



Introduction and Overview



1.1 Mission and contributions to NOAA

The mission of the Climate Diagnostics Center (CDC) is to advance understanding and predictions of weather and climate variations on time scales ranging from a week to centuries. To achieve its mission, CDC develops and applies a wide range of research methods, particularly emphasizing state-of-the-art diagnostic techniques, to elucidate fundamental processes governing climate phenomena such as droughts, floods, and the El Niño-Southern Oscillation (ENSO), and to identify the causes of longer-term (decadal to centennial) climate variations. CDC also performs extensive intercomparisons of observational and climate model data, an activity essential for improving current research and prediction models.

The development of improved environmental forecast and warning capabilities enhances the Nation's economic and environmental security, and is a fundamental part of NOAA's mission. CDC contributes directly to NOAA's mission through a coordinated program of observational, diagnostic and modeling studies aimed at significantly advancing understanding and predictions of climate variations. Diagnostic studies, for which CDC has exceptional breadth and expertise, vitally contribute to this process by link-

ing basic observational and theoretical research on climate processes to improvements in operational climate predictions and, ultimately, to the development of new climate products that better serve the public and decision-makers. NOAA Strategic Plan elements directly addressed by CDC research include: 1) Implementing seasonal to interannual climate forecasts; 2) Predicting and assessing decadal to centennial changes; and 3) Advancing short-term forecast and warning services.

1.2 Background and organization

The NOAA Climate Diagnostics Center was formed in 1993 through a Memorandum of Agreement (MOA) between the Environmental Research Laboratories (ERL) and the Office of Global Programs (OGP), with personnel derived from what had formerly been the Climate Research Division of the Climate Monitoring and Diagnostics Laboratory. The purpose of the ERL-OGP agreement was to establish a unique, focused center of expertise within NOAA to develop and apply diagnostic methods that would (i) aid in understanding the dominant processes influencing climate variability, and (ii) link observational analyses to model testing and evaluation. Under the terms of the MOA, CDC is managed as one of the Environmental Research Laboratories in NOAA's Office of Oceanic

and Atmospheric Research (OAR). The Center is staffed jointly by NOAA personnel and affiliated scientists from the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES).

CDC research activities are broadly organized by NOAA Strategic Plan goals to ensure a continuing focus on NOAA's mission and to provide an enhanced ability to respond to critical NOAA research requirements. Major Strategic Plan elements for which CDC has active research efforts include: 1) Implementing seasonal to interannual climate forecasts (diagnostic, modeling, and predictability studies); 2) Predicting and assessing decadal-to-centennial changes (diagnostic, modeling and satellite studies); 3) Advancing short-term forecast and warning services (diagnostic, modeling and observational studies of low-frequency variability and extreme events); 4) Providing environmental information, including a) climate impacts and outreach, and b) climate data set development and management.

Research activities at CDC are organized under the following themes: 1) Intraseasonal to Interannual Climate Research, including Modeling and Prediction and Empirical and Process Studies; 2) Decadal-Centennial Climate Research; 3) Hydrologic-Cycle Research; and 4) Human Dimensions. Chapters 2-6 provide reviews of specific activities under each of these themes, and chapter 9 includes an organizational chart and list of CDC personnel.

1.3 Research linkages

The NOAA Climate Diagnostics Center collaborates closely with the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES) in several areas of climate research, most extensively in observational and model diagnostic studies. Approximately fifty CIRES staff are directly affiliated with the CDC and participate in joint research efforts. In order to more explicitly recognize this large and focused set of joint activities, a new University Center within CIRES, also named the Climate Diagnostics Center, has been formed in this past year. This new organization better integrates and coordinates climate research in NOAA/ERL and CIRES with other existing University research and instructional programs, thereby enhancing prospects for mutually beneficial collaborations among NOAA and University scientists over a broad range of climate-related disciplines.

Specific goals of ongoing NOAA-CIRES CDC joint research projects include: (i) identifying key processes contributing to extreme short-term climate events, including major droughts and floods; (ii) advancing understanding and predictions of ENSO; (iii) developing new diagnostic techniques to improve determinations of fundamental atmospheric quantities, such as atmospheric heating distributions; (iv) improving monitoring and descriptions of climate variability with both surface and satellite data; (v) diagnosing general circulation and operational prediction model data to identify areas where model improvements are needed; (vi) identifying major patterns of climate

variability on decadal and longer time scales; (vii) investigating the role of ocean-atmosphere interactions in modulating longer-term variability; and (viii) improving interactions and communications with potential external users in areas such as water management, fisheries, and hazards reductions to increase the value to society of climate analyses and predictions.

CDC also conducts joint climate research with scientists at other universities and national laboratories, and collaborates closely with the National Centers for Environmental Prediction (formerly the National Meteorological Center) on projects aimed at improving climate analyses, medium-range weather forecasts and seasonal-to-inter-annual climate predictions. Particularly strong interactions exist with the Geophysical Fluid Dynamics Laboratory through the University Consortium project and with NCEP through the Coupled Model and Reanalysis projects. In addition, CDC has recently established a Memorandum of Agreement with the Experimental Climate Prediction Center of the Scripps Institution of Oceanography to promote and establish closer collaborations in climate research and related applications.

CDC is also one of seven Applied Research Center (ARCs) within the Climate Dynamics and Experimental Prediction Program of NOAA's Office of Global Programs. The central paradigm of ARCs is a system of closely linked centers focusing on applied climate research, with a major unifying goal being to improve predictions of the climate system on time scales ranging from a season to decades. CDC scien-

tists are centrally involved in major ARC activities, and have developed numerous collaborations throughout the ARC network (a detailed list of CDC collaborations is provided in Chapter 10).

1.4 Some significant accomplishments

Diagnostic studies play a fundamental role in linking together various disciplines, including observations, theoretical studies, modeling, predictions, and, ultimately, applications. Many CDC activities reflect this cross-disciplinary nature. Some examples of significant CDC accomplishments include:

- Contributing to fundamental scientific understanding of the ENSO phenomenon, and identifying characteristic regional and global-scale climatic responses to ENSO.
- Contributing to the development, assessment and improvement of models now used in seasonal climate predictions, including the NCEP operational ocean-atmosphere forecasting system.
- Providing fundamental scientific understanding of the dynamics of atmospheric low-frequency variability and of tropical-extratropical interactions.
- Pioneering the development of the Comprehensive Ocean-Atmosphere Data Set (COADS), which includes surface marine data and derived products for the period from 1854-1995. This dataset is a national resource for historical weather observations over the world oceans, and is widely used throughout the world as the benchmark dataset for global surface marine data.

- Leading efforts in the use of water vapor observations from the NOAA series satellites for climate and global change research. This work has led to a re-examination of the effects of water vapor feedback in climate change models and to improved uses of water vapor information in numerical weather predictions.

A comprehensive review of CDC research activities from 1993-97 is provided in the following chapters.

1.5 Future directions

CDC will continue its role as a focused center of expertise within NOAA for developing and applying diagnostic analyses in climate research. This work will increasingly involve intercomparisons of observational and climate model data, an activity essential for improving research and prediction models.

Vigorous CDC research activities will continue in specific areas where CDC has special expertise and is providing major contributions to NOAA's mission. Such areas include:

- Diagnostic and modeling studies to improve understanding and predictions of intraseasonal low-frequency variability.
- Studies to advance fundamental scientific understanding of ENSO and, more generally, the roles of ocean-atmosphere interactions in both the tropics and extratropics in interannual to multi-decadal climate variability.
- Model diagnostic and predictability studies to develop, assess and improve

numerical models used in weather and climate analyses and in seasonal climate predictions, particularly the NCEP ocean-atmosphere forecasting system.

- Applications of NOAA series satellite data for climate and global change studies, particularly emphasizing the role of water vapor in climate variability.

Proposed new areas for research include:

- Development of advanced-lead forecasts of severe large-scale weather and climate events.

The fundamental objective of this effort is to increase NOAA's lead time capabilities for providing watches and warnings of large-scale severe weather and climate events. This objective includes 1) increasing the skill and utility of forecasts on time scales ranging from approximately five days to a season, and 2) developing new products to provide forecasts and warnings for severe large-scale weather and climate events.

Achieving this objective requires an inclusive research strategy that effectively bridges the gap between short-range "weather" and longer-term "climate" in NOAA's research and operational activities. It includes the development of new products that generalize and extend NOAA's current operational prediction capabilities for high impact weather, such as severe convective storms, flash floods and hurricanes, to longer time scales and to a broader class of phenomena, including large-scale floods, droughts, heat waves and cold waves.

Major program components include: 1) enhanced real-time monitoring and analysis capabilities of severe large-scale events and weather-related disasters; 2) the development and application of dynamical and statistical prediction techniques to provide advanced warning capabilities of large scale severe weather events, with particular emphasis on ensemble forecast methods using NOAA's numerical weather prediction and climate models; and 3) development of operational forecast products to advance NOAA's warning capabilities on large-scale severe weather and climate events. It is proposed that this work be carried out jointly as an OAR-NWS collaboration involving CDC, the Geophysical Fluid Dynamics Laboratory, and NWS/NCEP Climate Prediction Center and Environmental Modeling Center.

- Development of a research program on climate variability and western water resources.

The effect of climate variability on water resources is an issue of vital national interest. The western U.S. is especially vulnerable to the effects of climate variations on water quantity and quality, due to its relative aridity, intensity of water management, and fragility

of vegetative cover. As the population of this region continues to increase, the ability of society to respond to climate-induced variations in water quantity and quality will become increasingly crucial to sustaining the economic well-being of the region.

In order to better anticipate and adapt to the needs of society for clean and plentiful water, CDC proposes to collaborate with the University of Colorado and other organizations to develop an intensive new multi-disciplinary research program focusing on climate variability and its effects on water resources in the western United States. Coordination of research efforts is proposed among scientists in several different, water-related disciplines, including the fields of meteorology, hydrology, cryospheric processes, biology, ecology, and social sciences (human dimensions). Proposed research sub-themes include: 1) Climate and Weather Variations (Analysis and Prediction); 2) Water Cycle in the West; 3) Water Quality and Ecosystems; and 4) Relationships between Water and Society. The proposed approach is to focus efforts on comprehensive analyses for two to three of the principal river basins within the western United States.

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