The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1989

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

FCM P1-1988

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

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U.S. DEPARTMENT OF COMMERCE
C. William Verity, Secretary

National Oceanic and Atmospheric Administration
William E. Evans, Under Secretary

APRIL 1988
WASHINGTON, D.C.

PREFACE

Interdepartmental cooperation in meteorological operations advanced remarkably in fiscal year 1988. In spite of tight government fiscal constraints, important meteorological initiatives were advanced and moved closer to realization. The Next Generation Radar moved into the limited production phase with tri-agency support. The Automated Surface Observation System, a National Weather Service program, gained support from the Federal Aviation Administration. New interdepartmental cooperation was achieved in the development of Automated Weather Information Systems. The coming fiscal year, reflected in this annual Federal Plan, will present new problems for the meteorological community. It is becoming quite clear, however, that the times are demanding increased cost-effectiveness and, in all probability, increased interdepartmental cooperation and coordination. The Office of the Federal Coordinator exists to facilitate that coordination. This document is one of the principal means for communicating our successes and failures in that regard.

This Federal Plan is prepared for the specific purpose of complying with the requirements of Section 304, Public Law 87-843. It 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 1988 and FY 1989.

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. The second section 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 1989 as compared to planned resources for FY 1988. The emphasis is on changes in resources and the related changes in programs. All fiscal data are current as of the end of January 1988. Section 4 gives a brief description and plan for government-wide acquisition of supercomputers used for meteorological programs. The appendices contain selected descriptions of agencies' weather activities, a description of the World Weather Program, and a list of acronyms.

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.

Robert L. Carnahan
Federal Coordinator for
Meteorological Services and
Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH, FY 1989

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SECTION 1

EXECUTIVE SUMMARY

This Federal Plan is the twenty-fourth published by the Federal Coordinator for Meteorological Services and Supporting Research. It is mandated by Public Law 87-843, Section 304. The plan provides for the Congress and the public a comprehensive review of Federal meteorological services and Federal research and development programs directly supporting meteorological services.

The Federal Plan is prepared by the Office of the Federal Coordinator (OFCM), an office established in response to the Office of Management and Budget (formerly Bureau of the Budget) Circular A-62. The Office is supported and staffed by the three departments with major roles in providing weather services: the Departments of Commerce, Defense, and Transportation. Within the OFCM structure, there are 14 agencies represented in various committees and working groups.

Major Programs

A major program with continuing funding in FY 1989 is the Next Generation Weather Radar (NEXRAD). This tri-agency program, supported by the Department of Commerce (DOC), Department of Defense (DOD), and the Department of Transportation (DOT), moved into the limited production phase within the past year. A Program Council, chaired by the Federal Coordinator, provides policy guidance and oversight to procure and install a system that will meet the common needs of the three agencies.

The NEXRAD system utilizes solid state technology, advanced signal processing, automation features, and Doppler radar techniques. The system will provide information on the location, intensity, and movement of hazardous weather. The system will also support water resources management activities of the National Weather Service. Once in place in the early 1990s, the NEXRAD system will consist of about 160 radar sites throughout the United States.

The Automated Surface Weather Observation program, under the guidance of a Program Council chaired by the Federal Coordinator, is supported in the FY 1989 budget request for the Departments of Commerce and Transportation. The Department of Defense is following the program and may participate in the future. This program will automate the surface weather observation network. There have been notable successes in the development stages of the program. For example, in FY 1986, the National Weather Service completed one year of operations of six prototype systems in an operational environment including a Federal Aviation Administration control tower. Large-scale deployment of the systems is now possible. Partly as a result of the demonstration, significant improvements in laser ceilometer technology have been made. Production delivery of these cloud height sensors has begun with field installations at primary NWS and U.S. Air Force locations. Tri-agency tests on precipitation identification sensors and freezing rain sensors have been, and continue to be, conducted. A test program for automated visibility sensors is underway.

A program being managed directly by OFCM is the Improved Weather Reconnaissance System (IWRS). This is a joint USAF - NOAA program to improve the quality and quantity of weather data obtained by USAF WC-130 weather reconnaissance aircraft. A production contract for procurement of six IWRS units for installation in USAF weather reconnaissance aircraft has been initiated. Funding for this ten million dollar program was provided in FY 1988.

Programs for automated weather information systems have been initiated in several agencies in response to their own unique requirements. These systems are being developed to reduce labor intensive functions and reduce the time for collecting, processing and interpreting weather data. Furthermore, these automated systems will reduce the time to produce weather forecasts and warnings, and will assist in the production of tailored products for specific Federal users. Rapid distribution of the products to users is yet another goal. A program council, a committee, and several working groups provide coordination for various aspects of the agencies' programs. Funding for the FAA and the DOD programs is in the FY 1989 budget request; however, funding for the DOC program (AWIPS-90) has been omitted from the FY 1989 budget. The DOC program has sufficient funds to proceed through the "definition" phase of the program.

The OFCM is also playing a role in establishing weather data collection standards by overseeing the revision and subsequent publication of the Federal Meteorological Handbook series. The preparation of these handbooks is being performed by the various committees and working groups within the OFCM infrastructure. There are currently ten published handbooks in use by the Federal agencies and the meteorological community in the U.S. Two of the revised handbooks will be published in FY 1989.

Resources

The resources available in FY 1989 for the Federal meteorological services and supporting research are now just over two billion dollars, a 22 percent increase from the $1,647 million in FY 1988. Of this amount, about $1,563 million will be for services and nearly $445 million for supporting research. The budget, by agency, is shown in Table 1.1.

A graphical illustration of these amounts is shown in Figure 1.1. Proposed spending for services by agency is shown in Figure 1.2. The Departments of Commerce, Defense, and Transportation account for approximately 99 percent of the total Federal budget for services. Proposed spending for supporting research is shown in Figure 1.3. NASA accounts for nearly half of the total budget.

A ten-year history of the proportional distribution of Meteorological Service and Supporting Research costs in the Federal government is illustrated in Figure 1.4. It shows that since 1979, the Department of Commerce share has decreased from about 45 percent to a little less than 22 percent. Meanwhile the DOD portion has increased from about 40 percent to about 45 percent. The DOT portion in this ten-year period grew from about 10 percent to 21 percent.

In regard to manpower, there will be about 16,223 personnel engaged in meteorological operations in FY 1989, a slight decrease from the 16,313 in FY 1988. A majority, or about 58 percent, will be associated with military meteorological operations.

The coordination of meteorological programs involves the formal cooperative efforts of the agencies. There are many memoranda of agreement between agencies for providing services on a reimbursable basis; about $56 million for meteorological services and $4 million for supporting research. Other informal cooperative efforts between agencies are much more numerous and attest to the dynamic nature and evolution of the provision of Federal weather services to the Nation.

Supercomputers for Meteorology

As begun in the Federal Plan for FY 1988, another element of the long-range functional plan for meteorological services is presented in Section 4. The focus in this document is on supercomputers which play a crucial role in the provision of Federal meteorological services, both civil and military. Advances in supercomputer technology have been rapid and impressive during the past three decades. In the mid-1960's the Control Data Corporation (CDC) model 6600 computer could perform about two million floating point operations per second. Today, the CRAY 2 can perform about 1 billion floating point operations per second. Numerical prediction models have unlimited capability to use computer processing capacity.

Table 1.1. Federal Budget of Meteorological Services and Supporting Research, Fiscal Year 1989 (in thousands of dollars)

Agency	Operations	% of Total	Supporting Research	% of Total	Total	% of Total
Agriculture	7,113	0.5	9,627	2.2	16,740	0.8
Commerce	371,164	23.8	62,297	14.0	433,461	21.6
Defense	762,833	48.8	136,380	30.8	899,213	44.8
Transportation	414,996	26.6	18,251	4.1	433,247	21.6
Envir. Protection Agency	0	0	6,542	1.5	6,542	0.3
NASA	5,996	0.4	210,400	47.4	216,396	10.8
Nuclear Reg. Comm.	182	+0	0	0	182	+0
TOTAL	1,562,284	100.0	443,497	100.0	2,005,781	100.0

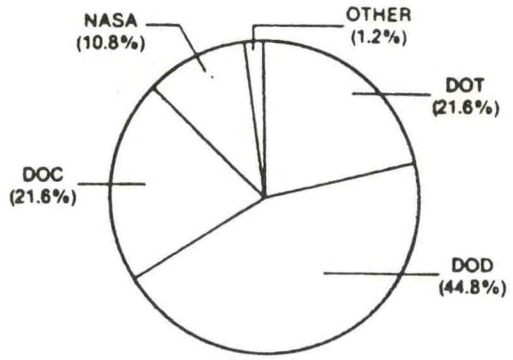


Figure 1.1
Federal Budget for Meteorological
Services and Supporting Research, FY 1989
(percentage of total budget)

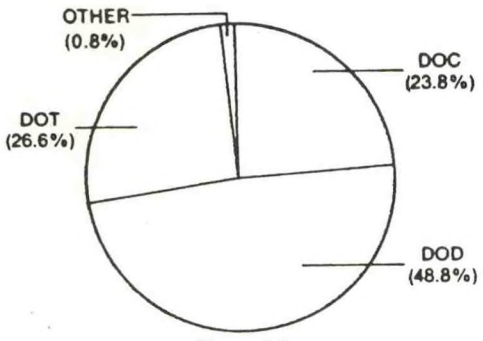


Figure 1.2
Federal Budget for Meteorological
Services, FY 1989
(percentage of services budget)

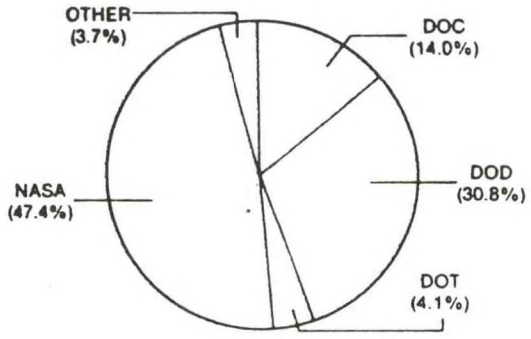
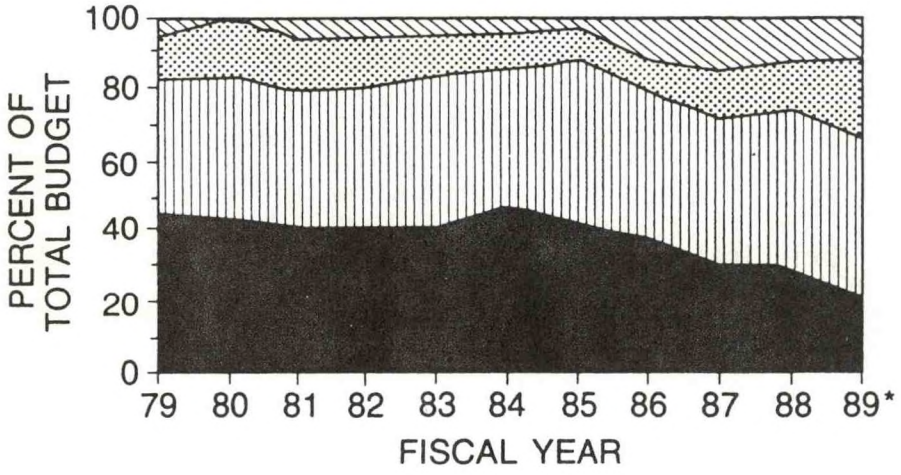


Figure 1.3
Federal Budget for Supporting
Research, FY 1989
(percentage of research budget)



*Denotes Budget Request

LEGEND:

Dept. of Commerce
Dept. of Transportation
Dept. of Defense
NASA

FIGURE 1.4 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS, BY AGENCY, FY 1979-89

SECTION 2

FEDERAL COORDINATION AND PLANNING

In 1963, activities in meteorology gave rise to concern in Congress and the Executive Office of the President as to whether Federal meteorological activities were being coordinated adequately. 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 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 relations 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 specialized meteorological services.

The implementation of Circular A-62 by the Department of Commerce led to creation of the Office of the Federal Coordinator for Meteorological Services and Supporting Research. 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 and several special purpose program councils. The organizational relationships are shown on the inside of the back cover of this document.

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

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

- o Review Federal weather programs and total Federal requirements for 14 weather services. 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.

- o 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.

- o 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.

- o 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," LCS-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 agency representative; DOC also provides administrative support to the Office of the Federal Coordinator. The Department of Defense (DOD) provides two staff officers (one Air Force colonel and one Navy captain) and contributes approximately $300,000 per year to the operation of the OFCM. DOT/FAA provides one professional staff member and contributes approximately $250,000 per year. The four assigned individuals act as assistant federal coordinators for liaison to their respective agencies. Based on current staffing, there are 11 professionals and three 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 are engaged 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.

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 for Basic Services, Operational Processing Centers, Automated Weather Information Systems, Aviation Services, Operational Environmental Satellites, and Space Environmental Forecasting.

Five Program Councils have been established within the OFCM structure to coordinate specific interagency cooperative programs. These are: Automated Weather Information Systems, Improved Weather Reconnaissance, Joint Automated Weather Observations, Aircraft Icing, and Next Generation Weather Radar. 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)/Doppler Radar

The Departments of Commerce (DOC), Defense (DOD) and Transportation (DOT) stated a common need in the late 1970's for a radar system with improved capabilities for detecting and monitoring hazardous weather. In 1979 the three Departments established a Joint System Program Office (JSPO) within the National Oceanic and Atmospheric Administration to plan, define, acquire and deploy a "Next Generation Weather Radar" (NEXRAD) network. A program council with members from the three Departments, and chaired by the Federal Coordinator, provides policy guidance and oversight to the JSPO.

The NEXRAD system combines solid state technology, advanced signal processing, and automation features with Doppler techniques to produce a moderately priced, highly reliable system meeting the common needs of the Departments of Commerce, Defense, and Transportation. These Departments all require information concerning the location, intensity, and movement of hazardous weather to meet their mission responsibilities. The Department of Commerce's National Weather Service also requires the same information to support effective management of water resources under non-hazardous conditions. Water resource management is rapidly increasing in visibility as a national problem, and the potential economic benefits from improved management made possible by modern radar techniques are very large.

The acquisition program is structured in four phases--system definition, validation, limited production, and full scale production. During the system definition phase (February to November 1982), three contractor teams produced competitive system designs. Two contractors were selected for the follow-on validation phase.

During Part 1 (May 1983 through April 1984) and Part 2 (May 1984 through June 1987) of the validation phase, the two selected contractors produced subsystem specifications, demonstrated their data processing and system display design, and completed the integration of the system. The

resulting preproduction models of the NEXRAD system underwent extensive system level testing and initial operational test and evaluation. The validation phase was completed June 30, 1987.

The Limited Production Phase contract was awarded to Unisys Corporation on December 1, 1987. Early in FY 1989, the NEXRAD prototype will be installed at the NEXRAD Operational Support Facility (OSF) in Norman, Oklahoma. The Government will conduct part 2 of Initial Operational Test and Evaluation (IOT&E) at the OSF early to mid-1989. Any deficiences to be corrected as a result of IOT&E(2) will be retrofitted into the limited and full scale production units. Field training for personnel will start in the 3rd quarter of FY 1989, and site preparation for the first 10 sites will be underway. The option to start full production will be exercised at the end of FY 1989.

Automated Surface Weather Observations

The Departments of Commerce, Defense, and Transportation (DOC, DOD, DOT) maintain approximately 950 surface weather observing sites requiring an estimated 1,000 staff-years annually. Most surface observations are taken manually and consume a significant amount of personnel time. In addition, sensor maintainability and reliability are presenting significant problems. A typical observing station now costs about $24,000 per year to maintain equipment, and this cost is projected to increase about 10 percent per year because of the increasing difficulty of obtaining replacement parts. Consequently, selective replacement of obsolete sensors is now taking place just to retain the current capability.

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 OFCM's recommendation, the Joint Automated Weather Observing Program (JAWOP) was established. The JAWOP Council, chaired by the Federal Coordinator, provides policy and oversight for the three Departments' automated surface observation program development efforts.

In FY 1986, a Government-wide audit of the development of automated weather systems was performed by the President's Council on Integrity and Efficiency (PCIE). It was a joint effort of the Inspectors General from DOC, DOD, and DOT to determine if overlap and duplication existed in the development of automated weather systems. During this same period, the Departments took actions to greatly improve coordination and lessen duplication and overlap in the Federal weather community. Specifically, NWS and FAA sought convergence of their programs by closely examining system commonality and revalidating system requirements. This resulted in an agreement in 1987 by the JAWOP Council to use the NWS's Automated Surface Observing System (ASOS) at the FAA's towered airport locations.

The PCIE audit supported this action; it concluded that NWS and FAA could achieve substantial cost savings by consolidating development and acquisition actions. Subsequently, the Administrators of NOAA and FAA agreed that NOAA will procure, install, operate, and maintain the NWS's ASOS to meet FAA requirements for both, the towered and most of the

nontowered airports. Towered airports are the large airports that have a control tower and FAA personnel to control airplane traffic. Immediate needs of the FAA will be satisfied by procuring 160 off-the-shelf automated weather observing systems as an interim system.

In FY 1986, NWS completed the first year of operation of prototype ASOS as part of its demonstration phase. The demonstration involved six systems at operational NWS offices in the State of Kansas, as well as a system for FAA control tower evaluation. In addition, other systems were placed in different climates for further evaluation and development of key sensors and algorithms. The demonstration modeled the future observing operation and provided very useful information on system, sensor, and algorithm performance. The experience has supported sensor development as well. Overall, the demonstration showed ASOS to be viable for large-scale deployment. The prototype systems will continue to operate in Kansas to foster user acceptance and develop operational procedures needed to transition into the future automated observing era.

The 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 begun with field installation underway at primary NWS observing locations. The new ceilometer will be used as part of the ASOS sensor suite at most locations. The Air Force has decided to use the NWS-developed Next Generation Ceilometer for replacement purposes and is presently acquiring ceilometers through the NWS. The Air Force is actively considering use of the NWS developed ASOS for general Air Force application.

The FAA and NWS test of precipitation identification sensors and freezing rain sensors was conducted during the 1986-1987 winter season, with continued testing of sensor refinements planned during the 1987-1988 winter season. This testing is part of a JAWOP plan to conduct comparative testing of these sensors. These tests of precipitation identification sensors were conducted at both the Air Force Geophysics Laboratory's Weather Test Facility at Otis Air National Guard Base, Massachusetts, and the NWS's Systems Research and Development Center at Sterling, Virginia. Freezing rain sensors were tested at Worcester, Massachusetts, Municipal Airport, which has frequent icing events.

A JAWOP Visibility Sensor Development Test Program was established in FY 1987 in order to support sensor development in industry; this program is currently in progress. The purpose of the test program is to minimize risk with this key sensor. The Working Group for Surface Observation's Task Group for Surface Instrumentation Standards has completed development of a standard for siting meteorological sensors of automated systems at airports. Development of Federal standard algorithms is expected to be completed in FY 1988.

The Air Force activity in automated sensor development is principally the responsibility of the Air Force Geophysics Laboratory (AFGL). Sensor development, test, and evaluation are carried out by AFGL at Otis Air National Guard Base, MA. Efforts are concentrated on airfield weather parameters, for example, the automation of type and intensity of present

weather, visibility, and lightning detection. AFGL is also investigating the use of an "all sky" camera to determine sector visibility and cloud cover. A further effort will be to determine the availability and utility of instruments and techniques for providing weather such as visibility and cloud height for AF tactical operations. Ongoing procurement and replacement of sensors include solid state temperature-humidity sensors, pressure sensors, and cloud height indicators.

The DOD's Department of the Navy is planning to automate the weather observing function at 87 Navy and Marine Corps facilities. It is currently evaluating all available options for accomplishing this goal. Options include the use of Navy's Shipboard Meteorological Oceanographic Observing System (SMOOS) and NWS's ASOS.

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, relative humidity, wind direction and speed, barometric pressure, soil temperature, and visibility at each data collection platform (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 1988 and FY 1989 include:

- NWS awarded two contracts in April 1988 for the competitive design, development, fabrication and testing of four preproduction prototype ASOS from each contractor selected. This is the initial phase of the "A-109" ASOS development being conducted under the guidelines of OMB Circular A-109, and will conclude with the awarding of the production contract to one contractor, scheduled for April 1990.

- FAA will issue an invitation for competitive bids to procure 160 off-the-shelf AWOS systems.

- NWS, FAA, and DOD under the auspices of the JAWOP will continue an evaluation of various precipitation identification sensors, with a final report scheduled for early 1989.

- Under the auspices of the JAWOP, the NWS, DOT's Transportation Systems Center, and DOD (AFGL), with support from FAA and Canada's Atmospheric Environment Service, will conduct an evaluation of visibility sensors in support of the ASOS production system acquisition.

- NWS will continue installation of Next Generation Ceilometers at its primary observing sites.

- The Task Group for Surface Instrumentation Standards will complete federal algorithm standards for automated surface weather observing systems.

- NWS will continue to operate its Kansas demonstration project to foster

user understanding and develop operational procedures needed to transition into the automated observing era.

- o OFCM will revise the Federal Meteorological Handbook No. 1 to reflect automated observing procedures.

- o USAF will continue selective replacement of aging sensors, including the purchase of new laser ceilometers by means of an add-on to the NWS procurement.

Automated Weather Information Systems (AWIS)

Automated Weather Information Systems (AWIS) is the term used within the Federal coordination mechanism to refer to the automated weather information systems of the various Federal agencies. The AWIS are being pursued to reduce labor intensive functions; to reduce the time required to collect, process and interpret weather data; to reduce the time to produce forecasts, warnings and special tailored products; and to expeditiously distribute these products to users. Major agency systems included in AWIS are the Department of Commerce's Advanced Weather Interactive Processing System for the 1990's (AWIPS-90), the Federal Aviation Administration's Central Weather Processor (CWP), the U.S. Air Force's Automated Weather Distribution System (AWDS), and the U.S. Navy's Naval Environmental Display Station (NEDS). 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.

Working under guidance from the Working Group for Automated Weather Information Systems, the Task Group for Communication Interfaces and Data Exchange (TG/CIDE) published, in 1986, the first revision to the 1982 document titled Standard Formats for Weather Data Exchange Among Automated Weather Information Systems. In 1986, TG/CIDE produced another standards document titled Standard Telecommunication Procedures for Weather Data Exchange Among Automated Weather Information Systems. 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.

The AWIS Program Council, which consists of high level representatives from the Departments of Commerce, Defense and Transportation, was established during February of 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 need 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 exist among the systems; and to produce a Federal Plan for the Coordination of AWIS Programs. The AWIS Program Council agreed to use the existing Working Group for Automated Weather Information Systems to support the Council's agenda.

In 1987 the Working Group for Automated Weather Information Systems was elevated to committee status (CAWIS) because of the growing importance of AWIS issues. In addition, the Task Group for Communications Interfaces and Data Exchange was elevated to working group status (WG/CIDE). And, a new Working Group for AWIS Meteorological Applications (WG/AMA) was established under CAWIS. WG/AMA will prepare an inventory of meteorological applications programs and techniques and provide a forum for coordination of developments in new or improved meteorological applications.

Improved Weather Reconnaissance System (IWRS)

The United States Air Force (USAF) and the National Oceanic and Atmospheric Administration (NOAA) have a requirement to improve the quality and quantity of weather data obtained from Air Force WC-130 weather reconnaissance aircraft. These data are needed to help improve the forecasts and warnings of tropical cyclones and East Coast winter storms. To provide improved data in support of the National Hurricane Center and the National Meteorological Center, the eight aircraft of the 53rd Weather Reconnaissance Squadron at Keesler Air Force Base, Mississippi, will be configured to use the Improved Weather Reconnaissance System now being procured under a contract with Tracor, Inc. The production contract, managed by the OFCM, incorporated all the user requirements of the IWRS pilot system that was successfully tested and accepted during 1987. The production units will include technological improvements since the design of the pilot system. Additionally, these will incorporate recent aircraft systems upgrades to the WC-130 fleet.

Planned activities for FY 1988 and FY 1989 include:

- Continued maintenance and operation of the pilot system through mid-1989.
- First Article Testing and acceptance -- January-March 1988
- Initial operational capability -- April 1989
- Full operational capability -- August 1989
- End of contractor-supplied maintenance -- March 1990

National Program for 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 which provide standard services to meet those needs.

Observations of solar activity with both 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) 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 the National Science Foundation (NSF) experiments 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 though 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. Most of the data gathered in this program are archived in data centers for use in future studies.

The complex of data gathered in the space environmental monitoring program needs 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 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: 1988-1993. The plan is currently being updated and will be reissued in 1988.

PLANNING ACTIVITIES, COMMITTEE CHANGES, AND METEOROLOGICAL PUBLICATIONS

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 decided to promote greater coordination in aircraft icing by forming 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, which was published in 1986. The planned program has dual objectives: improving aircraft icing technologies for the current generation of aircraft and promoting advances in aircraft icing 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 needs and objectives, and describes the efforts now underway and proposed in these areas of need. It is recognized that the scope,

definitions, and priorities may change as the National Aircraft Icing Technology Plan is implemented, and the plan will need to be updated to reflect accomplishments and changes in agency missions and goals.

One section of the technology plan on "Detecting, Monitoring and Forecasting" is detailed in the National Plan to Improve Aircraft Icing Forecasts prepared for the Committee for Aviation Services by an ad hoc group on Aircraft Icing Forecasts. This plan designated the NOAA Environmental Research Laboratories to provide the focus and leadership for an interagency forecast improvement program which is utilizing research aircraft and NOAA, NCAR, and FAA facilities in Eastern Colorado. The field portions of this program began in November 1987. Software developed for the Air Force will be evaluated under Army and FAA contracts.

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.

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.

At the present time The National Plan for Stratospheric Monitoring, 1988-1997 is under development, with an expected publishing date of 1988. This plan builds on the previous effort and, in particular, stresses that the problem is not simply one of detecting ozone change. The cause of this must be understood. 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 to be described.

The draft plan which is under review by the Working Group for Monitoring the Stratosphere has three themes:

(1) The monitoring system cannot rely on data from a single instrument because systematic errors in individual instruments can lead to erroneous trend detection. Intercomparison of data from different instruments is necessary;

(2) Monitoring requires a combination of a high quality/low spatial resolution ground-based system and a high spatial resolution satellite system;

(3) Changes in the stratosphere can result from natural and man-made perturbations. It is, therefore, essential that the agency research programs be complementary with the monitoring program.

From the viewpoint of sensors and sensor platforms, the overall timeframe of 1988-1997 can be subdivided into 3 general periods. From the present to the early 1990's, the emphasis is on the development of the Network for Detection of Stratospheric Change (NDSC) sponsored by NASA, NOAA, the WMO, and the Chemical Manufacturers Association (CMA). This is to be a high-technology ground-based program designed to supplement the current ground-based systems and provide, from at least 6 sites, information on many species and parameters. This Network will serve both to validate/calibrate the available satellite systems and provide information on possible causes of ozone change. Starting in the early 1990's, the NASA Upper Atmosphere Research Satellite (UARS) will make measurements of many of the parameters of interest in this Plan. UARS, which is planned to be launched in late 1991, is a unique instrument of opportunity that will be included within the monitoring program for as long as this satellite lasts. Finally, for the late 1900's, consideration is given to the next-generation NOAA operational satellite systems and the Earth Observing System.

Federal Meteorological Handbooks

At the direction of the ICMSSR, the OFCM is undertaking 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 Weather Radar Observations, is under development. The OFCM will reevaluate the status of the FMH series and revise each handbook, if appropriate, to highlight the responsibility for preparation and maintenance, develop a mechanism to make sure the FMHs remain current and complete, assure the merging of information from new or automated technology, meet requirements for utility of the primary users, and reenforce 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. When completed, the new handbooks will be available to private sector users through the National Climatic Data Center in Asheville, NC.

Meteorological Information Management

The effects of human activities on the environment have gained significant attention during recent years. Concern for this has been growing because many environmental changes are not well understood. Good observation systems and corresponding data archives are required to provide a basis for research to help understand the reasons for the changes. These are needed in order to prepare meaningful recommendations to the political and technical arenas.

There are concerns about possible changes in the global climate. Meteorological data, current and historical, are archived and available to users. Within the next few years, data from new technological weather observing systems such as the Next Generation Weather Radar, Automated Surface Observing Systems, wind profilers, and observational satellites will become available. But the current data management activities are not adequate to meet the anticipated needs of the user (research) community.

To help facilitate coordination of data management activities within the federal government, the ICMSSR created the Working Group for Meteorological Information Management. The Group's objective is to prepare an information management plan as it relates to retrospective data users. As a follow-on to the plan, the Working Group intends to develop guidelines for new and existing data systems to ensure that appropriate retrospective data are captured, quality controlled, and made readily available to those who need it.

Committee and Working Group Changes

A schematic of the Federal Committee structure is found on the back inside cover of this Plan. In the last year, ICMSSR took the following actions:

- The Working Group for Automated Weather Information Systems was elevated to committee status (CAWIS) because of the growing importance of AWIS issues.

- The Task Group for Communications Interfaces and Data Exchange was elevated to working group status (WG/CIDE) under CAWIS.

- A new Working Group for AWIS Meteorological Applications (WG/AMA) was established under CAWIS. WG/AMA will prepare an inventory of meteorological application's programs and techniques, and provide a forum for coordination of developments in new or improved meteorological applications.

- A new working group for Hydrometeorology was established under the Committee for Basic Services to address such issues as: local flood warning standards; meteorological products for hydrological applications; NEXRAD hydrological interfaces; climatological data products for hydrological applications; and improvements of real-time collection systems.

- The Working Group for Operational Processing Centers was elevated to Committee status (COPC).

- The Working Group for Cooperative Backup Among Operational Processing Centers was transferred to the COPC from the Committee for Basic Services and was renamed the Working Group for Cooperative Support and Backup (WG/CSB).

- o The Working Group for Dissemination of NMC Products (WG/DNP) was transferred to the COPC from the Committee for Basic Services.

- o The Committee for Systems Development was abolished.

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 below. Single copies are available upon request to OFCM.

Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 1989	April 1988	FCM-P1-88
National Severe Local Storms Operations Plan	May 1988	FCM-P11-88
National Hurricane Operations Plan	May 1988	FCM-P12-88
National Winter Storms Operations Plan	October 1987	FCM-P13-87
Federal Plans for Mutual Support and Cooperative Backup Among Operational Processing Centers	March 1985	FCM-P14-85
The National Aircraft Icing Technology Plan	April 1986	FCM-P20-86
National Plan to Improve Aircraft Icing Forecasts	July 1986	FCM-P21-86
Review of Aviation Weather Requirements and Services	December 1986	FCM-R10-86
Lightning Detection Study	November 1985	FCM-R8-85
Federal Standard for Siting Meteorological Sensors at Airports	May 1987	FCM-S4-87
Standard Telecommunication Procedures for Weather Data Exchange Among Automated Weather Information Systems	February 1986	FCM-S3-86
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	December 1986	FCM-S2-86

RELATED FEDERAL METEOROLOGICAL COORDINATION

The focus of OFCM and of this report is on Federal operational meteorological programs and direct 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.

National Climate Program

The National Climate Program (NCP) was established in 1978 by Public Law 95-367 to help "understand and respond to natural and man-induced climate processes and their implications." This interagency program of research and applications is managed by the National Climate Program Office (NCPO) for the Secretary of Commerce. The Act also mandates the development of an Intergovernmental Climate Program aimed at supporting "Federal and State cooperative activities in climate studies and advisory services" at state and regional levels, and the augmentation of climate research activities by the establishment of Experimental Climate Forecast Centers.

In 1986, the Act was amended by Public Law 99-272. An interagency Climate Program Policy Board is now responsible for coordinated planning and program review for the Program, review of all agency and department budget requests related to climate, submittal of a report to the Office of Management and Budget concerning such budgets, and consultation with users and producers of climate data, information and services. In addition, the NCPO is to be headed by a Director who represents the Board and is the spokesperson for the Program. The NCPO also serves as staff for the Board, reviews each agency budget request, coordinates interagency participation in international climate-related activities, and works with the National Academy of Sciences and other private, academic, State and local groups in preparing and implementing the 5-year plan and the Program.

Activities of the NCP are reported each year in an Annual Report to Congress, copies of which can be obtained from the National Climate Program Office, NOAA, 11400 Rockville Pike, Room No. 108, Rockville, MD 20852 [Tel: (301) 443-8981]. Copies of the Program's 5-year Plan are also available.

Subcommittee for Atmospheric Research

The Subcommittee for Atmospheric Research (SAR) was originally 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 Subcommitte of the FCCSET Committee on Atmosphere and Oceans (CAO). In I987 the CAO was disestablished and replaced by the Committee on Earth Sciences (CES). The SAR is now a standing subcommitte under CES.

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, 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 Meteorological Services and Supporting Research, the National Climate Program Office, and the Office of Science and Technology Policy complete the SAR.

SAR publishes a biennial report on the National Atmospheric Sciences Program that is distributed widely. The 1984-87 report will highlight those years for budget purposes and will focus on FY 1986 for the narrative involvement by agencies in atmospheric sciences and major field programs.

The SAR meets seven times a year to discuss issues of mutual interest. In 1987 and 1988, the SAR concentrated on coordination and actions for implementing the Global Tropospheric Chemistry Program (GTCP); for carrying out mesoscale meteorology research and field activities principally in the National STormscale Operational and Research Meteorology Program (STORM); planning selected aspects of the Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR); and the National Solar Terrestrial Program (NSTP).

World Weather Program

International activities relating to meteorological services and data exchange are carried out under the World Weather Program and the World Meteorological Organization which is a specialized agency of the United Nations. The World Weather Program is described in Appendix B.

SECTION 3

RESOURCE INFORMATION AND ANALYSES

Resources included in the Federal Government budget for FY 1989 for meteorological services and supporting research are increased by nearly 22 percent over those planned for FY 1988. The distribution of this increase varies widely from agency to agency, however. The tables in this section show an increase of 25.8 percent for the U.S. Air Force, an increase of nearly 100 percent for the Federal Aviation Administration and a decrease of 5 percent for the National Oceanic and Atmospheric Administration. These wide variations are largely the result of substantial new technology developments and planned organizational changes. Details relative to agency plans and budgeted resources are provided in this section.

The tables in this section summarize fiscal information of the Federal Government for the fiscal years 1988 and 1989. The funds shown are those used to provide meteorological services and supporting research which has as its immediate objective the improvement of these services. All fiscal data are current as of the end of January 1988 and are subject to later changes. These data do not have legislative approval and do not constitute a commitment by the U.S. Government.

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 funding level for FY 1988, the budget request for FY 1989, the percent change, and the individual agencies' percent of the total funding for FY 1988 and FY 1989.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 1989 is $16.74 million for operations and supporting research. The planned funding level for FY 1988 was $16.58 million. The supporting research component of this funding (approximately $9.63 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 funding for meteorological operations ($7.11 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 modernization of the snow telemetry system operated by the Soil Conservation Service and the replacement of manual fire rating stations with remote automated weather stations by the Forest Service. Installation of DWIPS has enhanced global monitoring capabilities through integration of satellite data with ground observations for global monitoring of crop conditions by the joint Agricultural Weather Facility.

The Forest Service initiated in FY 1988 a priority research program to

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

AGENCY	Operations FY88	Operations FY89	Operations %CHG	Operations % of FY89 TOTAL	Supporting Research FY88	Supporting Research FY89	Supporting Research %CHG	Supporting Research % of FY89 TOTAL	Total FY88	Total FY89	Total %CHG	% of FY88 TOTAL	% of FY89 TOTAL
Agriculture	6950	7113	2.3	0.5	9627	9627	0.0	2.2	16577	16740	1.0	1.0	0.8
Commerce/NOAA	391477	371164	-5.2	23.8	66470	62297	-6.3	14.0	457947	433461	-5.3	27.8	21.6
Defense(Subtot)	615372	762833	24.0	48.8	125152	136380	9.0	30.8	740524	899213	21.4	44.9	44.8
Air Force	486987	623737	28.1	39.9	68015	74729	9.9	16.8	555002	698466	25.8	33.7	34.8
Army	3427	3427	0.0	0.2	27807	31121	11.9	7.0	31234	34548	10.6	1.9	1.7
Navy	124958	135669	8.6	8.7	29330	30530	4.1	6.9	154288	166199	7.7	9.4	8.3
Transp/CG	1611	1601	-0.6	0.1	0	0	0.0	0.0	1611	1601	-0.6	0.1	0.1
Transp/FAA	197405	413395	109.4	26.5	18706	18251	-2.4	4.1	216111	431646	99.7	13.1	21.5
EPA	0	0	0.0	0.0	6215	6542	5.3	1.5	6215	6542	5.3	0.4	0.3
NASA	6221	5996	-3.6	0.4	202300	210400	4.0	47.4	208521	216396	3.8	12.7	10.8
NRC	180	182	1.1	0.0	40	0	-100.0	0.0	220	182	-17.3	0.0	0.0
TOTAL	1219216	1562284	28.1	100.0	428510	443497	3.5	100.0	1647726	2005781	21.7	100.0	100.0
% of FY TOTAL	74.0	77.9			26.0	22.1			100.0	100.0			

establish potential effects of global climate change and variability on forest health and productivity.

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 1989 total request of $433.4 million for meteorological programs is 5.3 percent lower than the FY 1988 available funds allocated for planned programs.

Changes in NOAA's operations and supporting research from FY 1988 to FY 1989 are presented below, subdivided by activities. The FY 1989 decrease includes the termination of the Advanced Weather Interactive Processing System (AWIPS) program ($19.3 million) and a $2.6 million reduction in the Automated Surface Observing System (ASOS) program which was a result of changes in the phasing of the program. Also included are plans to eliminate unneeded staff (35 positions) at eight Weather Service Forecast Offices (WSFO) saving $787 thousand. This will not affect station hours of operation. NOAA proposes to streamline NWS management by consolidating six of the National Weather Service (NWS) regions into four, saving a net of $1.2 million and eliminating 29 positions. Overall, NOAA proposes to reduce personnel engaged in meteorological operations by approximately 114 positions in FY 1989 by streamlining management, eliminating unnecessary positions and eliminating competition with the private sector in providing specialized forecasts. Additional items that affect the budget are discussed under Public Warning and Forecasts; Environmental Satellite, Data, and Information Services; and Atmospheric and Hydrologic Research.

- o Public Warning and Forecasts. Increases in this subactivity include $15 million for the Next Generation Weather Radar (NEXRAD) to continue limited production of NEXRAD units. Also included is an increase of $5 million for interim upgrades to extend the life of existing systems (AFOS, etc.).

  Proposed decreases include $542 thousand for reduced numbers of meteorological technicians; $540 thousand for the elimination of contractual data buoy system engineering and tests; $1.3 million for the elimination of agriculture weather services; $282 thousand for reducing fire weather services; $565 thousand for discontinuing maintenance of moored buoys surrounding Hawaii; $377 thousand for discontinuing non-critical upgrades of backup emergency power for NOAA Weather Radio; and $1.9 million for the Susquehanna River Basin Flood Warning System which will be completed in FY 1988.

- o Environmental Satellite, Data, and Information Service. Proposed funding for FY 1989 include increasing the polar satellite program by $55.3 million and geostationary satellite program by $44.1 million. This will allow for continuation of procurements to provide the spacecraft and instrument fabrication, integration and testing, launches, and ground system. The FY 1989 budget request will maintain a system of polar orbiting satellites that obtain global data and a system of geostationary satellites that provide near continuous observations of the earth's western hemisphere.

- o Atmospheric and Hydrologic Research. Under the Atmospheric and Hydrologic Research line item, there will be a decrease of $4.4 million. Major decreases are: $2.2 million in the State weather modification research program which has produced inconclusive results to date, $1.9 million in PROFS reflecting completion of specific projects and a savings of $0.3 million in severe weather research to be achieved through increased cooperation with universities.

The FY 1989 request includes $0.6 million for upgrades to NOAA's P-3 aircraft. Also included is $30 million, an increase of $1.7 million, for aviation weather services that are to be funded from the "Airport and Airway Trust Fund" administered by the Federal Aviation Administration (FAA).

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 1989 is $899.2 million which is 21.4 percent more than the total funding level for FY 1988. See discussion below.

U.S. Air Force

Operations. For FY 1989, the operations budget request is $623.7 million which is an increase of 28 percent from the $486.9 million appropriated by Congress for FY 1988. Seventy-three percent of the increase is attributable to a request for multiyear procurement funding of the Defense Meteorological Satellite Program. The remainder of the increase arises from full-year funding for procurement of the Automated Weather Distribution System (AWDS); restoration of spares, and operations and maintenance (O&M) funding to their FY 1987 levels; and funding for an additional 240 enlisted forecasters to meet previously established Air Force and U.S. Army worldwide operational weather support requirements. The FY 1989 budget also contains funding for the Air Force's share of the tri-agency Next Generation Weather Radar (NEXRAD) program.

The Air Force will maintain the 53rd Weather Reconnaissance Squadron and the Air Force Reserve's 815th Weather Operations Flight, both based at Keesler AFB, Mississippi, to provide weather reconnaissance support to the Department of Commerce in FY 1989.

Supporting Research. For FY 1989, the budget request for supporting research and development is $74.7 million which is an increase of 9.9 percent over the amount appropriated for FY 1988. The Defense Meteorological Satellite Program (DMSP) accounts for virtually the entire increase in the research portion of the budget. The increased funds will provide for the design of a fixed site DMSP receiver terminal which will replace the current network of logistically unsupportable systems, for the development of a mission sensor processing capability for these fixed site tactical terminals, and for the retrofit of the DMSP mission sensor processing capability into four existing mobile DMSP (tactical) terminals. The research funds will also allow for calibration and validation efforts on the microwave water vapor sounder slated to fly on future DMSP spacecraft.

The reduction of research funds in the weather systems engineering development area will limit Air Force participation in the Department of

Commerce's Automated Surface Observing System to monitoring the prototype development and testing.

U.S. Army

Funding of meteorological programs by the Army is primarily for supporting research. In FY 1989, the budget request for supporting research is $31.1 million, which represents a 12 percent increase over FY 1988. This is the budget for Army-sponsored meteorological research, development, test and evaluation, and includes support to Army test and evaluation sites throughout the U.S. and Panama. The basic research program is structured to provide understanding of the physical principles governing atmospheric behavior, structure, and specific phenomena that affect Army operations and systems. Equipment continues to be modified and added in support operations as mission scope and complexity increase. Additional funding is earmarked for incorporating weather effects into Tactical Decision Aids. Further increases will occur in Firepower Meteorology (Remote Atmospheric Profiler), application of space assets, and the Unmanned Aerial Vehicle Meteorological Sensor.

U.S. Navy

In the operations area, the FY 1989 budget request is $135.6 million, an increase of about 8.6 percent from the $124.9 million in FY 1988. The operations programs are described in detail below. In the supporting research area, the FY 1989 budget request is $30.53 million, an increase of 4.1 percent from the $29.33 million in FY 1988. A description of the ongoing research programs is presented in Appendix A.

Observations. A large fraction of the requested funding under this functional category ($41.7 million) is applied toward the Navy share for procurement of microwave imagers for the Defense Meteorological Satellite Program (DMSP), a joint USN/USAF project. This mission sensor is tailored for operation aboard a DMSP spacecraft which will provide data concerning ocean surface wind speed, precipitation intensity, and atmospheric water vapor and polar ice conditions. Funding of $21 million is programmed for two SSM/I (Special Sensor Microwave Imager) systems for DMSP satellites under a joint USN/USAF procurement. Additional increase items include the procurement of two additional Lightning Detection and Tracking Systems (LDATS) to upgrade the capability to observe and track lightning at shore facilities, meteorological sensor replacements, and a small increase in planned contractor engineering support.

Analysis and Forecasts. Satellite data processing within the Naval Oceanography Command (NAVOCEANCOM) will be upgraded to increase the capability to assimilate and analyze vast amounts of oceanographic data, most of which will be available with the launch of new satellite systems in the 1990s. New equipment and software will be required to support this major program. Continued upgrade of the Primary Environmental Processing System/Information System at the Fleet Numerical Oceanography Center (FLENUMOCEANCEN) will improve support and responsiveness to operational fleet units. A capability is also included for the Joint Typhoon Warning Center, Guam, to automate procedures for predicting the formation and movement of tropical cyclones in the Pacific and Indian Oceans. This

system, formerly the Typhoon Information Processing Systems - TIPS, is now the JTWC - Automation Project (JTWC-AP). The Tactical Environmental Support System (TESS 1 - AN/UMK1(V1)) is a system which provides afloat oceanographers ready access to environmental data for preparing tactical forecasts. TESS 1 upgrade to TESS 2 configuration will commence in FY 1988. TESS 3, an institutional "follow on" to TESS 1 and 2, scheduled for Initial Operational Capability in FY 1991, incorporates all of the capabilities resident within TESS 1 and 2 while also introducing significant new data assimilation, processing and display functions.

The NEDN Oceanographic Data Distribution and Expansion System (NODDES), formerly NODDES/SPADS, has been restructured under a new contractor. Deployment is now scheduled for the first and second quarters of FY 1990. Contractor support for climatological studies is also included in this category.

Communications. The Consolidated Communication System (CCS) replacement at FLENUMOCEANCEN will upgrade obsolete, logistically insupportable data communications hardware used to transmit environmental data and tailored tactical products to shore activities. The NODDES and Distributed Processing System Replacement (DPSR, at FLENUMOCEANCEN) projects are now under combined management. NODDES will replace most of the Distributed Processing System at FLENUMOCEANCEN, including CCS, with DPSR replacing three additional systems. Satellite display devices/receivers are part of the Navy Satellite Display Station (NSDS) and Aviation Support Display System (ASDS). ASDS will support both CONUS and overseas shore sites by serving as a stand-alone interface with a downlink capability for GOES data. ASDS will also distribute data to customers, such as aviation squadrons, greatly improving the dissemination capability within NAVOCEANCOM. The Mobile Oceanography Support Facility (MOSS) will provide data for Mobile Environmental Teams with TESS 2 software capability. The Satellite Digital Processing System will be placed at Pearl Harbor, Norfolk, and Rota to accept digital data from the United States and European geostationary weather satellites. The GOES satellite antenna upgrade will improve data reception capabilities at FLENUMOCEANCEN.

Dissemination to Users. This category encompasses upgrades to NAVOCEANCOM capabilities to provide satellite imagery and data to both ashore and afloat units. Funding supports NSDS, ASDS, and MOSS program objectives. Geostationary satellite reception upgrades are described in the previous category. Procurement of shared processing minicomputers will augment the NOAA/Air Force/Navy Shared Processing Network Communications Service. These computers will monitor the reception and transmission functions of each site.

General Agency Support. Items listed under this category involve upgrading existing meteorological equipment - overhauls, rework and reinstallations, and providing training to Navy personnel concerning the observing and tactical usage of data, and anticipated increases in personnel costs.

DEPARTMENT OF TRANSPORTATION (DOT)

Within DOT, the U.S. Coast Guard and the Federal Aviation Administration have reported on meteorological programs in FY 1988 and FY 1989.

U.S. Coast Guard (USCG)

All of USCG's funding for meteorological programs is for operations. In FY 1989, the requested funding level is essentially unchanged with $1.60 million as compared to planned funding of $1.61 million in FY 1988. A breakdown of the FY 1989 funding by functional categories is as follows:

- Observations -- $419,000
- Communications -- $211,000
- Dissemination to Users -- $70,000
- General Support -- $901,000

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)

The FAA total proposed funding for FY 1989 is $431.6 million which is an increase of about 100 percent over the $216.1 million planned for FY 1988. The FAA's role in meteorology is limited to observations, communications and dissemination of information to aviation users. Supporting research follows the same functional categories but also funds research for the detection and forecasting of phenomena that are especially important to aviation. This is normally accomplished through NOAA in close cooperation with NWS.

Operations Programs. The proposed FY 1989 funding for the operational meteorological programs is $413.4 million, an increase of 109 percent from $197.4 million for FY 1988. The changes are in the observation category discussed below.

- Observation or Data Acquisition. The major portion of the funding shown in this category comes from the FAA's Facilities and Equipment appropriation and is applied to the purchase of new equipment. This includes $46.6 million for FAA's FY 1989 share of NEXRAD costs, $252 million for terminal Doppler weather radar, and $10.4 million for automated surface observing systems.

- Communications. A reduction of almost $10 million in the communications area is largely due to the continuing reduction of teletypewriter use in the National Weather Service; these teletypewriters were maintained by FAA.

Supporting Research. For supporting research, the requested funding in FY 1989 is $18.2, as compared with $18.7 million budgeted for FY 1988. This decrease reflects the changing stages of various on-going programs and does not represent major program changes.

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

AGENCY	Observations FY88	Observations FY89	Analyses & Forecasts FY88	Analyses & Forecasts FY89	Communi-cations FY88	Communi-cations FY89	Dissem-ination FY88	Dissem-ination FY89	Gen'l Agency Support FY88	Gen'l Agency Support FY89	Total FY88	Total FY89	%CHG	% of FY89 TOTAL
Agriculture	3738	3888	1562	1574	0	0	1250	1251	400	400	6950	7113	2.3	0.5
Commerce/NOAA	137909	113954	177232	182720	5956	5772	38486	37639	31894	31079	391477	371164	-5.2	23.8
Defense(Subtot)	301542	405674	86686	101044	42496	41987	93948	104848	90700	109280	615372	762833	24.0	48.8
Air Force	261242	362531	66070	79835	32153	33184	70925	73625	56597	74562	486987	623737	28.1	39.9
Army	1441	1441	0	0	0	0	0	0	1986	1986	3427	3427	0.0	0.2
Navy	38859	41702	20616	21209	10343	8803	23023	31223	32117	32732	124958	135669	8.6	8.7
Transp/CG	430	419	0	0	214	211	70	70	897	901	1611	1601	-0.6	0.1
Transp/FAA	98459	324408	0	0	44144	34271	27817	27533	26985	27183	197405	413395	109.4	26.5
EPA	--------- Not Applicable ---------													
NASA	1460	1030	1540	1612	723	942	0	30	2498	2382	6221	5996	-3.6	0.4
NRC	0	0	180	182	0	0	0	0	0	0	180	182	1.1	0.0
TOTAL	543538	849373	267200	287132	93533	83183	161571	171371	153374	171225	1219216	1562284	28.1	100.0
% of FY TOTAL	44.6	54.4	21.9	18.4	7.7	5.3	13.3	11.0	12.6	11.0	100.0	100.0		

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of EPA funding of meteorological programs is for supporting research. The requested funding level in FY 1989 is $6.54 million versus $6.22 million in FY 1988. EPA is continuing its development and validation of air quality models for pollutants. The research will focus on urban, regional, and complex terrain models and will be used to develop pollution control strategies. The increase in funding is for meteorological work in ozone and climate.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Nearly all of NASA's funding is for supporting research. The requested funding for supporting research in FY 1989 is $210.4 million, an increase of 4 percent from FY 1988. The FY 1989 level reflects increased funding for the Upper Atmosphere Research Satellite (UARS) and decreased funding for the NASA Scatterometer (NSCAT). The launch of UARS has been delayed from October 1989 to October 1991; NSCAT is also scheduled for launch in 1991. The requested funding for operations in FY 1989 is $5.99 million which is a decrease from $6.22 million in FY 1988.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC budget request for meteorological activities is $182,000 for FY 1989 -- a decrease of 17 percent. All of this is for operations. The meteorological support program in the U.S. Nuclear Regulatory Commission (NRC) is primarily focused on obtaining and analyzing meteorological data and information to be utilized in atmospheric dispersion models used in the determination of 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. Budget reductions from FY 1988 to FY 1989 reflect the completion of certain tasks in the atmospheric dispersion model technical assistance and research program and in studies of the climatology and intensity of extreme weather events such as hurricanes and tornadoes, as well as the termination of further research related to atmospheric dispersion models due to budgetary constraints.

AGENCY OPERATIONAL COSTS BY FUNCTION

Table 3.2 shows how the agencies plan to obligate their funds for the five major operational functions involved in meteorological service operations. The funding levels in Table 3.2 for each agency were discussed above. Brief descriptions of the activities included in each of these major functions are provided below.

Observations. This function involves obtaining the data that underlie all weather forecasts and warnings. The observing function is divided into five program elements for planning and coordination: surface, upper air, weather reconnaissance, weather radar, and operational environmental satellite observing programs.

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

AGENCY	Observations FY88	Observations FY89	Description & Prediction FY88	Description & Prediction FY89	Dissemination FY88	Dissemination FY89	Systems & Support FY88	Systems & Support FY89	Total FY88	Total FY89	%CHG	% of FY89 TOTAL
Agriculture	2752	2752	2377	2377	131	131	4367	4367	9627	9627	0.0	2.2
Commerce/NOAA	11735	11851	18125	14743	227	231	36383	35472	66470	62297	-6.3	14.0
Defense(Subtot)	70351	79248	21133	24323	7578	5100	26090	27709	125152	136380	9.0	30.8
Air Force	51943	59825	10921	13000	5151	1904	0	0	68015	74729	9.9	16.8
Army	1459	2213	4977	5935	2062	2818	19309	20155	27807	31121	11.9	7.0
Navy	16949	17210	5235	5388	365	378	6781	7554	29330	30530	4.1	6.9
Transp/CG	---	---	Not Applicable	---	---	---	---	---	---	---	---	---
Transp/FAA	4015	4173	14691	11236	0	2842	0	0	18706	18251	-2.4	4.1
EPA	0	0	6215	6542	0	0	0	0	6215	6542	5.3	1.5
NASA	181400	189300	20900	21100	0	0	0	0	202300	210400	4.0	47.4
NRC	0	0	40	0	0	0	0	0	40	0	-100.0	0.0
TOTAL	270253	287324	83481	80321	7936	8304	66840	67548	428510	443497	3.5	100.0
% of FY TOTAL	63.1	64.8	19.5	18.1	1.9	1.9	15.6	15.2	100.0	100.0		

Analyses and Forecasts. This function involves centralized production of manual and computerized analyses of meteorological data as well as projections of the future states of the atmosphere and accompanying weather phenomena. This function is divided into three parts: analyses and forecasts on a global and hemispheric basis; products tailored for specific areas or user groups; and specific weather phenomena, such as hurricanes and severe thunderstorms.

Communications. This category involves the communication system needed to move the large amounts of data and information from the observation sites to the processing centers and the communications system required to send forecast products to forecast offices or units.

Dissemination to Users. This function represents the final step in preparing and delivering weather service products to the users. The field offices of DOC and DOD and the flight service stations (FSS) of DOT are the principal program elements involved.

General Agency Support. This function involves the planning, training, maintenance, and management activities common to any large dispersed activity. The general support function is divided into internal support and planning, engineering and mission-related work, maintenance of equipment and facilities, training of personnel, and overall program management.

Table 3.2 shows that in FY 1989 the agencies will devote about 54 percent of their resources to observations as compared with 45 percent in FY 1988. The principal changes year-to-year are associated with cyclic variations in satellite procurements and with costs for new equipment such as automatic weather observing stations and weather radars. Approximately 18 percent is devoted to analyses and forecasts where the major year-to-year changes are the result of replacing the computers that are the keystone of the operations. Communications costs, comprising about 6 percent of the total program, are usually stable year-to-year, reflecting the long-term nature of communications systems planning, engineering and operation. A large amount of the communications is accomplished by the private sector. The "dissemination to users" function is also usually stable from year-to-year at about 11 percent because the field office structures are not usually subject to large changes. General agency support, requiring approximately 11 percent, is subject to some year-to-year variations, especially in maintenance and training activities.

AGENCY SUPPORTING RESEARCH COSTS BY FUNCTION

Table 3.3 shows how the agencies plan to obligate their funds for supporting research in four functional areas: Observations, Description and Prediction, Dissemination, and Systems and Support.

The supporting research functions are defined roughly the same as those discussed previously for operational programs. About 65 percent of the research efforts is in the "observations" function and roughly 18 percent for "description and prediction." The research function of "systems and

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

AGENCY	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89
Agriculture	0	0	0	0	0	0	6950	7113	0	0	0	0	6950	7113
Commerce/NOAA	342896	321902	30000	30000	13864	13864	1336	1336	0	0	3381	4062	391477	371164
Defense(Subtot)	261766	367432	228693	246820	30730	34830	0	0	46723	62414	47460	51337	615372	762833
Air Force	218943	321563	202691	219265	0	0	0	0	30153	44961	35200	37948	486987	623737
Army	0	0	0	0	0	0	0	0	3427	3427	0	0	3427	3427
Navy	42823	45869	26002	27555	30730	34830	0	0	13143	14026	12260	13389	124958	135669
Transp/CG	1054	1046	0	0	557	555	0	0	0	0	0	0	1611	1601
Transp/FAA	5019	4387	192386	409008	0	0	0	0	0	0	0	0	197405	413395
EPA	--------- Not Applicable ---------													
NASA	0	0	0	0	0	0	0	0	0	0	6221	5996	6221	5996
NRC	30	32	0	0	0	0	0	0	0	0	150	150	180	182
TOTAL	610765	694799	451079	685828	45151	49249	8286	8449	46723	62414	57212	61545	1219216	1562284
% of FY TOTAL	50.1	44.5	37.0	43.9	3.7	3.2	0.7	0.5	3.8	4.0	4.7	3.9	100.0	100.0

support" takes about 15 percent of the resources; it covers the development and engineering research work related to maintenance, training, and engineering operations. A relatively small amount, 2 percent, goes into supporting research for the dissemination function.

Supporting research programs characteristically are stable year-to-year unless a major project is initiated or terminated by one or more of the agencies.

METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH BY SERVICE

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 45 percent of the total operational costs while Aviation Services require about 44 percent. The remaining 11 percent is used to support the other specialized services. The definitions of specialized and basic services are provided below.

Specialized Services

Aviation Meteorological Services. Those services and facilities established to meet the requirements of general, commercial and military aviation. Civil programs are included that are directly related to services in support of rotary wing aircraft and medium or long-range missile operations.

Marine Meteorological 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 Meteorological 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 Meteorological 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.

Other Specialized Meteorological 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.

TABLE 3.5 AGENCY SUPPORTING RESEARCH COSTS, BY SERVICE
(Thousands of Dollars)

AGENCY	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89
Agriculture	0	0	0	0	0	0	9627	9627	0	0	0	0	9627	9627
Commerce/NOAA	64203	60030	2267	2267	0	0	0	0	0	0	0	0	66470	62297
Defense(Subtot)	4688	2211	0	0	29330	30530	0	0	90784	102939	350	700	125152	136380
Air Force	4688	2211	0	0	0	0	0	0	62977	71818	350	700	68015	74729
Army	0	0	0	0	0	0	0	0	27807	31121	0	0	27807	31121
Navy	0	0	0	0	29330	30530	0	0	0	0	0	0	29330	30530
Transp/CG	--------- Not Applicable ---------													
Transp/FAA	0	0	18706	18251	0	0	0	0	0	0	0	0	18706	18251
EPA	0	0	0	0	0	0	0	0	0	0	6215	6542	6215	6542
NASA	200800	208900	1500	1500	0	0	0	0	0	0	0	0	202300	210400
NRC	40	0	0	0	0	0	0	0	0	0	0	0	40	0
TOTAL	269731	271141	22473	22018	29330	30530	9627	9627	90784	102939	6565	7242	428510	443497
% of FY TOTAL	62.9	61.1	5.2	5.0	6.8	6.9	2.2	2.2	21.2	23.2	1.5	1.6	100.0	100.0

Basic Services

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

AGENCY PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 3.6 shows how agency staff resources are distributed among the five functions involved in meteorological operations. Overall, agency staff resources for FY 1989 total 16,223--a decrease of 0.6 percent.

Observations. This function requires about 24 percent of the staff resources for weather operations. It is labor-intensive, particularly for around-the-clock observations required for forecasts, warnings and aircraft operations.

Analyses and Forecasts. This function consumes approximately 20 percent of the Federal staff resources for weather operations. This function, while requiring a substantial number of personnel, makes extensive use of computers and related automated processing systems to prepare a wide array of products employed by field offices to satisfy the needs of the public and specialized users of weather information. A significant portion of these staff resources are devoted to preparing and maintaining the computer programs necessary to produce new and more effective products.

Communications. This function requires about 8 percent of the staff resources. Communications has become less labor-intensive over the years as it has been possible to acquire and install more automated equipment.

Dissemination. This function requires approximately 26 percent of all staff resources. This reflects the large number of field offices operated by the Departments of Commerce, Defense and Transportation, with many of these operating around-the-clock to serve the general public, military needs and the aviation industry.

General Agency Support. This function requires approximately 22 percent of all staff resources. This includes management, planning, training, maintenance, and specialized agency programs.

INTERAGENCY FUND TRANSFERS

Table 3.7 summarizes interagency fund transfers for FY 1988 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.

Department of Commerce (DOC). The FAA will be reimbursed $450,000 for facilities support; the USCG $755,000 for support to the Data Buoy Center; and NASA $121,000 for support at Wallop's Island.

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

AGENCY	Observations		Analyses & Forecasts		Communi-cations		Dissem-ination		General Agency Supp		Total			% of FY89
	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	FY88	FY89	%CHG	TOTAL
Agriculture	50	58	22	22	0	0	4	5	5	6	81	91	12.3	0.6
Commerce/NOAA	1408	1369	1246	1202	30	29	1088	1074	508	492	4280	4166	-2.7	25.7
Reimbursed**			375	375			260	260			635	635	0.0	3.9
Defense(Subtot)	2225	2229	1415	1657	617	619	2383	2386	2493	2494	9133	9385	2.8	57.8
Air Force	1567	1565	919	1154	495	495	2154	2154	1723	1723	6858	7091	3.4	43.7
Army	331	331	0	0	0	0	0	0	88	88	419	419	0.0	2.6
Reimb.**									2	2	2	2	0.0	0.0
Navy	327	333	496	503	122	124	229	232	680	681	1854	1873	1.0	11.5
Transp/CG	24	23	0	0	12	12	4	4	26	26	66	65	-1.5	0.4
Reimbursed**									15	15	15	15	0.0	0.1
Transp/FAA	277	274	0	0	761	523	580	578	482	488	2100	1863	-11.3	11.5
EPA	--------- Not Applicable ---------													
NASA	--------- Not Applicable ---------													
NRC	0	0	3	3	0	0	0	0	0	0	3	3	0.0	0.0
TOTAL	3984	3953	3061	3259	1420	1183	4319	4307	3529	3521	16313	16223	-0.6	100.0
% of FY TOTAL	24.4	24.4	18.8	20.1	8.7	7.3	26.5	26.5	21.6	21.7	100	100		

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

Department of Defense (DOD). The Army will reimburse DOC $944,000 for expendables and coordination of supporting research; DOE $159,000 for meteorological modeling; and NASA $68,000 for technical assistance. The Navy will reimburse DOC a total of $1,010,000 of which $971,000 is for basic analysis and forecasting and $39,000 is for the Mariners Weather Log. The Air Force will reimburse DOC a total of $1.237 million--for climate data ($667,000), NOAA's satellite relay to AFGWC ($263,000), ionospheric data ($280,000), and miscellaneous support items ($27,000).

Department of Transportation/FAA. The DOC will be reimbursed about $48.48 million of which $13.70 million is for meteorological support at Center Weather Service Units (located with most Air Route Traffic Control Centers); $0.35 million for meteorological studies and "AM Weather" broadcast over public television (PBS); $5.93 million for surface observing systems at airports; and $28.50 million for FAA's FY 1988 share of expenses for the joint NEXRAD and Automated Surface Observing System programs.

National Aeronautics and Space Administration. The Department of Defense will be reimbursed $687,000 and NOAA will be reimbursed $1.14 million, principally for meteorological support to the space-shuttle operations.

Environmental Protection Agency. The DOC will be reimbursed $2.6 million for research related to air quality standards.

Department of Energy. The DOC will be reimbursed $2.25 million to support the Weather Service Support Office at the Nevada Nuclear Test Site.

Nuclear Regulatory Commission. NOAA will be reimbursed $40,000 for supporting research.

Department of Agriculture. The National Climate Program Office will be reimbursed $30,000 to support a study by the National Academy of Sciences.

LOCATIONS BY OBSERVING TYPE

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. A list of acronyms for the various platforms is found in Appendix C.

TABLE 3.7

INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Transferred from:		Agency Transferred to:	FY 1988 Funds (Thousands of Dollars Estimated or Planned) Operations	Supporting Research
Commerce/NOAA		DOT/FAA	450	
		DOT/USCG	755	
		NASA	121	
Defense:	Army	DOC		944
	Army	DOE		159
	Army	NASA		68
	Navy	DOC	1010	
	Air Force	DOC	1,237	
	Air Force	DOT		172
	Air Force	NASA		100
	Air Force	OFCM		11
Transportation/FAA		DOC/NOAA	48,480	
NASA		DOD/USAF	687	
		DOC/NOAA	1,140	
EPA		DOC		2,600
DOE		DOC	2,246	
NRC		DOC/NOAA		40
USDA		DOC/NOAA/NCPO		30

TABLE 3.8
LOCATIONS BY TYPE OF OBSERVATION

Type of Observation	Agency	FY 1988
Surface, land	Commerce (WSO, WSFO, WSMO)	237
	Commerce (WSCMO)	21
	Commerce (Marine Reporting/CG Station)	171
	Commerce (AMOS, RAMOS, AUTOB, DARDC)	132
	Commerce (Supplem. Av. Wea. Reportg Station)	402
	Defense (U.S.)	152
	Defense (Overseas)	86
	Transportation (Flight Service Station)	210
	Transportation (Limited Av.Wx. Rprtg Station)	146
	Transportation (FAA Contract Wea. Obs. Station)	19
	Transportation (USCG Coastal)	120
	NASA	2
Surface, marine	Commerce (Merchant Ship Coop Program)	1,500
	Commerce (Merch Ship Coop - Foreign Assisted)	250
	Commerce (SEAS-equipped ships)	149
	Commerce (Coastal-Marine Automated Network)	36
	Commerce (Moored Buoy)	42
	Commerce (Large Navigation Buoy)	9
	Defense (Ships with met. personnel)	33
	Defense (Ships without met. personnel)*	110
	Transportation (Coast Guard Ships)	81
Upper air, balloon	Commerce (U.S.)	96
	Commerce (Coop. foreign)	33
	Defense Fixed (U.S. & Overseas)	53
	Defense (Ships)	31
	Defense Mobile (U.S. & Overseas)	15
	NASA (U.S)	2
	Transportation (Coast Guard)**	10
Upper air, rocket	NASA	1
	Defense	9
Weather radar	Commerce (NWS)	129
	Commerce (At FAA Radars)	24
	Defense (U.S. & Overseas)	126
	Defense (Remote displays)	30
Weather reconn.	Commerce (NOAA)	2
(No. of aircraft)	Defense (USAF)	10

*Based on average monthly reporting.
**Inactive but available for use.

SECTION 4

SUPERCOMPUTERS FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

Weather prediction is often cited, along with high energy physics, geophysics, and space exploration as being among those fields that benefit from the use of supercomputers for continued progress and accomplishment. The ability to forecast accurately weather and climate is limited by the computational power. Consequently, weather analysis and prediction, climatology, and supporting research provide some of the best examples of the application of supercomputer technology.

Supercomputers are loosely defined as the most powerful computers available at any point in time. Using the most powerful computer available in 1958, it took about 2.5 hours to perform the computations of a crude numerical forecast while today that same model can be processed in about a second. While main memory capacities in 1958 were about 1.5 million bytes (i.e., 8-bit), today main memory capacities are expected to exceed 2 trillion bytes. While computers in 1958 performed their computations serially with a single processor, future supercomputer architectures may have as many as 64,000 processors performing computations in parallel. In short, advances in computer technology continue to remove barriers so more complex problems can be solved. Figure 4.1 illustrates the rapid growth in capabilities of supercomputers. On the average, the capabilities have increased by a factor of ten every seven or eight years. The range of capabilities reflects the different configurations and the different applications of typical supercomputers.

Forecasting accuracy has kept pace with the increase in available computing power, and there is no indication that a point of diminishing return has been reached. Research indicates that significant gains in forecast accuracy can be achieved by increasing the resolution of current forecast models and by new and more complex models that can be run with more powerful computers.

THE NEED FOR SUPERCOMPUTERS IN METEOROLOGY

Reductions in energy and transportation costs, reduced property and agricultural losses, and improvements in military operations have all been attributed to improved weather prediction and climatological assessments. Improved numerical weather prediction is a direct result of the advances in computer technology. This technology, along with improved observing systems, has allowed more sophisticated prediction models to be implemented and, over the years, has resulted in substantial improvement in forecast accuracy and significantly fewer large forecast errors. For example, for the period 1966 through 1986, the overall skill for 1 and 2 day precipitation forecasts nearly doubled, while the number of temperature errors exceeding 10 degrees Fahrenheit dropped 50 percent. Supercomputers also are making possible the development of increasingly valid climatological models for assessing the effects of industrialization on the environment and determining changes to global climate.

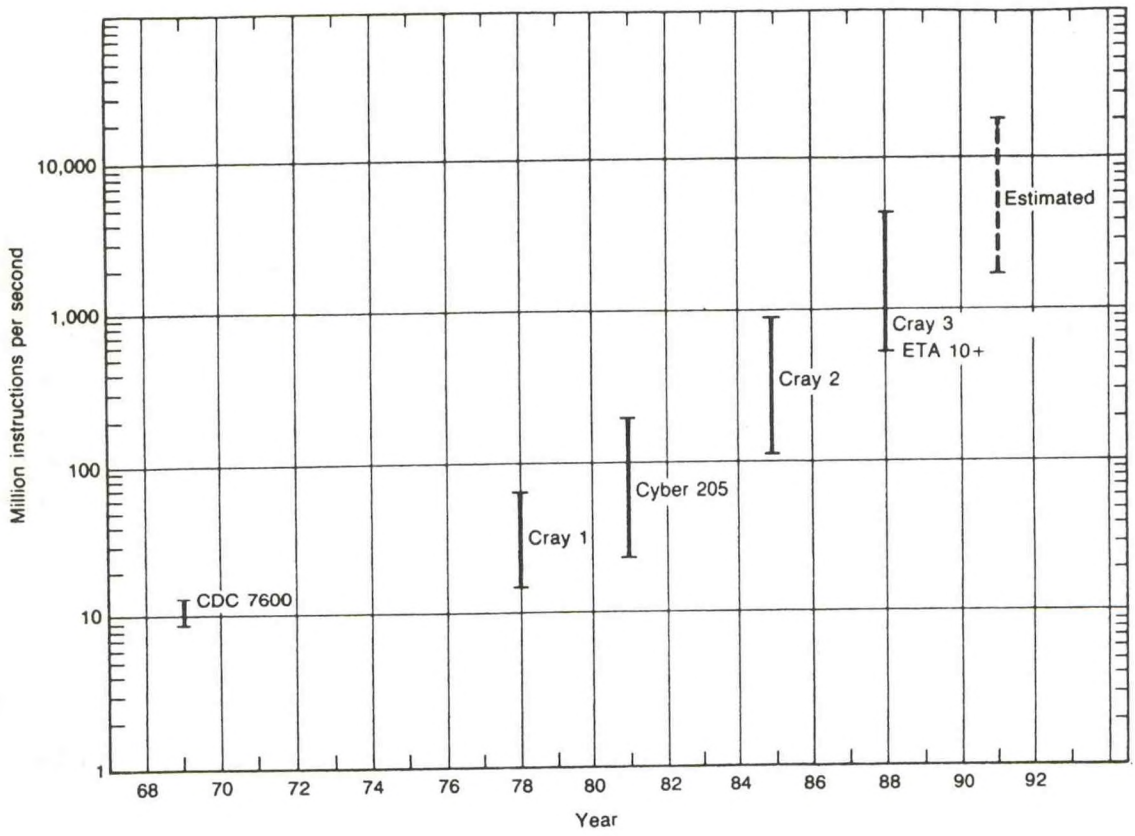


Figure 4.1 Growth of Supercomputer Performance

Vast amounts of data from satellite and worldwide sources are collected and processed at major centers. New automated observing systems, such as the Next Generation Weather Radar (NEXRAD), Automated Surface Observing System (ASOS), profilers, and satellites, discussed elsewhere in this report, will increase considerably the amount of data to be processed.

There are two classes of users of supercomputers in meteorology: those who require machines dedicated primarily for meteorological and climatological purposes, and those who use supercomputers for meteorology in a minor way to support specific missions of their agency. Agencies that have supercomputers dedicated to meteorology are the National Oceanic and Atmospheric Administration (NOAA), United States Air Force (USAF), United States Navy (USN), National Aeronautics and Space Administration (NASA) and National Science Foundation-National Center for Atmospheric Research (NSF-NCAR). Other agencies such as the Department of Energy (DOE) use relatively small amounts of supercomputer time for meteorological purposes. The following summary discusses the needs of these two classes of agencies.

Dedicated Supercomputers for Meteorology

Dedicated supercomputers are used for two primary purposes: operations and research. The NOAA-National Meteorological Center (NMC), USAF-Global

Weather Central (GWC) and the USN-Fleet Numerical Oceanography Center (FNOC) machines are used primarily for operations while the NOAA-Geophysical Fluid Dynamics Laboratory (GFDL), NSF-NCAR, and the Naval Oceanographic Office (NOO) machines are used for supporting research and development.

Operations. Supercomputers used for operations are primarily devoted to mission oriented applications; however, the machines are also used to develop, tailor and refine analysis and forecast models, special applications, and products to fulfill agency mission requirements. The developments and refinements usually are implemented as a result of research done elsewhere, but need integrating into very sophisticated operational environments which have priority requirements and demanding schedules. Consequently, reliability and timeliness are of paramount importance.

The NOAA-NMC is the nation's civil meteorological center devoted primarily to meeting the civil needs of the U.S. Therefore, most of NMC's effort is devoted to producing products and improving models to provide general operational support to the North American continent. However, much effort is expended on global modeling to support the more regional and localized models designed for the U.S. The global models not only provide the improved accuracy needed for the short term regional and local models, but are the basis for the extended outlooks in terms of weeks and seasons. NMC is the only center in the United States which produces these extended outlooks for North America. NMC also serves as a World and Regional Meteorological Center within the World Meteorological Organization's structure.

The USAF-AFGWC provides general and mission-tailored weather services to both the Army and Air Force throughout the world and to the Department of Defense command structure. Its primary focus is on areas outside the United States, although it also provides highly tailored service to Air Force and Army units within the United States, for operational purposes and for resource protection. Fast response with the most up-to-date products to meet mission and command and control requirements worldwide is necessary for reasons of national security. The supercomputer at AFGWC is an essential ingredient to providing that service.

The USN FNOC requires its supercomputer to provide general and mission-tailored products for operations on the oceans worldwide. The Navy uses its computers for operational oceanographic work where air-sea physical interactions are important. The numerical models it uses are therefore tailored to ocean operations.

These three centers --NMC, AFGWC, and FNOC-- provide cooperative support and backup by exchanging products and knowledge routinely. Their activities are coordinated by committees and working groups within the structure of the Office of the Federal Coordinator for Meteorology (OFCM).

Supporting Research and Development. As technological advancements in communications, processing, instrumentation, and transportation take place, and as the demand for improved accuracy in prediction on a finer scale and for climatological assessments has increased, the distinction between research, supporting research, and development has become hazy. This is particularly evident in the recent atmospheric research programs designed to

utilize new operational data systems such as Doppler radar, profilers, and satellites. These systems produce new types of data in vast quantities with increased resolution.

The NOAA-GFDL effort focuses on long-term prediction using global dynamic models; however, results of the efforts relate strongly to the operational missions of the NMC, GWC and FNOC. The complex physical and thermodynamical processes incorporated in the research models have more than ten times the number of computations than those used in operational models. Consequently, these models are not practical to use operationally until the next generation of supercomputer is developed. Moreover, the GFDL numerical models have a time scale that varies from seasonal periods to long-term global climatic changes. Since some present models take as much as 24 hours to compute, speed and reliability are of paramount importance.

NSF-NCAR supports a consortium of universities which have a wide range of research activities related to the atmosphere and oceans. These activities include research on mesoscale and synoptic scale meteorology, climate, cloud physics, upper atmosphere, astrophysics, basic fluid dynamics, and oceanography. Projects included in these activities vary in nature from local to global scales and include research on thunderstorms, tornados, hurricanes, climatology, global prediction, and the effects of these on agriculture, buildings and architecture, industrialization, transportation systems and land use. The scope and type of the myriad activities require the use of supercomputers.

The Navy has responsibility for global ocean modeling and prediction. The new supercomputer to be installed at the Naval Oceanographic Office (NOO) will be used for model research and development to support global ocean modeling for the Primary Oceanographic Prediction System (POPS). This system requires small horizontal and vertical spatial resolution globally to support real-time operations. Although the supercomputer will be used primarily for ocean modeling, about 20 percent of its use will be for modeling the air-sea interaction which is a key ingredient in POPS. NOAA's National Ocean Service and NOC are planning cooperative activities to maximize benefits from the new supercomputer.

Other Supercomputers Used for Meteorology

NASA and the Department of Energy are agencies which also use supercomputers for meteorology, but, in proportion to other mission requirements, to a limited extent. Their use is limited to highly specialized programs. NASA's supercomputers are shared by scientists engaged in space and earth sciences research.

DOE programs in environmental research and development require a basic understanding of meteorology and of the impact and effects of weather on a wide range of energy problems. These programs include activities relating to nuclear power plants, toxicology, wind, solar, and thermal power generation, etc. Except for the Lawrence Livermore National Laboratory (LLNL), those DOE units or their contractors use an average of less than one percent of their supercomputer capacities on meteorological problems--problems that are directly related to the main function of the organizational unit involved.

At Lawrence Livermore National Laboratory, however, about 18 percent of the use of a supercomputer is for atmospheric research; it focuses on diffusion of radioactive and toxic particles. LLNL played a major role in both the Three Mile Island and the Chernobyl nuclear power plant accidents since it is on the leading edge of diffusion research and has direct access to the world-wide operational weather data base at the USAF-GWC. LLNL also does diffusion work on highly localized toxic releases and has developed the capability to respond to problems at predetermined sites. A number of agencies have agreements with LLNL for support on a continuing basis.

A NASA supercomputer located at the Goddard Space Flight Center is used for earth and space science research. About 60 percent of the capacity is used for atmosphere and ocean research to gain insight into the required types of instruments (satellite-borne) and possible improvements to existing remote sensing instruments. Research programs which require the use of a supercomputer include studies related to short and long-term climate for the oceans and atmosphere, support of the Global Change Program, and mesoscale, upper atmosphere, atmospheric physics and ocean/atmosphere observational programs.

The Air Force Geophysical Laboratory (AFGL) has access to a Cray 1 and a Cray 2 at the Air Force Weapons Laboratory at Kirtland AFB, New Mexico. AFGL uses them for the development and testing of a global spectral model and a high-resolution mesoscale model.

NASA is also heavily involved in the development of a special purpose computer to be carried on a satellite. This is a massively multiple processor (MMP) which will have 64,000 processors operating in parallel. The MMP will be used for real-time data acquisition and data reduction on board a satellite. This is on the "leading edge" of computer technology and is in direct support of the ocean and atmospheric sciences.

ACQUISITION STRATEGIES

Table 4.1 shows currently installed computers, their date of installation, and planned upgrades or replacements. The Naval Oceanographic Office (NOO) currently is in the process of acquiring a supercomputer. No supercomputer development is envisioned by any of the weather agencies noted in this report. The agencies envision integrating the machines into their respective operating environments to achieve their most effective usefulness. However, the budget process and operating environment of each agency places certain restrictions on how much a given agency can change its operating environment.

The National Center for Atmospheric Research (NCAR), supported by the National Science Foundation (NSF), has made some key policy decisions regarding supercomputers that should achieve substantial long-term benefits. The NSF-NCAR's long range plan is to acquire a new supercomputer every three years in order to keep abreast of the state-of-the-art. Since NCAR has two machines, each machine will have a 6-year lifetime. This will allow a graceful and coordinated software and applications transition to the new machines. Additionally, NSF-NCAR plans to change its operating systems to a UNIX environment to take advantage of UNIX as a standard. Although this change will require substantial revisions to the NCAR local network, NCAR

mass storage systems and other parts of the system, it is expected to yield substantial long term benefits in terms of compatibility, easier transfer of applications software among systems, and ease of use by the multitude of users of the NSF-NCAR systems.

All agencies will use competitive procurements. Agencies are cooperating in the development of benchmark programs which can be shared among the agencies during their individual procurements. The NOAA-GFDL is taking the lead in preparing a standard set of benchmarks which agencies indicate meet their basic requirements. However, agencies are also preparing additional benchmarks which are unique to their particular operating environments. This approach is helping to minimize redundant efforts and will provide a measure of uniform comparison. Agencies are also exchanging information regarding other aspects of their respective procurements. The OFCM Committee on Operational Processing Centers plays a vital role in this coordination.

Purchase, lease, lease to purchase, lease with option to purchase, and service bureau are common methods of acquisition. The currently installed systems have been purchased, with the exception of the USN-FNOC computer which is leased. None of the agencies surveyed uses the service bureau method.

For future systems, NOAA will determine which method to use at the time of selection although NOAA-GFDL prefers to lease in order to keep abreast of the state-of-the-art. NASA intends to "lease to purchase" its supercomputers while other agencies plan to lease. None of the agencies intend to use the service bureau method.

System Objectives. Selection of supercomputers may vary from one agency to another beyond operational considerations and will be based on cost/performance or on maximum performance. All systems except for the NSF-NCAR systems will be assessed on the basis of cost/performance. NSF-NCAR requires the latest state-of-the-art machine that will give the maximum performance available at any point in time; hence its long-term acquisition strategy, as earlier discussed.

SUMMARY

This overview of supercomputer plans for Federal agencies is meant to provide some insight into agency objectives and needs, and to indicate fundamental differences among the agencies without eliciting details. Details may be found in individual agency plans and requirements documents.

Budget figures are not provided because of the uncertainty of agency plans relative to overall agency budget considerations, and because the cost of supercomputers is the same for relatively similar configurations. Costs will vary according to "front-end" and peripheral support configurations designed to meet operational needs.

Agency	Model	Date Accepted	Year of Planned Changes 88	89	90	91	92	93	94	95	96
DOC-NOAA											
NWS	Cyber 205-442	Oct 83	(There are no plans at present								
	Cyber 205-642	Jan 87	to replace Department of Commerce supercomputers.)								
GFDL	Cyber 205-642	Sep 82									
	Cyber 205-442	Nov 83									
DOD											
AFGWC	Cray XMP	Mar 85		U							
FNOC	Cyber 205-682	Nov 82	U			R					
NOO	To be determined		A			U					
NASA	Cyber 205-442	Dec 82			R						
NSF-NCAR	Cyber 1A	Jul 77	R					R			
	Cray XMP/48	Nov 86			R						R

Table 4.1 Schedule for Planned Supercomputer Changes

LEGEND
A = Additional
R = Replacement
U = Upgrade

APPENDIX A

COMPILATION OF STATEMENTS ON WEATHER PROGRAMS SUBMITTED TO THE OFFICE OF THE FEDERAL COORDINATOR BY THE AGENCIES

DEPARTMENT OF AGRICULTURE

Weather, through its effect on crop yields, is one of the most important factors influencing the Nation's total agricultural production. The Nation's food and fiber products which are critically important to our domestic and international economic situation, have taken on new dimensions in foreign affairs and national security. The recent shrinkage in export markets resulting from the substantial increase in global production of major commodities is having an adverse effect on the farm sector. The USDA conducts supporting research that focuses on understanding the interactions of weather and climate with plants and animals and assists the Department of Commerce in determining farmers' needs for weather information and in disseminating such information to them.

Historically, the Forest Service (FS) has collected meteorological data to assist 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 established 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 is being considered.

The Soil Conservation Service (SCS) operates a network of 1400 manual snow courses and over 525 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 Fiscal Year 1987, SCS implemented a new 5-year initiative to upgrade the SNOTEL data collection system at a total cost of $5 million. This included upgrading 510 data collection sites in the existing SNOTEL system with new state-of-the-art equipment. The data collection site upgrade will include replacement of snow pillows, transducers, damaged

precipitation gages, antennas, towers, solar panels, batteries, 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 agricultural commodities and products while minimizing any adverse effects of agriculture on 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 agricultural production and the environment.

The Cooperative State Research Service (CSRS) coordinates research programs in the State agricultural experiment stations, the 1890 Land Grant institutions, and cooperating forestry schools. These institutions conduct a wide variety of research applicable to agriculture and forestry. Meteorological research in these institutions is practically all climatological. A large 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.

Forest Service research includes efforts to: understand and control forest fire initiation by lightning; improve the translation of mid-range forecast elements to applicable forestry descriptions; incorporate drought information into fire management decision-making; and better describe how regional climatic variability affects the use of daily weather information by foresters.

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 using weather variables to predict crop yield were disappointing. Evaluations of plant growth simulation 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 condition is continuing. A preliminary investigation of polar orbiting meteorological satellite data showed a strong relationship between crop condition and reflectance data as determined by the agreement between measured and forecast final corn and soybean yields. The crop condition assessment procedures, based on meteorological satellite data, are being automated and application are being explored.

DEPARTMENT OF COMMERCE

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 and 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 Aircraft Operations (OAO).

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 basic 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 meteorological activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of meteorological 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.

- 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.

- Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for provision of weather observations and services to aviation.

- OMB Circular A-62 established criteria for Federal coordination of meteorological services and supporting research.

SERVICES

NWS provides two broad types of services, (1) real-time operation-oriented services and (2) technical, advisory and other supporting services relating to meteorological and hydrological considerations.

The three principal real-time operational services are (1) the measurement and description of the meteorological and hydrological conditions that prevail; (2) the prediction of the future state of these conditions; and (3) the warnings of specific conditions that threaten life, property and the conduct of business.

To support the basic warning and forecast services, the weather observations include measurements of sky conditions, temperature, wind, wind gusts, precipitation, visibility, pressure, humidity, waves, tides, currents, ocean thermal features, river stages, and solar radiation, as well as descriptions of severe weather events such as tornadoes, hurricanes, thunderstorms, dust storms, blizzards, tsunamis, floods, and flash floods.

To support the applied services, additional measurements or observations are made where appropriate; e.g.,

- Marine Weather: Coastal winds, waves, tides and currents, environmental hazards to navigation on the high seas, conditions for small craft operations, and ice and other factors affecting marine navigation.

- Aviation Weather: Cloud ceilings and visibility, altimeter settings, and such significant enroute aviation hazards as aircraft icing and turbulence.

- Agricultural Weather: Soil moisture and temperature, leaf wetness, sunshine and solar radiation, and evaporation.

- Fire Weather: Local meteorological conditions affecting wildfire control.

The forecasting services involve the prediction of the future state of these same measurements for various time periods. The content of the fore-

casts is influenced by the interests and the requirements of the various groups of users. Forecasts are issued on a regular, recurring basis.

The warning services are keyed to the occurrence of specific events or conditions, critical to a broad or a specific set of interests. The familiar hurricane, tornado, flood, and winter storm warnings have broad impact on public and private operations. Other warnings involve critical interests to agriculture, forest protection, highways, inland waterways, and lakes; and to oceanic, marine, and aircraft operations. The warning services are provided at two levels of urgency, (1) the advice that conditions are favorable for the event or condition to occur and (2) the specific warning that it will occur or is occurring.

The additional advisory and supporting services of the NWS include:

- o Hazard Awareness/Warning Coordination services.
- o U.S. interagency advice, coordination, and project management.
- o Assistance through the Voluntary Cooperation Program of the World Meteorological Organization (WMO).
- o International meteorological and hydrological advice and consultations.
- o The Climate Analysis Center (CAC) of the National Meteorological Center provides current climate data, information, and analyses; makes monthly and seasonal temperature and precipitation forecasts; and monitors global and regional climate anomalies in support of agricultural, energy, and water resource users.

PRODUCTION AND DELIVERY OF SERVICES

The operational services of the NWS are provided by a tri-level field structure (Figure A.1). There are three national guidance centers, 52 Weather Service Forecast Offices (WSFO) and 13 River Forecast Centers (RFC) that have regional responsibilities for weather and hydrology services respectively and more than 280 facilities that provide local services.

National Centers

The National Meteorological Center (NMC) at Camp Springs, MD, provides large-scale regional, hemispheric, and global atmospheric forecasts based on the techniques of numerical weather prediction (objective methods), and develops associated forecast guidance (a blend of objective methods and subjective technique); these materials are delivered to domestic and to international users. The Center also provides analyses and forecasts of marine weather and oceanographic conditions. In addition, the Center provides monthly and seasonal outlooks, assessments of climatic conditions to users on a world-wide basis, and functions as a WMO World Meteorological Center.

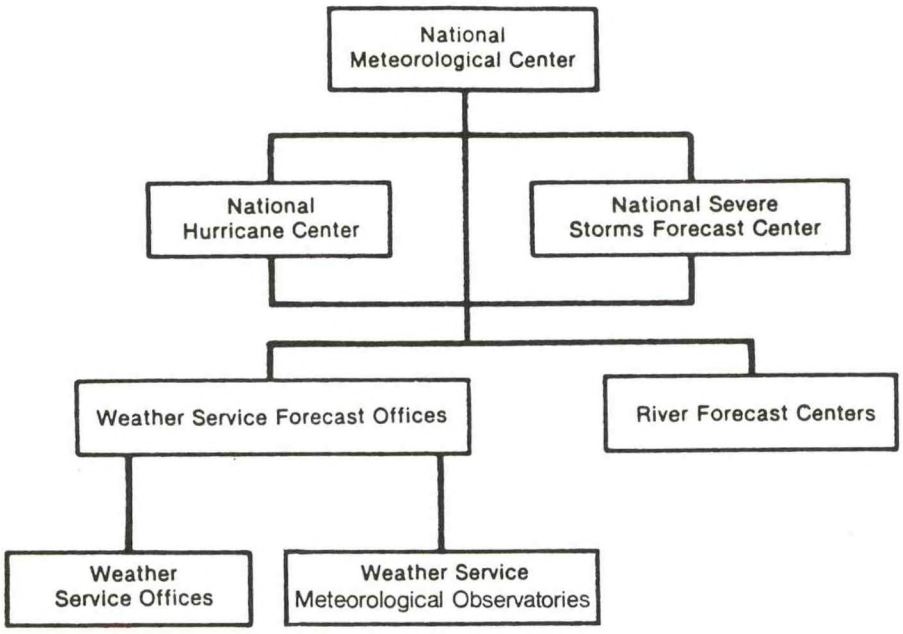


Figure A.1. NWS Field Structure for Technical Operations

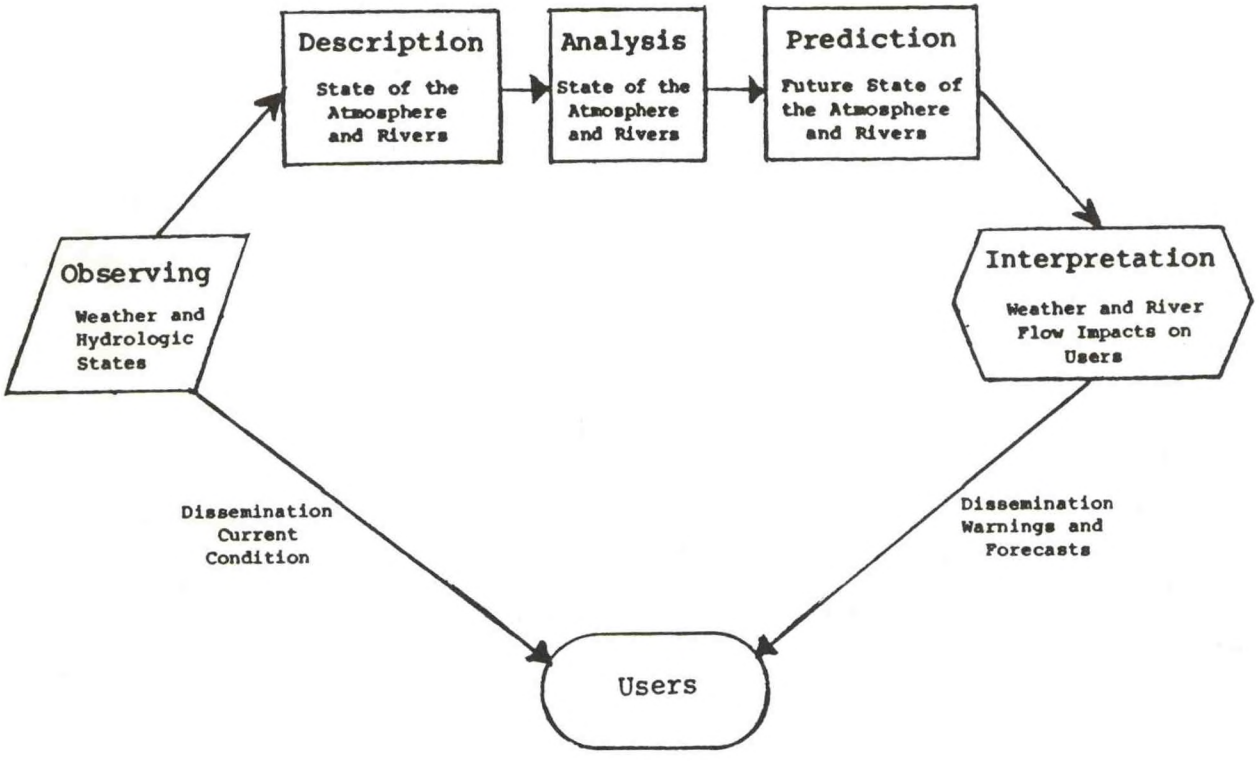


Figure A.2. Weather Service Activities.

The National Hurricane Center (NHC) at Miami, FL, and a regional center at Honolulu, HI, prepare specialized forecasts, watches, warnings, and associated guidance for hurricanes and tropical storms.

The National Severe Storms Forecast Center (NSSFC) at Kansas City, MO, prepares specialized forecasts, watches, and guidance for tornadoes and severe thunderstorms. NSSFC's National Aviation Weather Advisory Unit provides aviation area forecasts as well as advisories to aircraft concerning potentially hazardous weather conditions on their route of flight.

Regional, Local, and Specialized Service Offices

Fifty-two WSFOs prepare and issue medium and small-scale forecasts, weather watches, and warnings; they also acquire meteorological data. There is essentially one WSFO per state.

The 212 local Weather Service Offices (WSO) issue small-scale forecasts and weather warnings; they also acquire and generate meteorological and hydrological data. There are 24 Weather Service Meteorological Observatories (WSMO), 27 Weather Service Contract Meteorological Observatories (WSCMO), and some 600 automated observing stations that acquire data.

Thirteen RFCs produce specialized river and flood level forecasts and guidance material. Each RFC covers a major national watershed or portion thereof involving several states. Fifty-two of the NWS meteorological field offices with designated hydrologic service area responsibility provide hydrologic services.

The 21 Center Weather Service Units and the Central Flow Control Facility provide consultation and advice to air traffic managers/controllers about weather conditions that may affect safe and efficient flight operations in the National Airspace System.

Four Satellite Field Services Stations associated with WSFOs and National Centers provide interpretive products and data distribution services to Federal and non-Federal users.

BASIC FUNCTIONS

The basic functions of the weather services consist of weather observing (data acquisition), warning and forecast preparation (analysis, prediction and interpretation), and dissemination.

The information flows from many individual sources to central facilities for analysis and the preparation of guidance, then, flows back out for increasing levels of interpretation and tailoring to specific locations and/or applications (see Figure A.2). Figure A.3 illustrates the manner in which these functions are performed in the field operations structure.

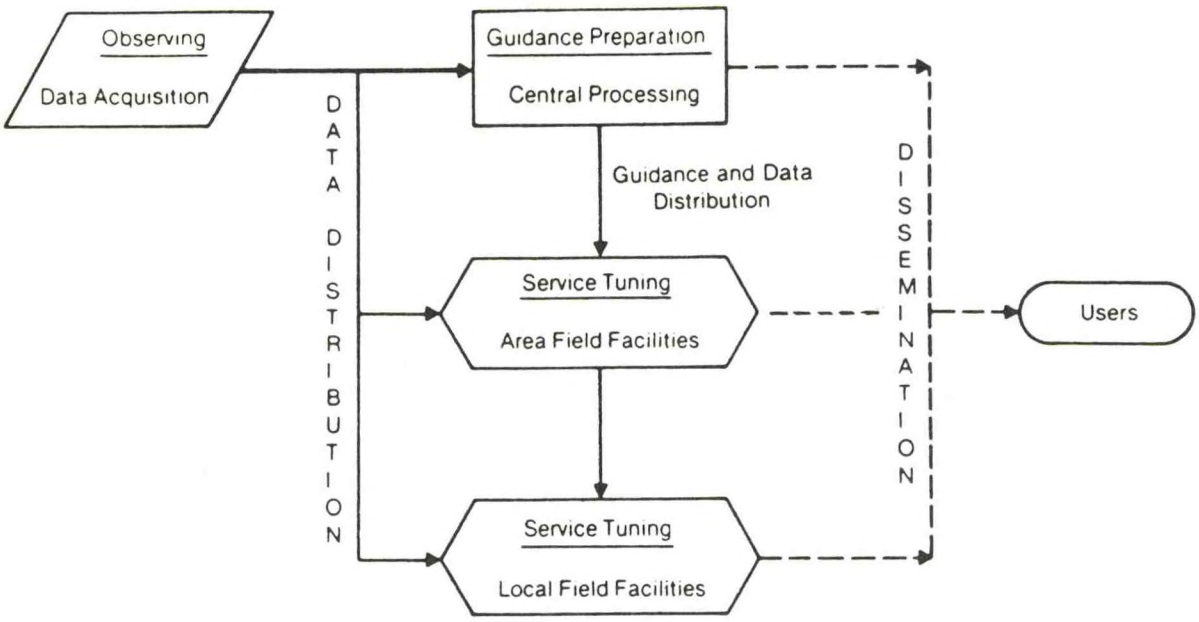


Figure A.3 Levels of Weather Service Functions.

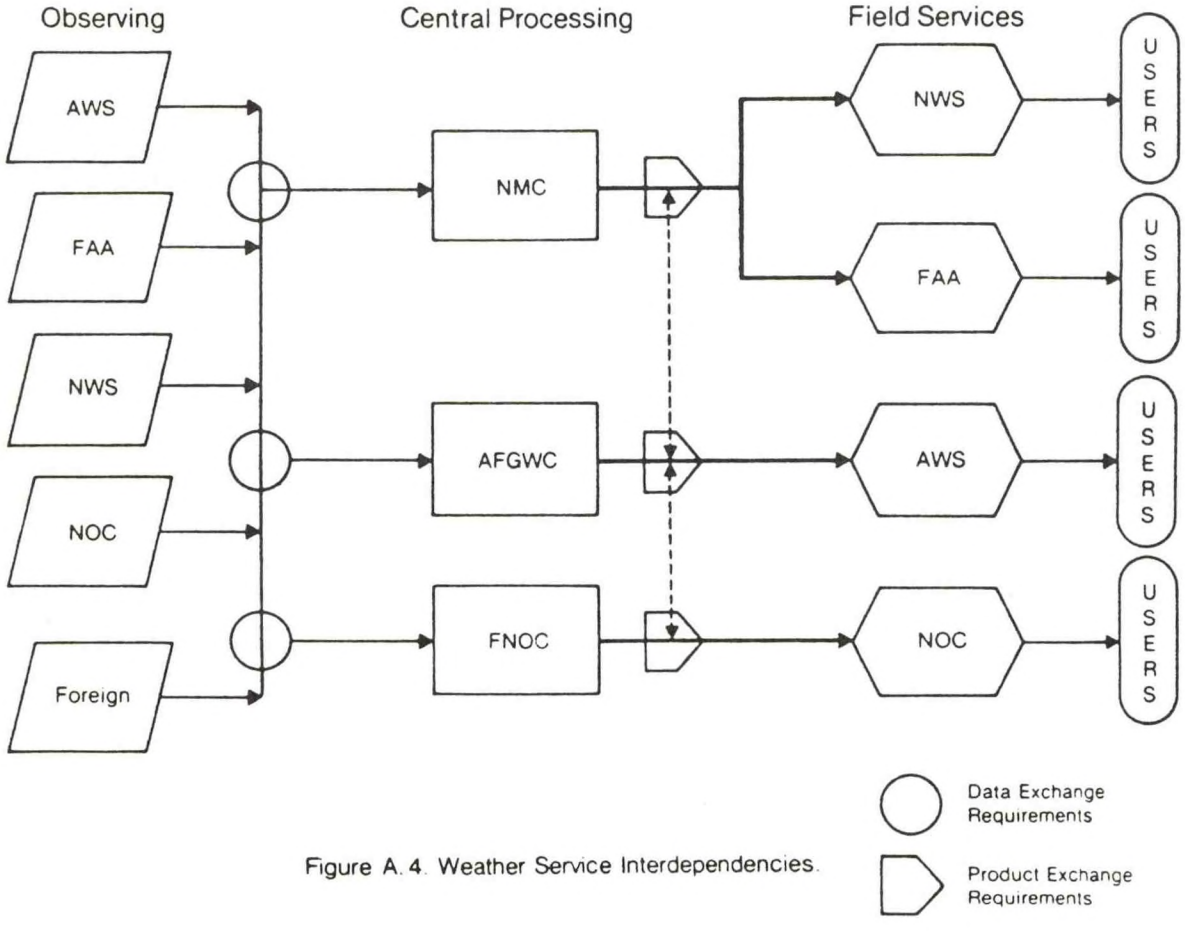


Figure A.4 Weather Service Interdependencies.

The basic weather service relies on the cooperative efforts of several agencies of the U.S. Government and the weather services of foreign countries. Figure A.4 illustrates the key interdependencies of these agencies.

Data Acquisition

The production sequence begins with the acquisition of data on atmospheric, hydrological, and oceanographic conditions for the United States and large portions of the rest of the world. Most of the data are collected by the NWS, FAA, USCG, NESDIS, the Department of Defense (DOD), weather services of other nations, and cooperative observers (the latter including land, oil platform, and ship-borne cooperative observers). Some of these data come from the U.S. Army Corps of Engineers, the Soil Conservation Service, the Forest Service, the U.S. Geological Survey, the Bureau of Reclamation, and regional agencies such as the Tennessee Valley Authority and the Salt River Project.

There are more than 1,000 principal surface observation points nationwide, with about 400 sites providing 24-hour service. Schedules at other sites are predicated on established needs; e.g., flight schedules. Most NWS and FAA observations are manually acquired. Elements observed include cloud cover, visibility, temperature, dew point, wind speed and direction, atmospheric pressure, and precipitation type and amount. These principal sites are augmented by 11,000 land-based cooperative observers, who report daily temperature and precipitation amounts.

Many of these field stations also send balloon-borne meteorological instruments aloft to measure temperature, moisture, pressure, and wind to 29 km above the surface. A few rocket soundings reach 100 km. There are 126 observation sites within the United States and its territories, the Caribbean, Mexico, and Central and South America. Most sites take two upper-air soundings per day at the standard analysis times of 0000 UTC and 1200 UTC. These soundings are augmented by weather observations from aircraft in flight and from satellites.

Specifically designed NWS weather radars monitor the location, extent, intensity, and movement of such severe or hazardous weather conditions as hurricanes, tornadoes, severe thunderstorms, and intense winter snowstorms. Weather radars are also capable of quantitative estimates of rainfall amount over specific watersheds to aid the forecasting of river floods and flash floods. Over 120 weather radars are operated by NWS. These are augmented by about 90 weather radars operated by the Department of Defense. Of the NWS radars, 56 are staffed and operated continuously. NWS also receives radar weather observations from 24 FAA air traffic control radars in the mountainous regions of the west.

Polar-orbiting and geostationary environmental satellites collect large volumes of weather data in the visible, infrared, and microwave spectrums by radiometry. NESDIS operated weather satellites observe cloud cover and motion, profile vertical temperature and humidity fields (soundings), measure sea surface temperature, portray sea and Great Lakes ice coverage, and provide data from which frost conditions, cloud tops, moisture (relative humidity) categories, and high and low altitude wind fields can be derived.

They also collect and relay environmental data observed by remotely located sensing equipment.

Hydrologic data are collected at about 7,000 points nationwide. Measurements are made of river levels and precipitation amounts as input to prediction models that forecast river stages for over 3,000 points. About 15 percent of these data are obtained automatically through the GOES data distribution system and the Centralized Automatic Data Acquisition System. In addition, there are several hundred unofficial sources of river and rainfall data from communities and site-specific local networks.

The NWS Airborne Snow Survey Program (ASSP) makes airborne snow water equivalent and soil moisture measurements each winter over large areas of the country subject to a severe and chronic snow melt flooding threat. The ASSP provides real-time snow water equivalent data measured from low-flying aircraft over a network of approximately 1200 flight lines covering 23 states and 5 Canadian Provinces from Maine to Oregon to Arizona.

NWS collects 90,000 to 95,000 marine surface weather observations monthly from cooperative weather observers aboard ships at sea worldwide. This program includes 49 countries that are recognized as contributors by the World Meteorological Organization (WMO). The U.S. Cooperative Ships Program is possibly the largest with 1,600 ships in the program. There are 17 Port Meteorological Officers strategically located at NWS offices near major U.S. ports to serve as liaison between NWS and the marine community. Thirty-five operational NOAA data buoys plus 12 other prototype or special purpose buoys provide hourly meteorological and sea state observations from critical nearshore and offshore locations. In addition, 39 automated stations in the Coastal Marine Automated Network (C-MAN) report weather conditions from selected coastal sites. These principal marine data programs are augmented by volunteer mariner reports (MAREPS) relayed through cooperative private coastal radio stations.

Oceanographic data include "profiles" of deep ocean temperature and salinity which are based upon measurements made by the DOD, U.S. research vessels, and cooperating merchant marine ships. Sea-surface temperatures are observed and reported by NOAA data buoys and satellites, the U.S. Navy and American research vessels, as well as by ships-of-opportunity of many nations. Observations of tides, sea and swell are also observed and reported daily.

Forecast Preparation

The data are transmitted to all NWS organizations that have pertinent warning and forecasting responsibilities. The organizations then process and analyze the data and use the results to prepare their respective outputs. These organizations include the WSFOs and the centers that have major responsibilities for preparing atmospheric, oceanographic, and/or climatic guidance.

Preeminent among these organizations is the National Meteorological Center (NMC) which in many respects is the key to the NWS' analysis and forecast function. NMC has the responsibility for preparing coordinated large-scale forecasts over the entire globe and providing associated guid-

dance for the United States and most of the remainder of the Northern Hemisphere, plus guidance for portions of the Southern Hemisphere. The Center produces a large number and variety of graphics and alphanumerics that describe both current and predicted conditions throughout these areas.

The current state of the atmosphere is depicted by 3- and 6-hourly pressure analyses at the surface, and 12-hourly analyses at selected levels above the surface. These products are produced by a mix of computerized numerical techniques (objective methods) and human interventions (subjective methods) and give the forecasters a generalized, three-dimensional picture of current weather conditions. In addition, analyses are prepared of oceanographic conditions for the Gulf of Mexico, the North American coastal areas, and portions of the North Atlantic and Pacific Oceans. Using these analyses, NMC then applies the techniques of numerical weather prediction to predict weather conditions for up to 10 days in the future. Also using dynamic oceanographic programs, marine phenomena are predicted for coastal and offshore waters.

NMC transmits these analyses and forecasts to NWS field offices throughout the Nation and to other users, both domestic and international, for the preparation of short and medium range forecasts. Thus, although NMC's products are primarily intended to guide public and private organizations in the preparation of short and medium range forecasts, virtually all of the Center's products become available to the public through NWS field offices. A few of the Center's computer forecast products, however, are disseminated without change either directly by NMC or by other NWS facilities.

Short range forecasting covers a less-than-national area, either a variable area determined by the current and future location of hurricanes, severe convective systems or other specific phenomena or by a fixed area determined by river and stream drainage. Forecasts from NSSFC and NHC fall into the first category; those from the RFC's into the second. However, all share two common characteristics, (1) they forecast only specific meteorological/hydrological phenomena and (2) their products represent important guidance to the WSFOs even though the products typically go to some users without change.

The National Severe Storms Forecast Center (NSSFC) prepares and issues tornado and severe thunderstorm "watches", which are then disseminated to the public in the threatened areas. A watch is a public-oriented statement which indicates that meteorological conditions are favorable for the development of severe thunderstorms or tornadoes. The watch statement may include advice as to what precautions should be taken by the public to protect itself from these hazards. As opposed to a watch, a warning of severe thunderstorms or tornadoes must be issued by the NWS field facility having county warning responsibility when the event has been sighted or indicated by radar.

The National Hurricane Center (NHC) issues advisories, watches, and warnings describing the current and future location, intensity, and movement

of hurricanes, other tropical storms, and associated coastal tides. These bulletins are considered final products and are issued either directly or through the WSFOs to the public and other interested groups without modification.

The River Forecast Centers (RFC) conduct analyses and prepare forecasts of river levels, stream flows, and flood stages to be expected in major national watersheds. They also provide runoff and snowmelt forecasts. RFC forecasts are normally disseminated to the public through the WSFOs without change. RFCs develop procedures for local flood warning systems used by over 1,000 communities to warn of impending floods, and provide WSFOs and WSOs with hydrologic guidance for use in preparing flash flood watches and warnings.

Building primarily upon the material provided by NMC, the 52 WSFOs prepare a large number of the warning and forecast products particularized in terms of area peculiarities and special user needs. These medium-scale forecasts often are issued directly to the public without further modification. A representative list of these products follows:

- Flash flood and winter storm watches and warnings are issued for states or portions of states and highlight areas where flash flood or winter storm events are likely. Watches focus on the potential risks while warnings focus on actual or imminent conditions.

- State forecasts cover general weather conditions out to five days. Information includes expected amount of sunshine or cloudiness, precipitation, diurnal temperature variations and wind conditions.

- Zone forecasts are similar in content to state forecasts but are further restricted to an area generally comprising several counties or parishes and cover a period of two days.

- Aviation advisories and forecasts again represent a further subset of weather elements, so that the information applies to airport weather conditions and inflight weather.

- Marine warnings and forecasts focus on the coastal and offshore areas, the Great Lakes and high seas. They cover general weather conditions with specific emphasis on wind, wave, ice and coastal surf conditions.

- Fire weather forecasts provide the weather elements for use in fire management planning, forest and rangeland management activities, and wildfire control. These forecasts are often very localized, site-specific and time-specific in nature.

In many instances the NMC guidance is modified to describe a specific locality, such as a city and its suburbs, an airport terminal, a national forest, a farming community, and space launch and recovery areas. This process considers two different sets of variables: (1) topographic and climatological peculiarities, and (2) unique adaptation of the basic weather elements to make them site specific. Examples of the latter would include all weather and flood warnings.

Many public weather forecasts are made by meteorological technicians at the WSOs. These forecasts are frequently described as local adaptive forecasts; they are not original forecasts but rather an adaptation and localization of NMC/WSFO forecasts to meet local needs.

Communications and Dissemination

In addition to the above discipline-oriented functions, there are substantial functions required to support the interchange of data and products within the service, the dissemination of the services to users, and the management and maintenance of operations.

The internal NWS communications systems are in a transition stage. The use of most of the teletypewriter and facsimile circuits has been phased out, and the communication of both alphanumeric and graphic data is concentrated on the Automation of Field Operations and Services (AFOS) system. The AFOS consists of high-speed circuits (one for each NWS region) driven and interconnected by the Systems Monitoring and Coordination Center (SMCC). The AFOS became the primary communication system of the NWS in 1982. The implementation of the Remote Terminal to AFOS (RTA) in 1986 completed the NWS effort to replace FAA-controlled circuits used for internal NWS communications within the continental U.S.

External communications (i.e., communications to the non-NOAA users of weather information) involve a number of types of systems which are used to deliver weather services directly to the public, to private industry, and to other specialized groups via some intermediary organization. These include:

- Government-operated teletypewriter systems to commercial TV, cable television and radio stations; e.g., NOAA's Weather Wire Service.
- Direct radio broadcasts to the public through the NOAA Weather Radio system.
- Facsimile broadcasts to Government and non-Government users.
- Automatic telephone answering devices which are operated by telephone companies and which directly give the public weather information furnished by NWS stations.
- Direct NWS-to-the-public telephones, including automatic answering devices at NWS field offices and personalized services for public civil preparedness officials.
- Cooperative "Hotline" telephone answering services that provide users access to the latest hurricane advisories on a fee-per-call basis.
- Special interfaces to the communications systems of the agencies; e.g., FAA and Coast Guard networks, civil defense systems, and systems operated by private companies.
- A family of services for high volume data users accessed in Washington, D.C. Services include a Public Product Service channel, Domestic Data Service, International Data Service, and Numerical Product Service.

To a large extent, the success of the dissemination of services depends on the close cooperation among NWS, other government agencies and private enterprise. Dissemination to the general public is largely carried on by the news media and NOAA Weather Radio. The NOAA Weather Wire Service, which is the chief interface to the media, is driven by the AFOS system. A contract to replace the NOAA Weather Wire Service teletype systems with new technology that will increase the volume and timeliness of transmissions was awarded in April 1988.

Technical Assistance to Other Organizations

Besides developing and issuing weather and hydrological reports, NWS provides a number of other services that essentially involve technical assistance, advice and consultation:

- Disaster preparedness assistance is designed to improve the response to forecasts and warnings by community officials and the public. It is carried out by WSOs and warning preparedness meteorologists assigned to WSFOs primarily in the eastern, midwestern and southern states. A Washington-based staff coordinates this program. The NWS effort is coordinated at all levels with the Federal Emergency Management Agency (FEMA) through a formal NOAA-FEMA Memorandum of Understanding.

- Technical hydrometeorological assistance is provided to Federal, state, and local agencies, and consulting engineers involved in water management. This involves the development of estimates of limiting rainfall amounts, probabilistic estimates of rainfall amounts and time and space distributions of rainfall associated with major storms.

- Support is provided to regional response teams and on-scene coordinators during oil and hazardous substance spills in the form of spill trajectory forecasts and data on winds and seas in the spill area to assist cleanup operations.

- Marine outreach liaison is established with the marine community through state Sea Grant Marine Advisory Service programs and NWS port meteorological officers.

- Comprehensive analyses of the meteorological factors associated with major historic storms are prepared for hurricane surge model development.

- NMC/CAC/Agricultural Weather Section serves as the NOAA component of the USDA/NOAA Joint Agricultural Weather Facility and provides advisory and information services in support of impact assessments of weather and climate on global agricultural production.

- The WSFOs and WSOs provide direct technical assistance to Federal, state, and local governmental agencies, educational institutions, and the news media on a local basis.

- Technical assistance is provided to communities in developing local self-help flash flood warning systems, nationwide.

- Technical assistance to Federal and state forest and land management agencies is provided in the areas of training, observation, instrumentation, and site selection and in the evaluation of weather-related developmental programs.

- The Voluntary Cooperation Program provides meteorological assistance to less developed countries.

- International meteorological and hydrologic advice, consultation, and assistance are available upon request.

- NWS supports the Department of Justice in weather-related litigation and provides certified weather records to the legal community.

- Climate services are offered by the Climate Analysis Center of NMC, WSFOs, WSOs, RFCs and AWSCs, in addition to that provided by the National Climatic Data Center of NESDIS.

APPLIED RESEARCH AND DEVELOPMENT

To ensure that the quality of NWS forecasts and services continues to improve and is in line with current state-of-the-art, applied research and development is being carried on in a number of areas within NWS.

Numerical Weather Prediction. The NMC conducts an ongoing program of research and development for improving day-to-day general forecasts, warning services, and medium-range forecasts (prediction out to 10 days) by placing the analysis and prediction system on a stronger scientific basis. This involves numerical weather prediction, which is the design of models that simulate atmospheric-oceanographic processes. These models are constantly improved as better techniques are developed for solving the underlying equations and as computer resources and advanced technology become available.

Forecast Techniques Development. In the design, development, test, and evaluation, the NWS focuses a significant amount of its research support on providing field forecasters with automated guidance on meteorological (and by extension, hydrologic) events of immediate concern to the public and to users of applied weather information, such as aviation, energy, and agriculture. Statistical techniques, as designed by the NWS' Office of Systems Development (OSD), are an integral part of this process. In particular, automated guidance for most weather elements in routine public forecasts and aviation terminal forecasts is produced by statistical techniques. This system is continually being monitored, expanded, and improved.

Marine Prediction. The NMC conducts a program of research and development for oceanographic analysis and forecast guidance. The effort examines physical methods and numerical techniques appropriate to operational marine forecasting and develops numeric oceanographic models that produce the data sets required for the prediction of oceanic conditions

along the North American coastal and Great Lakes areas off-shore waters, the high seas, and in the Gulf of Mexico. Additional modeling is conducted by OSD in the critical area of hurricane storm surge forecasting. OSD's SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model is used for real-time surge forecasts from a threatening hurricane and as a basis for comprehensive hurricane evacuation planning.

Short-term Climate Fluctuations. Research and development are aimed toward improving the accuracy, extent, information content and lead time of seasonal outlooks. Diagnostic studies are being conducted of short-term regional and global climate fluctuations.

Hydrologic Research. Research efforts concentrate on improved hydrologic services by providing longer warning lead times for short-fused (flash flood) events; by making more accurate long-term forecasts of river flows for flood warnings and for water resources decision makers; and in support of these, through research in hydrometeorological data processing and analysis. Studies, augmented by research contracts, involve techniques for site specific small basin forecasts and area-wide flash flood risk assessments; integration of quantitative precipitation forecasts with runoff models; real-time model updating; modeling snow melt processes; modeling complex river hydraulics including sedimentation and ice effects; dam break analyses; river flows through multiple reservoir systems; and extended streamflow prediction. Major work is underway to process, merge and quality control hydrometeorological data from multiple sources, especially concentrating on high resolution digital data from next generation radars.

Equipment Development. NWS conducts research to devise and develop new and improved techniques for measuring weather elements and provide new information systems to support the operations of the NWS National Centers and field offices. Meteorological instrumentation is being developed with a primary emphasis on automating the sensing and dissemination of the data. Integration of automatic sensing equipment with AFOS will allow for computer controlled collection and processing of observational data. Test and evaluation of weather equipment are conducted at Sterling, VA. This facility, which has the capability to simulate aspects of a typical weather station, conducts tests of equipment and procedures under a wide range of environmental and operational conditions. New buoy platforms and sensors for installation on existing platforms are developed and tested.

Specific Products. NWS also conducts ad hoc research and development to improve the quality and timeliness of forecasts and warnings issued to the public. Research and development are conducted in the Office of Systems Development, the Hydrologic Research Laboratory, the Regional Offices, the National Hurricane Center, the National Severe Storms Forecast Center, National Meteorological Center, River Forecast Centers, and many WSFOs to improve the forecasts of hurricanes, severe local storms, general weather, general flooding, flash floods, marine, and aviation weather conditions, using both dynamic and statistical techniques.

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 provides 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 Earth Satellite Service (NESS) and Environmental Data and Information Service (EDIS).

NESDIS currently operates polar-orbiting satellites that monitor daily weather and surface conditions over the globe. It also is responsible for operating two geostationary weather satellites -- one that monitors the Atlantic Ocean and U.S. East and Gulf Coasts, and one that monitors the Pacific Ocean and West Coast.

The second major area of NESDIS' responsibility is environmental data and information management and dissemination. NOAA gathers global data about the oceans, earth, air, 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 Services

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 Landsat 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 is being 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 superposes guidance products from the National Meteorological Center with the imagery. 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 Services Stations (SFSSs) analyze, interpret, and distribute processed geostationary satellite products to regional National Weather Service offices and other Federal agencies. The products also are made available to private activities at their expense. SFSSs are located in Washington, DC; Miami, FL; Kansas City, MO; Honolulu, HI; San Francisco, CA; and Anchorage, AK. The Anchorage SFSS distributes data from both the polar-orbiting and geostationary systems. The San Francisco SFSS 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. In addition, it assesses the requirements and goals of NESDIS research and applications programs, and evaluates their progress.

POLAR ORBITING SYSTEMS

The NOAA system of environmental polar-orbiting satellites replaced the ITOS system on July 15, 1979. TIROS-N, the NASA prototype, was launched by the Atlas launch vehicle on October 13, 1978; and, NOAA-6, the first NOAA-funded operational satellite of this series, was launched on June 27, 1979. On February 27, 1981, TIROS-N became inoperative when its power supply failed, causing complete loss of attitude control. On June 23, 1981, NOAA-7 was successfully launched, and it became operational August 24, 1981. On March 28, 1983, NOAA-8 was launched and became operational, replacing NOAA-6, on June 20, 1983. NOAA 8 failed on June 12, 1984. NOAA-9 was launched on December 12, 1984, and became fully operational on February 25, 1985. NOAA-6 was reinstated as marginally operational on July 2, 1984. NOAA-8 earth acquisition was recovered on May 10, 1985, and on July 1, 1985, replaced NOAA-6 as the operational descending spacecraft. Intermittent spacecraft clock problems again caused interruptions in service on September 7, 1985, and NOAA-6 was made operational on October 14, 1985. NOAA-10 was launched on September 17, and became fully operational in December 1986.

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 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, carries a search and rescue capability in addition to its standard instruments. NOAA-9 carries sensors to measure the earth's radiation budget and ozone.

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-10 and -9 operate in near-polar, sun-synchronous orbits of 810 and

850 km, respectively, and provide environmental observations of the entire earth four times each day. NOAA-10 crosses the Equator in a southward direction at 0730 local time and NOAA-9 crosses the Equator in a northward direction at 1430 local time. NOAA-9 orbits at a somewhat higher altitude to avoid extended periods of readout conflict. The orbital period of the satellites is 101.58 minutes which produces 14.2 orbits per day.

The NOAA system 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 readout 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 (HRIS/2), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). The primary instrument providing tropospheric data, HRIS/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 will be used in conjunction with the two IR instruments. The microwave data permit computations to be made in the presence of clouds.

The Data Collection and Location System (DCLS) is provided by the Centre National d'Etudes Spatiales of France and is called the ARGOS DCLS. The ARGOS DCLS 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 three detectors included within this instrument are the Total Energy Detector, Medium Energy Proton and Electron Detector, and High Energy Proton and Alpha 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 system data, as well as the geostationary system 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, NOAA-9 contains 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 um), and a shortwave channel (0.2 to 5 um). The sun-viewing radiometer measures the total solar spectrum (0.2 to 50 um). 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 um), longwave (5 to 50 um), and total (0.2 to 50 um).

NOAA-9 through NOAA-I will carry the operational monitoring of atmospheric ozone, and NOAA-9 and NOAA-G will contribute to experimental monitoring of the Earth's radiation budget. 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 Island, VA,

and Gilmore Creek, 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 using the RCA American Communications, Inc. commercial satellite communications network. This system, which includes Earth Stations at Suitland, Wallops Island, and Gilmore Creek, delivers the data to SOCC. These data are immediately passed on to the DPSS subsystem for initial processing.

During three (occasionally four) sequential orbits, the spacecraft is out of range of both NOAA CDA stations. To eliminate the resultant time delay in the receipt of the high-priority sounding data during the "blind" period, a Western European readout station was established at Lannion, France. This station acquires stored sounding data and transmits it to the United States via the eastern GOES satellite located at 75°W.

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. Design of a new system to ingest and process the raw data was started in 1983. This system is referred to as the Meteorological Satellite (METSAT) DPSS in that it ingests and processes data from both the polar and geostationary satellites.

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-6, launched April 20, 1983, is the current West operational geostationary satellite located 135 degrees west longitude and GOES-7, launched in March 1987 is the current East geostationary satellite located at 75°W longitude. The normal GOES System of two satellites consisting of an Eastern (75°W) and Western (135°W) spacecraft, provides repetitive 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 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 resolutions of 1, 2, 4 and 8 km in the visible wavelengths and 8 km and 16 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 efforts are underway to develop a ground system to use the VAS data to improve NOAA's operational weather analysis and forecasting programs. 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 comparison with radiosondes, and (5) synoptic large-area coverage.

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, a Solar X-Ray Telescope, and an energetic particle monitor.

Table A.1 shows the launch schedule for polar orbiting and geostationary satellites by NOAA.

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 Gilmore Creek, 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 Data Services in Federal Building 4, Suitland, MD.

Another major component is the Central Data Distribution Facility (CDDF) at the World Weather Building in Camp Springs, MD. The CDDF is connected in turn with the Gilmore Creek CDA station, the six Satellite Field Services Stations and with the NWS Weather Service Forecast Office at San Juan, PR. The Gilmore Creek CDA station also relays satellite data by land line and microwave circuits to the Anchorage SFSS and the NWS WSFOs at

Anchorage and Fairbanks. The WSFO at Juneau, AK, receives satellite data from the Anchorage SFSS. By the end of FY 1987, SATCOM consisted of the following links:

- The Wallops Island CDA station preprocesses and calibrates the "raw" GOES data. These data are retransmitted to the satellite which transponds the data to the Federal Office Building #4 (FOB-4) facility at Suitland, MD.

- Two full-duplex circuits for delivery of stretched VAS data from FOB-4 to the World Weather Building (WWB) at Camp Springs, MD (2.11 Mbps).

- Two full-duplex, voice-grade satellite and terrestrial data circuits connecting CDDF with the Anchorage SFSS and the Gilmore Creek CDA station for facsimile.

- Eighteen full-duplex circuits connect the computer facsimile outputs at the CDDF to the SFSSs. At the SFSSs, a total of about 325 "GOES-TAP" customer circuits relay the facsimile to nationwide locations. Several hundred other customers receive the facsimile over circuits that connect to the "GOES-TAP" customer circuits.

- Three full-duplex circuits from the Suitland FOB4 computer to the Wallops Island CDA station to transmit WEFAX information for GOES East, Central, and West Satellites.

- Two full-duplex, voice-grade circuits conditioned for digital transmission from the Wallops Island CDA station to WWB for relay of GOES Data Collection System (DCS) information.

- Additional digitally conditioned circuits, dedicated and dial-up, for delivery of DCS information from WWB to a multitude of users.

- A voice network connecting CDDF, FOB4 and Wallops Island CDA.

- Two digitally conditioned voice-grade circuits between FOB4 and WWB for transmitting temperature sounding data used for interactive processing.

- Five voice-grade full-duplex circuits from Wallops Island CDA to WWB (two circuits), Kansas City SFSS (two circuits), and Miami SFSS (one circuit) for transmitting full disc east and west GOES IR data.

- One full-duplex circuit for the transmission of facsimile data to Owings Mills, MD, for the "AM Weather" television program.

- Two C-2 conditioned circuits for the transmission of time code information from Goddard Space Flight Center to the CDDF and SOCC.

- Four full-duplex circuits for the transmission of polar-orbiter facsimile from FOB4 to the CDDF and GOES data in the opposite direction.

- GMS WEFAX is transmitted to the CDDF on the duplex side of a circuit to the Honolulu SFSS.

- Meteosat WEFAX is downlinked at CDDF from an antenna located on the WWB.

- One 50-line multipoint voice coordination and monitoring network at Suitland for control and integration of launch activities.

- One 15-line multipoint voice coordination and monitoring network at Suitland for control and integration of launch activities.

- Two 100 WPM multipoint teletypewriter circuits connecting various elements of the satellite telecommunications network.

- Two 1.33 Mbps simplex satellite circuits for relay of NOAA system data from the two CDA stations to Suitland, MD, and to the RCA Ground Receiving Station at Offutt Air Force Base, Omaha, NE.

- Four alternate 9,600 Hz data/teletype and voice full-duplex satellite and terrestrial circuits between the two CDA stations and Suitland, MD, to relay real-time NOAA system data, to transmit command and control functions to the NOAA spacecraft, and to provide alternate routing and backup for NOAA teletype and voice communications.

- Two full-duplex combination teletype and voice satellite and terrestrial circuits between the two CDA stations and Suitland, MD, for coordination of NOAA operations.

- Two simplex C-5 conditioned data facsimile circuits between the Wallops CDA station and Suitland, MD, for the relay of sectorized NOAA HRPT data.

- One simplex 48 kHz link from Wallops Island to Suitland shared with 36.2 kbps NOAA system Lannion (France) data to SOCC/DPSS and 43.7 kbps 4x4 IR GOES VAS data (4X4 mile resolution) to DPSS.

- One 9,600 bps full-duplex link between SOCC and NASCOM/GSFC for NOAA system launch support and spacecraft anomaly investigation.

- One 7,200 bps simplex link from NASCOM/GSFC to SOCC for NOAA system launch support and spacecraft anomaly data separation.

- Four voice circuits between NASCOM/GSFC and SOCC for NOAA and GOES launch operations and spacecraft anomalies; also, used for spacecraft backup support operations.

RESEARCH PROGRAM FOR FY 1989

Research and applications with environmental satellite data in FY 1989 will be devoted to the improvement of and advanced technique development for quantitative and qualitative products and services that serve national and international programs in weather analysis and forecasting; climate diagnosis; and other programs for agriculture, fisheries management, energy; and other weather, land and environmental applications. The data from current NOAA operational satellites in polar and geosynchronous

TABLE A.1

PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA H	CY 1988
NOAA D+	CY 1989
NOAA I	CY 1990
NOAA J	CY 1991
NOAA K	CY 1992
NOAA L	CY 1994
NOAA M	CY 1995

Instruments for Advanced TIROS N Series

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

+(NOAA D does not carry the SBUV, SAR, or ERBI)

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES I	CY 1990
GOES J	CY 1990
GOES K	CY 1992
GOES L	To be determined
GOES M	To be determined

Instruments for GOES Series

SEM	Space Environment Monitor
DCS	Data Collection System
VAS	VISSR Atmospheric Sounder
SAR	Search and Rescue (starting with GOES I)

*Launch date depends on performance of prior spacecraft.

orbits, as well as research satellites operated by other nations and by NASA will be used to develop improved techniques and algorithms for the derivation of the global, three-dimensional structure of atmospheric temperature and moisture that is essential for numerical weather analysis and forecasting.

The study and application of the near continuous stream of data available from the visible and infrared imagery, and the multispectral imagery and soundings from the geostationary environmental satellites, will help to understand the life cycle of severe storms and the morphology and evolution of the mesoscale meteorological systems within which they form. The cooperative program of NOAA's Prototype Regional Observing and Forecasting System (PROFS) will continue to study the use of satellite data as a tool for operational forecasting centers to apply to the problems of short term warnings of severe thunderstorms, tornadoes, and hurricanes.

Climate analysis, diagnosis, and monitoring performed at the National Meteorological Center's Climate Analysis Center rely upon satellite observations of the earth-atmosphere budget of incoming and outgoing radiation. Knowledge of the "radiation budget" of the earth-atmosphere system is essential for renewed national and international research efforts for assessing global changes in the Earth's environment and its climate. Research with satellite data is particularly useful in understanding the effects of clouds as regulators of incoming and outgoing radiation.

Research will continue towards the improvement of the derivation of sea surface temperature for climate diagnosis and other applications. The availability of multispectral data from passive microwave sensors on the DOD meteorological satellites and the continued improvement of infrared techniques will further this work.

Applications research will continue in improving techniques to estimate the amounts and global distributions of atmospheric aerosols, the effects of aerosols on climate, and on other satellite measurements. Methods for estimating precipitation from satellite data is important for flash flood forecasts on the local scale, and precipitation is important to the understanding of the effects of latent heat release on the global scale for use in numerical weather forecasts and numerical climate modeling. Other parameters such as solar insolation reaching the ground and parameters important to the study of geology, geography, and hydrology, are the subject of continuing research using satellite data from multiple national and international sources.

The expertise resident with the scientists at NESDIS will be called upon to provide scientific advice on future sensors and information processing systems as next-generation environmental satellites are proposed for development.

Environmental Data Bases

NATIONAL CLIMATIC DATA CENTER

The National Climatic Data Center (NCDC) is moving steadily ahead to meet its Congressionally mandated responsibilities to archive climatic

data, describe the climate, and disseminate climatic data and information. These functions become even more critical as the influence of global climate change and increasing awareness of the climate-induced impacts affect today's society. NCDC is moving forward on four broad fronts including Climate Data Management, Climate Research, Climate Description, and Dissemination of Climate Data and Information.

Climate Data Management

The management of climatic data has become increasingly complex as new automated high data volume observing systems replace more traditional manual systems. First, these new data sets must be integrated with the historical data. Secondly, the data are no longer just for the United States but indeed are global in nature.

In FY 1989, NCDC will begin receiving data in digital formats from new observing systems such as NEXRAD and PROFILER. This receipt of digital data directly from the observing system will continue a trend that came to fruition in FY 1987/88 with the implementation of the Automated Shipboard Acquisition Program (ASAP), Automated Radio Theodolite (ART), and the Microcomputer Aided Paperless Surface Observation (MAPSO).

New data sources that must be prepared for in FY 1989 include the Automated Surface Observing System (ASOS) and the Geostationary Operational Environmental Satellite (GOES-NEXT) systems. These ultra-high volume data collection systems will require new solutions in software, hardware, and data management practices. Continuing in FY 1989 will be NCDC's commitment to and participation in numerous international and interagency data management councils, committees, and working groups. This interchange of policies, requirements, and goals is necessary to avoid duplication of data and services while at the same time being able to provide for the needs of a variety of users.

In FY 1989, the NCDC-developed U.S. Climate Computer (U.S. CLICOM) will be fully operational in the Regional Climate Centers and a majority of State Climatologist offices. The U.S. CLICOM system is a microcomputer based data management system built around a core of commercially available software. U.S. CLICOM allows the user to enter, quality control, store, and retrieve vast amounts of climatological data. The system will allow for the common interchange of data from states, the regions, and even to the national level. The U.S. CLICOM system is also compatible with the WMO CLICOM system being developed and implemented on the international scene by the National Weather Service.

Being the world's largest climate data archive brings a special responsibility in having comprehensive and efficient inventory systems. To this end, NCDC will implement a Data Information System (DIS) in FY 1989. DIS will allow NCDC and external users access to a wide range of meta-data. Included in the DIS will be inventories, a data encyclopedia containing both a data set directory and catalog, station histories, and browse files (See Figure A.5).

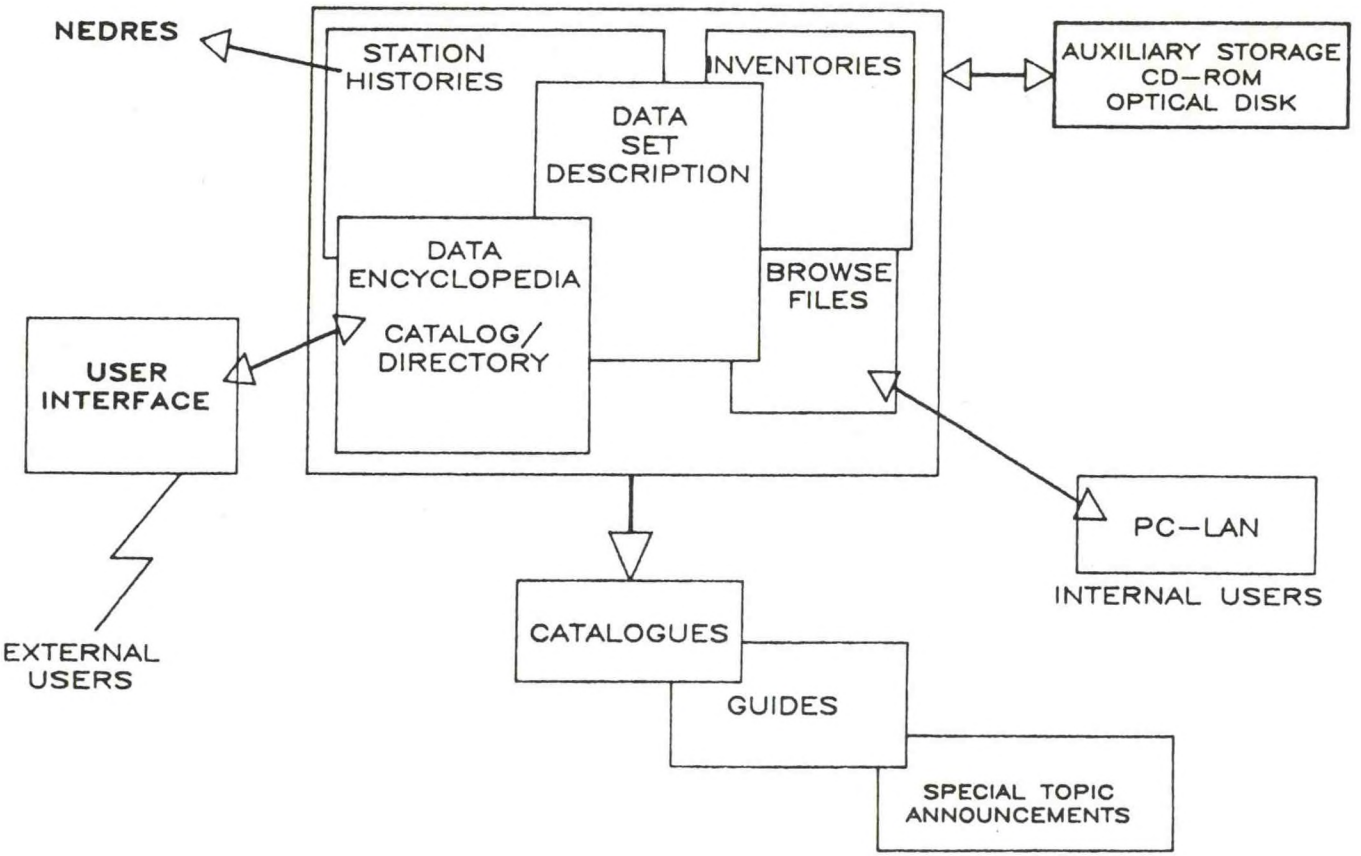


Figure A.5 NCDC Data Information System

Climate Research

In FY 1989 NCDC will begin full-scale support of research into the monitoring and prediction of global climate change. Beginning with an active participation in the data management aspects of the Experimental Climate Forecast Centers (ECFC), NCDC's role in NOAA's Global Climate Change Program will allow for the widest possible dissemination of data collected in various research programs including Global Precipitation Climatology Program, International Satellite Cloud Climatology Program, and other similar research programs. On a national scale, NCDC will play a key role in the Nationwide Climate Services System. This multi-agency approach will allow for services and research at the local level, as well as at the regional scale, and finally on the national and global scale.

Climate Description

The description of the nation's climate amounts to taking a census of a valuable resource. The major undertaking of FY 1989 will be the National Climate Information System (NCIS) and its dynamic atlas. Envisioned as a series of publications and digital data bases (disks, CD-ROM, etc.), the NCIS will address the climate resource and its risks to many sectors of the economy. Baseline data and climate indices will form the foundation for research needed in the determination of climate change. Probabilities will aid the decision maker in assessing risks whether it be in drought mitigation, flood control, energy conservation, building design, human health, or national defense.

In FY 1989, NCDC will combine conventional land-based observations with space-based remotely sensed data. This coupling of "looking up" and "looking down" data sets will give a more complete look of the climate system than is done today.

New climate studies involving the summarization of hourly observations will allow the engineering and construction industries to design and construct safe efficient structures. New freeze probabilities and frost-free-period statistics will allow American agriculture to select the best varieties of crops for their particular location. An improved climate anomaly identification system will assist decision makers to determine the extent and severity of ongoing climate variations. The new system will give greater detail to today's summaries by supplying near-real time data down to the county level.

Dissemination

All of these climate data, information, and descriptions would be useless unless they are available in a timely fashion to the myriad of users around the world. In FY 1989, NCDC will deliver more data via on-line computer systems. The user will be able to access NCDC's vast data bank containing inventories, catalogues, data set descriptions, etc. As data become available in near-real-time, the ability to gain timely access will become especially important. New digital media such as CD-ROM and optical disks will be used by NCDC so that the high volume data sets can be provided quickly and inexpensively. The National Climatic Data Center is committed to furthering the science of climatology and making climate data and

information available to all who desire it in the most cost-effective and efficient manner possible.

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 is engaged in providing data management, for example, to major climate-related studies such as the Tropical Ocean and Global Atmosphere (TOGA) program. In addition, the NODC provides data products and services individually to researchers and members of the operational marine community (e.g., the Navy, Coast Guard, shipping industry, fishermen). Although the NODC has traditionally served as a facility for retrospective, in situ data, the requirements of many projects and users for faster ocean-data access has necessitated that NODC begin to handle certain types of near-real-time data, as well as ocean satellite data. To meet the new demands being placed on it, the NODC continues upgrading its technological capabilities.

Data Management

The NODC provides data management for TOGA through an innovative, cooperative venture with the Scripps Institution of Oceanography (SIO). In FY 1987, the NODC and Scripps established a Joint Environmental Data Analysis (JEDA) Center for TOGA subsurface thermal data from the tropical Pacific. NODC acquires, tracks, and provides initial quality control for these data; Scripps provides further quality control by generating analytical TOGA data products. At the beginning of March 1988 NODC's TOGA Pacific data base held over 41,000 temperature profile observations (Table A.2). Over the nest three years, the JEDA Center plans to extend its processing and analysis of available upper ocean thermal data -- from the tropical Pacific to the entire Pacific in 1988, to the Indian Ocean in 1989, and to the North Atlantic Ocean in 1990.

TABLE A.2 NODC TOGA Database

(Tropical Pacific temperature profiles received through February 1988)

	Data Type			
Year	Radio Message	Delayed Mode	Total	% Delayed
1985	3,977	6,547	10,524	63%
1986	3,940	10,001	13,941	72%
1987	9,704	5,705	15,409	37%
1988	1,465	0	1,465	0%
TOTAL	19,086	22,253	41,339	54%

With the JEDA Center as a successful prototype, the NODC has established two more joint centers with academic institutions. In August 1987 the NODC and the University of Hawaii established the Joint Archive for Sea

Level (JASL). This center will initially focus on the management and dissemination of data from the Pacific Sea Level Network operated by the university's Department of Oceanography. The NODC will receive and provide to users filtered hourly, daily, and monthly mean sea level from a network of tide gauge stations located at Pacific islands and coastal sites around the Pacific rim. It is expected that this network will eventually be extended to other ocean basins and serve as the foundation for a global observing system.

In November 1987, the National Environmental Satellite, Data, and Information Service (NESDIS) concluded a Memorandum of Understanding with the College of Marine Studies of the University of Delaware creating the Joint Center for Research in the Management of Oceanographic Data (JCRMOD). JCRMOD is the result of strong working ties between the College of Marine Studies and the NODC. The agreement provides benefits to both institutions by extending and strengthening an existing research program. Rather than addressing the management needs of any specific type of data, JCRMOD will work to bring new methods and technologies to bear on fundamental problems of ocean data management, specifically how to cope with the huge volumes of data from new global climate programs.

NODC continues active participation in planning for other global programs that will reach full implementation in the 1990s. Among these are the World Ocean Circulation Experiment (WOCE) and the Global Ocean Flux Study (GOFS). NODC anticipates providing WOCE with data archival services as part of a distributed WOCE data management system still in the planning stages. During FY 1989 many details of this distributed data system -- and NODC's contribution to it -- will be finalized. In support of GOFS, the NODC has assembled from its present data holdings an initial global data base of photosynthetic pigments and productivity. In FY 1989, the NODC will survey and acquire data holdings of other agencies and institutions both in the U.S. and in other countries to add to this growing data bank.

The new era of global geosciences is made possible largely by the global coverage of ocean-sensing satellites. Since April 1987, the NODC has been distributing ocean wind, wave, and sea level data from the U.S. Navy Geodetic Satellite (GEOSAT) Exact Repeat Mission. GEOSAT was launched in March 1985 and for the first 18 months of operations, called the Geodetic Mission, collected data to meet its primary military objectives. Although this full data set is classified, the NODC will receive and disseminate a condensed data set from the Geodetic Mission that includes only radar cross section, wind speed, and significant wave height. GEOSAT continues functioning normally and is likely to continue providing data well past FY 1989.

Data Services

NODC's archival data holdings are a major resource for climate researchers. In FY 1987, the NODC provided data products and services to an all-time record high number of 6,783 customers. As the NODC augments its suite of near-real-time and ocean satellite data products, this number is expected to grow by at least 6 percent each year.

To provide users with easier, faster access to information about its data holdings and services, the NODC in FY 1988 inaugurated the NODC SPAN Information Exchange (NOSIE). This pilot system is a menu-driven, on-line information resource that includes descriptions of NODC data files; a catalog of NODC data products and publications; NODC data submission guide lines; an NODC bulletin board; and a facility that enables users to leave messages and submit data and information requests. NOSIE can be accessed over the NASA SPAN network or via dial-up modem. In the future NODC hopes to provide access to NOSIE via OMNET/SCIENCEnet on the Telemail network. NOSIE was developed in parallel with a similar system at the University of Delaware called SONIC (SPAN Ocean Network Information Center) that was designed specifically to support the WOCE and TOGA programs.

In FY 1989, the NODC will continue publication of the "Mariners Weather Log", a quarterly publication that provides comprehensive coverage of major storms of the North Atlantic and North Pacific, reports and annual summaries on tropical cyclones, information on the NWS Marine Observation Programs, as well as selected shipboard gale and wave observations, summaries of data from offshore buoys, and other data and information of value to the operational marine community.

Technology Enhancements

As NODC approaches the 1990s, system developments are focused largely on putting the expanding capabilities of desktop microcomputers to work in the service of ocean data management and developing networking links to the ocean research community. NOSIE, NODC's new pilot information system, operates on the NASA Space Physics Analysis Network (SPAN), which now links nearly all major academic and Federal oceanographic institutions into an Ocean Network. To improve its in-house operations, NODC has installed a local area network (LAN) that links 13 personal computers with NODC's two VAX computers.

NODC tested and provided to NASA its evaluation of the initial release of the Global On-line Data (GOLD) Catalog, the data inventory component of the NASA Ocean Data System (NODS). During 1988 NODC anticipates receiving and evaluating the revised, enhanced version of the GOLD Catalog.

As various individual components are developed, refined, and linked by improving networks, a distributed system is gradually emerging that will provide the infrastructure to support management of global ocean data through the last decade of the 20th century.

NATIONAL GEOPHYSICAL DATA CENTER

The National Geophysical Data Center (NGDC) carries out a number of programs which provide data for research in Meteorology and Climatology. These include historical data bases of volcanic activity; digital topographic data for global and regional circulation modelling; an extensive file of ocean bottom samples and ocean drilling data; specialized data sets from the CLIMAP project which interpreted climatic conditions and geographic features from marine sediments for glacial and interglacial intervals; a variety of data on solar variability, solar flares and upper atmosphere phenomena, which are used in the study of relationships between solar variability and

climate; a data inventory and coordination role for climate data derived from ice-cores; a collection of historical photographs of glaciers; a Department of Energy sponsored program to investigate Southern Hemisphere CO data in relation to variations in atmospheric circulation and sea ice conditions; temperature and pressure data from satellite-queried buoys placed on the central Arctic pack ice; and an extensive collection of mosaic imagery from the Defense Meteorological Satellite Program (DMSP) satellites, which is used for studies of snow and ice cover.

Additional activities include the acquisition of data from the DMSP satellites and the Solar Electro-optical Observing Network (SEON); management of data from the DOD/NOAA sea ice chart digitizing programs; provision of Marginal Ice Zone Experiment data management services; and development of a computer-based Cryospheric Data Management System for data acquired by the DMSP Special Sensor Microwave Imagery. NGDC plans to continue and expand the services outlined above in FY 1988.

ASSESSMENT AND INFORMATION SERVICES CENTER

The Assessment and Information Services Center (AISC) performs analysis of weather/climate events and the effects on all aspects of human activities. AISC promotes the development of the U.S. economy and the effective management of oceanic, atmospheric, and terrestrial resources by: 1) developing analyses of global and regional environmental impacts on human activities and; 2) providing access to environmental datasets and published information through the National Environmental Data Referral System.

The Center provides a bridge between research scientists and managers of natural resources who use and interpret environmental data and information. Upon request, the Center develops, adapts, and tests models and techniques for analysis of environmental impacts on human activities and resources. The tailoring of quantitative models and techniques to meet specific user requirements often requires presentation of information for various scenarios in a geographic information format. Baseline information and modelled scenarios are useful resources, for environmental impact assessment, management planning, and determination of "at risk" populations, mitigation strategies and policies.

Climate Impacts. AISC produces a monthly report to the DOC electronic bulletin board titled, "Climate Impact Assessment, United States, Energy." It contains weather-related cost estimates for residential consumption of heating fuels in the cold season and electricity for air-conditioning in the warm season. The publication provides population-weighted energy use information for selected cities in the United States, the 48 conterminous States, nine Census regions, and the country as a whole on a weekly, monthly, and seasonal basis. During the heating season, entries also include an international heating oil section with a weather/energy consumption indicator for several foreign countries.

In FY 1989, the Center will continue to improve this product by breaking down the cost estimates by type of fuel and to derive forecasting procedures for fuel costs during the entire season.

Marine Resources. AISC produces studies for understanding and monitoring of processes, conditions, and changes in the marine environment. Marine studies encompass gathering the data, performing analysis, and producing a synthesis and coherent report of all the information. The Center's marine reports provide an important extension service to the states, academia, and the private sectors. The Center develops and performs multi-disciplinary studies of regional, national, and global ocean-climate interactions with living marine resources and human activities. The Center performs these tasks using various approaches including time series analysis, numerical modelling, and statistical analysis. Special studies are performed for unusual events, such as, hurricanes, floods, and other large scale perturbations.

National Environmental Data Referral Service. This service includes a computerized database that is accessible on a major information retrieval system from any location served by commercial data communication networks. Published catalogs and a network of cooperating organizations provide up-to-date information about the existence, characteristics, and availability of environmental data. Part of the NEDRES program will be a National Climate Information Clearinghouse which will provide a national inventory of climatological data. An inventory of climatic data holdings in the North Central States is complete. In FY 1988, the climatic data holdings inventory for the Western States will be completed. This will complete the inventory of climatic data in the 48 contiguous States.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

Environmental Research Laboratories

Environmental Research Laboratories (ERL) R&D programs support NOAA space and meteorological 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 is any major natural hazard such as flash floods, strong winds, thunderstorms (including tornadoes and hail), and heavy snowstorms. ERL Laboratories will continue to conduct both inhouse and cooperative research with other NOAA components, joint institutes, and universities.

OBSERVING TECHNOLOGY

ERL will receive the first of 30 ground-based wind profilers from industry in early FY 1989. The first manufactured prototype profiler was installed during FY 1988. Data is being evaluated to assure specification compliance. The temperature and humidity Profiler at Denver, Colorado continued to operate in FY 1988. Additional radar wind studies will be undertaken to improve the accuracy and height resolution of temperature and humidity profiles. Ground-based Profiler data is being combined with GOES satellite profiles to improve overall sounding accuracy.

ERL will continue to operate a network of five automatic tropospheric wind profiling radars and total water (i.e., vapor and precipitation) measuring radiometers in eastern Colorado during FY 1989. This research effort will significantly contribute to development and test methods for effective use of continuous profile data to improve NWS short-range, local forecasts. The data will be used in real time by the Denver National Weather Service Forecast Office and ERL's Program for Regional Observing and Forecasting Services, as well as for research by the Weather Research Program.

The technology of infrared Doppler lidar will be advanced by continuing studies on the wavelength and geographical dependence of back-scattered energy in the 9-10.6 micrometers band with a high power (2 joules/pulse) infrared Doppler lidar.

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, an automated surface network, remote-sensing wind profilers, instrumented aircraft, and lightning location networks. NSSL provides significant technical and scientific support, including research and development, for the NOAA NEXRAD program.

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

In FY 1989, ERL's Environmental Sciences Group/Weather Research Program (WRP) and NSSL will continue to transfer knowledge of convective weather systems and associated heavy rainfall through courses at the NWS training center; through visits and interactions with NWS centers, regional headquarters, and forecast offices; and through cooperative research projects.

Environmental Sciences Group Program for Regional Observing and Forecasting Service (PROFS) is working to improve the effectiveness of short-range, locally specific, weather services. The improvements are achieved through a program of applied forecasting research and development which draws upon the improved understanding of the natural processes of storm development as determined by the research community and integrates these advances with emerging technologies, advanced observational systems (such as NEXRAD, VAS, and the Profiler), and conventional data. These quasi-operational systems are realized in specific hardware/software configurations of the highly flexible PROFS Exploratory Development Facility, with extensions into the Denver WSFO under the NWS AWIPS program. These advanced capabilities will be evaluated to reduce the risks of AWIPS procurement, and forecast improvement and effect on operations, as precursors to 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 Profiler as inputs to its quantitative mesoscale analysis and prediction model, thus expanding service improvement efforts to include nonsevere as well as severe weather.

With the support and cooperation of the Federal Aviation Administration, the National Weather Service, the Air Weather Service (USAF), and the National Aeronautics and Space Administration, the Environmental Research Laboratories will continue to develop real-time Doppler radar data displays and algorithms.

MESOMETEOROLOGY AND PRECIPITATION FORECASTING AND WARNING RESEARCH

The NSSL and WRP 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. A significant effort will be completed in FY 1989 to study data from NOAA P-3 aircraft, Profilers, Doppler radar, and microphysical data, gathered during the Oklahoma-Kansas PRE-STORM project, and to translate results to NWS prediction techniques.

WRP will continue an effort begun in FY 1987 to develop enhancements to the NWS operational LFM numerical model. The goal is to provide a continuing stream of improvements in the operational numerical guidance provided twice daily to weather forecasters.

HURRICANE ANALYSIS AND PREDICTION RESEARCH

The Hurricane Research Division (HRD) of ERL's 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. During FY 1989, HRD will begin to use new dual Doppler radars aboard the P-3 aircraft.

HRD develops numerical hurricane models using these and other sophisticated data to analyze and predict hurricane behavior. During FY 1988, HRD continued to gather synoptic-scale Omega Dropwindsonde (ODW) data to improve hurricane track prediction. This will be continued in FY 1989 to support NWS real-time forecasting and to provide data necessary to develop a next generation objective analysis scheme.

GFDL hurricane research efforts model 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. FY 1989 plans include research to:

- o Improve understanding of the genesis, development, and decay of tropical depressions by investigating the thermo-hydrodynamical processes using numerical simulation models.

- o Study small-scale features of hurricane systems, such as the collective role of deep convection, the exchange of physical quantities at the lower boundary, and the formation of organized spiral bands.

- o Investigate the capability of numerical models in the prediction of hurricane movement and intensity.

- o Develop next generation operational hurricane prediction model.

NUMERICAL ANALYSIS AND PREDICTION MODELING

The ERL Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton, NJ, 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 of NOAA missions. Three main areas of weather research are covered by the GFDL program -- Experimental Prediction, Hurricane Dynamics, 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. FY 1989 research plans are to:

- o Develop more accurate and efficient atmospheric and oceanic Global Circulation Models (GCM's) suitable for monthly and seasonal forecasts.

- o Identify important external forcing mechanisms for the forecast range of several weeks to several months; accurately specify initial states of the atmosphere, oceans, soil, and snow-ice.

- o Investigate the influence of additional internal processes such as orography, cloud-radiation interaction, and cumulus convection upon atmospheric variability on the seasonal time scale.

- o Study the mechanisms of various atmospheric phenomena such as blocking, orographic cyclogenesis, equatorial ocean-atmosphere interaction, tropical circulations, and teleconnections.

Mesoscale dynamics research efforts determine the practical limits of mesoscale predictability and simulate mesoscale phenomena and their interaction with larger and smaller scales. FY 1989 plans include efforts to:

- o Produce accurate numerical simulations of mesoscale processes to understand the role of synoptic scale parameters in the generation and evolution of mesoscale processes.

- o Understand the dynamics of mesoscale phenomena and their interaction with synoptic and smaller scales.

- o Understand the dynamics of mesoscale phenomena and their interaction with synoptic and smaller scales.

- o Determine practical limits of mesoscale predictability by means of sensitivity studies on numerical simulations of mesoscale phenomena.

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 the 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 in space and on high altitude aircraft, degradation of surveillance and monitoring systems for defense, errors in navigation systems, and perturbations of satellite orbits.

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 polar-orbiting NOAA satellites.

Data are collected, stored, and displayed for analysis; products are distributed through the Space Environment Laboratory Data Acquisition and Display System (SELDADS). The upgraded SELDADS II system, with greatly increased data capacity and analysis and display capabilities, became fully operational in FY 1986.

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.

The major FY 1989 research effort will be to develop solar prediction techniques using data which simulate those expected from the Solar X-ray Imager, to be flown on GOES-NEXT. This research will insure full utilization in operational forecasts during the GOES-NEXT era.

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 a national policy for oceans and their users. NOS coordinates marine activities pursued by the National Weather Service and the National Environmental Satellite, Data, and Information Service and provides products and services that support meteorological, climatic, and environmental programs.

The objective of the Ocean Services Program is to improve our ability to observe and predict physical changes in the global ocean environment. The principal value of an expanded global ocean data set lies in the enhancement of physical models used to predict environmental changes over all time scales. Vast economic and social benefits accrue for every day that forecast accuracy can be extended, and these benefits also increase as predictions are extended to weeks, months, seasons and beyond. Since environmental observations over the global oceans are far less numerous than those taken over land, we must make every existing measurement count. In addition, we must plan to establish the composite global network that will be needed to satisfy new, fine-mesh forecast model data ingest requirements in the 1990 decade.

This program provides a total systems management approach for collecting data in a timely manner, maintaining accuracy through quality control, analyzing data, and converting data into useful products for access by a wide range of users (weather forecasters, climatologists, researchers, the fisheries community, emergency preparedness agencies, offshore industries, etc.). The program accomplishes its mission by increasing the number and improving the quality of oceanographic and meteorological observations over the oceans, improving the capacity to analyze, model and predict ocean processes, and increasing and improving interagency coordination in global ocean data collection, analysis and prediction.

The Office manages real-time marine data collection programs using a variety of sensor platforms (e.g., Shipboard Environmental (Data) Acquisition Systems (SEAS), drifting buoys, moored buoys, etc.). To increase understanding of large-scale ocean processes and their effect on the atmosphere, the Office participates with other NOAA (e.g., Tropical Ocean and Global Atmosphere Program), U.S. Government, and international data collection programs. It provides operational support and long-term policy guidance for these programs.

The Ocean Services Program provides operational marine forecast and analysis guidance material in support of NOS and NWS field offices and private industry. It develops operational numerical prediction model output products and improves methods of data analysis. Output products may include analyses of: marine weather and boundary layer phenomena; waves and wave dynamics; and ocean thermal structure and dynamics.

The Office also enlists the substantial resources of the U.S. Navy's Fleet Numerical Oceanography Center (FNOC) in Monterey, CA, to conduct a program of activities in support of product development. It provides a

vehicle to ensure maximum cross utilization of ocean data, analyses, and predictions to provide services to civilian users and to assist the U.S. Navy in serving military users.

OFFICE OF AIRCRAFT OPERATIONS

The Office of Aircraft Operations (OAO) 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 NOAA Administrator.

OAO 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 OAO at Miami International Airport in Florida.

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

OAO 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. Because of this capability, the OAO has primary responsibility for reconnaissance of hurricanes within 24 hours of landfall on the United States and its territories. The OAO also augments reconnaissance by DOD aircraft on developing tropical storms and provides hurricane reconnaissance over foreign airspace where military aircraft may be prohibited.

DEPARTMENT OF DEFENSE

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 service directly supports all phases of military operations, from strategic planning to tactical operations. The U.S. Navy's Naval Oceanography Command and the U.S. Air Force's Air Weather Service are the primary military performing agencies. The Army and Marine Corps each have a small generic weather support capability, but depend upon the primary weather services for most 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 is no other conventional weather observing capability 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 and aerial weather reconnaissance to meet unique military requirements. The reconnaissance program also serves national needs for data from tropical and coastal winter storms. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES ARMY

U.S. ARMY METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

The U.S. Army Atmospheric Sciences Laboratory (ASL) is the leading Army laboratory for artillery meteorology, electro-optical climatology, atmospheric optics data, and atmospheric characterization. ASL's meteorological research program is, by necessity, very broad, covering such topics as: 1) microscale models of chemical transport and diffusion in complex terrain, 2) theoretical studies of the atmospheric interaction with high-energy laser beams, 3) advanced remote sensing techniques, 4) artificial intelligence techniques for meteorological applications, 5) sound/noise propagation through complex atmospheres, 6) meteorological techniques for near surface observation of target area, and 7) atmospheric effects on electro-optical propagation, to name a few.

The highest priorities in basic research are: remote sensing, boundary layer diffusion modeling and quantification of atmospheric effects on IR/MM wave imaging sensors. An important effort in remote sensing is the remote determination of vertical temperature, humidity, and wind characteristics to an altitude of 10 kilometers or more. This work will lead ultimately to the replacement of existing balloon-borne upper-air measurement systems that need both extensive manpower and logistical support. Another primary effort involves research on the application of ultraviolet (UV) lidar for remotely measuring not only temperature and humidity but also detecting airborne biological agents. This sensor offers the promise of providing a capability of describing and mapping contaminated areas using the UV lidar mounted on both aircraft and ground vehicles. Second to the U.S. Army Atmospheric Sciences Laboratory's focus on remote sensing is the development of advanced transport and diffusion models for use at chemical depots, in war-gaming

activities, and ultimately on the battlefield for tactical applications. Target acquisition using imaging sensors is of vital importance to the Army. The atmosphere degrades the images of battlefield targets due to turbulence and turbidity -- arising from smoke, haze and other particulate matters. ASL's research aims at quantifying these effects using algorithms which integrate the transfer functions of the imaging device and the degrading atmosphere.

The highest priority work in exploratory development is the Integrated Meteorological System (IMETS). IMETS will automatically sense, collect, process, and transform weather data into Tactical Weather Intelligence (TWI) products which assist the commander in making combat decisions. Mathematical, physical and empirical models, terrain coupled meteorology, and the latest techniques in display and artificial intelligence technologies are being exploited to derive the TWI products. Numerous software applications have already been fielded for use by the intelligence, aviation, chemical, and operations elements of Army divisions. The TWI software has been also inserted into the Brigade Planner System and the AirLand Battlefield Environment (ALBE) testbed. Feedback from units in Germany, Korea, and CONUS has been extremely positive and a strong desire expressed for more product development. Atmospheric effects on Army sensors and systems are described in the Electro-Optical Systems Atmospheric Effects Library (EOSAEL). The computer models in EOSAEL are used to aid in system design, system performance, countermeasure studies, wargaming, and system analysis.

TECHNICAL ACCOMPLISHMENTS IN FY 1988

The assessment of the use of UV lidar for remote sensing of meteorological parameters, biological agent detection and discrimination, and battlefield target detection has continued in FY88. A UV transmissometer system was developed to use in conjunction with the UV lidar to validate the use of the lidar as a transmission measurement system. The lidar itself has been modified in order to simplify and stabilize the optical system, and will be back in operation in FY89. A lidar simulation model was developed to describe UV lidar systems and the signal returns including elastic backscatter, Raman backscatter and atmospheric and target fluorescence. This model will be validated using the ASL lidar and the one operated at the Los Alamos National Laboratory. A small light weight sensor development was begun to demonstrate the ability of UV systems to detect manmade targets in natural backgrounds, using a nitrogen laser source and video detection. This sensor will operate only at night because of the solar UV background. Further development could lead to a daytime operable system.

Project WIND was designed to collect the appropriate meteorological measurements on four subscales of motion simultaneously for comparison to model simulations. A set of more than a half billion data points was obtained during Phase IV. The database is composed of measurements of wind speed, wind directions, wind turbulence, temperature, humidity, solar radiation, air pressure, soil heat flux, precipitation, and the boundary layer structure. These data were collected during subsidence conditions. This set will complement the existing data sets for cyclonic activity, shallow convection, and marine incursion. The total database of more than two billion data points will allow the test and evaluation of the hierarchy of nested models for four distinctly different meteorological conditions.

In this way, the generality and applicability of the Hierarchy can be properly established. The WIND database will, therefore, play a significant role in providing validated technology which will be directly applicable to chemical warfare/chemical-biological defense, smoke operations, wargaming, field support, etc. WIND is the first database of its kind and is unique because the hierarchy of nested models is unique. However, each scale of these models represents the domain of the battlefield. This translates to the Army having the means to more realistically compute, analyze, and evaluate the effects of variable terrain and significant land use upon the meteorology of the battlefield.

The Atmospheric Sciences Laboratory (ASL) has continued to assist the U.S. Army Training and Doctrine Command (TRADOC) by providing technical data on atmospheric effects to be modeled in force-on-force wargame simulations. Previous efforts have involved providing computer algorithms to include effects of smoke and dust obscuration in the battalion level models. Results of wargame simulations using these models were a part of the Comprehensive Smoke Study. The near real time JANUS model, in particular, is being distributed to the TRADOC schools for use in training. FY88 plans call for investigating improved methods for treating multiple volleys and for incorporating obscuration into the Lancaster approach to wargame simulation. ASL is also participating in planning Smoke Week X which will be conducted at Ft. Huachuca in October 1988, and is designed to test the validity of various target acquisition models used in the TRADOC wargame simulations. Data from Smoke Week X will be adapted for use in the Atmospheric Aerosols and Optics Data Library (AAODL) and will be made available to the user and research communities.

The Pasquill Stability Model was included in the Large Area Screening Systems (LASS) model for use in EOSAEL 87. The model is currently being adapted for use with modern image processing equipment in order to generate realistic computer generated photosimulations to evaluate various concepts of camouflage, concealment, and deception when used with smoke at large fixed military installations.

The intensity thresholds for the onset of laser-breakdown induced by aerosol particles were measured as a function of 1) ionization potential of the gas in which the aerosol particle is immersed (air, helium, argon, and xenon), and 2) gas pressure. The results show that breakdown is initiated first inside the aerosol particle for gases with relatively high ionization potential at high pressure. Conversely, breakdown is initiated first outside the particle in the gas for low ionization potential gases at low pressure. Research on aerosol-induced laser breakdown suggests that the atmospheric propagation of a high energy excimer or free electron laser beam could be severely affected by aerosols in the atmosphere for peak intensities of the order of tens to hundreds of MW per cm squared. The magnitude of the effect depends on the atmospheric pressure and aerosol loading, the laser pulse spatial and temporal characteristics, the laser fluence and peak intensity, and the overall laser beam size.

Meteorological dependence of radiant fire plumes from burning vehicles and petroleum were modeled and a capability developed to insert simulated fires into thermal imagery. The effort supports the simulation of the effects of emissive sources on simulated thermal sensor response. Methods

of treating the radiative signatures and obscuration effects of battlefield aerosol clouds were extended to include the scattering of sunlight and the attenuation of target signatures through fractal-based models of cloud inhomogeneities.

A model has recently been completed for the Vax/DeAnza image processing system that simulates image degradation due to optical turbulence for devices operating along any line of sight in the atmospheric surface boundary layer. Given any zero range image, the image is simulated to appear as if it were being viewed by some specified EO/IR imaging system operating under optical turbulence conditions defined by user-selected meteorological parameters. The basis for the characterization of optical turbulence is a newly developed model. The model format has been designed to consider all possible geographical locations, so that system performance may be extrapolated to various operating environments. Future updates to the imaging code include the addition of multiple scattering effects, emissive sources, rain, fog, battlefield smokes, MMW system performance, and the use of sensor fusion. Adaptive correction algorithms for adverse weather conditions are being investigated.

The development of the Target Contrast Characterizer (TCC) for quantifying atmospheric changes in target contrast continues. The basic concept of the TCC is to compare close up and engagement range target contrast scenes to isolate, for the first time, the inherent from the propagated changes in target contrast.

During the summer of 1986 a new version of Tactical Weather Intelligence (TWI) software for the Microfix Topographic Workstation was fielded by FORSCOM. This TWI software was prepared by ASL and addressed the following weather effects: Weather Utilities, Weather Analysis Applications, and Weather Effects Applications. Weather Utilities includes weather database management, a surface meteorological working file, and upper air profile. Weather Analysis Applications involve interpolation and contouring. Weather Effects Applications are Nuclear, Biological and Chemical (NBC), smoke, Mission Oriented Protective Posture (MOPP), night vision goggle use/non-use, and electro-optical (EO) sensor applications. During 1988 the software was improved to operate on an IBM PC compatible computer (MS-DOS). Graphical displays were reworked for the night vision goggle and the EO sensor applications programs to make them easier to understand. The database structure was redesigned for greater flexibility. A new utility was added to display graphical overlays of meteorological data. Two new programs were added: Tactical Weather Effects Messages and Density Altitude Predictions for Helicopters.

Software describing weather effects on target acquisition was improved and incorporated into various Army programs. The major improvements in model capabilities are the following: 1) obscuration effects due to large area smoke screens, white phosphorus screens, and artillery delivered white phosphorus smoke with dust have been incorporated into both the visible and infrared sensor performance routines, 2) a human-target, thermal contrast routine was added, 3) the model's calculations of detection and acquisition ranges for targets on a snow covered surface have been made more accurate, and 4) the user interface in the model has been upgraded to make the model resources more accessible to the user.

A computer model has been developed to estimate the thermal environment of the interior of combat vehicles for the purpose of assessing physical and psychological stress on drivers while they are wearing chemical hazard protection suits, i.e., MOPP gear. The model addresses the change in the interior crew compartment temperature due to exterior environmental changes.

ASL continued the development of a three-dimensional chemical hazard prediction model for use by aviators and ground-based personnel. This model represents an improvement over existing models in that the vertical extent of the hazard is predicted in addition to the areal coverage. This capability is especially critical for aviators avoiding incapacitation or contamination by chemical vapors. In the past, radioactive fallout effects upon low-flying aircraft were not considered. A three-dimensional fallout model has been developed which predicts "no fly boxes" in the vicinity of tactical nuclear bursts. A hazard volume is defined in order to allow aircraft to avoid exposure to contamination.

Low-level turbulence has been identified as a serious problem for helicopter flight operations at the National Training Center (NTC), Ft. Irwin, CA. At the present time, weather forecasters supporting NTC have very limited resources available to them for preparing turbulence forecasts. ASL developed a practical method for estimating thermal, mechanical, and lee wave associated turbulent motion that could adversely affect the flight patterns and/or endanger aircraft and aircrews flying training-related missions at NTC. A Low-Level Turbulence Decision Tree was selected as a method to tailor a semi-empirical solution to the prediction of turbulent effects upon low flying aircraft in the complex terrain of NTC.

Evaluations and verifications of complex-terrain, mesometeorological models were a major effort during FY 1988. Eight available models have undergone verification utilizing available databases. Verification techniques utilized include preparing a prognostication from experimental data for some finite time in the near (up to 12 hours) future and comparing the model results with critical measurements and conducting several statistical tests for significance. An algorithm was developed that functions in conjunction with a complex terrain wind field model to determine the optimum placement of meteorological sensors on the battlefield. This routine steps through several iterations until the solution converges yielding the optimum location of instrumentation that will best approximate the output of a prognostic mesoscale model. The algorithm successfully predicts instrument locations for areas ranging from 25 to 6400 square kilometers.

Criteria for establishing the stability of the planetary boundary layer utilizing the Kazanski-Monin hypothesis were developed and published. A semi-empirical power law using regression techniques was developed. Atmospheric stabilities can now be determined from readily available data.

A computer model was developed to predict the movement of aerosol clouds over irregular terrain and to compute optical path lengths and transmittance of dust and smokes on the battlefield.

An illumination model was developed and evaluated. This model gives the natural illumination levels at the earth's surface due to solar, lunar,

and sky background contributions. Solar and lunar angles are computed from time and location data. Atmospheric conditions considered are clear sky, overcast, partly cloudy, precipitation, and fog. Cloud conditions are described in three layers -- high, middle, and low. Initial model evaluation has been completed against actual data with excellent results.

ASL has entered into a joint program with the National Oceanic and Atmospheric Administration (NOAA) and the Federal Aviation Administration (FAA) concerning aircraft icing. An improved model for predicting icing conditions at low altitudes, the typical altitude for Army aviation, has been developed.

The meteorological data and information collected on the battlefield must be fused into a common database in order for the Tactical Decision Aids (TDAs) to have appropriate input values. A two-dimensional meteorological data fusion model was developed and implemented on the ATB computer system. This model takes real time ingested meteorological sensor package (MSP) surface data and interpolates it using a temporal/spatial objective analysis scheme into a gridded meteorological database. Rawinsonde data for upper air values were added in order to have a three-dimensional database. Evaluation and testing of this module has been initiated.

During FY 1987 the concept of utilizing fielded artillery radars, the TPQ-37 and TPQ-36 versions of Firefinder, was successfully tested. A detailed comparison was made for radar data reduction using Fast Fourier Transform, pulse-pair analysis, and maximum entropy methods. These comparisons confirmed the reliability of the pulse-pair analysis as a means for rapid processing of Doppler radar signals with minimal memory usage. The success of this method enables the artillery radar to provide timely wind data without interference or degradation to its primary mission. The adaptation of the artillery met message to internal usage in the radars permits a constant update of temperature and density, meteorological factors that influence radar performance.

An advanced and physically realistic vertical extrapolation algorithm for temperature and pressure was developed using current surface temperature and pressure measurements and the previous day's temperature extremes.

Analyses of meteorological data and data from live firings of the Multiple Launch Rocket System (MLRS) revealed that launch area wind measurements for heights between 20 and 300 meters at the time of launch, when used to update the lowest part of the computer met message, improved the performance of MLRS as compared to the performance using the normal met message obtained from upper air measurements with the Ground Meteorological Device (GMD) equipment. Analysis of data and results from simulated firings showed that a low level wind sensor only on the platoon leader's vehicle would not suffice in providing improvements for all of the launchers. A low level wind sensor, such as a laser doppler velocimeter, is needed for each launcher in order to decrease the met error.

Through a cooperative effort with the Ballistic Research Laboratory (BRL), the meteorological effects on the armor error budget were ascertained. Improvements could be made by using an optical refraction sensor, a path-averaging crosswind sensor, and hardware/software atmospheric pressure

correction. ASL participated with the Armor School, Armor and Engineering Board, and tank working groups in defining weather sensors for the future armored family of vehicles.

Three rain estimation models requiring meteorological satellite data as input information are operational on the VAX computer at ASL. These models are substantially automated, rapid in execution, and reasonably accurate.

The latest version of EOSAEL, EOSAEL 87, was completed during FY 1987. It contains new routines for target acquisition and system performance, terrain wind flow effects on obscurants, large area smoke screening, short-range refraction effects, and radiative transfer effects. In addition, improvements have been made in the vertical structure algorithm for fogs and hazes; new munitions have been added to the smoke munitions expenditures routine; vertical profiles have been upgraded in the high energy laser propagation model; fire-induced radiative transfer and turbulence effects have been upgraded in the fire model; and new regions have been added to the climatological module. The Seventh Annual EOSAEL/TWI Conference was held and attended by over 200 people with over 70 papers being presented.

Six Meteorological Sensor Package (MSP) units were delivered for Surface Tactical Automated Micrometeorological Systems (STAMS). The STAMS requirements called for modifications to the operational configuration of the MSP system. No central receiver capability was requested and the units were operated in a stand alone mode. STAMS is a candidate to provide real time meteorological data for the preparation of NBC warning messages. The units will be used with the Automatic Nuclear Biological System fielded within the 9th Infantry Division (motorized) for ADEA with the Combat Developments Experimentation Center (CDEC) Board acting as the test agency. STAMS data were collected to assess the operational performance. MANPRINT characteristics, logistics/maintainability, detectability, and transportability aspects of the STAMS, which performed to the specifications identified in the issues and criteria. Operator feedback and lessons learned provide valuable input to the Phase III MSP contract in progress.

ASL designed, fabricated, and tested a miniature meteorological package for Unmanned Aerial Vehicles (UAV). The hardware and sensor package weighs less than 320g (less cable), consists of a probe about 21cm long and 2cm in diameter, and a small electronics box about the size of two cigarette packages (7.6 x 6.4 x 3.8cm), and consumes about 2 watts. The UAV Meteorological Package (UAVMP) uses standard aircraft power and measures temperature, pressure, and humidity. The software resides in the ground station and converts navigation data into wind speed and direction, and processes voltage data from the sensor package to the other meteorological variables. The sensor package was observed and evaluated by TECOM evaluators and the results appeared in an official TECOM data report. Its accuracy is + or - 1 deg C from - 50 to + 50 deg C in temperature, + or - 1.5mb from 465 to 1027mb in pressure, and + or - 3% from 0 to 100% in humidity (temperature above 0 deg C). The UAVMP can provide realtime data to potential users, including artillery, intelligence, and aviation. The UAVMP is the only practical means to provide meteorological data from denied or target areas on a scale suitable for use by the Army. ASL also developed a preliminary method to obtain slant path transmittance passively in the thermal infrared from UAV that can provide useful values for most atmospheres over water and

most land surfaces. The technique uses data from existing types of infrared imagers. Additional work in the area of image processing produced preliminary results suggesting the ability to obtain slant path visual range in a passive manner. These techniques have the potential to provide passive means to obtain visibility and transmission data for a number of Army systems, including precision guided munitions, helicopters, submunitions, and surveillance systems.

The Lightweight Artillery Meteorological System (LAMS) was tested at Yakima Firing Center, WA and Ft. Lewis, WA from 19 May to 16 June 1987. LAMS, manufactured by Vaisala, Inc., is a candidate down-sized replacement for the GMD which utilizes the LORAN/OMEGA Navaids transmissions for upper air wind finding. Army participants in the test were the Combat Development Experimentation Center (CDEC), the Advanced Development and Employment Agency (ADEA), the U.S. Army Field Artillery School (USAFAS), the 9th Infantry Division and ASL. Five days of side-by-side comparison tests were conducted on a 24-hour basis. At the conclusion of the LAMS/GMD comparison tests, four days of mobility and set up/tear down testing was conducted. During the last three days of mobility testing, LAMS was deployed under simulated combat conditions during a Field Training Exercise. LAMS was successfully transported by CH-47 and UH-60 helicopters at Ft. Lewis after the Yakima portion of the test. LAMS failed to meet the required 110 hour Mean Time Between Failures at the 85% confidence level RAM criterion, did not provide all six of the required met messages and could not be directly interfaced to TACFIRE. The failure of LAMS to meet RAM requirements is not considered to be typical of Vaisala's upper air systems. Software upgrades should provide the entire suite of met messages and the required TACFIRE interface. LAMS has good potential as a GMD replacement if the cited deficiencies are corrected.

The U.S. Army Corps of Engineers and ASL initiated the AirLand Battlefield Environment program to develop computer-based Tactical Decision Aids (TDAs). Objectives of the program include developing and refining software capable of integrating environmental sensor and digital terrain data to produce TDAs in a manner that is transparent to the user; demonstrating the advantages of advanced sensor systems which allow the use of near-real-time battlefield environment data; and obtaining test data necessary to support implementation of TDAs on U.S. Army computer-based systems like the Integrated Meteorological System (IMETS), Digital Topographic Support System (DTSS), All Source Analysis System (ASAS), and Maneuver Control System (MCS). TDAs from six different categories (Army Aviation, Countermobility, Ground Mobility, Nuclear Biological and Chemical (NBC), Weapon System Performance, and Terrain and Atmospheric Utilities) have been generated to support demonstrations. To facilitate the implementation of the TDAs, data ingest and database programs were developed to support inputs from environmental sensors such as the Meteorological Sensor Package (MSP), Present Weather System (PWS), Soil Moisture Sensor (SMS) and the Lightweight Artillery Meteorological System (LAMS). These sensors will provide the near-real-time data to support the TDAs.

In early 1987 ASL was selected as the lead laboratory to develop a congressionally mandated demonstrated testbed called the Test Weather System (TWS). The goal of the TWS is to demonstrate the feasibility of collecting and integrating weather information from surface sensors, upper air systems,

meteorological satellites, weather networks and manual inputs of forecasts to produce weather intelligence products and TDAs for the Commander and his staff in a tactical situation. The ASL team tasked to develop the TWS conducted a preliminary design and cost estimate to determine the financial, technical and physical feasibility of developing a sophisticated system that could fit in an S 250 type shelter installed on a standard Army CUCV. This information was incorporated into the statement of work for a contractual effort to finalize the design, integrate the hardware with the required interfaces into the shelter and develop the required software. The TWS is the primary testbed for Phase II of the Army Space Demonstration which will show the feasibility of using space derived information in tactical situations. In addition to support for the Army Space Demonstration, the TWS is also serving as a proof of concept demonstration for the Integrated Meteorological System (IMETS) which is supported by a TRADOC approved Organization and Operation (O&O) Plan.

· The objectives of the visioceilometer effort are to determine the effectiveness of a 1.54 micrometer wavelength eyesafe, handheld, portable, single pulse lidar as an atmospheric characterization sensor and to develop a prototype instrument suitable for both RDT&E and tactical Army use. Two eyesafe visioceilometer units were taken to the field test site in southern California for calibration tests in obscured climate conditions. A database of visibility versus instrument response was collected on the ground, and ten helicopter flight tests were performed for slant visual range analysis. In other areas, visioceilometer technology was used to support Smoke Week IX trials at Eglin AFB; design was completed on a high speed digitizer that will reduce data processing time from about one minute to approximately 15 seconds and permit automatic operation of the system by computer; and the visioceilometer was coupled with a portable laptop computer capable of operation in remote and confined spaces (aircraft, tanks, Army operations areas).

ASL provided atmospheric consultation, measurements, analysis, and forecasts from thirteen permanent sites, CONUS and OCONUS, to Army and other Department of Defense RDT&E activities and to other government agencies. The meteorological teams supported 450 RDT&E projects, while field personnel provided support to 19 RDT&E projects with mobile and/or transportable meteorological equipment at temporary or remote test sites. The meteorological element at White Sands Missile Range's High Energy Laser System Test Facility (HELSTF) fulfills an integral role in the Army's Strategic Defense Initiative (SDI) laser testing. ASL provided critical measurements of crossbeam winds and optical turbulence as well as local precipitation forecasts and nowcasts. These measurements and forecasts are extremely critical factors in go/no-go decisions for all atmospheric laser tests. State-of-the-art instrumentation enhancements included: 1) integration of the windfinding radar and NAVAID upper air systems, 21 installation of the Surface Automated Meteorological System (SAMS) at the Redstone Arsenal, Ft. Belvoir, Ft. Huachuca (Electronic Proving Ground) and Dugway Proving Ground meteorological teams, and 3) acquisition of scintillometers and nephelometers for the ASL meteorological teams. This upgrade program has provided each team with state-of-the-art capabilities to meet the Army's research and development meteorological information requirements.

DEPARTMENT OF THE NAVY

OVERVIEW

Within the U.S. Navy, meteorological and oceanographic support is provided by the Naval Oceanographic and Meteorological Support System (NOMSS). The NOMSS is a collective title which includes environmental personnel and resources assigned to various 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 (NAVOCEANCOM). In addition, personnel and resources from the naval research, development, logistic, and training components are included within the NOMSS. Naval systems commands, laboratories, research facilities, and training commands constitute these various components.

Primary support for the NOMSS is provided by activities and detachments assigned to the NAVOCEANCOM. Shore field activities within NAVOCEANCOM having meteorological responsibilities include a primary numerical processing center, three regional Naval Oceanography Centers, two Naval Oceanography Command Centers, eight Naval Oceanography Command Facilities, over 50 Naval Oceanography Command Detachments, two Naval Oceanography Command components, and the Naval Oceanographic Office (NAVOCEANO).

The Fleet Numerical Oceanography Center (FLENUMOCEANCEN) Monterey, CA, operates the master computer center of the NOMSS and functions as the hub of the Naval Environmental Data Network (NEDN). The NEDN is designed for product distribution among the major NAVOCEANCOM activities. Through linkage with DOD and NOAA environmental satellite systems and U.S. Air Force and NOAA data distribution centers, FLENUMOCEANCEN acquires global coverage of environmental data. From these data, basic and applied numerical (computer) products are generated for distribution via the NEDN and other communications systems for use by other NOMSS activities in producing specific support products and services.

The three regional Naval Oceanography Centers--the Naval Western Oceanography Center (NAVWESTOCEANCEN) at Pearl Harbor, HI; the Naval Eastern Oceanography Center (NAVEASTOCEANCEN) at Norfolk, VA; and the Naval Polar Oceanography Center (NAVPOLAROCEANCEN) at Suitland, MD--are assigned broad geographical fleet support services and related matters within their specific areas of responsibility. NAVWESTOCEANCEN is responsible for the Pacific and Indian Ocean areas; NAVEASTOCEANCEN for the Atlantic and Mediterranean Sea areas; and NAVPOLAROCEANCEN for the Arctic and Antarctic areas. They utilize basic and applied numerical products from the FLENUMOCEANCEN to provide environmental broadcasts and tailored support in response to specific requests from the operating forces.

The two Naval Oceanography Command Centers (NAVOCEANCOMCENs) are located at Rota, Spain, and on the island of Guam. NAVOCEANCOMCEN Rota assists NAVEASTOCEANCEN in the Mediterranean Sea area. NAVOCEANCOMCEN Guam assists NAVWESTOCEANCEN 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. NAVOCEANCOMCEN Guam has an additional responsibility for operation of the "Joint Typhoon Warning Center" (with the Air Weather

Service of the U.S. Air Force), providing tropical warnings to USAF and issuing tropical cyclone warnings to U.S. interests in the Western Pacific and Indian Oceans.

Seven Naval Oceanography Command Facilities (NAVOCEANCOMFACs) at Brunswick, ME, Jacksonville, FL, San Diego, CA, Yokosuka, JA, Cubi Point, RP, Keflavik, IC, 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 FLENUMOCEANCEN is utilized by all facilities; the overseas facilities augment this guidance with data from local sources. The eighth facility, NAVOCEANCOMFAC Bay St. Louis, MS, is responsible for Naval Reserve matters of the NAVOCEANCOM and the management of programs concerning NAVOCEANCOM training, climatology, meteorological and oceanographic equipment, and NAVOCEANCOM publications and forms.

There are over 50 Naval Oceanography Command Detachments (NAVOCEANCOM-DETs). Although primarily located at Naval Air Stations, several are being 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 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 FLENUMOCEANCEN to provide meteorological and oceanographic services. Statistical oceanographic products prepared by NAVOCEANO are also utilized. Overseas detachments utilize foreign and Air Weather Service (ASW) products, as available, in addition to FLENUMOCEANCEN numerical products. Three of the detachments are oriented to provide specific technical support to the NOMSS; 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 Center at Offutt AFB NE.

NAVOCEANO operations are directed primarily to oceanography and Mapping, Charting and Geodesy (MC&G) matters. However, oceanography and meteorological climatology are included in many of their publications and appropriate atmospheric/oceanographic data bases are maintained for this purpose. On-scene environmental support capabilities such as the Integrated Command Acoustic Prediction System (ICAPS), Geophysical Fleet Mission Program Library (GFMPL), and Tactical Environmental Support System (TESS) provide in-situ tactical oceanographic support to operational forces. These systems were developed and are maintained by NAVOCEANO. In addition, an Operational Command Center established at NAVOCEANO will begin real time processing of remotely sensed oceanographic data which will then be provided to FLENUMOCEANCEN numerical models.

Oceanographic units permanently assigned to 39 aviation capable U.S. Navy ships further augment the NOMSS. These units, staffed with environmental 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 (METs), are temporarily assigned to

Navy ships upon request to meet short-term support requirements.

These METs, available from six NAVOCEANCOM activities (Rota; Norfolk; San Diego; Yokosuka; Cubi Pt. and Pearl Harbor) are outfitted with their own portable equipment. Navy ships without dedicated units also contribute to the NOMSS by providing vital meteorological and oceanographic observations, frequently from data-sparse oceanic areas. Technical guidance is provided by NAVOCEANCOM.

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 (FMF) aviation units, also staffed with meteorological personnel are indigenous to each of the twelve Marine Air Groups (MAG). They operate and maintain meteorological mobile facilities (METMF) 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 METMF equipment augment and support the host activity's weather unit.

PROGRAM DESCRIPTION

Toward meeting the mission of the Naval Oceanographic and Meteorological Support System (NOMSS), the Navy's meteorological support programs are designed to satisfy validated fleet requirements. The Navy's meteorological programs include surface and upper atmospheric observations, flight forecasting services, tailored forecast (WEAX) and optimum track ship routing (OTSR) 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, 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 1989 budget includes programs that address a total of 134 validated requirements, including 55 from the U.S. Atlantic Fleet, 52 from the U.S. Pacific Fleet, and 27 from the Naval Forces, Europe. Efforts are focused in three broad areas: shipboard tactical environmental support; upgrades to the Fleet Numerical Oceanography Center, NAVOCEANO and other Naval Oceanography Command (NAVOCEANCOM) centers, and their data distribution networks; and, enhanced capabilities at NAVOCEANCOM shore-based aviation support activities. Specific efforts in the FY 1989 program that support these broad areas are described below.

Tactical Environmental Support System (TESS). TESS is a modular, computer-based support system designed to provide Navy decision-makers with meteorological/oceanographic assessments and forecasts and to integrate air/ocean data with sensor/weapon platform parameters to assess system

performance. TESS will function as the operational, resident air/ocean master data base. Data sources will include in-situ sensors, meteorological and oceanographic satellites, U.S. and foreign radio weather broadcasts and data fields prepared ashore, principally at the Fleet Numerical Oceanography Center.

Acquisition strategy for TESS is to build upon an interim capability based on the Navy-Standard Desktop Tactical Support Computer. This interim capability is being implemented as a non-research and development effort and will be completed during FY 1989. A total inventory of over 70 units is planned with installations keyed to major fleet combatants and selected shore activities with significant command and control responsibilities. Follow-on capabilities are intended for all combatants.

Satellite Processing Center Upgrade (SPCU). Under a Memorandum of Agreement (MOA) on the Shared Processing of Satellite Data (1984), and the exchange of data via the Shared Processing Network (SPN), the concept of centers of expertise (COE) was established to describe the areas of primary emphasis of each of the three participants to the MOA. In this concept, the National Environmental Satellite, Data and Information Service (NESDIS) was designated the COE for atmospheric soundings, the Navy was designated the COE for sea surface temperature and microwave imager data, and the Air Force Global Weather Center the COE for cloud imagery. To satisfy Navy responsibilities under this MOA, a significant upgrade to FLENUMOCEANCEN's satellite processing capabilities and supporting communications is underway, as well as new initiatives which established an Operational Command Center and real time oceanographic data processing at NAVOCEANO. Two phases are planned under this Satellite Processing Center Upgrade at FLENUMOCEANCEN. The initial phase of the SPCU work (ICO June 88) replaces aging and difficult-to-maintain hardware with state-of-the-art minicomputers and flexible and programmable receiving and transmitting equipment. The second phase (DEC 88) will allow the Navy to participate in the SPN. The third phase allows for the transition of currently operational software as well as the implementation of new software on the new equipment. In addition to supporting shared processing, the SPCU will provide global satellite data for analysis and prediction models, imagery for product quality control, and supplementary imagery for regional oceanography centers to support areas outside local satellite data coverage. Additionally, the SPCU will be capable of exchanging data, information and products with NAVOCEANO's Large Scale Computer (class VII) and the Satellite Processing System, as soon as these systems are operational. Additional efforts to upgrade data processing within FLENUMOCEANCEN and the NAVOCEANCOM claimancy, including distribution capabilities, will facilitate the tailoring of overall product support to Fleet needs.

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 will replace a variety of existing Navy satellite reception systems. The SMQ-11 is composed of a dual-planar array antenna system and two equipment cabinets for data processing. It has the capability to process encrypted transmissions from the Defense Meteorological Satellite Program (DMSP) as well as imagery from national civil satellite systems (TIROS, GOES). Satellite information from this system can be provided to the Tactical Environmental

Support System (TESS) for additional processing and applications. Additional planning is underway to exploit data from other satellite systems (foreign and domestic) projected for the early 1990's. Production of the AN/SMQ-11 commenced in FY 1987. Delivery and installation of initial units is planned for FY 1988. A total inventory of 72 units are programmed.

Lightning Position and Tracking Systems (LPATS). The LPATS detects lightning cloud-to-ground (CG) strokes over a large area with a high degree of precision, timeliness and reliability. In the past, late detection and reporting of the existence of lightning has presented a particular threat to personnel working in exposed areas. On the other hand, unnecessary false alarms have seriously impacted work schedules. Aircraft and in-port ship refueling, weapons handling and fuel storage are highly dependent on early detection of the lightning threat as significant lead times are required to insure that proper safety precautions can be effected. The LPATS networks employ a new generation of technology providing enhanced detection efficiency and flexibility over existing systems. Network data communications, planned for installation over the next two years, will employ satellite links replacing more costly land lines used previously. A total of 18 LPATS networks are programmed with installations concentrated along the eastern and Gulf Coast of the U.S. Installation commenced in FY 1987 and will be completed in the spring of 1989.

Atmospheric Modeling. The primary goal of this effort is to improve fleet readiness and safety of ships and aircraft, and to enhance weapon system performance through the application of new numerical modeling technology. Weather prediction problems contain three elements: observation, forecasting, and product utilization. Improvements in product utilization are primarily being addressed within the Tactical Environmental Support System (TESS) program, previously described. Several efforts are underway to enhance the quantity, quality, and optimum utilization of observational data. Procurement of a portable mini-rawinsonde (MRS) system began in FY 1988, and will continue during FY 1988. MRS consists of a surface receiver/processor and lightweight balloonborne expendable sensor package capable of measurements of pressure, temperature, humidity, and wind speed and direction. The Shipboard Meteorological and Oceanographic Observing System (SMOOS) and Automated Observing System (AOS) programs are developing shipboard and shore-based systems for improving the timeliness, quality, and reliability of meteorological and oceanographic measurements. These modular, flexible and user-friendly systems will utilize proven, off-the-shelf technological components and equipments where possible. Efforts within the SMOOS program have been merged with TESS 3 development, as the SMOOS sensors provide inputs directly into TESS. Significant efforts are underway to optimize the utility of satellite data in Navy numerical modelling. In addition to data assimilation, the Air/Ocean Prediction (AOP) program plans further evaluation and optimization in FY 1989 of the Navy's Global Atmospheric Prediction System (NOGAPS) Spectral Model and Advanced Tropical Cyclone Model (ATCM). Both were initially implemented during FY 1987.

Summary. The impact of these programs on fleet readiness and operational capabilities is significant. By the end of FY 1989, 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 AIR FORCE

METEOROLOGICAL SERVICES

The Air Weather Service (AWS) of the Military Airlift Command (MAC) is tasked by Air Force Regulation (AFR) 23-31 to provide or arrange for staff and operational weather services to active and reserve United States Air Force (USAF) and Army units, designated unified or specified commands, and other agencies as directed by the Chief of Staff, USAF. The primary AWS mission is to support Air Force and Army combat operations in wartime. During peacetime, AWS prepares for this role by practicing special wartime support procedures and by providing or arranging daily weather support to its military customers. AFR 23-31 also defines certain related environmental and scientific support requirements to other DOD and U.S. Government agencies, foreign governments, or individuals. Collection, processing, and dissemination of atmospheric and space environmental data and weather modification are intrinsic to such support.

The Office of Management and Budget Circular A-62, 13 November 1963, divides meteorological services into two types--basic and specialized. Although involved in both services, AWS is more heavily oriented toward specialized services. The general functions involved in providing meteorological services include:

- o Observing weather conditions.
- o Communicating meteorological data and information.
- o Preparing analyses and forecasts.
- o Issuing and disseminating forecasts and warnings.
- o 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 under Space Environmental Forecasting Program below.

Surface observations are taken by AWS 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 the Air Force Global Weather Central (AFGWC) and to other military and civil locations throughout the world. In FY 1988, there are 174 AWS 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) and rocketsonde facilities operated by AWS. Additional upper air information from datavoid areas is obtained from in-flight pilot reports from both military and civil aircraft.

The Air Force performs aerial weather reconnaissance in support of national requirements in the Atlantic and Pacific oceans. Essential weather observations are obtained by specially instrumented weather reconnaissance aircraft from within tropical cyclones and over other data sparse areas of the world. Observations are taken at both the flight level of the aircraft and, by use of expendable weather sensing dropsondes, through a vertical slice of the atmosphere from the aircraft to the ocean below. Six WC-130 aircraft are provided by MAC's 23rd Air Force and four by the Air Force Reserve.

Weather radar is a principal source of information for making short term warnings of severe weather. AWS operates 90 fixed weather radar sets (19 at overseas locations) and six 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, thirteen of the AWS 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 the AFGWC and 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 military terminals located around the world.

The present DMSP satellite series (Block 5D-2) uses an Operational Line-scan 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 and is significantly better than earlier DMSP satellites. 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, and ice conditions.

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 Command (AFCC) 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 Automated Weather Network (AWN) is the backbone of military weather

communications. High-speed computers interconnected with 2400-4800 baud circuitry are used to deliver foreign and domestic weather data to designnated users. Weather intercept sites in key overseas areas obtain weather data from foreign weather broadcasts for AWN delivery to the AFGWC. The AWN also delivers these data to the Navy's Fleet Numerical Oceanography Center 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. The CONUS ADWS at Carswell AFB, TX, drives the CONUS Meteorological Data System (COMEDS) and special teletype systems within the CONUS, an integral part of the weather collection and dissemination function. COMEDS serves as the prime communications system for the collection and dissemination of military Notice to Airmen (NOTAM) message traffic to all DOD CONUS users.

The Weather Facsimile Switching Center (WFSC) at Offutt AFB, NE, is the hub of the facsimile system, providing graphic data to worldwide military users. WFSC drives the separate networks serving the CONUS, Europe, Central Amercia, 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 the AFGWC at Offutt AFB, NE. The AFGWC employs over 700 scientists and technicians (military and civilian) and uses eight computer systems. 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 decisionmaker. A significant improvement in the interaction between forecaster and machine was accomplished with the achievement on 28 May 1986, of Full Operational Capability (FOC) of the Satellite Data Handling System (SDHS) at AFGWC; SDHS consists of 35 interactive workstations capable of high-speed interaction with satellite and conventional meteorological data to prepare forecasts and other environmental products. Operational transition to SDHS is currently underway, with expected completion in December 1988. This transition will achieve the result of automating virtually all tasks currently 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, NMC's computational center for aviation wind forecasts, and NWS's National Severe Storms Forecast Center.

In support of tactical military operations, AWS operates centralized units consisting of AFGWC, USAF Environmental Technical Applications Center (USAFETAC), fixed theater Forecast Units (FUs), deployed Tactical Forecast Units (TFUs), and fixed Weather Support Units (WSUs). 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 which are for general purpose use by meteorologists who apply the information to specific areas or

missions. Theater Forecast Units 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 Tactical Forecast Unit provides the same services as a theater FU; however, it is activated and deployed to support a specific contingency, activity, or exercise which is not or cannot be supported by theater FUs. FU/TFU forecasts may be direct applications of AFGWC or theater FU products or may be refined based on information available locally at the FU/TFU. AFGWC directly supports deployed weather teams whenever the theater FU doesn't have support responsibilities, 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.

AWS contributes to the unique global needs of military aviation and makes its information available to civil aviation.AWS provides premission briefings, air/ground radio services, tailored observations, forecasts, and warnings for unique 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 AWS personnel serve as part of the working staff of supported Air Force and Army units. In this capacity, AWS 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 AWS 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 tactical 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 (AN/TPS-68), and tactical meteorological satellite direct readout terminals provide the means to acquire vital meteorological data within a theater. A high frequency radio broadcast system that will transmit alphanumeric and facsimile products to the theater weather support force is planned. This system will consist of a number of regional broadcast stations. Initial operation began at Clark AFB, PI, in 1985.

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 its parent organization (AFGWC), then sorts, checks, stores and employs these data to produce tailored products. USAFETAC also operates a facility collocated with the National Climatic 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 AWS supports an array of specialized requirements of the Air Force and Army. Some of these are described below.

AWS integrates Army weather support into its overall support concept. AWS personnel are trained and oriented on applicable Army organizations, concepts of operations, and weather sensitivities of Army operations and equipment. AWS 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 AWS. In a tactical environment, direct forecast support is normally provided down to corps, divisions, separate brigades, regiments, and groups. Observer support is normally provided at these levels and at brigade levels within the division.

AWS 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 the forecasting service for NASA's unmanned launches at the Kennedy Center. Recently, AWS established a staff weather office in the Headquarters, U. S. Space Command.

AWS 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° 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 to AFGWC, other U.S. Government agencies, and non-Government agencies such as universities.

Through the AFGWC, AWS directly supports DOD Special Strategic Programs, the National Command Authority, the National Military Command Sysem, and the National Security Agency. Tailored environmental support products are disseminated to these customers worldwide.

Planned Enhancements

USAF and Army operational requirements for environmental support are the basis for all AWS actions to improve existing or acquire new capabilities. AWS assesses these requirements and attempts to satisfy them through either hardware acquisitions or technique development.

AWS plans to modernize 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 budgeted for their R&D and procurement phases.

The AWDS will automate 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 will permit AWDS to be operated in a fixed or mobile environment and minimize staffing requirements. Initial installation is planned for mid-1989 with completion of overseas and tactical installations by 1992. AWDS will be able to receive information from the National Weather Service through the AFGWC via the AFOS at the AFGWC.

AWS plans to significantly enhance its tactical warfare weather support capability through employment of the Battlefield Weather Observation and Forecast System (BWOFS). BWOFS involves the development of two capabilities: one, called Tactical Decision Aids (TDA), to provide weather support for electro-optical target acquisition, weapons guidance, and reconnaissance systems, and the other, the Pre-Strike Surveillance/Reconnaissance System (PRESSURS), to acquire weather observations in uncontrolled or enemy controlled areas of the battlefield. TDA and automated algorithms are scheduled for initial fielding in tactical C2 computers by 1989; and, PRESSURS is scheduled for initial operation in 1993.

NEXRAD is being procured under the auspices of the NEXRAD Joint System Program Office. NEXRAD will be an automated, digitized, S-band Doppler system that will be jointly developed, procured, operated, and maintained by the DOD, NOAA, and FAA within the CONUS and by the USAF overseas. The system will be designed to incorporate 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. Installation of the NEXRAD is planned between 1989 and 1994.

Weather Reconnaissance is scheduled to have the Improved Weather Reconnaissance System (IWRS) operational in 1989. The IWRS prototype began test flights in 1985. The system, which will incorporate the new USAF inertial navigation system (INS) for improved positioning is being built as a joint NOAA and USAF project. IWRS will provide an automated data gathering capability, improved flight level wind determination, a windsounding capability, and satellite data relay from the reconnaissance aircraft. This greatly improved reconnaissance package will be capable of gathering and transmitting vastly increased quantities of data for use in computer prediction models.

A program of Preplanned Product Improvements (P3I) to the Satellite Data Handling System (SDHS) is currently underway at AFGWC, with scheduled completion by late FY 1989. This program will improve the reliability of the SDHS and add new capability such as the AWDS Product Driver to the Baseline SDHS.

The analysis and forecast preparation capability of the AFGWC has been enhanced by the implementation of the Advanced Weather Analysis and Prediction System (AWAPS). The AWAPS program hardware consists of a Class 6 computer for processing numerical models and two database computers to supply data to the Class 6 computer and to store and handle the increased resolution products from the Class 6 computer. The two Sperry 1100/70 database computers became operational in late 1984. The Cray X-MP Class 6 computer became operational during early 1985. Two new software models were implemented by the AWAPS. AWAPS software consists of the AFGWC developed High Resolution Analysis System (HIRAS), the Global Spectral Model (GSM) and the Relocatable Window Model. The latter two models were developed under contract by the National Meteorological Center (NMC). The three models will provide a significant increase in the accuracy and resolution of analyses and forecasts at the AFGWC. In June 1989, the Relocatable Window Model (RWM) will be implemented, joining the HIRAS and GSM models that became operational in 1985-1986.

An advanced solar proton prediction model was implemented by AFGWC during FY 1988. The new model has a number of significant improvements over the earlier versions of the model, which have been used for the past decade. The new version includes forecasts for "heavy ions" (atomic nuclei heavier than hydrogen), as well as improved algorithms for solar proton arrival time, magnitude, and time-intensity profiles. In addition, the new model can make predictions in 14 different energy ranges: 10 have been selected for satellite anomaly forecasting; two for predicting radiation dose expected for an astronaut inside or outside a polar-orbiting shuttle; and two channels to predict the amount of polar cap, high-frequency radio wave absorption.

The MARK IV B Tactical Terminal upgrade program, to begin in FY 1989, will upgrade the older logistically unsupportable terminals, add a capability to process microwave mission sensor data, and retrofit that new mission sensor capability into the mobile terminals. In January 1988, the Air Force awarded four competitive concept studies for Block 6, the follow-on to the Block 5D-2/5D-3 satellites. 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.

SPACE ENVIRONMENTAL SUPPORT SYSTEM

Many DOD systems operate in, or are affected by,conditions above 50 kilometers. The ionosphere, near-space, and deep-space are collectively referred to as the space environment. The AWS provides basic and specialized support to military electromagnetic communications, surveillance, and warning systems which operate in this environment. AWS provides environmental forecasting and specialized services in the major technical areas of:

(1) forecasting and specification of ionospheric variability, (2) state of the magnetosphere, (3) forecasting and specification of solar flare and solar particle events, and (4) providing geomagnetic and solar indices to users for determining upper atmospheric density variability. The 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 planning to move the space environmental support functions and manpower positions to Falcon AFS, CO, where they will be established as the Space Forecast Center.

Data Sources

USAF operates and funds for 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 four AN/FRR-95 solar radio telescopes; in Massachusetts, Hawaii, Australia, and Italy.

USAF operates, or funds for the operation of, numerous other geophysical sensors as shown in the following table:

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/ion temperature, and provide optical auroral pictures	Polar orbit
DOD Spacecraft	Measure high energy and low energy electron/protons	Geostationary orbit
Solar X-ray Imager (USAF funds for FY90; first available launch NET 1992)	Locate position of solar flares, measure solar x-rays	Geostationary orbit

The Solar X-ray Imager is a cooperative program with NOAA. The sensor will fly on a GOES-NEXT satellite and the data will be provided to the joint DOD/DOC center at Boulder, CO.

Data Provided

Space environmental support encompasses the present state and forecasts of 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, the actual work on exploitation of SOON data by applying advanced modeling techniques is being accomplished by the Air Force Geophysics Laboratory, Hanscom AFB, MA, and NOAA's Space Environment Laboratory (SEL) located at Boulder, CO.

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 has expanded its magnetospheric monitoring by using real-time low 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 and 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 upgrades will enhance AWS forecasts of solar proton events. AFGWC notifications of these events are usually provided within minutes of detection of a disturbance and are specifically tailored for each system operator.

SUPPORTING RESEARCH

The overall objective of the Air Force meteorological research program is the development of techniques and equipment 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, Research Objectives, Technology Needs, Statements of Operational Needs, and Development Goals. In addition, the Air Weather Service provides guidance in the form of documented geophysical requirements and research objectives. The Air Force Geophysics Laboratory (AFGL) 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 development in the environmental sciences, including meteorology. Its meteorology program in the area of exploratory development places emphasis on moisture and cloud numerical weather pre-

diction, ground-based and satellite remote sensing, climatological studies, boundary layer meteorology, cloud physics, and battlefield weather observation and forecasting. Research and development for the Defense Meteorological Satellite Program is also conducted, primarily under contract.

In the area of moisture and cloud forecasting, research is being pursued on global and mesoscales. The short-range (0-6 hr) advection model was upgraded with satellite input and is in the process of being upgraded with radar input. Research with a mesoscale cloud model is focusing on improved boundary conditions and accounting for local forcing. Global model cloud forecast errors were diagnosed, compared to AFGWC operational cloud forecasts, and new moisture-to-cloud algorithms are being developed. 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 will undergo testing and modification. The cloud scale model was tested in preparation for sensitivity studies. This model defines cloud development/dissipation effects. Forecaster effectiveness in an automated operational environment, such as the Automated Weather Distribution System (AWDS), will be evaluated using AFGL's Automated Interactive Meteorological System (AIMS). Also, an evaluation of the contribution of continuous wind measurements from a vertically pointing VHF radar to the numerical modeling and realtime monitoring of developing mesoscale weather systems is underway. An assessment of the utility of Artificial Intelligence/Expert Systems in short-range weather forecasting is being pursued. Support will increase in this area and additional funding will be used in a new effort called the Automated Meteorological Processing System (AMPS). AMPS will incorporate Artificial Intelligence (AI) and numerically-based approaches to the ingest and processing of copious amounts of data from emerging weather extraction systems. The long range goal of this entire effort is to transfer a revised Numerical Weather Prediction (NWP) model to AFGWC by FY 1989/1990.

In the ground-based remote sensing area, automated Doppler weather radar-based techniques are being developed for the detection of hurricane characteristics and severity, 4-D cloud and precipitation predictions, and hail-size estimation. There is an urgent need to incorporate these techniques into the joint DOD, DOC, and DOT Next Generation Weather Radar (NEXRAD), presently undergoing development. Coherent polarization diversity weather radar techniques to derive hydrometer characteristics, such as particle size distribution, orientation, and thermodynamic phase, will be tested. Also, instrumentation for combined weather radar and satellite imagery processing will be utilized for the automated estimation of cloud motion and for integrating these motions to map cloud and precipitation systems in three dimensions. Doppler weather radar techniques will be developed for the detection and assessment of clear air convection and convergence for the timely identification and forecast of regions conducive to thunderstorm initiation. A new task is underway to evaluate the potential of ground-based remote sensing techniques including a VHF Wind Profiler, a microwave Doppler weather radar, and a loransonde system to provide accurate and continuous vertical profiles of the horizontal winds in both clear and cloudy air and in all seasons of the year. This research directly supports the development of the Next Generation Weather Radar (NEXRAD) and is expected to remain constant.

In support of satellite meteorological requirements, improved inversion algorithms will be developed to compute more accurate vertical temperature and water vapor profiles from satellite-measured radiance data at far-infrared and microwave wavelengths. A versatile cloud-truth data field is being established. This data field is essential for the future evaluation of cloud algorithms using satellite observations. Algorithms for SSM/I microwave imagery data to map meteorological parameters such as rain rate, ocean surface wind speed, and soil moisture will be evaluated and improved. Also, techniques will be developed for incorporating microwave imagery data into the cloud analysis programs at the AF Global Weather Central. A moderate increase in support for this research is planned to develop the new analytical methods in satellite meteorology with the ultimate goal of more accurately depicting cloud characteristics i.e., cloud heights, cloud thickness, phase (ice/water) and rain areas. Additionally, a new task is underway to develop techniques based on satellite data to determine tropical storm location, intensity, and thermodynamic structure.

In climatological techniques 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 to include a mesoscale environmental simulation package to provide a realistic sequence of weather events at any specific 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 the specification of the probability for simultaneous cloud-free viewing from multiple sites under various cloud conditions is ongoing. The following climatological studies will be concluded, 1) rainrate duration modelling and, 2) analysis of high resolution cloud photographs taken from orbit used to quantify the distribution of cloud sizes, of clear intervals, and of the variation in apparent cloud cover as view angle changes. An increase in support for climatological studies is planned. These efforts will likely be applied to a problem now under investigation regarding reentry vehicles.

In boundary layer meteorology, work will continue on developing toxic chemical dispersion models for various scenarios. The toxic chemical dispersion model for smooth terrain and uniform wind fields (AFTOX) is now being reviewed by the Air Weather Service which is considering this model as a replacement to their current dispersion model. A heavy gas dispersion model has been developed and is available to DOD users. A user's manual for the terrain-induced surface wind flow model developed in FY 1986 will be written. Additional improvements and testing of the model over the next two years are anticipated. A complex terrain dispersion model, which is a combination of AFTOX and the wind flow model, will undergo further development and testing. The updated terrain dispersion model will be delivered to the AWS in FY 1989/ 1990. A small decrease in support has caused a delay in the delivery of the model.

The major thrust of the cloud physics program will emphasize the development of computerized mathematical models for forecasting the microphysical structure of clouds and cloud systems, given macroscopic statements about the nature of the atmosphere. Also, the extremely high frequency (EHF) data reduction and interpretation from the Division's Weather Attenuation Program will continue and the microphysics of the cloud model

will be tested against available data sets. The Weather Attenuation Program includes the simultaneous measurements of EHF attenuation and detailed microphysics of the clouds, rain and snow in the melting layer. The support in this research will change from meteorology observation to prediction with the long-term goal to develop the prediction capability for electro-optical attenuation, airframe icing, and missile targeting.

The battlefield weather program will emphasize the development of lowcost expendable instrumentation for measuring humidity, visibility at visible and infrared wavelengths, and the macroscopic characteristics of clouds and cloud systems (cloud cover amount, cloud tops and bases). A system capable of collecting weather information in battle areas not under friendly control is being fabricated and demonstrated at a test range. Operational Tactical Decision Aids (TDAs) are being developed for use on the Zenith computer system at all Air Weather Service base weather stations. TDAs for infrared, TV low-light-level and 1.06 um laser systems will be upgraded to include new targets, backgrounds, and systems, such as Night Vision Goggles used by our Special Operations Forces. Increased resources will be used to transition atmospheric research relating to cloud forecasting or cloud analysis to viable candidates and to prepare research products, that are ready for technology transition, for transition into the Improved Point Analysis Model (IPAM).

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.

DEPARTMENT OF INTERIOR

A principal meteorological activity of the Department of Interior (DOI) is the weather modification research program called Project Skywater, administered by the Bureau of Reclamation, dedicated to augmenting water resources in demonstration of a practical precipitation management technology. Other 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, also 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 two GOES direct readout ground stations (DRGS) in Denver, CO, and Boise, ID.

The Water Resources Division of the Geological Survey 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 1,800 GOES DCPs through four DRGS. 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 provides lead agency coordination for the atmospheric deposition monitoring program of the Interagency Task Force on Acid Precipitation.

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 Bureau of Land Management in DOI collects meteorological data from a system of remote automatic weather stations and operates a lightning detection system, containing wideband direction-finders that respond primarily to cloud-to-ground lightning, in its fire and resource management programs. This effort is fully integrated with the U.S. Forest Service

fire weather system. The Bureau of Land Management operates approximately 200 fire-weather DCPs and collects data from its own and another 200 Forest Service DCPs through a DRGS base at Boise, ID.

The Minerals Management Service Environmental Studies Program gathers offshore environmental data in support of its mineral leasing responsibilities. Currently, the Service supports approximately 20 data buoys which transmit via NOAA satellites.

The National Park Service monitors air quality in several national parks and monuments. Approximately 20 GOES DCPs are used to collect these data.

DEPARTMENT OF STATE

The Department of State interests in meteorology are general but touch a number of areas. They involve the international aspects of food and feeding the world, disaster warnings and assistance, long-range concern with the socio-economic effects of climate change, World Meteorological Organization 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 of storms in the Pacific.

DEPARTMENT OF TRANSPORTATION

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 information to pilots.

Weather information for pilots is made available through Flight Service Stations, recorded messages broadcast over navigational aids, special weather broadcasts, and telephone answering systems. 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. 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 and to 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. Facets of the program are conducted in close cooperation with the National Weather Service (NWS). Wherever practical, the objectives of this program are accomplished by enhancing existing and planned air traffic control and flight service station system components and facilities for the collection, processing, and dissemination of significant weather information.

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 en route applications. NEXRAD will provide accurate aviation-oriented products concerning reflectivity, wind velocity, and turbulence indicators based on software algorithms which take full advantage of the improved detection of these weather phenomena.

Radar weather presentations available from today's systems provide limited data for air traffic control (ATC). Improved weather data 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 FAA. The program is being managed by a Joint Special Projects Office 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 is scheduled to begin in 1989 and be completed in 1995. The number of NEXRAD units to be acquired is being determined by the participating agencies.

FAA is emphasizing the development of future algorithms that take advantage of the improved detection of precipitation, wind velocity, and turbulence, and 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, turbulence, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones-tornadoes. In FY 1989, research activity will concentrate on the development of icing, wind shear, and other aviation-related algorithms.

Terminal Next Generation Weather Radar (NEXRAD)

Initially, the FAA is diverting 17 of its non-network NEXRAD units to major airports where they will provide interim wind shear detection support until replaced by the Terminal Doppler Weather Radar (TDWR). These initial units will be identical to the NEXRAD hardware, but will utilize a different software package. Implementation of these units is scheduled for the 1990-1992 time frame. When replaced by the TDWR, the units will be relocated to their originally intended locations (principally in Alaska, Hawaii, and the Caribbean) where they will provide NEXRAD-type coverage for the National Airspace System.

Terminal Doppler Weather Radar (TDWR)

This program consists of the procurement and installation of a new terminal weather radar based on Doppler techniques. The TDWR will be optimized to detect microbursts and wind shear. In addition, it will produce weather products such as precipitation areas and intensity, wind, turbulence, thunderstorm location, and storm movement.

Microbursts are weather phenomenon that consist of an intense downdraft that may occur in clear air or in precipitation, and 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.

Trade studies that examined alternative designs, frequency comparisons, and other design considerations have been completed by the NEXRAD development con-tractors. These studies contributed to the specification of the TDWR. Algorithms are being developed by the Government. Data collected with the FAA transportable Doppler weather support facility (at Memphis, TN, Huntsville, AL, and Denver, CO) 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 evaluation of enhancements to the present algorithms and the development of new algorithms.

A competitive contract will be awarded late in FY 1988 for turnkey TDWR installations at sites specified by FAA. Field implementation will occur in the 1992 to 1996 timeframe.

Related FAA activities will provide algorithm enhancements to improve the detection and identification of dangerous wind shear and other hazards in the airport environment.

In FY 1989, research will continue on the enhancement of the microburst detection algorithm to provide an indication of where these phenomena are forming. This will provide advance warning of wind shear conditions. Also, work will be done on algorithms that will predict where thunderstorms will form.

Low Level Wind Shear Alert System (LLWAS)

LLWAS, also, provides pilots with information on hazardous wind conditions that create unsafe conditions for aircraft landings or departures. It is an ongoing program which, when completed, will provide 110 enhanced systems. The basic capability, to be completed at all 110 sites in 1988, 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.

LLWAS was initially conceived to be an interim system to be replaced when a better system matured. However, it now appears that the enhanced system may become an integral part of the terminal weather detection capability. Also, a combination of LLWAS/TDWR may result in a more effective capability, and will provide redundancy at high-threat/high-traffic airports.

Both near and long-term modifications lead to the implementation of the enhanced LLWAS. Near-term modifications consist of improving the algorithms associated with the 6-sensor basic capability systems, correcting sensor siting (including height), incorporating data recorders, and updating the computers. Field implementation of these modifications will be completed in FY 1988.

The long-term modifications include expanding the existing systems to 11 sensors, developing improved algorithms for the 11-sensor system, and installing new information/alert displays which enable controllers to provide pilots with runway specific, headwind gain or loss estimates. These

improvements will increase the system's wind shear detection capability, reduce false alarms and enhance maintenance features. Implementation is planned to begin in FY 1988 and is estimated to be completed in 1992.

In the future, LLWAS and TDWR will probably work in conjunction to provide wind shear detection and alarm. Studies will be conducted on how these systems can be combined into an integrated capability based on a single wind shear display for the air traffic controller, and on how integrated wind shear information can best be communicated 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

This includes the activities of the FAA in acquiring automated surface weather observing systems; acquiring related data acquisition systems; and development, test, and evaluation of weather sensors.

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 a need to implement as soon as possible Automated Weather Observing Systems (AWOS) at 160 airports to provide the basic aviation weather products directly to pilots approaching the airport. The majority of these systems would be installed at various nontowered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that currently do not have a local weather reporting capability. Some of these systems will be used to support an Air Traffic operational evaluation at former flight service locations that currently employ contract weather observers. The FAA plans to acquire these systems via a competitive invitation for bid based upon the specification established to qualify candidates AWOS systems for procurement by state and local governments. These systems, which are built to the standards of quality necessary to ensure the safety of flight operations, are believed to be available off-the-shelf as a commercial product.

The FAA has asked NOAA to procure, install, operate, and maintain ASOS systems at the remaining airports where FAA personnel take observations and at nontowered airports with instrument approaches.

Automated Weather Observing Systems (AWOS) for Non-Federal Applications. The majority of airports within the National Airspace System (NAS) do not have a local weather reporting capability. For example, operations for commercial operators under instrument flight rules are restricted at over 1,300 airports because of the unavailability of weather observations.

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 dollar 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 necessary to maintain the system. 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 three versions of the non-Federal AWOS. The AWOS I system contains sensors to measure wind data (speed and direction), ambient and dewpoint 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. 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 from the AWOS. This AWOS may also have the capability that enables the pilot (or other user) to call the AWOS on a telephone and obtain the current weather observation during his pre-flight activities. In addition, the observation may be transmitted to the data bank 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 automated surface observation equipment located at controlled and non-controlled airports within each air traffic control center's area of responsibility. It will distribute minute-by-minute AWOS/ASOS data within the center in which it is installed, and provide for national distribution of AWOS hourly and special observations through FAA's Weather Message Switching Center Replacement (WMSCR) facilities. This will make weather observation data available to pilots and air traffic controllers on a timely basis within the "local" area, and provide necessary distribution of the data to NWS, and other users.

The acquisition of ADAS will be accomplished via prototype and production. Field implementation is planned to start in 1991 and be completed in 1993.

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 observa-tions to 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. Sensor technologies being investigated include: 1) laser and infrared forward scatter and back scatter meters for visibility; 2) cloud height indicators for measure-ments above 5,000 feet; 3) laser-based detectors that can discriminate between hydrometers (rain, freezing rain, hail, snow, etc.) and lithometeors (dust, smoke, haze, etc.) and can measure any associated precipitation rates; 4) lightning detection systems;

and 5) evolving technologies for the detection and measurement of icing and clear air turbulence. Algorithms which utilize the measurements of several different types of sensors will be investigated to identify existing weather conditions.

In FY 1989, work will be conducted to refine precipitation-discrimination sensors. Lightning detection network data will be integrated into the automated surface observation systems to provide advisories on lightning activity in the vicinity of the airport directly to the pilot via an appropriate communications outlet.

Flight Service Station Automation System (FSAS)

This program will improve user access to weather and Notice to Airmen (NOTAM) information, simplify flight plan filing, and provide a flight service station automation system that will meet the projected increases in demand for flight services without proportional increases in staff. Automation is being developed and 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. Today there are 37 Automated Flight Service Stations and 13 Flight Service Data Processing Systems (FSDPS's) operating with Model 1. In addition to the 37 Model 1 AFSS's, there are eight AFSS's operating with the American Satellite Leased Service A & B System (LABS). Sixteen more AFSS's will be commissioned with LABS, for a total of 61 AFSS's. All of these facilities will be converted to Model 1 Full Capacity (M1FC). The first operational M1FC systems will be delivered in February 1990 and the last system will be delivered in January of 1993. M1FC will provide sufficient hardware and software to drive all of the terminals in the 61 AFSS's.

Direct Users Access Terminal (DUAT) system will become operational in May 1989. Pilot users will be able to access pilot briefing data and file their IFR and/or VFR flight plans from their home or office personal computer. FAA anticipates three national vendors providing DUAT service at no cost to the pilot.

Graphics Weather Displays Systems (GWDS) in the AFSS's consists 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 sole FAA gateway to the National Meteorological Center and, therefore, will be the source of NWS products for the National Airspace System.

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 will be implemented in the field in 1992.

Weather Communications Processor (WCP)

WCP will implement data link services to aircraft utilizing the discreetly addressed data link capability of the FAA's Mode S surveillance system. It will receive downlink 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.

Central Weather Processor (CWP)

CWP will improve the dissemination of weather information throughout the National Airspace System 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 which will greatly enhance their ability to summarize hazardous weather information and ensure that the latest and best information is dissemi-nated to all users. CWP will also provide for a near-real-time, area mosaic of weather radars (NEXRAD) for subsequent distribution to controller displays. These improvements are necessary to reduce the high percentage of accidents and delays directly related to weather.

The CWP is composed of two elements. The first is a commerically-available Meteorological Weather Processor (MWP) capability 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.

Initial MWP services will be available in 1990. 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 Advanced Weather Interactive Processing System of the 1990's 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

A new FAA project supports the development of the Central Weather Processor through the definition and design of new interfaces and products associated with the operation of the CWP.

The Working Group/AWIS, under direction of the Program Council within the Office of the Federal Coordinator, has developed a National Plan which integrates requirements, development, and implementation activities associated with AWIS programs and projects of the Department of Commerce, the Department of Defense and the Department of 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. Subjects being addressed include the use of FAA-generated NEXRAD mosaics by the planned NWS Warning and Forecast Offices (WFO), and the communication of these mosaic products via the planned NOAAPORT satellite system for use by FAA flight service facilities.

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.

Development also will be accomplished to support the utilization by CWP of new sensors/products such as GOES-NEXT, lightning detection networks, and the planned vertical Profiler network. 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 Traffic Management Processor to support the weather-information requirements of the Central Flow Control Facility, which is responsible for national flow control between the major air traffic hubs. Also, an interface with the CWP will be developed to provide NEXRAD mosaics for communication to the pilot, and receive Pilot Weather Reports from aircraft in flight.

Centralized Weather Information Processing

This is a new project to 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 5-year 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 continues to be on full-scale simulation tests of candidate system configurations of sensors, flight controls and cockpit displays that were established in the initial year of activity.

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 both the commercial and private vessels. Certain shore stations maintain visual displays authorized by the NWS to provide weather warnings to boaters.

U.S. Coast Guard Marine Science Technicians receive basic training in meteorology as part of their general scientific background.

The Coast Guard supplies a staff of up to 15 personnel to the NDBC (costs reimbursed by NDBC 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 Operations in Coast Guard Headquarters. Field management of meteorological activities is a collateral function of the Coast Guard area and district staffs.

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

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for working with state and local government agencies to ensure adequate air quality meteorological support programs. Applied research and meteorological support to EPA is provided by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC. Such meteorological support to the Office of Air and Radiation, the EPA Regional Offices, and other EPA components include: review of the meteorological aspects of environmental impact statements, state implementation plans, development and application of air quality dispersion models, and preparation of dispersion studies and evaluations.

EPA applied research is in such areas as: air quality dispersion model development; the evaluation, development and application of air pollution climatology; determination and description of pollutant effects on atmospheric parameters; and determination of meteorological effects on air quality. Dispersion models for inert and reactive pollutants are under development and evaluation on all temporal and spatial scales; e.g., urban, mesoscale, and regional. Particular emphasis is being given to the development of dispersion models for inhalable particulate matter and photochemical pollutants on several spatial scales utilizing data collected during earlier field programs. The data obtained from field programs initiated earlier will be used to develop and evaluate models in the FY 1988-89 period. Examination of the relationship between meteorology and air quality continues with emphasis on ozone, sulfates, acid deposition, particulate matter, and toxic air pollutants. Also specialized studies will be initiated to support stratospheric ozone and global climate change research.

FEDERAL EMERGENCY MANAGEMENT AGENCY

The Federal Emergency Management Agency (FEMA) was established in 1979, to merge closely allied Federal programs involved with preparedness, mitigation, response, and recovery to national emergencies ranging from natural and man-made hazards to nuclear attack. FEMA replaced five former agencies, consolidating into a single organization a dozen different Federal emergency-related activities, including such functions as community

awareness for meteorological emergencies and coordination of all emergency warnings.

One example of a FEMA activity that is directly related to meteorology is the hurricane preparedness program which funds local vulnerability and evacuation studies. Additional meteorologically related programs, within the Office of Natural and Technological Hazards, deal with flooding, dam safety, atmospheric releases of hazardous and radiological materials, and other meteorological hazards. Although FEMA has only one full-time meteorologist, the agency has called upon the Department of Commerce and other agencies for support during times of emergencies.

Within FEMA, the Office of Research serves as principal point of contact for technological studies and coordination. No specifically meteorological studies are funded in FY 1989, but a close watch is kept on selected programs of other agencies, including the Department of Defense.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OPERATIONS

The National Aeronautics and Space Administration (NASA) Headquarters Weather Support Program through its Weather Working Group has substantially improved weather support and operations capabilities from ignition to touchdown of the Space Shuttle, as will as other programs. Improved weather information includes better communication, integrated data management systems and displays, automated network of data gathering stations/systems and improved forecasting techniques and methods.

The NASA Weather Working Group has recommended changes which will improve its ability to know and predict the weather, and with extra assurance and safety, will be able to set more precise launch, landing, and operation criteria. To carry out this plan, NASA is in the process of organizing an office under the Office of Space Flight to oversee the requirements, services, operations, etc. of all weather activities for NASA Centers.

NASA plans to install and upgrade sensors for prediction and movement of lightning. This includes the installation of a lightning detection system at Wallops Island (WI) and improvement to the Field Mill Array at Kennedy Space Center (KSC).

NASA plans to deploy surface data buoys offshore of KSC to provide needed observations on water near the launch and landing sites.

NASA plans to improve its meteorological system moderization program to reduce space vehicle vulnerability to weather interruptions during ground processing and launch operations.

NASA has, in the past year, provided forecasters a much improved system for handling weather data. This Meteorological Interactive Data Display System (MIDDS) is now operating in its initial configuration. Completion of

this system should be within the next two years. This system allows remote and local access to a wide range of data from satellites and conventional observations, time lapse displays of imagery data, overlaid graphic, current and past meteorological data, etc. NASA's major objective of these systems is to provide a means of integrating all weather data and assisting the forecasters in their briefings and predictions responsibilities through integrated data base management and displays. These systems will reduce the time required to evaluate weather situations and increase the forecasters confidence in their decisions for launches, landings, and operations of the Space Shuttle, as well as operational redundancy and safety.

NASA plans to install a Wind Profiler at Kennedy Space Center to monitor the variation of the winds and also, to be used to monitor wind persistence during launch and landing sequence.

None of the improvements discussed above should be construed as a departure from NASA operational principle. These improvements will be structured to strengthen this approach and enhance information and communication to the decision makers, astronaut observers, and management posture for the Space Shuttle launches, landings and operations.

SUPPORTING RESEARCH

The National Aeronautics and Space Administration (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. Satellite sensors can and do provide not only global coverage, but obtain repetitive observations of limited areas more cost-effectively than by any other means. Space observations can and do provide information essential to advancing our knowledge of atmospheric processes.

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, 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.

- o Development of models to exploit the spatial densities and temporal frequencies inherent in satellite data to initialize and verify models and assess their value.

- o Development of parameterization schemes which serve as the basis for the use of space observations in atmospheric models of all scales.

- o Assessment of the performance of satellite sensors through numerical experiments which compare model output with and without satellite data.

In studying mesoscale phenomena, NASA uses geosynchronous satellite data (especially NASA-developed temperature soundings), aircraft instrumentation (e.g., Doppler lidar wind measurements), and ground-based techniques in addition to conventional observations to obtain data that will improve our understanding of the processes involved in the generation propagation and decay of severe weather phenomena. Models are being developed to use the quantitative information provided by these remote sensors.

NASA has been assigned lead responsibility for the National Climate Program principal thrust in solar and earth radiation. The earth's radiation budget, which is the central element of this research, describes the energy balance which exists between the sun, earth, and space. It is the geographical and temporal imbalance in this key relationship which governs the state and changes of regional climate. Earth radiation budget data acquired by Nimbus research satellites, beginning in 1976, are currently being processed and merged into a global climate data set, and are being augmented with data from the Earth Radiation Budget Experiment (ERBE) since 1984. Monitoring of the solar irradiance is also being accomplished by sensors aboard Nimbus-7 and the Solar Maximum Mission (SMM). The total solar irradiance (often referred to as the solar constant) is the basic source of energy for driving the climate system. Climate model studies have shown that persistent variability in this quantity could have a major impact on climate.

As part of its climate research activity, NASA is participating in the World Meteorological Organization-sponsored International Satellite Cloud Climatology Project (ISCCP) which began in July 1983. Both geosynchronous and low orbiting satellites are collecting a five-year data set for analysis and use in earth radiation budget studies. The cloud climatology, when developed, will be the most complete ever assembled. In addition, NASA has participated in the development of a plan for a field experiment to gather information needed to interpret the ISCCP data in detail. The regional experiment, the First ISCCP Regional Experiment (FIRE) was carried out in 1986. In support of FIRE, NASA has established a national project office at the Langley Research Center. NASA continues to supply NOAA with the TIROS-N and GOES series spacecraft (funded by NOAA) for operational meteorological deployment.

The data set gathered during the GARP Global Weather Experiment continues to serve as the basis for analyses under NASA research proposals. Emphasis is placed on observations obtained from space with the interpretation and application of these data to the development of advanced techniques for modeling and prediction. Nearly one hundred investigations,

by both NASA scientists and those from the external scientific community, involve the analysis, diagnosis, modeling, and evaluation studies using these 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 the ocean and the atmosphere.

Development of the Upper Atmosphere Research Satellite (UARS) is progressing. The UARS will address the coupling of chemical, radiative, and dynamic processes in the stratosphere and the mesosphere. NASA's Scatterometer (NSCAT), which continues in development, will measure surface wind velocity over the oceans with high accuracy.

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 and evaluation 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 1989 and beyond. Paleoclimatic reconstruction and climatic change models for high-level radioactive waste repositories will continue to be evaluated. Meteorological criteria for siting low-level radioactive waste repositories continue to be evaluated, including meteorological monitoring at these facilities. 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. Updated guidance on meteorological measurement programs and high winds and tornadoes is under development. The NRC is also concerned with the dispersion of toxic and explosive nonradioactive substances and their potential effects on the safe operation of nuclear facilities.

APPENDIX B

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), including the Global Atmospheric Research Program (GARP). 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, this section on the WWP has been included and has obviated the need for a separate report. Included at the end of this section are bilateral and regional international cooperative activities not under the WWP. While not exhaustive, most government programs are included. This section 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 is barely adequate over 20 percent of the earth while the remaining 80 percent, mostly over the oceans, remains 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 152 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. WMO and the ICSU clearly recognized the need for intensified research concerned with the

physical processes governing atmospheric motion and their formulation in mathematical models. To meet this need, the WMO and ICSU established the Global Atmospheric Research Program (GARP).

In addition to WWW and GARP, DOC through the National Oceanic and Atmospheric Administration (NOAA) is involved in two other major cooperative international programs. These are the Sahel Agrometeorological and Hydrological Program and the Bangladesh Disaster Alert/Agro-Climatic/ Environmental Monitoring Project. Funds for NOAA's participation and support of these programs are provided by the Department of State (DOS) Agency for International Development (AID).

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

Department of Commerce: Represents the U. S. at WMO and ICSU 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: 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: Stimulates and supports basic research by nongovernment 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: 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: Through the U. S. Coast Guard, provides personnel to support the 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 interface with NOAA's National Weather Service.

National Aeronautics and Space Administration: 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 operational elements that are closely linked and interdependent: Global Observing System (GOS), Global Data Processing System (GDPS), and Global Telecommunication System (GTS).

These elements are supported by the Monitoring and Operational Information Service which provides up-to-date information on the status of the WWW. Additionally, the WWW Implementation Support Activity arranges for the exchange of knowledge and methodology, and assists Members in the planning, design, establishment, and operation of WWW facilities and services.

Global Observing System (GOS)

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

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

Other elements are:

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

The space-based subsystem (satellite) has become increasingly important in supporting meteorological and hydrological predictions and warnings. The types of satellites which constitute the space-based subsystem and their functions are described below.

Meteorological satellites are divided into two groups, those in near-polar orbits and those in geostationary orbits. Those in near-polar orbits at low altitude (less than 1000km) provide global coverage (twice a day for each satellite) and customarily are used for precise radiance measurements needed for temperature and water vapor surroundings, sea surface temperature and radiation fluxes. Those in goestationary orbit (36,000 km above the equator) provide a continuous view of a large portion of the earth (except the polar areas). They are used primarily for a "continuous weather watch,"to produce wind estimates by measuring the motion of clouds viewed over a period of one to two hours, to monitor mesoscale cloud growth and for communications functions.

The present operational meteorological satellites in near-polar orbit are the METEOR-2 series of the Union of Soviet Socialists Republics and the NOAA series of the United States of America (USA). The operational geostationary satellites at present include the Geostationary Meteorological Satellite (GMS) series of Japan at 140°E, The Geostationary Operational Environment Satellites (GOES) of the USA at 75°W and 135°W, the Indian National Satellite (INSAT) at 74°E, and the METEOSAT series of Europe at 0°.

The different capabilities of the two satellite groups complement each other and are necessary parts of the spaced-based subsystem of the GOS. Although the polar satellite data usually have higher resolution and precision, the geostationary satellite data often are used to filter out the effect of ambient clouds which in some areas may obscure surface features, such as the sea surface for temperature determination. By processing a series of images acquired over a period of several hours, moving clouds in partly cloudy region scan be eliminated by digital filtering in a computer. The output is a single averaged image field of the surface without cloud interference. As well as taking observations directly, both types are capable of accomplishing data collection and data dissemination missions.

Besides taking observations directly, both types of satellites have a ground segment. This is composed of receiving and processing stations for satellite signals and data from Data Collections Platforms (DCPs). The ground segment also provides information and products for further distribution by 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 have been under constant review with an eye towards improving the GOS, GDPS and GTS. WMO identified a specific effort entitled the Integrated Systems Study (ISS) as one of the major activities of the World Weather Watch. The basic purpose of the ISS was to develop plans which would ensure a more complete implementation of the WWW plan. Results or recommendations of the ISS have been completed and are being incorporated into the WWW Plan for the next four years. Thus, the study has provided a realistic long-term plan for use by WMO Members in developing their national programs for future improvements of the WWW.

During 1984, progress was made in identifying the specific technological improvements that are possible for the late 1980's and early 1990's. Most significant was the identification of the ASDAR (Aircraft to Satellite Data Relay), ASAP (Automated Shipboard Aerological System), and drifting buoy systems as important contributors to improving the GOS in that time frame. Currently 13 ASDAR systems are in the process of being constructed for deployment on routes in the Atlantic, Pacific, and in selected locations of the Southern Hemisphere. A number of nations including the U. S. are in the process of planning or implementing test networks of ground-based doppler radars called profilers to provide soundings of wind on a continuous basis. If successful they may well prove to be important in forecasting small scale meteorological events. The concept of the Operational World Weather Watch Systems Evaluation (OWSE) has also been developed as a framework for regional implementation and evaluation plans have been developed and approved. The OWSE North Atlantic

was started in January 1987 and is expected to continue through the end of 1988. Data have been gathered and reports on the quality and reliability of information have been produced. Data impact studies have been planned.

The U. S. has agreed to undertake the development of a plan and evaluation of the feasibility of satellite sounding improvement techniques through the use of baseline upper air rawinsonde, rocketsonde and ASAP observing systems. The intention is to evaluate the quality of soundings calibrated during direct satellite overflight. If a better satellite sounding develops from this technique, then a global system will be implemented operationally through the WMO. The data gathering phase runs from January 15 through July 15, 1988 and the results are expected before the end of 1988.

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, employing suitable transmission techniques through the GTS, have real-time access to GDPS products which allow the Members to benefit from their participation in the WWW. Access to information in the non-real-time mode allow an exchange of delayed information for the Members to meet their requirements for observational and processed information.

The GDPS is organized as a three-level system. It consists of World Meteorological Centers (WMCs) and Regional Meteorological Centers (RMCs) at the global and regional levels, respectively, and the 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, analysis and prognosis, including derivation of appropriate meteorological parameters. The non-real-time functions include data collection and archival, 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. Melbourne specializes in forecast products for the Southern Hemisphere.

The RMCs 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, USSR; Lagos, Nigeria; Melbourne, Australia; Miami, USA; Montreal, Canada; Moscow, USSR; Nairobi, Kenya; New Delhi, India; Norrkoping, Sweden; Novosibirsk, USSR; Offenbach, Germany; Rome, Italy; Tashkent, USSR; Tokyo, Japan; Tunis, Tunisia; and Wellington, New Zealand. These centers provide regional products used for short and medium-range forecasting of small, meso and large-scale meteorological systems by WMCs. Products of RMCs can be used by Members at the national level for further processing or interpretation to provide assistance or service to users. The European Center for Medium Range Weather Forecasting (ECMWF) also prepares daily forecasts for its members for the 4-10 day

range, and a limited number of its short range products are also available to the WWW.

Further progress toward implementation of the World Area Forecast System (WAFS) was made during 1987. In this system, two centers (Washington and London) designated by the International Civil Aviation Organization (ICAO) as world area forecast centers (WAFC's) issue upper wind and temperature forecasts of up to global coverage to associated regional area forecast centers (RAFC's). The plan has been for this information to be redistributed as required within each regional center's service area.
The regional centers also prepare and similarly distribute forecasts of weather elements defined by ICAO as significant weather. Washington and London WAFC's have both been implemented since 1984. These two centers, also designated by ICAO as RAFC's, have also functioned as RAFC's since 1984. RAFC's associated with WAFC Washington include Brasilia, Buenos Aires, Tokyo, Wellington, Melbourne, and New Delhi. Of these RAFC's four- Tokyo, Wellington, Melbourne, and Washington - are considered to be implemented. The remaining three have continued efforts toward implementation; the degree of success, however is not known. RAFC's associated with London WAFC include London, Paris, Frankfurt, Moscow, Nairobi, Cairo, Los Palmas and Dakar. The first three are known to be implemented while the remaining five are in some stage of implentation.

The preceding paragraph deals with efforts towards implementation of the interim phase of the WAFS. However, it appears the final phase may overtake the interim phase implementation. In the final phase, as planned, the two world centers would prepare and issue computer based global wind and temperature forecasts already being issued by those centers. The regional function would be phased out. Satellite communication was expected to be a key ingredient in the forecasts distribution.

Based on the results of a recent meeting (November 2-4, 1987), it appears quite possible that the capability of the two world centers to produce the required global forecasts by computer, using some manual interaction, may be realized in the early 1990's.

Global Telecommunication System (GTS)

The GTS was established to provide communication services for the collec-tion, exchange and distribution of observational data and processed information from the WMCs and RMCs 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:

a. The Main Telecommunication Network (MTN);
b. The Regional Meteorological Telecommunication Networks (RMTN);
c. The National Meteorological Telecommunication Networks (NMTN).

The GTS is supported by telecommunication functions of the WMCs, Regional Telecommunications Hubs (RTHs), RMCs, and NMCs.

The MTN links the WMCs at Melbourne, Moscow, and Washington with the RTHs at Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Nairobi, New Delhi, Offenbach, Paris, Prague, Sofia, Tokyo, and Jeddah. The MTN provides a communication facility between the WMCs and designated RTHs. It ensures the rapid and reliable exchange of observational data and processed information required by the Members. During 1985, further progress was made in upgrading the speed of some of the MTN.

The RMTNs consist of an integrated system of links which interconnects RTHs, NMCs, and RMCs 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 1988 include:

- o Implementation of major improvements in automating RTH's (Brasilia, Buenos Aires, Beijing).
- o Improvement of the capacity of MTN links by inclusion of graphics (Washington-Tokyo-Melbourne).
- o Implementation of upgraded regional networks.
- o Continued support for the aircraft to satellite data relay system which will provide important observational data from selected aircraft operating in the tropics and over data-sparse areas.
- o Implementation of data collection platforms to enhance the collection of meteorological data from upper air and surface observing sites.
- o 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, this program 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 43 countries. Long-term fellowships, through which the students

receive baccalaureate or Masters degrees, have been completed by candidates from 38 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 within range of satellite Automatic Picture Transmission (APT) stations so that the countries may benefit more fully from satellite weather data.

The U. S. has contributed annually $1.5 million to VCP from 1969 through 1976, $2.0 million annually from 1977 to 1979, and $2.3 million annually from 1980 through 1984. In 1985 the U. S. contribution was reduced to $2.0 million and further reduced in 1986 to $1.89 million. The 1987 contribution was raised to $2.0 million. The expected contributions for 1988 and 1989 are $2.0 million and $2.2 million respectively. Other nations have contributed approximately $2.0 million annually. Contributions have been in three categories: equipment and services (80 percent), financial contributions (about 10 percent), education and training (about 10 percent).

In preparation for the First GARP Global Experiment (FGGE), conducted from December 1978 through November 1979, the United States, under the VCP, offered assistance to some developing countries of Africa, Asia, Southwest Pacific, and Central and South America. This offer of support included 15 wind finding radars for obtaining observations of upper-level winds, and 24 Automatic Picture Transmission (APT) Systems that permit direct readout of satellite weather data used in operational forecasting and severe weather warning.

To assist developing nations improve the quality and reliability of their weather observing and communications programs, the United States, through WMO-VCP, provides technicians to nations in Central and South America to assist in installation and maintenance of observing and telecommunications equipment. VCP also provides short-term training programs for foreign nationals at the National Weather Service's (NWS) training facility in Kansas City, and long-term fellowships for more advanced training in meteorology leading to the Bachelor of Science degree at U. S. universities.

Planned VCP activities for FY 1988 include:

- Replacement and/or implementation of APT/WEFAX satellite receiving systems mainly throughout the Caribbean, Central and South America to enhance local warning capabilities.

- 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.

GLOBAL ATMOSPHERIC RESEARCH PROGRAM (GARP)

The goals of GARP are: 1) to improve the time, range, and accuracy of weather forecasts for periods of one day to several weeks; and 2) to obtain a better understanding of the physical basis for climate. The goals are to be met by conducting regional and global experiments to acquire relevant data; to process and analyze those data; and to develop physical-mathematical models in order to understand the large-scale physical processes in the troposphere and stratosphere that control weather and climate. The second goal of GARP has been separately developed into a program called the World Climate Research Program (WCRP). U.S. activities related to the WCRP are contained in the "National Climate Program-5 Year Plan" prepared by the National Climate Program Office.

Base Program

GARP is an international effort under the cognizance of the United Nations' WMO and the ICSU. As stated earlier, the Department of Commerce (DOC) is the lead agency in coordinating the U. S. participation in the WWP, including GARP. Subsequently, the National Climate Program (NCP) Act of 1978, P.L. 95-367, assigned lead responsibilities to the DOC for the NCP which includes national and international activities organized under the World Climate Research Program (WCRP). Like GARP, the lead agency for coordinating and implementing the U. S. participation in the WCRP is NOAA.

Within the GARP there have been two types of observational experiments: (1) regional experiments which acquire data necessary to understand smaller scales of motion and their impact on the large-scale global circulation, and (2) a global experiment called the First GARP Global Experiment (FGGE), to understand global motions and circulation which determine the changes in weather over periods longer than a few days. FGGE is also referred to as the Global Weather Experiment (GWE).

On January 1, 1980, a new agreement between the WMO and the ICSU was implemented which established a World Climate Research Program (WCRP) as part of the World Climate Program (WCP). This program will build directly upon FGGE through extensive use of the FGGE data sets and through activities which are applicable to both FGGE and WCRP.

The economic gains to be realized from successful long-range weather and climate predictions will be substantial. Some of the activities that will benefit are:

- Agriculture: Increased production of food and fibers; avoidance of unnecessary reseeding; fertilizing and spraying operations; improved timing of hay, grain and fruit harvests.

- Construction: Efficient scheduling of the work force; protection of materials and equipment at construction sites.

- Water Management and Conservation: Advance warning and, where possible, avoidance of flood damage; better scheduling for navigation, irrigation and hydropower generation; better use of

public and rural water supply; and improved agricultural and industrial planning.

- o Public Utilities (Electric and Gas): Improved energy efficiency through more accurate prediction of demands; and more efficient methods of facility repair, maintenance and replacement, and switchover.

- o Transportation: More efficient routing and scheduling of air, highway, and water traffic; and decreased spoilage of perishable commodities in transit at terminals.

- o Public Interest: More adequate planning to protect health and property; and better scheduling of activities, including recreation and vacations.

GARP Projects and Activities

GARP Atlantic Tropical Experiment (GATE). This was a major regional experiment of the GARP. This program was undertaken to understand the effects of tropical weather systems on large-scale circulations and to improve numerical modeling and prediction methods. Many GATE research projects have been successfully completed with NOAA and National Science Foundation (NSF) funding.

First GARP Global Experiment (FGGE). Held in 1979, FGGE was a year-long international effort to observe the earth's atmosphere in greater detail than ever before. It is not likely that an observing program of this magnitude will be held again in the foreseeable future. The formal international observing period covered a complete annual cycle and included detailed observations within the summer and winter monsoon regions of Asia under a FGGE subprogram called the Monsoon Experiment (MONEX). The formal observing period was preceded by a buildup period during which the satellites of several nations and various specialized observing systems were launched and tested as were various data processing systems and models.

FGGE is now in the research phase. With the FGGE data, it is possible to see how well existing global dynamic models of the earth's atmosphere simulate large-scale atmospheric conditions. This is a necessary step in addressing the problem of climatic change.

The four basic objectives of FGGE are: (1) to improve our understanding of atmospheric dynamics and the general circulation of the atmosphere, and hence improve our ability to model those mechanisms responsible for the circulation; (2) to determine the theoretical and practical limits of atmospheric predictability; (3) to design an optimal, affordable observing system for the future; and (4) to improve models of climate change by fully and accurately simulating the annual cycle as observed over FGGE's Operational Year.

Major FGGE data management and archiving activities have been completed. NOAA, NASA and NSF supported a comprehensive research program based on FGGE data which continues in FY 1988.

Alpine Experiment (ALPEX). The last field experiment for GARP was the Alpine Experiment (ALPEX), an element of the GARP mountain subprogram. The key scientific objectives of this experiment for the U. S. are to determine the large scale effects of mountains on the atmosphere, the formation and dissipation processes of mountain winds, and the physical processes involved with the formation of cyclones on the downwind side of the mountain ranges.

The field phase of ALPEX was completed in the Spring of 1982. The ALPEX final data set was completed in 1985. The research phase will be supported through FY 1988.

The funding of the World Weather Program by U. S. agencies is shown in Table 5.1. Planned GARP activities for FY 1988-89 include:

- o NSF will continue to support research using MONEX, FGGE and ALPEX field data through FY 1988.
- o NOAA will continue to support research using FGGE data.

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Table B.1 Funding of World Weather Program*
(Millions of Dollars)

U. S. Agency	Program	FY 1987 Actual	FY 1988 Approved	FY 1989 Requested
DOC	GARP	1.10	1.05	0.20
NASA	GARP	0.30	0.25	0.25
NSF	GARP	2.50	2.00	-0-
DOS	WWW/VCP	2.00	2.00	2.20
	TOTAL	5.90	5.30	2.65

*These funds are for "direct" support only. They do not include funds for agency programs that indirectly support the World Weather Program.

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BILATERAL AND REGIONAL INTERNATIONAL COOPERATIVE PROGRAMS

Bangladesh Disaster Alert/Agro-Climatic/Environmental Monitoring Program

After a particularly severe typhoon caused hundreds of thousands of fatalities in the mid-1970s, the U. S. Agency for International Development (AID), responding to an urgent request from the Bangladesh Government, established the Interim Cyclone Warning System in 1978. This system primarily uses data from weather satellites. NOAA and NASA provided installation of a ground station and training to operate and maintain the system. The Bangladesh Government was able, for the first time, to track typhoons in the Bay of Bengal and to issue timely warnings of storms hitting populated areas.

The project was so successful and well managed by the Bangladesh Government that AID decided to upgrade the Bangladesh handling of satellite

information. NASA and NOAA were commissioned to install high-resolution picture receiving equipment and to train Bangladesh technicians to operate and maintain the equipment. This was handled under the Bangladesh Disaster Alert Project. The equipment enables Bangladesh technicians to track and forecast tropical disturbances as well as to improve river and coastal flood detection and forecasting. This project was completed in 1982.

As an outgrowth of the Disaster Alert Project, a very ambitious project was adopted by the Bangladesh Government, AID, NOAA and NASA--the Agro-Climatic/Environmental Monitoring Project (ACEMP) for Bangladesh. It consists of a highly sophisticated system of data processors, remote sensing data collection platforms (DCPs), and a research facility that will enable Bangladesh to become a main remote-sensing center in Southeast Asia. Data from LANDSAT and meteorological satellites as well as hydrological and meteorological data from DCPs now enables the Bangladesh Government to improve the management of its natural resources. This project permits the preparation of a land use map and aids the development of an in-country resource management information system. The project allows estimation of acreage in agricultural production and yields of principal crops; completion of a forest resource inventory; and detection of river siltation and flooding. Meteorological and hydrological uses include detecting and forecasting typhoons, river and coastal flooding, winter cyclones, and squall lines. The ACEMP system became operational in FY 1986.

The entire U. S. funding of $5,426,000 for the Bangladesh project was provided by DOS/AID. In FY 1987, AID provided an additional $184,500 for training of Bangladesh scientists.

Accomplishments of the Bangladesh project during FY 1987 were:

- o Continued training of Bangladesh scientists and technicians.
- o Training and support by the U. S. is likely to be concluded in FY 1988 with Bangladesh assuming full responsibility for the program.

Sahel Agrometeorological and Hydrological Program (AGRHYMET)

Subsequent to the severe drought which began in 1969 in the Sudano-Sahelian area of West Africa, which reached catastrophic proportions in 1972 and 1973, six countries (Chad, Mali, Mauritania, Niger, Senegal, and Burkina Faso) established a Permanent Inter-State Committee for Drought Control in the Sahel. Gambia and Cape Verde joined the Committee in 1974. The Ministers of these countries requested assistance of international organizations specializing in the study of problems relating to drought, including certain meteorological problems. The UN responded by directing its agencies to organize the necessary assistance. For this purpose, a mission (1974) involving the United Nations Development Program (UNDP), the Food and Agriculture Organization, and the WMO, defined in detail the needs of the eight countries and prepared a "Program for the Strengthening of the Agrometeorological and Hydrological Services of the Sahelian Countries and for the Establishment of a Center for Training and Applications of Agrometeorology/Operational Hydrology."

The objectives of the Program are to contribute to the social and economic development of the Sahel by:

- o Monitoring continuously and adequately the meteorological and hydrological conditions by means of modern observing networks;
- o Improving the understanding of these conditions and their variations in order to forecast them;
- o Applying this monitoring and understanding to human activities, and more particularly to agriculture and livestock rearing, with a view to increasing and regulating the production of the resources.

The program was developed to span 15 years and was divided into three phases of approximately five years each.

Phase I (1976-1981). A regional training and data processing center was established in Niamey, Niger, during Phase I. Also during this period, the program identified and began to fulfill the requirements to strengthen and modernize the national meteorological services. This was accomplished so that a fully functioning regional agrometeorological and hydrological information network could be developed during Phase II. AID contributed $6.3 million to Phase I, while other donors such as the UNDP and certain European countries provided approximately $20.3 million. Political unrest has delayed the implementation of AGRHYMET in Chad.

Phase II (1982-1987). The goal of Phase II has been to make the total system operational and capable of providing information to farmers, herders, planners and other users. This was accomplished by: 1) completing the agrometeorological and hydrological observing and reporting network throughout the Sahel; 2) implementing the data processing and analysis equipment in all the national services; and 3) training Sahelians in equipment technology, data processing, agrometeorology, hydrology, and administration. AID's contribution to Phase II was $7.7 million while the other donors, including the member countries, contributed an additional $59.6 million.

Phase III (1987-1991). The goal of the AGRHYMET program in Phase III is to implement the capabilities attained in Phase II by generating meteorological and hydrological products and forecasts and distributing them to the users in a timely fashion. AID has committed $9.0 million for continued support to the data processing system and for support of remote sensing activities. AID has begun this phase by providing NOAA $563,000 to maintain support and provide assistance during the transition to the provision of service through private contracts.

South Pacific Severe Storm Detection and Warning Project Fiji

NOAA/NWS undertook a project on behalf of AID to provide Fiji with satellite equipment to improve the timeliness and accuracy of typhoon and tropical storm forecasts and warnings. The equipment, which includes antennas, receivers, and a computer, enables the Fijian Meteorological Service to receive both GMS and GOES imagery and serve other computational needs. This project was completed early in FY 1987.

APPENDIX C

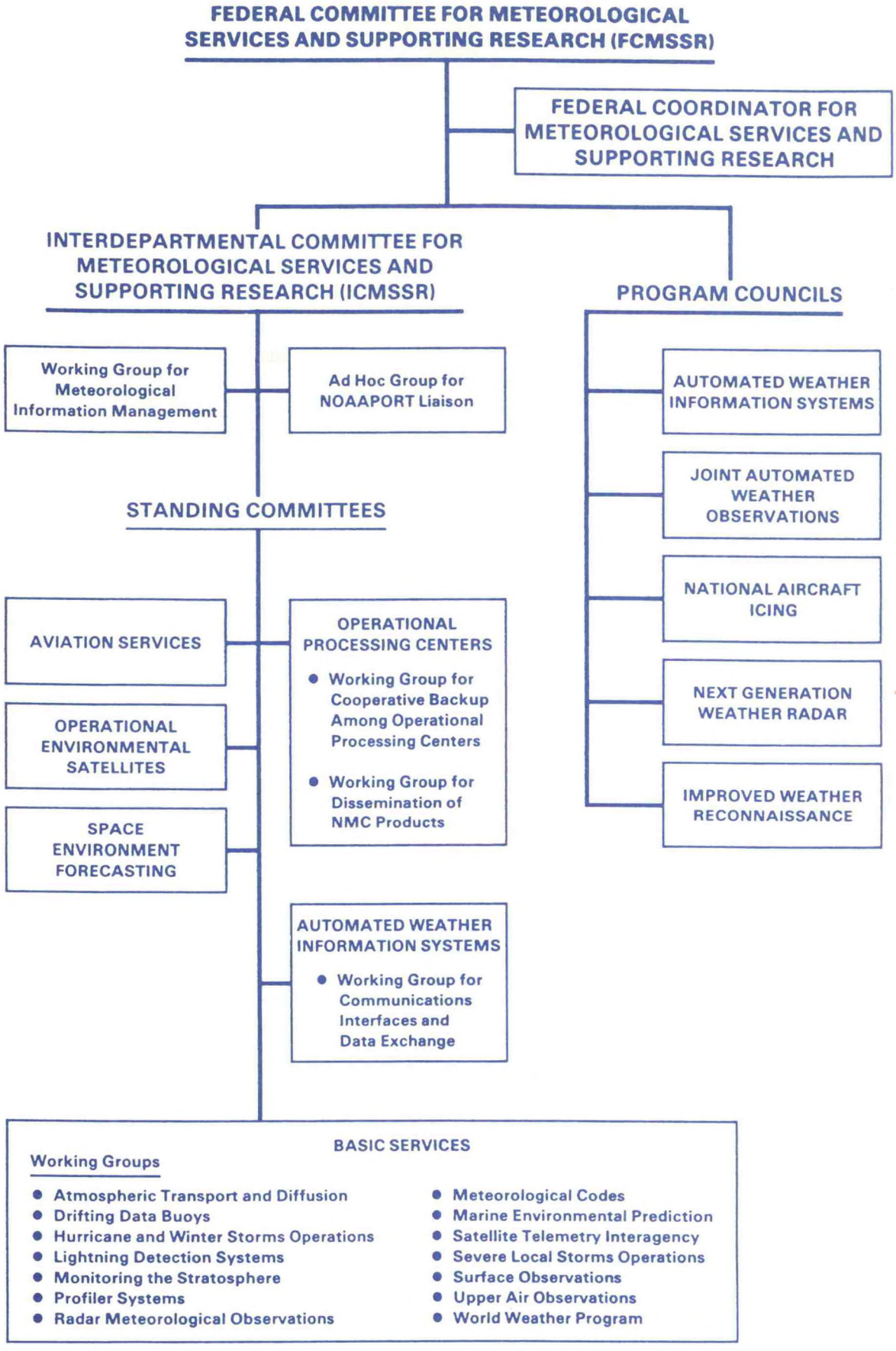
SELECTED ACRONYMS AND ABBREVIATIONS

AAODL	Atmospheric Aerosols and Optics Data Library
ADAS	AWOS/ASOS Data Acquisition System
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGL	Air Force Geophysical Laboratory
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
AFRES	Air Force Reserve
AFS	Air Force Station
AHOS	Automated Hydrologic Observing System
AI	Artificial Intelligence
AID	Agency for International Development
AISC	Assessment and Information Services Center
ALBE	AirLand Battlefield Environment
AMOS	Automatic Meteorological Observing System
AMR	Aircraft Microwave Refractometer
APT	Automatic Picture Transmission
ARGOS	French Data Collection System
ARINC	Aeronautical Radio, Incorporated
ARTCC	Air Route Traffic Control Center
ASL	U.S. Army Atmospheric Sciences Laboratory
ASOS	Automated Surface Observing System
ATC	Air Traffic Control
AUTOB	Automatic Meteorological Observing System
AVHRR	Advanced Very High Resolution Radiometer
AWDS	Automated Weather Distribution System
AWIPS	Advanced Weather Interactive Processing Systems
AWIS	Automated Weather Information Systems
AWOS	Automated Weather Observing System
AWN	Automated Weather Network
AWS	Air Weather Service
AWSC	Agricultural Weather Service Center
CAC	Climate Analysis Center
CAS	Committee for Aviation Services
CAT	Clear Air Turbulence
CBS	Committee for Basic Services
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CDDF	Central Data Distribution Facility
CEAS	Center for Environmental Assessment Services
COES	Committee for Operational Environmental Satellites
COMEDS	Continental U.S. Meteorological Data System
COMNAVOCEANCOM	Commander Naval Oceanography Command
CONUS	Continental United States
CSEF	Committee for Space Environment Forecasting
CWSU	Center Weather Service Unit (FAA)
DACS	Data Acquisition and Control Subsystem
DARDC	Device for Automatic Remote Data Collection

DCPLS	Data Collection and Platform Location System
DCS	Data Collection System
DMSP	Defense Meteorological Satellite Program
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
EO	Electro-Optical
EOSAEL	Electro-Optical Systems Atmospheric Effects Library
EPA	Environmental Protection Agency
ERBE	Earth Radiation Budget Experiment
ERBSS	Earth Radiation Budget Satellite System
ERL	Environmental Research Laboratories
ESSC	Environmental Studies Service Center
FAA	Federal Aviation Administration
FCMSSR	Federal Committee for Meteorological Services and Supporting Research
FEMA	Federal Emergency Management Agency
FGGE	First GARP Global Experiment
FLENUMOCEANCEN	Fleet Numerical Oceanography Center
FNOC	Fleet Numerical Oceanography Center
FSAS	Flight Service Automation System
FSS	Flight Service Station
FY	Fiscal Year
GAO	General Accounting Office
GARP	Global Atmospheric Research Program
GDPS	Global Data Processing System
GOES	Geostationary Operational Environmental Satellite
GOS	Global Observing System
GSFC	Goddard Space Flight Center
GTS	Global Telecommunications System
GWE	Global Weather Experiment
HRIS/2	Modified High Resolution Infrared Sounder
HRPT	High Resolution Picture Transmission
ICMSSR	Interdepartmental Committee for Meteorological Service and Supporting Research
ICSU	International Council of Scientific Unions
IMETS	Integrated Meteorological System
IR	Infrared
ITOS	Improved TIROS Operational Satellite
IWRS	Improved Weather Reconnaissance Systems
JAWOP	Joint Automated Weather Observation Program
JAWS	Joint Airport Weather Studies
JSPO	Joint System Program Office (NEXRAD)
LLWAS	Low Level Wind Shear Alert System
M	Million
MAC	Military Airlift Command
McIDAS	Man-computer Interactive Data Access System
MMS	Meteorological Measuring System

MOPP	Mission Oriented Protective Posture
MOS	Model Output Statistics
MSU	Microwave Sounding Unit
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communication Center
NAVEASTOCEANCEN	Naval Oceanography Center, Norfolk, VA
NAVOCEANCOMCEN	Naval Oceanography Command Center
NAVOCEANCOMDET	Naval Oceanography Command Detachment
NAVOCEANCOMFAC	Naval Oceanography Command Facility
NAVOCEANO	Naval Oceanographic Office
NAVPOLAROCEANCEN	Naval Polar Ooceanography Center, Suitland, MD
NAVWESTOCEANCEN	Naval Western Oceanography Center, Pearl Harbor, HI
NAWAS	National Warning System
NBC	Nuclear, Biological, and Chemical
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCP	National Climate Program
NCPO	National Climate Program Office
NDBO	NOAA Data Buoy Office
NDC	National Distribution Circuit
NEDN	Naval Environmental Data Network
NEDRES	National Environmental Data Referral Service
NEDS	Naval Environmental Display Station
NESDIS	National Environmental Satellite, Data, and Information Service
NEXRAD	Next Generation Weather Radar
NHC	National Hurricane Center
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOMSS	Naval Oceanographic and Meteorological Support System
NOTAM	Notice to Airmen
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
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
PATWAS	Pilot Automatic Telephone Weather Service
PROFS	Prototype Regional Observing and Forecasting Service
RAMOS	Remote Automatic Observing System
R&D	Research and Development
RD/T&E	Research and Development, Test and Evaluation
RFC	River Forecast Center
ROMS	Remote Ocean Surface Measuring System
SATCOM	Satellite Communications System
SBUV	Solar Backscatter Ultraviolet Instrument
SDHS	Satellite Data Handling System
SEL	Space Environment Laboratory
SEM	Space Environment Monitor

SFSS	Satellite Field Services Station
SIO	Scripps Institution of Oceanography
SMCC	Systems Monitoring and Coordination Center
SOCC	Satellite Operations Control Center
SSU	Stratospheric Sounding Unit
STIWG	Satellite Telemetry Interagency Working Group
TACOM	U.S. Army Tank Automotive Command
TDWR	Terminal Doppler Weather Radar
TDA	Tactical Decision Aid
TECOM	Test and Evaluation Command (U.S. Army)
TESS	Tactical Environmental Support System
TIROS	Television Infrared Observation Satellite
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS N Operational Vertical Sounder
TRADOC	U.S. Army Training and Doctrine Command
TWEB	Transcribed Weather Broadcast
TWI	Tactical Weather Intelligence
UAV	Unmanned Aerial Vehicles (Army)
UN	United Nations
USAF	United States Air Force
USAFETAC	USAF Environmental Technical Applications Center
USCG	United States 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
VTPR	Vertical Temperature Profile Radiometer
WCRP	World Climate Research Program
WEFAX	Weather Facsimile
WMC	World Meteorological Center(s)
WMO	World Meteorological Organization
WRP	Weather Research Program (ERL)
WSCMO	Weather Service Contract Meteorological Office
WSFO	Weather Service Forecast Office
WSMO	Weather Service Meteorological Office
WSO	Weather Service Office
WWP	World Weather Program
WWW	World Weather Watch


FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (FCMSSR)
FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH
INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (ICMSSR)
PROGRAM COUNCILS
Working Group for Meteorological Information Management
Ad Hoc Group for NOAAPORT Liaison
AUTOMATED WEATHER INFORMATION SYSTEMS
JOINT AUTOMATED WEATHER OBSERVATIONS
NATIONAL AIRCRAFT ICING
NEXT GENERATION WEATHER RADAR
IMPROVED WEATHER RECONNAISSANCE
STANDING COMMITTEES
AVIATION SERVICES
OPERATIONAL ENVIRONMENTAL SATELLITES
SPACE ENVIRONMENT FORECASTING
OPERATIONAL PROCESSING CENTERS
• Working Group for Cooperative Backup Among Operational Processing Centers
• Working Group for Dissemination of NMC Products
AUTOMATED WEATHER INFORMATION SYSTEMS
• Working Group for Communications Interfaces and Data Exchange
BASIC SERVICES
Working Groups
• Atmospheric Transport and Diffusion
• Drifting Data Buoys
• Hurricane and Winter Storms Operations
• Lightning Detection Systems
• Monitoring the Stratosphere
• Profiler Systems
• Radar Meteorological Observations
• Meteorological Codes
• Marine Environmental Prediction
• Satellite Telemetry Interagency
• Severe Local Storms Operations
• Surface Observations
• Upper Air Observations
• World Weather Program

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