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STRATEGIC PLAN FOR COLLABORATIVE RESEARCH ACTIVITIES BETWEEN NATIONAL WEATHER SERVICE OPERATIONAL OFFICES AND UNIVERSITIES

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Preface

This plan outlines the framework for collaborative research activities between modernized National Weather Service (NWS) operational offices and universities.

The plan is not intended to include the substantial research initiatives of the National Oceanic and Atmospheric Administration's (NOAA) Environmental Research Laboratories (ERL); the National Environmental Satellite, Data, and Information Service (NESDIS); and other research components within NOAA's Office of Oceanic and Atmospheric Research.

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Acronyms

AWIPS	Advanced Weather Interactive Processing System
COMET	Cooperative Program for Operational Meteorology, Education, and Training
DOH	Development and Operations Hydrologist
EFF	Experimental Forecast Facilities
ERL	Environmental Research Laboratories
FAA	Federal Aviation Administration
HIC	Hydrologist in Charge
MIC	Meteorologist in Charge
MOD	Meteorological Operation Division
NCAR	National Center for Atmospheric Research
NESDIS	National Environmental Satellite, Data, and Information Service
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OH	Office of Hydrology
OM	Office of Meteorology
RFC	River Forecast Centers
SOO	Science and Operations Officer
SSD	Scientific Service Division
STORM	Storm-scale Operational and Research Meteorology
TDG	Technique Development Group
UCAR	University Corporation for Atmospheric Research
WFO	Weather Forecast Offices
WSFO	Weather Service Forecast Office

1. Program Goal. The broad goal of collaborative research activities between NWS operational offices and universities is to advance the understanding of various hydrometeorological phenomena and to use this understanding to enhance weather warnings, forecasts, and other weather services to the Nation.

2. Objectives. The modernization of the NWS will provide new data sets to users along with advanced technological capabilities. These data sets and capabilities will enhance our understanding of hydrometeorological processes. Based upon this new understanding, improved local warning and forecast techniques can be developed. A key to substantially improved predictive capabilities is collaborative research activities among Weather Forecast Offices (WFO), River Forecast Centers (RFC), universities, and others in the scientific community.

Collaboration between forecasters and researchers is not a new concept. In the past, forecasting problems identified by operational meteorologists and hydrologists have been investigated by the research community. Similarly, new concepts developed through basic and applied research have been field tested and transferred to operations. Unfortunately, this type of collaborative effort has been limited since it has generally been difficult for forecasters and researchers to interact. Interaction between forecasters and researchers is far from automatic. Three major problems inhibit productive interaction.

Data - Forecasters and researchers often work with different types of data. Of primary importance in collaboration are data flowing both ways. Often, research entities have the resources to develop more complex local or mesoscale models than the operational offices. It is equally important for the field offices to have access to data sets or model output from outside their domain. Modernization will make it easier for each group to work with common data sets and numerical model outputs. One of the considerations in the development and implementation of new observing and processing systems has been the accessibility of the data by the community outside the NWS. Additionally, data transfer and data archival are extremely important. The existence of large and easily accessible archives will help in transferring research more quickly to the field.

Facilities - Forecast and research activities require an environment conducive to collaboration. Space and system support requirements recognized by the NWS's Office of Meteorology (OM) and the Office of Hydrology (OH) have been factored into a number of WFOs and RFCs and are listed in appendixes A and B, respectively. The Advanced Weather Interactive Processing System (AWIPS) requirements--which include Type I (alphanumeric workstation), Type IIA (image/graphics workstation), and Type III (animation workstation) support--vary according to anticipated research activities.

Time - Many operational meteorologists and hydrologists are able to define important research problems. Hundreds of case studies and local forecast techniques have been developed and published despite the fact that little time has been available for research. Researchers, on the other hand, have had little opportunity for real-time forecasting. Researchers would benefit from a better understanding of operational problems and the type of research required to improve weather prediction. Both groups will benefit from a shared exposure to the new WFO and RFC environments and new observing systems. The NWS modernization plans include 40 dedicated WFO staffing positions to provide for continuing education and to stimulate university interaction, especially at those offices listed in appendix A. Hydrologists at the RFCs will also be involved in university interaction.

The overall objective of collaborative activities is to increase knowledge and to transfer that knowledge to operational procedures. Specific objectives include the following:

Objective 1. Improve warnings and forecasts through the application of data from observations, numerical analysis and prediction models, and climatology.

- Investigate the utility and reliability of new data sources.
- Package data using common file structures and media formats to ensure broader use and compatibility within the atmospheric sciences community.
- Identify potential opportunities for use of different data sets, strategies, and techniques.
- Provide access to archived case history data sets and other climatological data.
- Share these data sets with universities and other scientific components for the improvement of prediction techniques.
- Devote particular attention to new data sets--especially the integration of these new data sets into improved operational forecasting procedures.
- Develop applications and process models utilizing all data sources to their full potential.

Objective 2. Assess the performance of the forecast system.

- Document significant hydrometeorological events and all significant forecast failures and successes in order to identify the need for new procedures and new data sources.
- Assess model performance in different situations.
- Assess forecast performance through the use of objective verification techniques.
- Assess long-range water resource forecasting procedures.

Objective 3. Develop a strategy and the techniques to improve short-term predictions.

- Develop conceptual models to assist forecast and research personnel in identifying clues to the development of mesoscale systems.
- Develop statistical techniques and conceptual models to predict significant hydrometeorological events.
- Develop improved conceptual forecast techniques for hydrologic models.

Objective 4. Promote interest in NWS careers among meteorology and hydrology students.

- Design teaching methods and materials that provide meteorology and hydrology students with a better understanding of weather forecasting.
- Encourage students to work on WFO and RFC research projects.
- Encourage qualified NWS meteorologists and hydrologists to serve as adjunct professors, graduate student advisors, or counselors to department heads.

3. Key Research Areas. Collaborative research activities will vary from office to office depending upon available resources and the motivation of those involved. The following areas form the core of the U.S. Weather Research Program (1990) as approved by the Subcommittee for Atmospheric Research, Committee on Earth and Environmental Sciences, Federal Coordinating Council for Science, Engineering, and Technology. These same areas suggest a variety of collaborative activities

that can be jointly investigated by NWS meteorologists, hydrologists, and researchers.

3.1 Mesoscale Weather Systems. Currently, the NWS is able to identify large areas at risk but not the specific sites where severe weather will occur. Studies need to be conducted to improve the understanding of the following: evolution and structure of mesoscale weather phenomena; optimal spatial and temporal assimilation of the vast amounts of new data which will soon be available; conceptual and numerical models of regional and local weather; inherent limits to our ability to predict the weather; and regions which show climatological preferences for mesoscale weather system development.

3.2 Scale-Interactive Processes. The exploratory research to date shows that mesoscale processes exercise significant upscale influence on weather development and evolution. For instance, even though mesoscale convective complexes usually encompass areas only about the size of a midwestern state, their effects on atmospheric circulation and subsequent weather evolution are far-reaching. Such influence is poorly accounted for in current numerical weather predictions. Research on these interactions will improve understanding of evolving larger-scale weather patterns leading to forecast improvements out to 48 hours and beyond.

Research is required on the origins of instabilities and initiation of convection in mesoscale systems, influence of larger-scale weather patterns on mesoscale processes, interactions of cloud and precipitation processes with mesoscale dynamics, influence of terrain and boundary layer processes on mesoscale weather system evolution, energy budgets associated with mesoscale systems, and mechanisms and processes associated with stratosphere-troposphere exchange.

3.3 Impact of Mesoscale Events on Hydrometeorological Processes. Observations show that precipitation is inherently mesoscale in character, occurring in smaller, localized regions of the parent weather system. Mesoscale precipitation events significantly shape hydrologic processes including stream flow and runoff. Inability to model and predict precipitation, especially amount and form (snow versus rain), is a critical constraint on progress across much of the NWS's programs--particularly natural disaster reduction and public safety, agriculture, transportation, and water resources management.

Studies must be conducted to better understand the processes governing development, timing, amount, and type of precipitation associated with mesoscale systems; techniques which allow remote sensing of atmospheric moisture; the constructs of regional hydrologic budgets and watershed models; the mesoscale processes which affect the earth's hydrologic cycle; moisture fluxes,

precipitation efficiencies, and atmospheric water budgets; and the coupling and modeling of atmospheric processes. Improvements in our knowledge and ability to predict and measure these mesoscale precipitation events will greatly improve warning services.

3.4 Limits of Predictability. Practical and theoretical limits need to be better understood including limitations in accuracy and resolution of observations and limits in computing power and numerical techniques. For example, what improvement in skill does extra effort buy?

4. Framework for Collaborative Activities. The overall framework for collaborative research activities includes:

- collaboration directed by the Science and Operations Officer (SOO) at the WFO and by the Development and Operations Hydrologist (DOH) at the RFC,
- collaboration at Experimental Forecast Facilities,
- collaboration at Cooperative Institutes, and
- collaboration at other NWS facilities.

The extent of collaborative interaction will depend upon available funding, scientific opportunities, and the interest levels of the local office and university staff.

4.1 Collaboration at Weather Forecast Offices and River Forecast Centers.

4.1.1 Base-Level Collaboration. Base-level collaboration is to be directed by the SOO and the DOH at the local level to enhance research activities. Together, the SOO position at WFOs and the DOH position at RFCs comprise a new approach to field science in the modernized NWS. The SOO serves as the WFO technical director and as the principal and senior scientific advisor to the WFO's meteorologist in charge (MIC) and staff. The position's primary focus is on the assurance of the technical integrity of all hydrometeorological products and services provided by the WFO. The SOO is fully responsible for initiating, planning, coordinating, and overseeing the transfer of new and emerging scientific technologies and techniques from the research community to the operational weather forecast and warning environment. In most respects, the DOH will pursue parallel efforts at each RFC. The DOH will provide direction for the integrated implementation of the hydrologic forecast technology employed at the RFC.

The SOO and DOH will actively lead and participate in significant collaborative research projects and developmental efforts with

universities and colleges; other Federal, state, and regional agencies; and related professional societies and organizations. Base-level collaboration will be easier to achieve when meteorology and hydrology departments are located nearby. In recognition of this, provisions have been made at those offices listed in appendixes A and B.

Research problems will normally be applicable at a local or regional level. The SOO and the WFO MIC, as well as the DOH and the RFC hydrologist in charge (HIC), must determine the need for studies to be undertaken such as algorithm development or the modification of warning and forecast procedures and techniques. The SOO and DOH are also responsible for directing these studies, advising the office staff during its participation, and evaluating study results for local application in coordination with the Scientific Services Divisions (SSD) at the NWS regions and the OM and OH at NWS Headquarters.

4.1.2 Collocated Collaboration. In order to compress the time required to transfer science and technology from forecast operations to research and from research to forecast operations, increased and sustained interaction between forecasters and researchers is necessary. Providing the research community access to the new technology and data bases may encourage more operationally-oriented research that may lead to improvements in warnings and forecasts. To speed this effort, the NWS has sought to establish locations where an NWS office could be collocated with a university having programs in the atmospheric sciences. In this plan, an NWS office is considered collocated if it is within walking distance of the research institute. NWS offices that are now or are proposed to be collocated with universities include:

- WFO Albany, New York, and the State University of New York at Albany;
- WFO/RFC Central Pennsylvania, and Pennsylvania State University;
- WFO Fairbanks, Alaska, and the University of Alaska;
- WFO Honolulu, Hawaii, and the University of Hawaii;
- WFO Oklahoma City, Oklahoma, National Severe Storms Laboratory (NSSL), and the University of Oklahoma;
- WFO Raleigh, North Carolina, and North Carolina State University;
- WFO Reno, Nevada, and University of Nevada's Desert Research Institute;

- WFO San Francisco, California, and the U.S. Naval Postgraduate School; and

- WFO Tucson, Arizona, and the University of Arizona.

Collocation at universities will promote continuous interaction between forecasters and researchers. The WFO MIC, SOO, RFC HIC, and DOH will encourage faculty and students to work with forecasters on specific forecast problems. Forecasters will be encouraged to attend university classes, seminars, and colloquia. Qualified forecasters--especially MICs, HICs, SOOs, and DOHs--may also have the opportunity to serve as adjunct professors, graduate student advisors, or counselors to department heads.

Several NWS offices are proposed to be closely affiliated with other research organizations. Collaborative research activities will also be conducted at these locations which include:

- WFO Boise, Idaho, and the Boise Interagency Fire Center;

- WFO Denver, Colorado, and ERL;

- WFO Memphis, Tennessee, and Agricenter International;

- WFO Missoula, Montana, and the U.S. Forest Service's Intermountain Fire Sciences Laboratory;

- WFO New York City, New York, and Brookhaven National Laboratory;

- WFO Phoenix, Arizona, and the Salt River Project;

- WFO/RFC Portland, Oregon, and the U.S. Army Corps of Engineers;

- WFO/RFC Sacramento, California, and the California State Department of Water Resources; and

- WFO/RFC Salt Lake City, Utah, and the Bureau of Reclamation.

4.2 Experimental Forecast Facilities (EFF). The pursuit of an organized program of operational research conducted by a staff of research forecasters at the WFO is the feature that distinguishes an EFF from other types of collaborative activity. EFFs will foster the working relationship among operational, research, and academic meteorologists aimed at solving local forecast and operational problems through the application of science and technology. In order for this relationship to be

successful, the WFO and university or research laboratory must possess a unique mix of motivated people.

What follows is a generic description of a model EFF. It should be recognized that each location will have its own characteristics which may differ from this model--especially in the early stages of EFF development.

4.2.1 Functions. The EFFs will involve a continuing long-term effort (several years per research project). This long-term approach by a dedicated staff is required since the identification of strengths and weaknesses of various operational forecasting methods will take time, requiring considerable direct experience in the operational environment. In addition, strategies for the optimum utilization of new technology are rarely obvious at the time new systems are introduced.

A primary task for the EFF is to remain aware of new developments in the operational and research communities by networking with other EFFs, regional SSDs, and WFOs involved in collaborative activities. The EFF staff must then decide which of these developments are appropriate for implementation into WFO operations. For a given weather forecasting problem, the EFF staff must identify candidate products, determine the best operational strategies or configurations, specify the appropriate meteorology, estimate processing requirements, and assess data availability. After a complete assessment, work may begin on developing the forecast technique aimed at solving a weather forecasting problem. Once developed, the technique must undergo a test and evaluation phase. If successful, the technique would be implemented in the WFO and elsewhere as applicable. The EFF staff would also provide focused forecaster training on this new capability--a crucial part of the technology transfer.

Many of the mechanisms for the successful functioning of an EFF are contained in a proposed organizational diagram shown in figure 1. The EFF is supervised by the WFO MIC who operates within the regional structure with technical guidance from the SSD Chief. The WFO SOO will be the technical leader of the EFF efforts. The MIC has the option of selecting a technical supervisor for the EFF from the ranks of the EFF staff if the primary focus of the SOO position becomes overloaded by EFF responsibilities. In all cases, the SOO should strive to enhance EFF operations.

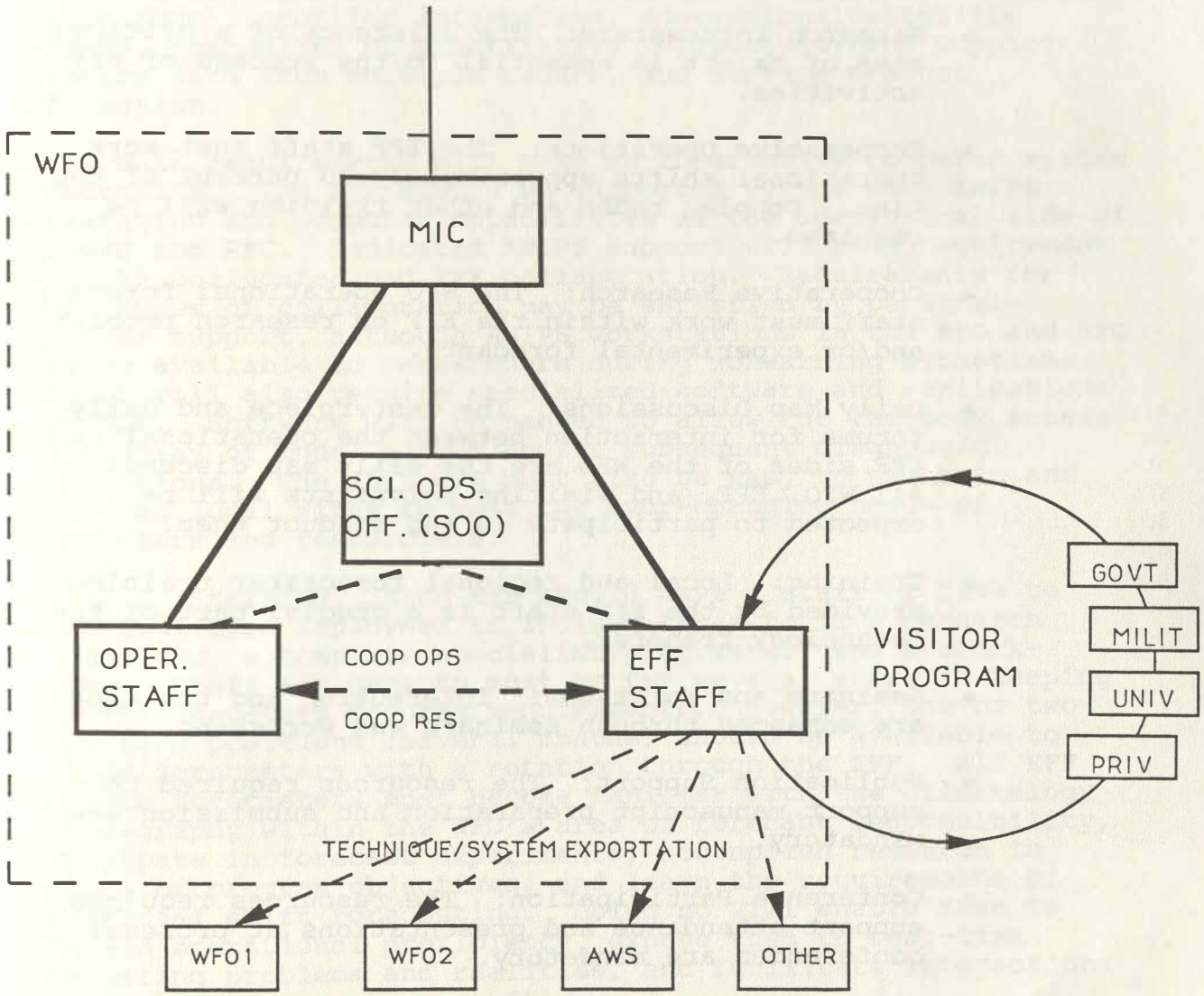

Figure 1. The organizational structure of an EFF.

The EFF fits within the WFO but has links to outside operations and research communities through the visitor program and export activities. An important internal activity is the cooperative research and operations link (McGinley, 1990).

4.2.2 Attributes. Several key ingredients are necessary for the successful functioning of an EFF. These include the following:

- Research Forecasters: The existence of a critical mass of talent is essential to the success of EFF activities.

- Cooperative Operations: The EFF staff must work operational shifts approximately 20 percent of the time. Doppler radar and other training will be required.

- Cooperative Research: The WFO operational forecast staff must work within the EFF on research problems and/or experimental forecasts.

- Daily Map Discussions: The centerpiece and daily forums for interaction between the operational and EFF sides of the WFO are the daily map discussions. All WFO, EFF, and visiting scientists will be expected to participate in and conduct them.

- Training: Local and regional forecaster training provided by the EFF staff is a crucial part of the technology transfer.

- Seminars and Workshops: Interaction and training are enhanced through seminars and workshops.

- Publication Support: The resources required to support manuscript preparation and submission are mandatory.

- Conference Participation: The resources required to support attendance and presentations at professional conferences are mandatory.

- Visitor Program: An EFF must be able to provide short-term positions to government, university, military, and private sector visitors to tap appropriate sources of expertise aimed at solving forecast problems.

- Data Archival: The capability to archive and access data sets is mandatory for the EFF mission.

It is generally recognized that collocation with a university or research organization enhances the likelihood of acquiring sufficient and dedicated participation.

4.2.3 Data and Systems Requirements. Of critical importance to the success of the EFF is the availability of data. The EFF data requirements will include, but not be limited to, access to gridded model forecast data sets from the National Meteorological Center (NMC), profiler information, conventional satellite imagery, composites of quantitative reflectivity and Doppler velocity data from multiple radars, and surface mesonet information.

These data requirements will make an interactive computer system a necessity. The EFF should be supported by the same AWIPS workstation and computer capabilities as the operational side of the WFO and RFC. Dedicated AWIPS support will be a requirement for both collocated and EFF collaboration. Requirements for other types of collaboration may be satisfied by personal-computer support, although AWIPS workstations in the WFO and RFC will be available to researchers during nonwarning situations. The EFF will also require specialized software and applications programs. Software will be needed to allow for the easy access and display of model output and/or subsequent diagnostic computations. The software must also be easy to maintain and expand at local sites to meet the ever-changing needs of forecasters and researchers.

4.2.4 Staffing. Each EFF should have a staff of five to seven full-time employees to include three to five research forecasters, a computer specialist/programmer, and a clerk-typist. Staff assignments must be for several years in keeping with the long-term program requirements. However, one or two short-term positions (several months) should be available to provide forecasters with a rotation through the EFF. All EFF research forecasters must become familiar with the climatology and geography within the WFO's area of forecast responsibility, participate in forecast experiments, accomplish research in support of program objectives, and learn the requirements of operational shift forecasting. Doing so will enable them to maintain operational proficiency, expose them to real-time forecasting problems and realities, and facilitate interactions with the WFO forecasting staff.

4.2.5 Locations. One of the tenets of the modernization and associated restructuring of the NWS has been to provide for the transfer of scientific and technological knowledge into NWS operations as quickly and efficiently as possible. At the Weather Service Forecast Offices (WSFO) at Denver, Colorado, and Norman, Oklahoma, this type of transfer is being explored. Therefore, the NWS has established the first two EFFs at Denver and Norman. A third EFF has been established at the National Severe Storms Forecast Center (NSSFC) at Kansas City, Missouri, under a joint agreement between the NWS and the Federal Aviation Administration (FAA). The NSSFC EFF will focus on forecasting hazards to aviation such as icing, turbulence, and severe

convection. A fourth EFF may be established at NMC in Camp Springs, Maryland, and operate under the direction of the Meteorological Operations Division in FY 1993. At these locations, operational meteorologists, researchers, and other scientists from government and universities will work side by side. The NWS should strive to establish at least one EFF per region. However, collaborative opportunities and special forecast and research requirements should be the primary consideration in the establishment of EFFs.

The following locations have been designated as EFFs (or potential EFFs) and are in the early stages of development.

a. Denver, Colorado. Strong interaction exists between WSFO Denver, the Environmental Research Laboratories, the National Center for Atmospheric Research (NCAR), Colorado State University, and the University of Colorado. Since WSFO Denver is one of the sites for testing the prototype workstation to be used in the NWS modernization, a unique working relationship has developed between the WSFO staff and researchers from these institutions. In fact, researchers from NCAR and ERL's Forecast Systems Laboratory have been involved in workstation assessment, technique development, local training, technique exportation, cooperative research, and experimental forecasting. During the modernization and associated restructuring of the NWS, the modernized Denver WFO will be collocated with the NCAR and ERL facilities in Boulder, Colorado.

b. Norman, Oklahoma. With WSFO Norman and NSSL located on the campus of the University of Oklahoma, EFF-like activities have been underway for several years. The Operational Support Facility, responsible for Doppler radar training and Doppler techniques development, is also a part of the EFF. Cooperative research among the meteorology faculty, students, NSSL, and the WSFO staff is well established. Program emphasis has been on the use of Doppler weather radar, mesocyclones, experimental mesoscale system forecasting, experimental quantitative precipitation forecasting, and experimental lightning forecasting.

c. Kansas City, Missouri (NSSFC). The Techniques Development Unit at the NSSFC has pursued collaborative research activities for many years. Collocation with the Severe Local Storm Unit and the National Aviation Weather Advisory Unit, and the nearby locations of the Center Weather Service Unit at the FAA Air Route Traffic Control Center in Olathe, Kansas, and the future WFO/RFC in Pleasant Hill, Missouri, makes the NSSFC an ideal site for an exchange of information among meteorologists and hydrologists. In addition to work with severe convective storms, the NSSFC will focus on aircraft icing and turbulence.

d. NMC Meteorological Operations Division (MOD). Funding will be sought for an EFF at NMC to operate within the MOD. The MOD EFF will focus on model-based studies including the increasing use of numerical simulations for diagnostic studies that help isolate the means by which various physical processes interact to produce significant weather events, the use of model simulations for testing the impact of new remote sensing data on weather forecasts, and the study of the strengths and weaknesses of operational numerical forecasts so as to identify biases as an aid to field forecasters and model developers.

Within the MOD, the Technique Development Group (TDG) is involved with model diagnostic/synoptic analyses and forecast verification studies. Studies include the development of computer graphics techniques for the interactive generation of graphic products and the implementation of interactive application software to access model output from research and operational models. The TDG is also investigating the ability of three operational models to predict the development, movement, and decay of extratropical cyclones, anticyclones, and precipitation patterns. University support would include access to data sets and long-term visits by faculty and students as part of a visiting scientist program.

4.3 Cooperative Institutes. Cooperative institutes also serve as a research interface between the NWS, other components of NOAA, and universities. The purposes of cooperative institutes are to promote research aimed at applying meteorological knowledge and data to the solution of specific applied and operational problems, to improve the effectiveness of research through close collaboration of two parent institutions, and to provide a center at which scientists working on problems of mutual interest may come together to work in an environment different from that already provided in the Federal and university structure. The program objectives and activities of cooperative institutes are selected to complement the research activities of the parent institutions while avoiding duplication.

Cooperative Institutes are structured to include a director, a council, an advisory board, and a full-time staff that includes NOAA and university scientists and visiting researchers. The selection of program objectives are normally developed by the Director and Council with the advice and approval of the Advisory Board. The overall research program is focused around a limited number of agreed-upon research themes as set forth in a memorandum of understanding. Allocation of university facilities and the adoption of appropriate policies and guidelines of operation are also determined within the administrative structure of the cooperative institute.

Cooperative agreements are generally long-term with financial commitments on the part of NOAA and the university to share administrative and faculty costs in a manner consistent with

usual practices and policies. Ongoing cooperative institutes are listed in appendix C.

4.4 Other NWS Collaboration. Interaction with universities is also pursued by other NWS entities. Each is able to provide a unique setting for research due to routinely available data sets and the availability of support equipment. These include:

- Climate Analysis Center
- Hydrologic Research Laboratory
- National Data Buoy Center
- National Hurricane Center
- NMC Development Division
- Scientific Services Divisions
- Spaceflight Meteorology Group
- Techniques Development Laboratory
- Tsunami Warning Centers

5. Sources of Research Funding.

5.1 Cooperative Program for Operational Meteorology, Education, and Training (COMET) Outreach Program. Funding for base-level and collocated collaboration will be available primarily through the COMET Outreach Program. COMET was established to enhance the mesoscale and synoptic-scale education of operational forecasters and to improve local forecasts by fostering professional interactions between NWS forecasters and university faculty and students. An area of program emphasis is on collaborative efforts between the operational and research communities. Types of collaboration include:

- activities which improve the use of new observing systems or the understanding of a local mesoscale forecasting problem;

- activities to assist operational forecasters in enhancing their educational backgrounds and keeping abreast of developments in research;

- activities to assist the university research community in keeping abreast of operational problems and needs; and

- activities which will create case studies or new data analysis techniques with wide applications and usefulness in teaching, research, or operational forecasting.

COMET is a program of the University Corporation for Atmospheric Research (UCAR) operating under a cooperative agreement with NOAA. Annual reports are prepared by UCAR (1991) describing a full range of activities. In an effort to bring the operational

and academic/research communities closer together and to promote applied research, COMET established the Outreach Program to support collaborative activities. The Partners and Cooperative Programs together form the basis for the COMET Outreach Program.

The COMET Partners Program supports collaborative activities between individual NWS forecasters and cooperating researchers. Research generally focuses on the production of a particular forecast study. As a result, this type of collaborative activity is of limited duration (less than 1 year). Partners Program research usually results in the preparation of a joint paper and/or adoption of a new forecast technique.

The COMET Cooperative Program supports broad collaborative activities between an NWS office and a university department or program. Activities may include forecast applications research, involvement of university faculty and graduate students in NWS professional development activities, and use of NWS data and personnel in university educational activities. Despite the fact that programs of this type may be related to specific short-term objectives (less than 2 years), they are more likely to involve the establishment or expansion of long-term relationships between a university department and an NWS office.

5.2 Storm-scale Operational and Research Meteorology (STORM) Program. The funding for collaborative research activities, and especially the EFFs, will be the responsibility of the NWS primarily through the STORM program (1983). Additional sources of funding, to be determined, are expected to be available from grants provided by other agencies whose research projects and interests crosscut the NWS mission. Agriculture, defense, energy, environment, science, and transportation resources are all impacted by weather. The success of many of the collaborative research objectives depends upon the cooperation and contributions of all the individual agencies.

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Appendix A

Facility Requirements at WFOs With Proposed Collaborative Research Activities

WFO	University/Center	Workstations	AWIPS Consoles		
			I	IIA	III
Albany	State University of New York at Albany	5	1	1	1
Anchorage	University of Alaska	2			1
Atlanta	Georgia Tech/Environmental Protection Agency	3	1		1
Boston	Massachusetts Institute of Technology	2	1		1
Central PA	Pennsylvania State University	5	1	1	1
Denver	ERL/NCAR/UCAR/Colorado University/ Colorado State University	5	1	1	1
Fairbanks	University of Alaska	1			1
Honolulu	University of Hawaii	3			1
Indianapolis	Purdue University	2	1		1
Lubbock	Texas Tech	2	1		1
Melbourne	NASA/Air Weather Service	3	1		1
Miami (WFO, NHC)	University of Miami/ERL/Atlantic Oceanographic and Meteorological Laboratory	6	1		1
Milwaukee	University of Wisconsin	1	1		1
Monterey	U.S. Naval Postgraduate School/ San Jose State	3	1		1
New York	Brookhaven National Laboratory	3	1		1
Norman	NSSL/University of Oklahoma	3	1		1
Omaha	Creighton University	2	1		1
Phoenix	Salt River Project/University of Arizona/Arizona State University	3	1		1
Raleigh	North Carolina State University	3	1		1
Rapid City	South Dakota School of Mines	2	1		1
Reno	University of Nevada	2	1		1
Sacramento	University of California at Davis	2	1		1
Salt Lake City	University of Utah	4	1		1
Seattle	University of Washington	5	1	1	1
St. Louis	St. Louis University/University of Missouri	1	1		1
Tallahassee	Florida State University	5	1	1	1
Tampa	University of Florida	5	1		1
Tucson	University of Arizona	3	1		1

Appendix B

Facility Requirements at RFCs With Proposed Collaborative Research Activities

RFC	University	Workstations	AWIPS Consoles
Alaska	University of Alaska	1	Shared
California-Nevada	University of California at Davis	1	Shared
Colorado Basin	University of Utah and Utah State University	1	Shared
Lower Mississippi	Tulane University	1	Shared
Middle Atlantic	Pennsylvania State University	1	Shared
Missouri Basin	University of Missouri	1	Shared
North Central	University of Iowa and University of Minnesota	1	Shared
Northeast	Massachusetts Institute of Technology	1	Shared
Northwest	Portland State University	1	Shared
Ohio	Ohio State University	1	Shared
Southeast	Georgia Tech	1	Shared
Tulsa	University of Oklahoma	1	Shared
West Gulf	Texas A & M	1	Shared

Appendix C

Cooperative Institutes

Institute	Agency	University
Cooperative Institute for Applied Meteorological Studies	NWS	Texas A & M
Cooperative Institute for Applied Meteorology	NESDIS	University of Missouri
Cooperative Institute for Climatic Studies	NWS/NESDIS	University of Maryland
Cooperative Institute for Limnology and Ecosystems Research	ERL	University of Michigan
Cooperative Institute for Marine and Atmospheric Studies	ERL	University of Miami
Cooperative Institute for Mesoscale Meteorological Studies	ERL	University of Oklahoma
Cooperative Institute for Meteorological Satellite Studies	NESDIS	University of Wisconsin
Cooperative Institute for Research in the Atmosphere	NESDIS/ERL	Colorado State University
Cooperative Institute for Research in Environmental Sciences	ERL	University of Colorado
Cooperative Institute Consortium for Hydrometeorological Forecasting and Water Resources	NWS	Proposed at MIT, University of Arizona, and University of Iowa
Joint Institute for Marine and Atmospheric Research	ERL/NWS	University of Hawaii
Joint Institute for the Study of the Atmosphere and Oceans	ERL	University of Washington