

## CLIMATE CHANGE SCIENCE PROGRAM

Climate has a pervasive effect on the U.S. through its impact on the environment, natural resources, and the economy. To respond to the challenge of understanding climate and climate variability, the Climate Change Science Program (CCSP) was established in 2002 ([www.climatescience.gov](http://www.climatescience.gov)) as a follow-on to the US Global Change Research Program (USGCRP). It is providing the Nation and the world with the science-based knowledge to predict change, manage risk, and take advantage of opportunities resulting from climate change and climate variability. Research conducted through CCSP builds on the scientific advances of the last few decades and deepens our understanding of how the interplay between natural factors and human activities affect the climate system. The CCSP engages thirteen U.S. agencies in a concerted interagency program of basic research, comprehensive observations, integrative modeling, and development of products for decision-makers. Consistent with the FY 2009 Interagency Implementation Priorities memo, NSF provides support for the broad range of fundamental research activities that form a sound basis for other mission-oriented agencies in the CCSP and the Nation at large.

The Earth's climate is determined by highly complex interactions between and among the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere. NSF programs address these components by investing in fundamental discovery, utilizing the full range of intellectual resources of the scientific community; research infrastructure, to provide advanced capabilities; and innovative educational activities. As a key participating agency in the CCSP, NSF encourages interdisciplinary activities and focuses particularly on Earth system processes and the consequences of change. High priorities for the agency include data acquisition and information management activities necessary for global change research, the enhancement of models designed to improve our understanding of Earth system processes, the development of new, innovative Earth observing instruments and platforms, and the development of advanced analytic research methods. NSF also supports fundamental research on the general processes used by organizations to identify and evaluate policies for mitigation, adaptation, and other responses to varying environmental conditions. Through its investment, NSF contributes to CCSP by providing a comprehensive scientific foundation for many of the synthesis and analysis products identified in the CCSP Strategic Plan.

### Climate Change Science Program Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request
Biological Sciences	\$15.10	\$15.10	\$15.10
Engineering	1.00	1.00	1.00
Geosciences	157.72	157.72	164.72
Mathematical and Physical Sciences	6.81	5.45	6.00
Social, Behavioral and Economic Sciences	15.50	15.48	15.48
Office of Polar Programs	10.50	10.50	18.30
<b>Total, Climate Change Science Program</b>	<b>\$206.63</b>	<b>\$205.25</b>	<b>\$220.60</b>

Totals may not add due to rounding.

### FY 2009 Areas of Emphasis:

**Atmospheric Composition** – NSF programs in tropospheric and stratospheric chemistry will continue in FY 2009 to address the composition of the atmosphere and its relation to climate variability and change, and linkages between the atmosphere and the biosphere, land surface, oceans, and cryosphere. Studies of the transport and transformation of gaseous constituents and aerosols provide insights into the radiative and cloud nucleating properties of the atmosphere. Greenhouse gases are particularly important since

they are the principal absorbers and re-radiators of heat. Results of these studies serve as important inputs for the assessment reports of the Intergovernmental Panel on Climate Change (IPCC).

**Climate Variability and Change** – In FY 2009, NSF programs will continue to emphasize climate variability and change across temporal and spatial scales, supporting observational campaigns and numerous analytical and modeling activities. These activities will help to address biases in global climate models. Ocean science efforts will concentrate on changes in ocean structure, circulation, and interactions with the atmosphere to improve our current understanding of the processes and models that address future changes, particularly those that may happen abruptly. The Community Climate System Model will continue to improve by incorporating additional complexity so that the model will better incorporate aerosol radiative forcing, stratospheric dynamics, interactive chemistry and biogeochemical cycles. Analyses of model output will focus on extreme climate events, such as hurricanes, droughts, and major ecological disturbances, in order to determine the mechanisms responsible and to evaluate their representation in models. Studies of paleoclimatology will continue to be supported as a means to provide baseline data on natural climate variability from the past and from key climatic regions. These studies improve our understanding of the natural variability of the climate system and in particular will enable reconstructions and evaluations of past environmental change as inputs for model validations.

**The Global Water Cycle** – NSF supports research to understand all aspects of the global water cycle. Relevant programs will continue to explore ways to utilize more effectively the wide range of hydrologic data types – continuous and discrete information from a variety of platforms – for research purposes. Information from process studies will be used to refine models through parameterizations of sub-grid processes, particularly the fluxes of water through the Earth system. High resolution cloud system models are being refined to address the persistent problems of moist convection and cloud processes – two of the more challenging and uncertain components in climate change calculations. Fifteen prototype observatories are being established to explore critical scientific issues related to the design of hydrologic observatories. The first established observatory is part of the Sustainability of Semi-arid Hydrology and Riparian Areas (SAHRA) Science and Technology Center and works with stakeholders in translating research advances into useful products and addressing uncertainty.

**Land-Use and Land-Cover Change** – Several NSF programs continue to address key aspects of land-use and land-cover change through studies in ecological rates of change and related species diversity, Arctic systems, temporal variability, water and energy influences on vegetative systems, and diverse human influences on land use.

**Global Carbon Cycle** – NSF provides support for a wide variety of carbon cycle research activities, for critical long-running oceanic time series stations and the Keeling CO<sub>2</sub> record, as well as for planning and data management. FY 2009 investigations will continue to examine a range of topics in terrestrial and marine ecosystems and their relations to the carbon cycle. Research in terrestrial settings will explore, for example, carbon storage, delivery of carbon by rivers, carbon fluxes from high-latitude soils, carbon export from mountains, and submarine groundwater discharge in the oceans, ocean acidification and remineralization in mesopelagic zones. Carbon cycle studies will integrate observational data into models to provide insights for understanding key aspects of the global carbon cycle and feedbacks on the climate system and on strategies to investigate and adapt to climate change through CO<sub>2</sub> sequestration.

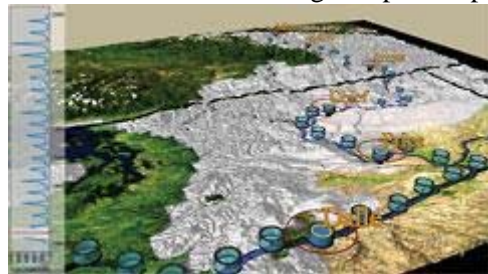
**Ecosystems** – Several NSF programs address terrestrial and marine ecosystems through observational, experimental, modeling, and laboratory studies. The Long Term Ecological Research (LTER) Program supports the collection of time-series data on key ecosystem processes and funds research on the drivers of ecosystem change in terrestrial and marine systems. The Global Ocean Ecosystem Dynamics program

will continue to study the impact of global ocean changes on marine ecosystems through specific synthesis activities focused on the North Atlantic and the North Pacific. Research will continue to focus on understanding the impact of increasing carbon dioxide levels on the calcification rates, productivity and symbiotic relationships of hermatypic (reef-building) corals.

**Human Contributions and Responses** – NSF supports basic research on the processes through which people (individually, in groups, or through organizations) interact with natural environmental systems. FY 2009 funding supports projects that focus on decision-making under uncertainty associated with climate change. These projects are expected to produce new knowledge and tools that should facilitate improved decision-making by various stakeholder groups trying to deal with uncertainties associated with future climate variability and change.

### Recent Research Highlights

► **Climate Change Impacts on Water Supply:** Climate scientists from the Scripps Institution of Oceanography and the Lawrence Livermore National Laboratory are collaborating with researchers from the NSF-funded San Diego Supercomputer Center to ascertain how global climate change is affecting



Supercomputer predictions of climate change impact on water flow in the Columbia River.  
Credit: Amit Chourasia, SDSC/UCSD.

water supply in the western U.S. The scientists first run a model of the global climate on supercomputers, "zoom in" to see the impact in the western U.S., and analyze the findings and verify the model accuracy by comparing results with real-world observations. Scientists are challenged with how to handle large amounts of generated data--many terabytes (a terabyte is one thousand gigabytes). To manage the data, move it between institutions, and share it, researchers are using a special tool, called the "Storage Resource Broker," developed by the San Diego Supercomputer Center.

► **Advancing U.S. Leadership in Climate Research and Education:** Project Atmospheric brown clouds (ABC) is a concerted effort among an international group of distinguished atmospheric scientists and researchers, governments in Asia, and research institutions in Asia, Europe, and the United States to address the causes and impacts of atmospheric brown clouds, which are a major environmental challenge facing the Asia-Pacific region. Unlike issues such as greenhouse gases and global warming, the effects on climate from pollution aerosols and other impacts are universally accepted throughout Asia. Project ABC provides high visibility for the United States in its leadership role on climate research and education in the South and Asia-Pacific region, which is home to more than half of the world's population.



ABC Training School at Hanimaadhoo, Maldives. Credit: V. Ramanathan.

► **Long-Term Study Leads to Elegant Understanding: Nitrogen**

**Cycling:** The release of nitrogen from decaying roots and leaves into the soil provides plants with this essential nutrient. Analyses of data from a ten-year study in 21 diverse ecosystems indicate that the amount of nitrogen released into the soil is almost universally controlled by the same two factors: the initial concentrations of nitrogen and the mass of remaining organic matter in the decaying roots and leaves. This finding led to the formulation of simple equations for modeling nitrogen release that are applicable to almost every type of ecosystem. By simplifying the calculation of nitrogen release, these equations will improve our understanding of plant growth and therefore improve the accuracy of carbon uptake calculations in global climate models.



Three types of bags were used in the Long-Term Intersite Decomposition Experiment. The mesh size on each bag varied to exclude different organisms from decomposing the leaves or roots in the bag. *Credit: Mark Harmon*