THE U.S. GLOBAL CHANGE RESEARCH PROGRAM

The United States Global Change Research Program (USGCRP) supports research on the interactions of natural and human-induced changes in the global environment and their implications for society. The USGCRP began as a Presidential initiative in 1989 and was codified by Congress in the Global Change Research Act of 1990 (P.L. 101-606). The statute directs the implementation of a program aimed at "understanding and responding to global change, including the cumulative effects of human activities and natural processes on the environment."

On June 11, 2001, President Bush announced the establishment of the U.S. Climate Change Research Initiative to study areas of uncertainty and identify priority areas for investment in climate change science. The definition of this new initiative is underway, and is expected to lead to changes in USGCRP climate research activities in FY 2003 and beyond. These changes will be highlighted in the next annual report of the USGCRP.

What is "Global Change?"

The Global Change Research Act defines global change as "changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life." This perspective recognizes the profound socioeconomic and ecological implications of global environmental change. The USGCRP focuses on four sets of interacting changes in the coupled human-environment system, a system that is undergoing change at a pace unprecedented in human history:

- **Changes in the natural and human-induced forces affecting the Earth system,** such as solar variability, volcanic eruptions, water vapor and clouds, atmospheric composition (such as carbon dioxide, other greenhouse gases, and aerosols), socioeconomic characteristics and activities (such as population growth, consumption patterns, and technological choices), and changes in land use and land cover;
- **Changes and variability in Earth system attributes that directly affect natural and human activities,** including temperature, precipitation, oscillations and modes of climate (e.g., El Niño-Southern Oscillation and the less well-understood North Atlantic Oscillation and Pacific Decadal Oscillation), sea level, extreme weather events, air quality, water availability and quality, and many others;
- **Changes in ecosystems,** from the relatively pristine to the intensively managed, including potential effects on the productivity of agriculture, forestry, fisheries, and the ability of natural systems to absorb or adapt to new conditions; and
- **Changes in human communities, organizations, societies, and economies** triggered by the above changes, as well as by our responses.

These changes are occurring on many time and spatial scales. Many feedbacks and interdependencies link them. The existence of many different types of forces complicate efforts to understand the interactions of human and natural systems and how these may affect the capacity of the Earth to sustain life over the long-term. Indeed, the interactions between changes in external (solar) forcing, human activities, and the intrinsic variability of the Earth's atmosphere, hydrosphere, and biosphere make understanding and projecting atmospheric and oceanic circulation, global energy and water cycles, and biogeochemical cycling among the most demanding scientific challenges.

Why a USGCRP?

The USGCRP was established as a multiagency effort to:

- Develop and coordinate a comprehensive and integrated program, in order to increase the overall effectiveness and usefulness of global change research supported by the U.S. Government;
- Address key scientific uncertainties about changes in the Earth system, both natural and human-induced;
- Observe, understand, predict, evaluate, and communicate the implications of global change for society and the environment; and
- Provide a sound scientific basis for policymaking and resource management decisionmaking on issues related to global change.

The basic questions of how human activities and natural variability may affect the capacity of the Earth to sustain life and provide environmental resources for society call for an integrated scientific approach, yet the issues are so complex and wide-ranging that they extend beyond the mission, resources, and expertise of any single agency. Through collaboration, the USGCRP agencies are able to support scientific research more effectively. Today the USGCRP combines and coordinates the research of ten Federal departments and agencies having active global change research programs and provides liaison with the Executive Office of the President. Since its inception, the USGCRP has strengthened research on key scientific issues and fostered much-improved insight into the processes and interactions of the Earth system.

The USGCRP sets priorities and carries out its activities in close association with, and in support of, coordinated science priorities of the national and international research community, particularly those advanced by the World Climate Research Programme (WCRP), the International Geosphere-Biosphere Programme (IGBP), and the International Human Dimensions Programme (IHDP). The USGCRP has benefited from a longstanding and ongoing interaction with several boards, committees, and panels of the National Research Council of the National Academy of Sciences. The Academy is responsible for evaluating periodically the scientific merit of USGCRP research priorities and activities. The National Research Council has issued more than 30 reports during the past decade that have advised the USGCRP on global change research.

During its first decade, the USGCRP pursued a wide-ranging research effort to investigate the issues raised by evidence of climatic and other changes in the Earth system. The USGCRP research strategy focused on improving understanding of broad, global-scale Earth system processes, characteristics, and change, with a focus on problems such as the depletion of the stratospheric ozone layer resulting from human activities, the timing and magnitude of greenhouse warming, the degree of predictability in El Niño events, and the relationships linking the health of ecosystems, changes in land cover, and climate change.

Research supported by the USGCRP has demonstrated that the observed changes in global environmental conditions during the 20th century exceeded the range of natural fluctuations during the past 1,000 years. USGCRP-supported research also has demonstrated that human activities worldwide are clearly responsible for changes in atmospheric composition, global climate, the global water cycle, land use and land cover, and systems of living organisms that contribute to the web of life. Collectively, humankind has become an agent of change that must be considered in efforts to understand and project the future of global environmental change.

Scientific Insights from Global Change Research

Among the body of scientific insights that has resulted from the study of the Earth system, global change researchers have:

- Observed and explained the growth in atmospheric concentrations of substances that deplete the stratospheric ozone layer, which protects living organisms from exposure to higher levels of ultraviolet radiation. Ongoing research and observations have shown that emission controls implemented under the Montreal Protocol have begun to decrease the concentrations of several ozone-depleting gases.
- Quantified the atmospheric residence time—from months to millennia—of ozone-depleting and greenhouse gases. Long residence times imply a quasi-irreversible commitment to the associated global change—an example is the unavoidable multidecadal time lag in the recovery of the ozone layer, despite curtailed emissions.
- Found that cooling of the stratosphere caused by the increase in the atmospheric concentrations of greenhouse gases is likely to enhance ozone depletion, potentially delaying the recovery of the stratospheric ozone layer.
- Predicted successfully the onset of the 1997-1998 El Niño and the subsequent La Niña, as well as some of the resulting climate anomalies around the world. Improvements in the accuracy and lead times of forecasts, as well as increased access to and familiarity with climate forecast information, have enhanced their usefulness in supporting decisions about resource planning and disaster mitigation.
- Recognized that several large-scale patterns of natural variability, including the El Niño/Southern Oscillation, the Pacific Decadal Oscillation, and the North Atlantic Oscillation/Arctic Oscillation may alter the frequency and intensity of occurrence of extreme weather and climate events over North America, Europe, and the adjacent ocean basins.
- Concluded that the observed increase in global average surface temperature during the past century is consistent with a significant contribution from human-induced forcing. The Intergovernmental Panel on Climate Change projects a global average temperature increase of 1.4° to 5.8° C by 2100 if emissions are not reduced.
- Determined from paleoclimatic reconstructions of pre-instrumental temperatures that the 1990s appear to have been the warmest decade (and 1998 the warmest year) in the past 1,000 years, and that the observed 20th century warming exceeds what would be expected from natural variability typical of the past 1,000 years.
- Demonstrated the cooling effect of atmospheric sulfate aerosol particles on climate, particularly in the Northern Hemisphere. This finding has made possible climate model simulations that better match observed global tem-

perature trends, and hence aid in providing more-credible simulations of future climate change.

- Identified declines in the extent and thickness of Arctic sea ice during the past several decades, and demonstrated that decreases in Northern Hemisphere sea ice extent exceed what would be expected from natural variability alone.
- Found in the paleoclimatic record of late glacial conditions that rapid climate change events and rapid transitions in climate apparently occurred within decades or less, and then lasted for centuries or longer.
- Documented that regional air pollution can be transported over long distances and affect atmospheric composition on transcontinental scales. Plumes of polluted air from industrializing areas of Asia, mineral dust from the Sahara Desert, and smoke and ash from Mexican and Canadian forest fires have been shown to reach the United States.
- Found firmer evidence that North American terrestrial ecosystems are sequestering a significant amount of carbon, thereby offsetting a portion of the increase in atmospheric CO_2 concentrations from fossil fuel emissions.
- Concluded that land use change (including regrowth of forests cleared for agriculture in the 19th and 20th centuries) and land management (such as fire suppression), along with CO_2 fertilization, nitrogen deposition, and climate change, all appear to play important roles in determining the magnitude of the North America terrestrial carbon sink.
- Estimated the global ocean carbon sink for the 1990s, identified major sources of uncertainty in this estimate, and discovered that iron is a limiting nutrient for photosynthesis in major regions.
- Documented and quantified, using satellite observations, large-scale changes in land cover and land use, such as the loss of tropical forest in Brazil, Southeast Asia, and Africa. These changes, driven largely by human activities, are contributing to the loss of biodiversity, changes in atmospheric composition, and climate change.
- Identified critical regions of rapid land-use change from the perspective of carbon storage, biodiversity, food supply, and human health.
- Detected, and attributed to 20th century climate change, alterations in ecosystems including shifting of animal geographic ranges, increases in growing-season leaf duration, earlier plant flowering seasons, changes in annual tree growth and reproduction, and die-off of tropical corals. Revealed the significant vulnerability of many ecosystems to global change.
- Identified and characterized, from long-term studies of watersheds, the processes that control water, energy, and chemical fluxes over a broad range of spatial and temporal scales.
- Obtained a multi-year record of observations of tropical rainfall from space and identified significant differences in the distribution of deep convective clouds, the occurrence of lightning, and precipitation patterns between continental and oceanic regions.

Table 1
U.S. Global Change Research Program
FY 2000 – FY 2002 Budget by Agency
(Discretionary budget authority in $millions)

Agency	FY 2000	FY 2001	FY 2002 Request
Scientific Research			
Department of Agriculture (USDA)	56	56	56
Department of Commerce / National Oceanic and Atmospheric Administration (DOC/NOAA)	67	80	93
Department of Energy (DOE)	113	119	121
Department of Health and Human Services / National Institutes of Health (HHS/NIH)	48	52	57
Department of the Interior / U.S. Geological Survey (DOI/USGS)	27	27	22
Environmental Protection Agency (EPA)	21	23	22
National Aeronautics and Space Administration (NASA)	232	254	253
National Science Foundation (NSF)	187	187	187
Smithsonian Institution (SI)	7	7	7
Scientific Research Subtotal	**758**	**805**	**818**
Observations and Data Systems			
National Aeronautics and Space Administration (NASA)	929	908	819
U.S. Global Change Research Program Total	**1,687**	**1,713**	**1,637**

Because Department of Defense (DoD) research activities are conducted for defense-related missions, they are not included in this USGCRP budget crosscut. Related DoD research does contribute to achieving 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.

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