



7 | Human Contributions and Responses and Decision-Support Resources Development

Human Contributions and Responses to Environmental Change Strategic Research Questions

- 9.1 What are the magnitudes, interrelationships, and significance of the primary human drivers of, and their potential impact on, global environmental change?
- 9.2 What are the current and potential future impacts of global environmental variability and change on human welfare, what factors influence the capacity of human societies to respond to change, and how can resilience be increased and vulnerability reduced?
- 9.3 How can the methods and capabilities for societal decisionmaking under conditions of complexity and uncertainty about global environmental variability and change be enhanced?
- 9.4 What are the potential human health effects of global environmental change, and what climate, socioeconomic, and environmental information is needed to assess the cumulative risk to health from these effects?

The Role of Decision-Support Resources Development

- Goal 1:* Prepare scientific syntheses and assessments to support informed discussion of climate variability and change and associated issues by decisionmakers, stakeholders, the media, and the general public.
- Goal 2:* Develop resources to support adaptive management and planning for responding to climate variability and climate change, and transition these resources from research to operational application.
- Goal 3:* Develop and evaluate methods (scenario evaluations, integrated analyses, and alternative analytical approaches) to support climate change policymaking and demonstrate these methods with case studies.

See Chapter 9 of the *Strategic Plan for the U.S. Climate Change Science Program* for detailed discussion of the strategic research questions and Chapter 11 for decision-support resources development.

O U R C H A N G I N G P L A N E T

Human activities play an important role in the Earth system and are significant drivers of change in the environment at all scales—local, regional, national and global. Humans also have the capability to respond to changes in their environment, and adaptations, when effective, enhance the resilience of both managed and natural systems. At the same time, social and economic systems are changing in a world that is more interconnected than ever. A better integrated understanding of the complex interactions between human societies and the Earth system is needed to identify vulnerable systems and pursue options that take advantage of opportunities to enhance resilience. The National Research Council (NRC) report, *Climate Change Science: An Analysis of Some Key Questions*,¹ concluded that: “In order to address the consequences of climate change and better serve the Nation’s decisionmakers, the research enterprise dealing with environmental change and environment-society interactions must be enhanced.” Such an enterprise should include “...support of interdisciplinary research that couples physical, chemical, biological, and human systems.”

The study of the human interface with change in the global environment is especially important because of its capacity to inform public policy. Decisionmaking, however, is challenged by uncertainties, including risks of irreversible and/or nonlinear changes that may be met with insufficient or excessive responses whose consequences may cascade across generations. The difficulties associated with uncertainty have become increasingly salient given the interest of policymakers in addressing global environmental change. Uncertainties arise from a number of factors, including problems with data, problems with models, lack of knowledge of important underlying relationships, imprecise representation of uncertainty, statistical variation and measurement error, and subjective judgment.²

It is well established that human health is linked to environmental conditions, and that changes in the natural environment may have subtle, or dramatic, effects on health. Timely knowledge of these effects may support public health systems in devising and implementing strategies to compensate or respond to them. Federally supported research has thus far provided information on a broad range of health effects of global change, including the adverse effects of ozone, atmospheric particles and aeroallergens, ultraviolet (UV) radiation, vector- and water-borne diseases, and heat-related illnesses and mortality.





HIGHLIGHTS OF RECENT RESEARCH IN HUMAN CONTRIBUTIONS AND RESPONSES TO ENVIRONMENTAL CHANGE

Selected highlights of recent research and activities supported by CCSP-participating agencies follow.

Innovative Approaches to Next-Generation Scenario Development. The international climate modeling and integrated assessment modeling communities have begun planning research that could ultimately be reported in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. Researchers from these communities are coordinating research programs to deliver scenarios of potential future concentrations of a broad range of greenhouse gases and short-lived species of reactive gases and aerosols as well as land cover to be employed by the climate modeling community to produce ensemble climate calculations. The approach being developed requires that integrated assessment models produce representative concentration pathways (RCPs) that extend further into the future (to the year 2300) and contain greater detail ($0.5^\circ \times 0.5^\circ$ grid size) than any in the past. Work by the climate modeling community to incorporate the normally occurring processes of the carbon cycle means that integrated assessment models must deliver RCPs that include geographically disaggregated land-cover data as well as the greenhouse gases and short-lived species of reactive gases and aerosols. U.S. researchers are leading these efforts.

Energy and Environmental Impacts Research. In an effort to strengthen connections between integrated assessment research and impact and adaptation research, and in response to some of the identified challenges in CCSP Synthesis and Assessment Products (SAPs), a modest, focused research effort was initiated at the Oak Ridge National Laboratory (ORNL) to improve understanding of select energy and environmental impacts of climate change. For example, in FY 2007, CCSP completed the first comprehensive summary of the effects of climate change on energy production and use in the United States (SAP 4.5), and it cooperated with other CCSP agencies in addressing impact concerns ranging from cities to the carbon cycle. In a collaboration between ORNL, the Joint Global Change Research Institute (JGCRI), and the Massachusetts Institute of Technology (MIT), the findings are now being connected with integrated assessment tools and analyses, and this work is being extended by ORNL to the development of databases on U.S. and international impact research and science and on adaptation processes and managed practices. Additionally, a solicitation for FY 2009 research grants addressing these and other topics was published to engage the university community and



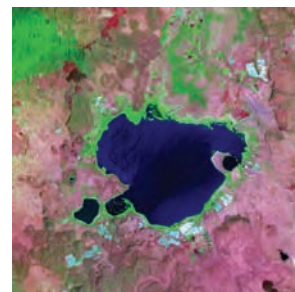
others in developing innovative approaches and methodologies for exploring and representing these impacts in integrated assessment models.

Connecting Communities of Practice: Integrated Assessment Research; Earth Systems Modeling; and Impacts, Adaptation, and Vulnerability (IAV). There has been substantial interagency cooperation over the past year in strengthening the capacity of the science community to incorporate an improved understanding of impacts and adaptation strategies in integrated assessments and in integrated modeling of the combined human and natural systems behaviors—both in driving climate change and responding to climate change. During the past year, a major week-long session was held in Snowmass, Colorado, which brought together ecologists, Earth system modelers, economists, energy experts, health experts, social scientists, specialists in adaptation, and multiple agency representatives, all of whom had been important contributors to the recently published IPCC reports. The exchange of perspectives, review of IPCC results, and presentation of more recent research has resulted in new collaborations being formed to investigate such issues as a more sophisticated integration of Earth system, IAV, and integrated assessment models, and an exploration of how the different research communities approach problems such as land use and land cover, with the intent of developing more coordinated approaches.

Interagency Scientific Workshops on Impacts and Adaptation in Integrated Assessment Research.

Historically, the integrated assessment modeling community has focused on understanding the processes that lead to changes in emissions of greenhouse gases, aerosols, and other chemically active gases over time. It is now clear that understanding the physical and socioeconomic processes of impacts and adaptation are equally important in building a more complete understanding of global change. Over the past year, the integrated assessment research community, led by the JGCRI and ORNL, has convened a series of workshops and discussion sessions among agencies and active researchers in these fields to explore the major research challenges for integrated modeling and improved process understanding for adaptation and impacts. Workshop presentations and a synthesis report on research challenges are in preparation.

Workshop on Climate Change and Water. In October 2007, the Centers for Disease Control and Prevention (CDC) hosted a workshop entitled *Climate Change, Drinking Water, and Public Health*. The purpose of the workshop was to share information across various sectors, including environmental, public health, and water utilities, to extend the breadth and depth of knowledge about the impacts of climate change on public health. This workshop was designed to identify priorities across the environmental and health sectors and begin the discussion on building a public health sector response to address the impacts of climate change on drinking water and human health.



Highlights of Recent Research and Plans for FY 2009

Effects of Climate Change on Human Health—North Carolina. This study linked 10 years of data related to daily asthma and myocardial infarction hospital admissions, air quality, and weather patterns in a number of cities in North Carolina (see cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/7887/report/2006). The effect of eight air mass types, classified using the Spatial Synoptic Classification system, on ozone and particulate matter (PM) concentrations and subsequent processes was evaluated. Preliminary results show that the distributions of air pollutant concentrations are different under different air masses. In addition, the analysis found that ozone and PM10 are positively related to asthma admissions for some cities under the Dry Tropical and the Dry Moderate air masses.

Valley Fever Public Health Decision-Support System. Valley Fever (coccidioidomycosis) is a disease endemic to arid regions in the Western Hemisphere, and is caused by soil-dwelling fungi. Arizona is currently experiencing an epidemic, with almost 4,000 cases in 2004, greatly exceeding other climate-related diseases such as hantavirus pulmonary syndrome or West Nile fever virus in the United States. The fungus responds to changes in climate conditions, such as precipitation and atmospheric dust. Climate models and satellite-derived spatial data on soil moisture and land-cover disturbance are being used to evaluate seasonal associations with Valley Fever incidence. Working in partnership with the Arizona Department of Health Services, the University of Arizona is developing a decision-support tool to make seasonal forecasts of disease incidence by geographic area and display spatial relationships with environmental conditions (see cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/7885/report/00).

HIGHLIGHTS OF HUMAN CONTRIBUTIONS AND RESPONSES TO ENVIRONMENTAL CHANGE – PLANS FOR FY 2009

Climate Change and Human Health. Exposure to allergens results in allergic illnesses in approximately 20% of the U.S. population. Climate change, including increased atmospheric carbon dioxide (CO₂) concentrations, could have significant impacts on the production, distribution, dispersion, and allergenicity of aeroallergens and the growth and distribution of organisms that produce them (i.e., weeds, grasses, trees, and fungus). Shifts in aeroallergen production and, subsequently, human exposures, may result in changes in the prevalence and severity of symptoms in individuals with allergic illnesses. EPA and CDC plan to investigate this potential health effect through the award of competitive multi-year grants as part of an interagency program on climate change and health.

This activity will address Question 9.4 of the CCSP Strategic Plan.

Climate Change and Water Quality. The movement of water through the atmosphere, the exchange of water between the atmosphere and the surface, and the movement and storage of water on and below the land surface are linked through physical and dynamical processes occurring over a variety of spatial and temporal scales. Watershed biogeochemical and other processes, including interaction with human stressors such as changes in land use, pollutant loading, and water flow management, likewise occur over a variety of spatial and temporal scales. Climate change has the potential to interact with these systems and stressors in complex ways, leading to potentially significant impacts on water quality. Cutting-edge research, conducted through a competitive grants program, will be undertaken to improve information and understanding regarding the ways climate change affects water quantity and quality that in turn will lead to better analysis and decisionmaking.

This activity will address Question 9.1 of the CCSP Strategic Plan.

Exploring the Role of Science and Technology in Climate Change Mitigation and Adaptation. A significant challenge for models that simulate human dimensions of climate change is their ability to incorporate the potential role of scientific advances into the mix and what this might mean for transformational shifts in technology, both to mitigate and adapt to climate change. Similarly, improved probabilistic frameworks and alternative methods are needed that provide complementary perspectives within and outside of existing integrated assessment models. During 2007, a workshop attended by many agencies and international researchers focused attention on this vexing challenge and offered alternative perspectives on methods and tools that should be considered. Two national laboratory teams and one university-based team have been challenged to take on this assignment at, recognizably, a modest level of effort. Recognizing the highly important role and corresponding uncertainties of potential advances in science and technology, especially as informed by SAP 2.1, additional analytical, computational, and mathematical expertise will be pursued in subsequent years as funding permits.

This activity will address Question 9.1 of the CCSP Strategic Plan.

Research into the Energy / Water Nexus. Climate change projections suggest that water availability is likely to be affected in coming decades, especially in regions whose surface water supply depends substantially on winter snowfall. The national laboratories, in partnership with universities and industry, are exploring new techniques for incorporating water demand and management strategies within the framework of integrated assessment models, particularly to understand the sensitivities of biomass production, agricultural land use, and energy production to adaptation and management decisions. Investigations are attempting to unravel a host of connections between such potential regional water-supply impacts of climate change and the Nation's energy systems. Examples range from effects on energy supply as climate change increases demands for cooling—related



Highlights of Recent Research and Plans for FY 2009

to such issues as hydropower resources, cooling water requirements for thermal electricity generation, and water requirements for bioenergy production—to energy needs for groundwater pumping and surface water transport, all of this in a context of demographic, economic, and land-use change. Additional future research will attempt to link improved precipitation modeling capacities in Earth system models with integrated assessment models and analyses of climate change impacts and adaptation potentials in order to anticipate needs for decision support related to possible pressures on the “energy/water nexus.”

This activity will address Question 9.2 of the CCSP Strategic Plan.

Understanding Infrastructure and Energy Vulnerabilities under Extreme Weather Challenges. In many cases, social concerns about the effects of climate change are focused on extremes rather than averages. Examples include severe storms, heat waves, and droughts. In addition, there is significant concern that many important ecosystem responses—such as the response of forests and crops to pests, pathogens, and fire—can be quite abrupt, as seen now in the pine bark beetle epidemics in the Pacific Northwest and the increase in fire frequency throughout the West. The integrated assessment community is developing methods for incorporating our best current understanding of such phenomena in the context of adaptation decisions. Close interactions with Earth system modelers and the ecological research community are important components of this research.

In the case of energy systems, particular concerns include effects of heat waves on electricity demand and distribution systems (as in the summer of 2006), effects of droughts on competition among economic sectors for scarce water, and effects of severe storms on energy infrastructures in vulnerable areas (as with Hurricane Katrina). One area of active research in the Earth system modeling community is enhancing the ability of climate models to project extremes. Linked to these developments and with regard to the human dimensions, research efforts are beginning that will improve capacities to understand and model implications of such extreme events for energy systems and infrastructures and their possible effects on national and regional economies.

This activity will address Question 9.2 of the CCSP Strategic Plan.



HIGHLIGHTS OF RECENT RESEARCH IN DECISION-SUPPORT DEVELOPMENT

One of the main purposes of CCSP is to provide information for decisionmaking through the development of decision-support resources. Decision-support resources include analyses and assessments, interdisciplinary research, analytical methods (including scenarios and alternative analysis methodologies), model and data product development, communication, and operational services that provide timely and useful information to address questions confronting policymakers, resource managers, and other stakeholders. This research is especially relevant to CCSP Goal 5: “Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change.”

Decision-support resources are targeted at three broad categories of uses: (1) discussion and planning based on state-of-the-science syntheses and assessments by decisionmakers, stakeholders, the media, and the general public; (2) operational adaptive management decisions undertaken by managers of natural resources and built infrastructure (i.e., “climate services applications”); and (3) climate change policy formulation. Each of these categories has a unique set of stakeholders and requires different decision-support tools. However, they share a common reliance on partnerships between scientists and stakeholders to define the problems to be addressed, the nature of decision-support resources to be developed, the expected information to be provided, and the approach for describing levels of confidence and key uncertainties.

Development of decision-support resources cannot be isolated in a single program element, disconnected from research throughout CCSP. Responsibility for developing decision-support resources is distributed across CCSP and success depends on developing strategies for integrating knowledge from the many diverse fields represented in the program. At the same time, CCSP’s strategy for improving understanding of human-environment interactions recognizes the need for basic research into both the natural sciences and the human dimensions of global change that may not lead directly to decision-support resources.

A primary activity to meet CCSP Decision Support Goal 1 (see page 122) is development of 21 synthesis and assessment products to support informed decisionmaking on climate variability and change by a broad group of stakeholders, including policymakers, resource managers, media, and the general public. The development of these SAPs stems from the Global Change Research Act (GCRA) of 1990 (P.L. 101-606, section 106), which directs the program to “...produce information readily usable by policymakers attempting to formulate effective strategies for preventing, mitigating, and adapting to



Highlights of Recent Research and Plans for FY 2009

the effects of global change” and to undertake periodic science “assessments.” A complete list of the 21 SAPs, by title, is given on page 29. Status updates can be obtained from <www.climate-science.gov/Library/sap/sap-summary.php>, including information on opportunities for public comment on draft products. Descriptions of those SAPs most relevant to either Human Contributions and Responses or Decision-Support Resources Development are described in the accompanying box.

The National Research Council's Committee on the Human Dimensions of Global Change. An important source of scientific expertise and judgment on societal issues related to global change is the NRC Committee on the Human Dimensions of Global Change (CHDGC). The committee was formed in 1989 to help guide U.S. research on the

SYNTHESIS AND ASSESSMENT PRODUCTS

Human Contributions and Responses

SYNTHESIS AND ASSESSMENT PRODUCT 2.1

Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations (Part A) and Global-Change Scenarios: Their Development and Use (Part B)

This product, which was publicly released in October 2007, provides a new long-term, global reference for greenhouse gas stabilization scenarios and an evaluation of the process by which scenarios are developed and used. SAP 2.1 consists of two parts. Part A uses computer-based scenarios to evaluate four alternative stabilization levels of greenhouse gases in the atmosphere and the implications for energy and the economy of achieving each level. Part A includes stabilization scenarios for the six primary anthropogenic greenhouse gases—carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride—and it uses updated economic and technological data and new tools for scenario development. Although these scenarios should not be considered definitive predictions of future events, they provide valuable insights for decisionmakers. Part B examines how scenarios have been developed and used in global climate change applications, evaluates the effectiveness of current scenarios, and recommends ways to make future scenarios more useful. Part B of the report concludes that scenarios can support decisionmaking by providing insights regarding key uncertainties, including future emissions and climate as well as other environmental and economic conditions.

SYNTHESIS AND ASSESSMENT PRODUCT 4.1

Coastal Elevations and Sensitivity to Sea-Level Rise

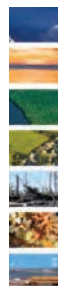
This product will examine the vulnerability of coastal areas in the U.S. mid-Atlantic states to sea-level change. Specific questions to be addressed include identifying which areas are low enough to be inundated by tides, how floodplains would change due to a changing climate, which areas might be subject to erosion, and locations where wetlands will be able to migrate inland versus locations where shores will be protected. The product will examine the implications of sea-level rise, including impacts on population and economic activity in vulnerable areas, costs of shore protection, ecological effects, flood damages, public access to modified shore areas, cases where sea-level rise justifies policy changes, options being considered by conservancies and governments, and lessons from the unfolding consequences of the 2005 hurricanes in the Gulf Coast region.

SYNTHESIS AND ASSESSMENT PRODUCT 4.2

Thresholds of Change in Ecosystems

There is a body of ecosystems research that focuses on enhancing understanding of climate change impacts on ecosystems (and *vice versa*) and developing the capability to predict potential impacts of future climate change. Increasing emphasis is being placed on climate-related thresholds that could result in discontinuities or sudden changes in ecosystems and climate-sensitive resources. Discontinuities in responses of ecosystems and resources are difficult to predict, and may significantly affect human societies that depend on ecosystem goods and services. Improved understanding of such sudden changes is essential to managing ecosystems and resources in the face of climate change. This report will synthesize the present state of scientific understanding regarding thresholds of change that trigger sudden changes in ecosystems and climate-sensitive resources. The report will develop a conceptual framework for characterizing sudden changes, and synthesize peer-reviewed studies that provide the best available evidence for defining circumstances that trigger discontinuities in response to climate change.

interactions between human activity and global environmental change. CHDGC focuses on two main tasks: developing the intellectual basis for progress in understanding human-environment interactions, and advising on future research directions. CHDGC recently completed a study entitled *Research and Networks for Decision Support in the NOAA Sectoral Application Research Program*. The Sectoral Applications Research Program (SARP) focuses on the needs for climate-related information to inform decisions in particular “sectors,” defined by resources (e.g., coastal, water resources, forests, agricultural lands) or by decision domains (e.g., emergency management, urban planning). SARP is a new program and CHDGC was asked to provide advice on the role that SARP could play, the best approaches to meet program goals, and how to monitor and evaluate the effectiveness of SARP. The report, which was released in



SYNTHESIS AND ASSESSMENT PRODUCTS (CONTINUED)

Human Contributions and Responses (continued)

SYNTHESIS AND ASSESSMENT PRODUCT 4.3

The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity

This report, publicly released in May 2008, addresses the effects of climate change on agriculture, forestry, land and water resources, and biodiversity. Air and water temperature, precipitation, and related climate variables are fundamental regulators of biological processes. For this reason, human-induced climate change has the potential to affect the condition, composition, structure, and function of ecosystems. Such changes may also alter the linkages and feedbacks between ecosystems and the climate system. Additionally, ecosystems produce a wide array of goods and services valued by humans and in many cases essential for human survival and property. Climate-related changes in ecosystems and other key resources could have impacts on human communities and economic conditions.

SYNTHESIS AND ASSESSMENT PRODUCT 4.4

Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources

Climate is a dominant factor influencing the distribution, abundance, structure, and function of, and services provided by, ecosystems. Many ecosystems are thus vulnerable to future changes in climate. The goal of adaptation is to reduce these risks of adverse ecological outcomes through management activities that increase the resilience of these systems to climate change. Resilience is defined here as the magnitude of disturbance that can be absorbed by a system before it shifts from one stable state (or stability domain) to another and the speed of return of a system to equilibrium after a disturbance has occurred. This report, which was publicly released in June 2008, provides a review and synthesis of information on adaptation options for selected climate-sensitive ecosystems in order to aid in designing management strategies that facilitate adaptation, provide examples of how to implement strategies in specific places, and identify issues and challenges associated with implementation of adaptation options.

SYNTHESIS AND ASSESSMENT PRODUCT 4.5

Effects of Climate Change on Energy Production and Use in the United States

This report, which was publicly released in October 2007, summarizes current knowledge of the potential effects of climatic change on energy production and use in the United States. It focuses on three questions: (1) How might climatic change affect energy use in the United States, (2) how might climatic change affect energy production and supply in the United States, and (3) how might climatic change have other effects that indirectly shape energy production and use in the United States? Great care was taken in answering these questions, for two reasons. One, the available research literature on these key questions is limited, supporting a discussion of issues but not providing definite answers. Two, as with many other aspects of potential effects of climatic change on the United States, the effects on energy production and use depend on more than climatic change alone; other potentially important factors include patterns of economic growth and land use, patterns of population growth and distribution, technological change, and social and cultural trends that could shape policies and actions, individually and institutionally.

SYNTHESIS AND ASSESSMENT PRODUCTS (CONTINUED)

Human Contributions and Responses (continued)

SYNTHESIS AND ASSESSMENT PRODUCT 4.6

Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems

This product will examine the effects of global change on human systems. It will address Goal 4 of the *CCSP Strategic Plan*: to “understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes”. The impacts of climate variability, climate change, shifting patterns of land use, and changes in population patterns are human problems, not simply problems for the natural or the physical world. This SAP will examine the vulnerability of human health and socioeconomic systems to global environmental change across three areas of potential impacts and adaptations: human health, human settlements, and human welfare. It will address the questions of what, where, and when climate variability and change will affect U.S. social systems. The challenge for this project will be to assess risks associated with health, welfare, and settlements and to identify and develop timely adaptive strategies to address human vulnerabilities. The primary goals for adaptation to climate change and variability focus on managing significant risks proactively when possible; establishing protocols to detect and measure risks; and leveraging technical and institutional adaptive capacity to address new climate risks, especially as they exceed conventional adaptive measures.

SYNTHESIS AND ASSESSMENT PRODUCT 4.7

Impacts of Climate Variability and Change on Transportation Systems and Infrastructure: Gulf Coast Study

This report, which was publicly released in March 2008, addresses the potential effects of climate variability and change on transportation infrastructure and systems in the central Gulf Coast of the United States. The purpose of this study was to increase the knowledge base regarding the risks and sensitivities of transportation infrastructure to climate variability and change, the significance of these risks, and the range of adaptation strategies that may be considered to ensure a robust and reliable transportation network. Implications for all transportation modes—surface, marine, and aviation—are addressed. This SAP is a case study that focuses on the Gulf Coast, and assesses the significant risks to transportation, develops methodology to be applied in other geographic locations, identifies potential strategies for adaptation, and develops decision-support tools to assist transportation decisionmakers in incorporating climate-related trend information into transportation system planning, design, engineering, and operational decisions.



Decision-Support Resources Development

SYNTHESIS AND ASSESSMENT PRODUCT 5.1

Uses and Limitations of Observations, Data, Forecasts, and Other Projections in Decision Support for Selected Sectors and Regions

This product will focus on characterizing a subset of the observations from remote-sensing and *in situ* instrumentation that are of high value for decisionmaking. The product will characterize observational capabilities that are currently or could potentially be used in decision-support tools, catalog a subset of ongoing decision-support activities that use these capabilities, and evaluate a limited number of case studies of these decision-support activities. The detailed evaluation of decision-support activities and demonstration projects will provide information to agencies and organizations responsible for developing, operating, and maintaining selected decision-support processes and tools. The evaluation will also provide information on the nature of interactions between users and producers of climate science information, approaches for accessing science information, and assimilation of scientific information in the decisionmaking process. The product will include an online catalog of decision-support demonstration projects with interactive links, which will be updated as additional experiments are conducted and new approaches to incorporating and benchmarking application of observations and other global change research products evolve.

SYNTHESIS AND ASSESSMENT PRODUCT 5.2

Best Practice Approaches for Characterizing, Communicating, and Incorporating Scientific Uncertainty in Decisionmaking

This product will address the issue of uncertainty and its relationship to science, assessment, and decisionmaking. Specifically, the product is intended to help improve the quality and consistency of information about scientific uncertainty presented to decisionmakers and other users of CCSP reports by identifying “best practice” options recommended in the literature on this subject; to improve communication between scientists and users of the products by providing recommendations for addressing uncertainty; and to provide a brief overview of the literature on approaches for communicating and considering uncertainty related to climate.

SYNTHESIS AND ASSESSMENT PRODUCTS (CONTINUED)

Decision-Support Resources Development (continued)

SYNTHESIS AND ASSESSMENT PRODUCT 5.3

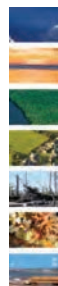
Decision Support Experiments and Evaluations using Seasonal to Interannual Forecasts and Observational Data

This product will concentrate on the water-resource management sector. It will describe and evaluate current forecasts, assess how forecasts are being used in decision settings, and evaluate decisionmakers' level of confidence in these forecasts. The participants in the development of this product (primarily consisting of government officials, researchers, and users) will evaluate forecasts as well as their delivery in order to identify options for improving partnerships between the research and user communities. It will inform decisionmakers about the experiences of others who have experimented with the use of seasonal and interannual forecasts and other observational data; climatologists and social scientists about how to advance the delivery of decision-support resources that use the most recent forecast products, methodologies, and tools; and science managers as they plan for future investments in research related to forecasts and their role in decision support.

September 2007, recommended specific research, workshop, and pilot project activities as ways to carry out the SARP program. The NRC study further recommended principles for selecting activities within each sector, including promotion of social innovation in using climate science, high-impact decisions, leveraging investments through partnerships, fertile ground, increasing resilience and adaptability, equity, and research of interest to social science.

SAP 2.1a—Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations. SAP 2.1a was produced under CCSP auspices by an independent advisory committee to one of the participating agencies under the provisions of the Federal Advisory Committee Act (FACA). The report applies three computer-based integrated assessment models in a comparison of five different scenarios of greenhouse gas emissions under alternative assumptions regarding long-term, global climate goals. The CCSP report is the first to use several alternative models to evaluate multiple stabilization scenarios in this way. SAP 2.1a produced numerous findings. One of the most important implications of the work reported was the primacy of technology in addressing climate change, not only in the near term, but also in the long term where investments in basic science and technology can lay the foundations for dramatically improved technologies to deploy.

Decision Assessment in the Gulf Coast and Chesapeake Bay Regions. Pilot studies in the Gulf Coast region and the Chesapeake Bay were undertaken to test different approaches to assessing the flow and use of climate change science information in decisionmaking, the factors and institutions that affect its use, and the types and characteristics of decisions most sensitive to climate change and most in need of additional reevaluation and research in light of projected changes. Results from these studies are being used to determine the applicability of a decision assessment approach to the national level and to decisions related to water quality.



Highlights of Recent Research and Plans for FY 2009



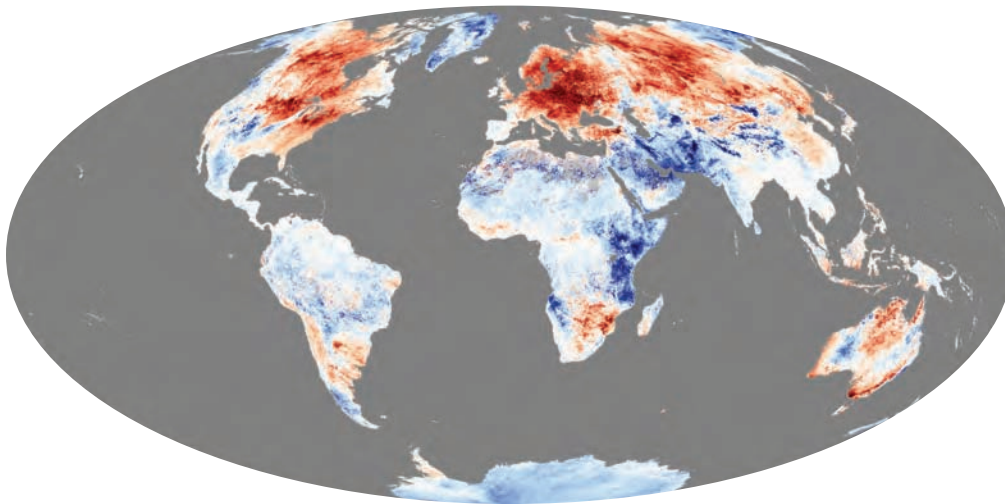
Integrated Evaluation of Climate Change, Mitigation, Bioenergy, and Land Use. The MIT Joint Program on the Science and Policy of Global Change completed its linkage of a multi-sector, multi-region general equilibrium model of the world economy with a terrestrial ecosystem model that simulates biogeochemical processes of land systems at a 0.5° latitude-longitude grid level. Additionally, MIT conducted initial testing and sensitivity analyses using these enhanced capabilities focusing on the effects of disturbances associated with the conversion of unmanaged forest and grassland to crop, pasture, and bioenergy production on greenhouse gas concentrations. Preliminary analysis confirms that second-generation biofuels technology could be an important mitigation option. However, depending on the nature of the land supply response and for some scenarios, biofuels also could lead to substantial deforestation and release of carbon. Looking toward the future, these new science-based modeling capabilities, and subsequent refinements, may prove valuable tools in helping to inform strategies to increase the benefits from biofuels while attempting to understand and manage to reduce unintended, undesirable consequences. The modeling facility will be further enhanced in 2009 to examine the complex interactions of Earth system change, agriculture and energy markets, and mitigation and adaptation.

Improving the Methodological Science Base of Integrated Assessment Research. The integrated assessment community sponsored a workshop in the summer of 2007 focused primarily on new methods for coupling integrated assessment models with Earth system models, and understanding the needs for mathematical and computational advances to achieve such. Topics of particular importance were the need for techniques for quantitative characterization of uncertainty in both model parameterization and model structure, the need to characterize the actual decisions that the models are meant to inform, and understanding of the interdisciplinary context within which decisions are to be made.

Development of Modeling Tools to Support Water and Watershed Management. Climate change presents a range of risks and opportunities to water managers. Managing these risks requires an improved understanding of potential impacts, and strategies for increasing the resilience of water and watershed systems to anticipated change. Given the uncertainty in projections of future climate at local and regional scales, water managers need to develop management strategies robust to the full range of plausible conditions and events. To enable managers to develop such strategies, a new climate assessment capability was developed within the Better Assessment Science Integrating Point and Non-point Sources (BASINS) watershed



modeling system. To demonstrate the tools' capabilities, a case study using the new BASINS system was undertaken to assess the sensitivity of hydrologic and water quality endpoints to climate change. The hydrologic and water quality endpoints used in the climate sensitivity study included mean annual streamflow; the 100-year flood event; 7Q10 low stream flow (lowest consecutive 7-day streamflow likely to occur in a 10-year period); and mean annual sediment, phosphorus, and nitrogen loads. The climate sensitivity study was conducted in the Monocacy River watershed.



Interagency Workshop on Decision Support for Heat Wave Preparedness. Excessive heat events are, and will continue to be, a public health threat in the United States. Empirical data demonstrate that these events often increase the number of daily deaths (mortality) and other nonfatal adverse health outcomes (morbidity) in affected populations. The number of extremely hot days is expected to increase; however, there are a number of low cost but effective responses that could reduce the health impacts of these events. An interagency workshop, *Excessive Heat Events: Confronting Climate Change, Vulnerability, and Urbanization by Improving Heat Health Services, Mitigation Strategies, and Communications*, was convened in November 2007. The goal of the workshop was to engage stakeholders—Federal, State, and local government agencies, academia, industry, and professional interests—in an effort to identify public health priorities, data gaps, and decision-support tools to enhance local responses to heat waves.



*Adaptation Guidebook.*³ The Climate Impacts Group (CIG), a CCSP-supported Regional Integrated Sciences and Assessments (RISA) team, and King County, Washington's Climate Team created a guidebook on preparing for and adapting to climate change. *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* is designed to help local, regional, and State governments prepare for climate



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change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools. The International Council for Local Environmental Initiatives (ICLEI) Local Governments for Sustainability contributed to the production and dissemination of the guidebook to make it accessible to local governments across the United States. The results of this guidebook will be used in future planning for CCSP-supported sectoral work on urban issues.

Decision-Support Workshop for Coastal Extension. CCSP convened a decision-support *Workshop on Climate Science and Services: Coastal Applications for Decision Making through Sea Grant Extension and Outreach* in Charleston, South Carolina (April 2007). Scientists associated with and supported by CCSP agencies shared important insights about impacts and adaptation, and potential methods for using climate information in decisionmaking. The workshop marks an important step in the development of an expanded partnership among CCSP's climate and coastal programs in an effort to provide enhanced support and services for national, State, and local constituencies concerned with coastal resource management and planning in the face of a dynamic climate system. Workshop presentations and related materials can be found at csc.noaa.gov/sgcw.

Decision-Support Research on Water Resources. CCSP continues to advance research on the linkages between climate and key sectors, including water resources. A sampling of the activities nearing or achieving completion include (1) a project by Stratus Consulting that is concentrating on the potential effects of climate change in combination with a repeat of long-term climate variability in Boulder, Colorado, and (2) a project recently completed by the National Drought Mitigation Center (NDMC) involving work with farmers to better understand the linkages between sustainable agriculture and drought management. Among the topics analyzed were the agricultural practices implemented to reduce the effects of drought, how drought information has been incorporated into agricultural management, and how drought and climate products could be enhanced to meet the needs of producers. The results of this study will be used both within the NDMC as well as for National Integrated Drought Information System (NIDIS) planning.



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Upcoming Report from the Committee on the Human Dimensions of Global Change. CHDGC is expected to release *Strategies and Methods for Climate-Related Decision Support* in FY 2009. This report will elaborate a framework for organizing and evaluating decision-support activities for CCSP, with special attention to sectors and issues of concern to the sponsors. It will also consider needs for science in support of decisions related to natural disasters and extreme events associated with climate change, such as droughts, floods, and hurricanes. The study panel will consider the range of relevant decisions, decisionmakers, decision contexts, spatial and temporal frames, and decision-support objectives, and current and potential strategies for organizing decision-support efforts to meet these objectives—taking into account the fact that, in some sectors, the desired outcomes of decision-support activities may not be clear in advance.

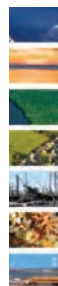
This activity will support Decision Support Goals 1 and 3 of the CCSP Strategic Plan.

Testing, Inter-Model Comparison, and Validation Methods for Integrated Assessment Research.

There is a recognized need to improve testing, inter-model comparisons, and validation of integrated assessment models as the rapidly expanding field assumes greater prominence and importance in helping to inform, at the national and regional levels, climate change policies and actions over the coming years. SAP 2.1 was a first of its kind U.S. effort that involved the comparison of three models from three independent teams: MIT, JGCRI, and the Electric Power Research Institute (EPRI). It marked an important beginning that, through subsequent discussions, has highlighted the many advanced techniques and methods that can and will be applied to help strengthen the scientific discipline and rigor within the field. The topic took on greater focus at the 2007 Integrated Assessment Annual Meeting with participation of many agencies and domestic and international researchers. The need for testing and validation was also separately highlighted by an independent advisory committee to one of the lead agencies that sponsors integrated assessment research. Several potential paths forward were discussed at the annual meeting and planning is underway to pursue select targets of opportunity. Close coordination with the Earth system modeling community is anticipated as this initiative takes shape.

This activity will support Decision Support Goal 3 of the CCSP Strategic Plan.

Modeling Tool to Enable Assessment of Soil Erosion. An online decision-support capability within the USDA Agricultural Research Service’s Water Erosion Prediction Project (WEPP) soil erosion model is being developed. New climate change assessment capabilities within WEPP will enable land managers to develop best management practices to lessen the impacts of climate variability and change on sediment loading



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from agricultural land to streams. The need for developing similar climate assessment capabilities for models applicable to urban drainage and design will be evaluated.

This activity will support Decision Support Goal 2 of the CCSP Strategic Plan.



Coping with Drought. CCSP, working with its partner Federal agencies through regional and sectoral projects, will support research and stakeholder interactions focused on using climate impacts information for drought planning and resource management. Emphasis will be placed on drought-prone areas of the western and southeastern United States where conflicts over water are growing. This will contribute to both the NIDIS being developed across a number of CCSP agencies and to the CCSP FY 2009 priority on climate, hydrology, and water management.

This activity will support Decision Support Goal 2 of the CCSP Strategic Plan.

Disaster Preparedness. The CCSP-sponsored International Research Institute for Climate and Society has entered into a partnership with the International Federation of Red Cross and Red Crescent Societies to use climate information and forecasts to improve disaster preparedness and response capabilities. Traditional climate tools are being tailored in innovative ways to identify areas that are especially vulnerable to climate-related disasters.

This activity will support Decision Support Goal 2 of the CCSP Strategic Plan.



Decision Support for Coastal Resource Management and Community Resilience. As part of a broader effort, CCSP plans to develop decision-support resources and research applications for coastal resource management and hazards preparedness through place-based interdisciplinary climate research and assessment focused on vulnerability, impacts, and adaptation. Examples of decision-support resources include web portals; derived data analysis products; geographic information system (GIS) tools that integrate social, economic, and climate data in a useful and interactive format; “guidebooks” for public distribution describing potential climate sensitivity in coastal regions; impacts assessments; and methodologies for applying climate information in management and policy activities related to coastal resources.

This activity will support Decision Support Goal 2 of the CCSP Strategic Plan.

HUMAN CONTRIBUTIONS AND RESPONSES
AND DECISION-SUPPORT RESOURCES DEVELOPMENT
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