Is there a basis for global warming alarm?

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The reality of global warming is frequently attested to by reference to a ***scientific consensus***:

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.”

Elizabeth Kolbert in *New Yorker*: “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.”

These references fail to note that there are many sources of climate change, and that profound climate change occurred many times both before and after man appeared on earth.

Given the ubiquity of climate change, it is implausible that all change is for the worse.

Moreover, the coincidence of increasing CO_2 and the small warming over the past century hardly establishes causality.

Nevertheless, for the most part I do not personally disagree with the *Consensus* (though the absence of any quantitative considerations should be disturbing). **Indeed, I know of no serious split, and suspect that the claim that there is opposition to this consensus amounts to no more than setting up a straw man to scoff at.**

However, I believe that people are being led astray by the suggestion this agreement constitutes support for alarm.

What is truly agreed (albeit with some controversy)

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.

Is there any reason to consider this basic agreement as being alarming?

Relatedly, is there any objective basis for considering the approximate 0.6C increase in global mean surface temperature to be large or small.

The answer to both questions depends on whether 0.6C is larger or smaller than what we might have expected.

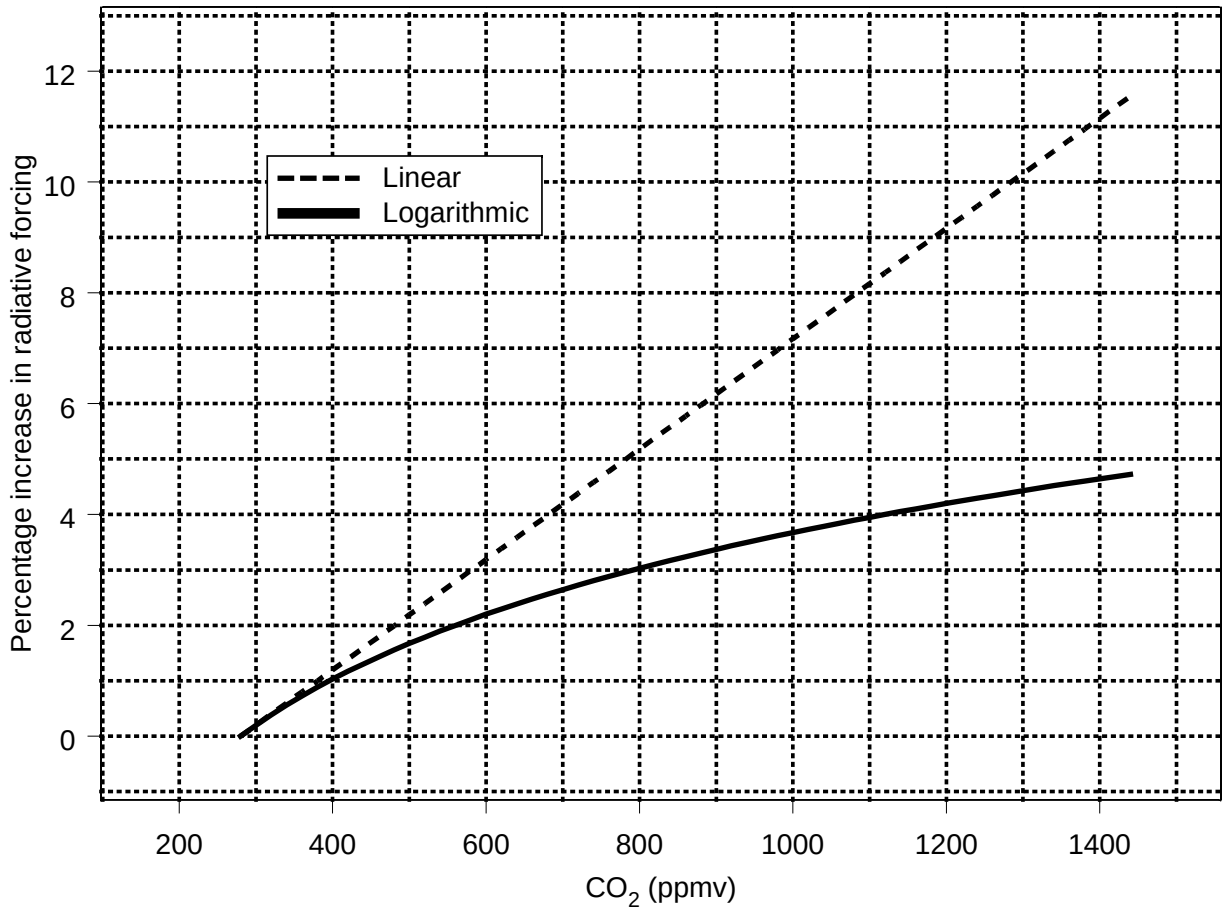
A useful approach to this question is to determine how the current level of man made climate forcing compares with what we would have were CO_2 to be doubled (a common reference level for GCM calculations).

In terms of climate forcing, greenhouse gases added to the atmosphere through mans activities since the late 19th Century have already produced **three-quarters** of the radiative forcing that we expect from 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. 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.



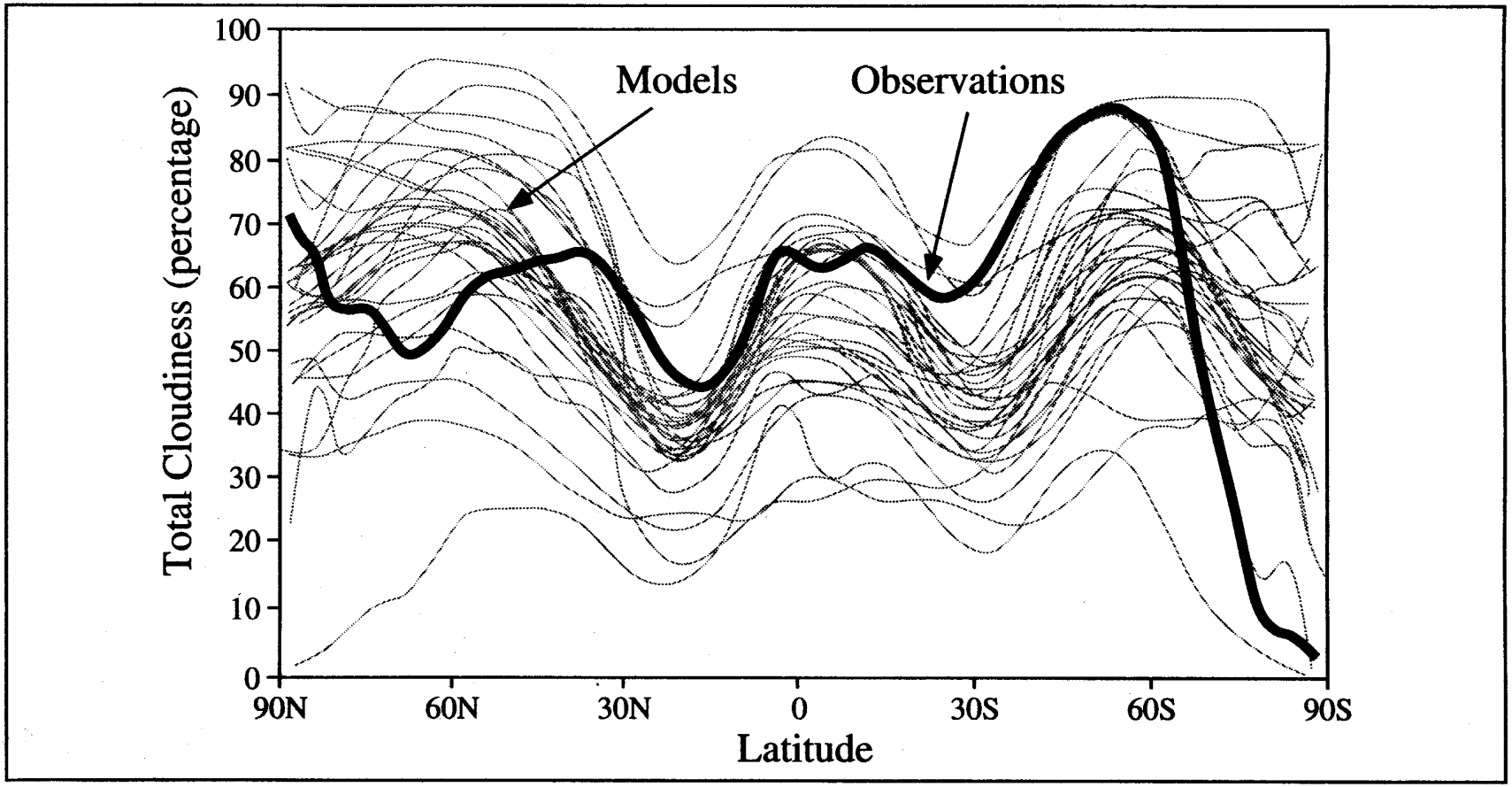
The CO_2 forcing follows the logarithmic rather than the linear curve. Note that the logarithmic curve rises ever more slowly as the CO_2 increases.

The easiest way to understand this is to consider adding thin layers of paint to a pane of glass. The first layer cuts out much of the light, the next layer cuts out more, but subsequent layers do less and less because the painted pane is already essentially opaque.

This brings us, finally, to the issue of climate models. Essential to alarm is the fact that most current climate models predict a response to a doubling of CO_2 of about 4C (which is much larger than what one expects the simple doubling of CO_2 to produce: ie, about 1C). 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. ***Thus, the model predictions are critically dependent on features that we know must be wrong.***

Here we see that treatment of clouds involves errors an order of magnitude greater than the forcing from a doubling of CO_2

Figure 1. Each thin gray line shows an individual model's hindcast of percentage cloud cover averaged by latitude. The black line shows the observed cloud cover.



Let me summarize the main points thus far:

1. It is NOT the level of CO_2 that is important, but rather the impact of man made greenhouse gases on climate.

2. Although we are far from the benchmark of doubled CO_2, climate forcing is already about 3/4 of what we expect from such a doubling.

3. Even if we attribute all warming over the past century to man made greenhouse gases (which we have no basis for doing), the observed warming is only about 1/3-1/6 of what models project.

We are logically led to two possibilities:

1. Our models are greatly overestimating the sensitivity of climate to man made greenhouse gases, or

2. The models are correct, but there is some unknown process that has cancelled most of the warming.

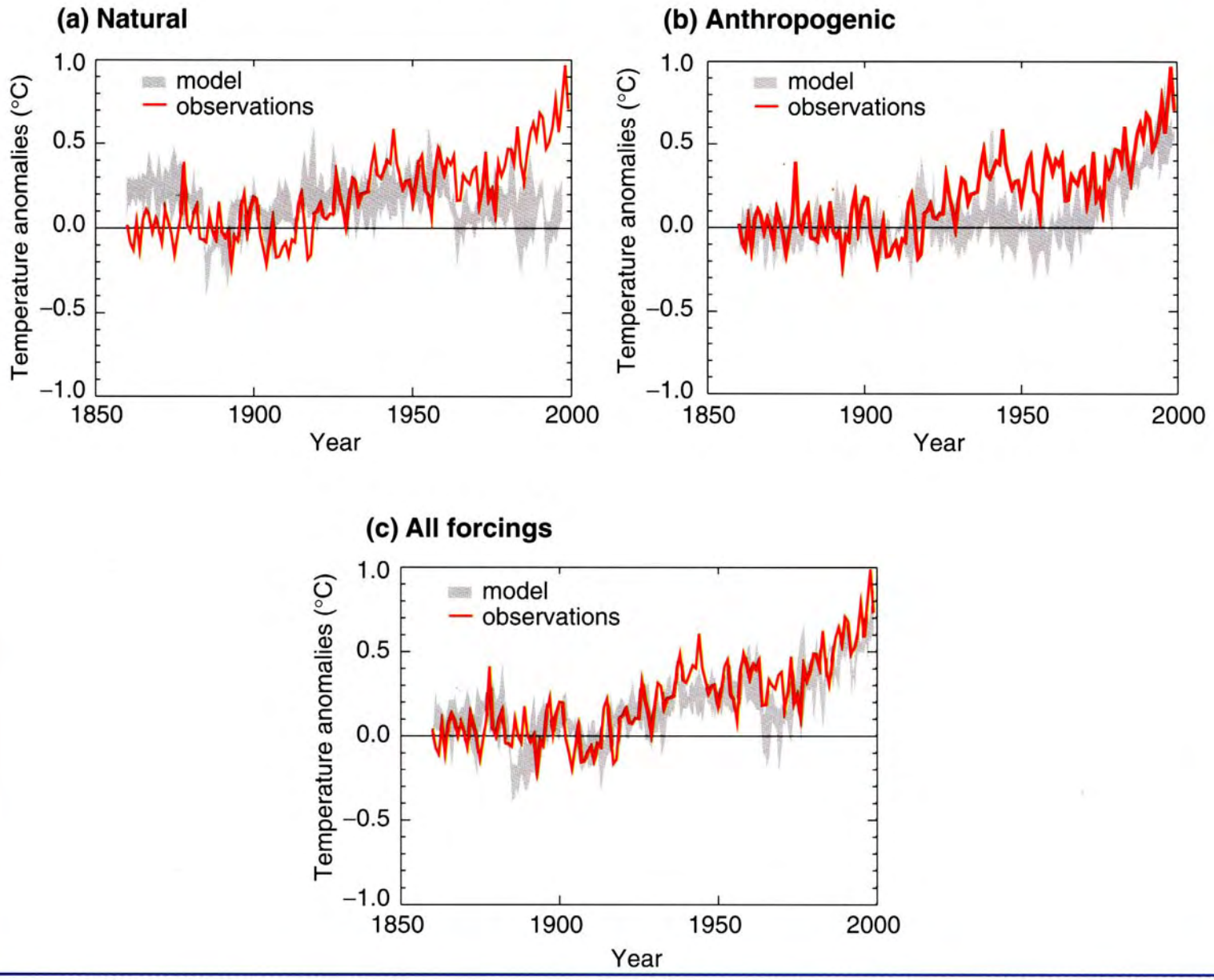
Note that calling the unknown process "aerosols" does not change this statement since aerosols and their impact are unknown to a factor of ten or more; indeed, even the sign is in doubt.

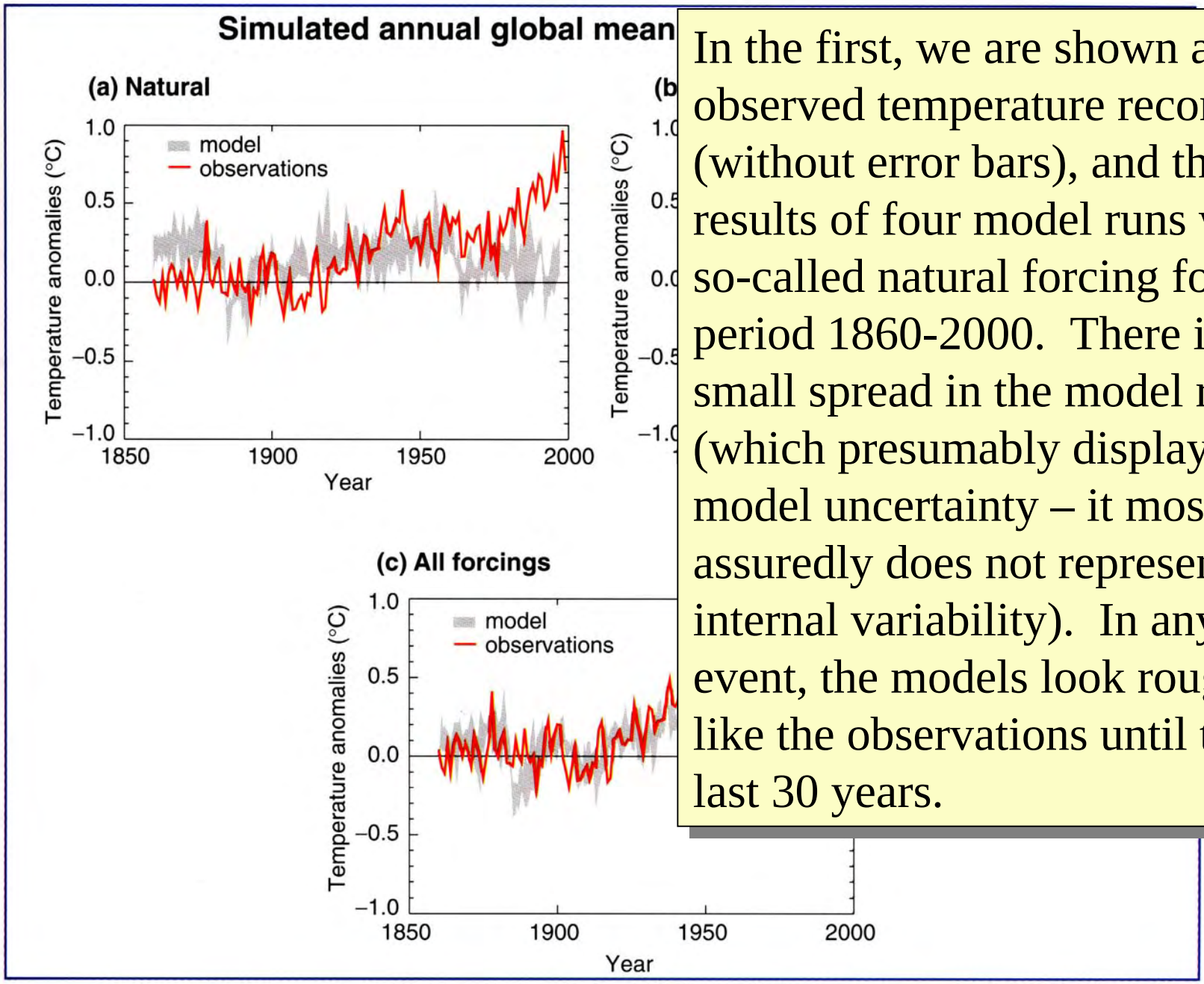
In arguing for climate alarmism, we are choosing the second possibility. Moreover, we are assuming that the unknown cancellation will soon cease.

How is the second possibility supported?

The IPCC TAR made use of a peculiar exercise in curve fitting using results from the Hadley Centre.

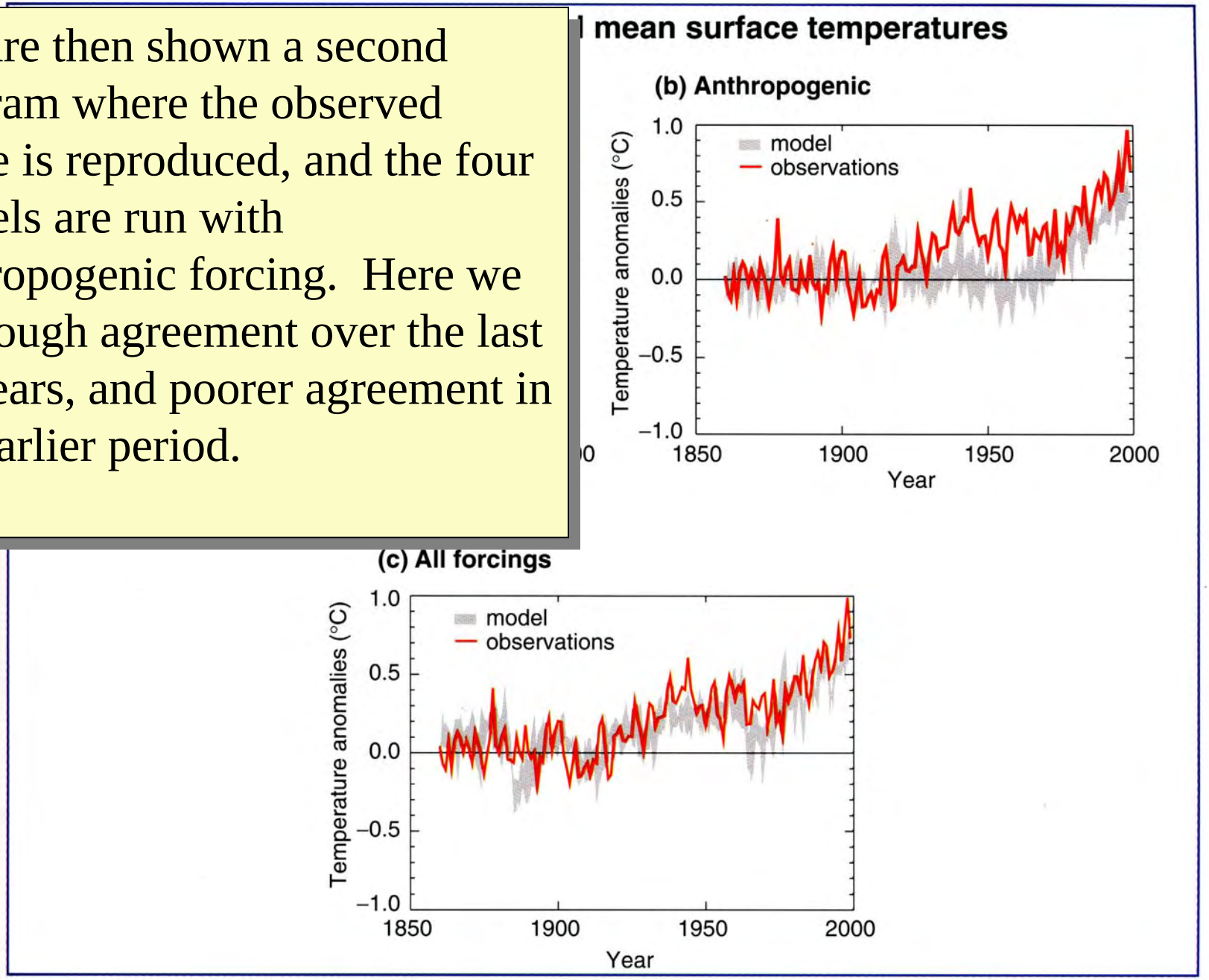
Simulated annual global mean surface temperatures



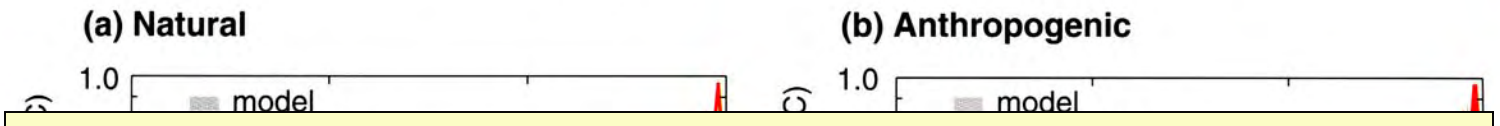


In the first, we are shown an observed temperature record (without error bars), and the results of four model runs with so-called natural forcing for the period 1860-2000. There is a small spread in the model runs (which presumably displays model uncertainty – it most assuredly does not represent internal variability). In any event, the models look roughly like the observations until the last 30 years.

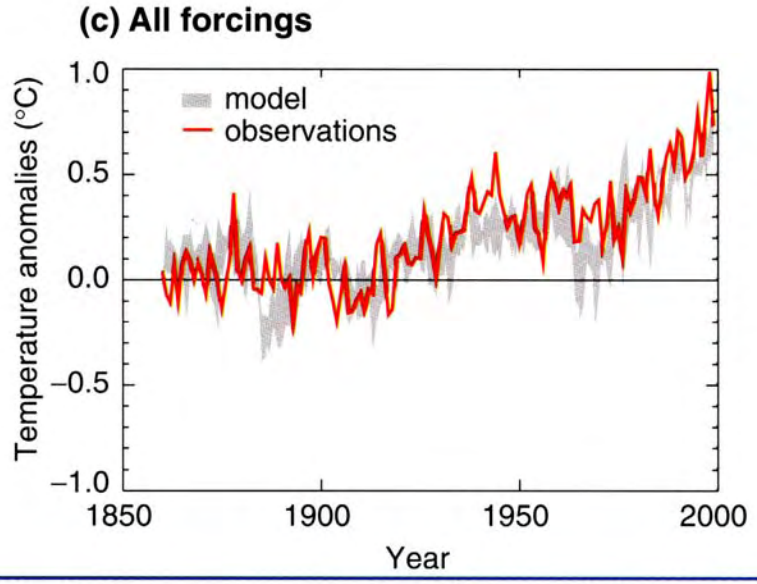
We are then shown a second diagram where the observed curve is reproduced, and the four models are run with anthropogenic forcing. Here we see rough agreement over the last 30 years, and poorer agreement in the earlier period.



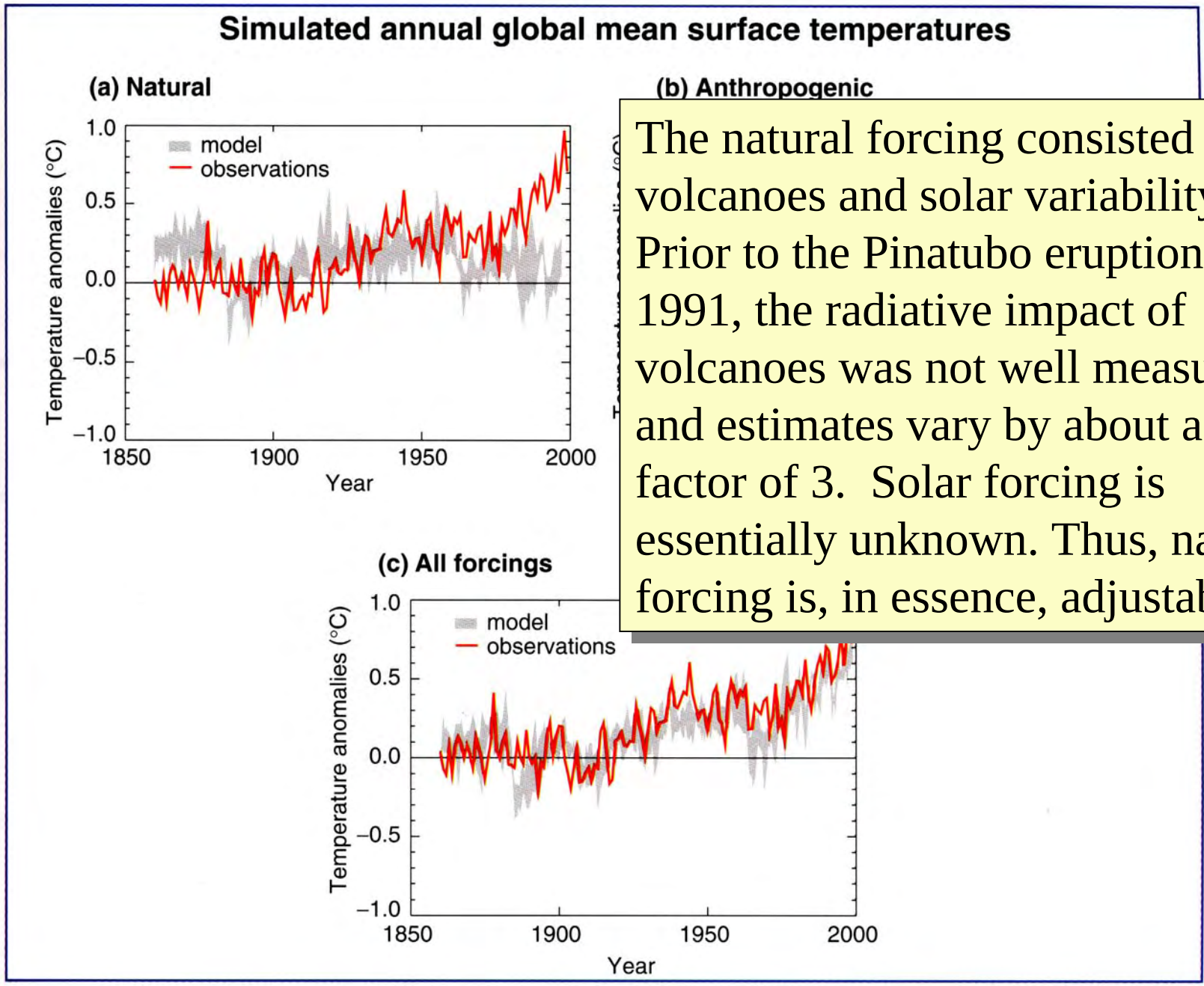
Simulated annual global mean surface temperatures



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. This exercise has sometimes been cited as evidence that models replicate the global mean temperature record of the past century.

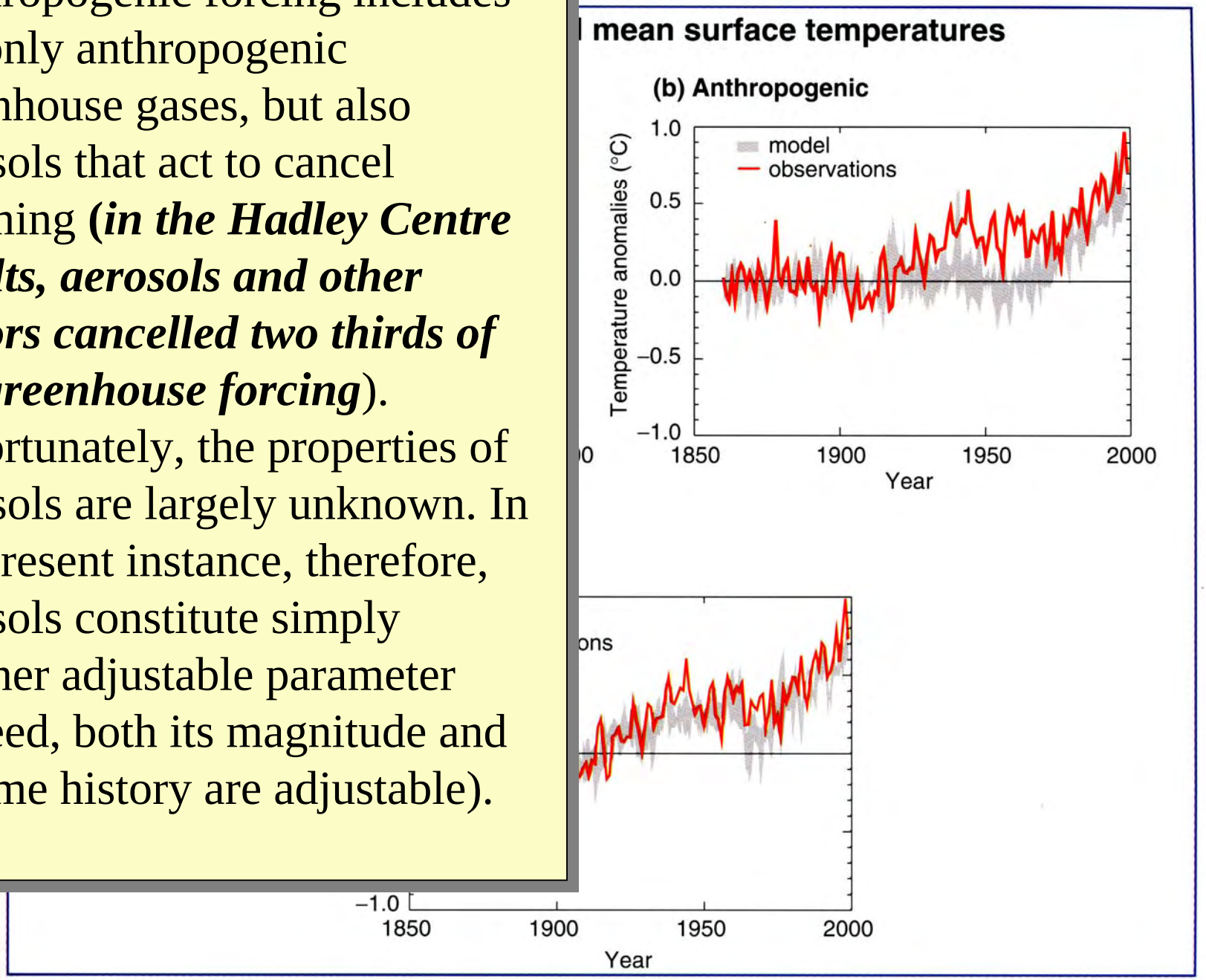


In order to know what to make of this exercise, one must know exactly what was done.



The natural forcing consisted in volcanoes and solar variability. Prior to the 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 results, 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).



Science, 2003

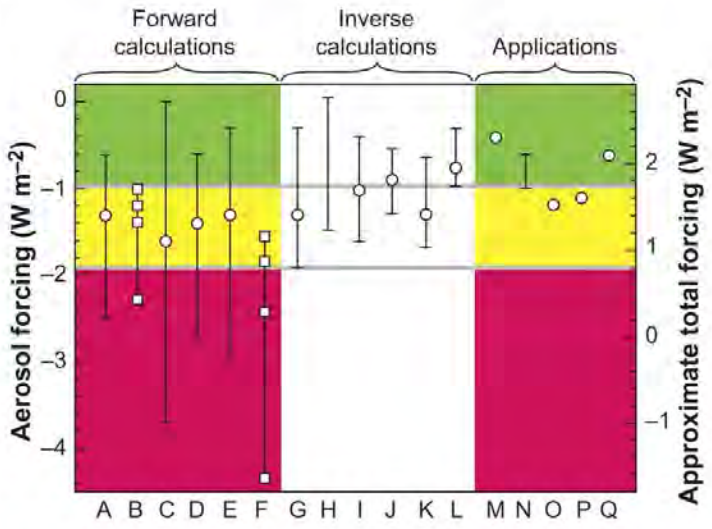
ATMOSPHERIC SCIENCE

Climate Forcing by Aerosols—a Hazy Picture

Theodore L. Anderson, Robert J. Charlson, Stephen E. Schwartz, Reto Knutti, Olivier Boucher, Henning Rodhe, Jost Heintzenberg

The global average surface temperature has risen by 0.6 K since the late 19th century. Ocean heat content has increased, and other climate indices also point to a warming world. Many studies have attributed this warming largely to top-of-atmosphere radiative forcing—a change in planetary heat balance between incoming solar radiation and outgoing infrared radiation—by anthropogenic greenhouse gases (GHGs) (*1*, *2*).

Such attribution studies compare temperature observations to climate model simula-



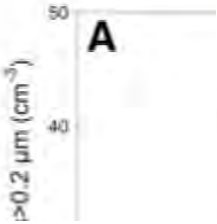
Uncertainties in aerosol forcings. Global-mean anthropogenic aerosol forcing over the industrial era (left axis) as estimated by forward (A to F) and inverse (G to L) calculations

The choice of models with relatively low sensitivity, allowed adjustments that were not so extreme.

This was remarked upon in a recent paper in *Science*, 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.

New uncertainties are always entering the aerosol picture. Some are quite bizarre.

Cellular (and protein) particles injected directly into the atmosphere include fur fibers, dandruff, skin fragments, plant fragments, pollen, spores, bacteria, algae, fungi, viruses, protein "crystals," and more, ranging in size from tens of nanometers to millimeters. Knowledge about



Abundance of Cellular Material and Proteins in the Atmosphere

Ruprecht Jaenicke

Atmospheric aerosols play a crucial role in regulating the global climate and can either enforce or suppress anthropogenic forcing. Their influence on climate forcing (natural as well as anthropogenic) has been estimated (*1*), but a better understanding of the composition and sources of atmospheric aerosols is needed to improve climate models. Here we report evidence that particles injected directly from the biosphere constitute a major portion of atmospheric aerosols.

Cellular (and protein) particles injected directly into the atmosphere include fur fibers, dandruff, skin fragments, plant fragments, pollen, spores, bacteria, algae, fungi, viruses, protein "crystals," and more, ranging in size from tens of nanometers to millimeters. Knowledge about dead or fragmented biological particles in the atmosphere is greatly limited. Tropical forests have been proposed as sources (*2*), and filter samples (*3*) in western Siberia at ground and aloft show ~3 μg/m³ of protein, but cellulose and protein make up only a fraction of primary biological aerosol particles (PBAPs).

The meteorological relevance of cellular particles could be high. Pollen grains attract water at relative humidity well below 100% and thus might act locally as cloud condensation nuclei, influencing the formation of clouds. Other biological particles, including decaying vegetation (and associated bacteria) and marine plankton, are excellent ice nuclei. Ice nuclei trigger precipitation and thereby remove water from the atmosphere. One can easily imagine the influence on global cloud cover, climate forcing and feedbacks, and precipitation distribution if the source and distribution of cellular atmospheric particles varies on a regional to global scale.

Atmospheric chemists and modelers have previously considered the biosphere a minor source of primary particles (*4*), and bioaerosols were thought to occur only in minute concentrations, with insignificant global emissions (*1*) for the year 2000 [56 Tg/year of biogenic carbonaceous aerosols (>1 μm in size) compared with 3300 Tg/year for sea salt and 2000 Tg/year for mineral dust]. Recently, however, a greater contribution to the atmosphere of particles from biological activities of the oceans has been reported (*5*). Still, some surveys (*6*) report as much as 20 to 40% of the aerosol measured as compositionally unidentified.

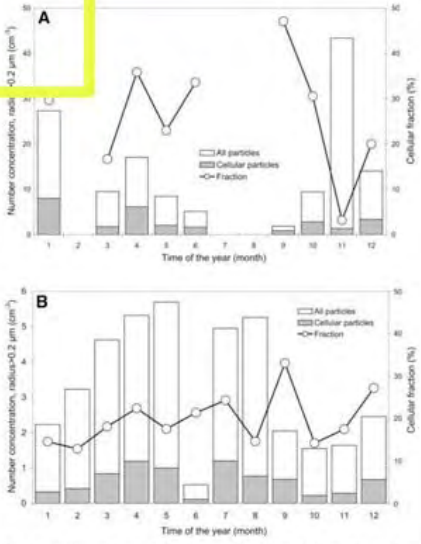


Fig. 1. Observation of PBAPs greater than 0.2 μm in radius. Particles were collected and stained with a protein dye; protein-containing particles then developed a bluish tint. The shape of the particles, the presence of characteristic elements, and their stability in an electron beam (microscope) were also used for identification. Cellular (and all) particles were individually sized and counted. (**A**) In Mainz, Germany (1990 to 1998, at a semirural location), a rather stable concentration plateau was observed. The PBAP fraction varied between 5% and almost 50%. The common assumption that, in winter, the biological fraction and its concentration are low was not confirmed. (**B**) Data from Lake Baikal, Russia (1996 to 1997, at a remote continental location) (*10*) support the year-round stable presence of PBAPs.

We observed PBAPs at several geographical locations and aloft, covering all seasons and many characteristic environments (Fig. 1). These data reveal the complete absence of a pronounced annual cycle, despite the common expectation that concentrations in spring or summer should be higher than in winter. A detailed analysis shows that the fractions of different biological compounds do vary, though: In spring, pollen is more abundant, whereas in winter, decaying cellular matter prevails. We have also observed that resuspension from exposed surfaces acts as a source in winter and in dry periods. This might be important for cellular particle production even from the cryosphere. Measurements in Ireland (1998, at a marine location) (*7*) also indicate a rather high portion for the PBAP fraction, on the order of 25%. Not surprisingly, recent measurements (2001) in a tropical forest reveal that particles smaller than 1 μm compose up to 40%, and particles larger than 1 μm up to 80%, of the total aerosol number concentration of PBAPs (*8*).

The biosphere is thus a major source (*9*) for primary aerosol particles, and cellular (protein-containing) particles are a major fraction of the atmospheric aerosol.

References and Notes

1. J. P. Penner *et al.*, in *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J. T. Houghton *et al.*, Eds. (Cambridge Univ. Press, Cambridge, 2001), pp. 289–348.
2. P. E. Artaxo Netto, *J. Geophys. Res.* **93**, 1605 (1988).
3. A. I. Borodulin, A. S. Safatov, B. D. Belan, M. V. Panchenko, *J. Aerosol Sci.* **34**, S681 (2003).
4. T. E. Graedel, P. J. Crutzen, *Atmospheric Change: An Earth System Perspective* (Freeman, New York, 1993).
5. C. D. O'Dowd *et al.*, *Nature* **431**, 676 (2004).
6. E. Andrews *et al.*, *J. Air Waste Manage. Assoc.* **50**, 648 (2000).
7. C. M. Kenny, S. G. Jennings, *J. Aerosol Sci.* **29**, S779 (1998).
8. B. Graham *et al.*, *J. Geophys. Res.* **108**, 4765 (2003).
9. Our estimate of the strength of the "source biosphere" for atmospheric primary particles, based on observed concentrations, the strength of other sources, and atmospheric residence times, is presently roughly 1000 Tg/year. Earlier estimates reflected a limited view of aerosolized biological components and were focused on organic aerosols.
10. The measurements at Lake Baikal were carried out by T. Khodzer of the Limnological Institute of the Russian Academy of Science at Irkutsk, Russia.
11. This research has been supported over many years by several organizations, naming only the German Science Foundation as a long-time supporter.

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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.

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.’ The scenario being defended is not a likely scenario about which one can have doubts. Rather, it is an unlikely scenario which is difficult to prove to be impossible. Uncertainty is the main defense of the scenario.

To be fair to the authors of Chapter 12 of the IPCC Third Scientific Assessment here is what they provided for the draft statement of the Policymakers Summary: *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.*

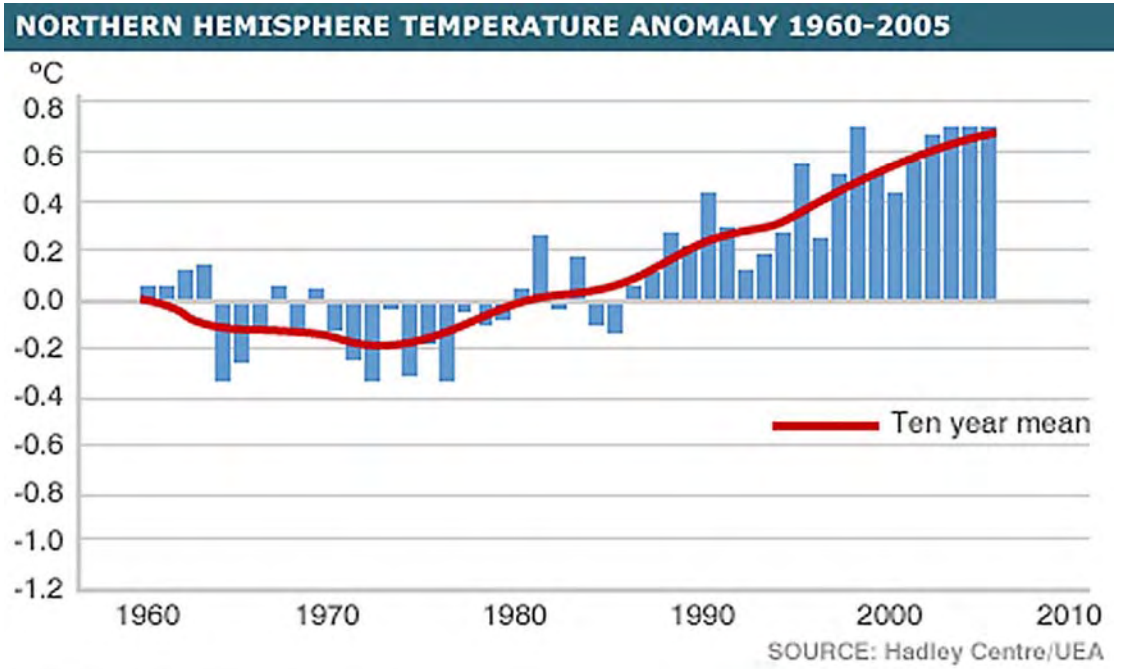
This statement is not too bad – especially the last sentence. To be sure, the model dependence of the results is not emphasized, but the statement is vastly more honest than what the Summary for Policymakers in the IPCC's Third Assessment Report ultimately presented:

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.

It is sometimes said that scientists cannot think of anything else that could account for warming since the global cooling concerns of the early 70's. Given internal variability, these scientists should think some more.

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.***

Claims concerning recent warming trends have been particularly misleading. The records on the right are completely consistent with a rapid rise from 1976 to 1986 and almost no rise since. This would be more like what is referred to as a regime change than a response to global greenhouse warming.



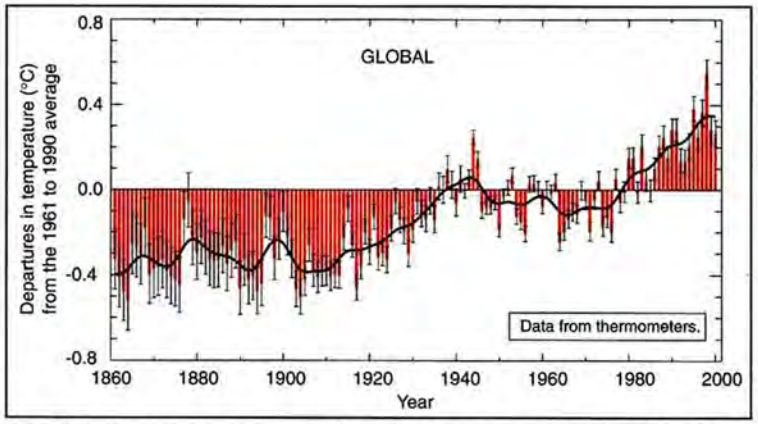
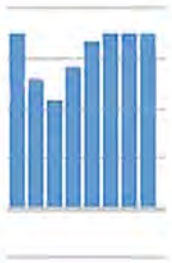


Figure 2: Combined annual land-surface air and sea surface temperature anomalies (°C) 1861 to 2000, relative to 1961 to 1990. Two standard error uncertainties are shown as bars on the annual number. [Based on Figure 2.7c]

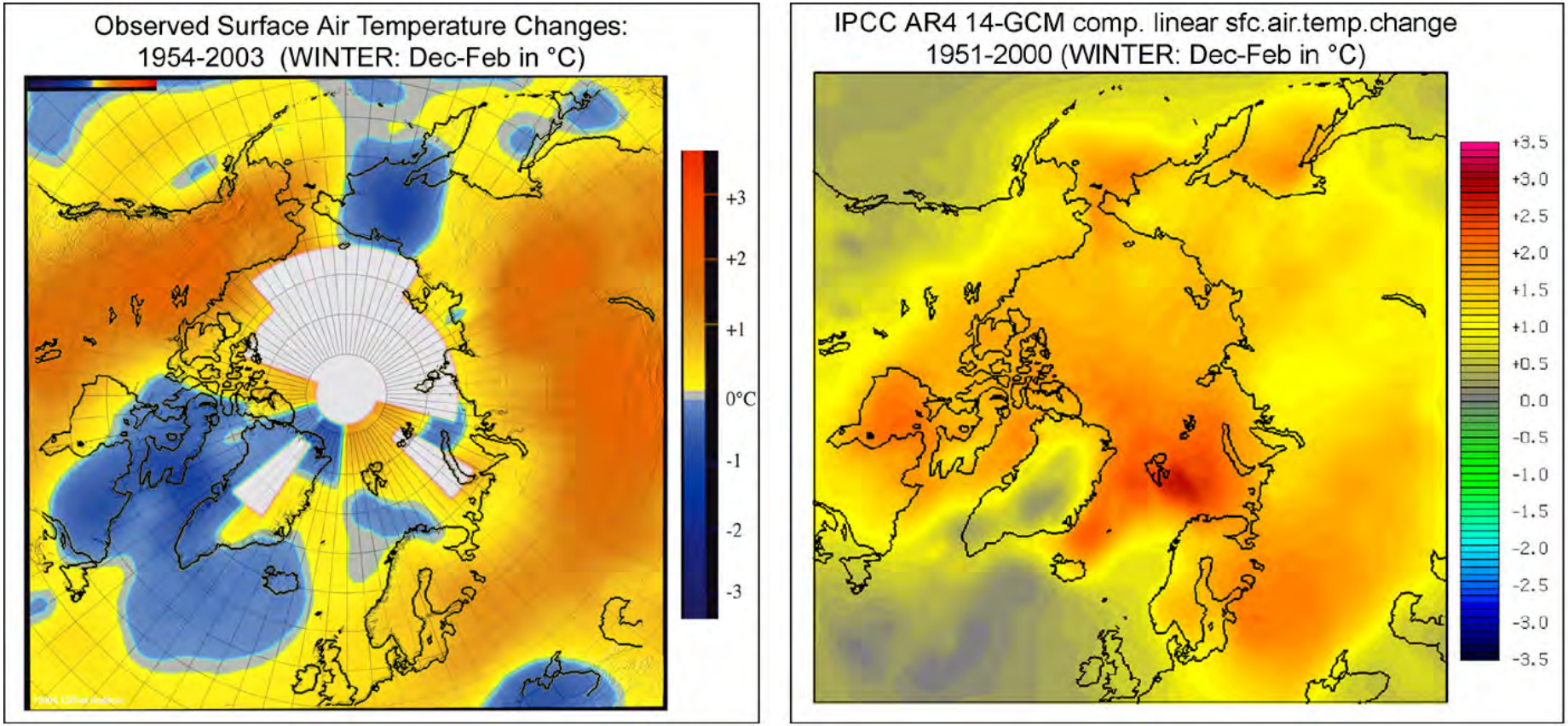


Moreover, the fact that we already have three quarters of the climate forcing expected from a doubling of CO_2 means that *if one truly believes the models*, then we have long since passed the point where mitigation is a viable strategy. What remains is to maximize our ability to adapt.

That the promotion of alarm does not follow from the 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 including increased storminess and variability, Greenland ice flows, dying polar bears, and arctic warming.***



(Figure 2)

We see that parts of the arctic are warming and parts are cooling. However, the models are predicting warming everywhere with a pattern unrelated to the observed pattern. Nonetheless, it has become common to say the models have predicted the warming.

You may have noticed that I focused on extratropical storms in the above example. However, given the relatively heavy hurricane season we've had, the emphasis of late has been on tropical storms. Recent papers suggesting that in a warmer world, such storms may become more powerful , have been seized upon with alacrity by political activists. Needless to add, the articles seized upon have been extremely controversial, but more to the point, no such relation was uncovered for storms reaching land – only for those over water. Moreover, the claim that a warmer world will involve more latent heat release ignores that cumulus mass flux scales by evaporation scaled by specific humidity, and this is unlikely to increase unless relative humidity decreases.

At this point, it is doubtful that we are even dealing with a serious problem. If this is correct, then there is no policy addressing this non-problem that would be cost-effective. Even if we believe the problem to be serious, we have already reached the levels of climate forcing that have been claimed to be serious. However, when it comes to Kyoto, the situation is even worse. Here, there is widespread and even rigorous scientific agreement that complete adherence to the Kyoto Agreement would have no discernible impact on climate regardless of what one believes about climate.

What about the first possibility: namely that the models on which we are basing our alarm are much too sensitive? Not only is this the possibility that scientists would normally have preferred on the basis of Occam's famous razor, but it is also a possibility for which there is substantial support.

I will focus on one line of this evidence: tropical warming in the 90's has been associated with much greater outgoing long wave radiation than models produce. This discrepancy points toward the absence of a strong negative feedback in current models.

The discrepancy has been confirmed by at least four independent groups.

Chen, J., B.E. Carlson, and A.D. Del Genio, 2002: Evidence for strengthening of the tropical general circulation in the 1990s. *Science*, **295**, 838-841.

Del Genio, A. D., and W. Kovari, 2002: Climatic properties of tropical precipitating convection under varying environmental conditions. *J. Climate*, **15,** 2597–2615.

Wielicki, B.A., T. Wong, et al, 2002: Evidence for large decadal variability in the tropical mean radiative energy budget. *Science*, **295**, 841-844.

Lin, B., T. Wong, B. Wielicki, and Y. Hu, 2004: Examination of the decadal tropical mean *ERBS* nonscanner radiation data for the iris hypothesis. *J. Climate*, **17**, 1239-1246.

Cess, R.D. and P.M. Udelhofen, 2003: Climate change during 1985–1999: Cloud interactions determined from satellite measurements. *Geophys. Res. Ltrs.*, **30**, No. 1, 1019, doi:10.1029/2002GL016128.

Clement, A.C. and B. Soden (2005) The sensitivity of the tropical-mean radiation budget**.** *J. Clim***., 18,** 3189-3203**.**

The preceding papers attempted to either attribute the discrepancy to circulation changes or to ‘unknown’ cloud properties – except for the last paper.

Clement and Soden (2005) showed that changes in dynamics could not produce changes averaged over the tropics. They showed this using 4 separate models, but it had been shown theoretically in

Chou, M.-D. and R.S. Lindzen (2004) Comments on “Examination of the Decadal Tropical Mean ERBS Nonscanner Radiation Data for the Iris Hypothesis”. *J. Clim.* 18, 2123-2127.

Clement and Soden also showed that the discrepancy could be resolved by allowing convective precipitation efficiency to increase with surface temperature.

Such a dependence is at the heart of the iris effect which was first found by

R.S. Lindzen, M.-D. Chou, and A.Y. Hou (2001) Does the Earth have an adaptive infrared iris? *Bull. Amer. Met. Soc.* **82**, 417-432.

and was theoretically predicted by

Sun, D-Z. and R.S. Lindzen (1993) Distribution of tropical tropospheric water vapor. *J. Atmos. Sci.*, **50**, 1643-1660.

In LCH, we attempted to do examine how tropical clouds responded to changing surface temperature, and found that existing satellite data was only marginally capable of dealing with this issue. The results, however, suggested that there were strong negative feedbacks -- counter to what models suggest. It was moreover, easy to show that models in no way replicated the cloud behavior that was observed.

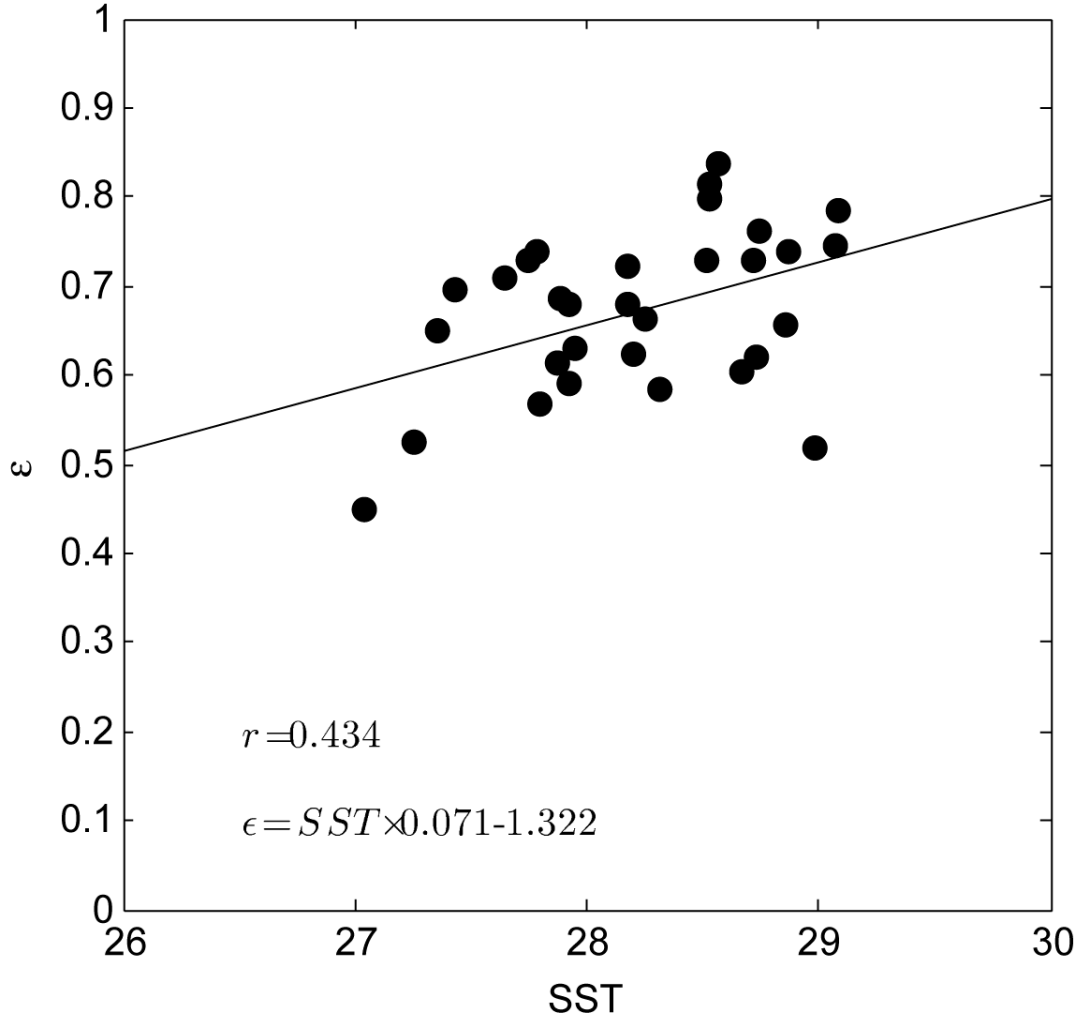
It now turns out that the rigorous measurement of precipitation can be done with ground based radar.

Ground based radar allows the almost continuous measurement of precipitation and the separation of convective precipitation from stratiform precipitation. In the tropics, both types of precipitation originate in condensation within cumulus towers. However, condensation that does not form precipitation is carried aloft as ice which is detrained to form cirrus from which the condensate eventually falls as stratiform precipitation.

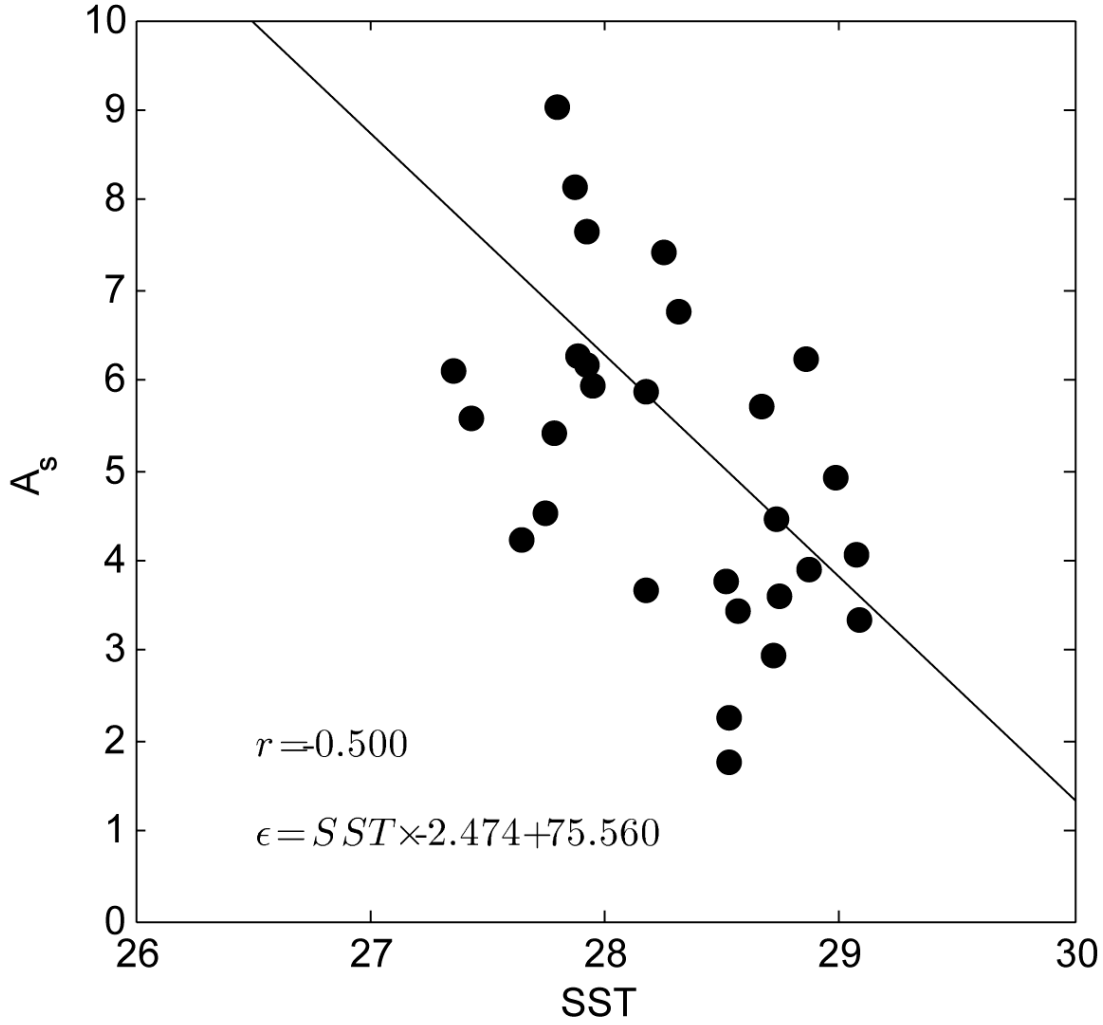
Precipitation efficiency is given by the relation

$$e = \frac{\text{convective precipitation}}{\text{convective precipitation + stratiform precipitation}}$$

Using data from Kwajalein Atoll in the western Pacific, we were able to study how *e* varies with sea surface temperature.



In addition, the Kwajalein radar allows one to explicitly look at the area of stratiform rain per unit of convective mass flux.



We see that *e* increases about 7.1% per degree C increase in SST (compared with 7.5% estimated by Sun and Lindzen, 1993), and that this increase is associated with a decrease in normalized stratiform area of about 25% per degree C (which is a bit larger than what was estimated from space observations by Lindzen, Chou and Hou, 2001).

This basically confirms the iris effect, and the fact that models have greatly exaggerated climate sensitivity because, in contrast to models, nature, itself, acts to limit rather than exaggerate the influence of added greenhouse gases. It should be added that the Kwajalein results have been further confirmed by data from all over the tropics obtained by the TRMM satellite.

What is the implication of these simple results?

The primary implication is that for over 25 years, we have probably based not only our worst case scenarios but even our best case scenarios on model exaggeration.

As far as I can tell, the main question we ought to be confronting is how long the momentum generated by this issue will prevent us from seeing that it has been an illusion based on model error.

In the mean time, we can continue to play our parts in the modern version of “The Emperor’s New Clothes.” Let us hope that our descendents will be amused rather than horrified.