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) as a follow-on to the acclaimed 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. 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 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Amount	Change over FY 2007 Percent
Biological Sciences	$15.10	$15.10	$15.10	-	-
Engineering	1.00	1.00	1.00	-	-
Geosciences	149.35	157.72	160.72	3.00	1.9%
Mathematical and Physical Sciences	5.45	5.45	5.45	-	-
Social, Behavioral and Economic Sciences	15.48	15.48	15.48	-	-
Office of Polar Programs	10.50	10.50	10.50	-	-
Total, Climate Change Science Programs	$196.88	$205.25	$208.25	$3.00	1.5%

Totals may not add due to rounding.

FY 2008 Areas of Emphasis:

Atmospheric Composition – NSF programs in tropospheric and stratospheric chemistry will continue in FY 2008 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 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

Climate Variability and Change – As a major focus in FY 2008, NSF programs will continue to emphasize climate variability and change across temporal scales. This research element supports observational campaigns and numerous analytical and modeling activities. 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. Major support will continue to permit the Community Climate System Model to improve model physics and parameterizations. Work continues to add additional complexity to the models so that they will better incorporate interactive chemistry and biogeochemical cycles. 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 a broad-based effort 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 time and space information from a variety of platforms – for research purposes. Information from process studies will be used to refine models through scaling and parameterizations of sub-grid processes, particularly the fluxes of water through the Earth system. Highly resolving models with cloud system processes models are being refined to address the persistent problem of moist convection and cloud processes – two of the more challenging and uncertain components in climate change calculations. Several prototype hydrologic observatories are being established through Science and Technology Centers that work with stakeholders responsible for water management who translate research advances into useful products, particularly on issues related to decision-making in the face of uncertainty as applied , for example, to the urbanizing and drought-prone Southwest.

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 – FY 2008 funding supports a wide variety of carbon cycle research activities. Investigations will 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, biotic and abiotic carbon cycling, and the upper ocean carbon budget are important issues to be addressed. 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.

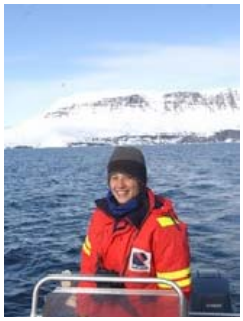
Ecosystems – Several NSF programs address terrestrial and marine ecosystems through observational, experimental, modeling, and laboratory studies. The Long Term Ecological Research (LTER) Program supports the collection of time-series data on key ecosystem processes and funds research on the drivers 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 2008 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

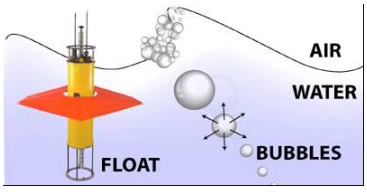
► **Arctic Cetaceans – Indicators of Climate Change:** The Arctic is currently experiencing dramatic changes in sea ice characteristics and marine productivity. The behavioral patterns, life history and ultimate existence of arctic cetaceans – mammals most fully adapted to aquatic life – are tightly linked with changes in the arctic environment. For this reason, they are both vulnerable to climate alterations, and are good indicators of cumulative changes.



Dr. Kristin Laidre in May 2005 in West Greenland during field work under the International Research Fellowship Program. *Credit: Kristin Laidre.*

Kristin Laidre, an early career researcher at the Greenland Institute of Natural Resources, investigated the vulnerability of arctic cetaceans to climate change by examining three species of cetaceans: the narwhal, beluga, and bowhead whales. The whales, which inhabit the arctic waters of West Greenland, are ideal for monitoring biophysical changes impacted by a warming climate.

Laidre measured the trends in sea ice and primary production using satellite telemetry data (the use of transmitters to track wildlife) on whale movements and diving behavior and remotely-sensed environmental data. Her work has facilitated the understanding of the potential effects of climate change on arctic marine mammals and led to the development of an index that ranks the mammals' vulnerability to these changes. (OISE).



Bubbles created by breaking surface waves, carried downward by currents and dissolving at about 10m depth supersaturated the ocean in oxygen and nitrogen. *Credit: Eric D'Asaro, UW/APL.*

► **Enhanced Gas Exchange between the Ocean and Atmosphere under Hurricanes:** Hurricanes and climate may form a vicious circle, some scientists have speculated. Even as global warming produces more hurricanes, they argue, the increasingly frequent hurricanes are churning up the surface of the ocean and releasing dissolved carbon dioxide back into the atmosphere, which enhances the warming.

Now, however, a team of NSF-funded researchers at the University of Washington and the University of Rhode Island have finally been able to test this hypothesis. They have developed a new generation of instrument-bearing floats that can reliably monitor the flux of carbon dioxide from the ocean surface, even in the midst of hurricane-force winds. They have made the first measurements of that flux during major storms, starting with Hurricane Frances in 2004. And they have found that, from a global perspective, hurricanes are *not* important in releasing dissolved carbon dioxide.

The new, air-deployable floats could also help scientists study many other aspects of the ocean in remote locations and in severe weather conditions, including the role of dissolved oxygen and nitrogen in the biological productivity of the ocean. (GEO).