Atlantic Oceanographic and Meteorological Laboratory
RESEARCH REVIEW TEAM DATA REQUEST

A brief history and mission of the laboratory.

AOML traces its origins to the founding in June 1967 of the Environmental Sciences Service Administration (ESSA) Atlantic Oceanographic Laboratory; it operated in leased office space in Miami, Florida. Construction of a federally owned building specifically designed to house the laboratory was begun on Virginia Key, Florida, in 1969 and completed in 1972. In February 1973 the laboratory was dedicated as the Atlantic Oceanographic and Meteorological Laboratories, a part of the then recently formed National Oceanic and Atmospheric Administration.
AOML addresses all three major goals in the NOAA Strategic Plan. AOML scientists study the relationships between ocean and atmosphere by conducting research in both near shore and open ocean environments. They cooperate with other federal, state, and local authorities to maximize research knowledge for use in economically and environmentally important projects. AOML also provides and interprets oceanographic data collected via ships, satellites, drifting buoys and floats, and conducts research relevant to annual-to-decadal climate change and coastal ecosystems. This research includes the dynamics of the ocean, its interaction with the atmosphere, and its role in climate and climate variability. AOML research improves the understanding and prediction of hurricane motion, intensity change, and the impacts from wind, surge, waves, and rain. A key to this work is the annual hurricane field program, supported by the NOAA Aircraft Operations Center research/reconnaissance aircraft.

Please provide a listing of major customers of the laboratory

See Attached file

Please provide a summary of research being conducted at the laboratory

<u>**AOML's Climate Goal Research**</u>

** Note: Climate activities described are predominantly **GLOBAL** in geographic scope with a **LONG TERM** time frame.

AOML is conducting global studies to better understand the large-scale setting for regional climate signals. AOML manages global ocean observing systems and with these and other data, conducts research in several areas. The research particularly emphasizes inter-annual and longer time-scale variability. Techniques utilized in these activities include process studies conducted from research vessels, observing systems that employ commercial vessels, novel tracers of ocean ventilation and circulation, deployments of autonomous instruments, and numerical models. In addition, AOML is the home of the Global Ocean Observing System (GOOS) Center.

1. Climate Observations and Analysis

In conjunction with National and international partners, AOML participates in the development of a sustained ocean observing system for understanding and predicting climate change, with particular emphasis on improved:

a) Oceanic indices: Established a web site depicting the intensity of various components of the Meridional Overturning Circulation. Determined an index for the position and intensity of the Gulf Stream to study decadal variability of the subtropical gyre of the North Atlantic. Determined an index for advection times in the deep western boundary current from the sub-polar to the sub-tropical Atlantic. Collected inverted echo sounder data along the Abaco line (26°30'N) to establish a monitoring system along that latitude to support these indices.
b) Sampling. Demonstrated the importance of maintaining several low-density XBT lines in the Atlantic for monitoring low frequency signals. Developed and implemented a new code to improve the deployment scheme for surface drifters. Developed a new methodology for interpolating the drifter data based on Lagrangian time scales and the seasonal cycle. Determined the impact of assimilating XBT data into the HYCOM ocean model for the Atlantic. Designed a methodology for assessing data, model, and error compatibility to improve data assimilation.
c) Instrumentation. Developed an automatic launcher (eight-probe multi-launcher) for high-density expendable bathythermograph (XBT) cruises. Developed a prototype system for combined measurements of depth, temperature, salinity and currents for calibration and interpretation of Florida Current cable observations. Developed and implemented an improved system (SEAS 2000) for transmitting data from voluntary observing ships (VOS). Implemented SEAS 2000 phase I (AMVER/MET), began fleet implementation of SEAS 2000 phase II (XBT). Continued development of SEAS 2000 (phase III) (auto-launcher, TSG, pCO_2).
d) Data collection and management. Collected, transmitted in real time, quality controlled, and distributed data for ARGO, global drifter data, global XBT network, Atlantic XBT high density lines, underwater cable in the straits of Florida. Collected and distributed CTD and current measurements from research cruises along the Abaco line (26.5°N).

2. Understand Climate Variability and Change
a) Indices. Studied and interpreted indices for climate change and to improve the understanding of inter-ocean and inter-hemispheric exchanges of mass and heat, critical components of the global climate system.
b) Tropical Atlantic Variability. Studied and interpreted tropical Atlantic Ocean variability (TAV) and its influence on climate and weather of the surrounding continents, in particular, the east coast of the US.
c) Western Hemisphere Warm Pool. Studied and interpreted variability of the tropical Western Hemisphere warm pool and its effects on climate in both the Pacific and Atlantic oceans.

3. Climate Forcing
a) Oceanic CO_2 inventories and fluxes. Provided a comprehensive synthesis of carbon system parameters of JGOFS/WOCE and OACES cruises in the 1990s. Produced first data-based anthropogenic CO_2 inventory in the Atlantic Ocean, based on data obtained from the 1990s. With companion data from the Pacific and Indian Ocean, determined that the global ocean has taken up 29 % of the anthropogenic CO_2 burden. Re-assessed the stoichiometric ratio of carbon and nutrients in the ocean which is critical to understand and quantify the role of the biological pump in the ocean. Completed the first CO2/CLIVAR repeat hydrography cruise on NOAA ship BROWN in the North Atlantic assuring that NOAA partners play a prominent role in this critical, multi-agency long term observing effort of the fate of CO_2. Determined the most complete direct estimate of anthropogenic and total CO_2 flux across 24°N in the Atlantic.

b) Air-sea CO_2 flux maps. Created new algorithms to extrapolate CO_2 flux data in time and space in the Caribbean Seas. Quantified air-sea CO_2 fluxes in the southern Ocean, a focus area with respect to climate and global change. Designed and contracted instrumentation to perform autonomous CO_2 measurements from Volunteer Observing Ships (VOS).

AOML's Ecosystem Goal Research

** Note: The Ecosystem activities described are **REGIONAL** in geographic scope with goals and objectives on **SHORT TERM, MEDIUM TERM, AND LONG TERM** time frames.

NOAA's capability to protect, restore, and manage the use of coastal and ocean resources through ecosystem management approaches depends on its ability to assess the effects of natural and man-made stressors on coastal and ocean ecosystems. The NOAA Ecological Observing System includes Coastal and Regional Environmental Research (CRER), which contributes to a complex of sustained regional observation networks in South Florida. The focus is on measuring and improving the measurement of physical (e.g. water temperature, currents, salinity, transparency), biological (e.g. - chlorophyll), and chemical (e.g. – nutrient and contaminant) parameters that affect water quality, resource management (e.g. fisheries, protected species) and the regional economic infrastructure. CRER components are linked to and supportive of specific Ecosystem Goal Programs including: Habitat Restoration, Fisheries Management, Protected Species, Coastal Resource Management, Corals and Protected Areas. It includes research and observations conducted in support of complex major interagency activities such as South Florida Ecosystem Restoration (SFER) and the Comprehensive Everglades Restoration Plan (CERP) as well as more limited collaborations defined by specific agreements with other federal agencies (principally the Army Corps of Engineers and the U.S. Environmental Protection Agency) and regional public utilities whose activities affect coastal ecosystem health and living marine resources.

The deficiencies have become acute with the implementation of the Comprehensive Everglades Restoration Program and the rapid pace of development with the coastal water shed of South Florida. New construction permits are being issued at a faster rate in South Florida than any other counties in the United States and the rapidly burgeoning population requires massive infrastructure development. Absent the active involvement and participation of NOAA, this would likely be accomplished at the expense of our invaluable coastal marine ecosystem – the foundation of a multi-billion dollar economy.

1. CRER South Florida Ecosystem Restoration Research

Along with coordinating the overall NOAA SFER program and staffing CERP and SFERTF committees, specific subprojects include:
a) Providing the sustained physical, water quality, and biological data required to verify CERP models and analyze alternative restoration scenarios;
b) Determining the degree to which restoration actions/alternatives threaten the Florida Keys National Marine Sanctuary and coastal living marine resources and protected species;
c) Implementing a real time regional interdisciplinary monitoring network utilizing state-of-the-art data assimilation, computational, and information dissemination methodologies;

d) Completing the oceanographic boundary subunit of the Interagency Hydrodynamic Model being developed by NOAA, USGS, and the South Florida Water Management District and using it to evaluate the effects of natural climatic variability.

2. CRER Fisheries Oceanography Research

Work on this topic has been conducted in collaboration with NMFS/Southeast Fisheries Science Center (SEFSC) scientists using the FV/Gordon Gunter. In essence, we are providing oceanographic data and analysis to support larval distribution and abundance studies in the Caribbean Sea, Gulf of Mexico, and Florida Straits. Specific activities include:

a) Collection and analysis of hydrographic data (temperature, salinity, dissolved oxygen, and silicate);

b) Acoustic acquisition and analysis of upper layer velocity/transport data;

c) Synthesis of (a) and (b) into circulation analysis;

d) Collaborative integration of circulation analyses with larval distribution and abundance data.

3. CRER Mammal Research

The overall goal of this effort is to improve understanding of marine mammal distribution, abundance and migration patterns, and possible deleterious interactions with human activities or man-made marine structures. Specific activities include:

a) Designing, developing, and constructing passive acoustic sensor arrays (and models) to monitor sperm whale abundance and, possibly, vertical distribution in the northern Gulf of Mexico;

b) Conducting passive acoustic surveys of baleen whale distribution throughout the Caribbean;

c) Implementing a data processing center to process NMFS/SEFSC marine mammal data utilizing AOML's parallel processing computation system;

4. CRER Technology Research and Development

The overall goal of these efforts is to develop the next generation sensors and Integrated Environmental Monitoring Systems. There is no question that the problems coastal managers and planners face require information on processes at both shorter time and space scales than previously studied, but over longer periods than previously available. In our view, progress requires Eulerian time series data sets that are best and most cost effectively obtained from fixed platforms, moorings, or buoys nested within remotely-sensed wider fields. Ship-based process studies have a role but will, in the future, no longer be exploratory in nature. Much greater use will be made of ships-of-opportunity and unmanned platforms. Recent advances have been made and will continue to be made both in regard to *in-situ* sensor technology and in adapting and integrating commercially available sensors into instrument packages tailored to our needs. Real-time data assimilation and creative analysis are now possible and practical due to advances in both computer hardware and software. All of these information sources will have to be integrated into end-to-end information systems to deliver the products relevant to society's needs. Specific activities include:

a) Developing remote sensor systems and assays based upon molecular quantification of planktonic organisms and microbial contaminant abundance;

b) Extending the concentration range over which we can measure key dissolved and atmospheric trace constituents;

c) Distributing value-added integrated analysis products in near-real-time to appropriate coastal managers, emergency managers, and environmental regulators. This includes, for example, the movement and interaction with adjacent water masses of dredge spoils, high salinity plumes, and sewage outfalls, and estimating their effects upon water quality and, in turn, the coastal marine ecosystem;
d) Adapting present and next generation sensors to a range of platforms, *e.g*., research ships, -moorings, towers, airplanes, ships-of-opportunity, and/or automated underwater vehicles.

AOML's Weather and Water Goal Research

** Note: All Weather activities described are **NATIONAL** in geographic scope with goals and objectives on **SHORT TERM, MEDIUM TERM, AND LONG TERM** time frames.

The Atlantic Oceanographic Meteorological Laboratory provides capabilities in support of the Tropical Program addressing NOAA's Strategic Plan Mission Goal 3 "Reduce Society's Risks from Weather and Water Impacts", Strategy 2 "Understand and Describe." AOML supports the strategic goals of NOAA and the Science and Technology Infusion program by advancing the understanding and prediction of hurricanes and other tropical weather. AOML research is based on integrating models, theories, and observations, with particular emphasis on data obtained with research aircraft.

AOML priorities, generated in accord with National and NOAA Tropical and Environmental Modeling Programs, focus on long-term research on tropical cyclones to provide underlying knowledge and techniques with potential to be incorporated by operational centers in future generations of data acquisition, assimilation, and numerical forecast systems beyond four to five years. The Tropical Program has stated that improvements in hurricane track, intensity, and rain forecasts will benefit most sectors of society. These forecasts are of critical use to such decision makers as emergency managers at the local, state, national and international levels; mariners including the U.S. Navy; NASA; and other U.S. federal agencies responsible for the well being of millions of people and billions of dollars of assets. The goals of this research are as follows.

1. Tropical Cyclone Intensity

Advance the prediction of tropical cyclone intensity change by improving understanding of the processes that modulate internal storm dynamics and storm interactions with the atmosphere and ocean.

2. Tropical Cyclone Tracks

Improve the prediction of tropical cyclone tracks by enhancing understanding of the interactions between a tropical cyclone and its environment through an optimal analysis of field observations.

3. Tropical Cyclone Impacts

Enhance the ability to diagnose and predict the impact of tropical cyclones on life and property through wind, rain, waves, and storm surge.

Much AOML research is based on the in situ and remotely-sensed observations in the inner core of tropical cyclones and their surrounding environment. These observations are primarily collected in our annual field program using the two NOAA turboprop aircraft and jet operated by the NOAA Aircraft Operations Center (AOC). The field program is used to carry out scientific experiments designed to address the goals stated above. Data sets gathered by these experiments, combined with dynamical and statistical models and theoretical development, range from global to microscale, forming the cornerstone of AOML hurricane research. Because of this extensive field experience, AOML scientists are recognized internationally for their knowledge of tropical cyclones as well as their expertise in technological areas such as airborne Doppler radar, dropsondes, cloud microphysics, and air-sea interaction, to name a few. These capabilities provide NOAA (and the world) a unique capability.

AOML coordinates parts of its programs with other NOAA organizations, e.g., NOAA's Aircraft Operations Center (AOC) and the National Center for Environmental Prediction (NCEP), and in particular with the Environmental Modeling Center (EMC) and Tropical Prediction Center/National Hurricane Center (NHC). AOML maintains active research programs with, and receives funding from, other governmental agencies; in particular, the Department of the Navy's Office of Naval Research (ONR) and the National Aeronautics and Space Agency (NASA).

In program areas where it is beneficial to AOML, it arranges cooperative programs with scientists at the National Center for Atmospheric Research, and at a number of universities. One of the highest priority experiments in 2003 (and through 2004) is the Coordinated Boundary Layer Air-Sea Transition (CBLAST) experiment focused on improving numerical model parameterization of the air-sea transfer of energy that fuels the storms. AOML also coordinated two recent NASA field experiments and a fifth Convective and Moisture Experiments (CAMEX-5) is being considered in 2005.

5.) Please provide a listing of 3-5 major accomplishments in the last five years.

Project: Understand and describe the Meridional Overturning Circulation
The Meridional Overturning Circulation (MOC) is a major component of the global climate system responsible for a large contribution to meridional oceanic heat flux by the ocean. The MOC is characterized in the Atlantic Ocean by northward flow of warm surface water, which is compensated for by southward flow of deep colder water. The Deep Western Boundary Current (DWBC) is the major conduit for the southward flow. Characterization of the properties of the mean and time dependent DWBC are necessary for validation of the numerical models that will be used to forecast long-term climate change. Monitoring of the DWBC is necessary to provide a measure of the intensity of the MOC. Paleo-climate studies have shown that the intensity of the MOC plays a major role in global climate and sustained observations of the DWBC can provide indicators for potentially dramatic climate variability (e.g., abrupt climate change). Observations collected at AOML along the western boundary of the North Atlantic have established that the DWBC is a continuous flow from the subpolar to the equatorial Atlantic. Time-series of the water mass characteristics of the DWBC off the Bahamas have demonstrated that advective times of the DWBC are considerably faster than found in earlier studies. The significance of this discovery is: (1) they provide characterizations of the present

ocean climate, characterizations that must be simulated by climate forecast model to develop confidence in their predictions and (2) demonstrate that it is possible to monitor the DWBC with present technology. The second result provided the stimulus for sustained observations of the DWBC, a project being conducting cooperatively with British oceanographers to study abrupt climate change. This will reduce the cost of operations.

Project: Understand and describe long-time scale signals in tropical storm formation
Both the annual number of Atlantic tropical storms forming south of 23.5N and of Atlantic major hurricanes increased between the 1970's/1980's and 1995-2000. These increases are coincident with a multi-decadal warming in the North Atlantic Sea Surface Temperature (SST) suggesting that the high activity of 1995-2000 may persist for the next ~10 to 40 years. However, during 1950-2000 strong decadal oscillations are superimposed on the multi-decadal changes in both SST and tropical storms (positive SST anomalies in the main development region for storms, increased storm activity). We appear to be entering a negative phase of the decadal SST signal in the main development region for disturbances implying that tropical storm, and most likely major hurricane, activity may be reduced in the next several years rather than remain at the very high 1995-2000 level when both signals were in their positive phase. Tropical storm activity during 2001 and 2002 is less than expected from the multi-decadal signal, but for 2002 the main cause may be El Nino. Thus, if verified with future data, another variable to be considered in hurricane forecasting will be available. The importance of this discovery is that better forecasts in the number of hurricanes and tropical storms will be provided.

Project: Global Carbon Cycle
First data-based inventory of anthropogenic CO_2 in the ocean: In close collaboration with PMEL and academic collaborators through OGP's Ocean-Atmosphere Carbon Exchange Study (OACES) we have determined the first inventory of anthropogenic CO_2 in the ocean based on observations, as opposed to models. The program commenced in the early 1990s in collaboration with DOE with measurements of referenced high quality carbon, nutrient, and hydrographic parameters on the long lines under auspices of WOCE, JGOFS, and OACES. At the completion of the field programs in 1998, NOAA/OGP sponsored an extensive data syntheses exercise led by scientists at AOML and PMEL, where the data necessary for the determination of anthropogenic CO_2 content (T, S, T CO_2, T-alk, NO_3, O_2, and CFC) were collated from over 70 cruises and quality assured with adjustments as necessary through exhaustive comparisons. Based on these high quality data sets, basin scale anthropogenic CO_2 inventories were determined. We have found that cumulatively the world’s oceans have absorbed 112 Pg C of CO_2 or 29 % of the excess CO_2 produced by man's activities since the start of the industrial revolution. The synthesized data set has also been used to study global cycles of nutrient regeneration in the deep ocean and the re-mineralization of calcite, which will have a significant impact on the future sequestration capability of the ocean. The findings are critical for national and international assessments of the long-term fate of anthropogenic CO_2, such as the IPCC report. The monetary value to which the annual sequestration of 2 Pg C by the ocean equates is a $4 billion dollar "service." Monitoring future uptake is thus essential.

Project: Climatology of air-sea CO_2 fluxes: The rate at which the ocean takes up CO_2 directly affects projections of future atmospheric CO_2 levels

Under the lead of Takahashi of Lamont Doherty Earth Observatory, we produced the first climatology of surface ocean p CO_2 levels and the CO_2 fluxes inferred from these levels. AOML and PMEL were the first laboratories in the U.S. to permanently install automated underway systems to measure p CO_2 in surface water on (NOAA) research ships and have operated the systems for the last decade. This dataset constituted a significant portion of the input for the monthly p CO_2 climatology. Scientists at AOML perfected relationships between gas exchange and wind speed based on theory and dedicated field studies. The gas exchange parameterization is necessary to convert surface water p CO_2 levels to CO_2 fluxes. The p CO_2 climatology is widely considered the most important contribution to oceanic and atmospheric carbon cycle studies in the last decade and is used extensively as a boundary or constraint in models and as a baseline for CO_2 flux anomalies resulting from, for instance, ENSO processes. Aside from the need to constrain the fluxes to predict future atmospheric levels, rising surface CO_2 concentrations are believed to have detrimental effect on coral ecosystems. Sustained monitoring is thus imperative.

Project: Improve the prediction of tropical cyclone tracks by enhancing understanding of the interactions between a tropical cyclone and its environment through an optimal analysis of field observations

Since 1997, the Tropical Prediction Center and the Hurricane Research Division have conducted operational synoptic surveillance missions with a Gulfstream IV-SP jet aircraft to improve numerical forecast guidance. Due to limited aircraft resources, HRD developed optimal observing strategies for these missions. Three dynamical models were employed in testing the targeting and sampling strategies. Target areas are represented by areas of large forecast spread in the NCEP bred-vector ensemble forecasting system. Assimilation of only the subset of data from the subjectively-found, fully-sampled target regions (generally encompassing between one-third and two-thirds of all the data) produced a statistically significant reduction of the track forecast errors of up to 25% within the critical first two days of the forecast. This is comparable with the cumulative business-as-usual improvement expected over eighteen years. This is the first effort to show that carefully selected targeted observations are better than gathering large amounts of regularly-spaced data. The results of this work were used to justify the Taiwanese starting the second operational tropical cyclone surveillance program in the world.

Project: Advance the prediction of tropical cyclone structure and intensity change by improving understanding of internal storm dynamics and storm interactions with the atmosphere and ocean

a) In the past, the lack of direct measurements at and near the surface in the eyewall of hurricanes prevented meteorologists from accurately determining a hurricane's maximum wind speeds, especially just prior to landfall. Surface wind speed estimates are used to decide the extent of warnings and evacuations in advance of a hurricane by the Tropical Prediction Center (TPC) and emergency managers and the insurance community. AOML scientists were instrumental in developing the GPS dropwindsonde and a new observational strategy that used this device to obtain the first detailed measurements of low-level hurricane eyewall winds. As a result of this work, scientists are now able to measure hurricane eyewall winds with far greater accuracy and detail than in the past.

b) AOML scientists published a breakthrough description of a storm's vertical wind speed structure and its relation to the tumultuous ocean surface below the storm. This new characterization could affect numerous computer models used to predict hurricane motion, intensity, and the associated waves and storm surge that can be devastating to near shore communities. New data collected from Global Positioning System (GPS) dropwindsondes provide information about the force the wind exerts on the sea surface, information that was previously difficult to measure and thus extrapolated from much weaker storms. Because the hurricane environment is too severe for conventional sensors, these are the first drag coefficient, stress, and roughness measurements to have been made in hurricanes. These results suggest that revisions are necessary for momentum flux parameterizations currently used in almost all numerical forecast models for a variety of disciplines including prediction of weather, storm surge, waves, and associated risk.

c) The intensification of a hurricane involves a combination of different favorable atmospheric and oceanic conditions. Hurricane Opal (1995) rapidly intensified as it passed over a strong oceanic warm core ring, indicating that the ocean may play a more important role in intensity change than previously thought. Several experiments carried out in Opal investigated air-sea heat exchange processes. New methodologies utilizing remotely sensed sea surface altimetry and very high resolution radiometry were developed. These procedures provide scientists another tool for forecasting hurricane intensity, particularly in the Gulf of Mexico. Monitoring the upper oceanic thermal structure is now a key observation element in the rapid intensification of hurricanes. It has also become a guidance tool for prediction of tropical cyclone intensification at TPC.

6.) Please provide a summary of legal mandates for the work in the laboratory/center.

For Climate Goal Activities:

- Earth Observation Summit (and Group on Earth Observation (GEO) Working Group).
- Global Change Research Act of 1990.
- Climate Change Science Program (CCSP) Strategic Plan.
- Global Climate Observing System (GCOS) Second Adequacy Report.
- Annual Guidance Memorandum (AGM)
- U.S. Climate Change Research Initiative (CCRI).
- Federal Data Quality Legislation (Act) (Public Law 106-554 Section 515) – section 515.
- 15 USC 313.
- 44 USC 31 PL 81-754 Federal Records Act of 1950
- 33 USC 883B
- 15 USC CH 29 PL 95 - 357 National Climate Program Act.
- National Archive and Records Administration (NARA) Regulations and Guidelines.
- NOAA Program Review Team (PRT) #38.

For Ecosystem Goal Activities:

- Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) – § 404
- National Coastal Monitoring Act (Title V of the Marine Protection, Research, and Sanctuaries Act) – 33 U.S.C. § 2803.

- National Marine Sanctuaries Act (NMSA) – 16 U.S.C. *Id.* at § 1440.
- The Water Resources Development Acts (WRDA) of 1996 and 2000
- Interagency Agreements between NOAA and the South Florida Water Management District
- Interagency Agreement between NOAA and the St. Johns Water Management District
- Interagency Agreement between NOAA and Brevard County
- Interagency Agreement between NOAA and U.S. EPA
- Special Studies Agreement – For the Design and Planning of a Coastal Studies Program executed between NOAA/AOML and the Florida Water Environment Association Utility Council. Approved July 2003.
- Permits - Issued to the Port of Miami by the Army Corps of Engineers, Jacksonville District, specifying that dredge disposal is permitted only when and if specifically approved by a real-time monitoring data and analysis to be provided by AOML.

For Weather and Water Goal Activities:

- Weather Service Organic Act, USC15, Chapter 9, Section 313
- Reorganization Plan No. 2 of 1965. Citation 3 CFR May 13, 1965 Section 3
- Reorganization Plan No. 4 of 1970. Citation: Department Organization Order 25-2A
- Global Change Research Act of 1990. Citation: Public Law 101-606 (November 11) 104 Stat. 3096-3104
- Weather Service Modernization Act of 1992, Public Law 102-567, title VI
- Coastal Zone Management Act 1972
- U.S. Weather Research Program (USWRP) Authorization Act
- Federal Response Plan (April 1999 – All-Hazards NWR) and Recovery Function to the Federal Response Plan (January 2003)
- Federal Plan for Meteorological Services and Supporting Research PL87-843 (1963), Federal Coordinator for Meteorology FCM-P1-2002
- National Polar Orbiting Operational Environmental Satellite System (NPOESS) Integrated Operational Requirements Document (IORD) II (December 10, 2001)