

aspects of key climate policy issues and support advances in knowledge of the physical, biological, and chemical processes that influence the Earth system. This breadth is required to continue improving our understanding of the complex interrelationships among a broad set of systems that regulate climate and the global environment, as described in NRC's seminal report, *Global Environmental Change: Research Pathways for the Next Decade* (NRC, 1999a). The Pathways report lays out a framework of research questions that has significantly influenced the development of this strategic plan. Other reports issued by several boards, committees, and panels of the NRC have advised the USGCRP on specific aspects of climate and global change research and have influenced specific components of its research strategy. Indeed, the program has benefited from extensive interaction with the NRC, which is responsible for evaluating the USGCRP periodically for scientific merit.

By investigating a targeted yet comprehensive set of questions, the CCSP seeks to focus attention on key climate changes issues that are important for public debate and decisionmaking, while maintaining sufficient breadth to facilitate the discovery of the unexpected. Establishing a careful balance between focus and breadth is essential if scientists are to develop knowledge of the interactions between natural variability and potential human impacts on the Earth system. This is an important management issue for the program and is a prerequisite for making as effective and productive use as possible of the significant resources allocated to this purpose. Establishing this balance, and a rational sequencing of research priorities and potentials, will require input from both decisionmaking and the science community.

3. Guiding Principles for CCSP

To fulfill its mission as the publicly sponsored research program addressing climate change issues for the United States, the CCSP must continuously adhere to three guiding principles that underpin the objectivity, integrity, and usefulness of its research and reporting:

(i) The scientific analyses conducted by the CCSP are policy relevant but not policy driven. CCSP scientific analyses (including measurements, models, projections, and interpretations) are directed toward continually improving our understanding of climate, ecosystems, land use, technological changes, and their interactions. In

developing projections of possible future conditions, the CCSP addresses questions in the form of "If * * *, then * * *" analyses. Policy and resource management decisions are the responsibility of government officials who must integrate many other considerations with available scientific information.

(ii) CCSP analyses should specifically evaluate and report uncertainty. All of science, and all decisionmaking, involves uncertainty. Uncertainty need not be a basis for inaction; however, scientific uncertainty should be carefully described in CCSP reports as an aid to the public and decisionmakers.

(iii) CCSP analyses, measurements, projections and interpretations should meet two goals: Scientific credibility and lucid public communication. Scientific communications by the CCSP must maintain a high standard of methods, reporting, uncertainty analysis, and peer review. CCSP public reports must be carefully developed to provide objective and useful summaries of findings.

4. The Research Strategy

This draft strategic plan for the CCSP, incorporating both the USGCRP and the CCRI, is built around a carefully constructed set of questions and objectives for each of the major areas of the program. Primary research questions that focus on broad science issues are supported by more detailed questions and objectives that can be addressed in specific research initiatives and projects. For each major question addressed, the strategy includes a very brief description of the state of knowledge, subsidiary questions, descriptions of products and deliverables, information of activities and infrastructure needed to make progress, and the benefits or "payoffs" from research. For each major program area, linkages to important national and international research activities are also described.

This plan should be considered a draft subject to substantial revision through public comment and independent review by the NAS.

Part I of the plan describes the components of the CCRI as discussed above. These are organized into three broad programmatic areas: (1) Research focused on key climate change uncertainties; (2) Climate quality observations, monitoring, and data management; and (3) Resources for decision support.

Part II of the plan describes major research questions about how the components of Earth's environmental system function, how the system may

change in response to human and natural forcing, and what the implications of these changes may be for a variety of human activities and natural environments and resources. For each major research question, a state of knowledge, illustrative research questions, research needs, and a list of products and payoffs are described. The specific topics addressed and their corresponding major research questions are:

(1) Atmospheric Composition

Question 1: What are the climate-relevant chemical and radiative properties, and spatial and temporal distributions, of human-caused and naturally occurring aerosols?

Question 2: What is the current quantitative skill for simulating the atmospheric budgets of the growing suite of chemically active greenhouse gases and their implications for the Earth's energy balance?

Question 3: What are the effects of regional pollution on the global atmosphere and the effects of global climate and chemical change on regional air quality and atmospheric chemical inputs to ecosystems?

Question 4: What are the time scale and other characteristics of the recovery of the stratospheric ozone layer in response to declining abundances of ozone-depleting gases and increasing abundances of greenhouse gases?

Question 5: What are the couplings among climate change, air pollution, and ozone layer depletion, which were once considered as separate issues?

(2) Climate Variability and Change

Question 1: What is the sensitivity of climate change projections to feedbacks in the climate system?

Question 2: To what extent can predictions of near-term climate fluctuations and projections of long-term climate change be improved, and what can be done to extend knowledge of the limits of predictability?

Question 3: What is the likelihood of climate-induced changes that are significantly more abrupt than expected, such as the collapse of the thermohaline circulation or rapid melting of the major ice sheets?

Question 4: Whether and how are the frequencies, intensities, and locations of extreme events, such as major droughts, floods, wildfires, heat waves, and hurricanes, altered by natural climate variations and human-induced climate changes?

Question 5: How can interactions between producers and users of climate variability and change information be optimally structured to ensure essential