Statement Concerning Global Warming

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I wish to thank Senators Chafee and Baucus, as well as the members of the Senate Committee on Environment and Public Works, for the opportunity to put forward my views on the issue of putative global warming.

Introduction

The issue of global warming is one of the more contentious issues in science today. Superficially, it is frequently portrayed as a 'simple' issue. Gases which absorb infrared radiation (known as greenhouse gases) inhibit radiative cooling of the earths surface and hence increasing greenhouse gases must lead to warming. The issue is rendered more complex by the fact that the surface of the earth does not cool primarily by means of radiation, but rather cools by evaporation and convection. Moreover, the main greenhouse gas is water vapor which is both natural in origin and highly variable in its distribution. In the absence of good records of water vapor we aren't even in a position to say how much total greenhouse gases have increased. If this weren't bad enough, it isn't even the total amount of greenhouse gas which matters; for example, a molecule of water vapor at 12 km altitude is more effective than a thousand molecules near the surface. All of this might not be relevant if models were trustworthy, but satellite measurements of upper level water vapor show profound discrepancies in model results. Under the circumstances, it is surprising that there is any agreement among scientists, but, in fact, most scientists working on climate dynamics would agree that increasing levels of carbon dioxide should have *some* impact on climate. The real argument is over whether the impact will be significant. The word 'significant,' in this context, has a rather specific meaning. The climate is a naturally variable system. That is to say, it varies without any external forcing. Human society already has to deal with this degree of variability – over which it has no control. For anthropogenic climate change to be 'significant,' it must be as large or larger than natural variability. For smaller changes, the historical record demonstrates our capacity to adapt. It is in this context that the statement frequently drawn from the 1995 IPCC (Intergovernmental Panel on Climate Change) report assumes some relevance. It is important, therefore, to know precisely what this statement does and doesn't say. Although it is likely that the statement is also incorrect, that turns out to be less important.

Discernable influence

Let us begin by quoting this statement (which, in contrast to earlier IPCC reports, gives considerably more attention to important caveats):

> "Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. These include the magnitude and patterns of long-term natural variability and the time-evolving pattern of forcing by, and response to, changes in concentrations of greenhouse and aerosols, and land-surface changes. Nevertheless, the balance of evidence suggests that there is a discernible human influence on global climate."

What it says is that the climate's behavior over the past century appears "unlikely to be due entirely to natural variability (IPCC 1995, p. 412)." As Chapter 8 of IPCC 95 points out, even this trivial assertion, which, as I have noted, seems totally compatible with our theoretical understanding and makes no claims concerning the magnitude of global warming, is dependent on the assumption that natural variability is replicated in models (IPCC 95 p. 430) – an assumption which is clearly untrue since major observed components of natural variability like the quasi-biennial oscillation and El-Niño are either not replicated at all or replicated very poorly. Indeed the very structure of the circulation in models is different from what is observed in the data (Polyak and North, 1997). The specific feature which led Santer (the lead author of Chapter 8 of IPCC 95) to claim discovery of the discernible impact of anthropogenic forcing fails the most elementary test of statistical robustness: namely, it disappears when additional data is considered. Chapter 8 concludes that our ability to quantify the magnitude of global warming "is currently limited by uncertainties in key factors, including the magnitude and patterns of longer-term natural variability and the time-evolving patterns of forcing by (and response to) greenhouse gases and aerosols." In brief, a decade of focus on global warming and billions of dollars of research funds have still failed to establish that global warming is a significant problem. Normally, this would lead one to conclude that the problem is less serious than originally suggested. While the IPCC 1995 report does not go so far as to state this explicitly, it is certainly the most subdued and reserved of the numerous IPCC reports issued since 1990.

It has been a remarkable example of semantic distortion that this weak and unsupportable statement has encouraged environmental advocates to claim that this report endorses various catastrophic scenarios. An appeal issued a few days ago by one such organization, The Union of Concerned Scientists, illustrates the general procedure. The statement begins with a clear misrepresentation of the IPCC statement: "Predictions of global climatic change are becoming more confident. A broad consensus among the world's climatologists is that there is now 'a discernible human influence on global climate.'" The UCS immediately continues: "Climate change is projected to raise sea levels, threatening populations and ecosystems in coastal regions. Warmer temperatures will lead to a more vigorous hydrological cycle, increasing the prospects for more intense rainfall, floods, and droughts in some regions. Human health may be damaged by greater exposure to heat waves and droughts, and by encroachment of tropical diseases to higher latitudes." The UCS proceeds to then associate climate change with forest depletion, water scarcity, food security, and species destruction. It concludes that scientists must endorse a

strong climate treaty at Kyoto. The implication is that the so-called IPCC consensus extends to these claims as well. This is clearly a misrepresentation of the IPCC.. I use the phrase 'so-called' advisedly. The IPCC went to great lengths to include as many names as possible among its contributors. Against my expressed wishes, even my name was included. I can assure the committee that I (and the vast majority of contributors and reviewers) were never asked whether we even agreed with the small sections we commented on. Nevertheless, the usual comment is that 2500 scientists all agree with whatever it is that the environmental advocates are claiming. To the credit of the IPCC, it extensively documented the shortcomings of various projections, and made few claims for any confidence. The document was deeply biased insofar as it took as its task the finding of global warming rather than the more objective approach of determining whether it is indeed a significant problem. Such an approach could be rationalized on the basis of sincere concern. However, even this document puts forward comments which are misleading. For example, on page 45 which deals with potential surprises, the possibility of an instability of the West Antarctic ice sheet is mentioned without any reference to the fact that such an unlikely instability is largely unrelated to climate (Bentley, 1997).

Genuinely Misleading Statement

One of the common claims in support of the reality and seriousness of global warming is that we have had a large portion of record breaking warm years during the last decade or so. This is not a claim used by the IPCC, and its presence in any discussion is a rather clear piece of evidence of the intent to deceive (especially when the claim is made by a scientist). As noted by Solow and Broadus (1989) and Bassett (1992), this is an inevitable occurrence when one has a single record breaker in a time series characterized by interannual variability, interdecadal variability and an underlying trend or longer period variability. Solow and Broadus show the clustered nature of record breakers. For those who can follow some mathematics, the situation is easily synthesized as follows.

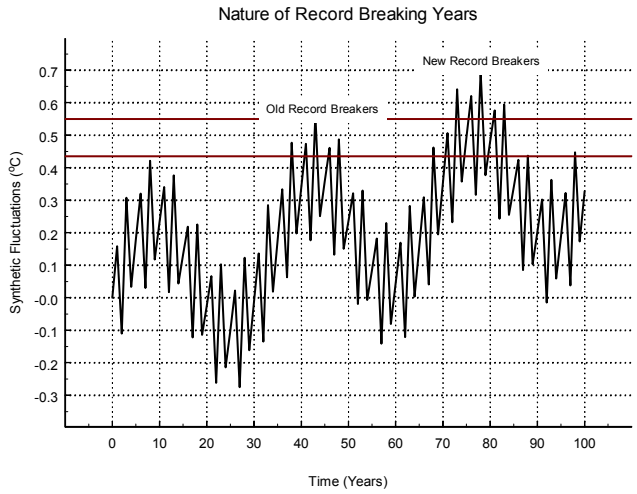


Figure 1

Let us represent the time series for temperature by the following expression:

$$f(t) = 0.2\sin(0.8\pi t) + 0.2\sin(\frac{2\pi t}{34}) + 0.4\frac{t}{100}$$

where the first term corresponds to interannual variability, the second term to interdecadal

variability, and third to longer term trends or variability. This series is shown in Figure 1.

Not surprisingly, record breakers cluster in exactly the manner found by Solow and Broadus (1989) in the observed temperature record. The occurrence of such record breakers contributes no additional information. Our prime concern remains with the determination of trend and the identification of such trends with emissions of carbon dioxide, and this remains a difficult and contested issue as the IPCC freely acknowledges.

Scientific waffling

S. Fred Singer has recently reported that the former head of the IPCC, Bert Bolin, has denied claims by Vice President Gore and environmental activists that "any floods, droughts, hurricanes, or other extreme weather patterns are the result of rising global temperatures." Bolin is quoted as saying "There has been no effect on countries from any current change," adding that efforts by activists to establish such a link "is why I do not trust the Greens." Although I was not present at the debate where Bolin is alleged to have made this remark, my personal experience suggests that it may be true. In 1993 at a mock trial of global warming held by the BBC in which both Bolin and I participated, Bolin made similar admissions. Nevertheless, in response to Singer's claims, Bolin has issued a formal denial. It may be of interest to look at this denial in some detail.

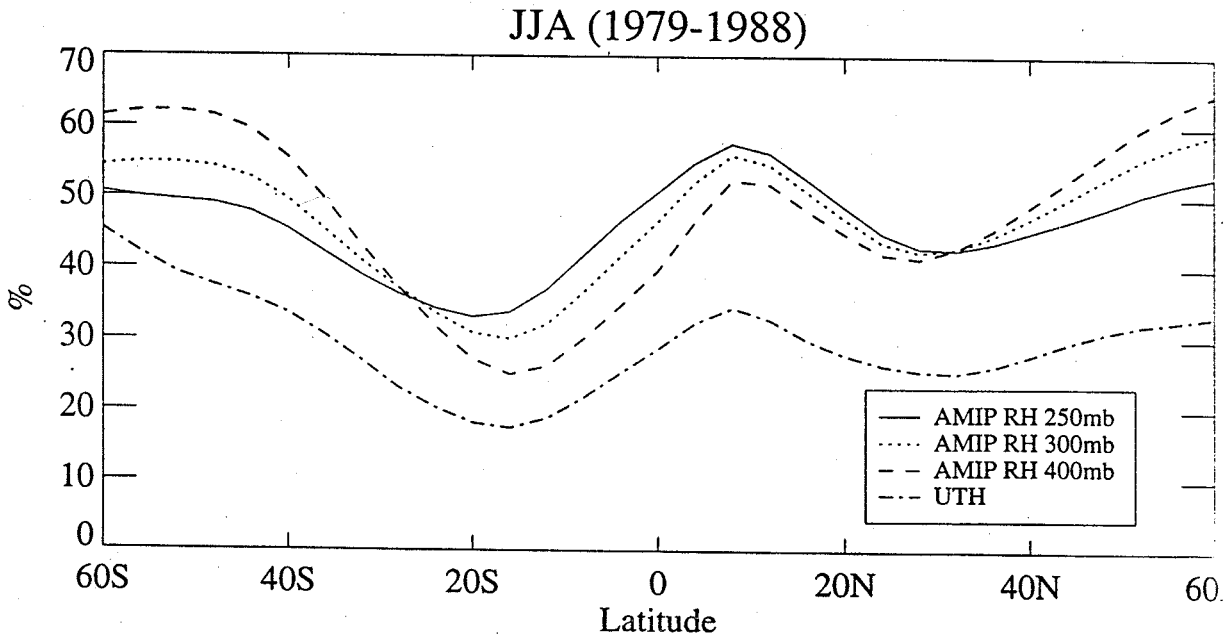
> "Observations show that some extreme events are becoming more intense (heavy rainfall events in some regions), some are becoming less intense (cold spells), while others show no statistically significant changes (hurricanes). These changes are consistent with the kind of changes that would be associated with a warmer climate. While it cannot yet be concluded that these changes are caused by human-induced changes of climate, neither can this association be excluded. To state that these sorts of changes that 'are consistent' with the predicted effects of climate change, as Vice-President Gore is quoted to have stated, is a scientifically accurate statement and no cause for criticism."

In saying this, Bolin parts company with normative science which recognizes the virtual impossibility of disproving unverifiable assertions and sticks to statements that are capable of 'falsification.' 'Consistency,' in this context merely means that the situation is so unclear that virtually anything will 'be consistent.' In the long run, the replacement of the precise and disciplined language of science by the misleading language of litigation and advocacy may be one of the more important sources of damage to society incurred in the current debate over global warming.

What can be said of the influence of increasing carbon dioxide?

Since the Charney Report of the NRC in 1979, the range of expected equilibrium global

warming due to doubling carbon dioxide has been stated to be from about 1°C to 5°C. This is simply a statement of the range of results obtained by existing models, and assumes, somewhat illogically, that the correct answer must be in the output of at least one model. However, as frequently noted by the IPCC, the correct answer depends on correctly simulating feedbacks which, at present, are only poorly known and modeled. Despite this uncertainty, there are some aspects of the problem that are somewhat better known. In general, the response to doubled carbon dioxide (or equivalent carbon dioxide where the effect of other anthropogenic greenhouse gases is expressed in terms of 'equivalent' carbon dioxide) in the *absence* of feedbacks is taken to be the response when all other atmospheric parameters are held constant. The changes due to concomitant changes in other parameters are called feedbacks. There is some disagreement over whether one should consider the distribution of temperature change as a feedback. If one does, then the no-feedback equilibrium response to doubled carbon dioxide is about 0.3°C (Lindzen, 1995a); if one does not, then the no-feedback response is about 1.2°C. The latter is much larger than the former because it includes the warming effect at the surface of cooling in the stratosphere. If one takes the latter approach, then the most important feedback is due to upper level (above about 2 km) water vapor. In all existing models (in the original models by explicit assumption), water vapor, the most important greenhouse gas, increases at all levels as surface



AMIP refers to the average over the 28 models participating in the Atmospheric Model Intercomparison Program

UTH refers to satellite measurements of upper tropospheric humidity

Figure 2

temperature increases, doubling the no-feedback response to doubled carbon dioxide. The presence of the positive water vapor feedback in current models also increases the sensitivity of these models to other smaller feedbacks such as those due to clouds and snow reflectivity. The

trouble with current models is that they generally lack the physics to deal with the upper level water vapor budget, and they are generally unable, for computational reasons, to properly calculate a quantity like water vapor which varies sharply both vertically and horizontally (Sun and Lindzen, 1993, Lindzen, 1995). Indicative of these problems is the recent work of J.J. Bates and D.L. Jackson at NOAA who found, using satellite data from infrared sounders, that, on the average, current models underestimate zonally averaged (averaged around a latitude circle) water vapor by about 20%. This is illustrated in Figure 2. It should be noted that this represents an error in radiative forcing of about 20 Watts per square meter, as compared with the forcing of 4 Watts per square meter due to a doubling of carbon dioxide (Thompson and Warren, 1982, Lindzen, 1995). More recent observational analyses by Spencer and Braswell (1997), using satellite microwave data, suggest that even Bates and Jackson have overestimated water vapor, and that the discrepancy with models is still greater. Under the circumstances, there seems to be little actual basis for the most important positive feedback in models. Given our inability to detect expected warming in the temperature data, one might reasonably conclude that models have overestimated the problem.

In some ways, we are driven to a philosophical consideration: namely, do we think that a long-lived natural system, like the earth, acts to amplify any perturbations, or is it more likely that it will act to counteract such perturbations? It appears that we are currently committed to the former rather vindictive view of nature.

What can be said of the implications of proposed policies for climate?

The above remarks dealt with the issue of global warming as a phenomenon. However, the current political concern deals with the proposed setting of firm emission limitations at the forthcoming Kyoto meeting in December. The underlying assumption is that stabilization of emissions at 1990 levels (or modest reductions of these levels) would spare the world from global warming, should the more extreme model forecasts prove correct (despite the patent shortcomings of these models, and the absence of convincing confirmation in existing data). It is important, therefore, to note that such emissions reductions would have no such effect regardless of what one believes about global warming. The effects of either lesser reductions or of restricting emission reductions to the developed world would be even more negligible in terms of climate impact. This is illustrated in Figures 3 and 4 taken from a recent report of Prinn et al (1997) based on the model developed for MIT's Program on the Science and Policy of Global Change. Figure 3 shows carbon dioxide levels for a variety of scenarios. The levels by 2100 vary from about 590 ppmv to 950 ppmv. Figure 4 shows global mean temperature change for various conditions indicated by three letters. The first letter refers to emissions, with H associated with the high values in Figure 3 and L with the low values; R refers to a reference case. The second letter refers to the ocean delay with H

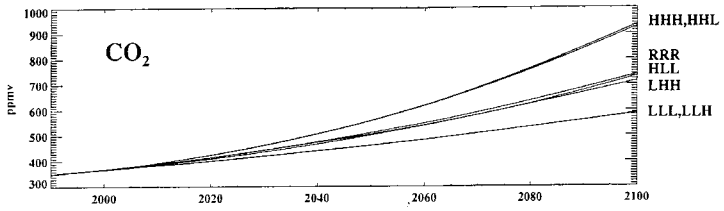


Figure 3

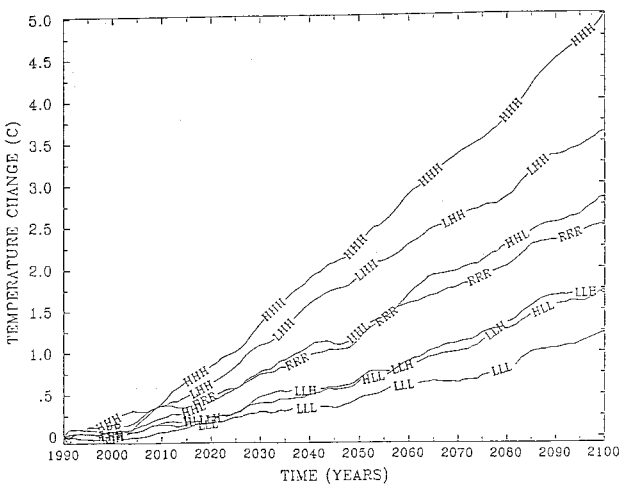


Figure 4

referring to short delay and L referring to long delay. The third letter refers to climate sensitivity with H referring to an equilibrium sensitivity to doubled carbon dioxide of about 4.5°C, and L to a sensitivity of about 1.5°C. We see that for high climate sensitivity we will get pronounced warming regardless of emission scenario, while for low sensitivity, emission scenarios will not matter. It is important to note that emission caps proposed for Kyoto, as difficult and expensive as they may prove, will not prevent global warming if the climate should prove sensitive. The impact of any proposed policy, currently reckoned as even marginally feasible, will likely be impossible to ascertain regardless of what the climate sensitivity is. However, what Figure 4 does tell us is that should there be little warming over the next 50 years, it won't be because of any policy we implement at Kyoto.

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