STATEMENT TO THE
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
OF THE UNITED STATES SENATE

Hearing on
"Natural Resource Adaptation: Protecting Ecosystems and Economies"

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

I thank the Chairman, the Ranking Member and members of the Committee for the opportunity to offer testimony today on *Natural Resource Adaptation*. I am Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. I have devoted 30 years to conducting research on topics including climate feedback processes in the Arctic, energy exchange between the ocean and 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 (CFAN) LLC, I have worked with decision makers on climate impact assessments, assessing and developing meteorological hazard and climate adaptation strategies, and developing subseasonal climate forecasting strategies to support adaptive management.

I have actively engaged in the public debate on climate change. Publication of a paper on hurricanes and global warming[1] several weeks after Hurricane Katrina exposed me to the rancor associated with the public debate surrounding climate change and the challenges and problems associated with mixing science and politics[2]. For the past several years, I have been promoting dialogue across the full spectrum of beliefs and opinion on the climate debate through my blog, Climate Etc. (judithcurry.com). I have learned about the complex reasons that intelligent, educated and well-informed people disagree on the subject of climate change, as well as tactics used by both sides to try to gain a political advantage in the debate. I have learned about the complexity of different decisions that depend, at least in part, on weather and climate information. I have learned the importance of careful determination and conveyance of the uncertainty associated with predictions, and the costs of overconfidence in predictions.

I am increasingly concerned that both the climate change problem and its solution have been vastly oversimplified.[3] I am concerned that the consensus seeking process used by the Intergovernmental Panel on Climate Change (IPCC) has introduced biases and acted to skew the science.[4] My research on understanding the dynamics of uncertainty at the climate science-policy interface has led me to question whether these dynamics are operating in a manner that is healthy for either the science or the policy process.[5] I see a growing gap between what science is currently providing in terms of information about climate variability and change and the information desired by decision makers.

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[1] Webster, P.J., G.J. Holland, J.A. Curry, H.-R. Chang, 2005: Changes in tropical cyclone number, duration and intensity in a warming environment. *Science.* 309 (5742): 1844-1846. http://webster.eas.gatech.edu/Papers/Webster2005b.pdf

[2] Curry, J. A., P. J. Webster and G. J. Holland, 2006: Mixing Politics and Science in Testing the Hypothesis That Greenhouse Warming Is Causing a Global Increase in Hurricane Intensity. *Bull. Amer. Met. Soc.,* 87 (8), 1025-1037. http://webster.eas.gatech.edu/Papers/Webster2006d.pdf

[3] Curry, JA and Webster PJ 2011: Climate science and the uncertainty monster. *Bull Amer Meteorol. Soc.,* 92, 1667-1682. http://journals.ametsoc.org/doi/pdf/10.1175/2011BAMS3139.1

[4] Curry, JA and PJ Webster 2013: Climate Change: No consensus on consensus. *CAB Reviews*, 8, 001. http://www.cabi.org/cabreviews/default.aspx?site=167&page=4051&LoadModule=Review&ReviewID=253640 http://judithcurry.com/2012/10/28/climate-change-no-consensus-on-consensus/

[5] Judith Curry, Statement to the Subcommittee on Environment of the U.S. House of Representatives Hearing on Policy Relevant Climate Science in Context, 25 April 2013.

With this context, my testimony focuses on the following issues of central relevance to climate policy and challenges of natural resource adaptation:

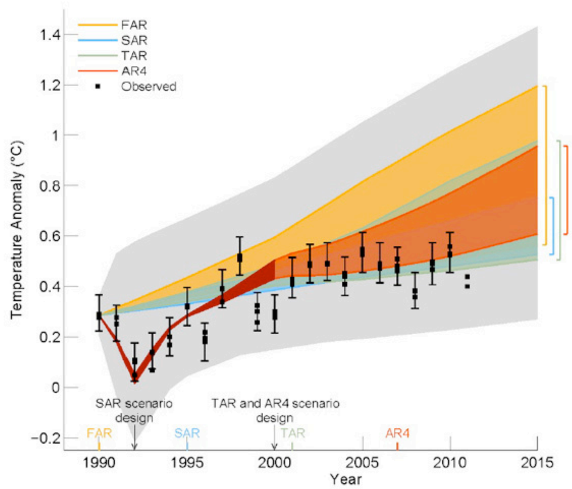
- Climate models: are they fit for the purpose of decision making?
- What do we know about regional climate change on decadal to multi-decadal timescales?
- Can we make good regional adaptation decisions under deep climate uncertainty?
- Moving forward: breaking the paradigm paralysis

Climate models: fit for what purpose?

The recently released Summary for Policy Makers (SPM) FOOTNOTE of the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report makes the following statement:

"There is very high confidence that climate models reproduce the observed large-scale patterns and multi-decadal trends in surface temperature, especially since the mid-20th century. (AR5 SPM, p 9)

The IPCC's own analysis seems to belie this statement, as evidenced by the following diagram from Chapter 1 of the AR5:



Estimated changes in the observed globally and annually averaged surface temperature since 1990 compared with the range of projections from the previous IPCC assessments. Observed global annual temperature change, relative to 1961–1990, is shown as black squares and the whiskers indicate the 90% uncertainty range of the dataset. The colored shading shows the projected range of global annual mean near surface temperature change from 1990 to 2015 for models used in FAR (1990), SAR (1995), TAR (2001), and AR4 (2007). The gray shading is not related to the model projections.

This figure shows that climate models have significantly over-predicted the warming effect of CO_2 since 1990, a period during which CO_2 increased from 335 to over 400 parts per million. The most recent climate model simulations used in the AR5 indicate that the warming stagnation since 1998 is no longer consistent with model projections even at the 2% confidence level[6] [7].

Based upon early (leaked) drafts of the AR5[8], the IPCC did not even mention this stagnation. Apparently the IPCC was pressured by reviewers and its policy maker constituency to address this stagnation specifically. Here is the relevant text from the final version of the AR5 Summary for Policy Makers:

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6 Fyfe, Gillett and Zwiers: Overestimated global warming over the past 20 years. *Nature Climate Change* 3, 767–769 (2013)

7 von Storch, Barkhordarian, Hasselman, Zorita: Can climate models explain the recent stagnation in global warming? (2013) http://www.academia.edu/4210419/Can_climate_models_explain_the_recent_stagnation_in_global_warming

8 http://www.stopgreensuicide.com/SummaryForPolicymakers_WG1AR5-SPM_FOD_Final.pdf

"Models do not generally reproduce the observed reduction in surface warming trend over the last 10 – 15 years." (SPM AR5, p)

"There is medium confidence that this difference between models and observations is to a substantial degree caused by unpredictable climate variability, with possible contributions from inadequacies in the solar, volcanic, and aerosol forcings used by the models and, in some models, from too strong a response to increasing greenhouse-gas forcing." (SPM AR5, p

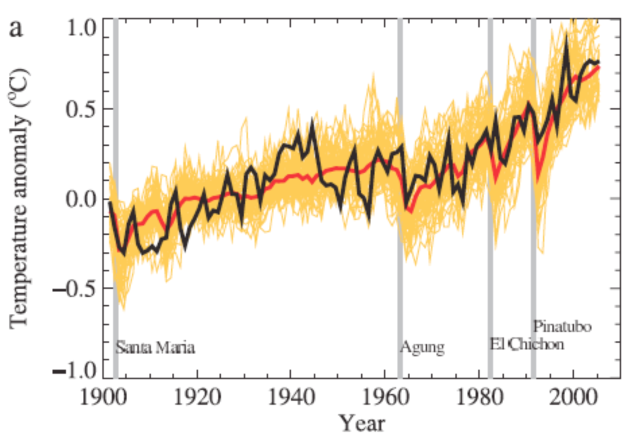
The failure of the IPCC to predict this stagnation in warming is raising serious questions about whether climate models are over sensitive to increasing greenhouse gases.[9] The IPCC's dismissal of the stagnation as being associated with unpredictable climate variability raises the question as to what extent the warming between 1975 and 2000 can also be explained by unpredictable climate variability.

Fitness for purpose

Climate models have made important contributions to understanding how the climate system works. Computer simulations of the complex climate system can be used to represent aspects of climate that are extremely difficult to observe, experiment with theories in a new way by enabling hitherto infeasible calculations and to explore the system to identify unexpected outcomes.

Uncertainties in climate models and their simulations are associated with incomplete understanding of the climate system, inadequacies of numerical solutions employed in computer models, uncertainty in model parameters and parameterizations of unresolved processes, and also uncertainty in initial conditions. Model outcome uncertainty, also referred to as prediction error, arises from the propagation of the aforementioned uncertainties through the model simulation.

User confidence in a prediction model depends critically on the confirmation of predictions, both using historical data (hindcasts, in-sample) and out-of-sample observations (prediction). Owing to the century-long time horizon of model simulations of future climate change, the focus has been on using historical hindcasts to confirm the climate models, as represented by this diagram from the IPCC AR4:



Comparison between global mean surface temperature anomalies (°C) from observations (black) and climate model simulations. All data are shown as global mean temperature anomalies relative to the period 1901 to 1950, as observed (black) and from 58 simulations produced by 14 (red). The multimodel ensemble mean is shown as a thick red curve and individual simulations are shown as thin yellow curves. Vertical grey lines indicate the timing of major volcanic events. (from IPCC AR4 WG I Chapter 9[10]

[9] summarized in Curry (2013) House testimony, op. cit.

[10] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch9s9-4-1-2.html

When I first saw this diagram, I found it to be a very convincing confirmation of climate models, since surely such strong agreement between observations and climate models was possible only if there were accurate observations of global surface temperature and external forcing data (e.g. solar, volcanoes, greenhouse gases) and if the models contained all of the relevant physical processes to simulate global climate variability.

Subsequently, I undertook a more thorough investigation of this analysis.[11] I concluded that this agreement between model simulations and the observations had been elevated by bootstrapped plausibility. The strong agreement between models and observations depends on the selection of forcing data sets and model parameters by inverse calculations designed to agree with the 20th century observations. A consequence of the selected external forcing is that multi-decadal natural internal variability has been eliminated as a causative factor for 20th century climate change. Hence, based on climate model attribution experiments, we cannot rule out substantial warming from other causes such as solar forcing and internal multi-decadal ocean oscillations.

While progress continues to be made in terms of introducing more processes into the climate models and increasing model resolution, the failure of the models to simulate the stagnation in warming since 1998 raises fundamental questions about the utility of climate models for decision makers. After several decades of expensive research, we still don't have a convincing answer as to the importance of CO2 relative to natural variability in causing climate change.

The large investment in climate modeling is justified by its perceived importance in supporting decisions. Decision making has focused on CO2 stabilization and climate sensitivity. However, users and decision makers increasingly include farmers, resource managers, financial sector, energy sector, national security, and regional planners. To support their decision making, these users need high-resolution regional accuracy on decadal time scales, with a focus on extreme events -- this is exactly where climate models have the least skill.[12] How will these needs be addressed by the climate modeling community?

Last year, the National Research Council (NRC) published a report *A National Strategy for Advancing Climate Modeling*[13]. From the Summary:

"The Committee finds that climate modeling in the United States can make significant progress through a combination of increasing model resolution, advances in observations and process understanding, improved representations in models of unresolved but climate-relevant processes, and more complete representations of the Earth system in climate models." (NRC, p 12)

"As these challenges are faced and models grow in complexity, they are likely to exhibit an increasingly rich range of behavior, full of surprises and unexpected results. Therefore, the Committee emphasizes that it is unwise to promise that successive generations of models will invariably result in firmer predictive capability. Progress on these challenges is important, however, to develop a fuller understanding of the climate system, reducing the likelihood of unanticipated changes and improving climate models in the long term." (NRC, p 12)

Given the complexity of the climate system and the climate models, climate modelers are wise not to promise a reduction of uncertainty or firmer predictive capability. The Report further states:

"The promise of uncertainty reduction, when not realized, stands as a metric of poor management, poor scientific method, or outright scientific failure." (NRC, p 118).

[11] Curry and Webster, 2011 (op. cit.)
[12] Kerr, RA 2013 Forecasting regional climate change flunks its first test. Science, 339, p 638. http://www.sciencemag.org/content/339/6120/638
[13] http://www.nap.edu/catalog.php?record_id=13430

The large investment in climate modeling, both in the U.S. and internationally, has been made with the expectation that climate models will support decision making on both mitigation and adaptation responses to climate change. So, are these complex global climate models especially useful for decision makers? The hope, and the potential, of climate models for providing credible regional climate change scenarios have not been realized.

We have arguably reached the point of diminishing returns from this particular path of climate modeling – not just for decision support but also for scientific understanding of the climate system.[14] In pursuit of this climate modeling path, the climate modeling community -- and the funding agencies and the policy makers -- have locked themselves into a single climate modeling framework with a focus on production runs for the IPCC, which has been very expensive in terms of funding and personnel. An unintended consequence of this strategy is that there has been very little left over for true climate modeling innovations and fundamental research into climate dynamics and theory -- such research would not only support amelioration of deficiencies and failures in the current climate modeling systems, but would also lay the foundations for disruptive advances in our understanding of the climate system and our ability to predict emergent phenomena such as abrupt climate change.[15]

Assessing regional risks of future climate change

On sub-continental and smaller scales, global and regional climate models show little skill even in hindcast predictions of past climate variability.[16] The reason for reduced skill on regional scales is associated with what the IPCC refers to as 'unpredictable climate variability,' which manifests from chaotic interactions between the atmosphere and ocean. The most familiar mode of natural internal variability is El Nino/La Nino. On longer multi-decadal time scales, there is a network of atmospheric and oceanic circulation regimes, including the Atlantic Multidecadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO).

Towards predictability of natural internal variability

A key cause of the lack of utility of 21[st] climate model simulations on regional and decadal time scales is their failure to simulate correctly the multi-decadal ocean oscillations. In an attempt to rectify this deficiency, the latest climate model simulations for the IPCC (CMIP5)[17] coordinated decadal hindcast and prediction experiments with initialization from observations of both the atmosphere and ocean. It was anticipated that the CMIP5 decadal simulations would provide a valuable new resource for predicting regional climate variability and change on decadal time scales.

Kim, Webster and Curry[18] assessed the CMIP5 decadal (10 year) hindcast simulations of seven coupled ocean-atmosphere models. We found that most of the models overestimate trends, whereby the models predict less warming or even cooling in the earlier decades compared to observations and too much warming in recent decades. The Atlantic Multidecadal Oscillation (AMO) is predicted in most of the models with significant skill, while the Pacific Decadal Oscillation (PDO) shows relatively low predictive skill. In fact, evaluation of the PDO forecasts showed that by far the best forecast was a simple persistence forecast. There is low prediction skill of North American surface weather in these 10 year simulations; what little prediction skill there is seems associated with the models' capability of simulating the AMO. Beyond 10 years, there is no apparent skill in predicting the AMO.

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[14] Maslin, M and P. Austin: Uncertainty: Climate Models at Their Limit? *Nature* **486**, 183–184 (2012) doi:10.1038/486183a

[15] NRC 2002: Abrupt Climate Change: Inevitable Surprises http://www.nap.edu/openbook.php?isbn=0309074347

[16] Kerr 2013, op. cit.

[17] http://cmip-pcmdi.llnl.gov/cmip5/

[18] Kim, H.-M., P. J. Webster, and J. A. Curry (2012), Evaluation of short-term climate change prediction in multi-model CMIP5 decadal hindcasts, Geophys. Res. Lett., 39, L10701, doi:10.1029/2012GL051644. http://webster.eas.gatech.edu/Papers/Kim_et_al.2012_GRL.pdf

A paper just published in the journal *Climate Dynamics* suggests that natural internal variability in climate on decadal to multi-decadal timescales behaves in a more predictable way than previously assumed. Wyatt and Curry[19] point to the so-called 'stadium-wave' signal that has been identified in a wide range of 20th century geophysical and ecological indices. The study finds that sea ice extent in the Eurasian Arctic and the AMO are key ingredients to the propagation and maintenance of this signal, which related analysis indicates has existed for at least 300 years.

The multi-decadally varying natural signal can periodically enhance or dampen the trend of long-term rising temperatures, which may explain the observed 15+ year stagnation of the rising global surface average temperature. The stadium-wave signal is not seen in climate model simulations, implying that this failure may partially explain the models' inability to simulate the stagnation in global surface temperatures so far in the 21st century. Further, the 'stadium wave' suggests an explanation for the incongruence of trends, such as periods of declining sea ice extent co-occurring with cooling hemispheric temperatures.

In the early years of the 21st century, a substantial shift in ocean circulation regimes coincided with an apparent end to the warming regime that began in the mid-1970s. After temperatures peaked in the late 1990s, hemispheric surface temperatures began to decrease while the high latitudes of the North Atlantic Ocean continued to warm and Arctic sea ice extent continued to decline. According to the 'stadium wave' hypothesis, these seemingly incongruent trends mark a forthcoming regime transition whereby a maximally warm North Atlantic Ocean starts to cool and sea ice in the Eurasian Arctic region begins to rebound. This oscillatory nature of the ice-ocean-atmosphere system can be described in terms of 'braking', whereby positive and negative feedbacks interact in such a way as to limit trends of sea ice growth and sea ice destruction.

Most interpretations of the recent decline in Arctic sea ice extent have focused on the role of anthropogenic greenhouse gas forcing, with some allowance for natural variability. Declining sea ice extent over the last decade is consistent with the 'stadium wave', and the signal's continued evolution portends a reversal of this declining trend. The stadium wave projects that sea ice will recover from its recent minimum, first in the West Eurasian Arctic and followed by recovery in the Siberian Arctic. Hence, the sea ice minimum observed in 2012, followed by an increase of sea ice in 2013, is suggestive of consistency with the timing of evolution of the stadium-wave signal. How changes in external forcing, such as increasing greenhouse gases, are affecting the Arctic sea ice in context of an apparent quasi-oscillatory ocean-ice-atmosphere system is a burning question.

What does the stadium-wave hypothesis imply for future climate change? While we cannot know if the variability, tempo, and sequential chronology of the stadium-wave signal will continue into the future, by using the signal's behavior of the 20th century to extrapolate future trends, we gain new perspective and testable hypotheses regarding the evolution of climate variability over the next several decades. Projections suggest that as the main indices align in phase, we can expect continued cooling and an eventual reversal of the sea ice decline. A past analogue for these dynamics can be found in the 1950s. The stadium-wave propagation sequence suggests that the overall cool phase will continue for the next few decades, perhaps through the late 2030s.

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[19] Wyatt, M and JA Curry, 2013: Role for Eurasian Arctic shelf sea ice in a secularly varying hemispheric climate signal in the 20th century. Climate Dynamics, DOI 10.1007/s00382-013-1950-2

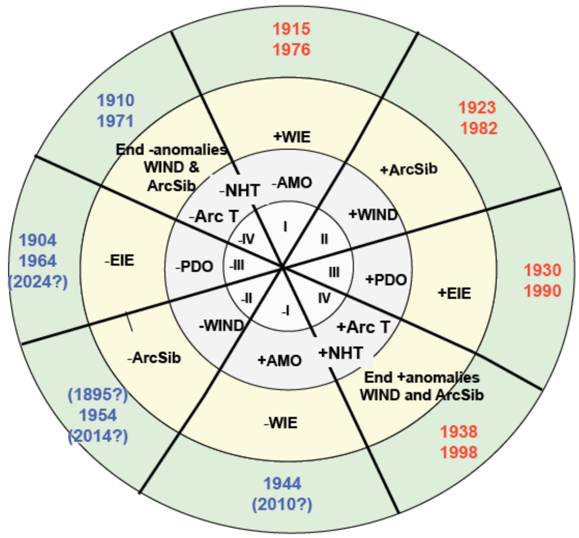


Illustration of the progression of the stadium wave. The stadium-wave 'wheel' is divided into segments (from center to perimeter): the light gray ring identifies the segment number; the dark gray ring indicates key hemispheric indices; sea ice indices are in the yellow ring; and the outer green ring provides peak dates for the segment. Segment I begins with a cold North Atlantic (-AMO), maximum sea ice extent in the European Arctic shelf seas (+WIE). Segments II through IV show evolution of the climate signal initiated in the cold Atlantic. As sea ice growth increases eastward into the Siberian Arctic (+ArcSib), strong winds develop that convert an initially cold ocean-ice signal into a warming atmospheric one (Segment II). Events proceed, carrying the signal across Eurasia and into the Pacific (+PDO; Segment III), ultimately culminating in maximum Arctic and NH surface temperatures in Segment IV. Segment –I follows with maximum warmth in the North Atlantic and minimal sea ice in the European Arctic shelf seas. This marks a shift whereby trends of AMO and WIE decrease and increase, respectively. An initial warm signal converts to a cooling one until reaching Segment –IV, where temperatures dip to their minima, followed soon after by shift to a warming regime (I). (adapted from Wyatt and Curry, 2013).

A complete understanding of past climate variability and projections of future climate change in context of the stadium wave hypothesis requires integrating the stadium-wave signal with external climate forcing from the sun, volcanoes, and anthropogenic forcing (e.g. CO_2). How external forcing projects onto the stadium wave, and whether it influences signal tempo or affects timing or magnitude of regime shifts, is unknown and requires further investigation.

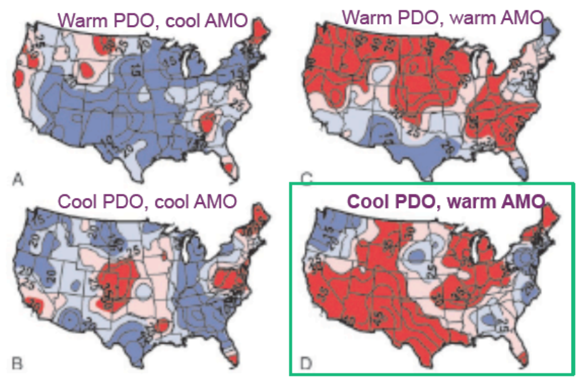
Scenarios of regional climate variability and change

Natural resource adaptation decisions are by nature regional/local, and relevant decision horizons are on the timescale of decades. Extreme weather events and disasters are arguably the greatest near term concern about climate change, and provide the greatest risk to infrastructure, ecosystems, and human safety. During the past several decades, virtually every locale in the U.S. has suffered from an extreme weather/climate event: heat wave, severe snowstorm, drought, hurricanes, floods, etc. In attempting to understand how global warming is changing the frequency or intensity of these extreme events, the IPCC Special Report on Extreme Events (SREX)[20] states the following:

"Projected changes in climate extremes under different emissions scenarios generally do not strongly diverge in the coming two to three decades, but these signals are relatively small compared to natural climate variability over this time frame." (SREX, p 9).

[20] http://ipcc-wg2.gov/SREX/

On decadal and multidecadal timescales, the statistics of extreme weather and climate events show substantial influence by the modes of natural internal variability such as the AMO and PDO. The influence of the AMO and PDO on U.S. climate is illustrated by this analysis of 20th century drought:



Drought frequency (in percent of years) for positive and negative regimes of the PDO and AMO. Positive values are shaded red, and negative values are shaded blue. Figure adapted from McCabe et al.[21]

We are currently in a regime characterized by the warm phase of the AMO and the cool phase of the PDO. The previous analogue for drought patterns during this regime was the period 1944-1963, with the greatest impact in the Midwest, Southwest, and the Rocky Mountains Great Basin area.

Rather than relying on climate model projections,[22] the need for projections of future extreme events on regional/local scales on decadal to multi-decadal time horizons can be far more usefully addressed by examining past events in the locale and interpreting them in the context of climate regimes associated with natural variability. Because extreme events are by definition rare, a long historical record is needed, which motivates the need for regional archaeological and historical analyses of extreme weather events prior to modern meteorological observations and also local paleoclimate analyses using proxies such as tree rings, sediment cores and speleothems from caves.

Extended records of extreme events for the locale of interest provide the basis for developing scenarios of the plausible worst case, the frequency of extreme events including clustering of events, and interpretation of these events in context of climate dynamics (e.g. the AMO, PDO and stadium wave) and also mean temperature. Additional scenarios can be created by including (as a multiplier effect) possible impacts from secular global warming from greenhouse gases, solar variability and/or volcanic activity. Consideration of these scenarios allows the user to assign more or less confidence to different assumptions used in constructing the scenarios in assessing the likelihood of the future scenarios. For a particular application, consideration of the full range of scenarios may be less relevant than the likelihood of scenarios in the vicinity of the user's vulnerability threshold.

This relatively simple approach to developing future regional scenarios of relevance to natural resource adaptation is much more likely to provide useful information on decadal to multi-decadal than the expensive and long-term strategy of hoping to improving global climate models so that they can provide useful information on regional and decadal time scales. Further, global climate models make basic assumptions about future solar and volcanic activity, and hence do not predict any climate change associated with changes to solar and volcanic activity.

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21 McCabe, GJ, MA Palecki, JL Betancourt, 2004: Pacific and Atlantic Ocean influences on drought frequency in the United States. *PNAS*, 101, 4136-4141

22 *Nature* editorial: Extreme Weather http://www.nature.com/news/extreme-weather-1.11428

The fundamental issue is this. Climate variability and change occur on a range of time scales, in response to external forcing (changes in solar and volcanic forcing and changes in atmospheric composition) and also to natural internal variability (associated with chaotic nonlinear interactions of the couples ocean and atmosphere system). Planning adaptation policies around climate model simulations that are able only to predict (at best) the response to increasing greenhouse gases has the potential to mislead decision makers about future risks from extreme weather and climate events. The stagnation in greenhouse warming observed over the past decade clearly illustrates that CO2 is not a control knob on decadal and regional climate variability.

Closing the adaptation deficit for extreme events that are known to have previously occurred in a region can go a long way towards reducing vulnerability to future extreme events. Apart from the issue of sea level rise and heat waves, there is little observational evidence that supports extreme weather and climate events as being worse in a warmer climate.[23] Specifically with regards to sea level rise, estimates of global sea level rise are not very useful for regional adaptation without context of local factors contributing to sea level, such as geological factors and land use practices. One recent study[24] found that groundwater use and changes in terrestrial water storage have contributed to 42% of the globally observed sea level rise between 1961 and 2003. In many locations in North America, these factors dominate the local sea level rise:[25] compare the locally observed values with the globally averaged rate of sea level rise of 3.2 mm/yr for 1993-2010[26].

Further, climate change on timescales of decades may be 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 are likely to be well prepared to cope with any additional stresses from climate change.

[23] IPCC SREX, op. cit.

[24] Pokhrel et al., 2012: Model estimates of sea-level change due to anthropogenic impacts on terrestrial water storage. *Nature Geoscience*, doi:10.1038/ngeo1476 http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo1476.html

[25] http://tidesandcurrents.noaa.gov/sltrends/

[26] IPCC AR5 SPM, op. cit.`

Breaking the paradigm paralysis

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 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. judithcurry.com. Dr. Curry currently serves on the NASA Advisory Council Earth Science Subcommittee and the DOE Biological and Environmental Research Advisory Committee, 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.

Financial declaration

Funding sources for Curry's research have included NSF, NASA, NOAA, DOD and DOE. Recent contracts for CFAN include a DOE contract to develop extended range regional wind power forecasts and a DOD contract to predict extreme events associated with climate variability/change having implications for regional stability. CFAN contracts with private sector and other non-governmental organizations include energy and power companies, reinsurance companies, other weather service providers, NGOs and development banks. Specifically with regards to the energy and power companies, these contracts are for medium-range (days to weeks) forecasts of hurricane activity and landfall impacts. CFAN has one contract with an energy company that also includes medium-range forecasts of energy demand (temperature), hydropower generation, and wind power generation. CFAN has not received any funds from energy companies related to climate change or any topic related to this testimony.

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For more information:

http://curry.eas.gatech.edu/
http://www.cfanclimate.com/
http://judithcurry.com

This could be a time of great opportunity for some climate scientists.

Let me explain. I know very little about climate science and I've never published a scientific paper in my life but I have filed at least couple of dozen patents and I recognise innovative opportunities when I see them.

Inventions are rarely made in isolation. Usually they are the solution to a problem or a novel improvement to overcome known difficulties. Climate science certainly has more than its share of problems and difficulties at the moment. This presents an opportunity for some climate scientists. I say “some” scientists because most of them are trying to ignore or minimise the problem associated with their models. The perceptive scientists will see the problems as having much more innovative potential than the models. Forget the models and see the problems as clues leading to the treasure.