UNDERSTANDING COMMON CLIMATE CLAIMS

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ABSTRACT

The issue of man induced climate change involves not the likelihood of dangerous consequences, but rather their remote possibility. The main areas of widespread agreement (namely that global mean temperature has risen rather irregularly about 0.6C over the past century, that atmospheric levels of carbon dioxide have increased about 30% over the past century, and that carbon dioxide by virtue of its infrared absorption bands should contribute to warming) do not imply dangerous warming. Indeed, we know that doubling carbon dioxide should lead to a heating of about 3.7 watts per square meter, and that man made greenhouse heating is already about 2.7 watts per square meter. Thus, we have seen less warming than would be predicted by any model showing more than about 0.8 degrees C warming for a doubling of carbon dioxide. This is consistent with independent identifications of negative feedbacks.

Alarming scenarios, on the other hand, are typically produced by models predicting 4 degrees C. After the fact, such models can only be made to simulate the observed warming by including numerous unknown factors which are chosen to cancel most of the warming to the present, while assuming that such cancellation will soon disappear.

Alarm is further promoted by such things as claiming that a warmer world will be stormier even though basic theory, observations, and even model outputs point to the opposite.

With respect to Kyoto, it is generally agreed that Kyoto will do virtually nothing about climate no matter what is assumed. Given that projected increases in carbon dioxide will only add incrementally to the greenhouse warming already present, it seems foolish to speak of avoiding dangerous thresholds. If one is concerned, the approach almost certainly is to maximize adaptability.

1. INTRODUCTION

After spending years describing the physics of climate to audiences concerned with global warming, I came to the realization that I was speaking to people who were not aware of the basic premises of the issue. The listeners were typically under the impression that the case for climate alarm was self-evident and strong, and that concern for the underlying physics constituted simply nit-picking in order to see if there were any remotely possible chinks in the otherwise solid case. Given that most people (including scientists) can rarely

follow 15 minute discussions of somewhat complex science, the conclusion of the listeners is that the objections are too obscure to challenge their basic prejudice.

I decided, therefore, to examine why people believed what they believed. What I found was that they had been presented mainly three claims for which widespread scientific agreement existed. While these claims may be contested, they are indeed widely accepted. The only problem is that these claims do not suggest alarm. Rather, upon careful analysis, they make clear that catastrophic implications are grossly unlikely, but cannot be rigorously disproved. Thus, the real situation is that the supporters of alarm are the real skeptics who cling to alarm against widely accepted findings. The profound confusion pertaining to this situation is only reinforced by quibbling over the basic points of agreement. Such quibbling merely convinces the public that the basic points of agreement must be tantamount to support for alarm. We will begin by analyzing the popular consensus.

2. THE POPULAR CONSENSUS

In a recent set of articles in the New Yorker, which defend climate alarmism, Elizabeth Kolbert[1] presented a fairly good summary of the popular consensus:

All that the theory of global warming says is that if you increase the concentration of greenhouse gases in the atmosphere, you will also increase the earth's average temperature. It's indisputable that we have increased greenhouse-gas concentrations in the air as a result of human activity, and it's also indisputable that over the last few decades average global temperatures have gone up.

To be sure, this statement makes the logical error of ignoring other sources of climate change or the ubiquitously changing nature of climate. However, strictly speaking, the statement is not wrong. A briefer summary was provided by Tony Blair:

The overwhelming view of experts is that climate change, to a greater or lesser extent, is man-made, and, without action, will get worse.

Of course, this statement is too brief to actually mean much, but, given that climate change is always occurring, it is implausible to argue that all change is for the worse. Certainly, North America and northern Europe are much more pleasant without 2 km of ice cover.

How have such anodyne statements become the mantra for alarmism? Let us break up these points of agreement so as to be able to better examine this question. Let us also begin introducing all-important numbers into the claims.

1. The global mean surface temperature is always changing. Over the past 60 years, it has both decreased and increased. For the past century, it has probably increased by about 0.6 ±0.15 degrees Centigrade (C). That is to say, we have had some global mean warming.
2. CO_2 is a greenhouse gas and its increase should contribute to warming. It is, in fact, increasing, and a doubling would increase the greenhouse effect (mainly due to water vapor and clouds) by about 2%.

3. There is good evidence that man has been responsible for the recent increase in CO_2, though climate itself (as well as other natural phenomena) can also cause changes in CO_2.

Let us refer to the above as the *basic agreement*. Consensus generally refers to these three relatively trivial points.

3. BEYOND THE TRIVIAL

In order to go beyond the trivial, we must be able to answer the following:

Is there any objective basis for considering the approximate 0.6C increase in global mean surface temperature to be large or small? The answer depends on whether 0.6C is larger or smaller than what we might have expected.

In a climate which is always fluctuating by several tenths of a degree, there is no particular concern that should attach to the mere sign of the change.

A useful approach to this question is to determine how the current level of man made climate forcing compares with what we would have were CO_2 to be doubled. While there is nothing intrinsically special about a doubling of CO_2, it has long been used as a reference level for describing the climate sensitivity of models to what I refer to as *gross forcing*.[2] By *gross forcing*, I mean forcing that is essentially uniform. In contrast, forcing by orbital changes, which is commonly implicated in the periodic ice ages, involves very little gross forcing, but, rather, involves major redistributions in the geographic pattern of heating. Such redistributions are likely to be important for several related reasons:

1. Changes in climate have been primarily associated with changes in the equator-to-pole temperature difference, as opposed to changes in the global mean temperature.
2. The equator-to-pole temperature difference depends on the transport of heat primarily by the atmosphere but also by the oceans.
3. The atmosphere and oceans are fluids where heat transport is mostly due to the motion of the fluids
4. Fluid motions depend on the gradients of temperature which are, in turn, dependent on the regional distributions of heating.

However, for purposes of the present discussion, we will focus on gross forcing. For such forcing, *greenhouse gases added to the atmosphere through mans activities since the late 19th Century have already produced three-quarters of the gross radiative forcing that we expect from a doubling of CO_2*[3]. 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.

As a technical matter, we are in a logarithmic regime for this forcing (as illustrated in Figure 1). For example, if doubling CO_2 from its value in the late 19th Century (about 290 parts per million by volume or ppmv) to double this (i.e., 580 ppmv) causes a 2% increase in radiative forcing, then to obtain another 2% increase in radiative forcing we must increase CO_2 by an additional 580 ppmv rather than by another 290 ppmv. At present, the concentration of CO_2 is about 380 ppmv. It should be stressed that we are interested in climate forcing, and not simply levels of CO_2.

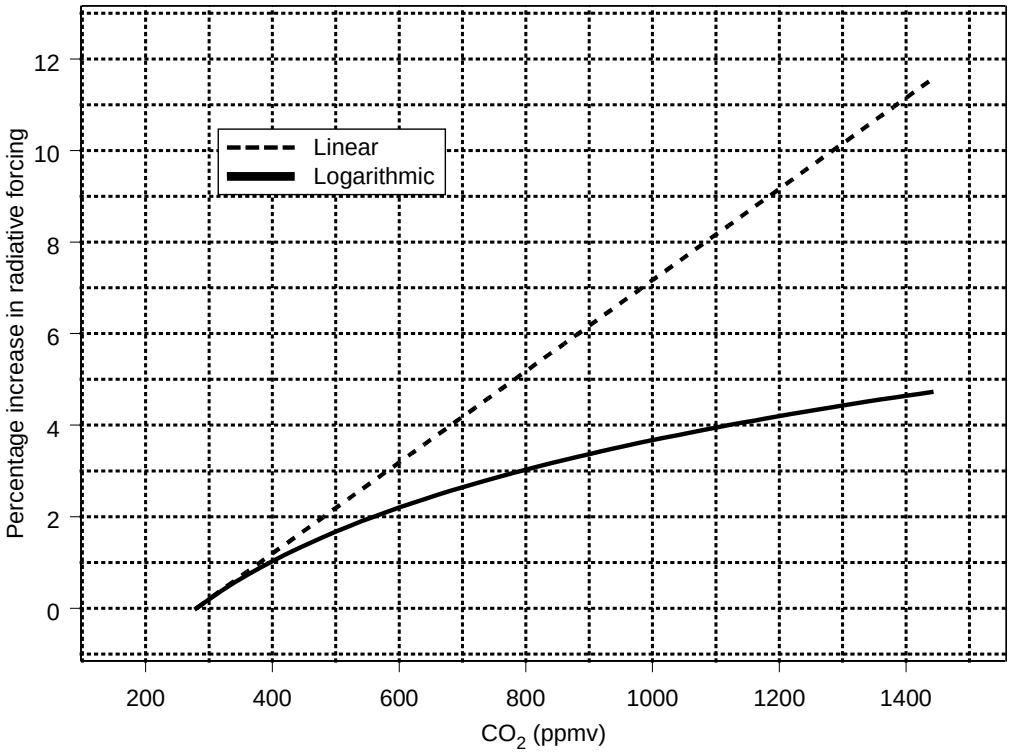

Figure 1: Percentage increase in gross radiative forcing as a function of CO2 concentration.

Now, it is relatively easy to show that a doubling of CO_2 which leads to radiative forcing of about 3.7 Watts per square meter should produce about 1C of warming in the absence of feedbacks. In the absence of an infrared absorbing atmosphere, this change would refer to the surface, but in the presence of such an atmosphere, it refers to some characteristic emission level for infrared radiation. For the earth's atmosphere, this is typically in the neighborhood of 5 km. The question of what happens at the surface is actually somewhat complex, but, in general, the change there should be somewhat less (Schneider et al, 1999[4]). Thus, the observed warming could be consistent with this calculation, though it is likely to be somewhat less.

Alarm, it should be noted, is not based on the above estimate. Rather, it is based on models that produce a very different result. Most current climate models predict a response

to a doubling of CO_2 of about 4C. The reason for this is that in these models, the most important greenhouse substances, water vapor and clouds, act in such a way as to greatly amplify the response to anthropogenic greenhouse gases alone (ie, they act as what are called large positive feedbacks). However, as all assessments of the Intergovernmental Panel on Climate Change (IPCC) have stated (at least in the text – though not in the Summaries for Policymakers), the models simply fail to get clouds and water vapor right. We know this because in official model intercomparisons, all models fail miserably to replicate observed distributions of cloud cover (as may be seen in Figure 2 from Gates et al[5]). Thus, the model predictions are critically dependent on features that we know must be wrong.

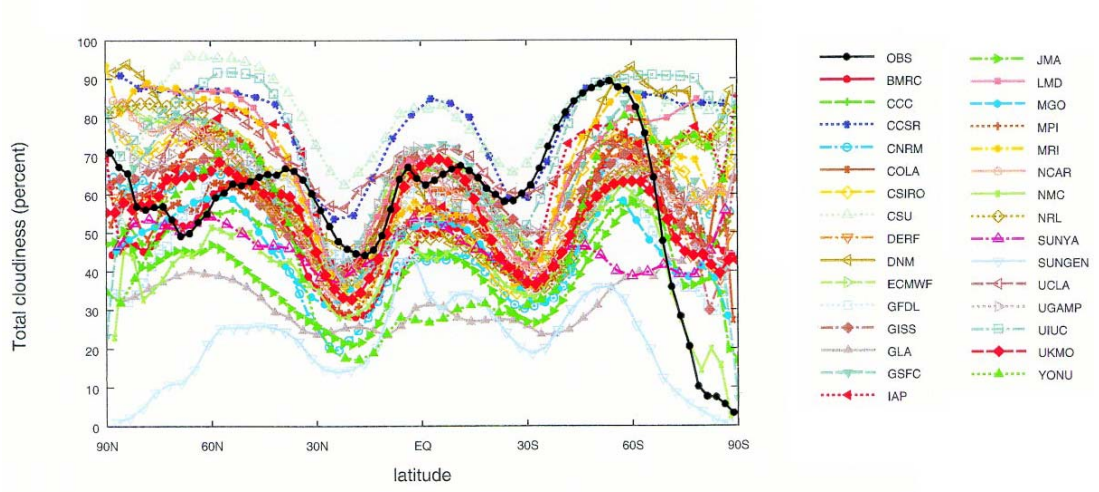

Figure 2: Individual model's hindcast of cloud cover averaged by latitude as well as observed distribution.

Predictions based on these models are greatly in excess of what has been observed. Thus, if predictions based on these models are correct (after all stopped watches are right twice a day), then man's greenhouse emissions have accounted for about 6 times the observed warming over the past century with some unknown processes canceling the difference. This is distinctly less compelling than the statement that characterized the IPCC Second Assessment and served as the smoking gun for the Kyoto agreement: *The balance of evidence suggests a discernible human influence on global climate.* The IPCC statement is simply an abbreviation of the *basic agreement* with the addition of a small measure of attribution. 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 compared to the predictions of the models that are drawn on in IPCC reports. How is it that such simple matters are ignored or taken to imply alarm? We turn to this next.

4. MISLEADING CONCLUSIONS AND SIMULATIONS

It appears that public presentations go to interesting extremes in order to avoid pointing out that the observed temperature change has been small. Thus, we are sometimes told that the global mean temperatures have recently been 'record breaking.' As Solow and Broadus[6] (1989) pointed out early on, given that we are at a high in recorded temperatures, and that temperatures have significant short term fluctuations, we should expect frequent record breaking years. None of this says anything about trends. However, if the underlying trends are positive, then the number of record breakers should become even more frequent. Indeed, the absence of any record breakers during the past 7 years is statistical evidence that temperatures are not increasing.

As the role of 'record breakers' has become less compelling, official documents such as the *Third Assessment Report* (TAR) of the IPCC in the *Summary for Policymakers* (SPM) have emphasized the claim that the temperature rise of the past century is 'unprecedented' in the past millennium. While there is immense controversy over this claim (currently involving even legal proceedings and Congressional hearings), this controversy only serves to convince the public that the result is truly important, while obscuring the fact that the temperature change has been small compared to what would be expected on the basis of current models.

There is finally the remarkable defense of models which is based on their 'ability' to simulate gross features of the past temperature record. Simulation can be an interesting and useful exercise, but it suffers from several problems as well. As any educator knows, when students are given the answer in advance, they will obtain that answer – albeit frequently by an incorrect method. In the case of general circulation models, the existence of many unknown factors allows considerable scope for adjusting results. The fact that many models have high sensitivity to gross radiative forcing gives greater scope to adjusting 'unknowns.' Moreover, the fact that the 'unknowns' are unknown means that the resulting simulation cannot so easily be proven incorrect.

The most commonly presented curve fitting exercise of this sort, which featured prominently in the TAR, is from the Hadley Centre. It consists in three plots which are reproduced in Figure 3. In the first panel, we are shown an observed temperature record (without error bars), and the outputs of four model runs with so-called natural forcing for the period 1860-2000. There is a small spread in the model runs (which presumably displays model uncertainty – it most assuredly does not represent natural internal variability[7]). In any event, the models look roughly like the observations until the last 30 years. We are then shown a second diagram where the observed curve is reproduced and the four models are run with anthropogenic forcing. Here we see rough agreement over the last 30 years, and poorer agreement in the earlier period. Finally, we are shown the observations and the model runs with both natural and anthropogenic forcing, and, voila, there is rough agreement over the whole record. It should be noted that the models used had a relatively low sensitivity to a doubling of CO_2 of about 2.5C.

In order to know what to make of this exercise, one must know exactly what was done. The natural forcing consisted in volcanoes and solar variability. Prior to the

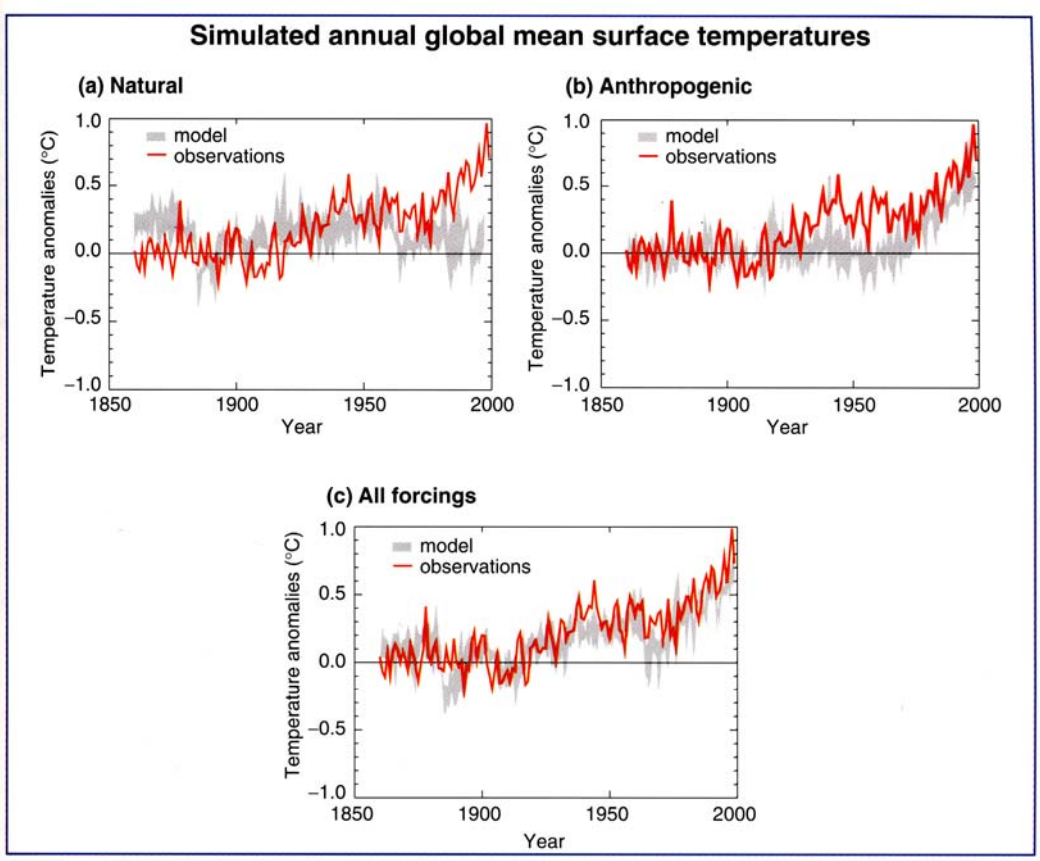

Figure 3. Simulations of global mean temperature with various combinations of 'forcing.'

Pinatubo eruption in 1991, the radiative impact of volcanoes was not well measured, and estimates vary by about a factor of 3. Solar forcing is essentially unknown. Thus, natural forcing is, in essence, adjustable. Anthropogenic forcing includes not only anthropogenic greenhouse gases, but also aerosols that act to cancel warming (in the Hadley Centre outputs, aerosols and other factors cancelled two thirds of the greenhouse forcing). Unfortunately, the properties of aerosols are largely unknown. In the present instance, therefore, aerosols constitute simply another adjustable parameter (indeed, both its magnitude and its time history are adjustable, and even its sign is in question). This was remarked upon in a recent paper in *Science* (Andersen, et al, 2003[8]), wherein it was noted that the uncertainty was so great that estimating aerosol properties by tuning them to optimize agreement between models and observations (referred to as an inverse method) was probably as good as any other method, but that the use of such estimates to then test the models constituted a circular procedure. This is as strong a criticism of model procedures as is likely to be found in *Science*. The authors are all prominent in aerosol work. The first author is the most junior, and when it was pointed out that the article reflected negatively on model outputs, he vehemently denied any such intent. In the present example, the choice of models with relatively low sensitivity, allowed adjustments that were not so extreme.

New uncertainties are always entering the aerosol picture. Some are quite bizarre. A recent article in *Science* (Jaenicke, 2005[9]) even proposed a significant role to airborn dandruff. Of course this is the beauty of the global warming issue for many scientists. The

issue deals with such small climate forcing and small temperature changes that it permits scientists to argue that everything and anything is important for climate.

In brief, the defense of the models starts by assuming the model is correct. One then attributes differences between the model behavior in the absence of external forcing, and observed changes in 'global mean temperature' to external forcing. Next one introduces 'natural' forcing and tries to obtain a 'best fit' to observations. If, finally, one is able to remove remaining discrepancies by introducing 'anthropogenic' forcing, we assert that the attribution of part of the observed change to the greenhouse component of '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. Note that the Hadley Centre acknowledges that the "aerosols" cancelled most of the forcing from CO_2.

The preceding analysis depended on the presence of many adjustable parameters. It is hardly better than the following attempt to relate Republican in the Senate to sunspots (Figure 4).

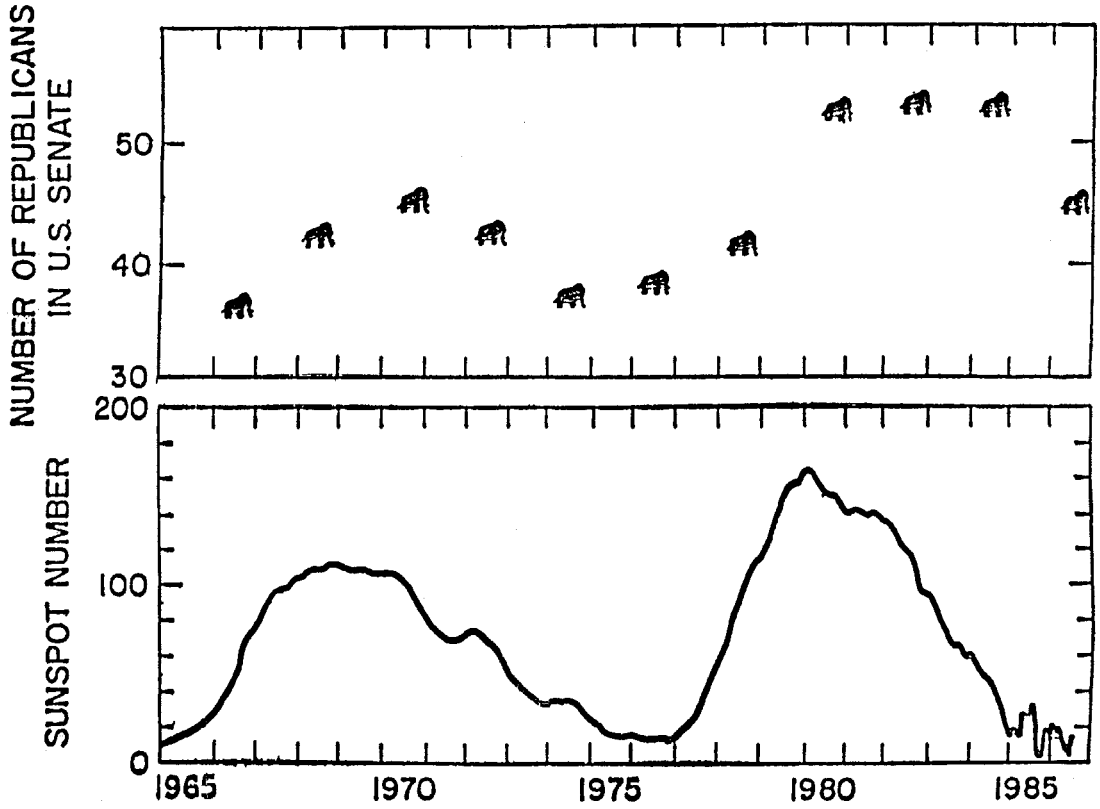

Figure 4. Upper panel shows Republicans in the US Senate. Lower panel shows sunspot number.

Yet, the 'argument' I have just presented is the basis for all popular claims that scientists now 'believe' that man is responsible for much of the observed warming!

It would appear that the current role of the scientist in the global warming issue is simply to defend the 'possibility' of ominous predictions so as to justify his 'belief.'

To be fair to the authors of Chapter 12 of the IPCC TAR here is what they provided for the draft statement of the SPM:

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.

This statement is not too bad – especially the last sentence. To be sure, the model dependence of the results is not emphasized, and the achievement is overstated, but the statement is vastly more honest than what the Summary for Policymakers in the IPCC's Third Assessment Report ultimately presented:

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.

This statement is simply dishonest. In point of fact, the impact of man remains indiscernible simply because the signal is too small compared to the natural noise. *Claims that the current temperatures are 'record breaking' or 'unprecedented', however questionable or misleading, simply serve to obscure the fact that the observed warming is too small compared to what models suggest.* Even the fact that the oceans' heat capacity leads to a delay in the response of the surface does not alter this conclusion (for example, the Hadley Centre outputs were for a coupled model).

5. TRANSLATION OF SMALL WARMING INTO ALARM

We already have three quarters of the climate forcing expected from a doubling of CO_2, and we have seen only small warming, which, moreover, is not out of the range of normal variability. 'Unusual' weather is, in fact, a normal feature of weather, and little has been seen that transcends this normalcy. A monthly publication of the US Weather Service describes the extreme events of that month. Its length has not changed significantly since 1950 when publication began. Nevertheless, a cottage industry has arisen which seeks to associate warming with all sorts of catastrophes. While the movie, *Day After Tomorrow*, went beyond the absurd in this respect, the current president of the US National Academy of

Sciences was reported by the New York Times to have credited the possibility that Holland could be inundated and unlivable in 15 years.

That the promotion of alarm does not depend on science, is clearly illustrated by the following example. 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 is 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 how warm low latitudes are and how cold high latitudes are. Given that we expect that high latitudes will warm much more than low latitudes in a warmer climate, the difference is expected to diminish, leading to less variance.

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 basic agreement discussed earlier signifies scientific 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 (Henderson-Sellers et al, 1998[10]). State of the art modeling suggests a negative impact (Sugi et al, 2002[11]), while there are theoretical arguments that suggest a positive impact on hurricane intensity (Emanuel, 1999[12]). This is all of significant intellectual interest, but it is not the material out of which to legitimately build alarm.

One of the more reprehensible attempts 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 and Munich Re 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.

6. 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 confusion among various things referred to as models. In fields which are not characterized by known underlying physical equations, the models are characterized by specified relations among the variables. Such models, although frequently subject to specified constraints, tend to be more flexible than models where the underlying equations are essentially physical laws. While certain simple climate models can be said to belong to an extent to the first category, General Circulation Models used in climate modeling are of the second sort and, therefore, much less flexible with respect to changing assumptions. 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 oceans 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 oceans 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 depend 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 reach this stage in the foreseeable future. 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. Processes on scales smaller than these meshes 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. It can also be seen that much of the behavior of these models can result from aspects of the numerical methodology rather than the underlying physics. 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. Figure 2, 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 increasing CO_2 involves a small perturbation to this budget. At the same time, one wonders if the failure of models to give coherent results is not sometimes exploited by alarmists who commonly claim model support for behavior that models do not display. The previously cited example of the association of enhanced storminess with rising global mean temperature, despite model results to the contrary, is an example.

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.

7. 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. The first part of this statement is only true if the relative humidity of air near the surface does not increase. 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 (note that the density of water vapor in the atmosphere decays with height with a scale height of about 2-3 km), and at least in the tropical half of the earth, this water vapor is mostly due to the re-evaporation of precipitation from above as well as dissipation of cumulus clouds 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 (Lindzen, Chou and Hou, 2000[13]). There were a flurry of hastily prepared papers[14] that appeared almost immediately claiming (incorrectly in our view[15]) errors in our study, and in the environmental literature, our work was quickly associated with the word, *discredited* (See for example Hansen, 2003[16]). (The word, *discredited*, has come to mean in the environmental literature that the reader should avoid considering such a possibility; it does not seem to mean that there is anything

demonstrably wrong with the *discredited* result.) 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) to show that there must have been some other reason for this[17]. None of this should have been surprising in retrospect. When, in 2003, the draft of the US National Climate Plan urged high priority for improving our knowledge of climate sensitivity, it appears that an NRC review panel was critical of this priortization, urging prioritization instead for broader support for numerous groups to study the impacts of the putative warming. One is tempted to suggest that the NRC panel was more interested in spreading the wealth than in finding an 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, 1985[18] and Lindzen, 1995[19], 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, 1998[20], Lindzen and Giannitsis, 2002[21], Douglass and Knox, 2005[22]), 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 et al, 2001[23]) supports current climate models. However, as noted in Lindzen, 2002[24], this result is largely 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 *basic agreement* we discussed at the beginning of this paper, and nothing in this result promotes the alarmism that has attached itself to the *basic 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.

8. SCIENTIFIC V. POLITICAL DISCOURSE

By now the reader should understand that the public discourse concerning global warming has little in common with the standards of normal scientific discourse. Rather, it should be considered as part of political discourse where comments are made to secure the political base and frighten the opposition rather than to illuminate the issues. In political discourse, any information is to be spun and used to reinforce pre-existing beliefs, and discourage opposition. The chief example of the latter is the perpetual claim of universal scientific agreement. This claim was part of the media treatment of global cooling (in the 1970's) and has been part of the treatment of global warming since 1988 (well before most

climate change institutes were created). The 'consensus,' in brief, preceded the research. However, in this section, I would like to focus on the former.

For example, in 2001, the U.S. National Research Council (NRC) issued a report: Climate Change Science: *An Analysis of Some Key Questions*. This report was prepared at the specific request of the White House. The brief though carefully drafted report of 15 pages was preceded by a totally unnecessary 10 page executive summary. The opening lines were appended at the last moment without committee approval. Nevertheless, all these lines did was to repeat the *basic agreement*.

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.

To be sure, this statement is leaning over backwards to encourage the alarmists (a point I will return to later). 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 indicates the lack of certainty, while the fact that we have not emerged from the level of natural variability is, in fact, mentioned albeit obliquely. What, as usual, goes unmentioned is that the observed changes are much smaller than expected.

As most readers are aware, this report is commonly cited as endorsing global warming alarmism. The response from many commentators 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. Such claims, though widely made, have no basis: they are nonsensical.

That media discourse should be political rather than scientific should, in fact, come as no surprise. However, as has already been noted, even scientific literature and institutions have become politicized. There are, at least, three aspects to this politicization. The first is typified by the above opening remarks to the NRC report. Some scientists issue meaningless remarks in what I believe to be the full expectation that the media and the environmental movement will provide the 'spin.' Given the fact that the societal response to alarm has, so far, been to increase scientific funding, there has been little reason for scientists to complain. This situation is illustrated in the cartoon shown in Figure 5 which describes the interaction of the 'iron rice bowl of science' with the triangle of alarm. 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. The situation has been recognized since time immemorial. In Federalist Paper No. 79, Alexander Hamilton brooded about abuses that might arise from legislative tampering with judges' salaries. "In the general course of human nature," he wrote, "a power over a man's subsistence amounts to a power over his will." Note that there is no suggestion of conscious cupidity in Hamilton's astute observation. The feeling of virtue is frequently genuine.

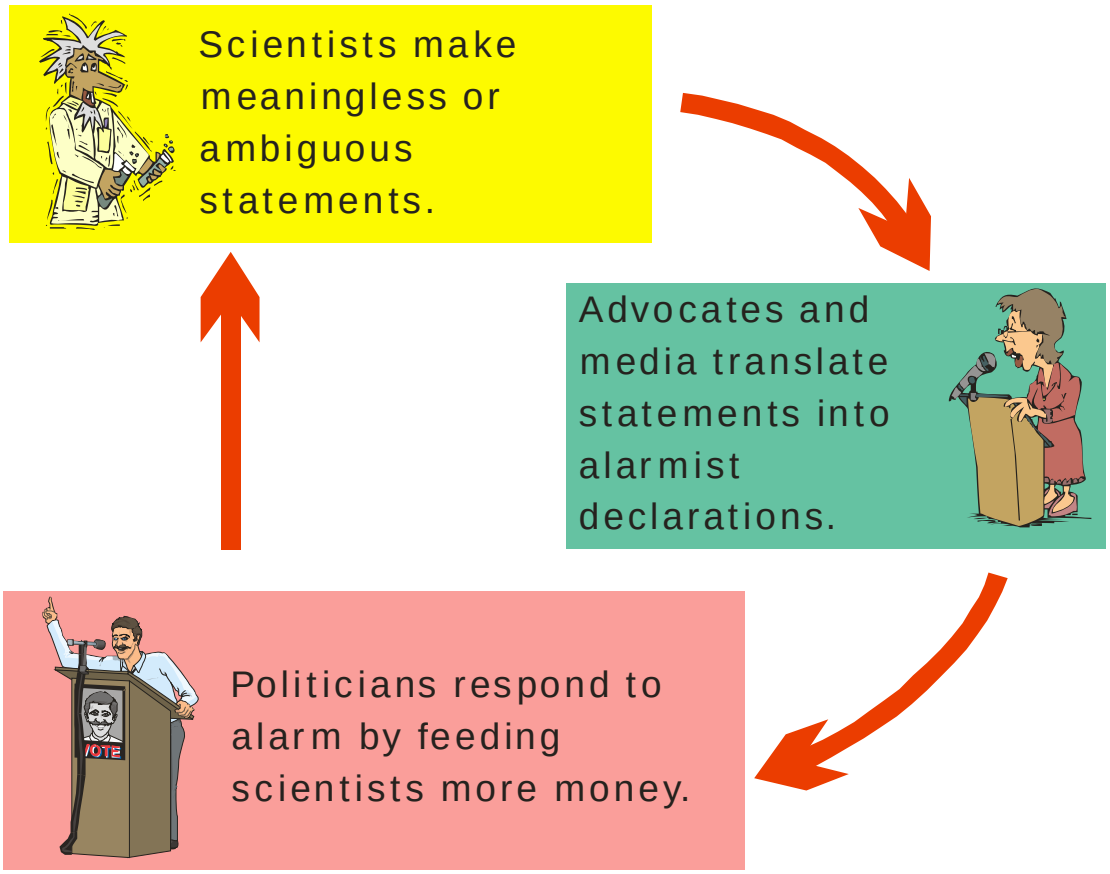

Figure 5. The sad tale of the triangle of alarmism and the iron rice bowl of science.

A second aspect of politicization of discourse specifically involves the scientific literature. Over the years, articles have been published which challenge the claim of alarming response to anthropogenic greenhouse gases. A number have already been mentioned (Lindzen, Chou and Hou, 2000, Douglass and Knox, 2005). There are several others including McIntyre and McKittrick[25] (2005) and von Storch[26] (2004). Not surprisingly, there quickly appear challenges to these papers. However, there are several aspects of these challenges that are anomalous. They appear unusually quickly, and they are usually published as independent papers rather than as correspondence concerning the original papers. Thus, any defense that the original author(s) may make does not appear until a frequently long delay (1.5 years in at least one instance). In my experience, the criticisms are usually hasty and without understanding of the original work. However, the original papers are immediately referred to as 'discredited.' When the responses of the original authors finally appear, they are accompanied by the response of the critics who generally ignore the responses of the original authors, and repeat their criticism. This is clearly not a process conducive to scientific progress, but it is not clear that progress is what is desired.

The case of ozone depletion is illuminating in this regard. Once the Montreal Protocol was adopted, all the major players in the identification of freons as a contributor to

ozone depletion were rewarded with accolades and prizes. However, funding for stratospheric research essentially disappeared. Indeed, most stratospheric research today claims to be seeking the role of the stratosphere in climate. Presumably, only the failure of the Kyoto Protocol to be universally adopted stands between further rewards for the leading promoters of alarm and the cessation of funding for the rest.

A final aspect of politicization is the explicit intimidation of scientists. It is essential to discuss this unsavory subject – albeit briefly and incompletely. Intimidation has mostly, but not exclusively, been used against those questioning alarmism. Victims of such intimidation generally remain silent for reasons that will become evident. Thus, prior to 1992, then Senator Gore ran at least two hearings in order to pressure scientists who questioned his views[27]. Scientists whose views he objected to were called before his subcommittee. Usually almost no other senators participated. However, other witnesses consisting in mostly government scientists and representatives of funding agencies were called, clearly with the intent of these additional witnesses criticizing the initial scientist. Generally, at least some of the attending scientists were appalled at the use to which they were being put, but Gore usually managed to extract enough from these hearings to place something in the *Congressional Record* to the effect that the target had 'recanted' or had been 'discredited.' In the early 90's after Gore had become Vice President, Ted Koppel on his evening television program, *Nightline*, announced that Vice President Gore had asked him to find connections to unsavory interests for scientists questioning global warming alarm. Koppel, after editorializing on the inappropriateness of Gore's request, proceeded to present a balanced exposure of both sides of the debate[28]. Of course, it was most unlikely that the Vice President had restricted his request to Koppel, and shortly thereafter an article by a relatively unknown journalist, Ross Gelbspan, appeared in *Harper's Magazine* proclaiming (libelously) that scientists who differed with Gore were stooges of the fossil fuel industry. Gelbspan, who had taken unusually early retirement from the *Boston Globe*, seems to have made this into a second career. He followed his article with extensive lecture tours and two books rehashing his position[29]. The second book has an effusive preface by Gore. Both the preface and Gelbspan, himself, refer to Gelbspan as a Pulitzer Prize winning journalist though the Pulitzer Foundation seems to have no record of this. All of this would be bad enough, but the real source of intimidation was the fact that neither the American Meteorological Society nor the American Geophysical Society saw fit to object to any of this. I should add that this brief treatment hardly exhausts the known cases. Perhaps, the best documented case (because it resulted in legal proceedings) involved the attempt to have the name of Roger Revelle removed from a published article in which Revelle expressed the view that the purported danger of global warming was not sufficiently established to take costly action (N.B. Gore frequently referred to Revelle as the person who introduced him to Global Warming.). Professor Fred Singer was accused of misrepresenting Revelle's participation in the paper. The resulting legal proceedings revealed a tangle of involvements including Vice President Gore, several environmental groups, and a young scientist claiming to be the intellectual heir of Revelle. The reader is urged to read Singer's detailed account of this incident.[30]

All of the above contrasted with other cases of political interference with climate science. For example, when William Happer, a professor of physics at Princeton University, was dismissed in 1993 from his position as Director of Energy Research at the Department of Energy after he expressed questions about global warming, the physics community was

generally supportive and sympathetic[31]. More relevant is the recent case of Michael Mann (currently on the faculty of Penn State) who, with colleagues, created a reconstruction of mean temperature going back 1000 years which purported to show that the half degree (Centigrade) rise of the past century was unprecedented[32]. Not surprisingly, this result was controversial (despite the previously mentioned fact that the observed rise was much less than models predict should have resulted from the anthropogenic increases in greenhouse forcing). Several papers have appeared challenging Mann's results by both climate scientists (Esper et al[33], Broecker[34], Soon et al[35], and von Storch for example) and other experts (Muller[36], McIntyre and McKittrick). There have also been papers claiming similar results (Jones and Mann[37], and Crowley and Lowery[38] for example). The difficulty in this controversy is that Mann has not released the details of his analysis so as to permit detailed checking. Because of the extensive use of Mann's result in the politics of global warming, Representative Barton of the US House of Representatives has demanded that Mann make public the details of his analysis since it was supported by US funds. Mann has refused (however, he appears to have subsequently posted his Fortran code on his website), and, interestingly, both the American Meteorological Society and the American Geophysical Union have formally protested Barton's request. One need not go into the relative merits of this controversy to see that this difference in the response of the relevant professional organizations sends a rather chilling message to those who question what has become climate orthodoxy; only the defenders of the orthodoxy will be defended against intimidation – regardless of the merits of the case or the lack thereof.

Not surprisingly, a large portion of the scientists challenging alarmism have been older and more senior scientists with the benefit of tenure (or even retirement). These included Professor William Nierenberg, former Director of the Scripps Oceanographic Institution, and Professor Jerome Namias also of Scripps and former head of the Weather Bureau's Long Range Weather Forecasting Division. Both are now deceased. For beginning scientists, I have little doubt that publicly questioning global warming alarm would be extremely detrimental to their careers. A potential exception to this is Willie Soon whose scientific position is in solar physics rather than climate. There has been a general tolerance for solar physicists who suggest solar influence as being important to climate. My personal impression is that this tolerance stems from the utility of the essentially unknown solar forcing in 'adjusting' models to better simulate observations (viz Section 4).

The situation in Europe has been similar. Before 1991, some of Europe's most prominent climate experts were voicing significant doubts about climate alarm. Note that the issue has always concerned the basis for alarm rather than the question of whether there was warming (however small) or not. Only the most cynical propagandist could have anticipated that sentient human beings could be driven into panic by the mere existence of some warming. In any event, among these questioners were such distinguished individuals as Sir John Mason, former head of the UK Meteorological Office, and Secretary of the Royal Society, Prof. Hubert Lamb, Europe's foremost climatologist and founder of the Climate Research Unit at East Anglia University, Dr. Henk Tennekes, Director of Research at the Royal Dutch Meteorological Institute, and Professor Aksel Wiin-Nielsen of the University of Copenhagen and former Director of the European Centre for Medium Range Weather Forecasting, and Secretary General of the World Meteorological Organization. All of these figures except Tennekes have disappeared from the public discourse. Lamb is now dead.

Tennekes was dismissed from his position, and Wiin-Nielsen was tarred by Bert Bolin (the first head of the IPCC) as a tool of the coal industry. The Italian situation was more benign. Some of Italy's leading younger atmospheric scientists like Alfonso Sutera and Antonio Speranza publicly questioned alarm and organized a meeting in early autumn of 1991 in Chianciano under the auspices of the Demetra Foundation. Shortly thereafter they too disappeared from the debate. Apparently their funding for climate research was cut off, but funding for other projects was provided, and they, quite reasonably, moved to other areas of research. In Russia, a number of internationally recognized pioneers of climate science like K. Kondratyev and Y. Izrael, continue to vocally oppose climate alarm, but Russian scientists eager for connections with the rest of Europe are much more reluctant to express such views.

9. SCIENCE AND POLICY

The mixture of science and policy often leads to absurdity, and global warming is no exception. The policy community appears to have no understanding of the science while the science community is in thrall to the policy community. This hardly helps communication. On top of everything is the fact that global warming and energy policy are intertwined, and many in the energy policy community are eager to take advantage of the connection — again with little regard for the science of climate. Consider, for example, one simple fact: as concerns climate change, what matters is not the emissions of CO_2 or even the concentration of CO_2 in the atmosphere, but rather the radiative forcing due to the anthropogenic greenhouse gases. Thus, policy and energy specialists talk endlessly (in seemingly unboundedly numerous meetings) about small reductions in emissions without reference to CO_2 levels, and (for the more sophisticated discussants) about CO_2 levels without reference to radiative forcing. Of course, even the simple relation of radiative forcing to climate is a chimera, given the importance of geographical distribution. For example, the likely forcing of ice age cycles by the earth's orbital variations (the Milankovich hypothesis) involves very little net radiative forcing but very large changes in the geographical distribution of this forcing. None of this should be surprising, given the facts that the atmosphere and oceans are fluids, that their motions are major transporters of heat, and that the motions depend on gradients of temperature rather than specific values.

We hear about 'insurance policies,' critical levels of CO_2, etc., etc. My impression is that when we speak of models calculating the climate response to doubled CO_2, the policy makers assume that we are far from this point. However, as I noted earlier, in terms of radiative forcing, we are, in fact, three quarters of the way to this point. The encouraging fact is that despite this forcing, we have not seen anything near what models predict. Indeed, it still is essentially impossible, in my estimation, to distinguish what has been seen from natural unforced variability. Moreover, what changes we have seen (regardless of cause) have not prevented profound advances in GDP, food production, life expectancy, etc. On the other hand, if one still chooses to take the model outputs seriously, we have long passed any point of 'no return' with respect to radiative forcing, and future additions of CO_2 will only add modestly to current forcing. Thus, policies such as the Kyoto Protocol, which don't seriously limit emissions and don't measurably impact concentrations, genuinely deserve the designation of 'no gain and all pain.' Indeed, there would appear to be little we can do at this stage other than to prepare to adapt. However, the policies that address adaptation are often

diametrically opposed to those involved in so-called mitigation, because at the heart of adaptive capacity is wealth. To people of good will, this should be welcome news. We are, in effect, saying that policies promoting the improvement of general welfare throughout the world are also, automatically, the appropriate policies with respect to climate change. It would appear, however, that most of the advocates in this issue are more concerned with their special interests (whether they be alternate energy sources, bureaucratic control, political preference, corporate image, etc.) than with general welfare.

10. CONCLUSION AND SUMMARY

So where does all this leave us? First, I would emphasize that the *basic agreement* frequently described as representing scientific unanimity concerning global warming is entirely consistent with there being virtually no problem at all. Indeed, the observations most simply suggest that the sensitivity of the real climate is much less than found in models whose sensitivity depends on processes which are clearly misrepresented (through both ignorance and computational limitations). Attempts to assess climate sensitivity by direct observation of cloud processes, and other means, which avoid dependence on models, support the conclusion that the sensitivity is low. More precisely, what is known points to the conclusion that a doubling of CO_2 would lead to about 0.5C warming or less, and a quadrupling (should it ever occur) to no more than about 1C. Neither would constitute a particular societal challenge. Nor would such (or even greater) warming likely be associated with discernibly more storminess, a greater range of extremes, etc.

Second, a significant part of the scientific community appears 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***. Alas, it is impossible to prove something is impossible.

As you can see, the global warming issue parts company with normative science at a pretty early stage. A very good indicator of this disconnect is the fact that there is widespread and even rigorous scientific agreement that complete adherence to the Kyoto Agreement would have no discernible impact on climate. This clearly is of no importance to the thousands of negotiators, diplomats, regulators, general purpose bureaucrats and advocates attached to this issue.

At the heart of this issue there is one last matter: namely, the misuse of language. George Orwell wrote that language "becomes ugly and inaccurate because our thoughts are foolish, but the slovenliness of our language makes it easier for us to have foolish thoughts." There can be little doubt that the language used to convey alarm has been sloppy at best. Unfortunately, much of the sloppiness seems to be intentional.

A question rarely asked, but nonetheless important, is whether the promotion of alarmism is really good for science? The situation may not be so remote from the impact of Lysenkoism on Soviet genetics. However, personally, I think the future will view the response of contemporary society to 'global warming' as simply another example of the appropriateness of the fable of the *Emperor's New Clothes*. For the sake of the science, I hope that future arrives soon.

ACKNOWLEDGEMENTS

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ENDNOTES:

[1] *New Yorker*, April 25, 2005

[2] The term, *forcing*, in this paper, refers to the imbalance in radiative energy flux that would be produced by the addition of greenhouse gases. We will generally describe such forcing as either a percentage increase in the greenhouse effect, or as a flux with units of Watts per square meter. Such a flux acts to warm the earth.

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