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GLOBAL WARMING

Popular Vision vs. Scientific Fact

FOR SOME, THE CONTINUING EMISSION OF GREENHOUSE GASES PORTENDS DISASTER. THE AUTHOR, ON THE OTHER HAND, STUDIES DATA THAT SHOW COOLER DAYS, WARMER NIGHTS, AND BETTER VEGETABLES.

In the popular vision, environmental apocalypse looms over the land. It's a vision of catastrophic global warming that ultimately leads to crop failures, rapid and inundating surges in sea level, enormous hurricanes, and burning forests incapable of renewing themselves.

It's become warmer, yes, and perhaps will be warmer still, but to the degree of catastrophe? The available data on climatic change say no. It's true that virtually all scientists directly involved in climatological research (this author included) believe that the earth will warm some as a result of the increase in emissions that absorb infrared radiation or enhance the greenhouse effect. Indeed, though the media portray the debate otherwise, global warming is not a struggle between true believers and skeptics. The fact is that while the scientists who have examined the issue know that the planet has warmed slightly in the last century, few will ascribe much, if any, of that warming to a change in the greenhouse effect.

Further, warming itself does not imply the apocalypse that dominates the rhetoric of many environmentalists. In fact, within certain quite broad limits, how much the world warms is irrelevant. More important is how it warms--whether during the day or at night, whether in the winter more than in the summer, and whether such other factors as changes in cloud cover can modify that warming.

Once you know how it warms, the spectre of environmental disaster dims rapidly.

A Changing Greenhouse

The greenhouse effect is real and, indeed, a natural and beneficial phenomenon. It is a warming of the lower layers of the atmosphere resulting from the absorption of solar radiation by certain gases. Water vapor is the most common gas, followed by carbon dioxide, whose net effect is an order of magnitude less.

While there are several greenhouse-enhancing trace gases that have increased as a result of man's activities, four kinds are responsible for almost all the current increase in radiative forcing: carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The enhancement and concentration of these gases in the lower atmosphere redirects toward the Earth's surface an increasing--although still extremely small--amount of solar energy.

Of these emissions, carbon dioxide, or CO_2, is the most important, producing approximately half of the overall greenhouse enhancement (that is to say, the enrichment of the "natural" greenhouse). It is also the emission that results from the combustion of fossil fuels--coal, oil, natural gas, and their fuel byproducts--with coal producing the largest amount per unit of energy released. Because coal combustion produces more than half of this nation's electricity, a serious attempt to stabilize greenhouse gases--requiring an 80 percent cut in emissions--would have serious and profound consequences for our energy economy.

Before the Industrial Revolution, CO_2 concentration was between 260 and 279 parts per million (ppm). The current atmospheric concentration of CO_2 is about 350 ppm, and if the warming influence of other greenhouse gases is translated into CO_2 terms, it's like adding another 80 ppm of CO_2, yielding a total effective concentration of approximately 430 ppm--up an additional 51-61 percent from the pre-industrial background range. Thus, we have already proceeded more than halfway to doubling CO_2 concentration in the atmosphere.

The Rise of the Popular Vision

Two events used this CO_2 rise to foster the popular fear of climate apocalypse. The first was the publication of data from general circulation model (GCM) climate simulations in the mid- to late 1980s. Factoring in an effective doubling of atmospheric CO_2 (which, at current emission rates, will occur around 2050), these computer models predicted a mean global warming of 4.2 degrees C, with a winter increase of as much as 18 degrees C in north polar regions.

The second was the Congressional testimony of NASA's James Hansen, a prominent environmental scientist, in the summer of 1988. He said that there was a "high degree of cause and effect" between current temperatures and human greenhouse alterations, but nowhere in his testimony (and, to my best knowledge, nowhere else) did he state that an enhanced greenhouse effect had caused the anomalously warm summer. Nevertheless, the press and the public concluded otherwise: 70 percent of the respondents to a subsequent CNN poll agreed with the statement that the 1988 drought was in fact caused by the greenhouse effect.

Facts vs. Popular Vision

But consider this. With a 61 percent increase in background CO_2, the current GCMs predict that the globe should have warmed considerably, especially in the high-latitude polar regions of the northern hemisphere. If something were not mitigating the warming, we should already have seen a rise of 2.0 degrees C or so. Yet, according to United Nations figures, the historical trend is a rise of 0.45 degrees C (+/- 0.1 degrees C) in the last

century. Further, as shown in Figure 1, nearly all of the northern hemisphere's upward trend in temperature occurred prior to 1945, before the major postwar enhancement of the greenhouse effect. In fact, a linear trend through the data since 1935 is statistically indistinguishable from no change at all. Trend analyses of global records also indicate that almost all of the observed warming occurred prior to 1945--before most of the greenhouse emissions.

One reason for the lack of observed warming is the lag effect caused by the deep oceans--it takes more energy to heat up water than to heat up land, after all. Several calculation by different scientists, however, demonstrate that even large estimates of this lag are insufficient to account for the lack of observed warming.

Also, the temperature records themselves reflect an upward bias that can skew the data. Many weather stations are in cities, and cities tend to grow up around their central weather stations. Consequently, temperature readings are generally higher because the city is generally warmer, which has nothing to do with global or enhanced greenhouse warming.

Washington, DC, is is a good example of this phenomenon. Temperatures in the Nation's Capitol have been skyrocketing since the 1920s (like the federal budget, some say). In fact, the mean January temperature measured at the urban Washington National Airport is now warmer than that measured at the Charlottesville (Virginia) Leander McCormick Observatory, 100 miles to the south! There are many uncertainties in the study of climatic change, but we are sure that Washington has not moved south. Rather, the urban landscape's infrastructure (containing pavement that retains heat and buildings that impede ventilating winds) is the main culprit.

In 1979, NASA launched the first of a series of satellites capable of measuring the temperature of the lower layer of the atmosphere with an accuracy of +/- 0.01 degrees C. The satellite's coverage is virtually global, and there's no urban effect in these data. From the charted 1979-1992 data in Figure 2 (page 37), it is immediately apparent that there is no significant warming trend in either hemisphere. In addition, the fairly rapid warming between 1979 and now--which seems obvious in the ground-based record--is absent in the satellite data.

Figure 3 (page 37, part of a presentation to this January's annual meeting of the American Meteorological Society) compares the performance of our most sophisticated GCM with observed temperatures over the northern hemisphere. It is apparent that the forecasts began to fail in the middle of the century--just as the current greenhouse enhancement became most important.

In his book, The Heated Debate (Pacific Research Institute, 1992), Robert Bailing convincingly demonstrates that observed warming of the planet has been far below even the most conservative projections of the GCMs. He also indicates that other industrial byproducts (such as sulfate aerosol, associated with acid rain) are largely responsible for this lack of warming. Several calculations (those of NASA's James Hansen, for example) indicate that the magnitude of compensatory cooling could be sufficient to have canceled all of the expected greenhouse warming to date.

In my opinion, however, the observed data on global climatic change demonstrate that the sulfate cooling hypothesis is insufficient. In fact, there is evidence for a concurrent increase in cloudiness that is not related to this aerosol, but rather is a result of the greenhouse enhancement itself. Enhanced cloudiness reflects solar radiation during the day and insulates the planet at night. The importance of increasing cloudiness in a world with an enhanced greenhouse effect cannot be overstated, for it spells the demise of the popular vision of apocalypse.

Send in the Clouds

In the popular vision, global warming has three major threats:

- agricultural damage from major reductions in crop yields;
- disastrous sea-level rise from the melting of large areas of land ice; and
- ecological disequilibrium and loss of species because climate will change faster than parent plant communities can migrate.

Each of these threats are diametrically attenuated in the face of a greenhouse enhancement that is mitigated by clouds.

The primary cause of agricultural yield loss is moisture stress and plant death from lack of water. Plant stress is at its highest generally during the day, especially on sunny, hot afternoons.

An increase in cloudiness will block the sun and mitigate daytime temperature rises, thereby reducing the stress. Also, temperatures at night generally mark the beginning and end of the growing season--and the lowest temperatures at season's end occur at the end of clear, calm nights. Warming these nights, or affecting the conditions under which cold air masses form, will therefore lengthen the growing season.

Large areas of high-latitude land ice--which must melt in order to create a significant sea-level rise--melt during summer. Yet all climate models, from the 1896 calculations of Solvendo Arrhenius (who wrote the first greenhouse warming study) to the most recent Princeton GCM (demonstrated in Figure 3), confine their strongest warming to high-latitude winter, which is spent in darkness or twilight. Further, by modifying the projected warming with an increase in cloudiness, we could cancel out entirely the warming in high-latitude summer. This is precisely what occurs in the most recent publication of the National Center for Atmospheric Research (NCAR) GCM: In the world of doubled CO_2, it forecasts not summer warming but actual cooling in many portions of the northern hemisphere's high latitudes!

The winter atmosphere--which contributes most to high-latitude snowpack accumulation--is now so cold that very little moisture can precipitate. By warming the winter, the amount of moisture and snowfall should increase--and then, under any warming scenario, the temperatures would still remain far below freezing.

In fact, snowfall apparently increased during the last warm period, from 4,000 to 7,000 years ago, according to 1991 studies by Eugene Domack et al. in the journal Geology and Gifford Miller and Anne de Vernal in Nature in 1992. These papers both argued that warming would actually increase the ice volume, further mitigating any rise in sea-level.

The third negative prospect from climatic change--ecological disequilibrium--also weakens in the face of a cloud-mitigated greenhouse. The primary cause of plant death, as I've said before, remains moisture stress, which is primarily generated during the day. In addition, Lehman and Keigwin, in a 1992 Nature article, found that temperature changes of 5 degrees C in fewer than 50 years--values that exceed those of current GCM projections--have been common in the last glacial cycle. These observed climatic changes, more rapid than those forecasted, were obviously insufficient to promote an ecological disaster.

Are there really more clouds? There's good, direct evidence that clouds are on the increase. James Angell of the National Oceanic and Atmospheric Administration (NOAA) has demonstrated that cloudiness has increased by 3.5 percent across the United States during the period of major greenhouse enhancement. In Europe, German scientist Gerd Weber has noted a decline in sunshine also caused by increasing cloudiness. And Steven Warren, of the University of Washington, has analyzed millions of shipboard observations (which generally are recorded every three hours) and found global cloud increases, especially in the northern hemisphere.

The circumstantial evidence is equally compelling. Increasing cloudiness from any source--including sulfates--should have a number of hypothetical effects:

- night warming, especially enhanced by an increasing greenhouse effect;
- counteraction of day warming;
- a consequent decrease in the difference between daily high and low temperatures;
- the greatest warming should be on the longest (winter) nights; and
- the greatest counteraction of warming--even cooling--should occur on the longest (summer) days.

And, in fact, the observed data support each of these effects.

Thomas Karl, laboratory director at the National Climatic Data Center, has created a "Historical Climate Network" (HCN) for the United States. He scrupulously avoids data that would reflect warming caused by cities. In his record, daily high temperatures have actually declined for most of the last 70 years, while night readings have risen since 1945. The difference between the high and low, shown in Figure 4, has been narrowing for the last three decades.

Karl also has created an HCN-like record for China and the former Soviet Union. I combined those results with the northern hemisphere's in the October 1992 Bulletin of the American Meteorological Society and divided them into day, night, winter, and summer. As is shown in the Table 1, it is apparent that summer daytime temperatures--the ones that must rise to give credence to disastrous global warming scenarios--have actually dropped.

Instead, there has been a dramatic rise in the winter night temperatures. When we search the climate record to pinpoint when and where this has occurred, it is apparent that the fabled Siberian Express--the coldest air masses into our hemisphere--has warmed up. The Express is the same air mass responsible for the death of citrus in Florida and massive consumption of energy for heating in winter.

Sulfate aerosol or greenhouse effect? As benign as these climatic changes are, the question of causation remains. Are they the result of a modification of the greenhouse effect by sulfate aerosol? If so, this is tantamount to treating an environmental situation with a deleterious cure: The precipitation of the aerosol is, after all, acid rain (although the perceived magnitude of that problem has declined dramatically in the last decade).

If, on the other hand, the observed (and fairly pleasant) climatic changes are by and large the result of the greenhouse effect, then we should be able to observe two additional phenomena:

- night, day, and seasonal changes at high-elevation land stations (such as mountaintops) should be similar in character to those observed at low elevations; and
- there should not be disproportionate night warming in the southern hemisphere, because its clean atmosphere contains little sulfate aerosol.

Theoretical calculations all agree that surface warming should he accompanied by some cooling of the upper layers, although most GCMs confine this cooling to regions above the earth's active weather zone (approximately 45,000 feet in the mid-latitudes). But NOAA's James Angell has demonstrated that cooling has been observed from approximately 25,000 feet and up, easily within the active weather zone. Everything else being equal, this should result in increased vertical motion of air masses and a propensity for increased cloudiness. Thus, the response to the greenhouse enhancement may be to increase mid-and high-level cloudiness.

Almost all sulfate aerosol is confined--along with other particulates--to the bottom 7,000 feet of the atmosphere. If the cloud increases were primarily a result of this process, then high-elevation stations should not show the night warming and counteraction of daytime warming that we see in low-elevation records.

Figure 5 details maximum (day) and minimum (night) temperatures for winter and summer from the Pic du Midi Observatory in the French Pyrenees. Data from this station are particularly significant. The terrain surrounding it is exceedingly difficult to navigate, which minimizes human interference; and it is above the timberline, so that growing trees cannot artificially warm the nights or cool the days. Perhaps most important, at 9,400 feet, it is above almost all of the sulfate aerosol.

Yet, its behavior is similar to that of the aggregate of low elevation stations detailed in the table. The rise in night temperatures (both for summer and winter) is highly significant, as is the decline in summer day temperature. The magnitude of these changes is clearly out of proportion with the miniscule amount of sulfate aerosol residing at or above 9,400 feet. Thus, we're left with the other cloud-enhancement mechanism--namely, the high-altitude cooling noted by Angell.

P.A. Jones, writing in Australian Meteorological Magazine in 1991, demonstrated that night warming in Australia also exceeded day warming, in this case by a factor of two (0.12 degrees C vs. 06C degrees per decade). The aggregate warming is still below projections made by GCM simulations. Interestingly, Steven Warren's cloud studies around Australia show increases in cirrus (high-altitude) clouds, but no concomitant increase in the low-level stratocumulus, which is the type one would expect to be enhanced by sulfate aerosol.

New Climate Models

As noted above, earlier climate models predicted an average warming of 4.2 degrees C for an effective doubling of atmospheric CO_2, which is to occur around 2050. Those models--which included very primitive ocean and cloud specifications--have since been improved, and there have been some important changes.

The United Kingdom GCM, for example, changed the distribution of water and ice within clouds, and its projected mean warming dropped from 5.2 degrees C to 1.9 degrees C. With an improved understanding of the relationship between ocean and atmosphere, the NCAR model showed that warming dropped to 1.6 degrees C for 30 years after an "instantaneous" doubling of CO_2, compared to 3.7 degrees C in an earlier calculation for total warming with a more primitive ocean. A slightly different version of this model, in which the greenhouse effect increases at a rate commensurate with industrial emissions, implies that the global temperature should have risen by 0.7 degrees C since 1950; the measured trend is less than half--0.33 degrees C--of what was projected.

The Princeton GCM still predicts a net equilibrium warming of 4.0 degrees C in its improved version--but as we saw in Figure 4, the observed data don't bear the model out.

Even though these new simulations appear to be too warm, they still predict most warming in high-latitude winter of the northern hemisphere. In the new version of the NCAR model, the area of projected warming of greater than 4 degrees C is less than 5 percent of the planetary surface. More important, because almost all of it is confined to latitudes higher than 60 degrees (just below the Arctic Circle) during the northern hemisphere's winter, the strong warming is therefore projected for either twilight or night, similar to what has been observed in the climate record. Note that these calculations are made without the addition of compensatory cooling by sulfate aerosol.

Benefits of CO2

For a long time, we've known that many plants display enhanced growth in the presence of increased CO_2. This shouldn't be surprising to those who learned basic biology: CO_2 is the prime reactant in the familiar equation of photosynthesis. In a recent multi-subject analysis of the scientific literature, Keith Idso documented 1,087 individual experiments detailed in 324 scientific papers. With an increase in the CO_2 content of the air, 93 percent of the plants showed an increase in productivity, while only 2 percent showed a decrease.

And if, as we saw earlier, the growing season lengthens, so too will the time in which deciduous plants can capture CO_2.

Several real-world surveys indicate an acceleration in vegetative growth. Writing in Science magazine in 1992, Pekka Kauppi has demonstrated that European forests have increased in biomass over the last two decades. It's his belief that "the fertilization effect of pollutants override the adverse effects, at least for the time being." According to Sherwood Idso, the effect has been noted in montane species in the western United States, in a carefully monitored virgin forest plot at the Oak Ridge National Laboratory, and in the northern forests of Scandinavia.

If these accelerations are indeed taking place, they are occurring at a time when acid precipitation ostensibly is retarding forest growth. If sulfate aerosol is one (albeit insufficient) factor involved in mitigating prospective warming, then its negative effects (acid rain) are being countered, in part, by enhanced CO_2. An additional factor of environmental importance is that enhanced cloudiness--whether caused by sulfate aerosol or upper cooling from the heightened greenhouse effect--serves to block incoming solar radiation, mitigating effects of a stratospheric ozone decline. This combination of factors is probably responsible for the findings detailed in Science and Geophysical Research Letters that surface u-vb radiation--the causal agent for basal-cell skin cancer--is actually declining across the United States and much of the northern hemisphere.

Well, What Apocalypse?

That decline in the radiation flux that causes cancer adds weight to the other factors that create doubt about the popular vision, even in the face of an effective doubling of CO_2 in the atmosphere. In fact, the actual lack of data pointing to overall warming, the prevalence of what warming there is during the night and winter rather than on summer days, the new evidence from improved GCMs, and the evidence for enhanced vegetative growth all suggest one thing.

The popular vision of climate apocalypse is wrong.

TABLE 1

TEMPERATURE TRENDS

USA, Continental China, and the Former Soviet Union

Area-weighted aggregate, degrees C / 100 years

Season	Mean Max (day)	Mean Min (night)
Winter	+0.6	+1.8
Summer	-0.4	+0.4
Annual	+0.05	+1.1

GRAPH: Figure 1: This record, from the University of East Anglia, is the one most cited by scientists. Two-thirds of the greenhouse enhancement took place to the right of the red line.

GRAPH: Figure 2 TEMPERATURE RECORDS FROM SATELLITES

GRAPH: Figure 3: Northern hemisphere observed temperatures (green line)and temperatures calculated for the last 100 years by the most sophisticated climate model (blue line).

GRAPH: Figure 4: Karl's Historical Climate Network demonstrates the difference between average daily maximum (day) and minimum (night) temperatures since 1900. That difference (blue line) has been narrowing.

GRAPH: Figure 5 DAILY MAXIMUM AND MINIMUM TEMPERATURES AT PIC DU MIDI

PHOTO (COLOR): An increase in /carbon dioxide in the atmosphere may be a fact, but the consequences for this farmer may be far from dismal.

PHOTO (COLOR): Scientists don't dispute the existence of the greenhouse effect. The public, however, interprets it incorrectly, with the wrong rhetoric.

PHOTO (COLOR): Studies show that clouds are on the increase, providing ecological benefit, not disaster.

PHOTO (COLOR): An increase in winter temperature increases snowfall, insulating the frozen snowpack.

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By PATRICK J. MICHAELS

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GETTING TO MAYBE: CLIMATE SCIENCE OR POLITICAL SCIENCE?

In the 1970s, it was global cooling. In the 1990s, it's global warming. Which is accurate? Both and neither. Yes, your eyes read correctly. Both statements have scientific data to support them and yet another set of data to refute them. Is it any wonder that policymakers are confused? What role can--and should--science play when the data do not support a clear policy choice?

Funding drives science and scientific research. Computers, the time to run them, laboratory equipment, and the drive for fame have driven the cost of research to an all-time high. The old axiom "publish or perish" has never been more true, this at a time when both academic and federal research budgets are shrinking. Competition is intense, and headline-making findings are a major tactic to ensure funding.

Is that tactic wrong? In the purely ethical sense, yes. But if a project or laboratory or department is not successful in winning the support it needs, how can it undertake the research necessary to advance scientific knowledge? Thus, the more practical answer to the question is, probably no. The challenge for policymakers is to let the funding rhetoric go by and pick out the facts they need to make fair public policy.

To do this, policymakers need to ask scientists the right questions and then insist that the answers be the best they can be with the data at hand. Too often, policymakers ask the wrong questions or often no questions at all. They allow the scientists to frame the questions they want to answer, even though the questions have no value to decisionmakers. The global climate change issue is rife with such examples. Refer, if you will, to the first two sentences of this sidebar. Within two decades, the same scientists, going back more than 150 years over the same historical climate records, reached completely opposite conclusions. Why? Primarily because the political climate changed.

During the 1970s, the first Decade of the Environment, politicians focused on basic environmental protection of air and water. Many laws went into the books, and by the passage in 1990 of the most sweeping legislation--the Clean Air Act Amendments--the targets for conventional environmental protection were all but exhausted. Climate science was a low priority for policymakers then, but now, in the current Decade of the Environment, it's been called up to the major leagues.

And the stakes have risen, too. What used to be minor congressional hearings heid in small, fourth-floor hearing rooms, attended by a few professors and one or two legislators, are now in the main committee room covered by C-SPAN and CNN: Political posturing and debate one-upmanship are the order of the day. The audience wants to know: Is warming occurring or not? Will New York, Miami, and New Orleans flood or not? No time for long, scientific dissertations on maybe answers--it's yes or no. And if it's no, it's back to the fourth floor, and the lights go out, and
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the cameras go home. If it's yes, interviews and headlines abound. Better still, if the answer is no and yes, then we have controversy, another hearing, and more research on both sides--a true "win-win" for those involved.

But is this good for science? Is it the best way to use science in the policymaking process?

Sometimes yes, most times no, but almost always, it is painfully slow and very expensive.

There is room for improvement on both sides. Policymakers must learn to ask the right questions to obtain the information they need to establish sound environmental policy. Scientists and researchers must answer those questions honestly. Those on opposite sides of an issue must stop presenting their own side as 100 percent correct while portraying the other side as environmentally radical or criminal.

Also, we must change the idea that because 300 scientists support side A and only 25 scientists support side B, side A must be correct. Elections may work that way, but the physical world does not. Neither scientific nor political opinion is always an accurate indicator of truth.

What matters here is not who's right but what's right. A more objective and less polarized debate would surely help us discover the answers sooner.

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By Robert Beck

Bob Beck is vice president of environmental affairs for the Edison Electric Institute.

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