

same period. This range of uncertainty incorporates both different estimates of climate sensitivity (the increase in temperature that results from a doubling of atmospheric concentrations of carbon dioxide (CO₂)) and a wide range in projections of future greenhouse gas emissions. Reducing uncertainty in climate models will involve improving understanding of the role of clouds in different parts of the atmosphere; improving characterization of the circulation and interaction of energy in the atmosphere and oceans; improving understanding of the Earth's natural carbon cycle; developing more detailed representations of features of the feedbacks from the land surface; incorporating additional types of forcing agents (e.g., "black carbon"); and making progress on other fundamental challenges. Improved projections of climate changes on decadal or longer timescales are also important for many areas of planning and resource management where decisions made today have implications for decades to come. However, at this point, modeled projections of the future regional impacts of global climate change are often contradictory and are not sufficiently reliable tools for planning.

Even if the scientific community were to develop a "perfect" model of the global climate, it would not be possible to predict the level and rate of future changes in climate resulting from human activities. This is because these activities are not predetermined, but rather depend on human choices, which will, in turn, affect future climate conditions. The activities in question—energy-related emissions of greenhouse gases; changing the surface of the land through clearing, conversion, and growth of different land covers; and the release of chemicals (both natural and human-made) that alter the productivity of the land and the oceans—all depend on a more basic set of human driving forces. These include population growth, living standards, characteristics of technology, and institutions (e.g., market conditions). While we cannot predict these conditions, we can use a different set of models to project the climatic and environmental consequences of different combinations of basic human driving forces. These models are useful for performing "If * * *, then * * *" scenario experiments that make it possible to begin to explore the potential implications of different technological and institutional conditions for future emissions, climate, and living standards.

Improving our ability to project potential future variations and changes

in climate and environmental conditions, subject to assumptions about natural and human forcing, could enable governments, businesses, and communities to reduce damages and seize opportunities to benefit from changing conditions by adapting infrastructure, activities, and plans. But realizing this potential will require sustained research and improved understanding of the interactions among climate, natural and managed environmental systems, and human activities. Scientific research needs to address a range of issues.

The complexity of the Earth's environmental systems, the unique conditions that they provide for life, and the state of these systems, including potential impacts on society, make climate and global change among the most important issues for our generation, and perhaps for generations to come. Given what is at stake, the Nation and the international community need the best possible science to inform public debate and decisionmaking in government and the private sector.

2. The Research Program

In February 2002, President George W. Bush announced the formation of a new management structure, the Climate Change Science Program (CCSP), to coordinate and provide direction to US research efforts in the areas of climate and global change. These efforts include the US Global Change Research Program (USGCRP), which began as a Presidential initiative in 1989 and was codified by Congress in the Global Change Research Act of 1990 (Pub. L. 101-606), and the Climate Change Research Initiative (CCRI), which was announced by the President in June 2001 to reduce significant uncertainties in climate science, improve global climate observing systems, and develop resources to support policy- and decisionmaking. Departments and agencies of the US Government that participate in the CCSP include the Departments of Agriculture, Commerce (the National Oceanic and Atmospheric Administration and the National Institute of Science and Technology), Defense, Energy, Health and Human Services, Interior (US Geological Survey), State, and Transportation; the Agency for International Development; the Environmental Protection Agency; the National Aeronautics and Space Administration; the National Science Foundation; and the Smithsonian Institution. The Office of Science and Technology Policy, the Council on Environmental Quality, and the Office of Management and Budget provide

oversight on behalf of the Executive Office of the President.

The CCRI provides a distinct focus to the overall research program. The focus is defined by a set of uncertainties about the global climate system that have been identified by policymakers and analyzed by the NRC (NRC, 2001a). Areas addressed in the NRC report include climate observations, aerosols, North American carbon sources and sinks, climate feedbacks and modeling, scenarios of human-induced forcing, and development of methodologies for risk management. The CCRI is described more completely in Part I of this draft strategic plan.

The CCRI accelerates key areas of research that have been under development over the past thirteen years in the USGCRP. Over this period, the United States has made a large scientific investment—totaling more than \$20 billion in the areas of climate change and global change research. With these resources, research programs supported by the agencies that participate in the USGCRP, in collaboration with several other national and international science programs, have mounted extensive space-based, surface, and in situ (at fixed sites) systems for global observations and monitoring of climate and ecosystems variables; have documented and characterized several important aspects of the sources, sinks, abundances, and lifetimes of greenhouse gases; have begun to address the complex issues surrounding various aerosol species that may significantly influence climate; have advanced our understanding of global water and carbon cycles (but with major remaining uncertainties); and have developed several approaches to computer modeling of global climate. The program has been a comprehensive, interagency collaboration that has facilitated scientific discovery. Program results have revealed and addressed many of the complex interactions of climate and other environmental systems, and have started to lay the foundation for understanding the relationships between natural variability and human activities that may contribute to change. US researchers have developed fundamental insights into how the climate and Earth system functions: Insights that are incorporated into advanced models throughout the world. The USGCRP is described more completely in Part II of this draft strategic plan.

CCSP's management will balance the CCRI's near-term focus on climate change with the USGCRP's breadth, creating a program that both accelerates development of answers to scientific