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What Happened to the Greenhouse Effect?

By Robert Jastrow

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By Robert Jastrow

A few years ago, I and my colleagues on the board of the George C. Marshall Institute, Bill Nierenberg and Fred Seitz, decided to take a look at the greenhouse effect, because it fitted into the general category of technical issues with a public policy impact. Bill Nierenberg had chaired the first major National Academy of Sciences study on the greenhouse problem, which came out in the 1980s. I had worked in this area when I was last doing active research in NASA at the Goddard Institute for Space Studies. In fact, I had gotten Jim Hansen, who since has become very active in the field, started on the problem when we were looking around for something terrestrial that would bring in some bread-and-butter funding after Jim had been doing his calculations on the atmosphere of Venus.

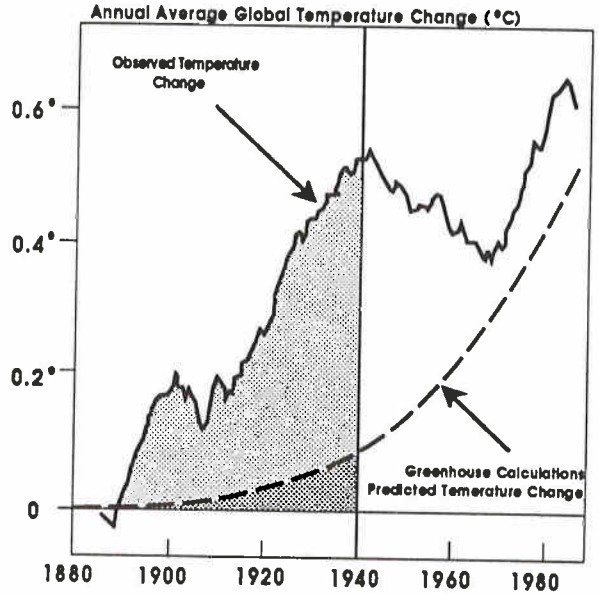
The fact which triggered our interest in the analysis at that particular time, about three years ago, is that the global average temperature has increased simultaneously with an increase in carbon dioxide and other greenhouse gases in the last 100 years. The suggestive correlation in the timing of the increases leads to the tentative conclusion that a global warming produced by the CO_2 increase may have been responsible for some of the warming in the last 100 years, and therefore, will be responsible for more warming in the next 100 years.

The increase in greenhouse gases is equivalent to about a 50 percent increase in CO_2, relative to the 19th century. Half of that is CO_2 itself and the other half is the equivalent in warming effect from other greenhouse gases like methane. The projections of energy growth into the next century suggest an increase of 100 percent in CO_2 equivalent over today's level, between now and roughly the mid-21st century. Recent revisions tend to push that doubling off to the end of the 21st century, but in any case, it is projected that some time in the next century the greenhouse gases will double and their warming effect will be correspondingly increased.

We looked into this matter, and being familiar with the computer models that are used to forecast climate in the next century, we counselled caution. As you may know, these models have some defects; one predicts, for example, equal amounts of rain in Scotland and in the Sahara Desert. So, they have to be used

Chart 1

Greenhouse Calculations Fail to Explain Global Temperature Changes



Note: Both greenhouse calculations and observed global temperatures of the last 100 years show a rise of about 0.5 C. However, most of the observed rise occured before 1940, while most of the greenhouse gases entered the atmosphere after 1940. The greenhouse gases cannot be the cause of a temperature rise that occurred before the gases existed. The lightly shaded area shows the observed temperature rise. The heavily shaded area shows the small part of the rise that can be attributed to the greenhouse effect.

Source: The George C. Marshall Institute, *Global Warming Update*, 1992. **Heritage DataChart**

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with caution, and we thought a few more years of study would give us better information.

But we also noticed something peculiar in our initial look at the temperature data, and that appears in Chart 1 (previous page).

This shows the measured values of average global temperature, as best you can fit together a global picture from a mixture of land stations plus a very sparse coverage over the oceans and the poles. The global average of the temperature measurements shows an increase of about a half a degree Celsius in the last hundred years. The calculations of rising temperature caused by the greenhouse effect—the one in the chart is taken from a paper by Jim Hansen—also show an increase of about half a degree in the last hundred years. That agreement seemed significant, and Dr. Hansen mentioned in congressional testimony in 1988 that he was pretty certain there was a connection between these two increases. He said in June 1988, "Global warming is now sufficiently large that we can ascribe with a high degree of confidence a cause-and-effect relationship to the greenhouse effect."

Other Factors. What we noticed that seemed peculiar was that nearly all of the temperature increase occurred prior to 1940; from 1940 to the present, the temperature moved up and down, but there has been little net change. However, most of the greenhouse gases—two-thirds to be precise—came into the atmosphere *after* 1940. Greenhouse gases cannot produce a warming that occurred before they existed, so the correlation between the two half-degree increases becomes suspect. This would seem to indicate conclusively that other factors are influencing climate besides, or in addition to, the greenhouse effect.

In the second Marshall report, we focused on setting a limit to the magnitude of the greenhouse warming, using the currently available data. We used the measured response of the earth to the 50 percent increase in greenhouse gases to date, as a way of calibrating what the earth would be doing in the next century, when these gases increase by another 100 percent over today's levels.

As I noted, a 50 percent increase in CO_2 and other greenhouse gases has produced roughly half a degree Celsius of warming. Actually, the greenhouse gases could not have produced that entire half-degree of warming. But for the purpose of deriving an upper limit on the magnitude of the greenhouse effect in the next century, we chose to attribute all the half-degree warming that has occurred to date to greenhouse gases, even though we knew that is not correct and at least part of the half-degree increase must be due to some other cause.

So, we assumed that a half-degree is the response of the earth—the real earth, with all the complicated cloud feedbacks and ocean feedbacks accurately entered, because this is the planet itself and not a computer model—to a 50 percent increase in CO_2. Now, for small temperature changes like this, and allowing for the roughly logarithmic dependence on the CO_2 concentration, if a 50 percent increase produces half a degree Celsius (C) of warming, then the 100 percent increase projected for the mid-21st century will produce roughly an additional one degree C of warming.

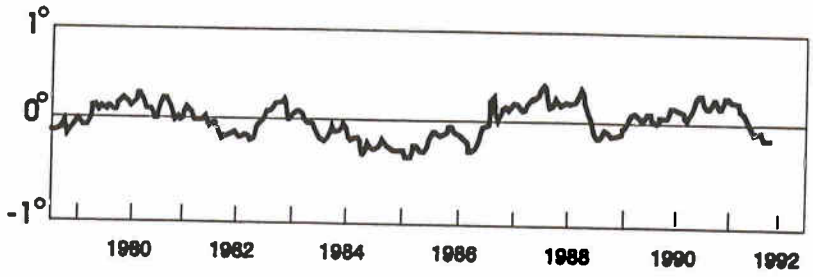
Doing the analysis in greater detail, with allowance for the so-called natural variability of climate as well as the uncertainty in the temperature observations, leads to 1.1 degrees C as our best estimate for the temperature increase in the next century. This result is to be compared with a "best estimate" of 2.5 degrees C put forward as the consensus of the computer models by the United Nations Intergovernmental Panel on Climate Change, or IPCC. So, our estimate for an upper limit on the mid-21st century warming is somewhat lower than the mid-range "best estimate" of the U.N. committee.

The Marshall Institute released a report including these results about a year ago. Our Board took another look at the situation more recently, by way of incorporating new evidence that has come to light in the interim. The latest Marshall findings are incorporated in a third report called "Global Warming Update." The principal information that led us to look at the matter again is the record of

thirteen years of accurate satellite measurements of global temperature. These satellite measurements are shown in Chart 2.

Chart 2

Global Warming? Satellites Show Minimal Temperature Increase Over Last Decade



Note: Satellite measurements of global temperature do not show the large expected upwards trend due to the greenhouse effect. Increases in some years are balanced by decreases in others. The average increase in the data is 0.06 C/decade. The 1992 Scientific Assessment report of the IPCC gives 0.3 C/decade as the consensus of theoretical predictions for the temperature increase due to the greenhouse gases -- five times greater than the effect revealed by the satellite measurements.

Source: The George C. Marshall Institute, *Global Warming Update*, 1992.

Heritage DataChart

They are interesting because they give a fairly uniform sampling over the oceans and the polar areas, and not only the continents. A check against measurements made on the ground shows that these satellite measurements reflect very accurately the actual temperature values on the surface of the earth. Scientists who disagree with the implication in the satellite measurements say the satellite data are subject to uncertainties because they measure the atmosphere rather than the ground. But the correlation between the ground measurements and the satellite measurements for the entire North American continent—a respectably large piece of real estate—is 0.98. Now, 1.00 is perfect correlation; that is how data correlate with themselves. A correlation of 0.98 is about as good as you can get for the agreement between two independently measured sets of data. It indicates that these are very reliable measures of ground temperature. In fact, they probably give a better global picture than the so-called global averages of the surface data, which must rely on very sparse ocean and high-latitude coverage.

Now to the point: The satellite measurements show essentially no trend in the last decade. The IPCC report quotes the consensus of the various computer models of climate change as predicting a greenhouse warming in the 1980s of about 0.3 degrees C per decade. That would be about 0.4 degrees C for the thirteen-year period shown here. The trend line through the satellite data yields 0.06 degrees per decade. This is one-fifth of the warming of 0.3 degrees C per decade which is the consensus of the computer models.

Once again, we have used the real earth, and its actual temperature changes, to calibrate the reaction of the earth's climate to an increase in greenhouse gases, and we find an answer which is one-fifth as large as the consensus of the computer models. So, if the IPCC gives the "best estimate" of the computer models as 2.5 degrees C for the mid-21st century, we suggest that this value should be cut by a factor of five to 0.5 degrees C. A rise of 0.5 degrees C should be the result of a 100 percent increase in CO_2. This result is consistent with the upper limit of 1.1 degrees C for a doubling of CO_2, which was reported in the previous Marshall analysis.

Based on satellite measurements which give the earth's real response to the real increase that has occurred to date, and not on theoretical models, this is the firmest evidence we have thus far on the magnitude of global warming to be expected in the next century.

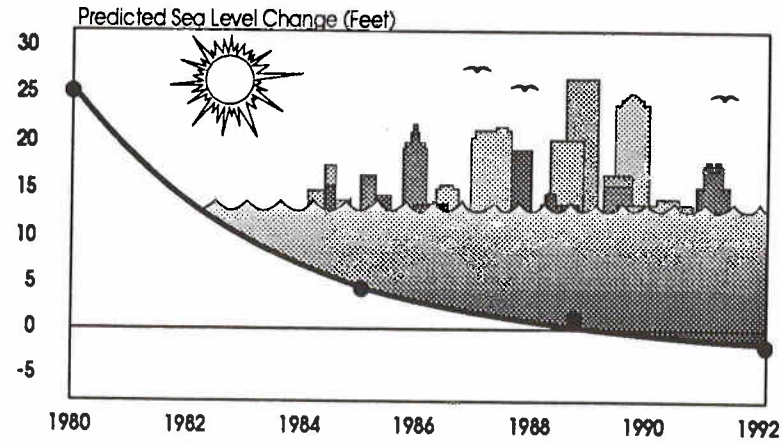
A half-degree rise, spread over the better part of a century, would not be noticeable against the natural background of temperature variations. It would not justify carbon taxes or any other kind of restriction on energy production and the burning of fossil fuels.

One final comment on the consequences of a greenhouse warming. Around 1980, a rise of 25 feet in sea level was suggested as a possible consequence of global warming and the melting of the polar ice sheets. In 1985, a panel organized by the National Research Council concluded that a rise of three feet was the best estimate for the increase in sea level resulting from the projected greenhouse warming in the next century. In 1989, the estimate was revised downward again, to one foot.

This sequence of predictions caught my eye. Plotting them against the year in which each prediction was made, and extrapolating the graph forward into the 1990s, I was able to predict that around 1991 or 1992, the *predicted* rise in sea level would cross zero and become negative—i.e., the experts would predict a *fall* in sea level. (Please note that it was the *prediction* for the sea level change in the next century which I expected to approach zero or a negative value around 1991 or 1992.)

Chart 3

Rising Oceans? Predictions of Global Warming Have Changed With the Times



Note: The most recent estimates indicate a net drop in sea level.
Source: The George C. Marshall Institute, *Global Warming Update*, 1992.
Heritage DataChart

Chart 3 plots the downward trend of these predictions.

In January 1992, *Science* published a paper based on the analysis of geological records of many millennia of ice cores, which concluded that the sea level may fall roughly one foot in response to the projected global warming.

It may seem paradoxical that warming can lead to drop in sea level. The explanation is that the air over the Arctic and Antarctic ice sheets is normally very cold and dry, and snowfall is limited by the dryness of the air. When the air above the ice sheets warms up somewhat, it contains more moisture, snowfall increases in the polar regions, and the polar ice caps thicken rather than thinning.

Nonetheless, one still sees apocalyptic references to the inundation of Bangladesh and other low-lying islands, and the possible submergence of a large part of Florida and the Gulf States. These forecasts are fifteen years out of date.

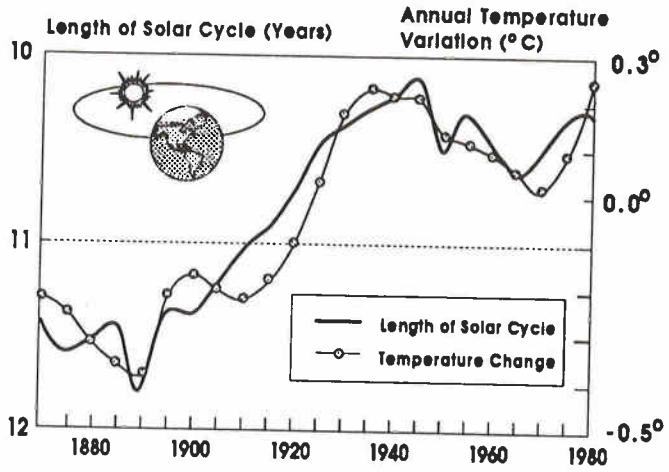
In conclusion, a parenthetical remark. As I noted, the evidence suggests that while there was a warming in the last century, the warming was not caused by greenhouse gases. This raises the interesting question as to what did cause it. There is suggestive evidence available on this scientifically interesting question.

Chart 4 shows measurements of temperature and measurements of magnetic activity on the surface of the sun; that means the kind of activity that produces sunspots (although this is not a sunspot record but another proxy for the level of solar activity). The two plots display a striking correlation,

so close that it seems unlikely the agreement can be a coincidence. However, it has been commented that while the agreement is interesting, unless a physical mechanism is proposed to account for the coincidence, the trained scientific mind must disregard it as coincidence nonetheless.

Chart 4

Length of Solar Cycle Mirrors Variations in Earth's Temperature



Note: During shorter solar cycles the sun has greater sunspot and surface magnetic activity and greater energy output. Temperature data is for Northern Hemisphere air temperatures over land.

Source: Friis-Christensen and Lassen, *Science*, November 1991.

Heritage DataChart

Solar Cycles. Fairly recent evidence indicates that there is such a mechanism. Satellite observations show that changes in solar activity are correlated with changes in solar brightness or energy output. These brightness changes would have a direct climate impact. The measured change over the one cycle of solar activity for which data are available is only 0.1 percent, which is too small to affect the climate appreciably. However, Dr. Baliunas of the Harvard-Smithsonian Center for Astrophysics has shown, by combining observations of the sun with observations of solar-type stars, that larger changes of magnetic activity occur, and are associated with larger changes of solar brightness than 0.1 percent. Applying her results to the record of solar activity changes over the last 100 years, as given by sunspot observations, she finds evidence of solar brightness changes of about a half percent—sufficient to explain all the changes of global temperature in the last 100 years as reproduced in the chart.

This seems small, but it is quite substantial in terms of the climate impact it can have. In fact, when I and another colleague, Eric Posmentier of Dartmouth College and Long Island University, fed the Baliunas results from the changes in the sun's brightness into a computer model of global climate, we found that the sun's changes nicely accounted for the changes in the earth's temperature observed in the last 100 years.

So there is a good candidate for the explanation of the temperature rise of the last hundred years. But that fact, while scientifically interesting, is not the main point I should like to bring to your attention, which is that the scientific evidence indicates the greenhouse warming in the next century will be considerably smaller than the computer models have predicted, and probably too small to be of any consequence.

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