On behalf of the University Corporation for Atmospheric Research (UCAR) and the larger university community involved in Earth sciences research and education, I submit this written testimony for the record of the House Committee on Appropriations, Subcommittee on Energy and Water Development, and Related Agencies. DOE’s programs and initiatives in science and education directly support university and laboratory communities. They are also key to building a broad-based national resiliency to handle the great challenges of the future, including climate change. DOE is on the frontlines building the capacity needed to address these challenges, maintain a competitive advantage for the U.S. internationally, and secure an economically and environmentally sustainable future.

For these reasons, I urge the Subcommittee to fund the President's full FY 2011 budget request for the DOE Office of Science at $5.121 billion and the Office of Energy Efficiency & Renewable Energy (EERE) at $2.355 billion. Furthermore, it is critical that the Subcommittee take every step to ensure that the DOE’s Science budget stays on track to double this decade, as authorized by the America COMPETES Act of 2007.

UCAR is a consortium of 75 universities that manages and operates the National Center for Atmospheric Research (NCAR) on behalf of the National Science Foundation and the university community. UCAR & NCAR serve as national hubs for research and education for the atmospheric and Earth system sciences community. UCAR also houses community programs that bring geosciences communities together to address large-scale, integrated research and education challenges. Our mission is to better understand the behavior of the atmosphere and related global systems and to help communities, states, and nations use this information to sustain and improve life on Earth.

I applaud the DOE’s ongoing leadership in the management of programs to develop clean, alternative sources of energy, enhance national security and independence from foreign oil, address climate change, and educate the workforce for the emerging global clean energy economy. With the following, I specifically want to highlight several science research and education programs that represent the DOE’s critical investments towards a more resilient and adaptable society.

Climate and Earth System Research
The Office of Biological and Environmental Research (BER) within the DOE Office of Science makes fundamental contributions to the nation’s premier climate and Earth
system models. Such models provide the scientific foundation for national and international decision-making on climate change – how we should respond to climate change, whether we should adapt or mitigate, etc.

In particular, BER provides indispensable support to the Community Climate System Model (CCSM), which is being released this year in its fourth major iteration for use in the U.N. Intergovernmental Panel on Climate Change’s (IPCC) Fifth Assessment Report, expected for release in 2014. A comprehensive and sophisticated model for analyzing Earth’s past, present, and future, CCSM contributed the most simulated data of any global model to the IPCC’s 2007 Fourth Assessment Report. It is providing decision makers around the world with a clearer picture of what the impact of sustained climate change will be on a global scale.

CCSM is also laying the scientific foundation for higher-resolution, downscaled models which will provide regional and local predictions about the impacts of climate change. This regional, downscaled approach is BER’s stated focus for climate and Earth system modeling research in FY 2011. Regional and local predictions will help states, communities, businesses, and individuals develop effective long-term strategies to minimize damages of climate change impacts, by either adapting or mitigating.

Thanks in part to BER support, the nation’s climate models are becoming more realistic, incorporating more precise and complex natural and now human processes that are shaping the global climate. While uncertainties will always persist, these new capabilities will allow the climate science community to address the new class of societally relevant questions in a way that has never been done in the past. CCSM 4, for example, will for the first time feature fully interactive carbon and sulfur cycles, as well as dynamic vegetation, aerosol effects on clouds, carbon chemistry, natural carbon sequestration via land surface and oceans, and interactions between the carbon cycle and climate.

Frontiers for climate modeling in FY 2011 include understanding more fully how aerosols affect cloud formation, and in turn radiative forcing, and how modes of natural climate variability (e.g., the El Niño Southern Oscillation, Pacific Decadal Oscillation, and Northern Annular Mode) will change as atmospheric greenhouse gas concentrations continue to increase. Feedback cycles such as high latitude ocean-ice interaction and methane release from Arctic permafrost are also areas of study where scientists still have much to learn and models still need improvement.

Understanding and responding to climate change extends far beyond the capabilities of any one laboratory or agency. This is a broad, interagency effort, in which DOE is a key partner. New contributions to the design and scientific content of CCSM will not come from NCAR alone. While CCSM is housed and managed at NCAR, it is an open source climate model, which means that scientists across the nation and the world make contributions and improvements.
In order to develop more accurate, increasingly realistic, and higher resolution climate models, with better predictive capabilities for individuals, businesses, and communities, I urge you to fund the Office of Biological and Environmental Research (BER) within the DOE Office of Science at the President’s full FY 2011 budget request of $627.0 million. BER support is critical to the university community’s most important and recognized climate modeling work.

**Advanced Scientific Computing Research**

Also within the DOE’s Office of Science, Advanced Scientific Computing Research (ASCR) delivers leading edge computational and networking capabilities to scientists nationwide, enabling advances in computer science and the development of specialized software tools necessary to research the major scientific questions being addressed by the Office of Science and the larger university community.

ASCR’s continued progress is of particular importance to atmospheric scientists involved with climate model development, because an enormous amount of computing power is required to address the interaction of the Earth’s systems and global climate change. The complex nature of the climate processes being simulated in climate models requires very advanced software engineering to compute efficiently at the petascale. For this reason, ASCR played a critical role in developing the computing and networking resources for the U.S. contributions to the IPCC Fourth Assessment Report, and ASCR is one of the most important resources supporting the next generation of state-of-the-science climate simulation tools for this country.

Because the complex and high-resolution climate scenarios produced using the CCSM are too processor intensive to be run at NCAR alone, they are outsourced to the DOE’s Leadership Computing Facilities, located at Oak Ridge National Laboratory (OLCF), where a 2.33 petaflop system is openly available to the scientific community, and also at Lawrence Berkeley National Laboratory / NERSC, Argonne National Laboratory, and Lawrence Livermore National Laboratory. Last year, scientists at NCAR and the University of Wisconsin used Oak Ridge’s OLCF to simulate abrupt climate change and shed new light on an enigmatic period of natural global warming in Earth’s relatively recent history. The work was featured in the July 17, 2009 issue of the journal *Science* and provides valuable new data about the causes and effects of global climate change. The scientists used nearly a million processor hours in 2008 to run one-third of their simulation. With 4 million processor hours allocated for 2009-2011, they will complete the simulation, capturing climate from 14,000 years ago to the present and projecting it 200 years into the future.

The results of this research and other research like this are brought to the broader scientific communities through another ASCR program, the Scientific Discovery through Advanced Computing (SciDAC) program. SciDAC facilitates the transfer of basic research efforts into computational science applications through direct partnerships between ASCR-supported applied mathematicians and computer scientists. In the case of climate change, there is a growing demand for the development of tools that will help inform decision makers about the options for addressing and adapting to climate change.
With computation and simulation, scientists can model what is known about the Earth’s systems, identify uncertainties of the models, and determine the observational data and experiments needed to further refine and improve the models.

_I urge you to fund the Advanced Scientific Computing Research (ASCR) within the DOE Office of Science at the President’s full FY 2011 budget request of $426.0 million. ASCR provides critical processor capacity and computational tools like SciDAC that are essential to predictive climate change research at high resolutions and over large time scales._

**Workforce Development for Teachers and Scientists**

The DOE Office of Science’s education programs, like the Workforce Development for Teachers and Scientists (WDTS) Program, are also essential to strengthening our nation’s resilience to modern challenges like climate change. DOE is taking a leadership role in educating and training the nation’s science, technology, engineering, and mathematics (STEM) workforce and facilitating the development of the knowledge and expertise that will prepare us to address energy and environmental challenges.

WDTS aims to recruit and train a pipeline of highly skilled and diverse STEM workers to meet our nation’s innovation and competitiveness challenges. To this end, WDTS sponsors workforce training and education programs, often based at DOE’s national laboratories, that motivate students and educators to pursue careers that will contribute to both basic and applied science.

WDTS has also launched the DOE Office of Science Graduate Fellowship Program to support U.S. graduate students pursuing degrees in areas of basic science and engineering, for up to three years of study. The goal of the Fellowship is to encourage talented students to pursue research-focused graduate studies in physics, chemistry, biology, mathematics, computer science, engineering, and environmental science.

Programs like WDTS have produced tens of thousands of leading scientists, engineers, and technicians who have dedicated their careers to working on the great challenges of the day, including climate change, while pursuing answers to many of the most important scientific questions in physics, chemistry, biology, environmental and atmospheric science, and other areas of basic science. Their work will be critical to our nation’s success in the 21st Century.

_I urge you to fund the Workforce Development for Teachers and Scientists (WDTS) program within the DOE Office of Science at the President’s full FY 2011 budget request of $35.6 million. We must ensure that the next generation workforce is better prepared to address growing energy and environmental challenges._

**Renewable Energy R&D**

Federal investment in the scientific research and technology development involved with renewable energy is one of the most important investments we can make in our nation’s
future and our ability to build resilience to economic and environmental challenges. Renewable energy conveys numerous cross-cutting benefits to society, including reducing our dependence on foreign oil, transforming the clean energy economy, decentralizing the energy market, providing new high-tech jobs, reducing the human toll on the environment, and mitigating global climate change.

Our national research universities, along with DOE laboratories and an emerging private sector, are driving the country’s growth in renewable energy and increasing the efficiency of new technologies. One example of such collaboration includes an NCAR partnership with DOE’s National Renewable Energy Laboratory (NREL) and the regional utility company, Xcel Energy, to develop sophisticated wind forecasts for operational use. These provide critical information to select the most productive locations for new wind turbine farms, better integrate wind-generated electricity into the power grid, and make critical decisions about powering down traditional coal- and natural gas-fired plants when sufficient winds are predicted.

*Given the critical importance to the nation of developing economically and environmentally sustainable technologies for producing energy, I recommend that the Subcommittee fully fund the President’s FY 2011 budget request for the Office of Energy Efficiency and Renewable Energy at $2.355 billion.*

**RE-ENERGYSE (Regaining our Energy Science and Engineering Edge)**

Within the Office of Energy Efficiency and Renewable Energy (EERE), RE-ENERGYSE is a broad educational effort designed to inspire students and workers to study and pursue careers in science, engineering, and entrepreneurship related to clean energy. Today at U.S. universities, opportunities to pursue clean energy education are far and few in between. RE-ENERGYSE will help universities and community colleges develop cutting edge programs, with redesigned and new curricula to produce tens of thousands of highly skilled U.S. workers who can sustain American excellence in clean energy in industry, trades, academia, the federal government, and national laboratories.

RE-ENERGYSE will also benefit from plans to partner with the National Science Foundation for program evaluation. This partnership will build on the scientific and engineering expertise of both agencies in the energy field and benefit from NSF’s successful track record of integrating research with education in programs it has developed and administered over the past two decades.

*I urge the Subcommittee to fund RE-ENERGYSE at the President’s FY 2011 request of $50.0 million.*

I want to thank the Members of the Subcommittee for their continued leadership in supporting basic and cutting-edge scientific research and in promoting education and workforce development in the environmental and other Earth sciences.