Army also provides Army-unique training and logistics support to USAF weather support personnel.

Army Space Command Demonstration Program

Army Space Command, Colorado Springs, CO conducts a Space Capabilities Demonstration Program to accelerate delivery of satellite capabilities into tactical Army units. Small commercial weather satellite receivers identified by the Demonstration Program have been chosen by Army MACOMs to equip USAF WETMs prior to fielding the IMETS. As a result, direct access by mobile fighting forces to civil meteorological satellite broadcasts emerged as a reliable mainstay of weather information during the Persian Gulf War and showed the need for Army tactical WETMs to receive Defense Meteorological Satellite Program (DMSP) imagery and data.

Army Space Command will demonstrate small, commercial, high resolution weather receivers during FY 1992 and 1993 to support Army training exercises and operations. This effort will: 1) help guide on-going development of the Defense Meteorological Satellite Program (DMSP) Small Tactical Terminal, 2) stimulate technical skill among military forecasters in the tactical environment, and 3) maintain contact with leading technology, suited for rapid acquisition in emergency situations.

During FY 1993, Army Space Command will demonstrate wide-band satellite communications utility using the NASA Advanced Communication Technology Satellite. This system will be tasked to deliver weather and terrain image data to military units deployed beyond the range of conventional terrestrial communications. Other commercial satellites terminals are planned for use in collecting remotely sensed weather observations from dispersed ground sensors.

Army Corps of Engineers Civil Operational Activities

The Corps of Engineers (COE) operates a network of 1573 land-based limited observing sites with NOAA/National Weather Service (NWS) funding support. The system measures precipitation in the continental United States and provides information for regulating COE dams and other large water projects. The COE transfers funds to NWS to collect and maintain precipitation information. NWS runs a combination of manually collected and automated observation sites for the COE. In addition, the COE operates 200 automatically telemetered precipitation observation sites. These data are made available to the NWS and other Federal agencies as well as to the COE.

Training and Doctrine Command Programs

The Training and Doctrine Command (TRADOC) 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 Field Artillery School (USAFAS), Fort Sill, OK, is the proponent for upper air support. The U.S. Army Intelligence Center (USAIC), Fort Huachuca, AZ, is the proponent for tactical weather support. TRADOC schools coordinate their requirements for weather support with the Combined Arms Center, Deputy Commanding General for Combat Developments, Fort Leavenworth, KS prior to submission to Headquarters (HQ) TRADOC.

TRADOC schools and centers have several roles related to weather support. They develop the requirements documents for weather equipment, write the concepts and manuals describing the operational doctrine for weather support procedures, write and teach weather training courses for Army personnel, and provide orientation training on Army procedures for the USAF personnel assigned to Army units.

USAFAS and USAIC write concepts to describe new organization, training, equipment, or doctrine (field manuals) needed to eliminate known deficiencies and improve Army weather support.

They work as a team with the Communications and Electronics Command (CECOM), the Materiel Developer, to acquire new weather support equipment. The Aviation Center, Chemical School, and Engineer School also incorporate weather support procedures into training programs in their mission areas. The Engineer School develops evaluation procedures considering the effects of weather conditions on terrain analysis, mobility and counter-mobility doctrine, training, and planning. The Aviation Center has unique operational requirements for weather support at remote training locations. Therefore, it maintains additional Army observing and communications equipment in conjunction with the USAF weather support at the Army airfield.

USAFAS trains all Field Artillery Meteorological Crew members with a staff of approximately forty military and civilian instructors. USAFAS trainers, as subject matter experts, also have 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 USAIC is responsible for writing tactical weather support doctrine, identifying deficiencies and base line weather data requirements, providing weather support training to intelligence and USAF personnel, and establishing requirements documents for weather support equipment, outside artillery support. The Intelligence Center developed a new Army operations familiarization training course for USAF personnel and started classes in FY 1992.

The Combined Arms Center, Commanding General for Combat Developments (CAC, CGCD) is responsible for coordinating and integrating combat weather support across branch and functional areas. The CAC, CGCD manages solutions to known weather support deficiencies. Determining and implementing solutions, part of the combat developments process, may be made through changing organizations, writing new support doctrine and procedures, or procuring new equipment. HQ TRADOC is the final approval authority for weather hardware requirements.

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

Under the Army-Air Force agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) to support the Army ground combat mission. The COE and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers' performance in the range of weather conditions expected in all theaters of operations.

Corps of Engineers (COE)

Topographic Engineer Center (TEC). The Topographic Engineer Center, Fort Belvoir, VA, provides applied climatological support to Army research and development programs and coordinates the development of tactical decision aids (TDAs) relative to environmental effects on combat systems and operations.

The Airland Battlefield Environment (ALBE) TDAs interpret the impact of weather conditions on Army systems and operations. ALBE TDAs are based on weather and terrain limitations, known as critical values. Critical values are determined from design criteria, in operational testing, or other evaluations of Army capabilities in adverse weather. They are displayed in formats showing the impact on Army war fighting capabilities. The ALBE software will be transitioned to terrain and weather support systems such as the IMETS, the Digital Topographic Support System (DTSS), and other Army Tactical Command and Control System (ATCCS).

Cold Regions Research and Engineering Laboratory (CRREL). Under the military portion of its civil and military support mission, the CRREL, Hanover, NH, provides weather support to Army research and development of weapon systems and combat missions in the winter environment. CRREL develops data bases and models predicting weapon system performance, and technology to enhance military operations in cold environments. Under a recent memorandum of understanding, the U.S. Army Test and Evaluation Command (TECOM) provides operational observing and forecasting services for CRREL's RDTE efforts.

Army Materiel Command (AMC)

AMC is responsible for the design, development, test and evaluation of equipment to satisfy requirements for meteorological support equipment. AMC 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 sub-commands and elements carrying out weather research and development responsibilities.

Test and Evaluation Command (TECOM). TECOM is a subcommand of AMC providing operational support to 14 ranges and test sites with 11 Meteorological (Met) Teams. Under responsibilities established in Army Regulation 115-10/Air Force Regulation 105-3, the TECOM Atmospheric Sciences Division, White Sands Missile Range, NM provides weather support and atmospheric characterization to Army RDTE. Test sites are located throughout the continental United States, and Alaska. Support services in the past have included professional meteorological consultation; test-tailored data collection; analyses and reports; forecasting and severe weather advisory services; and installation, operation, and maintenance of research quality mesoscale instrumentation and support systems. As the budget continues to be reduced, TECOM will only provide basic weather support services at the sites. The FY 1993 funding of $9.2 million is an 18 percent reduction from FY 1992 resourcing. In FY 1993, meteorological instrumentation will be acquired through Army technical development resources or through direct funding from RDTE projects for test-specific, unique requirements. Budget decrement will limit training, decrease parts inventories, and is expected to require a reduction in personnel.

Atmospheric Sciences Laboratory (ASL). The Army war fighting concept, AirLand Operations, is influenced by the natural environment. Weather and other atmospheric effects play a critical role in any contemporary battlefield scenario, as demonstrated in the Persian Gulf War. Today's battlefield commander, whether deploying an electro-optically guided weapon system or defending against airborne chemical agents, must effectively anticipate these environmental factors in order to be successful. The goal of ASL research and development is to give the battlefield commander the atmospheric advantage, turning potentially adverse atmospheric phenomena into force multipliers.

As leaders in boundary layer modeling and simulations, ASL researchers use advanced computational techniques to develop meso/microscale meteorological models to describe and predict weather elements over complex terrain, including the forward target area. State-of-the-art transport and diffusion models are being developed and tested to predict the behavior of atmospheric aerosols, obscurants, NBC agents, and dense gases. Other simulation efforts are investigating image propagation, information transfer, and cloud physics. In addition, realistic weather and battle-induced atmospheric conditions models are being incorporated into Army simulations to enhance the ability to describe real world effects on battle outcomes.

ASL has a wide ranging role in supporting Army weather support missions. ASL develops theory and models for scientific analysis of the impact of the atmosphere on combat operations, equipment, and personnel. ASL uses models and computer codes to describe the realistic battlefield atmospheres. In FY 1993, ASL will research the fundamental physical processes related to the propagation of energy through battlefield atmospheres contaminated by natural and combat-induced obscurants. ASL will continue to maintain and update a library of multi-disiplinary codes for describing atmospheric effects on operations relying on the propagation of electromagnetic or acoustic energy. Extensive field experiments will be conducted to validate friendly and threat system performance in realistic environments and to conduct validation of meteorological models.

In FY 1992, ASL made advances in weather data acquisition and processing technology for battlefield use. They investigated theories and techniques for remote detection of aerosols and profile measurements of the wind, temperature, relative humidity, and turbulence using passive, low signature methods. ASL scientists continued to develop remote, passive/low signature sensing techniques for use in an automated tactical atmospheric profiler, as well as the capability to collect data from atmospheric satellites sounders and imager data over target areas. New data fusion assimilation techniques are being developed to describe meteorological conditions over the battlefield area.

In FY 1992, ASL continued to develop technologies to exploit and mitigate environmental effects on the battlefield. Research efforts included computer models and tactical decision aids (TDAs) for lessening the multiple effects of adverse weather, smoke, dust, and low light levels on Army systems. Other modeling efforts sought to improve the use of smoke, camouflage, concealment, deception, and low observables technology. ASL continued to develop computer display techniques for visualizing battlefield environments, acoustic and electromagnetic models, noise abatement forecasts, and enhanced artillery meteorological messages to improve long-range artillery and smart weapons.

In FY 1993, ASL will start several new programs. One is the Artillery Met Improvements, designed to extract FIREFINDER (TPQ-37) radar wind data and combine it with existing artillery met section data to update artillery messages.

In support of the war on drugs, researchers will help develop a dual band infrared/ultraviolet lidar system to detect and identify clandestine drug activities. A joint program with the U.S. Department of Agriculture is planned to develop a new surface energy balance model.

ASL's unique instrumentation and data analysis capabilities over the White Sands Missile Range, NM will be used to support the calibration and ground truth validation of multi-agency satellite sensors.

ASL will continue in FY 1993 to provide highly specialized instrumentation for smoke and obscurant testing, atmospheric characterization for electro-optical (EO) systems testing and other unique meteorological measurement capabilities tailored to the needs of the DOD RDTE community. This sophisticated instrumentation includes:

a. Simultaneous Multispectral Absolute Radiometer Transmissometer (SMART). Measures visible and infrared transmissivity through an environment degraded by obscurants.

b. Mobile Imaging Spectroscopy Laboratory (MISL). Characterizes the changes in propagation of images as a function of atmospheric conditions in near-real-time for weapon system comparison testing.

c. Multispectral Imagery Data Analysis System/Atmospheric Transmittance Large Area System (MIDAS/ATLAS). Measures smoke cloud growth and movement, and estimates transmittance through smoke clouds.

d. Transportable Atmospheric Characterization System (TACS). Provides an array of particles spectrometers, scintillometers, infrared temperature sensors, path integrated humidity sensors, and standard meteorological sensors.

e. Research Visible and Infrared Transmissometer (REVIRT) and Multiple Path Transmissometer/Radiometer (MPTR) both measure the percentage of relative transmission of visible and infrared radiation through obscurants.

f. Mobile Atmospheric Spectrometer (MAS). Measures spectral transmittance using high resolution Fourier transform spectrometer techniques.

g. Atmospheric Turbulence Measurement and Observation System (ATMOS). Measures the transverse coherence length, the isoplanatic angle, and determines the phase structure function for characterizing high energy laser and imaging environments.

h. Fluorescent Target Detection System (FTDS). Uses ultraviolet laser-induced fluorescence to detect ground-based military materials and chemical substances.

i. Meteorological Optical Measurement System (MOMS) and the Mobile Atmospheric Sensing System (MASS). Supports directed energy programs and instrumentation development.

j. Wind and Turbulence Profiling Radar Facility (WTPRF). Uses acoustic and radar information to detail temperature, wind and turbulence profiles up to 20 km to support DOD system test bed measurements.

Army Research Office (ARO). The ARO manages the Army's basic research program in 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 ways. The Individual Investigator Program and the University Research Initiative both focus research on atmospheric processes and effects in 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 leading to better understanding of atmospheric effects on soldiers, material, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on air flow and the development of natural obscurations. Developing instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture in the boundary layer at turbulence scales is an essential element of research. One University Research Initiative center will concentrate on boundary layer processes; the other will concentrate on boundary layer sensing for multiple fields.

Missile Command (MICOM). The MICOM Research, Development and Engineering Center (RDEC), Chemical and Material Sciences Group, Redstone Arsenal, AL develops climatological models and reports about atmospheric criteria to support specific design efforts. Climatology is used to support missile design and establish satisfactory criteria for weapon systems and program development efforts.

Communications and Electronics Command (CECOM). The CECOM Electronic Warfare/Reconnaissance, Surveillance, and Target Acquisition (EW/RSTA) Directorate, Fort

Monmouth, NJ is conducting research and development on meteorological systems, including the Meteorological Measuring System (MMS), and the Meteorological Data System Improvement Program. The Program Executive Office, Intelligence and Electronic Warfare (PEO, IEW) manages these programs while CECOM EW/RSTA Directorate provides technical support. Funding for the MMS is programmed to continue in FY 1993.

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 climate extremes. The sensitivity of the soldier to weather parameters, especially ambient air temperature, dew point temperature, wind speed, and solar radiation defines an operational envelope for unimpaired human performance. Applied research goals are to develop methods to assess and extend the boundaries of the envelope in an operational setting. On-going research efforts include laboratory and field studies to:

a. Validate requirements for thermal strain predictive models by using soldier subjects.

b. Quantify psychological and task performance decrements associated with weather extremes by using soldier subjects.

c. Provide technical testing support to the U.S. Army Medical Materiel Development Activity for development of a pocket-sized electronic Heat Stress Monitor for use at the small unit level.

d. Evaluate satellite Remote Sensing and Geographic Information System technology for 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 Real-time Weather Processor (RWP) 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 by 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. In 1992, the production displays were utilized at Orlando.

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

Other Weather Radar Programs

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 Radars (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 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 edge 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.

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 is programmed to begin in 1992. LLWAS-3 is scheduled to be fully deployed by 1998.

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, barometric pressure, 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 currently do 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 NOAA to procure, install, operate, and maintain Automated Surface Observing Systems (ASOS) systems at the remaining airports where the FAA provides observations and at additional non-towered airports without current 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 system was installed in August 1991.

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 readings. 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/or 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.

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 RWP and DLP (via NADIN) within the center in which it is installed. It will also distribute AWOS data to the National Airspace Date 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 is planned to start in 1993 and 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 the National Oceanic and Atmospheric Administration's (NOAA) 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.

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 in two stages: 1) FSAS Model 1 (limited automation), and 2) Model 1 Full Capacity (full automation).

The first Model 1 system was commissioned in 1986. As of December 1988, there were 39 Automated Flight Service Stations (AFSS) and 13 Flight Service Data Processing Systems (FSDPS's) operating with Model 1. In addition to the 39 Model 1 AFSS's, there are seven AFSS's operating with the American Satellite Leased Service A & B System (LABS). Fifteen more AFSS's will be commissioned by 1994 for a total of 61 AFSS's. All of these facilities will be converted to Model 1 Full Capacity (MIFC). The first field MIFC was commissioned in August 1991. MIFC will provide sufficient hardware and software to drive all of the terminals in the 61 AFSS's.

The Direct Users 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 Displays Systems (GWDS) in the AFSS's consist of a variety of different systems. FAA intends to provide a Standard National GWDS to replace the interim systems now in use.

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 data bases. 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 late 1993.

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 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 data bases 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 is scheduled to begin 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, Real-Time Weather Processor (RWP), Meteorological 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.

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 Meteorological Weather Processor (MWP) which will be procured through a series of 5-year leases. This will provide 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 Real-time Weather Processor (RWP) which will automatically create unique NEXRAD-based mosaic products. The RWP 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 will be completed in 1992. The MWP leased in the second 5-year period will interface with the RWP which should become operational in 1995. 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 integrated by 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 data base 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 data base, development of a suitable structure for this data base, specification of machine-readable output products, and development of a rigorous set of algorithms for the generation of these products.

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 in FY 1992 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 Meteorological Services and Supporting Research 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 program for FY 1992 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 U.S. Coast Guard's activities is the collection and dissemination of meteorological information for the benefit of the marine community. In pursuit of this aim, the Coast Guard provides use of information and facilities to the National Oceanic and Atmospheric Administration (NOAA), specifically the National Weather Service (NWS) and the National Data Buoy Center (NDBC).

Coast Guard seagoing cutters submit weather observations to the National Weather Service and the U.S. Navy. Certain coastal stations submit weather observations to the National Weather Service. Additionally, NWS sensors on Coast Guard Large Navigational Buoys automatically transmit data to NWS centers. These data are utilized by the NWS in formulating its forecast products. NWS weather forecasts are disseminated in part by the Coast Guard through radio broadcasts to commercial and private vessels. Certain shore stations maintain visual displays authorized by the NWS to provide weather warnings to boaters.

In 1989 the International Ice Patrol, a Coast Guard unit, began air-deploying satellite-tracked drifting buoys equipped with barometric sensors in the northwest Atlantic. These data are available to all users through GTS.

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

The Coast Guard supplies a staff of up to 15 personnel to the NDBC (costs reimbursed by NOAA at its facility in Mississippi) to provide technical expertise in the operation and management of the project. In addition, the Coast Guard makes available vessel, shore and aircraft support for stationing, monitoring and maintaining buoys.

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

The U.S. Coast Guard operates or provides support for Omega and LORAN-C radionavigation stations in the U.S. and in some overseas locations in accordance with the Federal Radionavigation Plan and bilateral agreements with other nations. In addition to providing signals for aviation and maritime navigation systems, the Omega and LORAN-C systems and other electronic navigation systems (e.g., Global Positioning System) provide signals for the operation of radiosondes and dropsondes that are essential to the Meteorological observation network in the U.S. as well as for the international weather community.

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 certain grains has exceeded production 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 remote automatic weather stations (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 5-year 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 1991. 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 fine 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 also 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 this Plan. The narrative below describes the full range of meteorological activity in the Interior Department.

The Bureau of Reclamation activities including water scheduling, flood hydrology, irrigation project management, and reservoir operations, as well as projects related to the development of wind and solar energy resources, require the collection and use of meteorological data. Currently, Reclamation operates approximately 400 hydrometeorological data collection platforms (DCPs) and collects near real-time data through a NOAA Geostationary Operational Environmental Satellite (GOES) Direct Readout Ground Stations (DRGS) in Boise, ID. 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.

The Geological Survey's Water Resources Division collects precipitation, stream flow, and other climatological data for a number of projects concerning rainfall/runoff and hydrologic processes. Currently, the Geological Survey collects hydrometeorological data from approximately 3,000 GOES DCPs through six DRGS. In January 1991, the Survey's Colorado Office installed the first direct readout, terminal (DROT) to receive domestic satellite (DOMSAT) retransmission of all data collected on NOAA's GOES data collection system. This prototype system is being developed into a much more efficient and economical data source as compared with conventional DRGS receivers. The survey is preparing a contract to purchase DROTs in mid 1992. Precipitation and dryfall atmospheric deposition samples are collected in a number of studies for the 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 Geological 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 near real-time assessments of snowpack from space. The Survey also carries out research in past climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology.

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 the eleven western states and 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 220 of these being fielded. The network is planned to ultimately reach 359 fielded systems. Completion of the network as planned is based on acquiring the personnel to implement and maintain the total number of planned 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 the 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 BLM conducts primarily 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 necessary to assess local climatic influences. These data are primarily used for natural resources 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 areas 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 monitors air quality and visibility in several national parks and monuments. Approximately 20 GOES DCPs are used to collect these data. The Service has contracted research to develop and test models to assess long-range transport of anthropogenic pollutants including sulfur dioxide and sulfur deposition. It also is monitoring atmospheric deposition in a number of locations to determine its effects on park ecosystems and historic structures.

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, through its Weather Working Group, has continued to improve NASA's 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 landing. 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 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. The upgraded lightning sensors network to monitor and to aid in predicting the occurrences of lightning in the Kennedy Space Center (KSC) area has been completed.

NASA has upgraded weather observing capabilities at the shuttle landing and alternate landing sites. This includes completion of the Meteorological Interactive Data Display System (MIDDS) that facilitates the transfer of meteorological data and reduces the time required to evaluate weather situations and increase the forecaster's confidence in their recommendations for launches, landings, and operations of both manned and unmanned space vehicles. This technology also provides for operational redundancy and increases safety.

NASA has also installed a Doppler radar vertical wind profiler at the Kennedy Space Center to monitor the variation of wind aloft. The unit, located near the Shuttle Landing Field, is currently under test and evaluation. The goal of this system is to aid in the prediction of and avoidance of those weather impacts associated with adverse weather phenomena in a subtropical coastal environment.

NASA plans to conduct a special Jimspheres wind profile data acquisition and analysis project to support launch and post-launch requirements. To support enhanced vertical wind data acquisition processing, and transfer capabilities, the winds ingest computer has been upgraded.

None of these improvements is intended to depart from NASA's adherence to traditional operational principles. These improvements are designed to strengthen this approach and enhance information available to the launch/operations control decision makers, astronaut observers, and management team for space vehicle launches, flight, and landings. Attention is being given to improved prediction models, model verification techniques, and measurement accuracy. The long range goal of the program is to provide support that uses the latest technological developments.

Supporting Research

The NASA Atmospheric Sciences Research Program conducts research using space technology to improve our understanding of atmospheric behavior on scales ranging from the mesoscale to the planetary scale and from periods of hours to decades. NASA's role in this endeavor is based upon the unique perspective of the Earth's atmosphere and surface provided by space platforms.

The NASA program includes the following major components:

- Development of space-borne observing systems and supporting ground-based systems to observe the state of the atmosphere, and important atmospheric and surface parameters such as temperature, moisture, winds, albedo, clouds, etc.
- Development of algorithms and inversion techniques to derive useful atmospheric parameters from remote observations.
- Development of data processing and data assimilation techniques to address the problems peculiar to the use of satellite data in atmospheric analyses and modeling.
- Analysis of satellite data to improve our understanding of atmospheric processes on temporal and spatial scales consistent with satellite observing capabilities.
- Development of models to exploit the spatial densities and temporal frequencies inherent in satellite data to initialize and verify models and assess their predictive value.
- Development of parameterization schemes which permit the representation of space observations of sub-grid scale phenomena in atmospheric models.
- Assessment of the performance of satellite sensors through numerical simulation experiments which compare model output with and without satellite sensor data.

NASA continues to support research and development activities to improve our remote sensing capabilities for possible future deployment on satellites. Studies involve remote sensing of atmospheric temperature, pressure, moisture, and winds using passive and active techniques. Successful flights of remote sensing instruments on several aircraft have been made using sensors to study the dynamics and radiative properties of cloud tops, and the fluxes of heat, moisture, and momentum between land and ocean surfaces and the atmosphere. Background aerosol loadings have also been measured in support of the proposed spaceborne instrument for measuring winds; the Laser Atmospheric Wind Sounder (LAWS).

The proposed NASA space-based program is responsive to scientific and policy needs. The NASA space-based program includes: (i) EOS precursor satellite mission such as the Upper Atmosphere Research Satellite (UARS), launched in September 1991, to study the chemical, dynamical and radiative processes that control the abundance and distribution of stratospheric ozone, (ii) TOPEX, scheduled for launch in August 1992, to study ocean circulation; (iii) a series of Earth Probes including Total Ozone Mapping Spectrometers (TOMS) on various satellites to measure

atmospheric ozone, a scatterometer (NSCAT) to measure ocean surface winds, a Tropical Rainfall Measurement Mission (TRMM) to measure precipitation in the tropics; (iv) Missions Operations and Data Analysis of satellite and shuttle experiments, including the current TOMS and ERBE data, and (v) EOS which will provide an integrated comprehensive monitoring program of simultaneous measurements of key global change variables, coupled with a comprehensive data and information system.

NASA has completed the restructuring of the Earth Observing System (EOS) from a program in which the instruments were to be flown on a series of large platforms to one in which the instruments will fly on intermediate-sized and smaller spacecraft. The restructuring was undertaken (i) to provide the EOS program with greater resilience and flexibility; (ii) to adjust the program to the reduced levels of funding expected from the Congress; and (iii) to take advantage of new launch opportunities for the EOS spacecraft, particularly, the expected availability of Atlas IIAS launch vehicles from the west coast.

The Tropical Rainfall Measuring Mission (TRMM) is being developed jointly by the United States and Japan. Scheduled for launch in 1997, TRMM will measure tropical rainfall and its variation from space. Tremendous uncertainty exists about the quantity and distribution of precipitation, especially in the tropics. Given this uncertainty and the importance of understanding the hydrologic cycle of the tropics, a minimum of 3 years of climatologically significant observations of rainfall in the tropics are planned. TRMM will be placed in a low-inclination orbit for frequent time-varied observations of low-latitude regions.

TOPEX/Poseidon is a joint U.S.(NASA) and French (Center National d'Etude Spatiales) mission designed to make substantial contributions to the understanding of global ocean dynamics. Radar altimeters will be used on a well-tracked satellite to make accurate observations of the oceanic sea surface topography. These data will enable the study of oceanic circulation and heat transport, and its interaction with the atmosphere. The role of the ocean in moderating the global climate must be better understood if models are to adequately account for this very substantial effect. The TOPEX/Poseidon mission is scheduled for launch during FY 1992.

The NASA Scatterometer (NSCAT) will fly on the Japanese Advanced Earth Observing Satellite (ADEOS) in 1995. NSCAT will contribute systematic high-resolution wind observations over the ocean, serving as a precursor to the scatterometry elements of the EOS program. These data are critical in understanding fundamental processes in which the oceans and atmosphere play a role in moderating the Earth's climate. NSCAT, an Earth Probes mission, will be a key contributor to the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean Global Atmosphere (TOGA) programs, both components of the World Climate Research Program (WCRP).

The International Satellite Cloud Climatology Project (ISCCP) was established as part of the World Climate Research Program (WCRP), and has been ongoing since July 1983. ISCCP is producing global calibrated radiance data set, together with other basic information on the radiative properties of the atmosphere and surface from which cloud properties can be derived. Among its significant conclusions so far are that cloud cover over the oceans is about 10 percent higher than previously inferred, and that, while much of this is very low-altitude cloudiness, cirrus cloud cover seems to be more common as well. A validated global cloud climatology will serve as an important component for a comprehensive understanding of global change. The program also coordinates basic research on cloud analysis techniques and promotes research using ISCCP data sets to improve climate model cloud parameterizations. ISCCP data collection and processing will continue through 1995.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for working with state, local, and other Federal Government agencies to ensure adequate air quality meteorological programs to support regulatory applications. Applied research and meteorological support is provided by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC. Meteorological support to the EPA Office of Air and Radiation, the EPA Regional Offices, and to state and local agencies includes: review of the meteorological aspects of environmental impact statements, state implementation plans, and variance requests; development and application of air quality dispersion models for pollution control and exposure assessment strategies; and preparation of dispersion studies and model evaluations. Meteorological expertise and guidance is also provided for the air quality standard, modeling guideline, and policy development activities of the EPA.

In the light of recent 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 five years. In the area of acid deposition, the evaluation of nitrogen and oxidant chemistry in addition to the sulfur chemistry will be completed within the framework of meteorological dispersion model formulations. Further development and evaluation of existing air quality models will take place to permit 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 between oxidant, ozone, sulfur oxides, nitrogen oxides, and volatile organic compound controls as well as developing predictable methods of forecasting impacts on visibility and acid aerosol effects.

With respect to inhalable particulate model development, dispersion grid models will be enhanced to accurately predict aerosol growth from precursors over regional transport distances. To assist in the evaluation of the contribution of various sources to regional air quality, inert tracer and tagged species numerical models will be developed. These models would introduce separate calculations for inert or reactive chemical species emitted from a particular source or region. The calculations would 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 must be elucidated along with the development of a better understanding of the fundamental aspects of the ozone nonattainment problem such as multi-day transport.

Atmospheric research in the areas of climate and climate change include the chemistry of the global troposphere that affects the distribution and fate of reactive green house gases, and regional climate studies addressing the interaction of climate with the biosphere. The climatology program involves both analytical and statistical climatology as well as 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, mesoscale, and regional. Other efforts include the construction and application of air pollution climatologies; determination and description of pollutant effects on atmospheric parameters; and 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 1992-93 period.

DEPARTMENT OF STATE

The Department of State is assuming a much more active role in international climate/meteorological policy making as a result of growing public concern with possible substantial warming of the global atmosphere due to the "greenhouse gas effect." The Assistant Secretary of State for Oceans, International Environmental and Scientific Affairs, chairs the U.S. Delegation to the Intergovernmental Panel on Climate Change (IPCC) which held its first meeting at Geneva in November 1988. The purpose of the IPCC is to serve as a government forum to call for scientific examination and assessment of future global climate change due to atmospheric warming from the greenhouse effect. It is anticipated that the IPCC will draw upon scientific assessment support from the World Meteorological Organization (WMO), the United Nations Environmental Program (UNEP), the International Council of Scientific Unions (ICSU) and their various international climate assessment programs.

The Department of State is also active on the Committee on Earth and Environmental Sciences (CEES) of the Federal Coordinating Committee on Science, Engineering and Technology (FCCSET). The CEES was established in 1987 by the President's Science Advisor to coordinate all domestic programs dealing with global change, including global climate change assessments. The CEES is the chief Federal interface with the National Research Council's global change program which is a part of the ICSU's emerging International Geosphere/ Biosphere Program (IGBP) which is charged with assessing and analyzing Earth systems science and changes in the Earth systems as a whole. Through the CEES, the State Department is able to help shape and define U.S. international science policies regarding global change, including global climate change.

These new responsibilities are in addition to, but do not replace, traditional Department responsibilities set forth in earlier annual Federal Plans, i.e., international aspects of global food policies, disaster warnings and assistance, WMO activities, international meteorological programs, and concern with some programs which start as operating programs but develop international interest and concern such as the possibility of seeding Pacific storms.

Finally, the Department is monitoring and implementing international actions to enforce the provisions of the 1985 Vienna Convention on the Preservation of the Ozone and the subsequent Montreal Convention Protocols on enforcement of chloroflourocarbon (CFC) reduction. All of the above activities -- especially IPCC, IGBP and CEES responsibilities, and the ozone monitoring and implementation actions -- will be continued for many years.

NUCLEAR REGULATORY COMMISSION

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

Office also develops and conducts confirmatory research programs in support of activities of the other offices and in support of rule-making and standards activities.

There are several meteorological areas in which the NRC will have an interest during FY 1993 and beyond. Paleoclimatic reconstruction and climatic change models for high-level radioactive waste repositories will continue to be evaluated. Improvements in the meteorological capabilities of the NRC and the operators of nuclear facilities to cope with emergencies involving unplanned releases of radioactive material are expected to continue. The NRC is also concerned with the dispersion of 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 Nuclear 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 FEMAs 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. Recently, 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 (WG/WWP) of the Committee for Basic Services within the Federal meteorological coordination mechanism.

GOALS AND ORGANIZATION OF THE WORLD WEATHER PROGRAM

The goals of the World Weather Program (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 160 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.

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 World Weather Watch 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
Wind Profilers
Solar Radiation Stations
Atmospheric Detection Stations
Meteorological Rocket Stations
Ozone Stations
Background Pollution Stations
Tide Gage Stations

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-I (which will become NOAA-13 when operational) will be available for launch in an afternoon orbit when needed after September 1992.

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 50° 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. Since 1989, GOES-7 has been alternately positioned at 108°W (winter season) and 98°W (hurricane season). NOAA plans to launch the next satellite in this series (GOES-I, to become GOES-8 when operational) in late 1993.

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.

During the last few years, several systems have been under development and/or have been partially deployed which will contribute to improving the GOS. Among these are the family of automated aircraft reporting systems (AMDAR) including the Aircraft to Satellite Data Relay (ASDAR) and the Aircraft Communications Addressing and Reporting System (ACARS). British Civil Aviation Authority (CAA) and U.S. Federal Aviation Administration (FAA) certifications for ASDAR System airworthiness have been completed for both the B-747 and DC-10 aircraft. Flight tests for the CAA certified ASDAR system have been completed while those for the FAA certified systems are near completion. These ASDAR equipped aircraft, coupled with the four operational geostationary meteorological satellites, will provide the capability for global upper air observations in data sparse areas. By late March 1992, 6 aircraft were equipped and flying with operational ASDAR systems aboard, and another 3 aircraft were scheduled to be outfitted with operational systems soon afterwards.

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. Between 10,000 and 20,000 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 mid to late 1990's.

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 15 of its systems now 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. By the late Spring of 1992, a network of 29 wind profilers will be operating primarily in the central U.S. In February 1992, data from these systems was released to the private sector in the U.S. and by the summer of 1992 it is expected to by released on the GTS. After a multi-year effort, NOAA was successful in obtaining 449 MHz as a permanent frequency for future wind profilers operating in the United States.

The concept of the Operational World Weather Watch Systems Evaluation (OWSE) has also been developed as a framework for regional implementation. The OWSE-Africa has been initiated 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. Specifically, it is designed to implement and test the data collection system for receipt of meteorological observations from various countries in Africa. Thus far, 36 data collection platforms have been installed in Kenya, Ethiopia, Ghana, Sudan, Nigeria, Sierra Leone, Zaire, Egpyt, Madagascar, St. Helena, Guinea, and Cape Verde. When completed it is expected 150 of these platforms will have been deployed and activated. Evaluations are being carried out to gage the improvement of observations and preliminary results show that when systems are operating, high receipt rates are achieved.

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 is expected to begin in late 1993. 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 from the WMCs, RSMCs and NMCs operating within the GDPS 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 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 1992 include:

- Improvement of the capacity of MTN links and inclusion of graphics (e.g., Washington-Bracknell, Washington-Brasilia, Washington-Buenos Aires, Washington-Montreal, Washington-Tokyo, Bracknell-Toulouse and Bracknell-Offenbach;
- 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 Program 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 1991, DOS funding for WWW/VCP programs was $2.00 million. In FY 1992, $2.00 million was approved and in FY 1993, $2.30 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 1992 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;
- Continued support for the implementation of VCP projects in Latin America and the Caribbean areas in support of the hurricane and tropical storm programs;
- Installation and training on the CLICOM climate data management system for countries in Africa, Central and South America, Asia and Eastern Europe; hosting the WMO CLICOM Experts Group meeting; distribution of CLICOM version 3.0 worldwide; and implementation of enhanced graphic output capabilities.

BILATERAL AND REGIONAL INTERNATIONAL COOPERATIVE PROGRAMS

United States - Peoples Republic of China (PRC) Protocol in Atmospheric Science and Technology

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.

Over the past year, collaborative efforts with visiting PRC experts took place in the areas of tree-ring collection and analysis and in the reconstruction of Chinese climate from historical records. A Climate Dynamics Workshop was held in Washington, DC with eight PRC scientists attending. Two U.S. heavy rain experts lectured throughout China to assist the PRC in developing its PC-based technology. Within the mesoscale meteorology program, two PRC scientists participated in the one month WSR-88D doppler radar training course while one U.S. expert lectured in China on mesoscale modeling. The Third Joint Mesoscale Meteorology Workshop will be held in Fall of 1992 in China with up to 12 U.S. scientists participating. In the area of satellite meteorology, a senior PRC scientist is working in the U.S. on incorporating PRC data sets into the existing records at the U.S. National Climate Data Center. In atmospheric chemistry, both U.S. and PRC scientists jointly conducted intensive ground based observations at Lin An station in support of the Pacific Exploratory Mission - West flight made in October 1991. Within the TOGA Program, a PRC scientist is spending a year in the U.S. on coupled ocean-atmosphere modeling and El Nino Southern Oscillation prediction. The Training and Participation Program hosted five Chinese trainees in the fields of hurricane operations and modeling, weather service management, advanced weather interactive processing systems and a Chinese trainee will begin a one-year program in fire weather operations and research.

APPENDIX F

SELECTED ACRONYMS AND ABBREVIATIONS

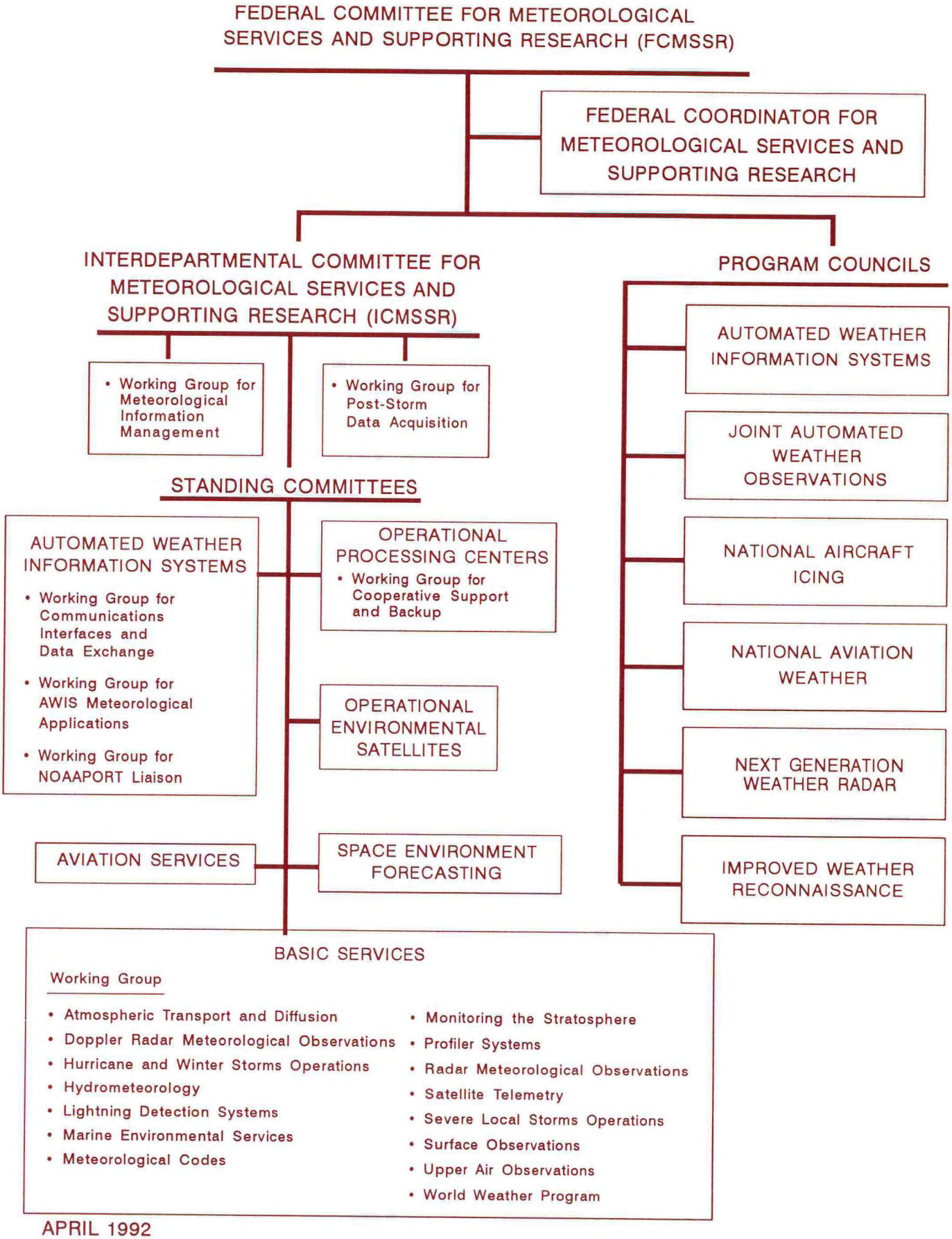
ADAS	AWOS/ASOS Data Acquisition System (FAA)
ADLP	Aeronautical Data Link Program (FAA)
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services (NOAA/NWS)
AFRES	Air Force Reserve
AFS	Air Force Station
AFSS	Automated Flight Service Station (FAA)
AI	Artificial Intelligence
AIP	Airport Improvement Program (FAA)
ALBE	AirLand Battlefield Environment (Army)
AMR	Aircraft Microwave Refractometer
ARGOS	French Satellite Data Collection System
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)
CAC	Climate Analysis Center (NOAA/NWS)
CAS	Committee for Aviation Services (OFCM)
CAT	Clear Air Turbulence
CAWIS	Committee for Automated Weather Information Systems (OFCM)
CBS	Committee for Basic Services (OFCM)
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CECOM	Communications and Electronics Command (Army)
COES	Committee for Operational Environmental Satellites (OFCM)
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
FNOC	Fleet Numerical 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)
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
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

MMS	Meteorological Measuring System (Army)
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
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
NODC	National Oceanographic Data Center (NOAA)
NODDES	Naval Oceanographic Data Distribution and Expansion System (USN)
NOMSS	Naval Oceanographic and Meteorological Support System (USN)
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)
PL/GP	Phillips Laboratory, Geophysics Directorate (DOD/AFSC)
PROFS	Program for Regional Observing and Forecasting Service (NOAA/ERL)
R&D	Research and Development
RD/T&E	Research and Development, Test and Evaluation
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)

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
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
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

*U.S. G.P.O.:1992-313-153:60706


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 Meteorological Information Management
• Working Group for Post-Storm Data Acquisition
PROGRAM COUNCILS
AUTOMATED WEATHER INFORMATION SYSTEMS
JOINT AUTOMATED WEATHER OBSERVATIONS
NATIONAL AIRCRAFT ICING
NATIONAL AVIATION WEATHER
NEXT GENERATION WEATHER RADAR
IMPROVED WEATHER RECONNAISSANCE
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
SPACE ENVIRONMENT FORECASTING
BASIC SERVICES
Working Group
• Atmospheric Transport and Diffusion
• Doppler Radar Meteorological Observations
• Hurricane and Winter Storms Operations
• 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
• Upper Air Observations
• World Weather Program

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