
CHAPTER 1



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, 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 vital to improving current research and prediction models.

The development of improved climate assessments and predictions enhances the Nation’s economic and environmental security, and is a fundamental part of NOAA’s mission. Diagnostic studies, for which CDC has exceptional breadth and expertise, vitally contribute to this process by linking basic observational and theoretical research to improvements in operational climate predictions and, ultimately, to the development of new cli-

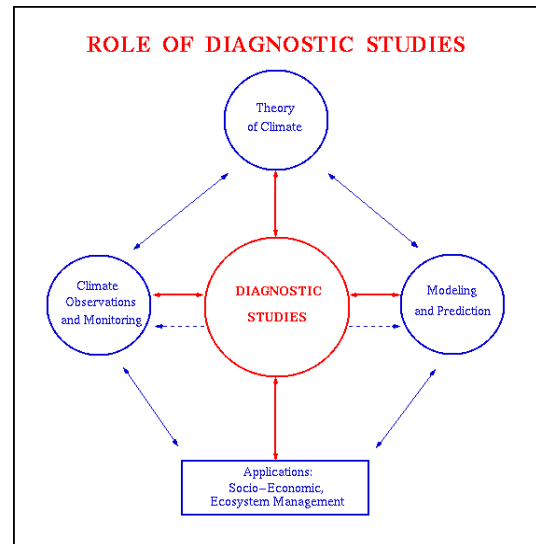


Fig. 1.1 Illustration of the linkages between diagnostic studies and other climate disciplines.

mate products that better serve the needs of the public and decision-makers (**Fig. 1.1**). NOAA Strategic Goals 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

Office of Oceanic and Atmospheric Research (OAR) 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 OAR-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 Research Laboratories in OAR.

CDC is staffed by NOAA personnel and affiliated scientists from the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES), with approximately forty CIRES staff and fourteen federal staff directly affiliated with the CDC. In order to more explicitly recognize this large and focused set of joint activities, a University Center within CIRES, also named the Climate Diagnostics Center, was formed in 1997. This organization integrates and coordinates climate research in NOAA/OAR 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 disciplines.

Specific goals of ongoing CDC research include: (i) identifying key processes contributing to extreme short-term climate events, including major droughts

and floods; (ii) advancing understanding and predictions of El Niño-Southern Oscillation, other major modes of climate variability and their global and regional impacts; (iii) developing new diagnostic techniques to improve determinations of fundamental atmospheric quantities, such as atmospheric heating; (iv) improving monitoring and descriptions of climate variability; (v) diagnosing general circulation and operational prediction models to identify areas where model improvements are needed; (vi) identifying sources for climate variability on decadal and longer time scales and assessing to what extent they may be predictable; (vii) investigating the role of ocean-atmosphere interactions in modulating longer-term variability; (viii) developing new approaches, including stochastic methods, for climate diagnostics and predictions; and (ix) improving interactions and communications with potential external users in areas such as water, energy, and environmental resources management, in order to increase the value to society of climate analyses and predictions.

CDC also conducts joint climate research with scientists at other universities, NOAA research laboratories and other national laboratories, and with the National Centers for Environmental Prediction on projects aimed at improving medium-range weather forecasts, seasonal-to-interannual climate predictions, and developing new climate products. Strong and growing interactions exist with the Geophysical Fluid Dynamics Laboratory in climate model diagnostics, and with NCEP Climate Prediction Center and Environmental Modeling Center

on real-time diagnostics, seasonal climate predictions and the development of experimental medium-range and seasonal climate forecasts. CDC also is one of five Applied Research Centers (ARCs) within the Climate Dynamics and Experimental Prediction Program of the Office of Global Programs. The ARCs serve as a system of linked centers focusing on applied climate research, with a major unifying goal being to improve predictions of climate on time scales ranging from a season to a decade. CDC is one of the central contributors to ARC research, and CDC scientists have developed collaborations across the ARC network. Important objectives of ARC research include supporting the development of improved forecast capabilities and experimental climate products for applications by NCEP, the International Research Institute for Climate Prediction (IRI), and regional assessments projects funded by the NOAA Office of Global Programs. In addition, CDC collaborates extensively with CIRES and other University of Colorado partners in an OGP-supported regional assessment of Water, Climate and Society in the Interior Western United States.

1.3 Research themes

CDC research is organized into three principal themes: 1) Intraseasonal-to-Interannual Climate Research, including modeling and prediction research and empirical and process studies; 2) Decadal-to-Centennial Climate Research; and 3) Experimental Climate Services. Chapters 2–6 provide reviews of recent research accomplishments in these areas;

chapter 7 describes CDC's computing, network, web, and data services; chapter 8 lists CDC publications since 1997; and chapter 9 provides an organizational chart and list of current CDC personnel associated with each of these areas.

The first two themes directly support the long-term NOAA Strategic Goals to "Implement Seasonal to Interannual Climate Forecasts" and "Predict and Assess Decadal to Centennial Climate Change". Research within the first theme extends down to sub-seasonal time scales in order to address emerging research priorities linking climate and weather. The third theme was developed to support future requirements for NOAA's Climate Services, which in FY01 was supported as a new program. Research in this third component focuses on the climate-society interface, and particularly on how interactions between scientists and decision-makers can accelerate development of more useful climate products, and thereby improve the value of the climate information that NOAA will provide to address a broad range of social, economic, and environmental issues.

All of the above themes involve ongoing, long-term research that is central to NOAA's mission. Within the general themes, specific research foci are adjusted as needed to meet current mission requirements or anticipated future priorities. For example, over the past few years, CDC has placed increasing emphasis on developing new capabilities for forecasting climate probability distributions, including the likelihood of extreme events. This enhanced research

emphasis has led to new advances in ensemble prediction methods, the development of new stochastic approaches to modeling and predicting climate variability, and new experimental forecast products. CDC is also gradually redirecting resources to increase research into the mechanisms and predictability of decadal-to-centennial climate variability and assessment of long-term climate change, including diagnosis of GFDL models used to study climate change in response to human-induced forcings.

1.4 Future directions

CDC will continue its role as a focused center of expertise within NOAA for developing and applying diagnostic analyses to address fundamental climate problems. This work will increasingly involve intercomparisons of observational and climate model data, an activity central to improving climate models.

Continuing key research areas

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

- Diagnostic and modeling studies to improve understanding and predictions of intraseasonal variability.
- Studies to advance fundamental scientific understanding of El Niño-Southern Oscillation (ENSO) and, more generally, the roles of ocean-atmosphere interactions in both the tropics and extratropics

in interannual to multi-decadal climate variability.

- Model-based research to assess and improve climate models used in analyses, short-term climate predictions and climate change projections, with particular emphasis on NCEP operational prediction models and GFDL climate models. Increasingly, advances in this area require expertise in understanding and diagnosing fundamental physical processes, such as convection, cloud-radiation interactions, and land surface-atmosphere interactions, and the use of ensemble methods for analyses and predictions.
- Development of stochastic approaches for climate modeling, parameterization, and prediction.

Emerging research thrusts

Emerging areas of new research are strongly motivated by a few overarching questions that CDC is well-positioned to address, including:

- What are the links between climate variability and weather, particularly extreme events such as floods, droughts, and hurricanes, and how might these links be exploited to develop new and more useful NOAA climate forecast products?
- What are the relationships between short-term climate phenomena such as El Niño, decadal variability, and global change, and to what extent do these relationships offer prospects for improved

understanding and predictions of regional climate variability and change?

- How can climate information and products be improved to increase societal benefits and mitigate potential adverse impacts related to climate variability and change?

Corresponding emerging areas for CDC research include:

- *Improving understanding and predictions of the links between climate and extreme weather events.*

Our fundamental objective is to increase NOAA's lead-time capabilities for providing watches and warnings of large-scale severe weather and climate events. Research goals include increasing the skill and utility of forecasts on time scales ranging from approximately ten days to a season, and developing new products that extend NOAA's current operational prediction capabilities for high impact weather and climate events. This research supports the NWS operational objective to create an integrated suite of forecast products spanning time scales from minutes to years in advance. The FY01 budget includes new funding in this area under the Climate Observation and Services line, based on an Initiative developed in part by CDC.

- *Improving understanding and forecasts of sub-seasonal tropical-midlatitude interactions.*

The fundamental goal is to improve NOAA's weather and climate forecasts

through advances in observations, analyses, understanding, and modeling of sub-seasonal tropical-midlatitude interactions and their regional impacts on the U.S. This area builds on research indicating that sub-seasonal tropical variability, such as the Madden-Julian Oscillation, can modulate mid-latitude sub-seasonal weather variability in a manner somewhat analogous to El Niño's effects on seasonal climate, and on other work indicating that current models are severely deficient in simulating this tropical variability. An FY02 Initiative in this area has been developed jointly between CDC and ETL, and is a component within the NOAA FY02 Climate Observations and Services budget currently before Congress.

- *Conducting regional integrated science and assessments research.*

It has become increasingly clear that, to be useful for many applications, climate information and forecasts must be provided at regional-to-local scales. Accordingly, CDC will devote increased emphasis on assessing predictability and developing new climate products at regional scales, with the interior western U.S. serving as one focus for development and evaluation. This physical science research will be coordinated with ongoing social science assessments designed to identify current and possible future uses of climate information and forecasts, and to clarify the relationships between climate, society and ecosystems in this highly climate-sensitive region. The initial stages of this research have been funded through the OGP regional

assessments program as a joint project between CDC and CIRES. CDC will also participate in and assist other regional assessment projects, as well as the International Research Institute for Climate Predictions (IRI), to fully exploit our climate diagnostic expertise in addressing other fundamental regional climate problems.

- *Increasing CDC research on the connections between short-term climate variability and decadal-to-centennial variability and change.*

One of the critical issues facing society is understanding, and potentially predicting, the links between short-term and long-term climate variability and change. The issue is paramount if we are to minimize the possibility of “climate surprises” as well as identify potential impacts of longer-term climate variability on ecosystems and society. Toward this end, CDC has been redirecting some of its resources toward longer-term climate issues, and is also establishing stronger linkages with GFDL (and other climate modeling institutions) to clarify mechanisms for longer-term climate variability and change. Increasing emphasis in this area is likely to continue over the next several years.

Linkages

The above issues are not independent, and we envision considerable coordination among activities. Likely foci will include the western U.S. as a testbed for evaluating climate forecasts and other experimental regional climate products, and the Pacific sector as a major focus

region for evaluating mechanisms for producing climate variability, particularly coupled atmosphere-ocean and tropical-extratropical interactions. Such efforts will also enable coordination with other research programs that are planned in these areas over the next decade under the auspices of programs such as CLIVAR and GEWEX.

In addition to the above areas, over the next 5-10 years CDC envisions opportunities to expand its research to help contribute toward addressing several problems of major societal importance. Much of this work is fundamentally interdisciplinary in nature, and will require collaborations with other research organizations within and outside NOAA. Examples include climate and air quality, climate and human health, and climate effects on ecosystems, including marine resource management in support of NOAA’s fundamental environmental stewardship mission. Pilot efforts in some of these areas are already underway.