

**STATEMENT TO THE  
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT  
OF THE UNITED STATES HOUSE OF REPRESENTATIVES**

**Hearing on  
“Rational Discussion of Climate Change: the Science, the Evidence, the Response”**

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Judith A. Curry  
Georgia Institute of Technology  
curryja@eas.gatech.edu

I thank the Chairman and the Committee for the opportunity to offer testimony today on "Rational Discussion of Climate Change." I am Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. As a climate scientist, I have devoted 30 years to conducting research on a variety of topics including climate feedback processes in the Arctic, energy exchange between the ocean and the atmosphere, the role of clouds and aerosols in the climate system, and the impact of climate change on the characteristics of tropical cyclones. As President of Climate Forecast Applications Network LLC, I have been working with decision makers on climate impact assessments, assessing and developing climate adaptation strategies, and developing subseasonal climate forecasting strategies to support adaptive management and tactical adaptation. Over the past year, I have been actively engaging with the public (particularly in the blogosphere) on the issue of integrity of climate science, and also the topic of uncertainty.

**The climate change response challenge**

Climate change can be categorized as a “wicked problem.”<sup>1</sup> Wicked problems are difficult or impossible to solve, there is no opportunity to devise an overall solution by trial and error, and there is no real test of the efficacy of a solution to the wicked problem. Efforts to solve the wicked problem may reveal or create other problems.

The United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) have framed the climate change problem (i.e. dangers) and its solution (i.e. international treaty) to be irreducibly global. Based upon the precautionary principle, the UNFCCC’s Kyoto Protocol has established an international goal of stabilization of the concentrations of greenhouse gasses in the atmosphere. This framing of the problem and its solution has led to the dilemma of climate response policy that is aptly described by Obersteiner et al.<sup>2</sup>:

The key issue is whether “*betting big today*” with a comprehensive global climate policy targeted at stabilization “*will fundamentally reshape our common future on a global scale to our advantage or quickly produce losses that can throw mankind into economic, social, and environmental bankruptcy.*”

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<sup>1</sup> Rittel, Horst, and Melvin Webber; "Dilemmas in a General Theory of Planning," pp. 155–169, Policy Sciences, Vol. 4, Elsevier Scientific Publishing Company, Inc., Amsterdam, 1973.

[http://www.uctc.net/mwebber/Rittel+Webber+Dilemmas+General\\_Theory\\_of\\_Planning.pdf](http://www.uctc.net/mwebber/Rittel+Webber+Dilemmas+General_Theory_of_Planning.pdf)

<sup>2</sup> [http://helda.helsinki.fi/bitstream/handle/1975/292/2001-Managing\\_climate\\_risk.pdf?sequence=1](http://helda.helsinki.fi/bitstream/handle/1975/292/2001-Managing_climate_risk.pdf?sequence=1)

In a rational discussion of climate change, the question needs to be asked as to whether the framing of the problem by the UNFCCC/IPCC and the early articulation of a preferred policy option by the UNFCCC has marginalized research on broader issues surrounding climate change, and resulted in an overconfident assessment of the importance of greenhouse gases in future climate change, and stifled the development of a broader range of policy options.

The IPCC/UNFCCC have provided an important service to global society by alerting us to a global threat that is potentially catastrophic. The UNFCCC/IPCC has made an ambitious attempt to put a simplified frame around the problem of climate change and its solution in terms of anthropogenic forcing and CO<sub>2</sub> stabilization policies. The result of this simplified framing of a wicked problem is that we lack the kinds of information to more broadly understand climate change and societal vulnerability.

### **Uncertainty in climate science**

Anthropogenic climate change is a proposed theory whose basic mechanism is well understood, but whose magnitude is highly uncertain owing to feedback processes. We know that climate changes naturally on decadal to century time scales, but we do not have explanations for observed historical and paleo climate variations, including the warming from 1910-1940 and the mid 20<sup>th</sup> century cooling. The competition for the theory of anthropogenic climate change is our recognized ignorance about what we don't know about natural climate variability.

I have been raising concerns<sup>3</sup> since 2003 about how uncertainty surrounding climate change is evaluated and communicated. The IPCC's efforts to consider uncertainty focus primarily on communicating uncertainty, rather than on characterizing and exploring uncertainty in a way that would be useful for risk managers and resource managers and the institutions that fund science. A number of scientists have argued that future IPCC efforts need to be more thorough about describing sources and types of uncertainty, making the uncertainty analysis as transparent as possible. Recommendations along these lines were made by the recent IAC<sup>4</sup> review of the IPCC.

Because the assessment of climate change science by the IPCC is inextricably linked with the UNFCCC policies, a statement about scientific uncertainty in climate science is often viewed as a political statement. A person making a statement about uncertainty or degree of doubt is likely to become categorized as a skeptic or denier or a "merchant of doubt,"<sup>5</sup> whose motives are assumed to be ideological or motivated by funding from the fossil fuel industry. My own experience in publicly discussing concerns about how uncertainty is characterized by the IPCC has resulted in my being labeled as a "climate heretic"<sup>6</sup> that has turned against my colleagues, and Sourcewatch<sup>7</sup> has been busy trying to identify any ties to the oil industry.

### **Climate change winners and losers**

The view of the climate change problem as irreducibly global ignores the possibility that some regions may actually benefit from a warmer and/or wetter climate. Areas of the world that currently cannot adequately support populations and agricultural efforts may become more desirable in future climate

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<sup>3</sup> <http://curry.eas.gatech.edu/climate/pdf/crc-102103.pdf>

<sup>4</sup> <http://reviewipcc.interacademycouncil.net/>

<sup>5</sup> Oreskes, N. and E.M. Conway, 2010: Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco to Global Warming. Bloomsbury Press, 368 pp.

<sup>6</sup> <http://www.scientificamerican.com/article.cfm?id=climate-heretic>

<sup>7</sup> [http://www.sourcewatch.org/index.php?title=Judith\\_Curry](http://www.sourcewatch.org/index.php?title=Judith_Curry)

regimes.

Arguably the biggest global concern regarding climate change impacts is concern over water resources. This concern is exacerbated in countries where population is rapidly increasing and water resources are already thinly stretched. China and South Asia (notably India, Pakistan, and Bangladesh) are facing a looming water crisis arising from burgeoning population and increasing demand for water for irrigated farming and industry. China has been damming the rivers emerging from Tibet and channeling the water for irrigation, and there is particular concern over the diversion of the Brahmaputra to irrigate the arid regions of Central China. China's plans to reroute the Brahmaputra raises the specter of riparian water wars with India and Bangladesh.

The IPCC AR4 WGII makes two statements of particular relevance to the water situation in central and south Asia:

*“Freshwater availability in Central, South, East and South-East Asia . . . is likely to decrease due to climate change, along with population growth and rising standard of living that could adversely affect more than a billion people in Asia by the 2050s (high confidence).”<sup>8</sup>*

*“Glaciers in the Himalaya are receding faster than in any other part of the world and, if the present rate continues, the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km<sup>2</sup> by the year 2035 (WWF, 2005).”<sup>9</sup>*

The lack of veracity of the statement about the melting Himalayan glaciers has been widely discussed, and the mistake has been acknowledged by the IPCC<sup>10</sup>. However, both of these statements are inconsistent with the information in Table 10.2 the IPCC AR4 WG II and the statement:

*“The consensus of AR4 models . . . indicates an increase in annual precipitation in most of Asia during this century; the relative increase being largest and most consistent between models in North and East Asia. The sub-continental mean winter precipitation will very likely increase in northern Asia and the Tibetan Plateau and likely increase in West, Central, South-East and East Asia. Summer precipitation will likely increase in North, South, South-East and East Asia but decrease in West and Central Asia.”<sup>11</sup>*

Based on the IPCC's simulations of 21<sup>st</sup> century climate, it seems that rainfall will increase overall in the region (including wintertime snowfall in Tibet). The importance of these inconsistencies or mistakes by the IPCC is amplified by the very real prospect of riparian warfare in this region that supports half of the world's population.

Apart from the inconsistencies and mistakes, the IPCC WG II report seems more designed to convince that climate change is “dangerous” globally, rather than to assess regional societal vulnerabilities or possible benefits. A serious assessment is needed of vulnerabilities, region by region, in the context of possible climate change scenarios, demographics, societal vulnerabilities, possible adaptation, and current adaptation deficits. A few regions have attempted such an assessment. Efforts being undertaken by the World Bank Program on the Economics of Adaptation to Climate Change to assess the economics of adaptation in developing countries are among the best I've seen in this regard. This is

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<sup>8</sup> [http://www.ipcc.ch/publications\\_and\\_data/ar4/wg2/en/ch10s10-es.html](http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10s10-es.html)

<sup>9</sup> [http://www.ipcc.ch/publications\\_and\\_data/ar4/wg2/en/ch10s10-6-2.html](http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10s10-6-2.html)

<sup>10</sup> <http://www.ipcc.ch/pdf/presentations/himalaya-statement-20january2010.pdf>

<sup>11</sup> [http://www.ipcc.ch/publications\\_and\\_data/ar4/wg2/en/ch10s10-3.html#10-3-1](http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch10s10-3.html#10-3-1)

the kind of information that is needed to assess winners and losers and how dangerous climate change might be relative to adaptive capacities.

### **Climate surprises and catastrophes**

The uncertainty associated with climate change science and the wickedness of the problem provide much fodder for disagreement about preferred policy options. Uncertainty might be regarded as cause for delaying action or as strengthening the case for action. Low-probability, high-consequence events in the context of a wicked problem provide particular challenges to developing robust policies.

A climate surprise is an abrupt or discontinuous change that presents a gap between reality and expectations. Catastrophes are major large-scale events that produce great and sudden harm. Extreme events such as landfalling major hurricanes, floods, extreme heat waves and droughts can have catastrophic impacts; while such events are not unexpected, their frequency and/or severity may increase in a warmer climate and they are a surprise to the individual locations that are impacted by a specific event. Natural events become catastrophes when the population is large and infrastructure is exposed in vulnerable locations and when humans tamper with ecosystems that provide a natural safety barrier (e.g. deforestation, draining wetlands). The recent catastrophic flooding in Pakistan<sup>12</sup> apparently owes as much to deforestation and overgrazing as it does to heavy rainfall. Catastrophes associated with extreme events are mostly about vulnerability. Addressing current adaptive deficits and planning for climate compatible development will increase societal resilience to future extreme events that may be more frequent or severe in a warmer climate.

Abrupt climate change<sup>13</sup> is defined as a change that occurs faster than the apparent underlying driving forces. Abrupt climate change, either caused by natural climate variability or triggered in part by anthropogenic climate change, is a possibility that needs investigation and consideration. Catastrophic anthropogenic climate change arising from a climate sensitivity on the extreme high end of the distribution has not been adequately explored, and the plausible worst case scenario has not been adequately articulated. To what extent can we falsify scenarios of very high climate sensitivity based on our background knowledge? What are the possibilities for abrupt climate change, and what are the possible time scales involved? What regions would be most vulnerable under this worst-case scenario?

Weitzmann<sup>14</sup> characterizes the decision making surrounding climate change in the following way:

*“Much more unsettling for an application of expected utility analysis is deep structural uncertainty in the science of global warming coupled with an economic inability to place a meaningful upper bound on catastrophic losses from disastrous temperature changes. The climate science seems to be saying that the probability of a system-wide disastrous collapse is non-negligible even while this tiny probability is not known precisely and necessarily involves subjective judgments.”*

When a comprehensive decision analysis includes plausible catastrophes with unknown probabilities, the policy implications can be radically different from those suggested by optimal decision making strategies targeted at the most likely scenario. Weitzmann argues that it is plausible that climate change policy stands or falls to a large extent on the issue of how the high impact low probability catastrophes are conceptualized and modeled. Krugmann<sup>15</sup> has interpreted Weitzmann’s argument as

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<sup>12</sup> <http://judithcurry.com/2010/09/20/pakistan-on-my-mind/>

<sup>13</sup> <http://www.nap.edu/openbook.php?isbn=0309074347>

<sup>14</sup> [http://dash.harvard.edu/bitstream/handle/1/3693423/Weitzman\\_OnModeling.pdf?sequence=2](http://dash.harvard.edu/bitstream/handle/1/3693423/Weitzman_OnModeling.pdf?sequence=2)

<sup>15</sup> [http://www.nytimes.com/2010/04/11/magazine/11Economy-t.html?\\_r=1](http://www.nytimes.com/2010/04/11/magazine/11Economy-t.html?_r=1)

implying that “You might think that this uncertainty weakens the case for action, but it actually strengthens it.”

In summary, the IPCC focus on providing information to support the establishment of an optimal CO<sub>2</sub> stabilization target doesn’t address two important issues for driving policy:

- reducing vulnerability to extreme events such as floods, droughts, and hurricanes
- examination of the plausible worst case scenario.

### **There are no “silver bullet” solutions**

Xu, Crittenden et al. argue that “gigaton problems require gigaton solutions.”<sup>16</sup> The wickedness of the climate problem precludes a gigaton solution (either technological or political). Attempts to address the climate change problem through a U.N. treaty for almost two decades have arguably not been successful. The climate change problem now walks hand-in-hand with the ocean acidification problem, the link between the two problems being the proposed stabilization of atmospheric CO<sub>2</sub>. The proposed solution to the wicked climate problem and ocean acidification in terms of stabilization of atmospheric CO<sub>2</sub> has revealed and created new problems in terms of energy policy. Energy policy is driven by a complicated mix of economics and economic development, energy security, environmental quality and health issues, resource availability (e.g. peak oil), etc.

Even if climate change is not the primary driver in energy policy, the climate-energy nexus is a very important one. Not just in the sense of anthropogenic climate change motivating energy policy, but weather and climate are key drivers in energy demand and even supply. On the demand side, we have the obvious impact of heating and cooling degree days. On the supply side, we have oil and gas supply disruptions (e.g. hurricanes in the Gulf of Mexico) plus the dependence of hydro, solar, and wind power on weather and climate. What is perhaps the most important connection, and one often overlooked, is the energy-water nexus, whereby power plants requiring water for cooling compete with domestic, agricultural, industrial, and ecosystems for the available water supply.

The complexity of both the climate and energy problems and their nexus precludes the gigaton “silver bullet” solution to these challenges. Attempting to use carbon dioxide as a control knob to regulate climate in the face of large natural climate variability and the inevitable weather hazards is most likely futile. In any event, according to climate model projections reported in the IPCC AR4, reducing atmospheric CO<sub>2</sub> will not influence the trajectory of CO<sub>2</sub> induced warming until after 2050. The attempt to frame a “silver bullet” solution by the UNFCCC seems unlikely to succeed, given the size and the wickedness of the problem. The wicked gigaton climate problem will arguably require thousands of megaton solutions and millions of kiloton solutions.

### **Moving forward**

Climate scientists have made a forceful argument for a looming future threat from anthropogenic climate change. Based upon the background knowledge that we have, the threat does not seem to be an existential one on the time scale of the 21st century, even in its most alarming incarnation. It is now up to the political process (international, national, and local) to decide how to contend with the climate problem. It seems more important that robust responses be formulated than to respond urgently with a policy that may fail to address the problem and whose unintended consequences have not been adequately explored.

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<sup>16</sup> <http://www.spp.gatech.edu/faculty/marilynbrown/sites/default/files/attachment/Gigaton%20Problems%20Need%20Gigaton%20Solutions.pdf>

The role for climate science and climate scientists in this process is complex. In the past 20 years, dominated by the IPCC/UNFCCC paradigm, scientists have become entangled in an acrimonious scientific and political debate, where the issues in each have become confounded. This has generated much polarization in the scientific community and political attacks on scientists on both sides of the debate, and a scientist's "side" is often defined by factors that are extraneous to the actual scientific debate. Debates over relatively arcane aspects of the scientific argument have become a substitute for what should be a real debate about politics and values.

Continuing to refine the arguments put forward by the IPCC that focus on global climate model simulations projections of future climate change may have reached the point of diminishing returns for both the science and policy deliberations. Further, the credibility of the IPCC has been tarnished by the events of the past year. It is important to broaden the scope of global climate change research beyond its focus on anthropogenic greenhouse warming to develop a better understanding of natural climate variability and to further explore the uncertainty of the coupled climate models and the capability of these models to predict emergent events such as catastrophic climate change. And far more attention needs to be given to establishing robust and transparent climate data records (both historical and paleoclimate proxies).

Regional planners and resource managers need high-resolution regional climate projections to support local climate adaptation plans and plans for climate compatible development. This need is unlikely to be met (at least in the short term) by the global climate models. In any event, anthropogenic climate change on timescales of decades is arguably less important in driving vulnerability in most regions than increasing population, land use practices, and ecosystem degradation. Regions that find solutions to current problems of climate variability and extreme weather events and address challenges associated with an increasing population will be well prepared to cope with any additional stresses from climate change.

Hoping to rely on information from climate models about projected regional climate change to guide adaptation response diverts attention from using weather and climate information in adaptive water resource management and agricultural on seasonal and subseasonal time scales. Optimizing water resource management and crop selection and timing based upon useful probabilistic subseasonal and seasonal climate forecasts has the potential to reduce vulnerability substantially in many regions, particularly in the developing world where much of the agriculture is rain fed (i.e. no irrigation). It would seem that increasing scientific focus on seasonal and subseasonal forecasts could produce substantial societal benefits for tactical adaptation practices.

The global climate modeling effort directed at the IPCC/UNFCCC paradigm has arguably reached the point of diminishing returns in terms of supporting decision making for the U.N. treaty and related national policies. At this point, it seems more important to explore the uncertainties associated with future climate change rather than to attempt to reduce the uncertainties in a consensus-based approach. It is time for climate scientists to change their view of uncertainty: it is not just something that is merely to be framed and communicated to policy makers, all the while keeping in mind that doubt is a political weapon in the decision making process. Characterizing, understanding, and exploring uncertainty is at the heart of the scientific process. And finally, the characterization of uncertainty is critical information for robust policy decisions.

Engagement of climate researchers with regional planners, economists, military/intelligence, development banks, energy companies, and governments in the developing world to develop a mutual understanding about what kind of information is needed can promote more fruitful decision outcomes, and define new scientific challenges to be addressed by research. The need for climate researchers to engage with social scientists and engineers has never been more important. Further, there is an

increasing need for social scientists and philosophers of science to scrutinize and analyze our field to prevent dysfunction at the science-policy interface.

And finally, climate scientists and the institutions that support them need to acknowledge and engage with ever-growing groups of citizen scientists, auditors, and extended peer communities that have become increasingly well organized by the blogosphere. The more sophisticated of these groups are challenging our conventional notions of expertise and are bringing much needed scrutiny particularly into issues surrounding historical and paleoclimate data records. These groups reflect a growing public interest in climate science and a growing concern about possible impacts of climate change and climate change policies. The acrimony that has developed between some climate scientists and blogospheric skeptics was amply evident in the sorry mess that is known as Climategate. Climategate illuminated the fundamental need for improved and transparent historical and paleoclimate data sets and improved information systems so that these data are easily accessed and interpreted.

Blogospheric communities can potentially be important in identifying and securing the common interest at these disparate scales in the solution space of the energy, climate and ocean acidification problems. A diversity of views on interpreting the scientific evidence and a broad range of ideas on how to address these challenges doesn't hinder the implementation of diverse megaton and kiloton solutions at local and regional scales. Securing the common interest on local and regional scales (referred to by Brunner and Lynch as "adaptive governance"<sup>17</sup>) provides the rationale for climate adaptation strategies. Successes on the local and regional scale and then national scales make it much more likely that global issues can be confronted in an effective way.

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<sup>17</sup> <http://www.press.uchicago.edu/presssite/metadata.epl?mode=synopsis&bookkey=8917780>

## Short Biography

Judith Curry  
Chair and Professor, School of Earth and Atmospheric Sciences  
Georgia Institute of Technology  
Atlanta, GA 30332-0349  
curryja@eas.gatech.edu

Dr. Judith Curry is Professor and Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology and President of Climate Forecast Applications Network (CFAN). Dr. Curry received a Ph.D. in atmospheric science from the University of Chicago in 1982. Prior to joining the faculty at Georgia Tech, she has held faculty positions at the University of Colorado, Penn State University and Purdue University. Dr. Curry's research interests span a variety of topics in climate; current interests include air/sea interactions, climate feedback processes associated with clouds and sea ice, and the climate dynamics of hurricanes. She is a prominent public spokesperson on issues associated with the integrity of climate science, and has recently launched the weblog Climate Etc. Dr. Curry currently serves on the NASA Advisory Council Earth Science Subcommittee and has recently served on the National Academies Climate Research Committee and the Space Studies Board, and the NOAA Climate Working Group. Dr. Curry is a Fellow of the American Meteorological Society, the American Association for the Advancement of Science, and the American Geophysical Union.

For more information:

<http://curry.eas.gatech.edu/>

<http://www.cfanclimate.com/>

<http://judithcurry.com>

Wikipedia: [http://en.wikipedia.org/wiki/Judith\\_Curry](http://en.wikipedia.org/wiki/Judith_Curry)

Sourcewatch: [http://www.sourcewatch.org/index.php?title=Judith\\_Curry](http://www.sourcewatch.org/index.php?title=Judith_Curry)