

## DEPARTMENT OF ENERGY

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### Principal Areas of Focus

Research supported by DOE's Office of Biological and Environmental Research (BER) is focused on the effects of energy production and use on the global Earth system. Research includes climate modeling, aerosol and cloud properties and processes affecting the Earth's radiation balance, and sources and sinks of energy-related greenhouse gases (primarily carbon dioxide). BER research also examines the consequences of climatic and atmospheric changes on ecological systems and resources, develops improved methods and models for conducting integrated economic and environmental assessments of climate change and options for mitigating climate change, and educates and trains the next generation of scientists for climate change research.



### Program Highlights for FY 2004 and FY 2005

DOE's Office of Science supports climate change research at its National Laboratories and other public and private research institutions, including universities. In FY 2004 and FY 2005, DOE—along with the other CCSP agencies—will continue to integrate research on climate processes, climate theory, and computational science to accelerate progress in climate simulation model development, testing, and application. In support of the *CCSP Strategic Plan*, the Office of Science climate change program includes research activities in the following four areas 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 and hydrology, atmospheric chemistry and carbon cycle, ecological processes, and human dimensions.

#### *Climate and Hydrology*

The Office of Science will develop, improve, evaluate, and apply the best, fully coupled atmosphere-ocean-sea ice-land surface general circulation models (GCMs) that simulate climatic variability and change over decadal to centennial time scales. Data collection at the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Test Bed sites in the U.S. Southern Great Plains, the tropical western Pacific Ocean, and on the North Slope of Alaska will continue in FY 2004 and FY 2005 to improve understanding of the radiative transfer processes in the atmosphere and to formulate better parameterizations of these processes, especially cloud and aerosol effects, in GCMs. ARM will conduct a campaign in FY 2004 to collect a focused set of observations needed to advance understanding of the dynamical processes in mixed-phase arctic clouds. Research on data assimilation methods will be increased both to improve the use of high-quality observational data streams provided by the ARM program and other climatic data programs, including satellite programs, and to evaluate GCM performance. Support will be provided in FY 2004 and FY 2005 to provide climate modelers access to the high-end computational resources needed to conduct climate model experiments and to complete ensembles of climate simulations using coupled GCMs. DOE will continue support of a multi-institutional climate modeling research consortia to further the development of comprehensive coupled GCMs for climate predictions that are of higher resolution and contain more accurate and verified representations of clouds and other important climatic processes.

As part of the Administration's Climate Change Research Initiative (CCRI), DOE will produce ensemble projections of multi-century climatic variability and change using the Community Climate

## Appendix

System Model (CCSM). In FY 2004 and FY 2005, climate model experiments will produce various climate scenarios, such as atmospheric carbon dioxide (CO<sub>2</sub>) concentration stabilization scenarios and other climate forcing scenarios to be used as input to climate change assessments. The DOE component of the CCRI in FY 2004 will also include development, testing, and deployment of a mobile climate observatory, as part of the ARM program.

### *Atmospheric Chemistry and Carbon Cycle*

DOE carbon cycle research in both terrestrial and marine environments will improve understanding of the global carbon cycle. Research supports the Climate Change Science Program, as described in Chapter 7 of the *CCSP Strategic Plan*. In support of the Administration's CCRI, eight new field investigations were initiated to strengthen the AmeriFlux Network, and to support the comprehensive North American Carbon Program (NACP). This research will continue in FY 2004 and FY 2005 to provide direct measurements of net CO<sub>2</sub> flux between the atmosphere and representative terrestrial ecosystems. The CCRI augmentation of the AmeriFlux network allows it to play an important role in the comprehensive NACP study, assuring the acquisition of important data on the magnitude of terrestrial carbon sequestration and the processes that control it. DOE carbon cycle research also supports model predictions of changes in atmospheric CO<sub>2</sub> concentration and terrestrial carbon storage in relation to projected increases of CO<sub>2</sub> emissions. Increased emphasis will be placed on linked carbon cycle and climate modeling research in FY 2004, with modeling and simulation studies of carbon cycle-climate feedbacks carried out in FY 2005. In FY 2005, research will be initiated to further focus the AmeriFlux network measurements on field "intensive" investigations of the NACP. This contribution will be coordinated with field research of NASA, NOAA, NSF, and other agencies that jointly support the NACP science implementation strategy.

In ocean carbon cycle research, DOE's Biotechnological Investigations-Ocean Margins Program (BI-OMP) is using the tools of modern molecular biology, including functional genomics, to investigate the linkages between carbon and nitrogen cycling in nearshore marine environments. In FY 2004, BI-OMP will take advantage of the availability of data on newly sequenced diatom and marine bacterial genomes to understand the molecular-level regulation of carbon and nitrogen transformations in the ocean. In FY 2005, BI-OMP researchers will begin to take ecogenomic approaches to investigating marine microbial communities and their responses to climate change.

DOE's Atmospheric Science Program (ASP) will be transitioning in FY 2004 and FY 2005 from research on the effects of energy-related emissions on urban air quality to research on aerosol radiative forcing of climate. In FY 2004, results of research from the April 2003 Mexico City Megacity Study supported by the ASP will be published. These results will address the export of aerosols and precursors from the Mexico City Basin into the regional atmosphere, the radiative effects of the aerosols (including potential reduction of photochemistry by aerosol absorption), and the resistance of black carbon to rainout. In FY 2005, the entire ASP will be focused on aerosol radiative forcing to reduce the uncertainties associated with the indirect effect of aerosols on clouds and the roles of black carbon and organic aerosols on climate. The new research to be funded by the ASP in FY 2005 will address many of the research needs related to aerosol forcing identified in Chapter 3 of the *CCSP Strategic Plan*.

### *Ecological Processes*

DOE designs, implements, and maintains large-scale and long-term experimental field manipulations of environmental factors to study effects of energy production on important North American ecosystems. During FY 2004 and FY 2005, this will include field facilities that accomplish controlled manipulations of temperature, moisture, atmospheric CO<sub>2</sub> concentration, atmospheric ozone concentration, and/or

nitrogen deposition in a boreal forest, arid shrublands, temperate grasslands, and several temperate forests. These facilities and the experiments they support are needed to test the ability of ecological models to realistically predict effects of environmental changes on the structure and functioning of terrestrial ecosystems; such models form the basis of most assessments of the potential effects of projected future environmental change on ecosystems. A new research initiative is planned for initiation in late FY 2004 that will examine how quantitative information obtained at the level of macromolecules (e.g., genes, RNAs, and enzymes) can be used to understand and predict how processes in, and states of, whole ecosystems would be affected directly and indirectly by environmental changes associated with energy production.

### ***Human Dimensions***

The DOE human dimensions program supports fundamental research to develop and improve data, models, and methods for use by others to analyze and assess the economic, social, and environmental implications of climate change and of various potential policy options for mitigating or adapting to climate change. In FY 2004, research will continue on climate change technology innovation and diffusion, with particular emphasis on understanding forces that will assist the prediction of the penetration of new technologies to non-OECD countries such as China. Research initiated in FY 2002 and concluding in FY 2004 will improve projections of energy demand and associated greenhouse gas emissions by analyzing demographic variables. The research will use three case studies—the United States, China, and Indonesia—and focus on variations in energy use across household types. During FY 2004 and FY 2005, the representation of hydrogen production, transportation, and use will be improved in integrated assessment models. DOE's human dimensions research in FY 2004 will also include analysis and application of explicit models of methane and other non-CO<sub>2</sub> greenhouse gas emissions.

DOE will also continue support of its Global Change Education Program in FY 2004 and FY 2005, including support of undergraduate and graduate students. Support will also continue for the Carbon Dioxide Information and Analysis Center (CDIAC) in FY 2004 and FY 2005 to enable it to archive data on greenhouse gas emissions and concentrations and to respond to requests from users from all over the world for such information and data.

### **Related Research**

DOE plays a major role in carbon sequestration research to reduce atmospheric concentrations of energy-related greenhouse gases, especially CO<sub>2</sub>, and their net emissions to the atmosphere. DOE's carbon sequestration research is part of the Climate Change Technology Program. 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 CO<sub>2</sub> in terrestrial and ocean 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.