Statement of:

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Before the

House Committee on Science and Technology

Subcommittee on Energy and the Environment

Mr. Chairman, Ranking Member Inglis, and members of the Committee: Thank you for inviting me to address the Committee and provide my perspective Department of Energy, Office of Science's Climate Change Research Program.

My name is David Bader and I am the newly-appointed manager for the Climate Change Research Program supported at Oak Ridge National Laboratory by the DOE Office of Science.

From June 2003 until June 5 of this year, I was the Director of the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at Lawrence Livermore National Laboratory. The PCMDI is part of the Department of Energy's Climate Change Prediction Program. Program for Climate Model Diagnosis and Intercomparison pioneered the concept of standardized climate model experiments, which has been a major factor in the scientific advancement of climate models over the last 20 years.

Most recently, PCMDI established and maintained the international global climate model output archive for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2007. Through the definition of standardized experiments and imposition of data standards, this archive revolutionized the use of climate model results by the international climate research community. Whereas in the past, only the researchers with access to the modeling centers were able to utilize climate model results in their work, several thousand users now are able to download and analyze the output from all of the world's major modeling groups from a single location in a standardized format. The IPCC has recognized the significance of this transformational activity by stating in its most recent Assessment, "In particular we wish to acknowledge the enormous commitment by the individuals and agencies of 14 climate modeling groups from around the world, as well as the archiving and distribution of an unprecedented amount (over 30 Terabytes) of climate model output by the Program for Climate Model Diagnosis and Intercomparison (PCMDI). This has enabled a more detailed comparison among current climate models and a more comprehensive assessment of the potential nature of long term climate change than ever before."

Prior to joining Lawrence Livermore, I spent over 12 years in various roles helping to plan, organize and manage climate modeling programs for the Office of Science. In addition, I worked with leaders of modeling programs in other federal agencies, particularly NASA, NOAA and NSF, to develop a national climate modeling strategy as part of the Climate Change Science Program Strategic Plan published in 2003. From these experiences, I gained valuable perspectives on the importance of climate modeling, simulation and prediction, in preparing the Nation and the world for the future. Furthermore, I developed an appreciation for the critical roles in the national and international modeling enterprise that the Office of Science program and the national laboratory system play.

As documented in the U.S. Climate Change Science Program Synthesis and Assessment Report 3.1, "Climate Models: An Assessment of Strengths and Limitations," (for which I was convening lead author) models have successfully answered many questions regarding the role of human activities in global climate change. Recent simulations of the observed climate over the twentieth century are far superior to those of just a few years ago.

Although imperfect, climate models offer the only tools to quantitatively estimate future climate variability and change. Figure 1 below was taken from the most recent IPCC Assessment. It shows unanimous agreement among all models that significant further global warming is likely over the next several decades through the end of the century under all reasonable greenhouse gas emission scenarios. The amount of projected warming, however, varies substantially among models. Moreover, there is considerable disagreement among models as to how global scale temperature changes will be manifested as changes in precipitation on regional and local scales, where most impacts will be experienced and must be addressed (Fig. 2).

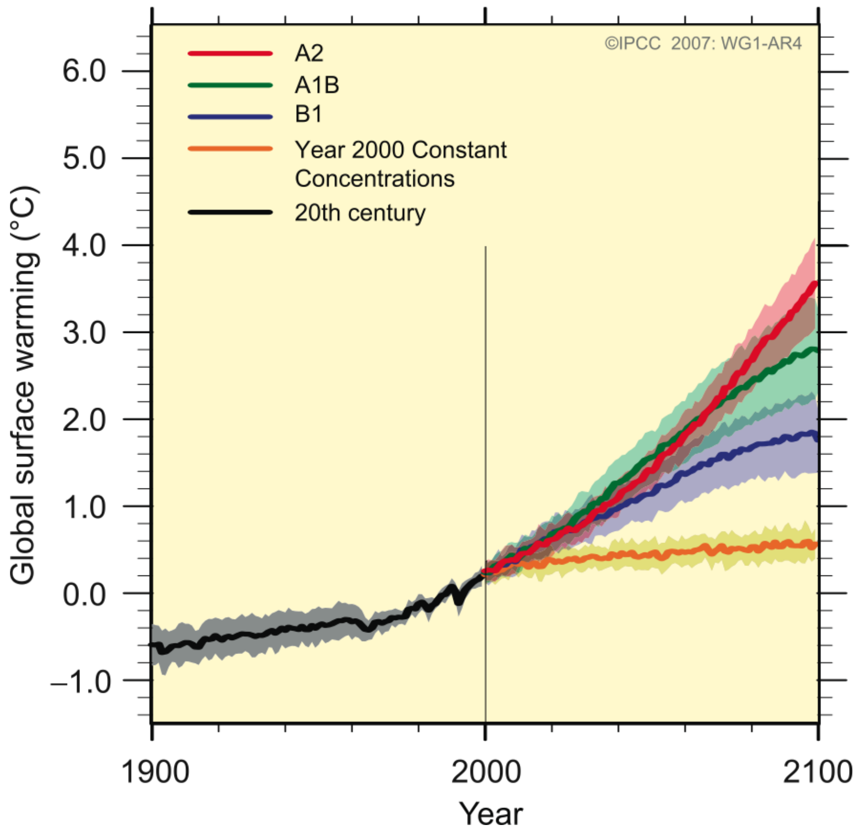

Figure 1: *Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2 (831 ppm CO_2 at year 2100), A1B (703 ppm CO_2 at year 2100) and B1 (540 ppm CO_2 at year 2100), shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line is for the experiment where concentrations were held constant at year 2000 values (From 2007 IPCC Working Group I Report).*

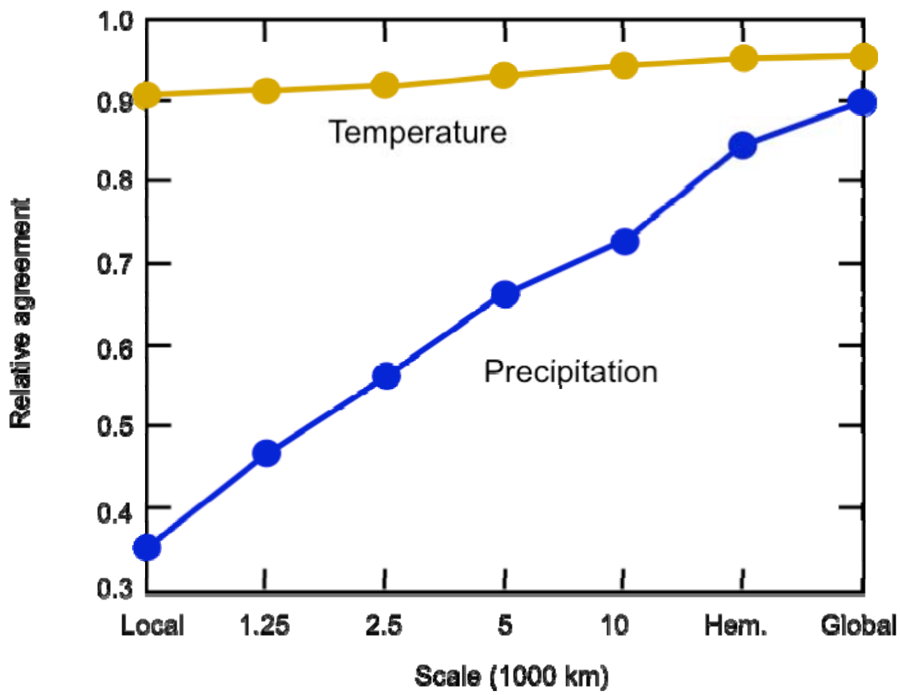

Figure 2: *Statistics of annual mean responses to the A1B scenario, for years 2080 to 2099 relative to 1980 to 1999, calculated from 21 model runs from the IPCC AR4 multi-model archive. Results are expressed as a function of horizontal scale on the x axis ('Loc,' is about 200 km; 'Hem': hemispheric scale; 'Glob': global mean) plotted against the y axis showing the relative agreement among individual model runs. This result shows general agreement on temperature changes at all scales, but little agreement among models for changes in precipitation for regions smaller than 2500 km (From 2007 IPCC Working Group I Report).*

The demands for new information from climate simulations and predictions far exceed the skill of the current generation of models. Climate simulation and prediction is required by DOE as it evaluates alternative technology options to mitigate climate change many decades into the future. The science community must quantify, understand, and reduce these uncertainties so that both near-term and long-term decisions can be guided with confidence.

We are on the verge of transformational changes in climate simulation and prediction, which will be realized by the combination of enhanced understanding of how the climate system operates and the advent of Exascale computing capability. This requires not only the investment of dollars, but also a rethinking of the organizational paradigms that develop and apply climate models. Vast knowledge and understanding has been and continues to be gained from investments in observational programs and research studies. Tremendous potential exists to improve the prediction capabilities of models through the integration of this knowledge with increasing computational power, such as the current and future systems at the ORNL Leadership Computing Facility supported by the Office of Science.

Major advancements will come from increasing the spatial resolution of models so that they more accurately simulate small scale atmospheric and oceanic phenomena, such as tropical cyclones and mesoscale convective complexes, that are critical to predicting not only changes in mean climate, but also to correctly predicting the probability of damaging events like floods and hurricanes. Unlike current climate models, the coming generation of models include explicit biogeochemical cycles to examine feedbacks between climate change and carbon sources and sinks. The Office of Science continues to invest in the Atmospheric Radiation Measurement (ARM) program and carbon cycle observational and experimental programs necessary to inform the development of these Earth System models. The challenge for the Office of Science is to accelerate the translation of knowledge gained in these programs into more realistic and accurate global models capable of projecting changes over many decades and centuries.

Transforming climate prediction by integrating knowledge with computational power cannot be achieved through reductionist approaches. In an unprecedented multi-institutional and multi-disciplinary partnership, DOE laboratory computational scientists, in collaboration with Warren Washington at the National Center for Atmospheric Research, pioneered the use of massively parallel computing systems for climate simulation in the 1990s to produce the DOE Parallel Computing Model. The legacy of the collaboration continues today. The DOE Climate Change Prediction Program supports an interagency partnership to develop and apply the Community Climate System Model (CCSM), one of the three U.S. modeling groups contributing to the last IPCC Assessment. Department of Energy laboratory scientists are integral to the development of key pieces of the modeling system, including the ocean, sea ice and terrestrial carbon cycle components. Major climate change simulations using the CCSM are run on the Office of Science computing facilities at Oak Ridge and Berkeley. The emphasis today, however, has devolved to improvement of the pieces, and the vision for the next generations of climate models has been somewhat lost.

Several key elements are needed to continue a vibrant climate modeling enterprise in the Office of Science. First, climate modeling is one of the most complex simulation problems in science. It requires the correct representation of highly interactive processes across a broad range of time and space scales. Future models will be developed by multi-disciplinary teams of climate researchers and computational scientists supported to achieve a common purpose. They will construct new models that can be run on tomorrow's Exascale computers. This computational power additionally will allow us to employ advanced mathematical and statistical techniques for uncertainty quantification practiced in other fields to better understand predictability limits of models.

Second, it must be recognized that climate model development, evaluation and application all occur simultaneously. While a new generation of models typically appears every five years, some aspects of model development take much longer to complete. This puts a tremendous strain on all of the elements of the modeling community. The long-term commitment to maintain a core infrastructure of people and computational capabilities is needed to support such an enterprise. The resources and capabilities of the national laboratory system meet those needs, but cooperation among the laboratories requires a common direction and purpose articulated by the Office of Science program management.

Last, as was demonstrated in the IPCC Assessment, no single model is the best in all respects and the community continues to need the results of multiple modeling groups to best understand potential climate changes, particularly at local and regional scales. As it turns out, the best representation of current climate is achieved by averaging the results from all of the models participating in the coordinated experiments. The Nation benefits from having multiple groups, including the CCSM partnership supported by the Office of Science.

In the past, the Office of Science executed a successful climate modeling strategy by providing long-term support for teams of researchers from its national laboratories and academic stable of investigators. Continued support will lead to even greater success.

Mr. Chairman, I want to thank you and members of the Committee for the opportunity to appear today. I would be pleased to answer any questions you may have.