



7 | Decision-Support Resources Development and Related Research on Human Contributions and Responses

CCSP Decision-Support Goals

Decision-Support 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.

Decision-Support 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.

Decision-Support 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.

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?

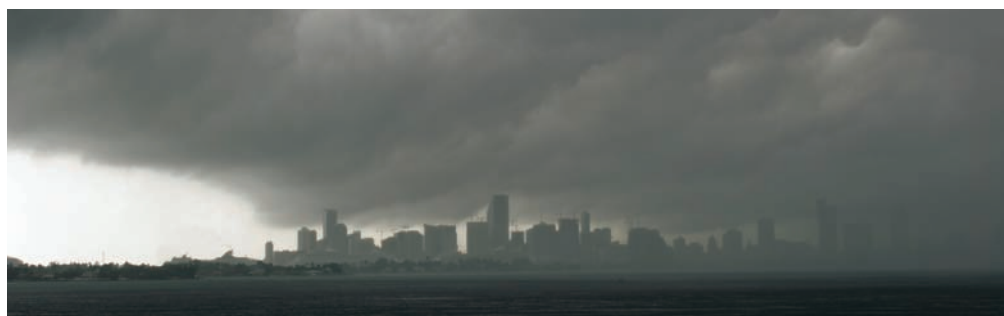
See Chapter 11 of the *Strategic Plan for the U.S. Climate Change Science Program* for detailed discussion of decision-support resources development and Chapter 9 for these specific research questions.

One of the main purposes of CCSP is to provide information for decisionmaking through the development of decision-support resources. Decision-support resources, systems, and activities are climate-related products or processes that directly inform or advise stakeholders to help them make decisions. These products or processes include analyses and assessments, interdisciplinary research, analytical methods (including scenarios and alternative analysis methodologies), model and data product development, forecasts, communication, and operational services. Decision-support resources and activities include research activities based in the natural sciences and activities related to human contributions and responses to climate variability and change, such as demography, economics, history, anthropology, political science, and sociology.

Decision Support Goal 1: Scientific Syntheses and Assessments

The *CCSP Strategic Plan* defines “assessments” as “processes that involve analyzing and evaluating the state of scientific knowledge (and the associated degree of scientific certainty) and, in interaction with users, developing information applicable to a particular set of issues or decisions.” Assessments are an effective means for integrating and analyzing CCSP research results with other knowledge, and communicating useful insights in support of a variety of applications for decision support. Assessments also help identify knowledge gaps and thus provide valuable input to the process of focusing research.

A primary activity within CCSP is the development of 21 synthesis and assessment products (SAPs) 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 the effects of global change” and to undertake periodic science “assessments.”



DESCRIPTION OF CCSP SYNTHESIS AND ASSESSMENT PRODUCTS

CCSP Goal 1: Improve knowledge of the Earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and changes.

SYNTHESIS AND ASSESSMENT PRODUCT 1.1

Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences

Temperature change is a fundamental measure of climate change. This product, which was the first to be completed, addresses temperature changes from the surface through the lower stratosphere and understanding of the causes of these changes. It assesses progress made since the reports by the National Research Council (2000) and the Intergovernmental Panel on Climate Change (2001) and highlights differences between the individual temperature records determined by components of the existing observational and modeling systems and documents the potential causes of these differences.

SYNTHESIS AND ASSESSMENT PRODUCT 1.2

Past Climate Variability and Change in the Arctic and at High Latitudes

The Arctic and the high latitudes have warmed more rapidly than almost any other region on Earth over at least the last millennium. This warming has been accompanied by a decrease in sea ice cover and thickness and a decrease in ocean salinity. In addition, significant changes in the permafrost active layer are now being detected. The impacts on humans and ecosystems that are associated with these changes were reported in the *Arctic Climate Impact Assessment*, which was partially funded by CCSP-participating agencies. The present synthesis and assessment product on the Arctic and high latitudes will focus on the state of knowledge concerning past changes in the physical climate of this region and the implications of this record of past changes for current and future change. This information is vital since high-latitude regions are projected to continue to experience the greatest warming in the future.

SYNTHESIS AND ASSESSMENT PRODUCT 1.3

Reanalyses of Historical Climate Data for Key Atmospheric Features: Implications for Attribution of Causes of Observed Change

A reanalysis is a detailed, retrospective study of the state of the atmosphere using a consistent numerical model of the dynamics of the system and based on observations for the time period of the study. This product provides an assessment of the capability and limitations of state-of-the-art climate reanalysis to describe past and current climate conditions, and the consequent implications for scientifically interpreting the causes of climate variations and change. The product will be in the form of a report that summarizes the present status of national and international climate reanalysis efforts, and discusses key research findings on the strengths and limitations of current reanalysis products for describing and analyzing the causes of climate variations and trends that have occurred during the time period of the reanalysis records (roughly the past half-century). The report will describe how reanalysis products have been used in documenting, integrating, and advancing our knowledge of climate system behavior, as well as in ascertaining significant remaining uncertainties in descriptions and physical understanding of the climate system.

CCSP Goal 2: Improve quantification of the forces bringing about changes in the Earth's climate and related systems.

SYNTHESIS AND ASSESSMENT PRODUCT 2.1

Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations, and Review of Integrated Scenario Development and Application

This product, which was publicly released in 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, *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations*, 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, *Global Change Scenarios: Their Development and Use*, 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.

DESCRIPTION OF CCSP SYNTHESIS AND ASSESSMENT PRODUCTS (CONT.)

CCSP Goal 2 (continued)

SYNTHESIS AND ASSESSMENT PRODUCT 2.2

North American Carbon Budget and Implications for the Global Carbon Cycle

This product provides a synthesis and integration of the current knowledge of the North American carbon budget (including land, atmosphere, inland waters, and adjacent oceans) and its context within the global carbon cycle. In a format useful to decisionmakers, it summarizes knowledge of carbon cycle properties and changes relevant to the contributions of, and impacts upon, the United States and the rest of the world; and provides scientific information for U.S. decision support focused on key issues for carbon management and policy. It addresses carbon emissions; natural reservoirs and sequestration; rates of transfer; the consequences of changes in carbon cycling; effects of purposeful carbon management; effects of agriculture, forestry, and natural resource management; and socioeconomic drivers and consequences. The report includes an analysis of North America’s carbon budget that documents the state of knowledge and quantifies uncertainties.

SYNTHESIS AND ASSESSMENT PRODUCT 2.3

Aerosol Properties and their Impacts on Climate

Aerosols can cause a net cooling or warming within the climate system, depending upon their physical and chemical characteristics. In addition to these direct effects, aerosols can also have indirect effects on radiative forcing of the climate system by changing cloud properties. The first phase of development of this product is to produce major scientific reviews of the following three topics: dependence of radiative forcing by tropospheric aerosols on aerosol composition in the north Atlantic, Pacific, and Indian Ocean regions; measurement-based understanding of aerosol radiative forcing from remote-sensing observations; and model intercomparison to quantify uncertainties associated with indirect aerosol forcing. The second-phase product will draw upon the scientific information gathered by the development of the Intergovernmental Panel on Climate Change Fourth Assessment Report and the National Research Council review, *Radiative Forcing of Climate Change*. These community-wide assessments of climate change (and the aerosol-climate topic inclusively) will be drawn from in writing SAP 2.3.

SYNTHESIS AND ASSESSMENT PRODUCT 2.4

Trends in Emissions of Ozone-Depleting Substances, Ozone Layer Recovery, and Implications for Ultraviolet Radiation Exposure

Measurements of ozone-depleting gases in the atmosphere have shown that the concentrations of these gases are declining in response to the agreements reached under the Montreal Protocol. This report will provide an update on trends in stratospheric ozone, ozone-depleting gases, and ultraviolet radiation exposure; progress in improving model evaluations of the sensitivity of the ozone layer to changes in atmospheric composition and climate; and relevant implications for the United States. This information is key in ensuring that international agreements to phase out production of ozone-depleting substances are having the expected outcome—recovery of the protective ozone layer. The report will derive most of its information from recent international assessments of stratospheric ozone, ozone-depleting substances, and climate.

CCSP Goal 3: Reduce uncertainty in projections of how the Earth’s climate and related systems may change in the future.

SYNTHESIS AND ASSESSMENT PRODUCT 3.1

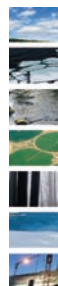
Climate Models: An Assessment of Strengths and Limitations

The topics addressed by this product are the strengths and limitations of climate models at different spatial and temporal scales. Its purpose is to provide information on the results from climate models, in ways that will allow the potential user of the information to evaluate how best it may be applied. The product will focus on natural and human-caused factors influencing climate variability and change during the period from 1870 to 2000. It will characterize sources of uncertainty in climate models and their implications for estimating future climate change. This product will be limited to the models and their sensitivity, feedbacks, strengths, and limitations, rather than making specific future projections.

SYNTHESIS AND ASSESSMENT PRODUCT 3.2

Climate Projections for Research and Assessment Based on Emissions Scenarios developed through the Climate Change Technology Program

This product will have two distinct components. The first will be to produce climate projections for research and assessment based on greenhouse gas emission scenarios and atmospheric concentrations as reported in SAP 2.1a. The second will be to assess the future climate impacts of short-lived gaseous and particulate species.



DESCRIPTION OF CCSP SYNTHESIS AND ASSESSMENT PRODUCTS (CONT.)

CCSP Goal 3 (continued)

SYNTHESIS AND ASSESSMENT PRODUCT 3.3

Weather and Climate Extremes in a Changing Climate: North America, Hawaii, Caribbean, and U.S. Pacific Islands

The impact of climate extremes can be severe and wide-ranging. There is evidence that the economic impact of weather and climate extremes in the United States has increased over the past several decades, but the evidence for increases in extreme weather and climate events varies depending on the event of interest. These events may be related to temperature parameters (severe freezes, heat waves), precipitation (wet spells, heavy precipitation events, droughts, ice and hail, snow cover and depth), or tropical and extratropical storm frequency. Identifying recent changes and trends in such parameters will be a focus of the report, as well as identifying what can be said about future changes. Since extreme weather and climate events on a global scale are regularly addressed in international assessments, this product will focus on weather and climate extremes primarily across Canada, Mexico, and the United States.

SYNTHESIS AND ASSESSMENT PRODUCT 3.4

Abrupt Climate Change

The paleoclimate record reveals that Earth's climate can change rapidly and strongly between different stable states. Various scenarios portray future abrupt climate change large enough to pose a significant challenge to society. The goal of this product is to review and synthesize our current understanding of abrupt climate change and to identify gaps in our knowledge. The report will integrate information from the paleoclimate record, the instrumental record, and numerical model-based studies at various spatial scales. Key identified risks, such as changes in ocean thermohaline circulation and alteration of terrestrial hydrologic conditions (e.g., the location or amount of precipitation) will receive special attention because the potential impacts on society are large.

CCSP Goal 4: Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes.

SYNTHESIS AND ASSESSMENT PRODUCT 4.1

Coastal Elevation 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.

SYNTHESIS AND ASSESSMENT PRODUCT 4.3

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

This report will address 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.

DESCRIPTION OF CCSP SYNTHESIS AND ASSESSMENT PRODUCTS (CONT.)

CCSP Goal 4 (continued)

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 will provide 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 Global Change on Energy Production and Use in the United States*

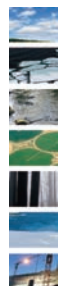
This report summarizes what is currently known about potential effects of climatic change on energy production and use in the United States. It focuses on three questions: (1) How might climatic change affect energy use in the United States, (2) how might climatic change affect energy production and 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 is being taken in answering these questions, for two reasons. One, the available research literatures 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 PRODUCT 4.6*Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems*

Synthesis and Assessment Product 4.6 will examine the effects of global change on human systems. This product will address Goal 4 of the five strategic goals in 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. This product 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 product will address 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 is 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—will be addressed. The three-phase study will focus on the Gulf Coast, and will assess the significant risks to transportation, develop methodology to be applied in other geographic locations, identify potential strategies for adaptation, and develop decision-support tools to assist transportation decisionmakers in incorporating climate-related trend information into transportation system planning, design, engineering, and operational decisions.



DESCRIPTION OF CCSP SYNTHESIS AND ASSESSMENT PRODUCTS (CONT.)

CCSP Goal 5: Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change.

SYNTHESIS AND ASSESSMENT PRODUCT 5.1

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

The 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 Climate 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 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, 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.

As of September 2007, the following synthesis and assessment products have been released:

- 1.1 *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences*
- 2.1 *A. Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations and B. Global-Change Scenarios: Their Development and Use.*

Several other SAPs are expected soon. The accompanying box provides a brief description of the scope of each product. Up-to-date status on all SAPs can be found at www.climate-science.gov/Library/sap/sap-summary.php.

CCSP supports research and tool development that focus on human behavior and socioeconomic trends. Assessments need to incorporate projections of social and economic change (e.g., population and technological change), as well as the effects of

environmental change on communities and sectors (e.g., transportation, health, agriculture). Decision support also requires methods and tools to undertake comparative work across communities, regions, and sectors.

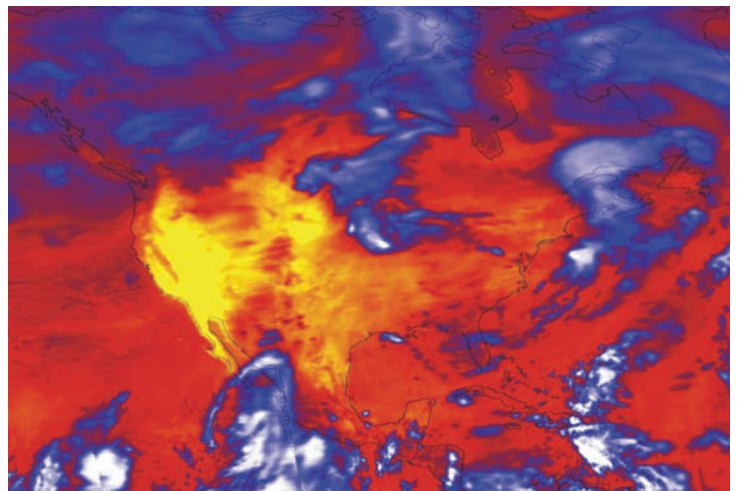
Decision Support Goal 2: Adaptive Management and Planning Decisions

A number of efforts are underway to support adaptive management and planning decisions (operational decisions for managing resources, societal response mechanisms, and long-term infrastructure planning). These activities involve sectoral analyses examining agriculture, forestry, water supply, fisheries, and human health. Drought and variations in the frequency of temperature extremes, severe precipitation, and runoff are key climate challenges being addressed. Progress is being made to engage stakeholders at local and regional levels in an effort to bring information about the impacts of climate variability and change to bear on their management and planning decisions. Bringing climate science to decisionmakers, analyzing the impacts of climate on their decisions, and collaborating with them to produce new knowledge and tools are all key parts of this goal.

Decision Support Goal 3: Methods to Support Climate Policymaking

Climate is a primary or significant factor in policy considerations, such as options for reducing greenhouse gas emissions, long-term ecosystem management, and infrastructure planning. CCSP, in collaboration with the CCTP, is providing useful information related to these issues.

CCSP also supports the development of integrated modeling frameworks that are useful for exploring many dimensions of climate and global change. Full integration of information on human activities, greenhouse gases and aerosol emissions, land-use and land-cover change, cycling of carbon and other nutrients, climatic responses, and impacts on people, the economy, and resources is necessary for analysis of many important questions about the potential economic and environmental implications of changing greenhouse gas concentrations and alternative technology portfolios. Answers from integrated analysis can only reflect the existing



Highlights of Recent Research and Plans for FY 2008

state of knowledge, but it is important to develop frameworks and resources for integration, exercise them, and learn from analysis of the results. CCSP is encouraging innovation and development of approaches to integrated analysis.

HIGHLIGHTS OF RECENT RESEARCH

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

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 Committee on the Human Dimensions of Global Change (CHDGC) of the National Research Council (NRC). The committee was formed in 1989, to help guide U.S. research on the interactions between human activity and global environmental change. The CHDGC focuses on two main tasks: developing the intellectual basis for progress in understanding human-environment interactions, and advising on future research directions. Recently completed and soon-to-be-completed studies include:

- *Analysis of Global Change Assessments: Lessons Learned.* Global change assessments inform decisionmakers about the scientific underpinnings of a range of environmental issues. With dozens of assessments conducted to date by various U.S. and international groups, this report took the opportunity to draw on these experiences to improve future efforts. The report, which was produced by the NRC Board on Atmospheric Sciences and Climate and was released in February 2007, identifies 11 essential elements of effective assessments and provides recommendations on evolving the process to better support decisionmaking.
- *Public Participation in Environmental Assessment and Decisionmaking.* This report will use available research and experience and some specially commissioned studies in order to draw conclusions and recommendations about how best to implement broader public participation in environmental assessment and policymaking. The



study seeks to specify indicators of success and variables believed to influence these indicators; identify lessons from experience concerning which approaches work well under which conditions; state testable hypotheses that would allow verification or refinement of the lessons drawn from currently available information; and propose ways for government agencies to learn systematically from their own experience and the experience of others.

- *Putting People on the Map: Protecting Confidentiality with Linked Social-Spatial Data.* Precise, accurate spatial information linked to social and behavioral data is revolutionizing social science by opening new questions for investigation and improving understanding of human behavior in its environmental context. At the same time, precise spatial data make it more likely that individuals can be identified, breaching the promise of confidentiality made when the data were collected. Because norms of science and government agencies favor open access to all scientific data, the tension between the benefits of open access and the risks associated with potential breach of confidentiality pose significant challenges to researchers, research sponsors, scientific institutions, and data archivists. *Putting People on the Map*, a CHDGC report released in March 2007, finds that several technical approaches for making data available while limiting risk have potential, but none is adequate on its own or in combination.

*New Alaska Center for Climate Assessment and Policy.*¹ A new Regional Integrated Sciences and Assessments (RISA) effort focused on Alaska was launched in September 2006. The new Alaska Center for Climate Assessment and Policy (ACCAP) will synthesize data and information to quantify the effects of changes in seasonality of weather and climate on Alaskan people and ecosystems, determine stakeholder needs for enhanced information, conduct research to facilitate product enhancement, and assess vulnerability and adaptive capacity of various Alaskan sectors. Transportation will provide the initial focus for these activities. Federal partners include NOAA and the U.S. Bureau of Land Management; other partners include nongovernmental organizations, state agencies, tribal governments, and the private sector.

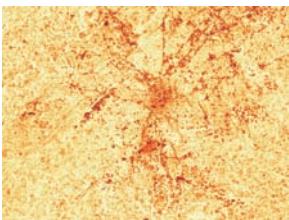
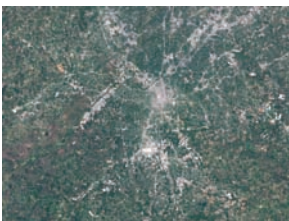
National Integrated Drought Information System Program Office. In support of the Western Governors Association report, *Creating a Drought Early Warning System for the 21st Century: The National Integrated Drought Information System*, and the National Integrated Drought Information System (NIDIS) Authorization Bill signed in 2006, the interagency NIDIS program office has been established. The goal of NIDIS is to create an interagency and interstate coordination program to (1) improve public awareness of drought and attendant impacts, (2) improve the capacity of counties and watershed organizations to reduce drought risks proactively, and (3) provide guidance on filling information gaps including those for monitoring, forecasting, and impact



Highlights of Recent Research and Plans for FY 2008

assessments as needed. The interagency NIDIS Implementation Plan, which addresses these three goals, was released in 2007.

Climate Change Impacts on Agricultural Efficiency in Central America. Over the last decade, there has been engagement in developing criteria and tools for assessing the potential effects of climate change and climate variability on agricultural systems, natural ecosystems, and other systems and sectors worldwide. The present task is to apply those tools in key regions to provide policymakers and practitioners in various affected countries with the means to anticipate, mitigate, and/or adapt to changes in the mean values and potential extremes of a changing climate. An exploratory study of the effects of climate change on agricultural efficiency in the state of Costa Rica will be undertaken. Costa Rica lies at the center of the climate-sensitive Isthmus of Central America. One scenario product that will be developed in this research effort involves the use of global climate models to determine how storm tracks may change in both the Pacific and Caribbean subregions of Central America.



*Environmental Public Health Tracking Network.*² CCSP scientists have been working with the Centers for Disease Control and Prevention (CDC) and partners in environmental public health to provide environmental data products that would be of benefit to the Environmental Public Health Tracking Network (EPHTN). EPHTN will establish a national network of local, state, and Federal public health agencies to track trends in priority non-infectious health effects. This effort is being undertaken as part of the Health and Environment Linked for Information Exchange in Atlanta (HELIX-Atlanta) project. This effort is demonstrating a process for developing a local environmental public health tracking (surveillance) network. In a 2006 report, it was found that augmenting the EPA Air Quality System (AQS) observations with NASA Moderate Resolution Imaging Spectroradiometer (MODIS)-derived PM_{2.5} (particulate matter that is 2.5 μm or smaller in size) observations increases the temporal and spatial resolutions of fine particulate estimates. The report also found that such augmentation also increases the accuracy in estimating concentrations of an environmental hazard such as PM_{2.5}, which is absolutely critical for environmental public health tracking. High concentrations of PM_{2.5} are associated with adverse health reactions (e.g., respiratory and cardiovascular problems).

Representation of Expectations in Assessment Models. One source of divergence among alternative economic models in assessments of emissions mitigation is the way the models represent expectations of future developments—that is, whether current decisions are based on future as well as current conditions (i.e., the model is forward-looking) or each time period is analyzed independently (i.e., recursive dynamic). To provide a basis for studying these differences in approach, the Massachusetts Institute



of Technology (MIT) Joint Program on the Science and Policy of Global Change has completed the development of a forward-looking version of its Emissions Prediction and Policy Analysis (EPPA) model, which was originally developed in a recursive-dynamic form. Application of the two versions to the same set of mitigation proposals allows a direct comparison of methods. In terms of timing of mitigation efforts, the two versions show similar results but the

macroeconomic effects of mitigation are smaller in the forward-looking model because it optimizes over time, and smoothes out bumps in the consumption path. Solving the forward-looking model is computationally demanding, and to do so requires simplifications that reduce the model dimensions, such as the number of regions, sectors, or time steps. The fact that the recursive and the forward-looking versions give similar results in terms of mitigation allows for continued use of the recursive model where a longer time horizon or greater regional detail is required.

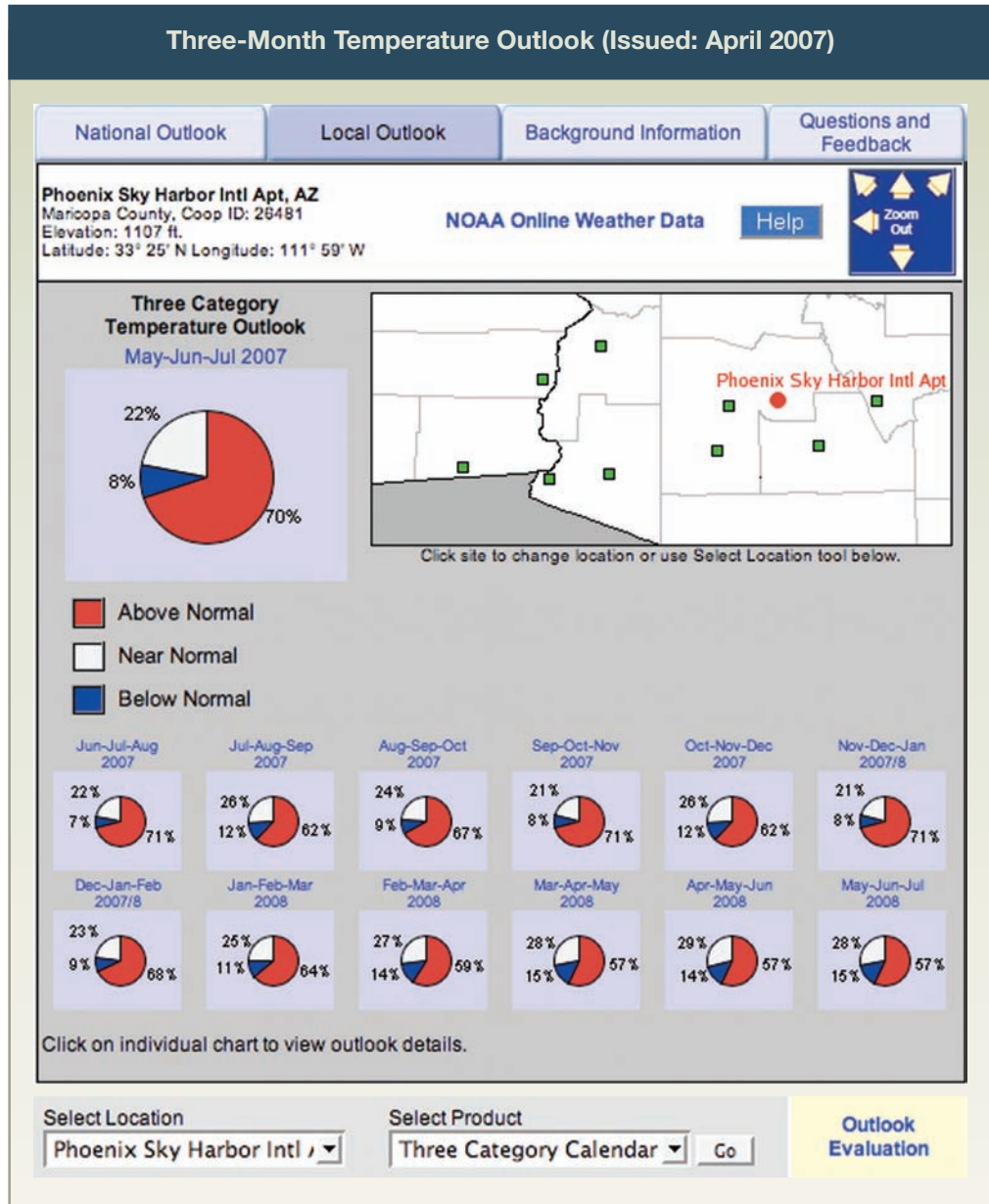
*New Local 3-Month Temperature Outlook.*³ A new climate forecast product, the Local 3-Month Temperature Outlook (L3MTO), was released in 2007. This product represents years of development by climate services personnel utilizing climate forecasting best practices from the Climate Prediction Center. This product also leverages extensive research from the RISA program on communicating probabilistic information to diverse decisionmakers to help them make economically, socially, and environmentally sound decisions. L3MTO is presented in various levels of complexity for different types of users. It incorporates copious help documentation as well as users' guides. Comments and feedback have been used to improve L3MTO and will continue to be addressed in the future.

Plans call for expansion of the product suite to include precipitation in the near future.

Figure 13 provides an example of this product.



Figure 13: Three-Month Temperature Outlook (Issued: April 2007). This screenshot provides an example of a local 3-month temperature outlook (L3MTO) forecast for Phoenix, Arizona, and vicinity. Credit: J. Bollinger, NOAA / National Weather Service.



*Projected Energy Usage in a Warmer Future.*⁴ Gradually increasing temperatures will create a greater demand for air conditioning and, in turn, a greater demand for energy and greater demand for coal to fuel power plants to produce the needed energy. A recent analysis of the effects of future projected climate change on energy usage and costs for the period 2000 to 2025 uses a numerical economic model driven with output from a climate model. The economic model includes data on building codes and census figures from every county in the United States, along with expected population changes during the time period. The coupling of a global climate model

with output at regional scales with state-of-the-art economic modeling to assess the effects of future climate change on energy use makes this study noteworthy.

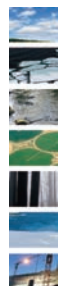
HIGHLIGHTS OF PLANS FOR FY 2008

*New Regional Integrated Sciences and Assessments Effort Focused on Drought.*⁵ Under the auspices of the Coping with Drought through Research and Regional Partnerships effort described in the FY 2007 edition of *Our Changing Planet*, a new activity will be initiated in a region not currently covered by the RISA program. This new RISA activity will have drought impacts research and stakeholder work as a central theme and will provide an avenue within the region chosen for interagency work focused on climate impacts.

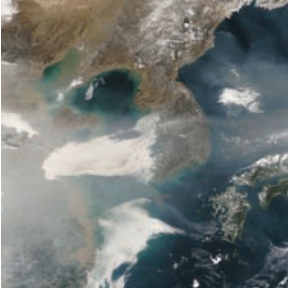
This activity will address Question 9.2 of the CCSP Strategic Plan, and will support Decision-Support Objective 2.1.

Development of Modeling Tools to Support Water and Watershed Management. Climate change presents a range of risks and opportunities to water managers. To minimize risk and take advantage of opportunities, tools are necessary to promote adaptive and forward-looking environmental management by decisionmakers at all levels. In 2007, a new climate assessment capability was developed within the Better Assessment Science Integrating Point and Non-point Sources (BASINS) watershed modeling system. The new tool facilitates assessment of the influence of climate variability and change on water quantity and quality and provides a capacity to evaluate adaptation strategies that increase the resilience of water systems to changes in climate. A case study using the new BASINS system is underway to assess the sensitivity of hydrologic and water quality endpoints to climate change in the Monocacy River watershed, a tributary to the Potomac River and Chesapeake Bay. An online decision support capability with the USDA ARS Water Erosion Prediction Project (WEPP) soil erosion model also is under development. 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 from agricultural land to streams. In FY 2008, the need for developing similar climate assessment capabilities for models applicable to urban drainage and design will be determined.

This activity will address Questions 9.2 and 9.3 of the CCSP Strategic Plan, and will support Decision-Support Objectives 1.2 and 2.1.



Highlights of Recent Research and Plans for FY 2008



Decision Assessment in the Gulf Coast and Chesapeake Bay Regions. Several pilot studies in the Gulf Coast region and the Chesapeake Bay were initiated 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 re-evaluation and research in light of projected changes. Plans are to evaluate the results of these pilot studies to determine the applicability of a decision assessment approach to decisions related to water quality, aquatic ecosystems, and air quality.

This activity will address Question 9.3 of the CCSP Strategic Plan, and will support Decision-Support Objectives 2.1 and 3.2.

Integrated Evaluation of Climate Change, Mitigation, Bioenergy, and Land Use. Biofuels represent a potentially important source of energy that, depending on how they are produced, could reduce carbon dioxide (CO₂) emissions by replacing fossil fuels. However, greatly expanded use of biofuels would put pressure on food and forestry prices and could lead to conversion of land and release of carbon from soils and vegetation. At the same time, changes in climate, CO₂ levels, and concentrations of other pollutants such as ozone will affect the productivity of crops, pasture, and forestland. The MIT Joint Program on the Science and Policy of Global Change will complete 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. The linkage will allow examination of the effects on greenhouse gas cycles of disturbances associated with the conversion of unmanaged forest and grassland to crop, pasture, or bioenergy production. Also, because it will be fully integrated with economic projections, the linked system will provide the ability to evaluate the feedbacks of changing environmental conditions on agricultural productivity, the resultant effects on the global and regional economy, consequent impacts on land use, and the further effects of land-use change on biogeochemical cycles and feedbacks on atmospheric composition and climate.

This activity will address Question 9.1 of the CCSP Strategic Plan, and will support Decision-Support Objective 3.1.



Integrated Impacts on and Adaptation to Climate Change of Terrestrial Ecosystems, Water Resources, and Agriculture. Terrestrial ecosystems, water resources, and agriculture represent important systems and pathways through which climate change could be experienced. Integrated models of drivers and systems response have generally lagged progress on the discrete research topics and associated models. In FY 2008, the foundations will be laid for incorporating these features into an integrated model in a way that reflects the state-of-the-art in relevant disciplinary research. Scoping meetings will be conducted to explore the state-of-the-art, identify methods for incorporation, and deliver a research plan. In addition, first steps will be taken to implement that

plan, including a preliminary evaluation of climate impacts on water resources with implications for agricultural impacts and adaptation.

This activity will address Question 9.2 of the CCSP Strategic Plan, and will support Decision-Support Objectives 2.1 and 3.1.

Scale and Timing of Climate Forcing. General circulation models, including those with coupled oceans and integrated terrestrial carbon cycles and atmospheric chemistry models, require time-dependent trajectories of greenhouse gases, chemically active gases, and aerosols to be run in forecast mode. In FY 2008, researchers will build on work reported in CCSP's SAP 2.1a to develop time-dependent trajectories that can be used by climate and atmospheric chemistry models.

This activity will support Decision-Support Objectives 1.2 and 3.1.

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 natural extreme events associated with climate change, such as droughts, floods, and hurricanes. To do this, 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 address Question 9.3 of the CCSP Strategic Plan, and will support Decision-Support Objectives 1.1 and 3.2.



DECISION-SUPPORT RESOURCES DEVELOPMENT CHAPTER REFERENCES

- 1) See <uaf.edu/accap>.
- 2) **Rosen**, R., A. Chu, J.J. Szykman, R. DeYoung, J.A. Al-Saadi, A. Kaduwela, and C. Bohnenkamp, 2006: Application of satellite data for three-dimensional monitoring of PM_{2.5} formation and transport in San Joaquin Valley, California. In: *Remote Sensing of Aerosol and Chemical Gases, Model Simulation/Assimilation, and Applications to Air Quality* [Chu, A., J. Szykman, and S. Kondragunta (eds.)]. Proceedings of SPIE - International Society of Optical Engineering, **6299**, doi:10.1117/12.681649.
- 3) See <weather.gov/climate/l3mto.php>.
- 4) **Hadley**, S., D.J. Erickson III, J. Hernandez, C. Broniak, and T.J. Blasing, 2006: Responses of energy use to climate change: A climate modeling study. *Geophysical Research Letters*, **33**, L17701, doi:10.1029/2006GL026131.
- 5) See <climate.noaa.gov/cpo_pa/risa>.