The Decline and Fall of Global Warming

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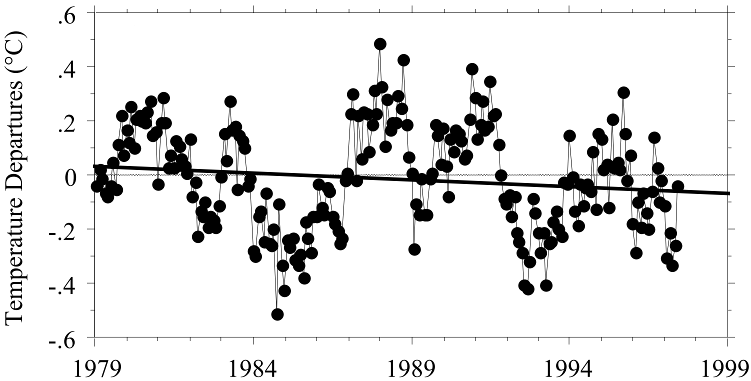
Any argument for an expensive and potentially disruptive policy to reduce greenhouse-gas emissions based upon forecasts of global warming requires strong scientific backing. In the course of the last year, the requisite science largely disappeared. Yet, many nations—especially the European Union and the United States—continue to propose policies such as mandatory reductions in greenhouse-gas emissions that are increasingly hard to justify in light of what is now known about greenhouse science. This paper details the scientific evolution of this issue.

The global temperature history based upon measurements from satellites that became operational in 1979 (figure 1) leaves little doubt that a dramatic warming of the atmosphere is not occurring. While it is not a measure of ground temperatures, it faithfully reproduces global mean temperatures measured between 5,000 feet and 30,000 feet by weather balloons. This history shows a statistically significant net cooling when averaged over the 18.5 year period of record. As reported in the issue of *New Scientist* for July 19, 1997, "This is not what is predicted by the computerized climate models on which all estimates of

Figure 1 Global temperature trends measured by satellites that became operational in 1979 show a statistically significant cooling trend in the lower atmosphere.



global warming depend" (Pearce 1997). Yet, on June 27, 1997, President William Clinton in his address to *Earth Summit + 5* told the United Nations: "The science is clear and compelling: we humans are changing the global climate." Mr. Clinton is probably correct but the changes are so small and of such a benign nature that they are insufficient to support any expensive or disruptive policy. If anything, they indicate that the best policy is probably to do nothing.

Climate change: an inevitable result of human activity

Ever since the first hominid cleared a patch of land, the climate has been changed. Only the scale of the effect has increased with technological evolution. Today, the earth's landscape bears the marks of a large-scale modern human civilization; so does its climate. Large, expansive cities, built with billions of tons of concrete, store the heat of the day, raising temperatures by several degrees. Downstream of these heat islands, thunderstorms become larger and more violent (Huff 1978).

In areas that were once desert, oases now exist with water piped in from hundreds of miles to keep them green. This water eventually makes its way into the air where there was none before. Fully one-third of the small rise in sea level during the last century—glibly attributed to "global warming"—is actually a result of the "dewatering" of continents by man's activity (IPCC I1996). Huge areas of monocrop agriculture stretch across previously diverse regions, changing the colour of the land, changing the moisture balance, changing the regional climate, and feeding increasing billions of people an increasingly better diet.

These influences on the climate are mainly local, in most cases not extending far past the reaches of the underlying landscape change. Over the course of the last 150 years, however, human influences on the climate have increased greatly. Primarily through the burning of fossils fuels for energy, we have altered the chemical make-up of the earth's atmosphere. Carbon dioxide and other radiatively active gases, such as methane (from bovine flatulence and rice-paddy agriculture), and chlorofluorocarbon refrigerants, have increased to the point where they may have subtly changed the climate. The change has been inadvertent—a necessary result of human technological advancement.

These gases absorb infrared radiation emanating from the surface of the earth, which is warmed by solar heating. Since these gases redirect (re-radiate) this energy, an increasing fraction goes back down towards the surface of the earth as the concentrations of these gases increase. This phenomenon is called the greenhouse effect. Humans have very slightly enhanced this natural process that keeps the surface of the planet some 33°C warmer than it otherwise would be.

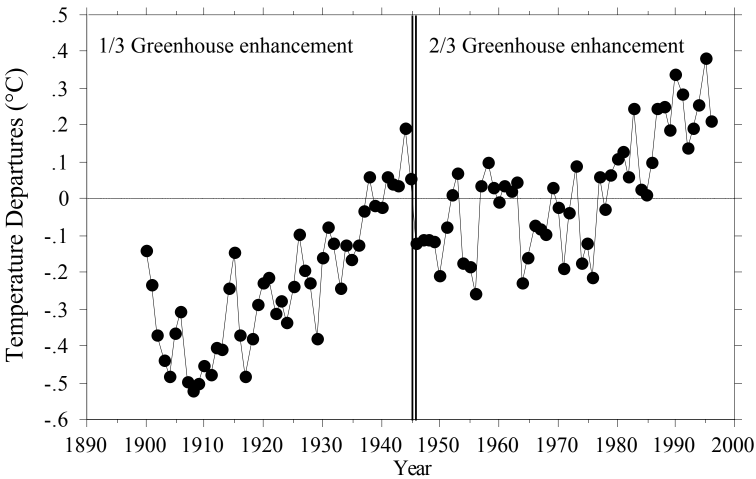
The prime greenhouse gas in the atmosphere is water vapor, the concentration of which is determined by the planetary mean temperature. Over 30°C of the natural greenhouse effect results from water, and only about 1.5°C of the total of 33°C is caused by carbon dioxide, which is the primary greenhouse gas produced by human activity.

The scientific ferment about climate change has never been about the question whether human beings could (or would) change climate. That is an inevitable consequence of known physics. But, the more important questions—how much and in what fashion—is clearly a matter of great debate. The facts that have emerged in the last year, in spite of a public climate of fear, are very reassuring. How much? Relatively little. How? In a benign or perhaps even beneficial fashion.

Background

In 1990, the first scientific assessment of the United Nations' Intergovernmental Panel on Climate Change (IPCC) stated that

Figure 2 The ground-based temperature history in the last 100 years (IPCC 1995) shows that at least half of the warming occurred before World War II. The large changes in the greenhouse effect occur in the postwar period.



"when the latest atmospheric models are run with the present atmospheric concentrations of greenhouse gases, their simulation of climate is generally realistic on large scales" (IPCC 1990: xxviii).

This statement created considerable disagreement in the scientific community. As later shown by Mitchell *et al.* (1995), the most popular type of climate model referred to in the IPCC's statement as producing simulations that were "generally realistic" predicted that, by now, the earth's temperature should have warmed between 1.3°C and 2.3°C (the larger figure refers to the northern hemisphere), as a result of changes in greenhouse gases caused by human activity.

Clearly this has not been the case. Figure 2 shows the surface temperature history of the northern hemisphere, calculated from land-based thermometers and published by the same United Nations' panel. The warming in the record is about 0.6°C, or more than three times less than what was predicted. At least half of that warming was prior to major changes in the greenhouse effect, i.e., before 1945. Everything else being equal, then, the maximum contribution of the enhanced greenhouse effect was 0.3°C.

Figure 3 The statistically significant drop in global average temperature (figure 1) is largely a result of changes in the southern hemisphere, which, because it is virtually free of the cooling effects of sulfates produced by human activity, should have warmed in a consistent fashion from greenhouse gas changes.

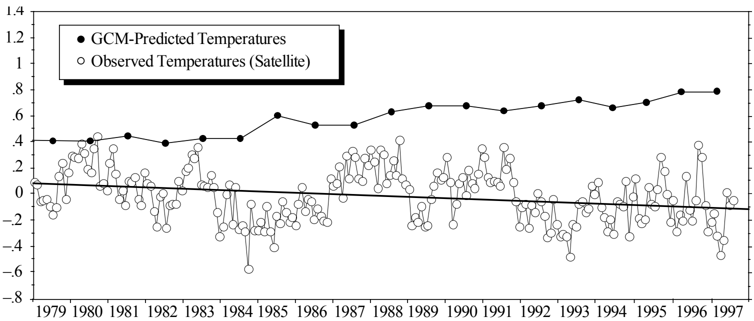


Figure 3 shows the satellite temperature history from the southern hemisphere. The statistically significant decline in global temperatures (cf. figure 1) is largely a result of this negative trend in the southern hemisphere.

As noted in the opening section of this paper, weather balloon temperature anomalies in the 5,000 foot to 30,000 foot layer and satellite readings show a remarkable annual correspondence since the two records became concurrent in 1979 (figure 4).

Figure 4 Temperatures measured by the MSU satellites (closed circles) match up nearly perfectly with temperatures measured by weather balloons in the layer between 5,000 and 30,000 feet (open circles).

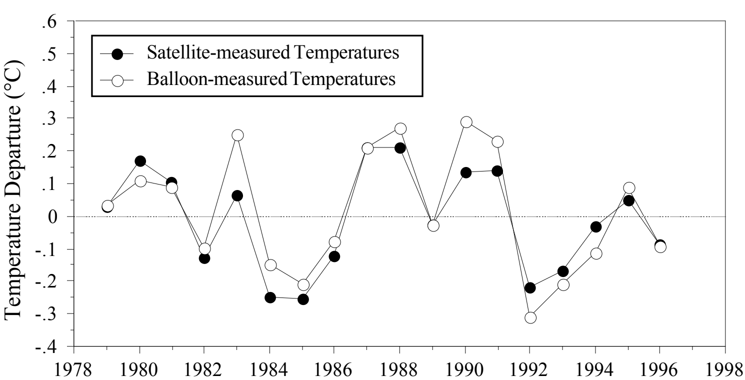
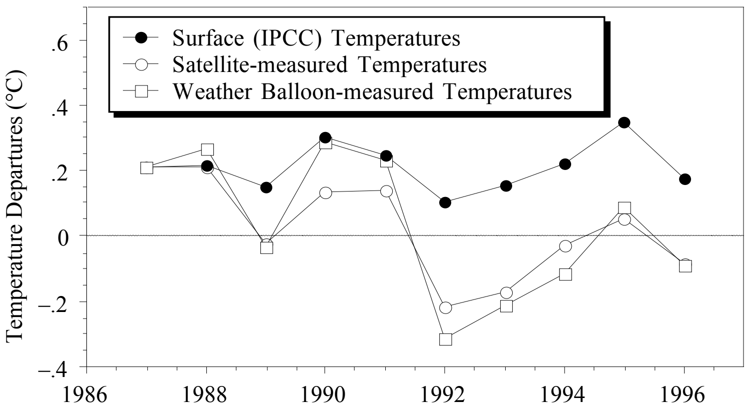


Figure 5 Surface, satellite-measured, and weather balloon records (5,000–30,000 ft) all show no warming in the last decade.



Through 1996, both showed no warming trend whatsoever. None of the three temperature histories (and they are the only three that exist), surface, satellite, or radiosondes (weather balloons) in the analogous level to the satellite, show any net warming in the last decade (figure 5).

While there has been no overall warming in these records, regional patterns of warming are present. The pattern is particularly amplified when seasonal differences are examined. The difference in temperature trends (winter minus summer) in the satellite data shows that the warming has been predominantly occurring in the coldest air masses—over Siberia in the wintertime (Figure 6). The IPCC data on surface temperatures, which has sufficient coverage since the mid-1940s over most of the northern hemisphere, shows a similar pattern of relative (winter minus summer) warming over a large part of northern Eurasia and northwestern North America, which are the source regions for the coldest air masses (Figure 7).

Greenhouse theory is consistent with this observation, inasmuch as the water vapor and carbon dioxide behave similarly over a considerable portion of their absorption spectra, and these air masses are virtually devoid of water vapor. Small changes in the absorption in these wavelengths have a logarithmically decreasing effect on temperature as the carbon-dioxide

Figure 6 Winter warming minus summer warming in the satellite data. The concentration in the mid-latitudes of the Northern Hemisphere shows that, in general, it is the coldest air masses that have changed.

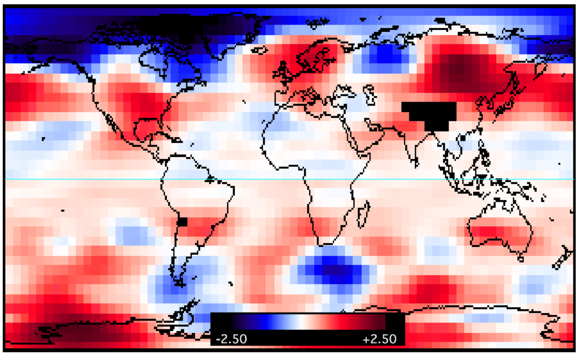
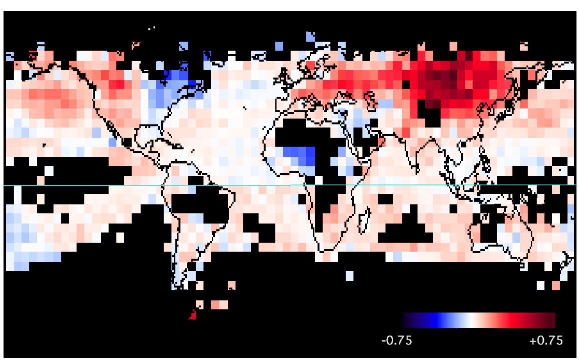


Figure 7 Winter warming minus summer warming in the surface temperature record over the last 50 years. This clearly shows that the bulk of climate change is in the coldest air masses that most people experience—in Siberia and northwestern North America.



concentration increases. In other words, the first increments of either water vapor or carbon dioxide to these very dry air masses results in substantial warming. In general, warm air masses contain much more moisture, so they are not as sensitive to changes in the concentration of carbon dioxide.

Observations, therefore, confirm that what little, if any, greenhouse warming has occurred, is characterized by the following:

- according to the satellites, warming is not "global," inasmuch as there is a slight (but statistically significant) negative trend
- according to ground-based thermometers and the satellites, the character of observed warming is a change in the coldest air masses.

These data undermine the IPCC's 1990 statement about the correspondence between observed climate and what was predicted by climate models.

Five years later, the IPCC produced its second assessment of climate change (IPCC I 1996). It contains a remarkable sentence that I have never seen quoted in the mainstream media:

> When increases in greenhouse gases only are taken into account ... most [general circulation models] produce a greater mean warming than has been observed to date, unless a lower climate sensitivity is used ... There is growing evidence that increases in sulfate aerosols are partially counteracting the [warming] due to increases in greenhouse gases (IPCC I 1996: 295).

The new consensus might be paraphrased as follows: either it is not going to warm up as much as earlier indicated or something, like sulfate aerosols, is hiding the warming.

Why observed warming was less than predicted: the sulfate hypothesis

The sulfate explanation for the lack of warming is simple in principle. The finely divided sulfate particles directly reflect away solar radiation and also serve to brighten existing clouds. They do not reside in the atmosphere for long, so their cooling is primarily in the northern hemisphere, where almost all are produced by the combustion of fossil fuel, which contains small amounts of sulfur.

Recently, the sulfate hypothesis has been challenged. Hansen *et al.* (1995) reported that the direct cooling effect of sulfates was too small to account for the lack of observed warming. Further, the magnitude of the indirect cooling (from cloud brightening) is highly speculative, as Hansen *et al.* (1997) argued that a "semi direct" heating of the lower atmosphere by aerosol absorption may minimize the indirect cloud effect. Most recently, Hobbs (1997) reported that air samples from the eastern United States showed a predominance of soot (carbon), which should have created a net warming, rather than sulfates, which should have caused cooling.

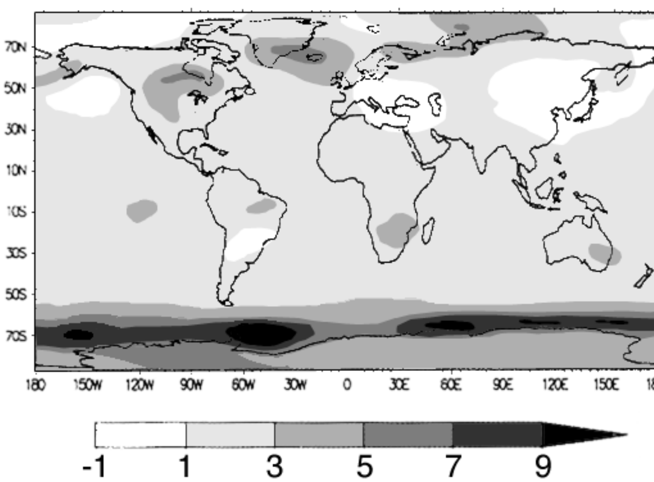
Further, the internal inconsistency of the attempts to explain the lack of planetary warming leads inexorably to the default argument: the planetary surface temperature is simply not as responsive to small changes in the natural greenhouse effect as it was once thought (modeled) to be.

Without sulfate aerosols, modeling results indicate that the planetary mean temperature should have risen between 1.3°C and 2.3°C as a result of the greenhouse enhancement (Mitchell 1995). The observed surface rise of 0.6°C in the last 100 years and the lack of any warming observed by the satellites demonstrate quite decidedly the lack of connection between observations and forecasts.

The sulfate hypothesis has been prominently championed by Wigley (1989), Hansen and Lacis (1990), Taylor and Penner (1994) and most recently by Santer *et al.* (1996). There are, however, several problems with the models that they propose, notably with the changes that they assume in warming radiation.

It is generally thought that human beings have increased the amount of radiation affecting the planetary surface by about 2.5 watts per square meter (W/m^2) as a result of the changes in greenhouse gases. But Taylor and Penner (1994) used a positive greenhouse change of 1.26 W/m^2 or half of the known value of 2.45. Further, they assume a cooling from sulfate aerosol of –0.9 W/m^2, which is much more than most other estimates. The combined net change (greenhouse warming + sulfate cooling) is only 0.3 W/m^2, far less than any estimate used at the time they published their model. Since then, the further reduced estimates of sulfate cooling (Hanson *et al.* 1995, 1997; Hobbs 1997) have made this model even more unrealistic.

Figure 8 Ultimate warming for today's concentration of greenhouse gases and sulfate aerosols calculated when the Taylor and Penner (1994) model is forced to use the observed changes in the greenhouse effect. It is clear that this model simply predicts too much warming.

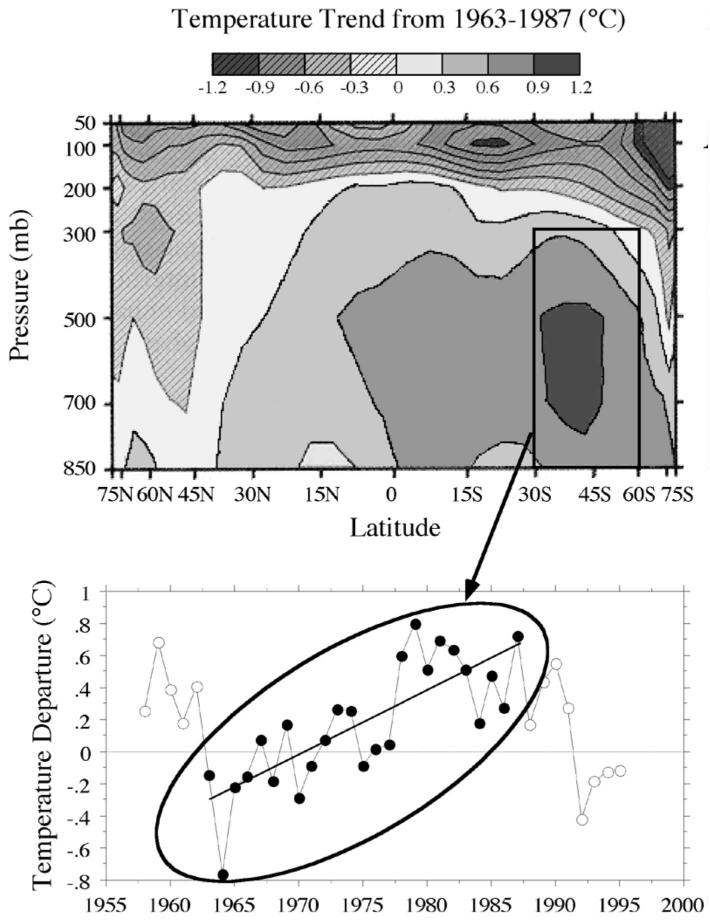


Even if one allows this exaggerated estimate for the cooling effect of sulfates, using a linear estimation of the temperature change when Taylor and Penner's model is forced to use the observed changes in the greenhouse effect of 2.50 W/m^2 yields an equilibrium warming solution that is clearly unrealistic (figure 8), especially over the Southern Ocean, where temperatures rise nearly 10°C.

The study done by Santer *et al.* (1996), although it is often cited as the definitive evidence for the sulfate + greenhouse hypothesis, was especially controversial (Michaels and Knappenberger 1996) because the portion of the troposphere that showed the most dramatic warming during the study period (1963–1987)was found to show no change whatsoever when the entire radiosonde record (1958–1995) was used (figure 9).

It is instructive to use the recent lower estimates of sulfate cooling. Hobbs (1997) implies a global effect of approximately –0.25 W/m^2, resulting in a net greenhouse-sulfate forcing upon a model of approximately 2.25 W/m^2 (2.50 minus 0.25).

Figure 9 Observed warming (°C) in Santer *et al.* (1996) from 1963 to 1987 (top). The highlighted region in the Southern Hemisphere shows the strong observed warming. The entire temperature history over the same region from 1957 to 1995 shows no significant warming trend (bottom). However, the period that was chosen for study by Santer *et al.* (filled circles) warms dramatically.



It is generally assumed, based upon a series of empirical arguments, that the sensitivity of the planetary surface to greenhouse changes is about one degree (C) for every one watt change in the radiation affecting the surface. But the United Nations

1995 statement opens the possibility that this is wrong, when it says that climate models for changes in the greenhouse effect tend to produce too much warming "unless a lower climate sensitivity is used."

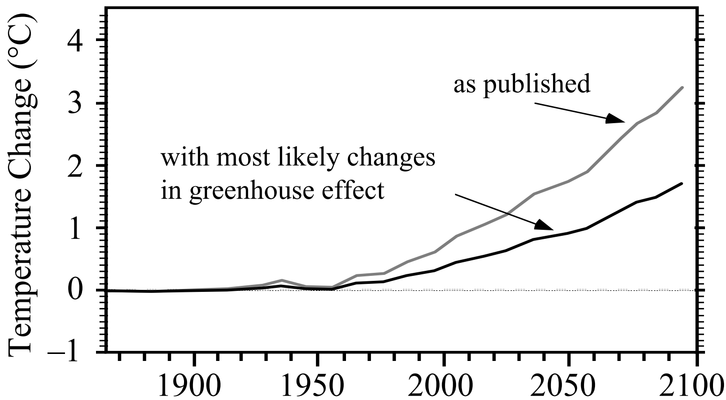
Assuming again that one-half of the observed warming (0.3°C) is from greenhouse changes, either the sensitivity to greenhouse changes is much lower than current estimates of $1°C/W/m^2$ or the thermal lag of the ocean is enormously long; i.e. the 2.25 degrees of warming would take hundreds of years to appear. If that is the case, any policy attempt to mitigate or prevent global warming is simply futile.

Schlesinger and Jiang (1991) and others have argued that response times for ocean heating are fairly short, on the order of 40 to 60 years. The relatively small observed warming that can be ascribed to greenhouse changes would then yield a lower sensitivity (assuming a 1950 net greenhouse change of 30 percent of the total net: $0.3 \times 2.2 = 0.66 W/m^2$). At $1°C/W/m^2$ sensitivity, this implies a warming of about 0.6°C plus nearly twice that for the increase since 1950, or a total of roughly 1.6°C for effectively doubling the natural carbon dioxide greenhouse effect. The implication is that, unless sulfate aerosols are exerting a much greater effect than is now thought, the sensitivity is about 25 percent of the previously accepted value. This would reduce warming projections for doubled concentrations of atmospheric carbon dioxide from a mean ultimate value of nearly 4°C down to 1°C, assuming a continuation of small sulfate cooling.

It is interesting that this rather simple calculation is not appreciably different from the results from two recent general circulation models. Mitchell and Johns (1997) and the National Center for Atmospheric Research (NCAR; described in Kerr 1997) have new models that, when adjusted for the median emission scenarios from IPCC (IPCC I 1996), produce 1.7°C (Mitchell and Johns) and 1.3°C (NCAR) of additional warming to the year 2100.

Unfortunately, neither of these results were published with realistic changes in the greenhouse effect produced by human activity (readers may speculate as to why this might have occurred). Mitchell and Johns (1997) uses 859 ppm effective carbon dioxide concentration by the year 2050, and NCAR increases the effective CO_2 concentraton by 1 percent per year. IPCC (IPCC I 1996) gives the most likely value for the year 2050 of approximately 604 ppm, and it is well known that the in-

Figure 10 Temperatures predicted by the UKMO model (Mitchell and Johns 1997). The grey line uses an unrealistic CO_2 concentration of 859 ppm by 2050. The black line estimates the warming if the most likely concentration, as given by IPCC I 1996, is used.



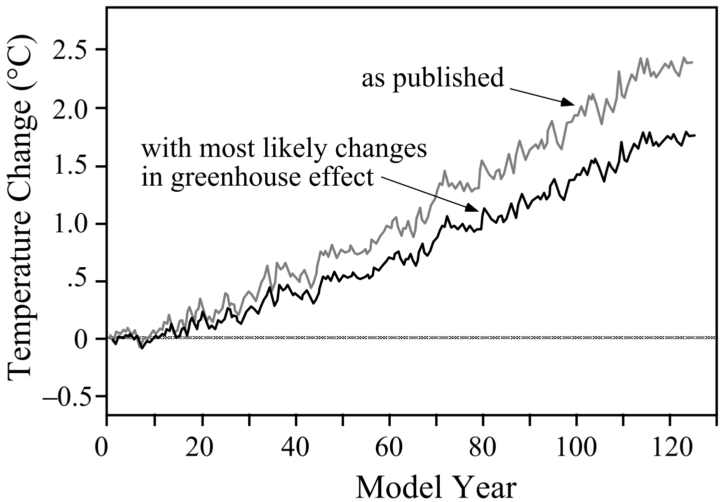
crease in combined effect from all greenhouse gases is not in excess of 0.7 percent/year (and probably somewhat less). In other words, these models project future changes in the greenhouse effect itself that are extreme; it is not surprising that they then predict more warming than they should.

Figures 10 and 11 give the results of these models as published and as adjusted for the more realistic greenhouse changes. It is noteworthy that the NCAR result is achieved without sulfate cooling. Clearly the implied sensitivity is much less than 1°C/W/m^2. Assuming the 50-year ocean lag and a greenhouse change of 4.5 W/m^2 by the middle of the twenty-first century, the implied sensitivity is again found to be approximately 25 percent of the previously accepted value.

Why observed warming was less than predicted: the solar hypothesis

Friis-Christensen and Lassen (1991) and, more recently, Lean *et al.* (1995) have found some rather striking correlations between the temperature history of northern hemisphere during the twentieth century and the history of solar activity during the same period. Lean *et al.* (1995) estimate that approximately one-half of the warming of the last 130 years was a result of solar

Figure 11 Temperatures predicted by the new NCAR model. The dashed line increases effective CO_2 by 1 percent per year but a more realistic increase is 0.7 percent per year. The solid line estimates the temperatures using the more realistic value. The nominal starting time is around 1965.



changes. In particular, much of the warming of the early twentieth century—prior to the greenhouse enhancement—appears to be a product of the sun.

The solar argument also favours the concept of reduced sensitivity to greenhouse gases produced by human activity. It leaves the same 0.3°C of warming in the last 100 years as a residual, possibly to be explained by greenhouse changes. This gives the same low implied sensitivity and reduced estimates of overall warming that are consistent with the lowest forecasts now being generated by general circulatory models with realistic greenhouse changes.

Conclusion

Remember IPCC's statement in their recent (1995) volume as noted above:

> when increases in greenhouse gases only are taken into account . . . most [general circulation models] produce a greater mean warming than has been observed to date, unless a

> lower climate sensitivity is used ... There is growing evidence that increases in sulfate aerosols are partially counteracting the [warming] due to increases in greenhouse gases.

It is highly likely that attempts will continue to be made to explain the lack of warming with some compensating emission like sulfate aerosol. In fact, it is also likely that there will be considerable resistance to the alternative explanation—that the sensitivity was simply overestimated. Nonetheless, the balance of evidence suggests there is, at best, a very small human influence on global climate. President Clinton was correct when stated that humans change the climate. But the fact that the changes are very small, primarily in the coldest air, and likely to remain small, spells the end of the greenhouse scare—at least in a world controlled by reason.

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