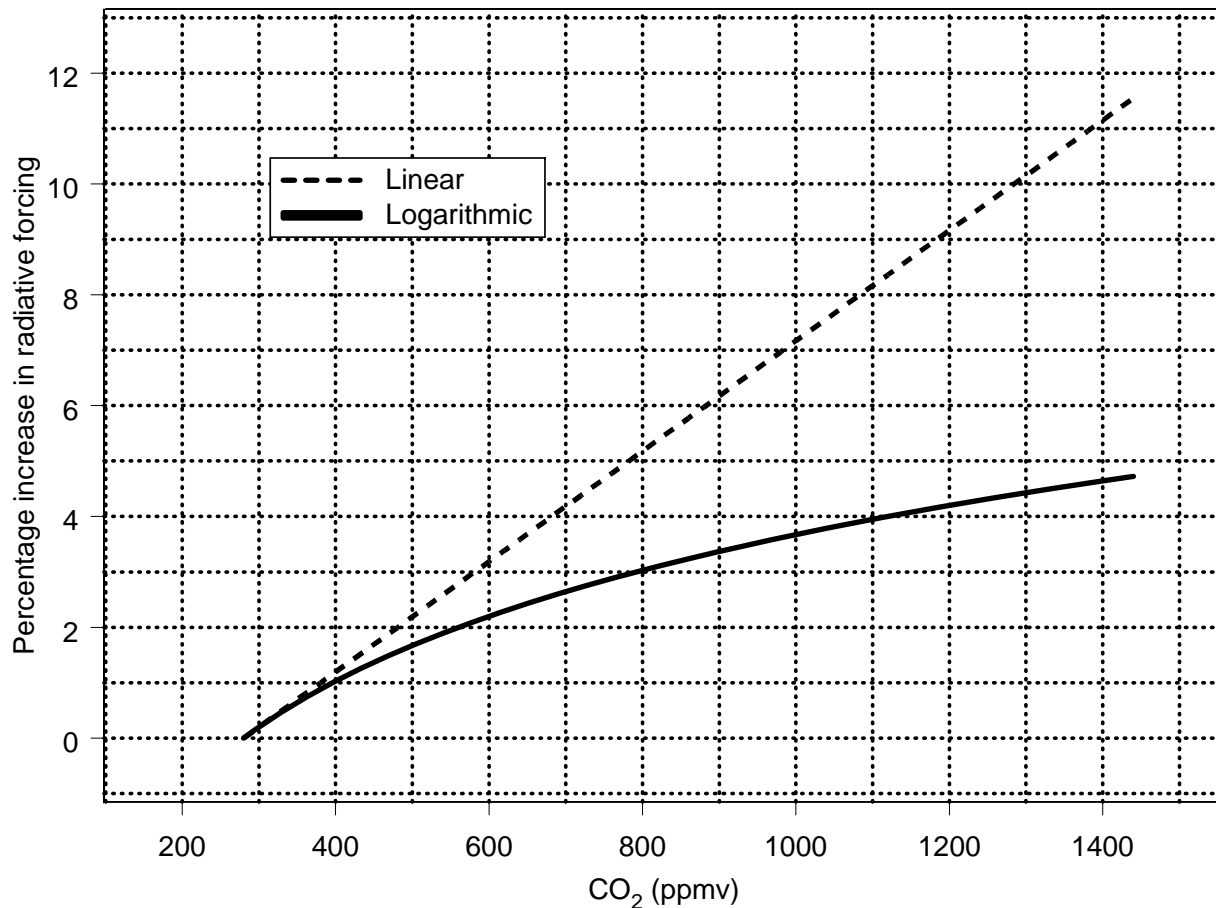


In terms of climate forcing, greenhouse gases added to the atmosphere through mans activities since the late 19th Century have already produced **three-quarters** of the radiative forcing that we expect from a doubling of CO₂. The main reasons for this are

1) CO₂ is not the only anthropogenic greenhouse gas - others like methane also contribute; and

2) the impact of CO₂ is nonlinear in the sense that each added unit contributes less than its predecessor. For example, if doubling CO₂ 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 CO₂ by an additional 580 ppmv rather than by another 290 ppmv. At present, the concentration of CO₂ is about 380 ppmv.

It should be stressed that we are interested in climate forcing, and not simply levels of CO₂.



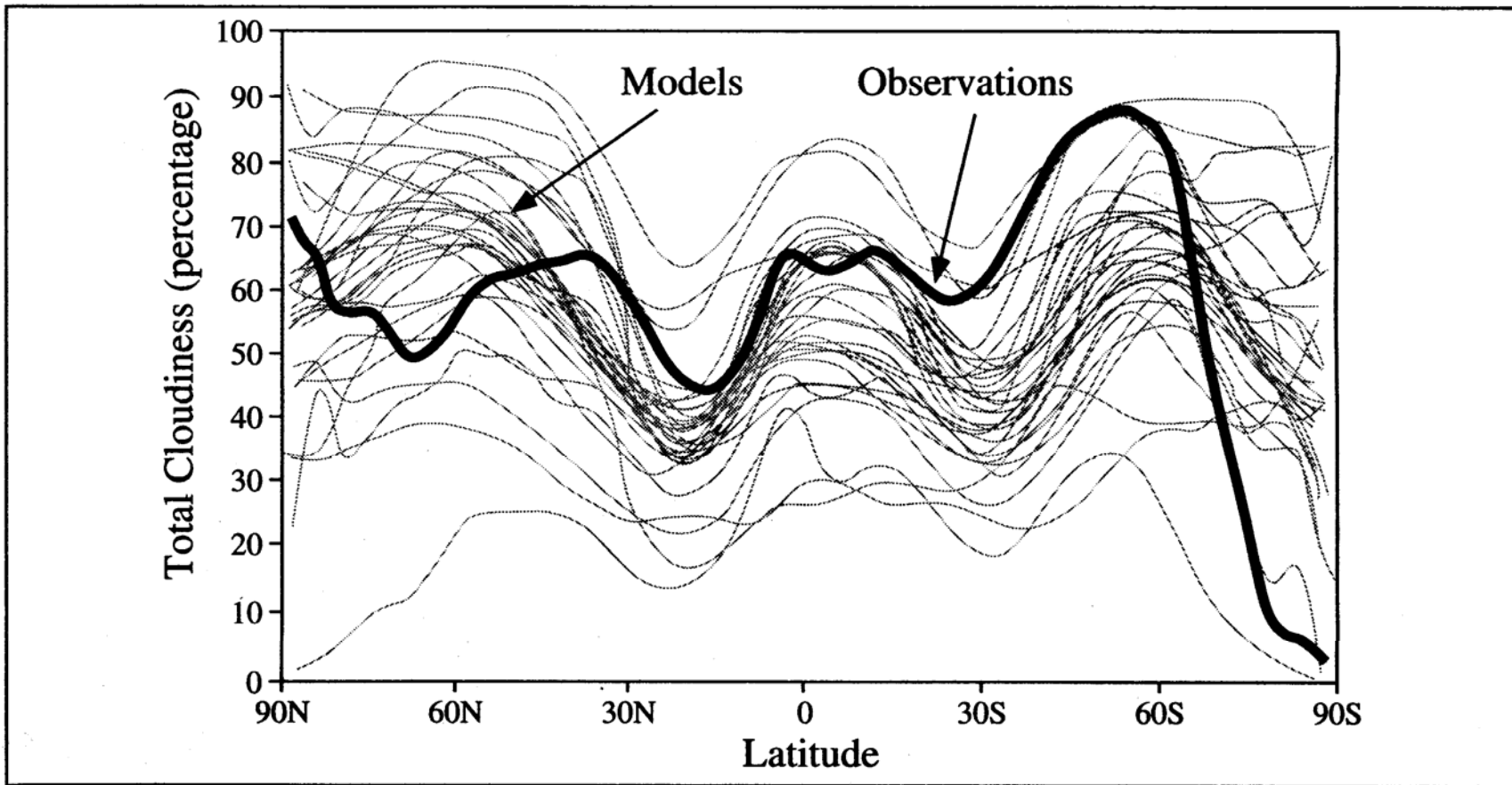
The CO₂ forcing follows the logarithmic rather than the linear curve. Note that the logarithmic curve rises ever more slowly as the CO₂ increases.

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 CO₂ of about 4C (which is much larger than what one expects the simple doubling of CO₂ 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 CO₂

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 CO₂ that is important, but rather the impact of man made greenhouse gases on climate.
2. Although we are far from the benchmark of doubled CO₂, 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.

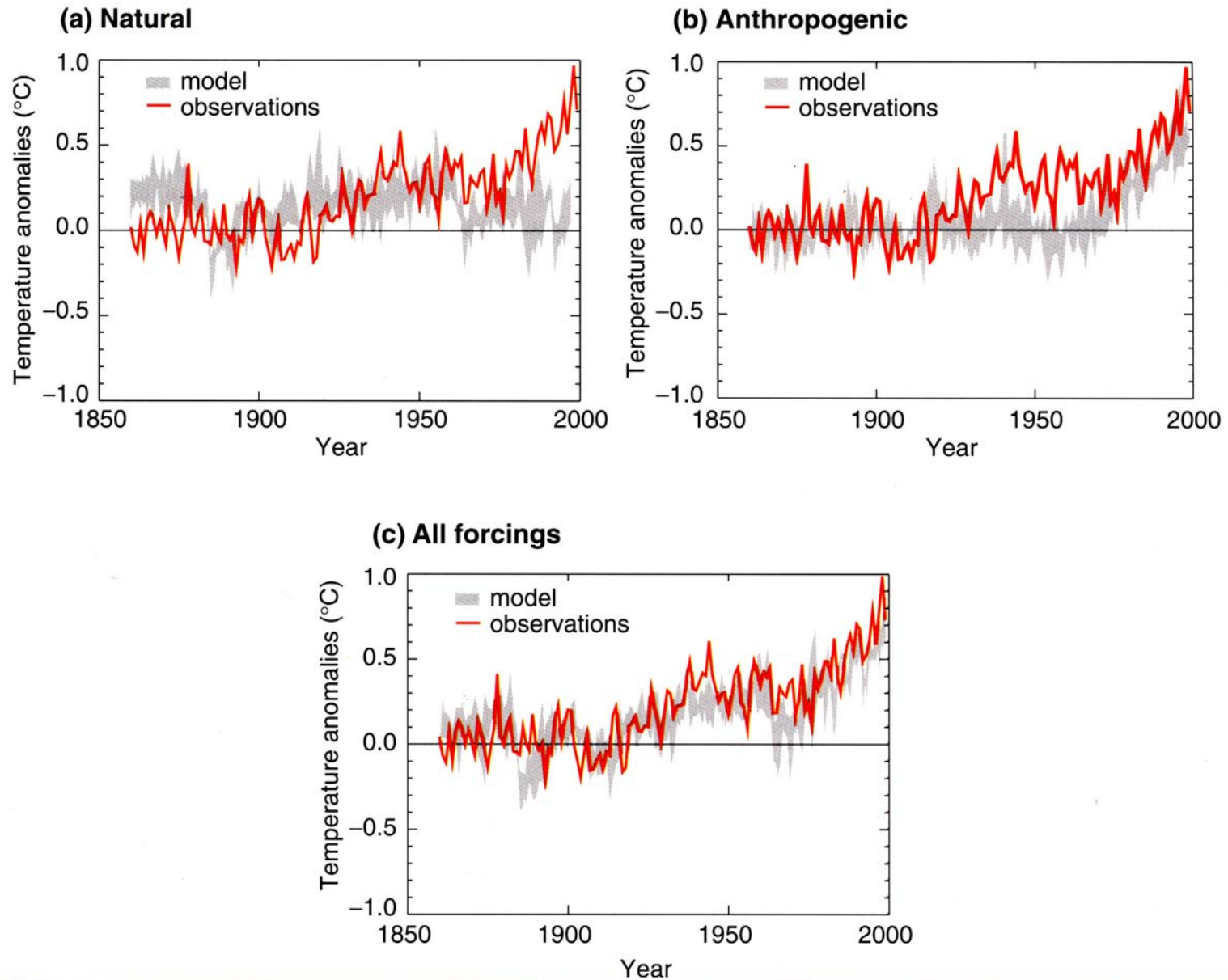
Note that calling the unknown process “aerosols” does not change this statement since aerosols and their impact are unknown to a factor of ten or more; indeed, even the sign is in doubt.

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

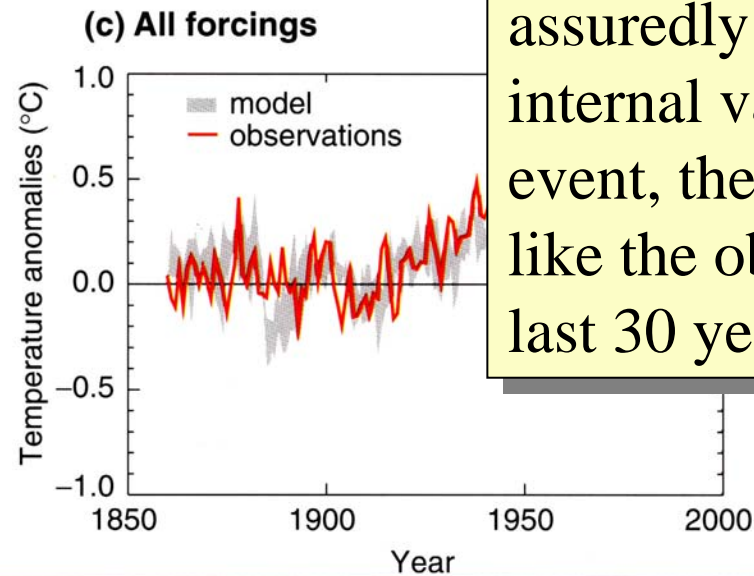
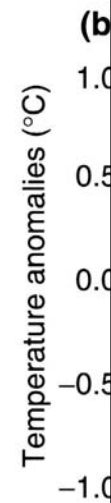
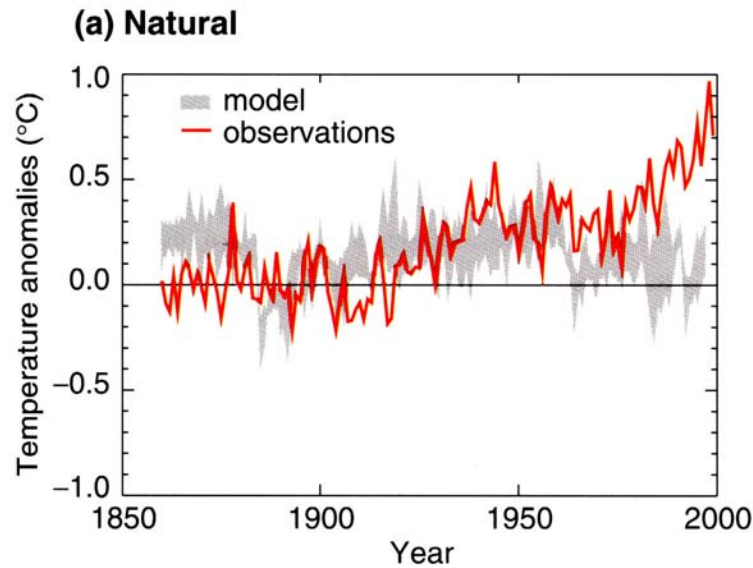
How is the second possibility supported?

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

Simulated annual global mean surface temperatures



Simulated annual global mean

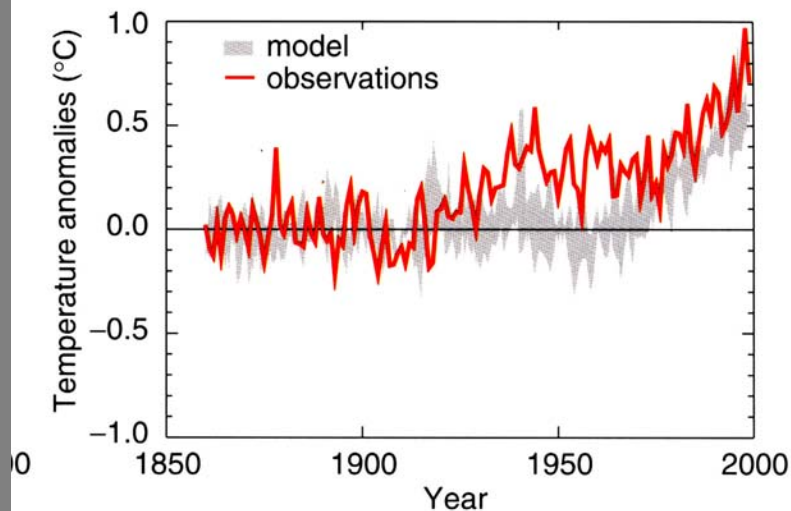


In the first, we are shown an observed temperature record (without error bars), and the results of four model runs with so-called natural forcing for the period 1860-2000. There is a small spread in the model runs (which presumably displays model uncertainty – it most assuredly does not represent internal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

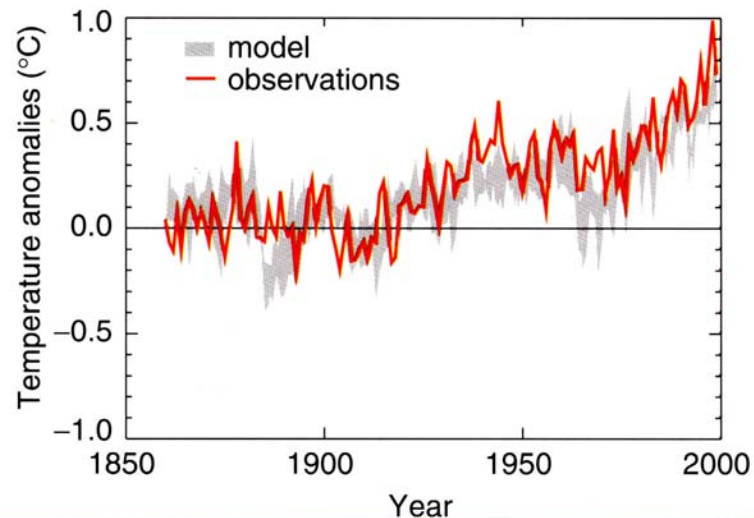
We are then shown a second diagram where the observed curve is reproduced, and the four models are run with anthropogenic forcing. Here we see rough agreement over the last 30 years, and poorer agreement in the earlier period.

mean surface temperatures

(b) Anthropogenic

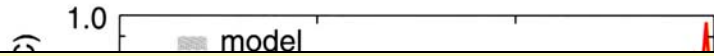


(c) All forcings

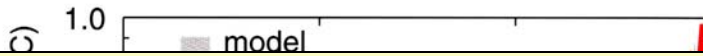


Simulated annual global mean surface temperatures

(a) Natural

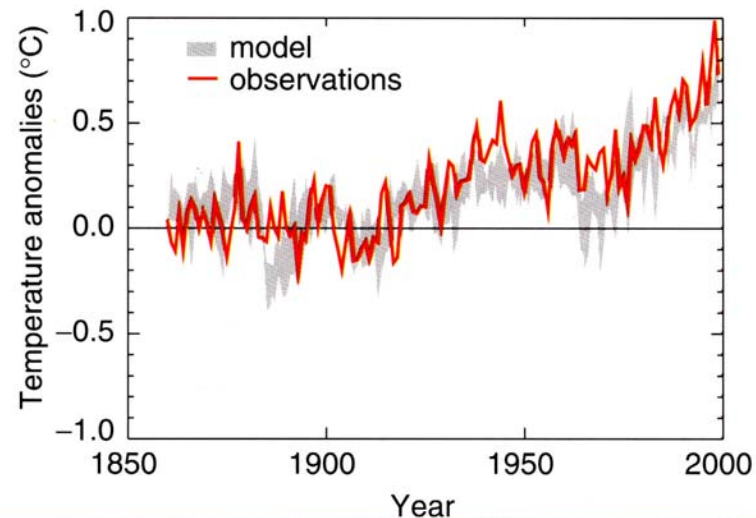


(b) Anthropogenic



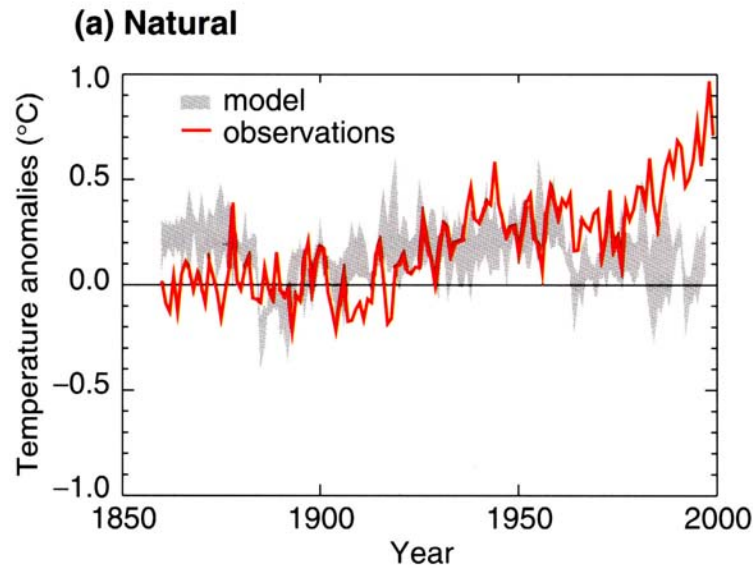
Finally, we are shown the observations and the model runs with both natural and anthropogenic forcing, and, voila, there is rough agreement over the whole record. It should be noted that the models used had a relatively low sensitivity to a doubling of CO₂ of about 2.5C.

(c) All forcings



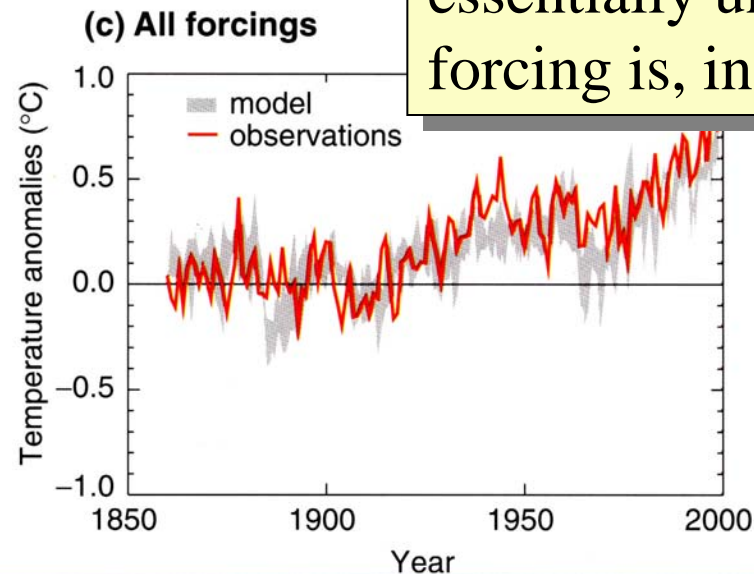
In order to know what to make of this exercise, one must know exactly what was done.

Simulated annual global mean surface temperatures



(b) Anthropogenic

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.

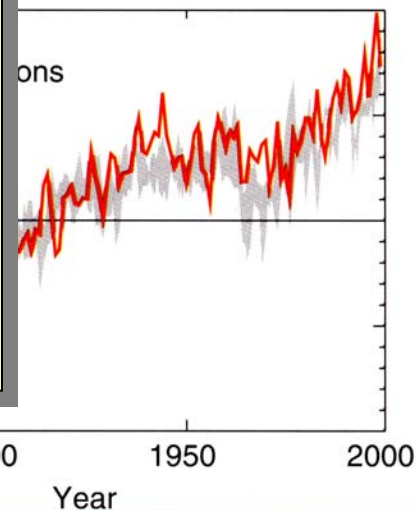
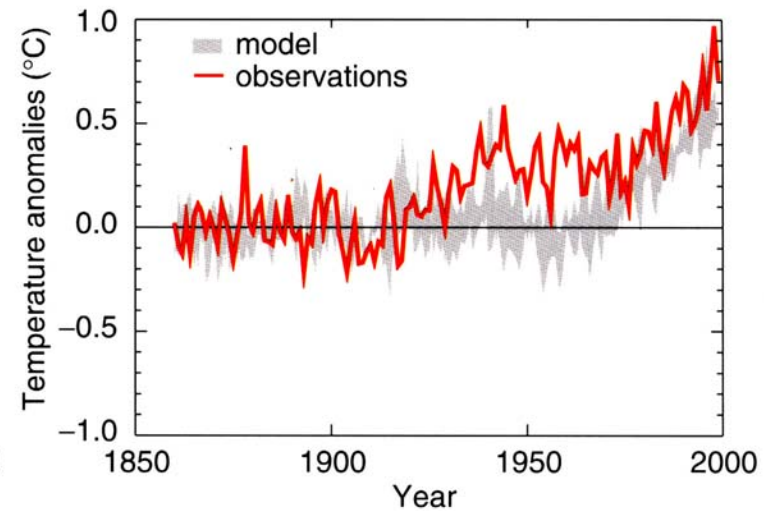


Anthropogenic forcing includes not only anthropogenic greenhouse gases, but also aerosols that act to cancel warming (*in the Hadley Centre results, aerosols and other factors cancelled two thirds of the greenhouse forcing*).

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).

mean surface temperatures

(b) Anthropogenic



Science, 2003

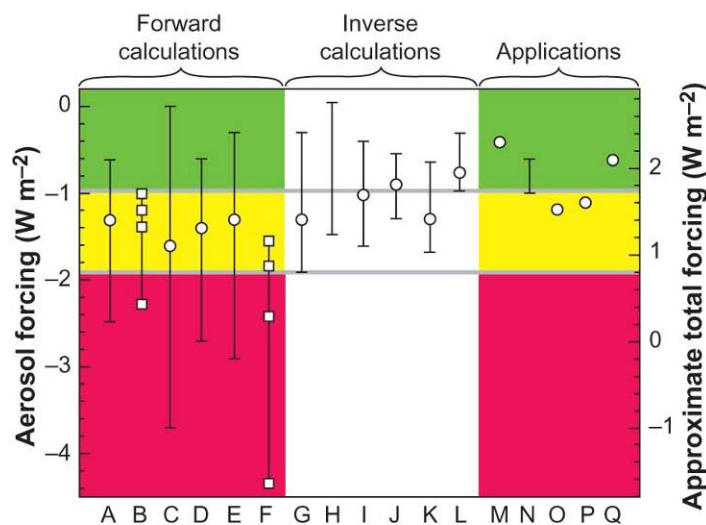
ATMOSPHERIC SCIENCE

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-



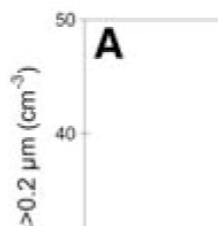
Uncertainties in aerosol forcings. Global-mean anthropogenic aerosol forcing over the industrial era (left axis) as estimated by forward (A to F) and inverse (G to L) calculations

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



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 ocean 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 $\sim 3 \mu\text{g}/\text{m}^3$ 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 con-

sidered 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 ($>1 \mu\text{m}$ 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.

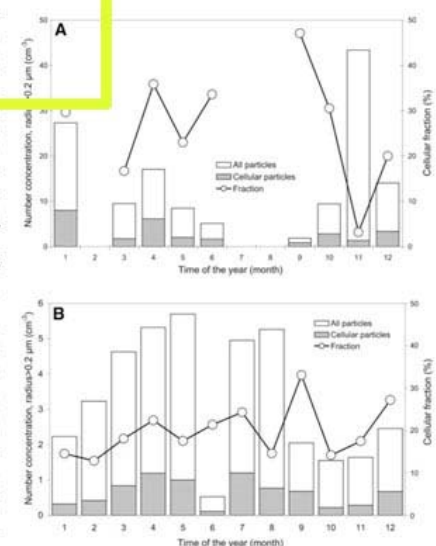


Fig. 1. Observation of PBAPs greater than $0.2 \mu\text{m}$ in radius. Particles were collected and stained with a protein dye; protein-containing particles then developed a bluish tint. The shape of the particles, the presence of characteristic elements, and their stability in an electron beam (microscope) 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.

Abundance of Cellular Material and Proteins in the Atmosphere

Ruprecht Jaenicke

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 $1 \mu\text{m}$ compose up to 40%, and particles larger than $1 \mu\text{m}$ 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.

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- 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.
- The measurements at Lake Baikal were carried out by T. Khodzher of the Limnological Institute of the Russian Academy of Science at Irkutsk, Russia.
- 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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Institut für Physik der Atmosphäre, Universität Mainz, 55099 Mainz, Germany. E-mail: jaenicke@uni-mainz.de

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 CO₂ 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 CO₂.

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 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.

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.

Moreover, the fact that we already have three quarters of the climate forcing expected from a doubling of CO₂ 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.