DEPARTMENT OF ENERGY

Principal Areas of Focus

Research supported by DOE's Office of Science is focused on the effects of energy production and use on the global climate system, primarily through studies of climate response to changes in greenhouse gas and aerosol concentrations. Research covers three program areas: 1) climate change modeling, 2) climate forcing, and 3) climate change response.

Program Highlights for FY 2007

DOE will continue support of climate change research at its National Laboratories and other public and private research institutions, including universities. In support of CCSP, the DOE Office of Science's Climate Change Research Program will continue to provide the data and predictive understanding that will enable objective, scientifically rigorous assessments of the potential for, and consequences of, human-induced climate change

Climate Change Modeling

DOE continues to develop, improve, evaluate, and apply fully coupled atmosphere-ocean-sea ice-land surface general circulation models (GCMs) that simulate climatic variability and change over decadal to centennial time scales. As one of its contributions to the suite of synthesis and assessment products (SAPs) being prepared by CCSP, DOE will lead the effort on SAP 3.1, "Climate Models: An Assessment of Strengths and Limitations for User Applications."

In FY 2007, DOE researchers will participate in the analysis of multi-model ensemble runs under various forcing scenarios as part of the U.S. contribution to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, scheduled for release in 2007. IPCC model simulations from major national and international high-end modeling centers are currently archived at Lawrence Livermore National Laboratory (LLNL)/Program for Climate Model Diagnosis and Intercomparison (PCMDI), and made accessible to the climate research community. Under the DOE-wide Scientific Discovery through Advanced Computing (SciDAC) initiative, DOE will support model development of the CCSM to incorporate atmospheric chemistry and coupled biogeochemistry, in addition to improved physics and dynamics. DOE will also continue ongoing development of high-resolution comprehensive coupled GCMs that incorporate more accurate and verified representations of clouds and other important climatic processes. DOE will continue support of innovative approaches to climate model development—for example, the geodesic grid model intended to lead to a prototype climate model that could potentially overcome some of the problems and limitations of current generation climate models.

Climate Forcing

Collection and analysis of data from DOE's Atmospheric Radiation Measurement (ARM) Cloud and Radiation Test Bed (CART) sites will continue in FY 2007 to improve understanding of the radiative transfer processes in the atmosphere and to formulate better parameterizations of these processes, especially cloud and aerosol effects for use in climate models. DOE will also report on results of two

major international campaigns: Tropical Warm Pool – International Cloud Experiment (TWP-ICE) and the 1-year deployment of the ARM Mobile Facility in Niger, Africa. The latter is part of the field phase of the African Monsoon Multidisciplinary Analysis (AMMA) to obtain atmospheric and radiation data on meteorological conditions ranging from deep, tropical convective clouds in the humid tropical air masses prevalent in the wet season to the aerosol-laden dry air masses found during the dry season. AMMA field data will provide unique opportunities to evaluate and improve the parameterization schemes used in climate models across a wide range of meteorological conditions. The TWP-ICE was conducted around the ARM site in Darwin, Australia, and focused on the effects of cirrus clouds on the transfer of radiation in the atmosphere. TWP-ICE employed multiple research aircraft and balloon-borne meteorological sensors from an array of sites to measure cloud properties and their impacts on the transfer of radiation in the atmosphere throughout the storm life cycle as well as the atmospheric state. Data from this experiment will be used to both evaluate and test how well existing models simulate cloud properties and to improve the modeling of cloud properties and their effects on the transfer of radiation in the atmosphere. In 2007, the mobile facility will be deployed to the Black Forest in Germany to participate in the Initiation of Convection and the Microphysical Properties of Clouds in Orographic Terrain (AMF + COPS). The region of deployment can be characterized by significant orographic precipitation with most of the summertime precipitation being convective. The experiment is designed to improve the prediction of precipiation in this environment. In 2007, ARM will conduct an experiment to study the impact of land surface conditions on continental cumulus convection. This experiment—the Cloud LAnd Surface Interaction Campaign (CLASIC)—will last 1-3 months and will straddle the winter wheat harvest when large changes in the land surface lead to large changes in the surface albedo, latent heat flux, and sensible heat flux. By DOE's invitation, CLASIC will be developed further as an integrated, interagency project—contingent on FY 2007 funding and on expressions of multi-agency interest.

DOE's Atmospheric Science Program will continue research in FY 2007 to reduce uncertainties in aerosol radiative forcing of climate. Research will focus specifically on atmospheric loading and geographical distribution of aerosols, on the properties that influence their scattering and absorption of radiation, their influence on the microphysical properties of clouds, and the processes that influence aerosol loading, geographical distribution, and properties. In FY 2007 a campaign will be conducted, in conjunction with the ARM Program, to examine interactions of aerosols with fair-weather cumulus clouds. Analysis of data from prior field studies will continue, principally from a FY 2005 campaign that examined aerosol influences on marine stratus and a FY 2006 campaign conducted in and around Mexico City to examine the properties and processes of aerosols emanating from a large metropolitan area. Data from the campaign will be used to characterize changes in aerosol composition, size distribution, light scattering coefficient, absorption coefficient, optical depth, soot-specific absorption, and radiative fluxes at the surface. Results will be utilized to develop or improve detailed models of aerosol processes required by the climate modeling community.

DOE's carbon cycle research will continue to improve understanding of the role and importance of terrestrial ecosystems in the global carbon cycle. Research in FY 2007 will address the questions and elements described in Chapter 7 of the *CCSP Strategic Plan*. DOE's Terrestrial Carbon Processes (TCP) research will continue to contribute to the North American Carbon Program (NACP) through support of experiments, observations, and modeling of atmospheric CO_2 and the terrestrial carbon cycle. In FY 2006, TCP was formally reviewed, and it was recommended that the program continue to focus on the AmeriFlux network of observations, and that experimental, modeling, and synthesis research

continue to provide fundamental information for understanding the terrestrial carbon cycle, including exchange of CO_2 between terrestrial systems and the atmosphere. Temporal and spatial observations of gross and net carbon dioxide fluxes, and real-time information on ecosystem carbon states and sinks, will be made available to researchers that are investigating regional CO_2 exchange, continental-scale carbon sinks and sources, and carbon cycle-climate relationships. DOE will also support the NACP strategy of a model-based comparison of "bottom-up" (distributed ecosystem models driven by land surface and meteorological information) and "top-down" (inferring spatially distributed surface fluxes from atmospheric measurements) approaches to estimating ecosystem carbon dioxide fluxes for different regions of the United States. DOE will provide information on biogeochemical, physiological responses and terrestrial ecosystem feedbacks related to climate change as part of joint carbon cycle-climate change research to improve simulation models.

Climate Change Response

DOE will continue to design, implement, and maintain large-scale and long-term experimental field manipulations of environmental factors affected by energy production in important North American ecosystems. This includes support of the Free-Air CO_2 Enrichment (FACE) experimental facilities for study of the response of terrestrial ecosystems to elevated atmospheric concentrations of carbon dioxide (and in some cases ozone). The goal is to understand, and be able to predict, effects of environmental change and variability on the structure and functioning of terrestrial ecosystems. The research focuses on the physiology, growth, and reproduction of plants and microbes; nutrient and water cycling in ecosystems; plant community dynamics; plant-microbe interactions; and acclimation and adaptation of plants, microbes, and whole ecosystems to environmental change and variability.

Ongoing experimental research will be continued in FY 2007, including field manipulations of temperature, precipitation and soil moisture, carbon dioxide concentration, ozone concentration, and/or enhanced atmospheric nitrogen deposition in a range of terrestrial ecosystems, including boreal forest, arid shrublands and desert, temperate grasslands, temperate woodlands, and temperate deciduous and evergreen forests. Such experiments will provide the data and information needed to evaluate (test) the ability of ecological models to realistically predict effects of environmental change and variability on terrestrial ecosystems; such models form the basis of most assessments of potential effects of environmental change on ecosystems. The research initiative implemented in FY 2004 dealing with "scaling" in ecological systems will also be continued in FY 2007. This initiative will continue to examine how quantitative information obtained at the level of macromolecules (e.g., genes and enzymes) can be used to understand and predict how processes and states of whole terrestrial ecosystems would be affected both directly and indirectly by natural and human-induced environmental changes, such as climatic changes caused by energy production. Ecosystems that will be studied include forest, shrubland, grassland, and crop.

The DOE Integrated Assessment of Global Climate Change Research Program will continue to support research that examines and models global economies, technologies that emit greenhouse gases, and natural systems associated with climate change. These studies help provide understanding of the relative efficiencies and impacts of potential mitigation strategies. In FY 2007, the two large integrated assessment models funded by the program will improve their representation of renewable energy derived from biological sources. The portrayal of uncertainty in emission scenarios will also be studied to help identify methods that represent important variability with a small number of alternative scenarios. In FY 2007, research will develop a new modeling tool to assess the effects of technological change in agriculture

and forestry on the future path of global carbon sequestration. The research will assess the influence of technology on land uses, explicitly assessing carbon flows to develop estimates of future carbon emission or sequestration. In FY 2007, research will generate empirical information on the direct costs and benefits of research and development (R&D) on low-emission technologies as well as the "external" benefits ("spillover effects") from R&D. The key question is whether an increase in climate R&D represents new R&D spending, or whether some (or all) of the additional climate R&D comes at the expense of other R&D.

DOE will also continue support of its Global Change Education program in FY 2007, including support of undergraduate and graduate students through the DOE Summer Undergraduate Research Experience (SURE) and the DOE Graduate Research Environmental Fellowships (GREFs). Support will also be continued for the Carbon Dioxide Information and Analysis Center (CDIAC) to enable it to respond to data and information requests from users all over the world who have a need for data on, for example, greenhouse gas emissions and concentrations.

Related Research

DOE plays a major role in carbon sequestration research to reduce atmospheric concentrations of energy-related greenhouse gases, especially carbon dioxide, and their net emissions to the atmosphere. The research builds on, but is not part of, the CCSP. It focuses on both developing the scientific information needed to enhance the natural sequestration of excess atmospheric carbon dioxide in terrestrial systems, and assessing the potential environmental consequences and ancillary benefits of that enhanced sequestration. It also includes research to develop biotechnological approaches for sequestering carbon either before or after it is emitted to the atmosphere. Funding for DOE's carbon sequestration research is part of the Climate Change Technology Program (CCTP). CCTP also provides related research funding to support a balanced and diversified portfolio of advanced technology R&D, focusing on energy-efficiency enhancements; low-GHG-emission energy supply technologies; carbon capture, storage, and sequestration; and technologies to reduce emissions of non-CO_2 gases. Together, CCSP and CCTP will help lay the foundation for future progress. Advances in the climate change sciences under CCSP can be expected to improve understanding about climate change and its impacts. Similarly, advances in climate change technology mitigation under CCTP can be expected to bring forth an expanded array of advanced technology options at a lower cost that will reduce greenhouse gas emissions.