

# RESEARCH PROGRAM: NEAR-TERM PLANS

**Table 2**  
**U.S. Global Change Research Program**

FY 2001 – FY 2002 Budget by Research Program Element  
(Discretionary budget authority in \$millions)

Program Element	FY 2001	FY 2002 Request
Climate Variability and Change	533.0	486.4
Atmospheric Composition	345.6	309.8
Global Carbon Cycle	214.2	221.1
Global Water Cycle	312.6	309.4
Changes in Ecosystems	204.9	199.2
Human Dimensions of Global Change	99.5	107.4
<b>U.S. Global Change Research Program Total<sup>1</sup></b>	<b>1,713</b>	<b>1,637</b>

<sup>1</sup>USGCRP FY 2001 and FY 2002 totals include \$3.1 million for DOE Small Business Innovative Research/Technology Transfer (SBIR/STTR) program.

Because DoD research activities are conducted for defense-related missions, they are not included in this USGCRP budget crosscut. Related DoD research does contribute to USGCRP goals, however.

Operational space-based and in situ observing systems and programs are not included in the USGCRP budget crosscut, but contribute to achieving USGCRP goals.

## Climate Variability and Change

The USGCRP budget includes \$486 million in FY 2002 for research and observations related to understanding climate variability and change. The Earth's prevailing climate is a fundamental element in the well-being of societies and natural systems. Climate strongly affects the viability of agriculture, the distribution and productivity of forests and rangelands, the diversity of flora and fauna, the availability of water, the spread of insects and rodents that carry human disease organisms, the intensity and frequency of floods and severe weather events, and much more. The essential scientific questions about climate system behavior range across all timescales, from seasons and years to decades, centuries, and millennia.

USGCRP-supported research has played a leading role in major scientific advances, which have provided valuable new climate information to the public and decisionmakers. While progress in climate science has been impressive, there remain many unresolved questions about key aspects of the climate system, particularly with respect to certain issues that have major societal implications. For example, improving understanding about the causes of climate change and reducing uncertainty about current and projected future changes is essential to providing a sound scientific underpinning for climate impacts assessments and future policy decisions. We are just now beginning to understand how climate variability and change influence the occurrence and severity of extreme events such as hurricanes, droughts, and floods. We have identified several important patterns of climate variability other than El Niño events, but do not yet know to what extent they are predictable. Our predictive capabilities at local and regional scales show promise in some regions and for some phenomena, but are still inadequate in many instances. We have yet to obtain confident estimates of the likelihood of abrupt global and regional climate transitions, although such events have occurred often in the past and, in some climate model simulations, have been projected to occur during the 21<sup>st</sup> century. And, perhaps most fundamentally, we do not yet have a clear understanding of how climate variability may be modified in the future by human-induced climate changes, particularly on regional and local scales, and how such changes in climate may alter the vulnerability and sustainability of both human and natural systems.

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## Recent Accomplishments

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- Applied climate models to simulate the observed global warming over the past century, in which the warming occurred primarily in two distinct 20-year periods, from 1925 to 1944 and from 1978 to the present. The results showed that while the latter warming is primarily attributable to increases in greenhouse gas (radiative) forcing, the warming of the early 20<sup>th</sup> century could have resulted from a combination of human-induced radiative forcing and an unusually high variability of the coupled ocean-atmosphere system.
- Documented that the heat content of the upper 3000 meters of the Earth's oceans has been increasing since the 1950s. In addition to this warming trend, there is a decadal signature to the variability in many of the oceans that requires improved physical understanding.
- Showed in two studies, each using a different sophisticated climate model, that the ocean warming that has been measured over the last half-century is virtually the same as what would be expected from the observed increase in greenhouse gases and aerosols in the atmosphere.
- Identified an enhanced rate of heating of the Northern Hemisphere tropical oceans. This rapid warming has contributed to unprecedented coral bleaching over the past decade.
- Began deployment of the Argo array of profiling floats in the global oceans. This observational system will increase our capabilities to observe long-term trends in ocean temperatures, currents, and salinity, as well to improve predictions of the influence of events such as El Niño and La Niña on seasonal climate.

- Carried out the first detailed comparisons of cloud-resolving model simulations and single column model results with observational data, based on three years of continuous observations in the Atmospheric Radiation Measurement Program’s Southern Great Plains site. These comparisons give the first detailed look at how cloud parameterizations in climate models actually perform in real atmospheric situations.
- Made accurate, systematic satellite measurements of solar variability, now completed through a full 22-year solar cycle, using the ongoing collection and analysis of data from ACRIMSAT, which was launched in December 1999.
- Deployed the Global Lake Drilling System (GLAD 800) to Lake Titicaca in Bolivia/Peru in an international collaborative research effort to retrieve a 500,000-year record of atmospheric dynamics and climate in this tropical region.
- Recovered an unprecedented record of changing temperature variability from a Himalayan glacier at an altitude of 23,500 feet, showing the last 50 years were warmer than any other equivalent period in the last 1,000 years.
- Submitted to Congress an assessment of climate change titled *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, which was produced by a team of authors operating under the auspices of the Federal Advisory Committee Act. The assessment includes an overview of about 150 pages and a foundation volume that is about 600 pages long.

### Table 3 Climate Variability and Change

FY 2002 Budget by Agency  
(Discretionary budget authority in \$millions)

<b>Scientific Research</b>	
DOC/NOAA	44.8
DOE	70.8
DOI/USGS	4.5
NASA	61.9
NSF	92.4
Smithsonian Institution	2.0
<b>Scientific Research Subtotal</b>	<b>276.4</b>
NASA Space-Based Observations	193.7
NOAA Surface-Based Observations	16.3
<b>Observations Subtotal</b>	<b>210.0</b>
<b>Climate Variability and Change Total</b>	<b>486.4</b>

## Improving the Effectiveness of U.S. Climate Modeling

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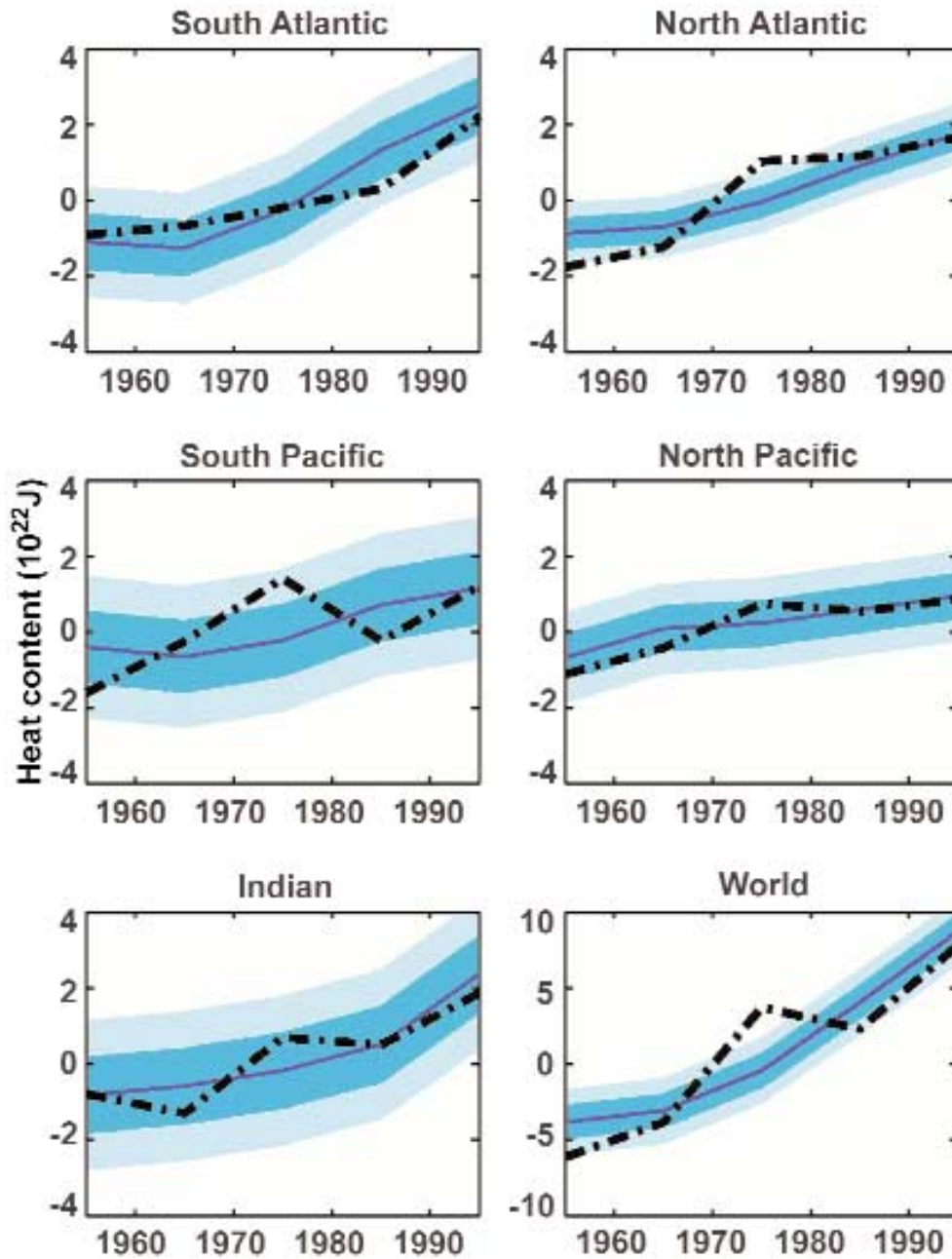
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The USGCRP commissioned the National Research Council (NRC) to prepare two reports to provide guidance on how to further develop U.S. modeling efforts. *Capacity of U.S. Climate Modeling to Support Climate Change Assessment Activities*, was published in 1998. In March 2001 the NRC released *Improving the Effectiveness of U.S. Climate Modeling* as a follow-up. Also, an Ad Hoc Working Group on Climate Modeling, established by the Subcommittee on Global Change Research, released its report, *High-End Climate Science: Development of Modeling and Related Computing Capabilities*, in December 2000. These reports provide valuable guidance on how to improve U.S. climate modeling efforts. They emphasize several findings: 1) the acknowledged U.S. leadership in basic climate science research that feeds both domestic and international modeling programs; 2) current conditions within the U.S. high-end climate modeling structure that impede integrating the basic knowledge into a world-leading climate modeling capability; and 3) the challenges of moving to quasi-operational high-end climate modeling, including software, hardware, human resource, and management issues, and most importantly, the need to establish a dedicated capability for high-end modeling activities.

The USGCRP's immediate challenge is to correct the problems identified in (2) above and develop a strategy and implementation plan for enhancing high-end modeling. Over the longer term, the USGCRP will develop criteria to determine when the national high-end modeling effort has reached a point where it can routinely produce high-quality standard products on demand as was identified in (3) above. Further, the USGCRP must ensure that a productive partnership is maintained between product-driven climate modeling activities and the high-end modeling research program that will ensure its future success.

A number of significant steps have been taken toward addressing the immediate challenge:

- The capability and capacity of computing facilities at several major U.S. modeling centers have been upgraded or are scheduled for upgrade.
- Common modeling frameworks are being developed to help ensure that software advances can be more readily shared among centers and laboratories.
- Investigation of the suitability of distributed memory, high-end computers for climate modeling is underway.



**Figure 1. Ocean Warming Since the 1950s**

Decadal values of anomalous heat content ( $10^{22}$  J) in various ocean basins. The heavy dashed line is from observations, and the solid line is the average from five realizations of the state-of-the-art Parallel Climate Model forced by observed and estimated anthropogenic forcing. Both curves show significant warming in all basins since the 1950s.

Source: Barnett, et al. *Science*, 13 April 2001. See Appendix B for additional information.

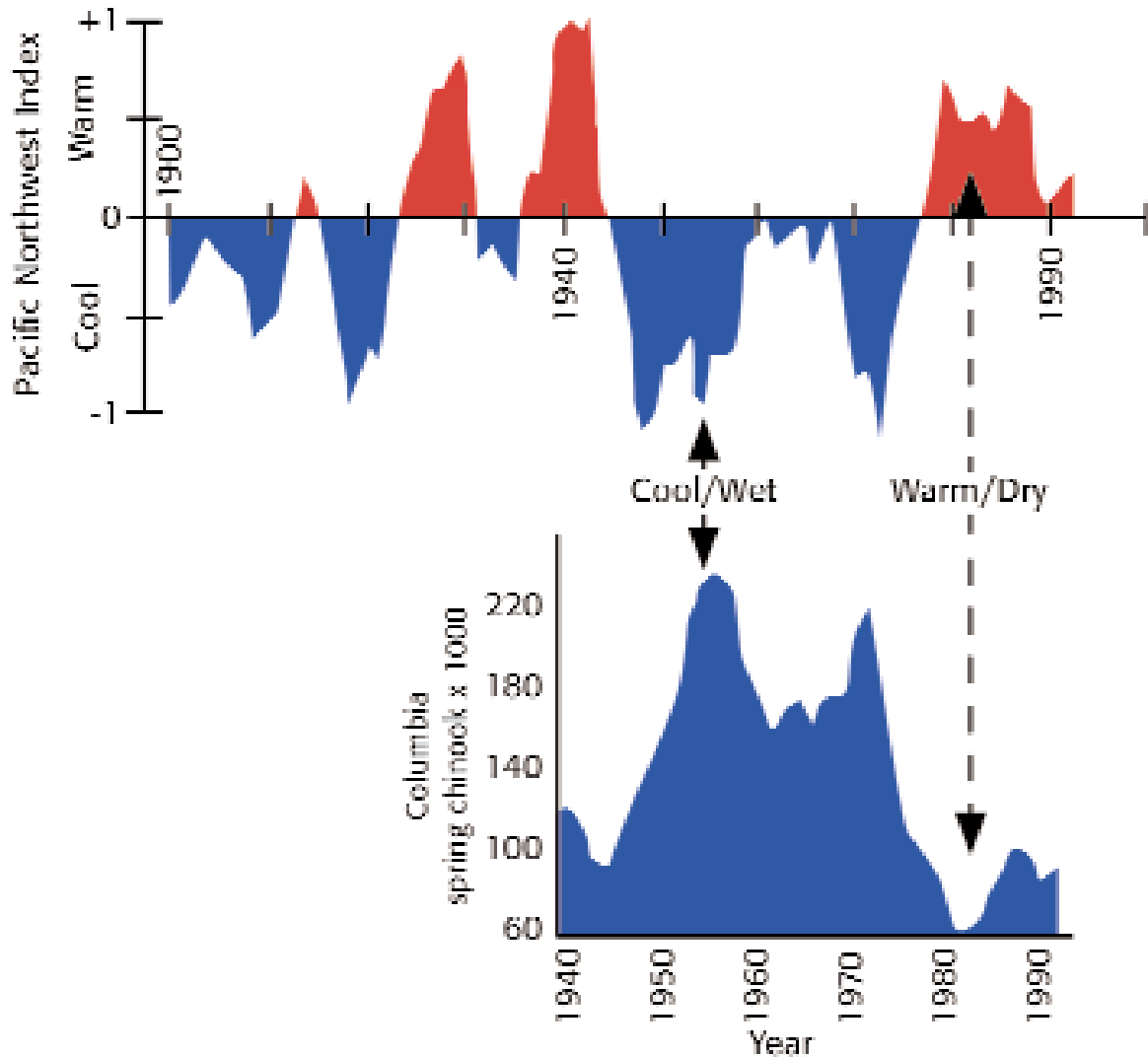
## FY 2002 Plans

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The USGCRP will continue to enhance observational and modeling capabilities for improved understanding, prediction, and assessment of climate variability and change on all timescales. Key research goals for FY 2002 include:

- Enable more realistic climate simulations and more confident climate projections by making the next generation of the Community Climate System Model (CCSM-2) available to scientists for research and assessment applications. The model will have improved ocean, atmosphere, sea ice, and land surface components. Major software engineering improvements to the CCSM-2 system will enable significantly more rapid scientific development and testing because the model (and model components) will be easier to use and computationally more efficient.
- Improve the radiative flux calculations and associated heating rates in climate models with measurement and modeling efforts using data collected at the Atmospheric Radiation Measurement Program (ARM) Cloud and Radiation Testbed sites.
- Expand, from 150 to 280 floats per year, the U.S. contribution to the international array of profiling floats that measure upper-ocean temperatures and salinity. This is a step in developing the global observing system necessary to support climate research and prediction, and for climate change detection and attribution. The United States has made a commitment to supply and maintain a total of 1,000 floats within the designed global array of 3,000 floats. In addition, surface-drifting buoys will be deployed in undersampled regions to complete the Global Drifter Array. The composite global ocean observing system that is being developed is crucial for more accurate assessment of the ocean's role in climate variability and change.
- Document the effects of tropical ocean temperature and rainfall patterns on changes in the frequency, location, and intensity of extreme weather events over the United States, as well as air-sea interactions in both tropical systems and midlatitude oceanic and landfalling storms, through expanded diagnostic and modeling efforts. This will improve capabilities to calculate the connections between climate and weather, particularly climatic influences on extreme events such as droughts and floods. The derivation of regional-scale forecasts of climate variations from global model forecasts will be enhanced using higher-resolution regional models.
- Improve near-term climate forecasts using enhanced climate monitoring capabilities, advances in coupled ocean-atmosphere modeling, and insights about climate variability. New products to be developed include biweekly to multi-season forecasts of droughts, hurricane activity in the Atlantic and Pacific oceans, and changes in seasonal risks of temperature extremes and wildfires. The benefits of using satellite altimeter observations on improving 12-month El Niño forecasts with a state-of-the-art coupled ocean-atmosphere model will be quantified.
- Assimilate near-decade-long satellite time-series data on sea-surface topography into a high-resolution Pacific Ocean model to improve understanding of the mechanisms contributing to the Pacific Decadal Oscillation and its role in seasonal to decadal climate variations.
- Analyze cores recovered from Lake Titicaca in Bolivia/Peru by the Global Lake Drilling System (GLAD 800) to strengthen our knowledge of natural climate vari-

ability over geologic time in this tropical region. Outfitting the GLAD 800 system with the capability to maintain drilling stability in rough waters will enable cost-effective drilling in large lakes, which are a currently untapped and potentially important storehouse of paleoclimate information.



**Figure 2. Observed Effects of Climate Variability on Salmon**

Abundances of many salmon stocks closely track interdecadal climate variation. Since 1940, Upper Columbia bright spring Chinook are abundant when the Pacific Northwest Index (one measure of decadal climate variation) is negative. Both are 5-year moving averages.

Source: National Assessment Overview report, p.70. See Appendix B for additional information.