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### The U.S. National Climate Change Assessment: Do the Climate Models Project a Useful Picture of Regional Climate?

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**THE U.S. NATIONAL CLIMATE CHANGE ASSESSMENT:  
DO THE CLIMATE MODELS PROJECT  
A USEFUL PICTURE OF REGIONAL CLIMATE?**

by

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*From testimony presented to the House Subcommittee on Oversight and Investigations, July 25, 2002, and published in Colorado Water, April 2003, 15-19.*

In this reproduction of my House testimony, I'd like to convey the following two points:

1. The perspective I am presenting does not easily fit into the conventional two-sided debate over climate change. This third perspective, as I have written elsewhere, "suggest[s] that humans have an even greater impact on climate than is suggested by [international and national assessments]. The human influence on climate is significant and multi-faceted."
2. Any attempt to accurately predict future climate is fundamentally constrained by the significant and multi-faceted characteristics of the human influence on climate. By focusing on vulnerabilities rather than prediction as a focus of research, I believe that the scientific community can provide more comprehensive and likely more useful, information to decision makers.

These points are consistent with the American Association of State Climatologists Policy Statement on Climate Variability and Change which was approved on October 25, 2001. The American Association of State Climatologists is a professional scientific organization composed of state climatologists (one per state), directors of the six Regional Climate Centers of the National Oceanic and Atmospheric Administration within the Department of Commerce, and associate members who are persons interested in the goals and activities of the Association. State Climatologists are individuals who have been identified by a state entity as the state's climatologist and who are also recognized by the Director of the National Climatic Data Center of the National Oceanic and Atmospheric Administration as the state climatologist of a particular state.

State Climatologists currently exist in 47 states and Puerto Rico. They are typically either employees of state agencies or are staff members of state-supported universities. Associate members may be assistant state climatologists or other climatologists under the employ of the state climatologist, representatives of federal climate agencies, retired state climatologists, or others interested in climate services. The total membership of the Association is approximately 150.

AASC Policy Statement on Climate Variability and Change

*Our statement provides the perspective of the AASC on issues of climate variability and change. Since the AASC members work directly with users of climate information at the local, state, and regional levels, it is uniquely able to put global climate issues into the local perspective needed by the users of climate information. Our conclusions are as follows:*

1. *Past climate is a useful guide to the future – Assessing past climate conditions provides a very effective analysis tool to assess societal and environmental vulnerability to future climate, regardless of the extent the future climate is altered by human activity. Our current and future vulnerability, however, will be different than in the past, even if climate were not to change, because society and the environment change as well. Decision makers need assessments of how climate vulnerability has changed.*

*2. Climate prediction is complex with many uncertainties – The AASC recognizes climate prediction is an extremely difficult undertaking. For time scales of a decade or more, understanding the empirical accuracy of such predictions – called “verification” – is simply impossible, since we have to wait a decade or longer to assess the accuracy of the forecasts.*

Climate prediction is difficult because it involves complex, nonlinear interactions among all components of the earth’s environmental system. These components include the oceans, land, lakes, and continental ice sheets, and involve physical, biological, and chemical processes. The complicated feedbacks and forcings\* within the climate system are the reasons for the difficulty in accurately predicting the future climate. The AASC recognizes that human activities have an influence on the climate system. Such activities, however, are not limited to greenhouse gas forcing and include changing land use and sulfate emissions, which further complicates the issue of climate prediction.

Furthermore, climate predictions have not demonstrated skill in projecting future variability and changes in such important climate conditions as growing season, drought, flood-producing rainfall, heat waves, tropical cyclones, and winter storms. These are the types of events that have a more significant impact on society than annual average global temperature trends.

1. Policy responses to climate variability and change should be flexible and sensible. The difficulty of prediction and the impossibility of verification of predictions decades into the future are important factors that allow for competing views of the long-term climate future. Therefore, the AASC recommends that policies related to long-term climate not be based on particular predictions, but instead should focus on policy alternatives that make sense for a wide range of plausible climatic conditions regardless of future climate. Climate is always changing on a variety of time scales and being prepared for the consequences of this variability is a wise policy.

2. In their interactions with users of climate information, AASC members recognize that the nation’s climate policies must involve much more than discussions of alternative energy policies – Climate has a profound effect on sectors such as energy supply and demand, agriculture, insurance, water supply and quality, ecosystem management and the impacts of natural disasters. Whatever policies are promulgated with respect to energy, it is imperative that policy makers recognize that climate – its variability and change – has a broad impact on society. The policy responses should also be broad.

Thus, to address the issues of climate variability and change, modernizing and maintaining high quality long-term climate data must be a high priority in order to permit careful monitoring. With the rapid dissemination of these data, State Climate Offices, as well as the Regional Climate Centers, and the National Climatic Data Center can better monitor emerging climate threats to critical national resources, such as our water supply, agriculture, and energy needs. The climate data must include all-important components of the climate system (e.g., temperature, precipitation, humidity, and vegetation health and soil moisture). We also recommend that the nation strengthen its local, state, and regional climate services infrastructure in order to develop greater support capabilities for those decision makers who have to respond to climate variability and change.

Finally, ongoing political debate about global energy policy should not stand in the way of common sense action to reduce societal and environmental vulnerabilities to climate variability and change. Considerable potential exists to improve policies related to climate; the AASC is working to turn that potential into reality.

In the remainder of this text, I provide several examples of the scientific basis that underlie the AASC Statement. Greater detail is available in the peer-reviewed scientific publications that are listed at the end of my testimony.

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\*Impacts on climate are compared in terms of radiative forcing, which can be considered as perturbations to the earth’s radiation budget prior to feedbacks from the rest of the climate system.

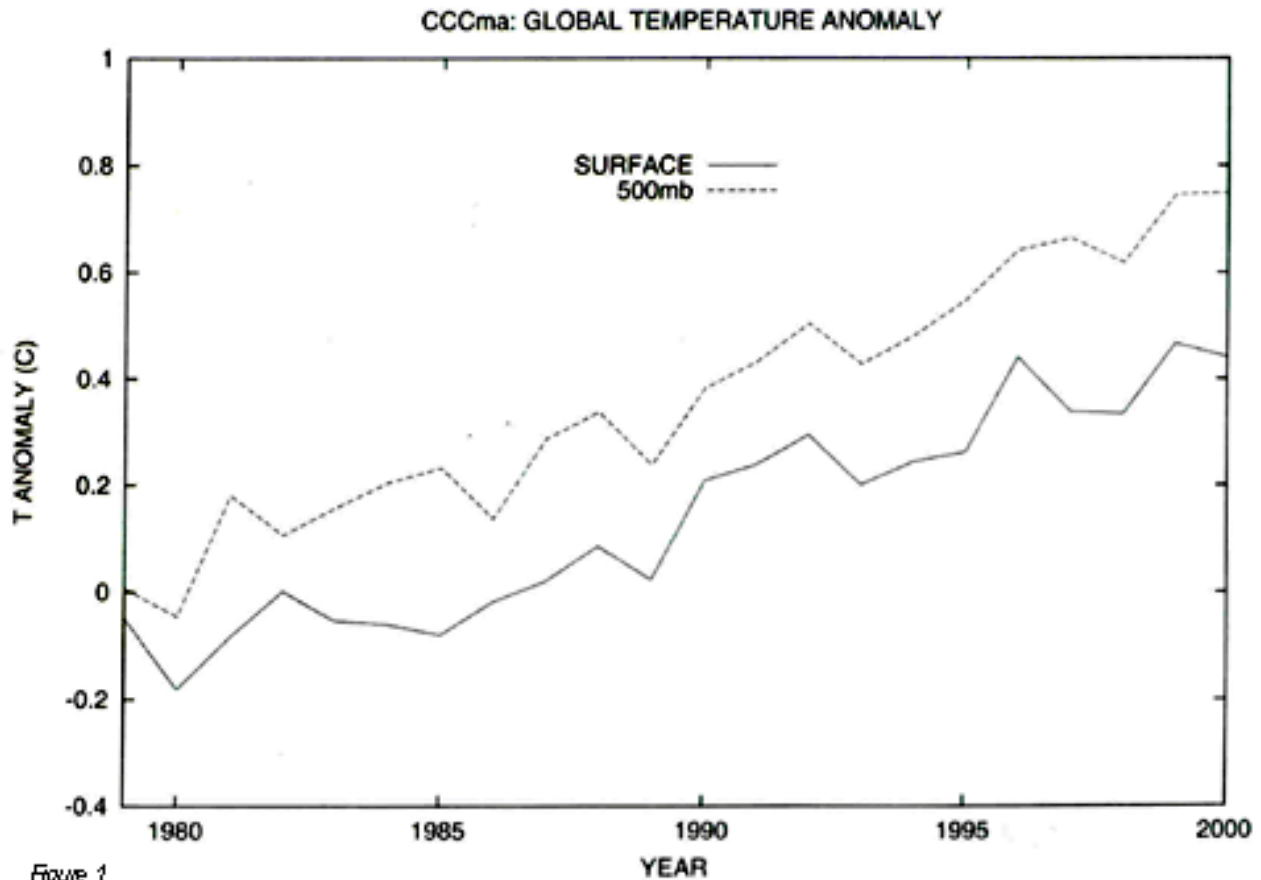


Figure 1: Canadian GCM projection of surface and 500 mb temperature for the period 1979-2000. Plot prepared by Dr. Thomas Chase, CU, Boulder, from data at <http://www.cccma.bc.ec.gc.ca/data/cgcm2/cgcm2.shtml>

A fundamental basis of the U.S. National Assessment is the use of the Canadian and Hadley Centre General Circulation Models (GCMs) to project the future state of the climate as the basis for discussion of climate impacts and ultimately alternative courses of action by decision makers. The perspective I offer here suggests that in relying on GCMs to, in effect, bound the future state of the climate, the U.S. National Assessment may have had the effect of underestimating the potential for change and overestimating our ability to accurately characterize such changes with computer models.

The hypothesis for using these models is that including human-caused increases of carbon dioxide and other greenhouse gases and aerosols in the models are sufficient to predict long-term effects on the climate of the United States. The position presented here is that such forcings are important, but a subset of those needed to develop plausible projections, and even if all forcings were included, accurate long-term prediction would remain challenging, if not impossible. To test the hypothesis that GCMs can accurately project climate, it is possible to compare model performances with observed data for the period 1979-2000. One test is the ability of the model to predict the averaged temperatures of the earth's atmosphere over this 20-year period. Such a test is a necessary condition for regional projection skill, since if globally-averaged, long-term changes cannot be skillfully projected; there will necessarily be no regional skill. During this period, for example, at around 18,000 feet above sea level, the Canadian GCM projects a 0.7° C warming of the global averaged temperature (Figure 1). The Hadley Centre model also has atmosphere warming for this time period. In contrast, observations have no statistically significant

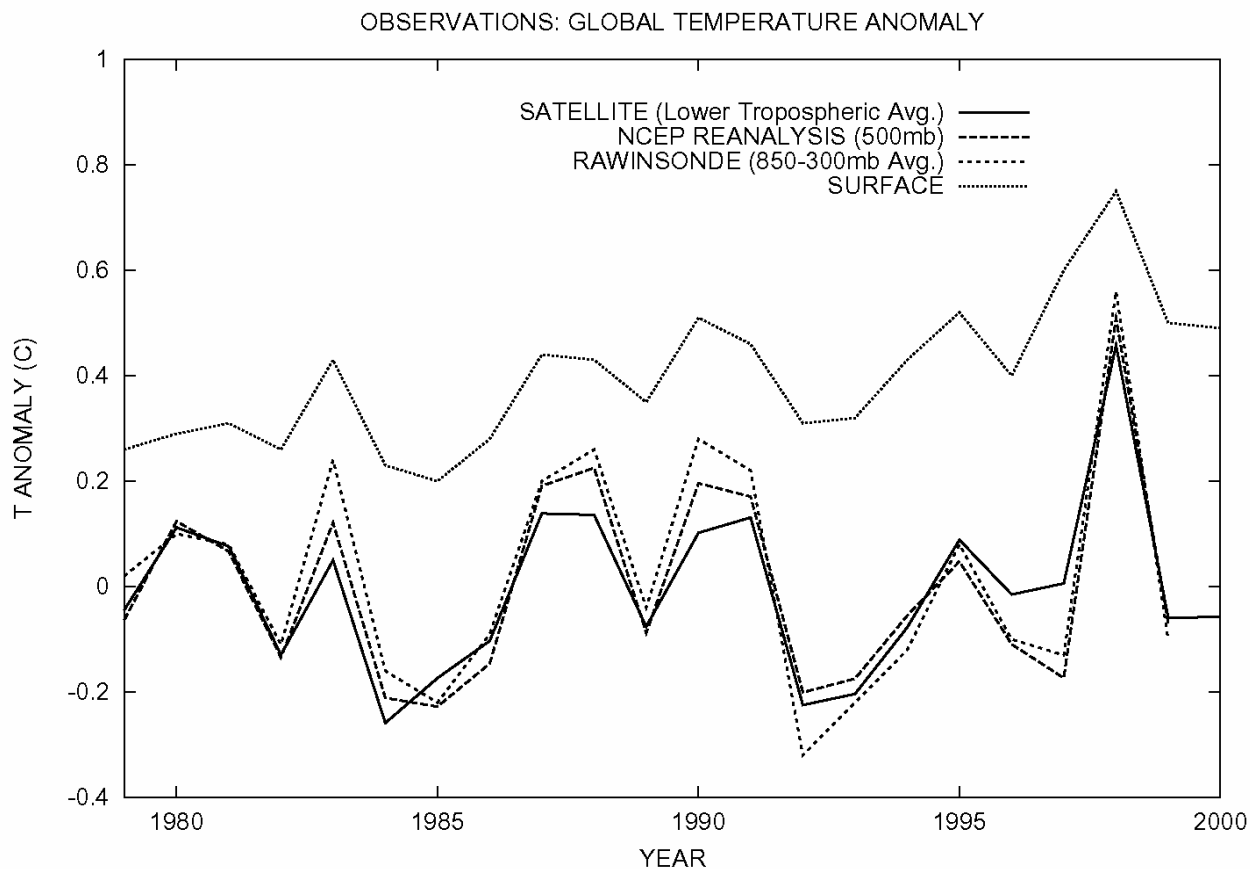


Figure 2: Observations of global temperature anomalies from surface, satellite, rawinsonde, and model reanalysis for the period 1979-2000. Data are from <http://www.cru.uea.ac.uk/> (surface); <http://weather.msfc.nasa.gov/MSU/msusci.html> (satellite); <http://cdiac.esd.ornl.gov/> (rawinsondes); <http://dss.ucar.edu/pub/> (NCEP model reanalysis). Plot prepared by Dr. Thomas Chase, CU, Boulder, CO.

change in these averaged atmospheric temperatures (Figure 2). Thus, either the models or the observations must be incorrect; both cannot be correct. Since, for the 1979-2000 time period, satellite, radiosonde, and National Center for Environmental Prediction model reanalysis each agree closely with respect to global averages, the observations should be interpreted as our best estimate of reality.

The scientific evidence, therefore, is that the models have failed to replicate the actual evolution of atmospheric temperatures over the time period 1979-2000. Thus using the results of these models as the basis for assessments, much less for particular decisions, for the next several decades is not justified. Such models clearly have usefulness as scientific tools with which to conduct sensitivity experiments, but it is important to not overstate their capabilities as predictive tools.

Moreover, there are overlooked issues concerning the spatial representativeness of the surface land data. The National Climate Data Center (NCDC) under the leadership of Tom Karl has contributed significantly to develop representative data sets, but as yet there has been no attempt within the scientific community to incorporate regional

and local land-use change, except urbanization effects, into these data sets. Even with urbanization, there is no adjustment for the different effect on temperatures depending on the geographic location. Denver, for instance has a distinctly different effect on local temperature variations than Washington D.C.

The temperature measuring sites themselves have not been investigated to determine their exposure to the air, and whether local biases are affecting the temperature. In eastern Colorado, for example, several of the Historical Climate Reference sites have exposure which would result in a non-spatially representative warming. As an example, Figure 3 shows that one of the sites is located adjacent to the south face of a brick building next to an air conditioner unit. Since this data is part of the U.S. Historical Climate Network it presumably has been used in the construction of the global surface analysis which is the basis for the claim of global averaged surface warming.



Figure 3: Fort Morgan Colorado Climate observing site (from Hanamean et al. 2003).

The GCM projections clearly have difficulty capturing the actual evolution of the earth's climate system (e.g., see Figure 4). One major reason for this difficulty is the absence and/or inadequate representation of significant human-caused forcing of the climate. These include land-use changes over time, the effect of aerosols on clouds and precipitation, and the biogeochemical effect of carbon dioxide. The Intergovernmental Panel on Climate (IPCC), itself, concludes that there is “a very low level of scientific understanding” of these forcings.

The importance of one of the effects can be illustrated by a newly published study of the influence of human-caused land-use change on the global climate. Even with a conservative estimate of land-use change, the global redistribution of heat is at least as large as simulated by the existing GCM model projections. As an example, Figure 5 illustrates the near-surface 10-year averaged January temperatures that resulted from this simulation study.

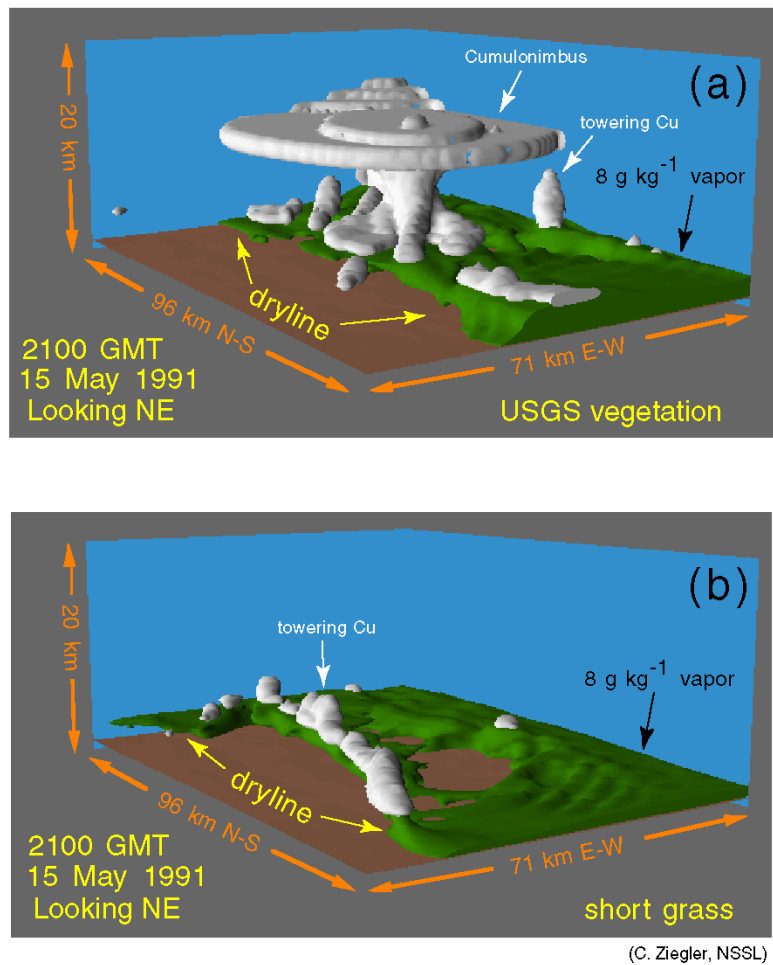


Figure 4: Model simulation of afternoon weather over the Texas Oklahoma panhandle region for May 15, 1991 with the current landscape (top) and if the natural landscape existed instead (bottom). (From Pielke, R.A., T.J. Lee, J.H. Copeland, J.L. Eastman, C.L. Ziegler, and C.A. Finley, 1997: Use of USGS-provided data to improve weather and climate simulations. *Ecological Applications*, 7, 3-21.)

## NEAR SURFACE TEMPERATURE DIFFERENCE

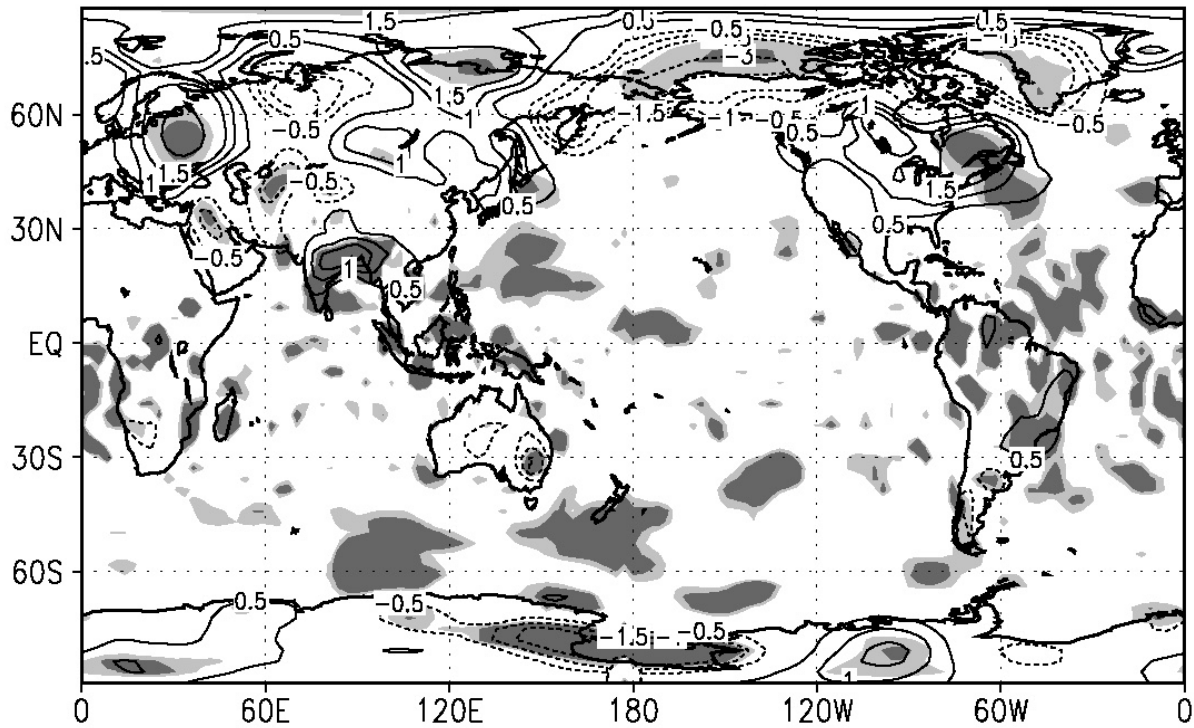


Figure 5: Difference in the 10-year averaged January near-surface air temperature (current-natural). (From Chase, T.N., R.A. Pielke Sr., T.G.F. Kittel, R.R. Nemani, and S.W. Running, 2000: Simulated impacts of historical land cover changes on global climate in northern winter. *Climate Dynamics*, **16**, 93-105.)

The inherent limitations on predicting future climate has lead the International Exosphere-Biosphere Programme to conclude their new book, entitled *Vegetation, Water, Humans and the Climate: A New Perspective on an Interactive System. A Synthesis of the ICBP Core Project, Biospheric Aspects of the Hydrologic Cycle*, with a chapter entitled "How to evaluate the vulnerability in changing environmental conditions." That chapter proposes an approach to environmental assessment focused on vulnerability which first seeks to identify the exposure of human and environmental systems to human and environmental driven change and variability. After such vulnerabilities are assessed, all available tools should be used to create plausible scenarios for future societal and environmental outcomes, as a function of alternative courses of action. This includes the historical record (e.g., what would happen today or in 10 years, if the weather of the dust bowl years of the 1930s reoccurred?), the paleo-



record (e.g., what would occur if the megadrought of the 16th Century happened again?), synthetic analysis (e.g., connecting the most serious drought years of the last 100 years into a consecutive ten-year period), and plausible GCM simulation results in which all important feedbacks and forcings are included. In this vulnerability framework, GCMs play an important role in science and assessment but cannot be depended on to accurately define the entire range of possible future conditions.

The Intergovernmental Panel on Climate Change, I have been told by colleagues, is embracing a greater focus on vulnerability and several U.S. programs, most notably the Regional Integrated Science and Assessments (or RISA) program of NOAA, have also acknowledged the importance of vulnerability as a scientific organizing theme.

Finally, I wish to underscore that the inability of the U.S. National Assessment models to skillfully predict climate change does not mean that the radiative effect of anthropogenic greenhouse gases on climate is not important. Nor does it suggest which policy responses to the issue of climate change make the most sense. Such matters of policy go well beyond any discussion of the science of climate and well beyond the information presented in my testimony today.

Effective mitigation and adaptation policies in the context of climate variability and change do not depend on accurate prediction of the future, and consequently a lack of ability to generate accurate predictions should not be used as justification to ignore the policy challenges presented by climate. Too often debate over the science substitutes for debate over policy.

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