

U.S. Senate Committee on
Commerce, Science, & Transportation
Subcommittee on Space, Science and Competitiveness
8 Dec 2015
Testimony of John R. Christy
University of Alabama in Huntsville.

I am John R. Christy, Distinguished Professor of Atmospheric Science, Alabama's State Climatologist and Director of the Earth System Science Center at The University of Alabama in Huntsville. I have served as a Lead Author, Contributing Author and Reviewer of United Nations IPCC assessments, have been awarded NASA's Medal for Exceptional Scientific Achievement, and in 2002 was elected a Fellow of the American Meteorological Society.

It is a privilege for me to offer my analysis of the current situation regarding our understanding of climate change, the effect of regulations on climate, the popular notion of extreme climate events, and the unfortunate direction research in this area has taken. My research area might be best described as building datasets from scratch to advance our understanding of what the climate is doing and why – an activity I began as a teenager over 50 years ago. I have used traditional surface observations as well as measurements from balloons and satellites to document the climate story. Many of our UAH datasets are used to test hypotheses of climate variability and change.

How well do we understand climate change?

A critical issue in our era is to determine whether emissions from human activities impact the climate and by how much. This is made especially difficult because we know the climate system already is subject to changes without the influence of humans. Because there is no measuring device that explicitly determines the cause of the climate changes we can measure, such as temperature, our science must take a different approach to seek understanding as to what causes the changes, i.e. how much is natural and how much is human induced. The basic approach today utilizes climate models. (The projections of these models are being utilized for carbon policies as well.)

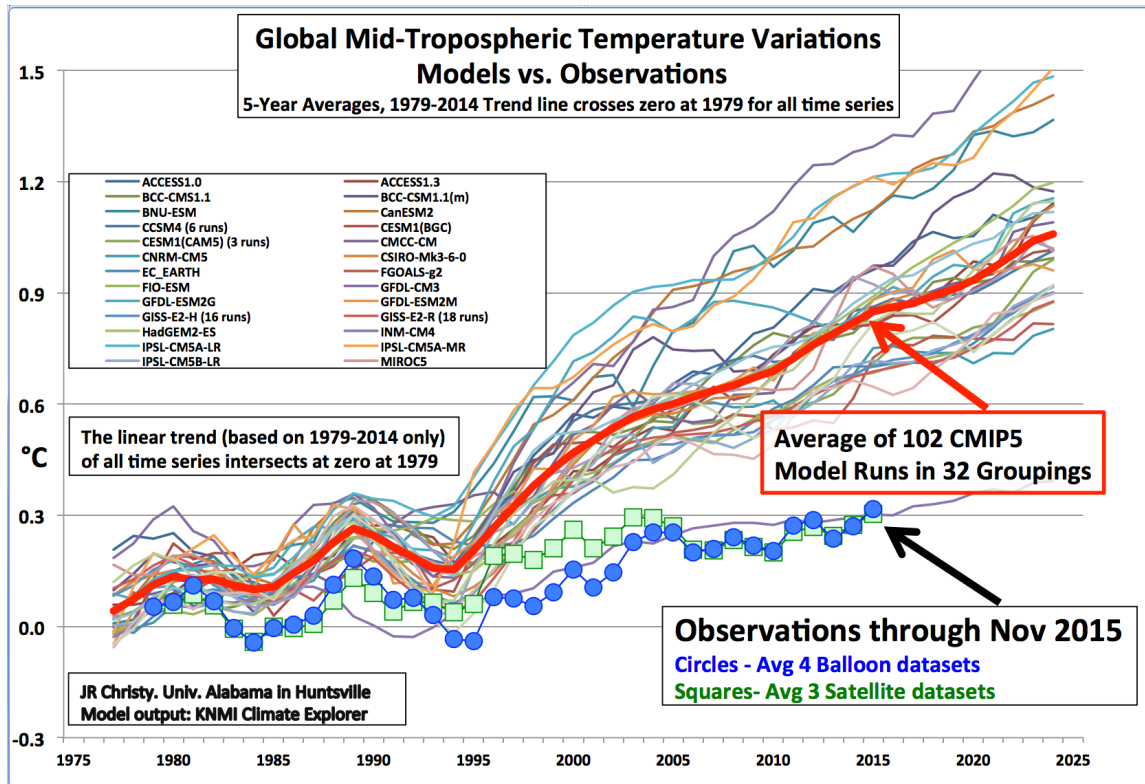
It is important to understand that output from these models, (i.e. projections of the future climate and the specific link that increasing CO₂ might have on the climate) are properly defined as scientific hypotheses or claims – model output cannot be considered as providing proof of the links between climate variations and greenhouse gases. These models are complex computer programs which attempt to describe through mathematical

equations as many factors that affect the climate as is possible and thus estimate how the climate might change in the future. The model, it is hoped, will provide accurate responses of the climate variables, like temperature, when extra greenhouse gases are included in the model. However, the equations for nearly all of the important climate processes are not exact, representing the best approximations modelers can devise and that computers can handle at this point.

A fundamental aspect of the scientific method is that if we say we understand a system (such as the climate system) then we should be able to predict its behavior. If we are unable to make accurate predictions, then at least some of the factors in the system are not well defined or perhaps even missing. [Note, however, that merely replicating the behavior of the system (i.e. reproducing “what” the climate does) does not guarantee that the fundamental physics are well-known. In other words, it is possible to obtain the right answer for the wrong reasons, i.e. getting the “what” of climate right but missing the “why”.]

Do we understand how greenhouse gases affect the climate, i.e. the link between emissions and climate effects? A very basic metric for climate studies is the temperature of the bulk atmospheric layer known as the troposphere, roughly from the surface to 50,000 ft altitude. This is the layer that, according to models, should warm significantly as CO₂ increases – even faster than the surface. Unlike the surface temperature, this bulk temperature informs us regarding the crux of the global warming question – how much heat is accumulating in the global atmosphere? And, this CO₂-caused warming should be easily detectable by now, according to models. This provides a good test of how well we understand the climate system because since 1979 we have had two independent means of monitoring this layer – satellites from above and balloons with thermometers released from the surface.

I was able to access 102 CMIP-5 rcp4.5 (representative concentration pathways) climate model simulations of the atmospheric temperatures for the tropospheric layer and generate bulk temperatures from the models for an apples-to-apples comparison with the observations from satellites and balloons. These models were developed in institutions throughout the world and used in the IPCC AR5 Scientific Assessment (2013).

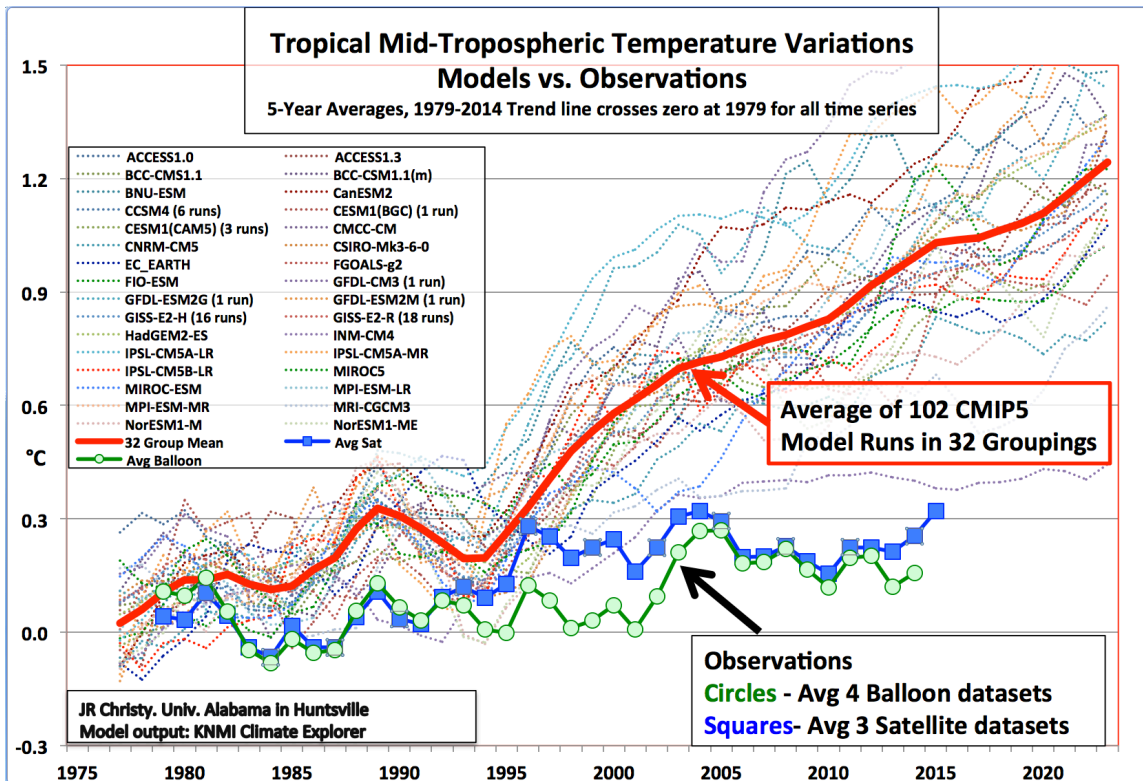


Above: Global average mid-tropospheric temperature variations (5-year averages) for 32 models (lines) representing 102 individual simulations. Circles (balloons) and squares (satellites) depict the observations.

The information in this figure provides clear evidence that the models have a strong tendency to over-warm the atmosphere relative to actual observations. On average the models warm the global atmosphere at a rate three times that of the real world. This is not a short-term, specially-selected episode, but represents the past 37 years, over a third of a century. This is also the period with the highest concentration of greenhouse gases and thus the period in which the response should be of largest magnitude.

Using the scientific method we would conclude that the models do not accurately represent at least some of the important processes that impact the climate because they were unable to “predict” what has already occurred. In other words, these models failed at the simple test of telling us “what” has already happened, and thus would not be in a position to give us a confident answer to “what” may happen in the future and “why.” As such, they would be of highly questionable value in determining policy that should depend on a very confident understanding of how the climate system works.

There is a related climate metric that also utilizes atmospheric temperature which in models has an even larger response than that of the global average shown above. This metric, then, provides a stronger test for understanding how well models perform regarding greenhouse gases specifically. In the models, the tropical atmosphere warms significantly in response to the added greenhouse gases – more so than that of the global average atmospheric temperature.



Above: Tropical average mid-tropospheric temperature variations (5-year averages) for 32 models (lines) representing 102 individual simulations. Circles (balloons) and squares (satellites) depict the observations.

In the tropical comparison here, the disparity between models and observations is even greater, with models on average warming this atmospheric region by a factor of four times greater than in reality. Such a result re-enforces the implication above that the models have much improvement to undergo before we may have confidence they will provide information about what the climate may do in the future or even why the climate varies as it does. For the issue at hand, estimates of how the global temperature might be affected by emission reductions from regulations would be exaggerated and not reliable.

Impact of Regulations Will Not Be Attributable or Detectable

The impact on global temperature for current and proposed reductions in greenhouse gases will be tiny. To demonstrate this, let us assume, for example, that the total emissions from the United States were reduced to zero, as of last May 13th, 2015 (the date of the last congressional hearing on which I testified). In other words as of that day and going forward, there would be no industry, no cars, no utilities, no people – i.e. the United States would cease to exist as of that day. Regulations, of course will only hope to reduce emissions a small amount, but to make the point of how minuscule the regulatory impact will be, we shall simply go way beyond reality and cause the United States to vanish. With this we shall attempt to answer the question of climate change impact due to emissions reductions.

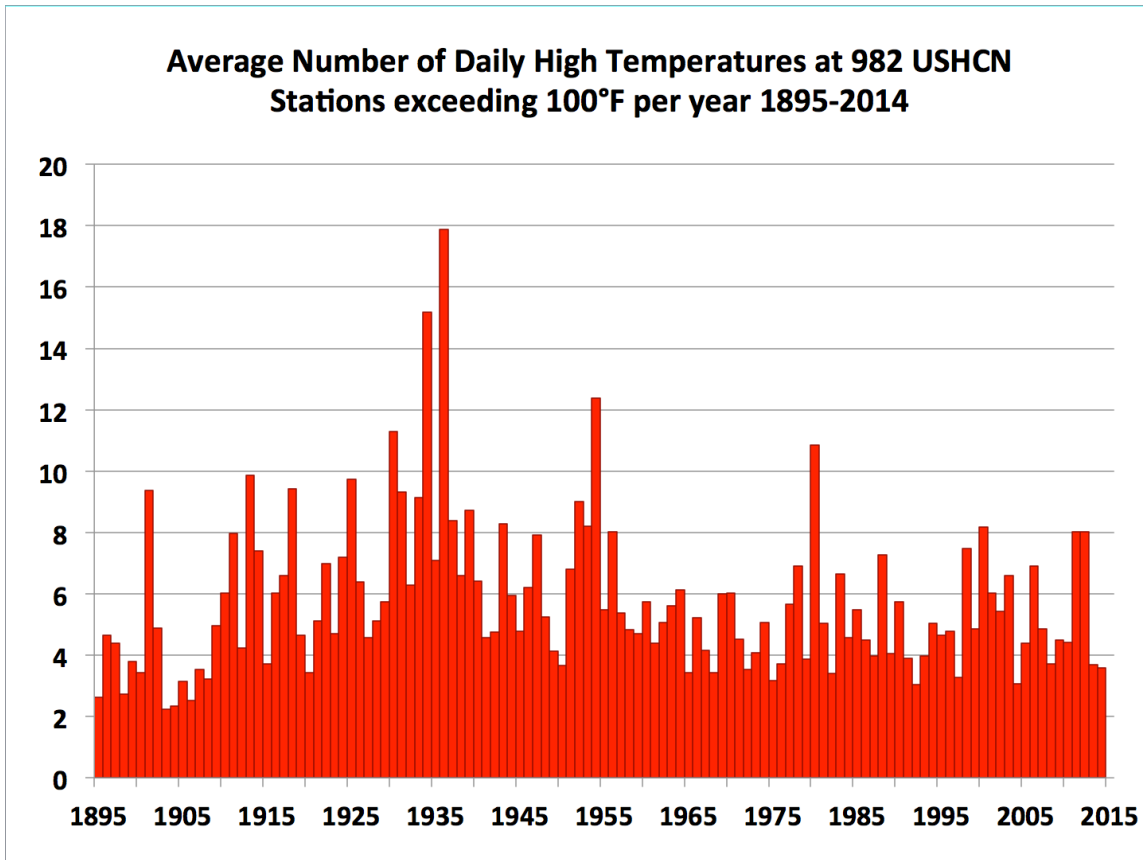
Using the U.N. IPCC impact tool known as Model for the Assessment of Greenhouse-gas Induced Climate Change or MAGICC, graduate student Rob Junod and I reduced the projected growth in total global emissions by U.S. emission contribution starting on this date and continuing on. We also used the value of the equilibrium climate sensitivity as determined from empirical techniques of 1.8 °C. After 50 years, the impact as determined by these model calculations would be only 0.05 to 0.08 °C – an amount less than that which the global temperature fluctuates from month to month. [These calculations used emission scenarios A1B-AIM and AIF-MI with U.S. emissions comprising 14 percent to 17 percent of the 2015 global emissions. There is evidence that the climate sensitivity is less than 1.8 °C, which would further lower these projections.]

Because changes in the emissions of our entire country would have such a tiny calculated impact on global climate, it is obvious that fractional reductions in emissions through regulation would produce imperceptible results. In other words, there would be no evidence in the future to demonstrate that a particular climate impact was induced by the proposed and enacted regulations. Thus, the regulations will have no meaningful or useful consequence on the physical climate system – even if one believes climate models are useful tools for prediction.

Alleged impacts of human-induced climate changes regarding extreme events

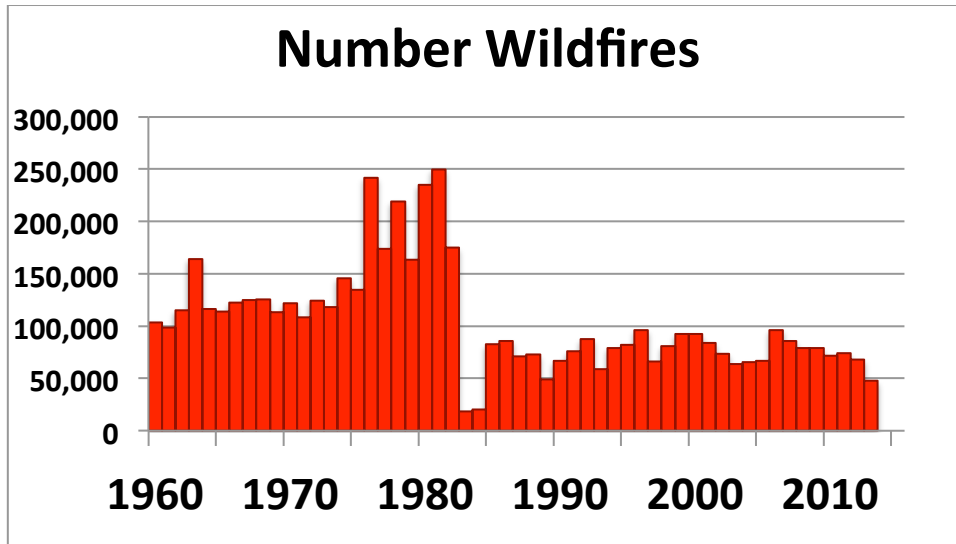
Much of the alarm related to increasing greenhouse gas concentrations shifted in the past decade from global temperature changes to changes in extreme events, i.e. those events which typically have a negative impact on the economy. These events may be heat waves, floods, hurricanes, etc.

In terms of heat waves, below is the number of 100 °F days observed in the U.S. from a controlled set of weather stations. It is not only clear that hot days have not increased, but it is interesting that in the most recent years there has been a relative dearth of them.

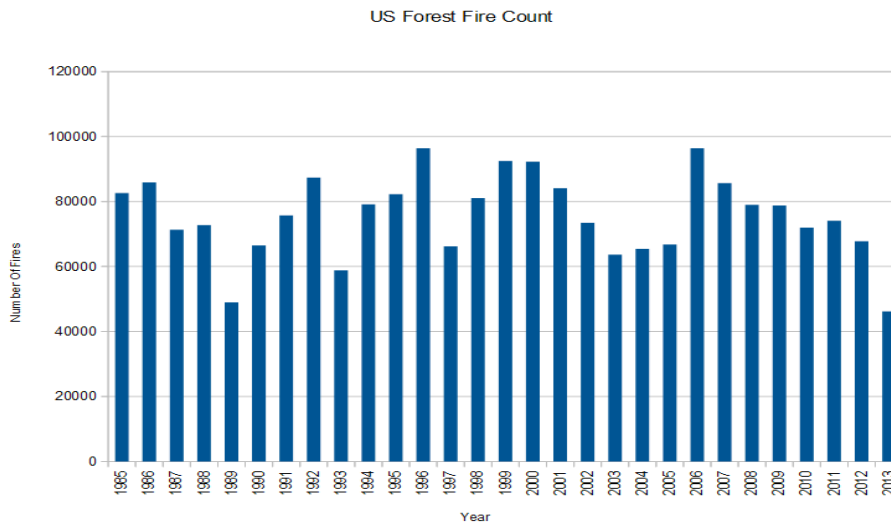


Above: Average number of days per-station in each year reaching or exceeding 100°F in 982 stations of the USHCN database (NOAA/NCEI, prepared by JRChristy).

Forest and wild fires are documented for the US. The evidence below indicates there has not been any change in frequency of wildfires. Acreage (not shown) shows little change as well.



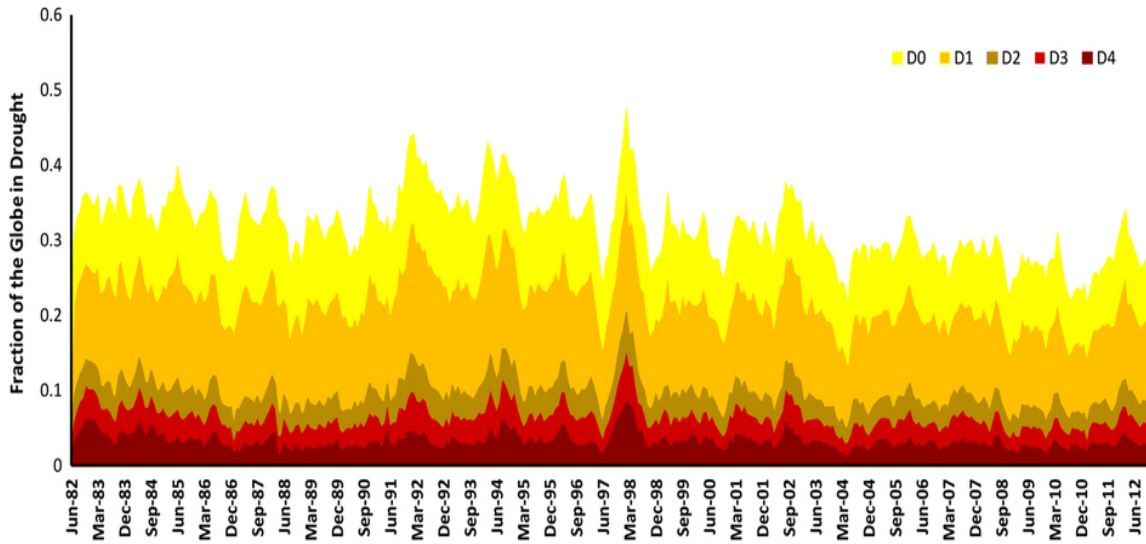
Above: Number of U.S. wildfires. As the management of these events changes, and thus the number also changes, but the number of events since 1985 has remained constant. (National Interagency Fire Center <https://www.nifc.gov/fireInfo/nfn.htm>)



Above: Number of U.S. forest fires per year since 1965.

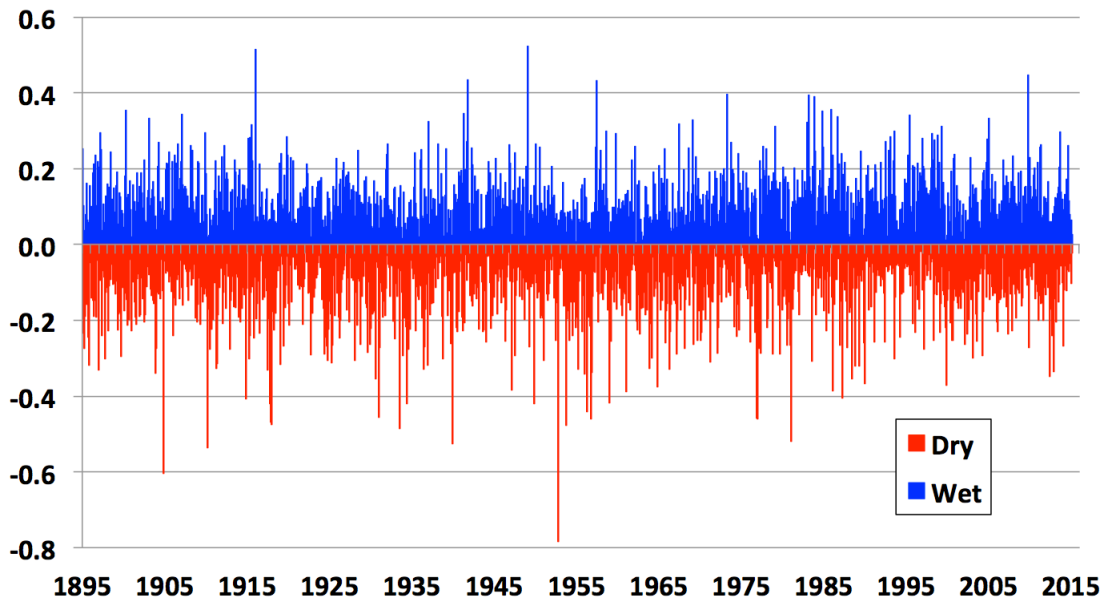
The two figures above demonstrate that fire events have not increased in frequency in the United States during the past several decades.

The claims that droughts and floods are increasing may be examined by the observational record as well.



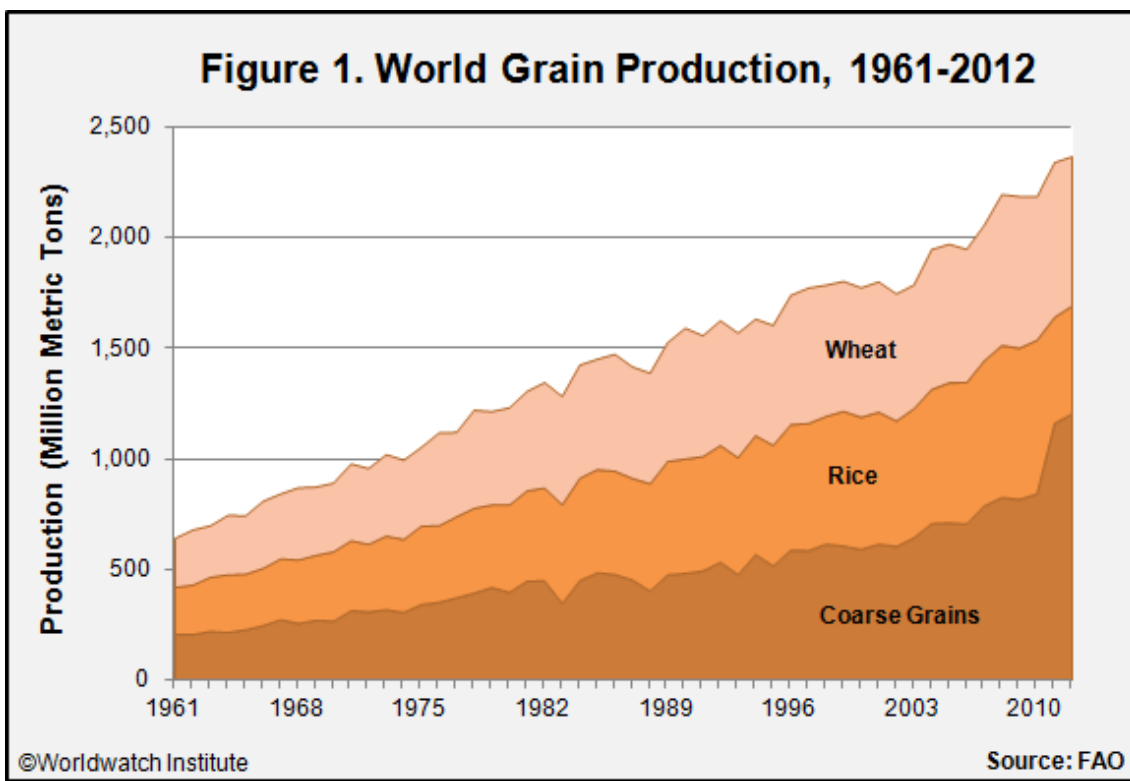
Above: Global areal extent of five levels of drought for 1982-2012 where dryness is indicated in percentile rankings with $D0 < 30$, $D1 < 20$, $D2 < 10$, $D3 < 5$ and $D4 < 2$ percentile of average moisture availability. (Hao et al. 2014)

**Monthly Fraction of US with Very Wet (floods) or Very Dry (drought) Conditions
Jan 1895 – Feb 2015 NOAA/NCDC**



Above: Areal fraction of conterminous U.S. under very wet (blue) or very dry (red) conditions. NOAA/NCEI.

The two figures above demonstrate that moisture conditions have not shown a tendency to have decreased (more drought) or increased (more large-scale wetness). Such information is rarely consulted when it is more convenient simply to make unsubstantiated claims that moisture extremes, i.e. droughts and floods (which have always occurred), are somehow becoming even more extreme. Over shorter periods and in certain locations, there is evidence that the heaviest precipitation events are tending to be greater. This is not a universal phenomenon and it has not been established that such changes may be due to changes in greenhouse gas concentrations as demonstrated earlier because the model projections are unable to reproduce the simplest of metrics.



Above: World grain production 1961-2012. U.N. Food and Agriculture Organization.

It is a simple matter to find documentation of the ever-rising production of grains. One wonders about the Federal Council on Environmental Quality's allegation that there has been "harm to agriculture" from human-induced climate change because when viewing the total growth in production, which appears to be accelerating, one would assume no "harm" has been done during a period of rising greenhouse gases.

With the evidence in these examples above, it is obviously difficult to establish the claims about worsening conditions due to human-caused climate change, or more generally that any change could be directly linked to increasing CO₂. This point also relates to the issue of climate model capability noted earlier. It is clear that climate models fall short on some very basic issues of climate variability, being unable to reproduce “what” has happened regarding global temperature, and therefore not knowing “why” any of it happened. It is therefore premature to claim that one knows the causes for changes in various exotic measures of weather, such as rainfall intensity over short periods, which are not even explicitly generated in climate model output.

The Disappointing Scientific Process

I have written much for previous congressional hearings and other venues about the failure of the scientific community to objectively approach the study of climate and climate change. (See Appendix) Climate science is a murky science with large uncertainties on many critical components such as cloud distributions and surface heat exchanges. As mentioned above, there is no objective instrumentation that can tell us “why” changes occur. That being the case, we are left with hypotheses (claims) to put forward and then to test. The information given above, in my view, is clear evidence that the current theoretical understanding of “why” the climate changes, as embodied in models (and on which current policy is based), fails such tests. Indeed, the theoretical (model) view as expressed in the IPCC AR5 in every case overestimated the bulk tropical atmospheric temperature response of extra greenhouse gases (see above and IPCC Supplementary Material Figure 10.SM.1) indicating the theoretical understanding of the climate response is too sensitive to greenhouse gases.

One problem with our science relates to the funding process for climate studies, the vast majority of which is provided through federal agencies. Funding decisions are decided by people, and people have biases. Our science has also seen the move toward “consensus” science where “agreement” between people and groups is elevated above determined, objective investigation. The sad progression of events here has even led to congressional investigations designed to silence (with some success) those whose voices, including my own, have challenged the politically-correct views on climate (i.e. congressional investigation by Rep. Grijalva, 22 Feb 2015, <http://www.scribd.com/doc/256811029/Letter-to-UAH-re-John-Christy>.)

Today, funding decisions are made by review panels. In this process, many proposals for funding are submitted to the agencies, but the agencies only have a fraction of the funds available to support the proposals, so only a few proposals can be funded and these are selected by panels. In the area of climate, it is clear the agencies are convinced of the

consensus view of dangerous climate change as indicated by their various statements and press releases on the issue. Therefore, when a contrarian proposal is submitted that seeks to discover other possible explanations besides greenhouse gases for the small changes we now see, or one that seeks to rigorously and objectively investigate climate model output, there is virtually no chance for funding. This occurs because the panel determines by majority vote whom to fund, and with tight competition, any bias by just a couple of panel members against a contrarian proposal is sufficient for rejection. Of course, the agencies will claim all is done in complete objectivity, but that would be precisely the expected response of someone already within the “consensus” and whose agency has stated its position on climate change. This brings me to “consensus science.”

The term “consensus science” will often be appealed to regarding arguments about climate change to bolster an assertion. This is a form of “argument from authority.” Consensus, however, is a political notion, not a scientific notion. As I testified to the Inter-Academy Council in June 2010, wrote in *Nature* that same year (Christy 2010), and documented in my written testimony for several congressional hearings (e.g., House Space, Science and Technology, 31 Mar 2011) the IPCC and other similar Assessments do not represent for me a consensus of much more than the consensus of those selected to agree with a particular consensus.

The content of these climate reports is actually under the control of a relatively small number of individuals - I often refer to them as the “climate establishment” – who through the years, in my opinion, came to act as *gatekeepers* of scientific opinion and information, rather than *brokers*. The voices of those of us who object to various statements and emphases in these assessments are by-in-large dismissed rather than accommodated. This establishment includes the same individuals who become the “experts” called on to promote IPCC claims in government reports such as the endangerment finding by the Environmental Protection Agency.

As outlined in my previous testimonies, these “experts” become the authors and evaluators of their own research relative to research which challenges their work. This becomes an obvious conflict of interest. But with the luxury of having the “last word” as “expert” authors of the reports, alternative views vanish. This is not a process that provides the best information to the peoples’ representatives. The U.S. Congress must have the full range of views on issues such as climate change which are (a) characterized by considerable ambiguity (see model results) (b) used to promote regulatory actions which will be economically detrimental to the American people and, most ironically, (c) will have no impact on whatever the climate will do.

I've often stated that climate science is a "murky" science. We do not have laboratory methods of testing our hypotheses as many other sciences do. As a result what passes for science includes, opinion, arguments-from-authority, dramatic press releases, and fuzzy notions of consensus generated by preselected groups. This is not science.

We know from Climategate emails and many other sources that the IPCC has had problems with those who take different positions on climate change than what the IPCC promotes. There is another way to deal with this however. Since the IPCC activity and climate research in general *is* funded by U.S. taxpayers, then I propose that five to ten percent of the funds be allocated to a group of well-credentialed scientists to produce an assessment that expresses legitimate, alternative hypotheses that have been (in their view) marginalized, misrepresented or ignored in previous IPCC reports (and thus the EPA Endangerment Finding and National Climate Assessments).

Such activities are often called "Red Team" reports and are widely used in government and industry. Decisions regarding funding for "Red Teams" should not be placed in the hands of the current "establishment" but in panels populated by credentialed scientists who have experience in examining these issues. Some efforts along this line have arisen from the private sector (i.e. *The Non-governmental International Panel on Climate Change* at <http://nipccreport.org/> and Michaels (2012) *ADDENDUM: Global Climate Change Impacts in the United States*). I believe policymakers, with the public's purse, should actively support the assembling all of the information that is vital to addressing this murky and wicked science, since the public will ultimately pay the cost of any legislation alleged to deal with climate.

Topics to be addressed in this "Red Team" assessment, for example, would include (a) evidence for a low climate sensitivity to increasing greenhouse gases, (b) the role and importance of natural, unforced variability, (c) a rigorous and independent evaluation of climate model output, (d) a thorough discussion of uncertainty, (e) a focus on metrics that most directly relate to the rate of accumulation of heat in the climate system, (f) analysis of the many consequences, including benefits, that result from CO₂ increases, and (g) the importance that affordable and accessible energy has to human health and welfare.

What this proposal seeks is to provide to the Congress and other policymakers a parallel, scientifically-based assessment regarding the state of climate science which addresses issues which here-to-for have been un- or under-represented by previous tax-payer funded, government-directed climate reports. In other words, our policymakers need to see the entire range of findings regarding climate change.

Summary

The messages of the four points outlined above are: (1) the theoretical understanding of the way greenhouse gases affect climate, as embodied on climate models, fails simple evaluation tests, (2) even if one accepts climate model output, the impact of reducing emissions by any of the regulations now enforce or proposed will be negligible, (3) the claims about increases in frequency and intensity of extreme events are generally not supported by actual observations and, (4) official information about climate science is largely controlled by agencies through (a) funding choices for research and (b) by the carefully-selected (i.e. biased) authorship of reports such as the EPA Endangerment Finding and the National Climate Assessment.

IAC 15 June 2010

Montreal

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Director, Earth System Science Center
Alabama State Climatologist
University of Alabama in Huntsville

IPCC Lead Author: 2001 TAR
Contributor: 1992 Supplement
Contributor: 1994 Radiative Forcing of Climate Change
Key Contributor: 1995 SAR
Contributing Author: 2007 AR4, WG I and II

NASA Medal for Exceptional Scientific Achievement
American Meteorological Society Special Award for satellite observations
Fellow, American Meteorological Society

Mr. Chairman and members of the IAC panel, thank you for inviting me to offer my views on the IPCC process. Five years ago the *New York Times* quoted me saying that an IPCC-like process, "... is the worst way to generate scientific information, except for all the others." (23 Aug 2005) I now think I was a bit too generous.

A fundamental problem with the entire issue here is that climate science is not a classic, experimental science. As an emerging science of a complex, chaotic climate system, it is plagued by uncertainty and ambiguity in both observations and theory. Lacking classic, laboratory results, it easily becomes hostage to opinion, groupthink, arguments-from-authority, overstatement of confidence, and even Hollywood movies. When climate scientists are placed in the limelight because this issue can generate

compelling disaster scenarios, we simply don't want to say, "We just don't know."

I have been a contributor to the IPCC Assessments since 1992 and a Lead Author in the Third Assessment of 2001. Though I had some good things to say about the IPCC, I did respond in 2001 to the US National Academy of Sciences when they solicited information about certain problems (see Appendix A).

At the time, I was more concerned about the product rather than the process. The first objection I raised regarding the Third Assessment was that the fabled Hockey Stick was oversold as an indicator of past climate change. This was well before the critical work of the Wegman Report, National Academy of Sciences, McIntyre's papers and the East Anglia emails. *Indeed, I urge you in the strongest terms to engage Stephen McIntyre in your deliberations at a high level as he has accurately documented specific failures in the IPCC process, some of which I can attest to, as I was there.*

My second objection to the TAR was its overstatement of confidence in model projections.

My role in the Fourth Assessment of 2007 was limited to that of a Contributing Author. This means I submitted recommendations that were dealt with by the Lead Authors who tended to disagree with my published findings. Thus, their views carried the day in the report. In this process, the final result really boils down the opinions of those selected as Lead Authors, a point I will address below.

In March of last year, 8 months before the email fiasco, about 140 former IPCC Lead Authors gathered in Hawaii for a preview of what the Fifth Assessment might tackle. I was the only one there well-known to be essentially outside the IPCC “consensus.” I had come to the conclusion that the IPCC establishment demonstrated a disturbing homogeneity-of-thought regarding the hypothesized but unproven role that greenhouse gases might impose on the climate system. My short talk (Appendix B) and poster (Appendix C) at that meeting last year dealt with three science issues and offered a recommendation. The three issues were (1) the surface temperature record is flawed in many ways, but is flawed in particular as a metric to detect greenhouse-imposed warming, (2) direct tests of the so-called fingerprint of climate model temperature changes versus observations indicated significant differences, failing simple hypothesis tests, and (3) the critical value of climate sensitivity to greenhouse gases was overstated because it had not been properly calculated. All of these were supported by peer-reviewed publications which even now continue to appear.

In my view, the IPCC process had drifted away from allowing authors to serve as Brokers of climate science, in which various views are given attention, to becoming Gatekeepers of climate science in which one view is elevated and promoted. The IPCC Assessment had become a “consensus of those who agreed with the consensus.” Since “consensus” is a political notion, not a scientific notion, a goal of “consensus” in any forum is at its heart a political goal.

My recommendation last year was to include a chapter written by credentialed climate scientists who would provide evidence concerning these heretofore minimized issues, in particular the low sensitivity of the climate system. My assumption at that time was that the IPCC writing process would be the same, i.e. that the Lead Authors of this chapter, as the others, would be given the sacred right of being their own final reviewers to let a new voice be heard. No one at the meeting thought this was a useful suggestion, I believe, because it would allow the expression of reasonable alternatives to claims too entrenched in the message of looming climate disasters promoted with IPCC indulgence.

Since last March, much has happened to expose some of the scientists who dominated the IPCC, whom I call the establishment, as less than transparent, subject to bias, and who suppress alternative views while using the IPCC's perception as a near-sacred document to promote their own opinions. This establishment dominates not only the IPCC but also the review process of the peer-reviewed literature, making it extremely difficult for alternative evidence to even be published now. This happens when your type of science is rather murky to begin with.

In my view, the three fundamental flaws in the current IPCC process are (1) the two-step political filter by which Lead Authors are selected, (2) the review-authority granted the Lead Authors who write the chapters and synthesis reports, and, (3) the very limited word-count available for each topic, which encourages short and overconfident statements about questions that in truth are plainly nasty to deal with.

In February of this year, *Nature* magazine asked me for a brief discussion about the IPCC and a way forward (Appendix D, last page). My main concern there was to define a process that would let the world know that our ignorance of much of the climate system is simply enormous and we have much to do. Mother Nature has a tremendous number of degrees of freedom up her sleeves, many of which we don't even know about or account for.

So, I suggested a living, carefully-managed, wikipedia-style process. Important questions, most of which are already laid out in the IPCC manifest, would be addressed by teams of Lead Authors who would be far less constrained by the word-count rules, and so would allow fuller expression of uncertainty and disagreement – expressions contributed by the specific people who perform whatever research is being discussed. The Lead Authors main task would be to organize and summarize the information on each question, acting strictly as Brokers, not Gatekeepers. With web-based links to actual text (and data) the Lead Authors would be far less tempted to be biased. Lead Authors need to know they do not have to agree with the findings they report. I believe such transparency would spur the Lead Authors to be fairer and more humble in their summary comments.

Peer-reviewed research of course would dominate the source material, but other documents – whose source is clearly identified – could contribute to the discussion. I know there would be significant issues of managing such a process, but I believe it would be far better than producing big books every six years that are limited, biased and out-of-date when they are printed. We *are* in the 21st Century, and, to the despair of those who find comfort in

absolute answers, there are only continuously evolving levels of understanding (and ignorance) to most of the climate questions being asked. This situation begs for a dynamic assessment process.

The selection of Lead Authors through a two-step political process is a problem too. Presently, national governments nominate to the IPCC those who over the years, they can generally count on to be consistent with national policy. From this pool, the IPCC itself selects those it wants to be Lead Authors. To combat the political influence of governments and the U.N., to a small extent, I would recommend that Lead Authors be nominated by appropriate learned societies, such as yours, and selected for overlapping, rotating terms. I'm not completely comfortable with this as I'm aware that councils of science are deeply involved in political maneuvering which is why I state that to a "small extent" the political influence of governments and the U.N. might be mitigated.

Some Lead Authors could and should be scholars from other disciplines but who have a keen awareness of the hard rules of hypothesis testing, admissible evidence, and the power of language ... physicists, chemists, engineers and yes, even lawyers. As I told a colleague the other day, it is clear to me now that climate science needs some adult supervision.

I realize such a recommendation creates consternation among those who have controlled the process up to now and who believe deeply that the "science is settled" because they find comfort in easy and unimaginative answers to difficult questions. For example, why doesn't the IPCC report on (and funding agencies invest in) major research about the internal

dynamical properties of the climate system? At present these properties are incapably represented in climate models to date, and yet have been shown to be a major source of the variability we've seen. Why must we be so unimaginative that we just give up and claim that nothing else but enhanced greenhouse forcing explains most of the temperature rise in the past 50 years?

Others will complain that such an open process I describe will not generate the definitive statements necessary to drive policy. To those I say, "Welcome to climate science." If a specific policy is desired, climate science is a weak leg on which to stand which means a policy should have multiple, defensible reasons for adoption.

You will hear from those within the IPCC establishment that the IPCC does a terrific job of getting down to the truth about climate science and that the consensus reports are the best documents for policymakers. But as one mostly outside the "consensus", I can not agree, and I am far, far from being alone in that disagreement. I say this as a working-stiff climate scientist who builds datasets from scratch to create understanding and test assertions about the climate system. The process followed in the Fourth Assessment, in my view, simply did not provide to the world the true ambiguities, uncertainties and contentions of our fledgling science.

In summary, to me, the impediments to providing a more honest expression of our science to the world in the current IPCC process are (1) Lead Authors essentially having final review authority, (2) the Lead Author selection process which encourages government-approved, homogeneity-of-thought,

and (3) the limited size, the dead-line character, and the past-expiration-date of printed documents. Thank you.

OPINION

ChristyJR Appendix A

IPCC: cherish it, tweak it or scrap it?

As calls for reform intensify following recent furores about e-mails, conflicts of interest, glaciers and extreme weather, five climatologists propose ways forward for the Intergovernmental Panel on Climate Change. Their suggestions range from reaffirming the panel's governing principles to increasing the number and speed of its publications to replacing the volunteer organization with a permanently staffed structure.

Split into three panels

Mike Hulme

Coordinating lead author, lead author, review editor (AR3), University of East Anglia, Norwich, UK

Much has changed since the late 1980s when the Intergovernmental Panel on Climate Change (IPCC) was designed, notably the nature of scientific practice and its relationship with society. How the world's knowledge communities are mobilized to enlighten policy deliberations also needs to be different. The assessments published by the IPCC have firmly elevated anthropogenic climate change to one of the major international political issues of our time. But they have made this impact by drawing in an ever-widening subset of the social, technological, environmental and ethical dimensions of climate change — well beyond the physical sciences.

The IPCC is no longer fit for purpose. It is not feasible for one panel under sole ownership — that of the world's governments, but operating under the delegated management of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) — to deliver an exhaustive 'integrated' assessment of all relevant climate-change knowledge. As I remarked three years ago in these pages, "The IPCC needs a complete overhaul. The structure and process are past their sell-by dates."

My suggestion for radical reform is to dissolve the IPCC after the Fifth Assessment Report (AR5) in 2014. The work would be split into three types of assessment and evaluation, each rather different to the three existing IPCC working groups.

The first would be a Global Science Panel (GSP). An IPCC-like assessment process should continue to operate for the physical sciences that observe and predict the Earth system. Rather



STR/AFP/GETTY

An IPCC meeting: the panel will publish its Fifth Assessment Report (AR5), in 2014.

than comprehensive reports every six years, this panel would commission, on a rolling basis, a larger number of smaller, sharply focused syntheses of knowledge on fast-moving topics that have great scientific or policy salience. Perhaps two or three would be in production at any one time and each would be no more than 50 pages in length. These would need to be globally coordinated and could be governed either through an intergovernmental process as now, or devolved to a governing council of representative national academies of science.

The second group would be made up of Regional Evaluation Panels (REPs). The cultural, social, economic and development dimensions of climate change are essentially regional in nature. Each region — five to ten continental or sub-continental regions in all — should conduct its own evaluation of relevant knowledge. This should use the work of the GSP, but also draw in a much more diverse set of expertise, knowledge and scholarship. As well as being structured according to the concerns of

each region, the ownership and governance patterns of these REPs would vary regionally, but should ideally involve a consortium of national governments, civil-society organizations and businesses.

The third group would be the Policy Analysis Panel (PAP) — a standing panel of expertise, global in reach, with interdisciplinary skills and a diverse analytical capacity. Perhaps 50–100 strong, this panel would undertake focused and rapid (6–12 months) analyses of specific proposed policy options and measures that have global significance. These could be subjects such as environmental effectiveness of controlling black carbon, economic implications of carbon border tariffs or new financing options for reducing emissions from deforestation. The policy options to be analysed can be brought forward by UN bodies, non-governmental organizations (NGOs), businesses and groupings of national governments. The PAP could be governed by a council of women and men of international stature and strong cultural significance to represent the breadth of civil society around the world. Such high quality and transparent policy evaluation would broaden the options available

"A new class of short, rapidly prepared, peer-reviewed reports is needed."

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for national and international deliberations.

This restructuring would allow clearer distinctions to be made in areas that have been troublesome for the IPCC: assessments of published knowledge versus policy analysis and evaluation; the globalized physical sciences versus more geographically and culturally nuanced knowledge; a one-size, top-down model of ownership and governance versus more inclusive, representative and regionally varying forms of governance. It would better serve the world, and its peoples, in understanding and responding to anthropogenic climate change.

Independent agency needed

Eduardo Zorita

Contributing author (AR4), GKSS Research Center in Geesthacht, Germany

Like the financial sector last year, the IPCC is currently experiencing a failure of trust that reveals flaws in its structure. This presents the climate-change community with the opportunity to address these faults. The IPCC currently performs as a diffuse community of government-nominated academic volunteers occupying a blurred space between science and politics, issuing self-reviewed reports under great stresses and unmanageable deadlines. Its undefined structure puts it at the mercy of pressure from advocates.

The IPCC should be made stronger and independent. We do not need to reinvent the wheel; there are excellent examples of agencies that society has set up when credibility is of the utmost importance. The European Central Bank, the International Atomic Energy Agency (IAEA), the International Energy Agency and the US Congressional Budget Office all independently navigate their way through strong political pressures, delivering valuable assessments, advice, reports and forecasts, tapping academic research when necessary. These agencies are accountable and respected.

An international climate agency (ICA) along such lines would have a staff of around 200 full-time scientists who would be independent of government, industry and academia. Such an agency should be resourced and empowered to do the following: issue streamlined biennial state-of-the-climate reports; be a repository and quality-controller of observational climate data; advise governments on regional assess-

ments of climate impacts; and coordinate the suite of future-climate simulations by research institutes.

An ICA could be built, for instance, on the IAEA template, encompassing many more countries than the IAEA but with a smaller staff. ICA reports should be independently reviewed in a transparent process, draw only on established, peer-reviewed literature, and highlight research gaps. External reviews would then be incorporated into the reports to form white papers to include possible opposing views in a transparent way.

The process of moving towards such an ICA could start now, alongside the preparation of the next IPCC assessment report, and culminate after its completion. Those climate researchers in the IPCC Bureau who have widely recognized credibility could initiate this transformation, supported by lead authors and review editors more numerous and with a bigger say than presently. These review editors should be elected not by governments but directly by scientific unions, for instance the American Geophysical Union, the European Geosciences Union and similar associations from Asia.

As with finance, climate assessment is too important to be left in the hands of advocates.

Apply best practice rules

Thomas F. Stocker

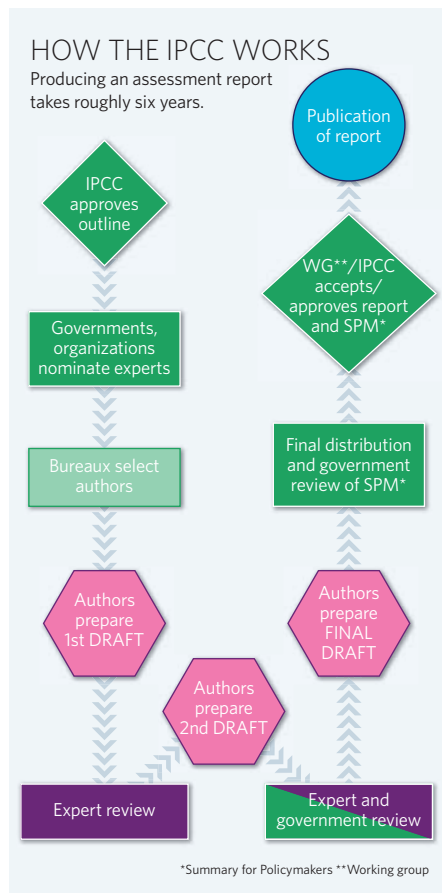
Co-chair IPCC Working Group I (AR5), coordinating lead author (AR3, AR4), University of Bern, Switzerland

The basis of the IPCC is the voluntary contributions of thousands of dedicated scientists from all over the world. The *Principles Governing IPCC Work* (IPCC, 1998) provide a clear framework for an open, transparent and robust process. This bottom-up endeavour is a unique model of providing scientific information, mainly from the peer-reviewed scientific literature, for decision-making on a challenging problem. It has worked extremely successfully for the past 21 years.

Recent controversies have demonstrated both the value and the limitations of these procedures. The team structure of the chapter authors, the multiple reviews by peers and governments, and the full and public documentation of this process largely eliminate personal views or biases in the science assessment. But procedures are only as strong as their enforcement at all levels of the assessment process. When I served as a coordinating lead author of Working Group I in the Third and Fourth Assessment Reports (AR3 and AR4), I was deeply impressed by the strict adherence to these principles by the co-chairs who ensured that these standards were applied at all levels. The combination of the best scientists and clear procedures constitute the authority of the IPCC.

Calls for reform of the IPCC have been made before. Changes were discussed after the completion of the Fourth Assessment Report in 2007. One possibility mooted was the production of more frequent assessments, more limited in scope. Fast-track assessments in support of the United Nations Framework Convention on Climate Change process were also considered. However, the panel concluded that the production of comprehensive reports roughly every six years is preferable because it ensures the robustness required for a thorough and rigorous assessment. Faster turnover would jeopardize the multi-stage review and thus compromise authority and comprehensiveness. In asking scientists to produce reports and assessments every year, say, we could lose their support rather quickly.

The IPCC has served as an honest broker in the past and will do so, hopefully, in the future. Now that the problem of climate change is on the



SOURCE: IPCC

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radar screen of the world, there are many NGOs and other groups, even groups of scientists and institutions, that provide climate-change information in various forms and quality, often lacking comprehensiveness and proper recognition of uncertainties. There is a strong pressure to provide 'just-in-time' scientific updates for policy-makers and stakeholders, as was the case in the preparations for the 2009 climate-change conference in Copenhagen. The IPCC must not yield to this pressure.

In this field of different and divergent forces, confusion may arise. An honest broker therefore is an asset. From my perspective, the IPCC has fulfilled this role with remarkable rigour and integrity. This role is now at risk, as the stakes are higher than ever before. The requirement that assessments are policy relevant but never policy prescriptive, as formulated in the *Principles Governing IPCC Work*, is of paramount importance. Our task is to inform the policy-makers and the public strictly in a 'what if' mode. Any other approach must be left to NGOs, negotiators or individuals. Only with strict adherence to procedures and to scientific rigour at all stages will the IPCC continue to provide the best and most robust information that is needed so much.

Produce more reports faster

Jeff Price

Lead author (AR3, AR4), director, climate-change adaptation, WWF United States

The IPCC is accepting nominations (until 12 March 2010) from governments and participating organizations for authors for its Fifth Assessment Report. One recommendation for the IPCC that could be implemented immediately is in how its coordinating lead authors and review editors are selected.

Currently, authors are selected to represent "a range of views, expertise, gender and geographical representation". However, given the importance placed on these assessments, the most senior positions should be filled by the nominees most expert in their field, regardless of balance. These authors should be the most knowledgeable nominee about the range of topics in their chapter, best able to cooperatively work with a team of international scholars. Preferably, they should have previously been involved in an IPCC assessment and be familiar with IPCC standards and methodologies. Geographic and gender balance should then

be used in selection of lead authors. The level of work required in preparing an assessment is large. Increasing the number of lead authors would provide better balance and give more scientists the ability to participate in the process.

A new class of short, rapidly prepared, peer-reviewed reports is also needed. At present, publication options include supplemental material (no peer review required), technical papers (based on existing assessments) or assessments and special reports that undergo two reviews (expert and government/expert, usually taking more than two years to complete). For topics of emerging importance or uncertainty, we need reports based on expert meetings and literature synthesis that undergo only a single round of extensive peer review with review-editor oversight before publication. The IPCC should also expand the number of specialist task forces, task groups and hold more expert meetings to provide additional scientific review and oversight for the broadening array of models (including model comparisons and validation) and methodologies used in emissions reporting, estimating and monitoring impacts, and in developing assessments and adaptation plans.

Finally, the current period between assessments is too long. One option would be for the IPCC, or another body, to produce an annual review, assessment and synthesis of the literature for policy-makers (for example, three annual review volumes with a synthesis chapter in each volume) prepared by experts in the field. Although the editors of the volumes should ideally be drawn from past IPCC authors and editors, the review articles could be submitted by any author, as they would for a journal, with appropriate peer review and assessment for publication.

Open debate: Wikipedia-style

John R. Christy

Lead author (AR3), University of Alabama in Huntsville, USA

Since 1992 I have served as an IPCC contributor and in 2001, as a lead author. My experience has left me of the firm conviction that the IPCC should be removed from UN oversight.

The IPCC selects lead authors from the pool of those nominated by individual governments. Over time, many governments nominated only authors who were aligned with stated policy. Indeed, the selections for the IPCC Fourth

Assessment Report represented a disturbing homogeneity of thought regarding humans and climate.

Selected lead authors have the last word in the review cycle and so control the message, often ignoring or marginalizing dissenting comments. 'Consensus' and manufactured-confidence ensued. The recent leaking of e-mails from the Climatic Research Unit at the University of East Anglia in Norwich, UK, put on display the unsavoury cycle of marginalizing different viewpoints. Now several errors of overstatement, such as that of the melting rate of the Himalayan glaciers, have been exposed.

Unfortunately, prestigious media, including *Nature*, became cheerleaders for these official reports, followed then by governments trying to enact policies that drastically reduced emissions to 'stop global warming' while increasing energy costs.

I recommended last year that the next IPCC report invites published authors to write about the evidence for low climate sensitivity and other issues. The IPCC then would be a true reflection of the heterogeneity of scientific views, an 'honest broker', rather than an echo chamber. My recommendation assumed a business-as-usual IPCC process.

However, voluminous printed reports, issued every six years by government-nominated authors, cannot accommodate the rapid and chaotic development of scientific information today. An idea we pitched a few years ago that is now worth reviving was to establish a living, 'Wikipedia-IPCC'. Groups of four to eight lead authors, chosen by learned societies, would serve in rotating, overlapping three-year terms to manage sections organized by science and policy questions (similar to the Fourth Assessment Report). The authors would strike a balance between the free-for-all of true science and the need for summary statements.

Controversies would be refereed by the lead authors, but with input from all sides in the text, with links to original documents and data. The result would be more useful than occasional big books and would be a more honest representation of what our fledgling science can offer. Defining and following rules for this idea would be agonizing, but would provide greater openness.

The truth, and this is frustrating for policy-makers, is that scientists' ignorance of the climate system is enormous. There is still much messy, contentious, snail-paced and now, hopefully, transparent work to do. ■

See also **Perspectives**, page 747.

Have your say on the future of the IPCC at go.nature.com/orzWau.