On the Anatomy of Alarmism

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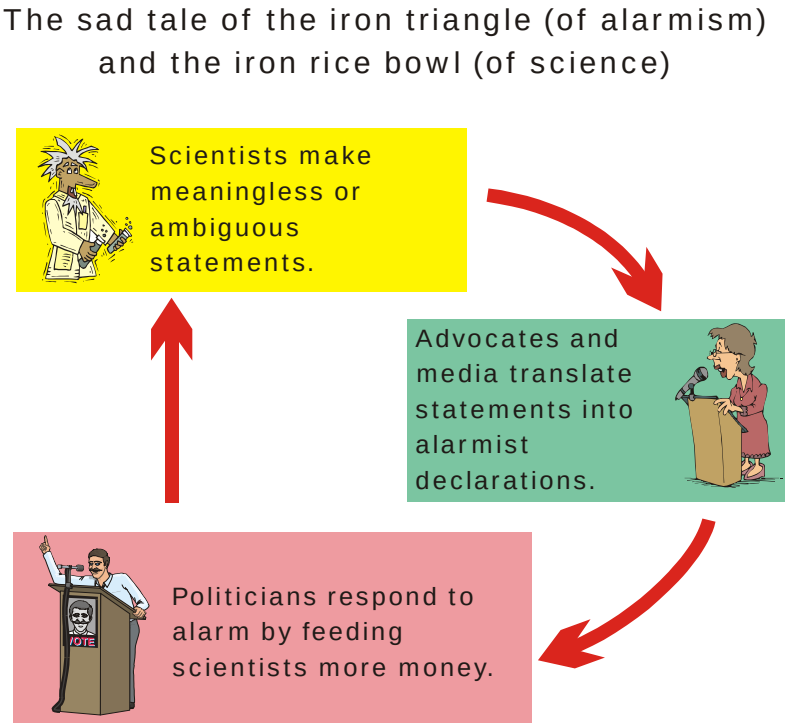
Introduction

Some 16 years ago, when the issue of Global Warming emerged on the popular radar screen, I was struck by the weakness of the case. I tried to explain my position in a couple of popular and semi-popular papers (BAMS, Regulation). However, as pointed out to me by Lester Lave, 'the train had already left the station'. It has been steaming ahead ever since. The present paper is simply a reflection of the frustrations I have encountered in trying to deal with this issue. Although my earlier Regulation piece (and a subsequent article that appeared in a book edited by Bob Hahn) anticipated the difficulties in dealing with politicized science, I had not been prepared for the specific difficulties of communicating with the public.

Politicization leads to a meaningless polarization associated with meaningless questions (at least from a scientific perspective): *Do you believe in global warming? Are you a skeptic or a believer?* Given the many facets of the issue, if you are a believer, what exactly is it that you believe? What I was unprepared for, was the fact that this question hardly mattered. Regardless of whether you are a believer or not, you are likely to hear only what you expect to hear.

This leads to an obvious question: Why am I still bothering with this issue? I suppose it is some combination of stubbornness and the optimistic hope that science will somehow regain its integrity. The role of science in this issue is considerably less than the public is led to think. However, it is, by no means, negligible. I have occasionally referred to the interactions among science, advocacy, and politics as the embedding of the iron rice bowl of science within the iron triangle of alarmism. The nature of this interaction is illustrated in the accompanying cartoon. The scientists make ambiguous and frequently irrelevant claims, which are translated by environmental advocates into assertions of apocalyptic alarm for which they claim the universal support of science. Politicians, called upon to do something, proceed to provide funding to the scientists thus encouraging them to acquiesce in the whole procedure. Should the



scientist ever feel any guilt over the matter, it is assuaged by two irresistible factors: 1. The advocates define public virtue; and 2. His administrators are delighted with the grant overhead. Later in this paper, I will provide specific examples of such interactions.

To the extent that Global Warming is being put forward as a matter to be believed rather than understood, it is appealing to religious instincts rather than intellect. The fact that warming is presented as something where one is either a believer or a skeptic, and where skepticism is treated as corrupt heresy, is indicative of the weakness of the scientific case. This weakness is hidden by failure to indicate what exactly the scientific argument is about.

It is *not* about whether global mean surface temperature is increasing. This quantity is always changing. Over the past 60 years, it has both decreased and increased. For the past century, it has probably increased by about 0.6C. It is *not* about whether the minor greenhouse gas, CO_2, is increasing. It is and a doubling would change the greenhouse effect (mainly due to water vapor and clouds) by about 2%. It is not even over whether man is responsible for this increase in CO_2. There is good evidence that we are, though over longer periods, climate itself can cause changes in CO_2. The claim that common though by no means universal agreement over these relatively trivial issues constitutes support for alarm is one of the great scams of our era. The primary importance of these issues (at least in isolation) stems from politics and scientific illiteracy. What might be of interest is that the change over the past century has been small. Claims that this change has led to 'record breaking' years (often before the year is out) or that the change is 'unprecedented' serve only to disguise the fact that the change has been small. Especially the latter claim has been sufficiently implausible to give rise to numerous opposing studies. However, the resulting conflict serves, in turn, to perpetuate the inflated importance of the small rise over the past century.

In point of fact, the scientific source for alarm arises from model predictions for the response of the climate to large increases in CO_2 (nominally a doubling). In connection with the temperature record of the past century, the only question of relevance is whether the observed warming is consistent with the alarming predictions.

It does perhaps pay to speak about the levels of atmospheric CO_2. They are increasing. As has already been noted, when and if the levels double, they will increase the radiative forcing of the planet by about 3.7 Wm^{-2} (Watts per square meter) or about 2%. The scientific question of relevance is what do we expect such an increase to do? The answer, most assuredly, is not to be arrived at by a poll of scientists – especially of scientists who do not work on this question.

The issue of consensus is, in this respect, extremely malign – especially when the consensus is merely claimed though not established. However, the whole idea of consensus is problematic.

Even within politics, the use of consensus is suspect. As Margaret Thatcher noted in *The Downing Street Years*, "CONSENSUS is the process of abandoning all beliefs, principles, values and policies in search of something in which no one believes , but to which no one objects; the process of avoiding the very issues that have to be solved. merely because you cannot get

agreement on the way ahead." Thatcher astutely observes that consensus does not signify real agreement, but rather is meant to disguise its absence.

With respect to science, consensus is often simply a sop to scientific illiteracy. After all, if what you are told is alleged to be supported by all scientists, then why do you have to bother to understand it. You can simply go back to treating it as a matter of religious belief.

Argument

Surprising to many is the fact that what is agreed on thus far, primarily supports the notion that global warming is not an alarming problem. The argument runs as follows: we have already noted that a doubling of CO_2 will lead to climate forcing of about 3.7 Wm^{-2}, and alarm-provoking models predict that this will lead to an increase in globally averaged surface temperature of 4C or more. What is less commonly mentioned is that anthropogenic climate forcing has already reached about 2.8 Wm^{-2}. That is to say, we are already three quarters of the way to the forcing represented by a doubling of CO_2. The main reasons for this are 1) CO_2 is not the only anthropogenic greenhouse gas – others like methane also contribute; and 2) the impact of CO_2 is nonlinear in the sense that each added unit contributes less than its predecessor. Thus, these models suggest that man has accounted for almost 6 times the observed warming. Even less alarming models suggest that we have accounted for 3 times the observed warming. To be sure, these are equilibrated values, and equilibration takes time, but even this does not significantly impact these results. The simplest and most reasonable conclusion one can reach is that the climate is far less sensitive than the models suggest. I will briefly describe additional evidence for this later in this paper. What is important to recognize at this stage is that this conclusion is not only consistent with the points of agreement described in the Introduction, but actually makes use of them. They are as consistent with the conclusion that the impact of anthropogenic greenhouse gases will be relatively unimportant as they are with alarm. This should be kept in mind when confronted by misleading studies such as that by Oreskes in a recent Science article which argues that the agreement on trivialities constitutes agreement for alarmism, and that arguing about the alarmism is merely quibbling. The alarmists' conclusion is somewhat different. They argue (in somewhat different words) that some unknown process or processes have cancelled the forcing due to increased anthropogenic greenhouse gases, and that such processes will disappear in the future. This is unconvincing special pleading at its worst. It will be important to analyze the alarmist argument is some detail, but first, I would like to offer two of the worst examples wherein the trivial agreement has been used very effectively to promote alarmist agendas.

The Policymakers Summary of Second Scientific Assessment by the IPCC (Intergovernmental Panel on Climate Change of the UN) in 1995 featured the following version of the trivial agreement:

The balance of evidence suggests a discernible human influence on global climate.

While one could question the use of the word 'discernible,' there is no question that human

influence should exist, albeit at a level that may be so small as to actually be indiscernible. As we have already noted, however, even if all the change in global mean temperature over the past century were due to man, it would still imply low and relatively unimportant influence. Nevertheless, this silly statement is generally considered to have been the 'smoking gun' that justified Kyoto.

The second example consists in the opening lines of the executive summary of the NRC 2001 report: *Climate Change Science: An Analysis of Some Key Questions*. This hurried report was prepared at the specific request of the White House. The brief and carefully drafted report of 15 pages was front ended by the totally unnecessary 10 page executive summary. The opening lines were appended at the last moment without committee approval. Here they are:

Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising.

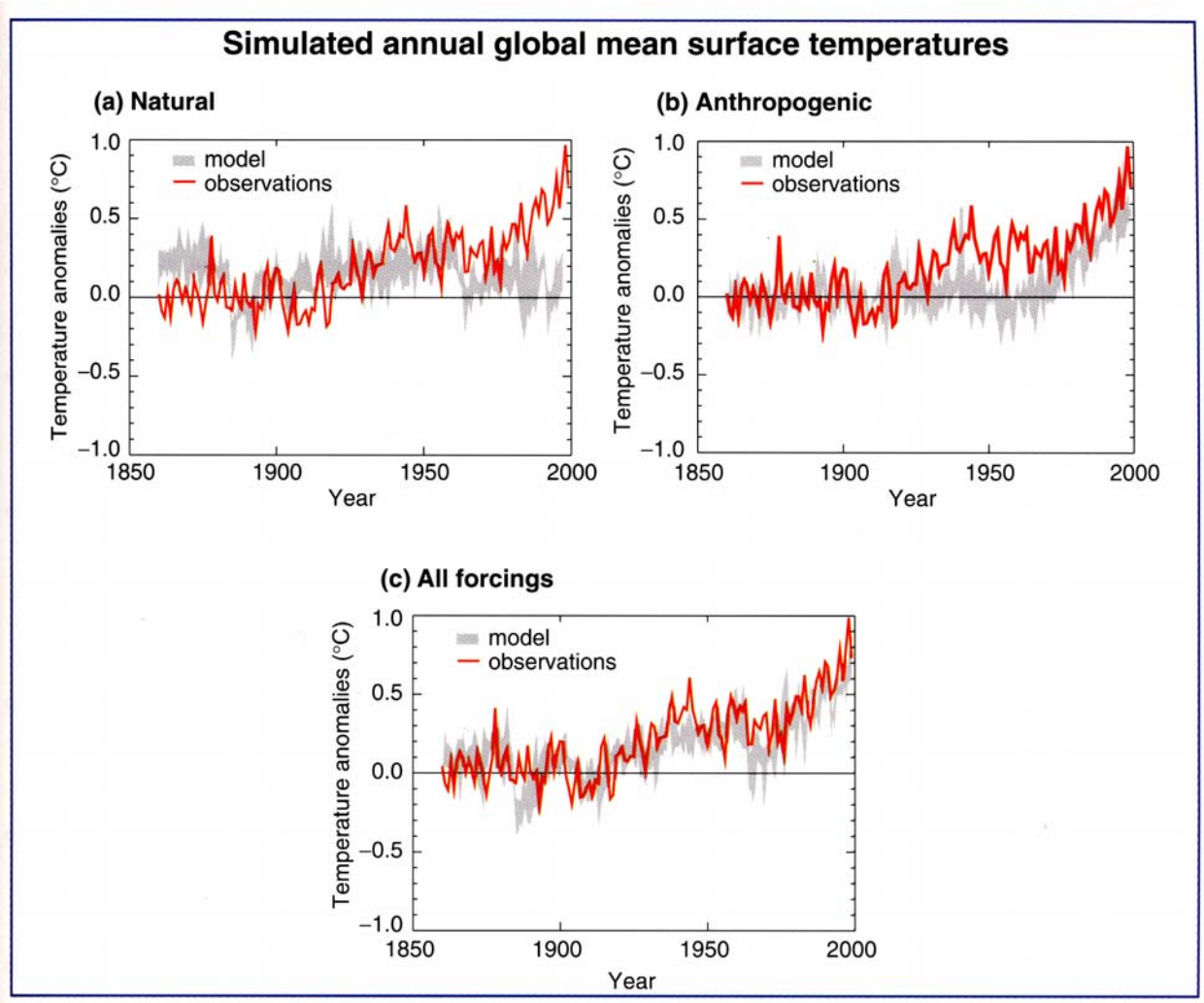
The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability.

By now, you should be able to recognize these lines as another variant on the trivial points of agreement. To be sure, this statement is leaning over backwards to encourage the alarmists. Nevertheless, the two sentences in the first claim serve to distinguish observed temperature change from human causality. The presence of the word 'likely' in the second statement is grossly exaggerated, but still indicated the lack of certainty, while the fact that we have not emerged from the level of natural variability is, in fact, mentioned. What, as usual, goes unmentioned is that the observed changes are much smaller than expected.

The response was typical and restricted to the opening lines. CNN's Michelle Mitchell characteristically declared that the report represented "a unanimous decision that global warming is real, is getting worse, and is due to man. There is no wiggle room." Mitchell's response has, in fact, become the standard take on the NRC report. A particularly egregious example was John Holdren's testimony before Senator McCain's Commerce Committee. John Holdren, president-elect of the AAAS, is a professor at Harvard's Kennedy School of Government, and an associate of the Woods Hole Research Center, an environmental advocacy organization whose name serves to confuse it with the Woods Hole Oceanographic Institution, which is, in fact, a research institute.

Counter Argument

We now return to the question of how model based alarmism has been 'justified' despite the fact that the observed warming over the past century is much less than was anticipated by the models. As usual, the argument involves obscuring this fact. The accompanying figure summarizes the argument presented in the 2001 Third Assessment Report of the IPCC. The three panels are



labeled *Natural*, *Anthropogenic*, and *All Forcings*. Understanding these panels is not easy since each is misleadingly labeled, but in a political issue, graphs serve the purpose of simply intimidating the reader, and, as such, these have served well. In each of the panels, the red curve represents the 'observed' globally averaged surface temperature. No error range is assigned to this curve (or really to any of the curves presented). It should be about +/- 0.2C with a clear understanding that statistically we expect a certain number of observations to lie outside this range. The fuzzy grey curves in each panel show model runs using a UK Meteorological Office Hadley Center model with a sensitivity to a doubling of CO_2 of about 2.5K. This is at the low end of model sensitivity – a fact that is not without significance. The fuzziness of the grey curves comes from the fact that the authors made several model runs, and these differed among themselves. I suppose that this is a measure of 'model uncertainty.' However, what we want is a measure of internal unforced variability – indicative of the fact that climate can vary even in the absence of external forcing. Such variability is essentially random, and should have led to uniform width of the grey curve. Judging from examples of unforced internal variability like ENSO and the well reported regime shift around 1976, this width should have been on the order

of 0.4C. Thus, a depiction of 'unforced' climate would consist in an horizontal line at the mean temperature of the period considered with a band around it with a width of about 0.4C. Such a depiction would have clearly shown that there is very little need of any forcing to explain the difference between observations and model calculations – especially when the error spread of the observations is included. That is to say, that the broadened red and grey curves would overlap almost everywhere. Note, however, that the fuzzy grey curve in the *Natural* panel does include external forcing due to what are referred to as natural sources of forcing: namely, volcanoes and solar variability. However, volcanic forcing prior to Pinatubo in 1991 was extremely uncertain (Bradley,), as is solar forcing. Thus, the natural forcing is, in effect, something that can be adjusted to optimize agreement. The results in the *Natural* panel fail to show the observed rise in the past 30 years (though this could surely have been remedied by a judicious choice of solar variation had this been the aim).

We thus next turn to the *Anthropogenic* panel. Here the fuzzy grey curve results from model runs where natural forcing is omitted, but where forcing due to *both* increasing CO_2 and aerosols is included with the latter assumed to provide a cooling effect. The trouble here is that we really don't know either the time history of aerosol production (at least prior to 1964), or the radiative properties of the aerosols. Thus, aerosols are an adjustable quantity whose time dependence has to be essentially invented. This problem was pointed out in a Science article in 2003 (Anderson, Charlson et al). In a number of ways, the Science article was notably coy. The authors referred to the adjusted aerosol effect as having been obtained by what they called the 'inverse' method, by which they meant that the values were chosen to be such as to make the model agree with observations. The authors took pains to note that given the present degree of uncertainty, this 'inverse' method was probably as good as any other method for pinning down the properties of aerosols. However, they felt that it was circular for these properties to be used, in turn, for testing the models. This would all be funny if it were not indicative of the extent to which normative scientific methodology is being distorted to promote alarmism. Presumably, the Hadley Centre of the UK Meteorological Office used a relatively low sensitivity model so as not to have to make extreme assumptions about the aerosols. Otherwise, they would have obtained excessive warming from the models. Of course, the agreement in the *Anthropogenic* panel is not perfect. However, when natural and anthropogenic forcing are combined in *All Forcings* panel, the agreement is nearly so. Thus, I suppose one can conclude that to the extent that the adjustments cannot be proven to be impossible, it remains possible that the model could be correct.

The conclusion offered by the scientists who presented the above figure was as follows:

From the body of evidence since IPCC (1996), we conclude that there has been a discernible human influence on global climate. Studies are beginning to separate the contributions to observed climate change attributable to individual external influences, both anthropogenic and natural. This work suggests that anthropogenic greenhouse gases are a substantial contributor to the observed warming, especially over the past 30 years. However, the accuracy of these estimates continues to be limited by uncertainties in estimates of internal variability, natural and anthropogenic forcing, and the climate response to external forcing.

Although this statement fails to mention the extreme model dependence of the results, it is not nearly as misleading as what finally appeared in the 2001 IPCC Summary for Policymakers:

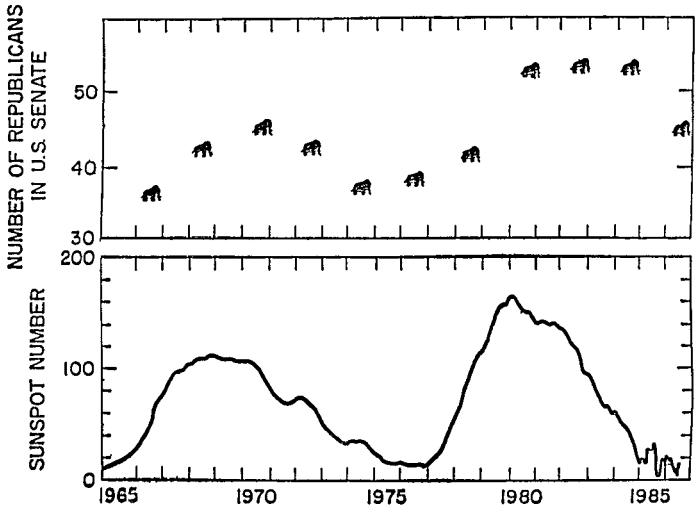
In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.

In summary, the counter argument runs as follow:

- We start by assuming the model is correct including its internal variability. We also start with the answer.
- We then attribute differences between the model behavior in the absence of external forcing, and observed changes in 'global mean temperature' to external forcing.
- We separately introduce 'natural' and 'anthropogenic' forcing in such a manner as to obtain a 'best fit' to observations.
- If we succeed (which is inevitable in this procedure), we assert that the attribution of part of the observed change to the *greenhouse component* of the 'anthropogenic' forcing must be correct.

Of course, model internal variability is not correct, and 'anthropogenic' forcing includes not only CO_2 but also aerosols, and the latter are unknown to a factor of 10-20 (and perhaps even sign). Finally, we have little quantitative knowledge of 'natural' forcing so this too is adjustable.

This would have been an embarrassment even to the Ptolemaic epicyclists. In point of fact, it is not even as fair as the following famous attempt to relate Republicans in the Senate to sunspots.



The Alarmism Connection

We still have not really addressed the interesting question of how modest warming has come to be associated with alarm. Here we must leave the realm where fudging and obfuscation are the major tools to a realm of almost pure fantasy. A simple example will illustrate the situation.

According to any textbook on dynamic meteorology, one may reasonably conclude that in a

warmer world, extratropical storminess and weather variability will actually decrease. The reasoning is as follows. Judging by historical climate change, changes are greater in high latitudes than in the tropics. Thus, in a warmer world, we would expect that the temperature difference between high and low latitudes would diminish. However, it is precisely this difference that gives rise to extratropical large scale weather disturbances. Moreover, when in Boston on a winter day we experience unusual warmth, it is because the wind it blowing from the south. Similarly, when we experience unusual cold, it is generally because the wind is blowing from the north. The possible extent of these extremes is, not surprisingly, determined by the temperature difference between high and low latitudes as well, and should diminish in a warmer world. Nevertheless, we are told by advocates and the media that exactly the opposite is the case, and that, moreover, the models predict this (which, to their credit, they do not) and that the agreement of scientists on the previously described trivial issues signifies their agreement on this matter as well. Clearly more storms and greater extremes are regarded as more alarming than the opposite. Thus, the opposite of our current understanding is invoked in order to promote public concern. *The crucial point here is that once the principle of consensus is accepted, agreement on anything is taken to infer agreement on everything advocates wish to claim.*

Again, scientists are not entirely blameless in this matter. Sir John Houghton (the first editor of the IPCC scientific assessments) made the casual claim that a warmer world would have more evaporation and the latent heat would provide more energy for disturbances. This claim is based on a number of obvious mistakes (though the claim continues to be repeated by those who don't know better). For starters, extratropical storms are not primarily forced by the latent heat released in convection. However, even in the tropics, where latent heat (the heat released when evaporated water vapor condenses into rain) plays a major role, the forcing of disturbances depends not on the evaporation, but on the evaporation scaled by the specific humidity at the surface. It turns out that this is almost invariant with temperature unless the relative humidity decreases in a warmer world. As we will discuss later, this would suggest that the feedbacks which cause models to display high climate sensitivity are incorrect. The particularly important issue of whether warming will impact hurricanes, is a matter of debate. There is no empirical evidence for such an impact (reference). State of the art modeling suggests a negative impact (reference), while there are theoretical arguments that suggest a slight positive impact on hurricane intensity (reference). This is all of significant intellectual interest, but it is not the material out of which to legitimately build alarm.

Perhaps the most reprehensible attempt to generate alarm over global warming has been seen in connection with the recent tragic tsunamis in South Asia. In an event wherein an ocean bottom earthquake excited huge and devastating waves, Friends of the Earth, Greenpeace UK, and Munich Re all could not resist blaming it on Global Warming. Munich Re? According to Steve Milloy on Fox News, *insurer Munich Re used the event as an opportunity to renew its call for action to fight global warming, which the insurance industry has recently started to blame for natural disasters. Concerned about large payouts for natural disaster claims, insurance companies are very eager to establish global warming as a contributing factor to those disasters, so they can sue deep-pocket businesses supposedly responsible for that global*

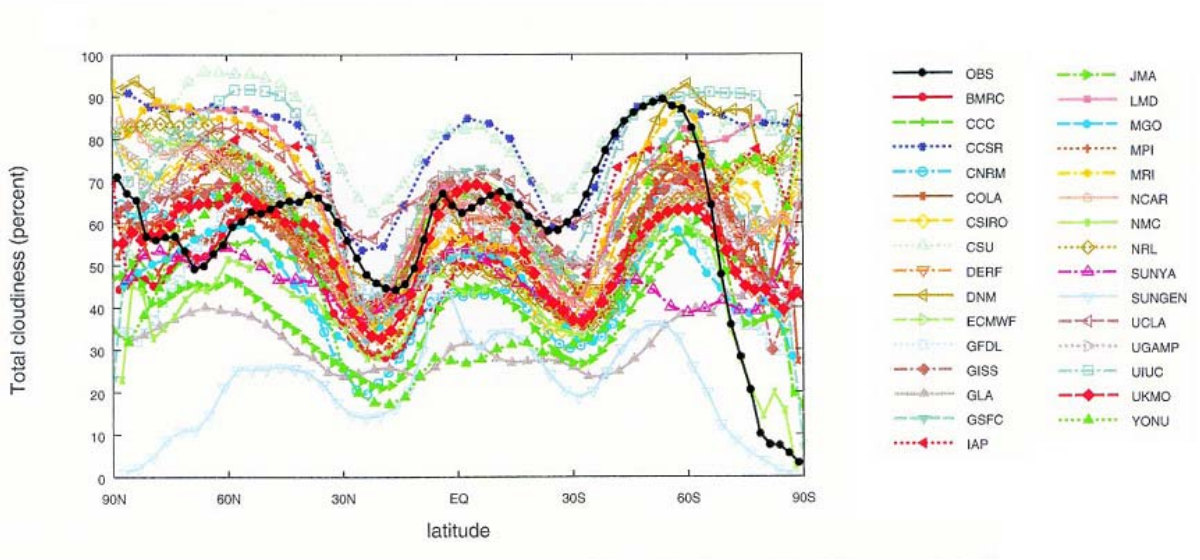
warming. However specious the preceding example was, it follows in what has become an almost self-parodying habit of those proclaiming alarm of attaching any severe, unusual or even common but not well known event to global warming while suggesting that the event had indeed been predicted by models

How can models misbehave.

Despite their frequent failure, there remains a touching faith in models. When overt failures appear, there is the notion that one can simply replace a misbehaving component with something else. This notion is probably associated with a confusion among various things referred to as models. Certain models, most notably in economics, consist simply in specified relations between unknowns and inputs. Changing relations in such models is, indeed, relatively simple. However, most of the General Circulation Models used in climate modeling are of a different sort. Being models of physical systems, they nominally begin with known equations based on classical physical laws of motion and thermodynamics as well as the assumption that fluids constitute continuous viscous fluids. These equations are nonlinear partial differential equations whose solutions consist in velocity, temperature, pressure and density at all points on earth and at all heights and depths of the ocean and atmosphere. For reasons we will describe, the solution of such a system is still almost impossibly difficult. But the real situation is more complicated still. Neither the atmosphere nor the ocean are simple uniform fluids. Rather they are mixtures of various substances including the three phases of water (ice, liquid and vapor), and minor gases such as CO_2, ozone, methane, salt (in the ocean) and many others. The concentrations of these substances depends on the motion, temperature, etc. The changes in state of water are associated with important changes in energy. Also, many of the substances absorb, emit and scatter radiative energy in a way which depends complicatedly on the wavelength and direction of the radiation. The radiative terms depend on integrals, and hence, convert the basic equations into nonlinear partial differential integral equations. Some of the minor constituents have significant impacts on radiation. They also have important sources and sinks, many of which are poorly understood, and some of which may not even be identified; some constituents are involved in active chemical reactions. While the primary driving energy for the system is the sun, even the properties of solar radiation are only imperfectly known. One could go on at some length, but the reader will already appreciate the Herculean nature of the task. A particularly crucial difficulty is embedded in the word *nonlinear*. The fact that each of the numerous components actively interact with each other causes the system itself to generate a continuous range of spatial and temporal scales ranging from planetary scales to almost microscopic scales associated with turbulent eddies, and from the time scales associated with acoustic disturbances to scales associated with deep ocean overturning and glacial dynamics which can amount to thousands of years. For much longer periods, we generally assume that external forcing is responsible, but even this is uncertain once one factors in interactions with the solid earth. It should come as no surprise that such a system will vary without any external forcing. At the least, we see that the notion that the climate is simply a responder to external forcing is exceptionally naive. In principle, if we could solve such a system precisely, we would see the complete behavior of the climate system emerge in the solution. I think it is fair to say that no one expects that we will ever reach this stage. The problem of simply understanding the small turbulent scales has

continued to defeat some of the best minds in science. The more comprehensive problem of climate modeling has been more a matter of 'fools walking in where angels fear to tread.'

What is done in climate modeling is to replace the terms in the equations with approximations over a coarse mesh (even the finest mesh proposed is still coarse). These approximations are not at all unique, and call for more sophistication than is often used by climate modelers. A whole field of study, *Numerical Analysis*, is devoted to such matters. Scales smaller than this mesh are assumed to be parameterizable. However, the parameterizations are largely ad hoc. The resulting numerical solutions are by no means guaranteed to be close to solutions of the underlying equations. 'Fixes' of various forms are introduced including artificial damping to prevent unphysical instabilities in the solutions. Some models even require the addition of air to make up for its artificial loss. As in other fields, the collateral impact of these 'fixes' is rarely identified. It should be added that the very use of a coarse mesh implies artificial diffusion and damping. Thus, the impact of fiddling with parameterizations is handicapped by the gross uncertainty as to how these changes will interact with other problems. By now, the reader should have no difficulty understanding how models can be wrong. What is, perhaps, surprising is that they do as well as they do. Nevertheless, much of the agreement is gross and sometimes based on tuning. The accompanying figure concerning clouds shows how bad things can get. It should be noted that clouds have a huge impact on the earth's radiative budget, and that the problem of evaluating the impact of impact of increasing CO_2 involves a small perturbation to this budget.



Model hindcasts of percentage cloud cover averaged around latitude circles. The black dotted curve refers to observations. Gates, et al, 1999.

If this is all we have to show after the expenditure of billions of dollars on research, then we have good reason to question the value of the research thus purchased. In point of fact, more has been accomplished, but there can be no question that much of the expenditure has been wasted. Such waste might, however, be justified by the ambitiousness of the task. Still, large scale

modeling of the sort described above is not the only approach to the problem. It constitutes a relatively crude attempt at a frontal assault. In science, as in war, success often comes from finessing the difficulties and focusing on what we really need to know. The issue of climate sensitivity may be an example.

Climate Sensitivity

The complexity of the climate problem tends to obscure the simple question of whether a two percent perturbation in climate forcing is likely to produce a large response. Rather, the scientific community has preferred to assume that it does, because if such a small forcing is important, then everything is likely to be important. In fact, it is a relatively easy matter to calculate the direct impact of a doubling of CO_2. In the absence of feedbacks, we are reasonably certain that a doubling of CO_2 would produce about a 1C increase in global mean temperature. Why, then, do models predict much more than this? The answer, almost certainly, is that *in models*, the major greenhouse substances, water vapor and clouds, act so as to amplify this perturbation; ie, they constitute positive feedbacks. However, as we saw above, the uncertainties in cloud cover are huge – amounting to about an order of magnitude more than the impact of doubling CO_2 alone. Clouds and water vapor are intimately related, and it would be difficult to believe that clouds could be so badly represented while water vapor was not. Trivial arguments have been put forth to the effect that a warmer atmosphere can hold more water vapor. This has no more validity than the claim that a larger glass must necessarily have more water in it. Similarly, it has been claimed that a warmer world will have more evaporation and hence more humidity. However, the only thing that will be associated with more evaporation is more precipitation. How much water vapor remains in the atmosphere cannot be deduced from this argument. Moreover, the water vapor relevant to the greenhouse effect is mostly that part above 4 km or so, and at least in the tropical half of the earth, this water vapor is mostly due to the reevaporation of precipitation from above rather than direct transport from below. Although most readers may shy away from such technical issues, it is still true that to replace such considerations with overtly false simplifications is less than honest on many counts. So what to do? General circulation modeling is hardly the answer given the present state of the art. However, there are alternatives.

First, one can attempt to observe how clouds behave under varying temperatures. Given present data, this is by no means easy to do with any confidence. However, in a paper with some colleagues at NASA, we attempted it and discovered what we referred to as the Iris Effect wherein the upper level cirrus clouds associated with a cumulus tower contracted with increased temperature, providing a very strong negative climate feedback sufficient to drive the response to a doubling of CO_2 well below 1C (reference). There were a flurry of hastily prepared papers (references) that appeared almost immediately claiming (incorrectly in our view, references) errors in our study, and in the environmental literature, our work was quickly associated with the word, *discredited* (reference). Our paper implied that satellite measurements in the 1990's should show anomalously high infrared cooling relative to the 1980's compared to what large models predicted. This was confirmed in several papers, but each of these papers attempted (incorrectly again in our view) that there must have been some other reason for this (references).

None of this should have been surprising in retrospect. When, in 2003, the NRC reviewed a draft of the US National Climate Plan, they severely criticized the draft for assigning high priority to the improvement of our knowledge of climate sensitivity. Instead, they urged more support for those investigating the potential impacts of putative warming. Rarely has there been a clearer statement by the scientific establishment that it preferred spreading the wealth to finding the answer.

It turns out that there is another way to estimate climate sensitivity. It has long been recognized that given the heat capacity of the ocean, it will take time for its surface temperature to respond to a change in radiative forcing. However, as noted by Hansen et al () and Lindzen (), the more sensitive the climate, the longer will be this delay. This may, at first, seem counter-intuitive. However, the argument is quite simple. Climate sensitivity is merely a ratio of the change in temperature to the change in the flux giving rise to that temperature change. For a high sensitivity, there will be a large temperature change associated with a small flux, but it is the flux that will act to change the ocean temperature. Given that this flux is small, the ocean will take longer to respond. One can use this notion to examine the response to various impulsive forcings such as volcanoes or the so called regime shift in the atmosphere around 1976. Several papers have done this (Lindzen and Giannitsis,, Lindzen,, Douglass and Knox,), and the result is inevitably a short delay implying a small sensitivity indicative of an overall negative feedback. It should be noted that it is sometimes claimed that the observation of warming in the deep ocean (Levitus,) supports current climate models. However, as noted in Lindzen (), this result is independent of the models' climate sensitivity.

The upshot of all this is an expectation that a doubling of CO_2 would lead to a warming of about 0.5C which is to say that man's greenhouse gas emissions may well have accounted for about half of the observed increase in temperature over the past century. Nothing in this result violates the trivial agreement we discussed at the beginning of this paper, and nothing in this result promotes the alarmism that has attached itself to the trivial agreement. Indeed, because of the nonlinear dependence of radiative forcing on CO_2 levels, even a quadrupling of CO_2 would lead to only about 1C of warming – still reckoned to be easily dealt with.

Concluding remarks

So, what is the final message?

1. The data currently represented as 'consensus,' even if correct, does not imply alarm. On the contrary, the evidence thus far is that we have only a small response to the small forcing represented by potential increases in anthropogenic greenhouse gases.

2. The scientific community is committed to the maintenance of the notion that alarm may be warranted. Alarm is felt to be essential to the maintenance of funding. The argument is no longer over whether the models are correct (they are not), but rather whether their results are at all possible.

3. Although we haven't discussed this, there is, in fact, no regulatory solution to the 'problem' of preventing increases in CO_2 (reference). Certainly, it is generally accepted that Kyoto will do almost nothing in this regard (reference). However, the ubiquity of CO_2 emissions which are associated with industry and life itself remains a tempting target for those with a regulatory instinct.

4. Resistance to such temptations will require more courage and understanding than are currently found in major industrial or governmental players. The main victims of any proactive policies within the developed world are likely to be consumers, and they have little concentrated influence. As usual, energy restrictions would have a negative impact on developing countries. However, the damage to the credibility of science may have profound consequences that are difficult to foretell.

And so we can continue to sit in the stands, viewing the parade, and admiring the emperor's new clothes.