**Human Imprint on Climate Change Grows Clearer: Human Influences on Changing Climate Are Becoming ...**
By WILLIAM K. STEVENS
*New York Times (1923-Current file);* Jun 29, 1999; ProQuest Historical Newspapers: The New York Times
pg. F1

# Human Imprint on Climate Change Grows Clearer

By WILLIAM K. STEVENS

As evidence that the earth's atmosphere is warming continues to accumulate, scientists are making slow progress toward an answer to the big question raised by the evidence: how much of the warming is due to human activity and how much to natural causes?

The United Nations' Intergovernmental Panel on Climate Change, the group of scientists widely considered the most authoritative voice on the subject, has already concluded that there is a "discernible human influence" on the global climate. Now the panel is deep into another of its periodic full-scale scientific assessments of global climate change, to be finished in about 18 months. While the group's conclusions are unformed, some experts on the problem say the human imprint on climate is becoming clearer, and may even have been the dominant factor in the global warming of recent decades. Not everyone agrees — there is a range of judgments — and virtually all experts say that in any case, a reliable estimate of the human imprint's magnitude still remains some distance off.

A number of influences, both natural and man-made, cause the planet's temperature to vary. The natural ones include changes in solar radiation, and sulfate droplets called aerosols cast aloft by erupting volcanoes, which cool the atmosphere by reflecting sunlight. The human influence stems mostly from emissions of waste industrial gases like carbon dioxide, which trap heat in the atmosphere, and sulfate aerosols from industrial smokestacks.

The combined impact of industrial aerosols and greenhouse gases creates complex and distinctive temperature patterns. It was mostly an analysis of those patterns that led the intergovernmental panel in 1995 to abandon its previous position that global warming observed over the past century might as easily be natural as human-induced. Human factors appeared to be playing a part, the panel said then, but it offered no judgment on whether that part was big, small or in between.

One recent piece of evidence suggesting a strong human influence, which seems likely to carry some weight with the intergovernmental panel, appeared recently in the journal Nature. Scientists at the Hadley Center for Climate Prediction and Research, a British Government organization, analyzed the global climate record of the last century

*Continued on Page 9*

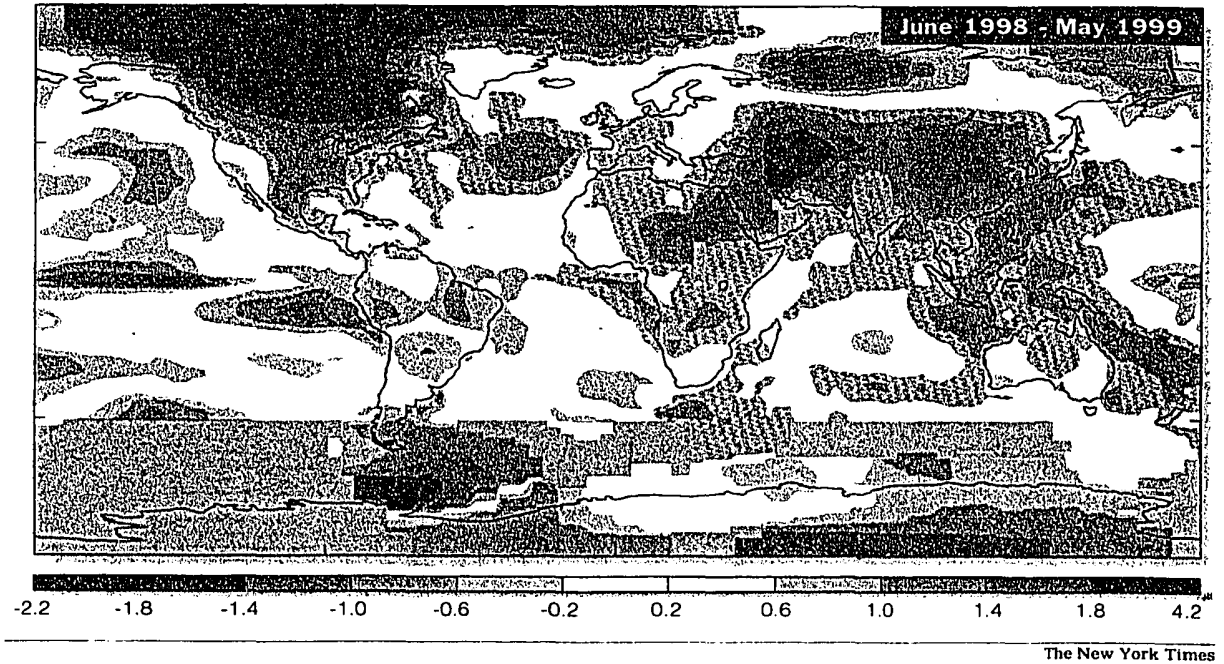
## A Warmer Planet

The earth's average surface temperature for the 12 months ended May, 31 was nearly 1 degree Fahrenheit above the baseline average for 1951 through 1980, according to NASA's Goddard Institute for Space Studies.

Map shows distribution of the change in degrees Celsius, which are nine-fifths of a degree on the Fahrenheit scale.

Data were unavailable for gray areas.

*Source: NASA Goddard Institute for Space Studies*




The New York Times

# Human Influences on Changing Climate Are Becoming Clearer

*Continued From First Science Page*

in an effort to isolate and quantify the major factors producing the century's rise of about 1 degree Fahrenheit in the earth's average surface temperature.

The research team led by Dr. Simon F. B. Tett found that in the earlier part of the century, the rise could be explained either by an increase in solar radiation or a combination of stronger solar radiation and heat-trapping greenhouse gases emitted by industrial economies. But they found that after the mid-1970's, when about half the century's warming took place, the warming resulted largely from the greenhouse gases.

Other researchers have lately come to a similar conclusion.

The Tett study represents "another jigsaw puzzle piece," said one expert, Dr. Tom M. L. Wigley of the National Center for Atmospheric Research in Boulder, Colo. "There is still a long way to go" in completing the puzzle, he said, "but we're beginning to see the smile on the face of the Mona Lisa, I think — or perhaps it should be a frown."

Dr. Wigley was a principal author of the section of the intergovernmental panel's 1995 report dealing with detection of the human imprint on climate, but not for the new report. He and his co-assessors of four years ago "would now make a stronger statement" if they were writing their report today, he said at a recent panel discussion sponsored in Washington by Resources for the Future, an independent research group.

But other participants in the discussion were more cautious. One, Dr. Michael E. Schlesinger, a climatologist at the University of Illinois at Urbana-Champaign, says that experts have insufficient knowledge of the magnitude of natural climatic variations, especially solar radiation, to gauge how large the human impact is by comparison.

Another, Dr. Ronald Prinn of the Massachusetts Institute of Technology, said that although there was "accumulating evidence that humans are having an influence on the climate system," it would not be possible to discern its magnitude until the degree of natural climate variability could be pinned down better.

Meanwhile, though, evidence of warming and its effects continues to mount. Earlier this year, scientists at the University of Massachusetts and the University of Arizona reconstructed the average annual surface temperature trend of the Northern Hemisphere for the last 1,000 years. While cautioning that the margin of error was large enough to render data from the early centuries untrustworthy, they found that the 20th century was the warmest of the millennium, by far.

This and other analyses have found that the warmest years of all occurred in the 1990's, with 1998 the warmest on record. El Niño, the great pool of warm water in the tropical Pacific Ocean that from time to time heats the atmosphere and disrupts weather patterns, was responsible for some of the 1998 heating. A preliminary analysis by Dr. Wigley, however, has shown that when El Niño's effects are filtered out of the global temperature record statistically, 1998 still ranks as the warmest year. (This year is also shaping up as unusually warm, but not as warm as 1998.)

Two studies reported in Nature this month suggest that the warming is being reflected in patterns of wildlife behavior and distribution. In one study, Dr. Camille Parmesan, a biologist at the National Center for Ecological Analysis in Santa Barbara, Calif., and 12 colleagues analyzed distribution patterns of 35 species of European butterflies. They found that for two-thirds of the species, their range of habitat had shifted northward by 22 to 150 miles, coincidentally with Europe's warming trend.

In the other study, Humphrey Q. B. Crick of the British Trust for Ornithology and Timothy H. Sparks of the Institute of Terrestrial Ecology in Cambridgeshire, England, analyzed the nesting habits of 20 species of birds in Britain. They found that, again coincident with a recent warming trend, the birds were laying their eggs earlier in the spring. This is the latest in a series of studies indicating that meteorological spring is coming earlier in the Northern Hemisphere. Some have also shown that fall is coming later.

A third study in Nature this month reports, on the basis of bubbles of atmospheric gas contained in ice cores extracted from the Antarctic ice sheet, that present-day atmospheric levels of heat-trapping carbon dioxide are higher than at any other time in the last 420,000 years. At 360 parts per million, they are 20 percent higher than in any previous warm period between ice ages, and double the typical concentrations during an ice age.

If greenhouse gas emissions are not reduced, the United Nations scientific panel has consistently said, atmospheric concentrations will continue to rise and warm the earth further. In its 1995 report, it projected a warming of 2 to 6 degrees Fahrenheit, with a best estimate of 3.5 degrees, by the year 2100. The warming would not end in 2100, the panel found, but would continue. By comparison, the earth has warmed by 5 to 9 degrees since the depths of the last ice age some 20,000 years ago.

The amount of warming projected by the panel, it said, would create widespread climatic and ecological changes, including a shift in climatic zones, an increase in heat waves, warmer northern winters, increased precipitation when it rains but worse droughts when it does not, and a rise in sea level that could inundate many small island nations and drive tens of millions of people away from the coasts when storm surges develop.

For a long time, the global warming debate focused on how much warming a given increase in greenhouse gases — say, a doubling of atmospheric concentrations — would produce. Though skeptics say it would be small, the dominant view for 20 years has been that a doubling would produce a warming of 3 to 8 degrees, other things being equal. This is a measure of the climate system's sensitivity to "forcing," as experts call it, by external heating and cooling influences, and many mainstream scientists say confidence that it is right has grown.

Now attention is shifting to the relative strength of the external forcings. This is the crux of the problem of figuring out the magnitude of humans' influence on the climate. There are basically three main forcings: greenhouse gases and solar radiation, which warm the atmosphere, and sulfate droplets, or aerosols, from both volcanoes and industrial sources, which cool it.

The amount of carbon dioxide and other greenhouse gases in the atmosphere has been firmly established and continuously monitored, though it is difficult if not impossible to predict how much there will be in the future. Once greenhouse gases diffuse throughout the entire lower part of the atmosphere they remain there for decades to centuries.

Sulfate aerosols from volcanoes sometimes spread to the stratosphere, where they, too, diffuse globally and cool the earth. But they dissipate in two or three years. That is what happened with Mount Pinatubo in the Philippines, which temporarily cooled the earth by about 1 degree Fahrenheit after it erupted in 1991.

Sulfate aerosols from industry generally rise only into the lower part of the atmosphere and fall out, as acid rain, within a few days. Moreover, their extent and impact is mostly regional rather than global. Until recently, they affected primarily the industrial countries of Europe and North America, but scientists now believe that they are diminishing in that part of the world because of controls on pollution. They are growing fast, however, in India, China and Southeast Asia.

Experts have difficulty in getting a handle on the constantly shifting amounts and patterns of industrial aerosols, and they have a similarly hard time establishing the varying strength of solar radiation.

**Studies suggest wildlife is adapting to warming climate.**

Some mainstream scientists say that because the earth's average surface temperature has not varied by more than a degree or two since the last ice age, variations in the strength of the sun's radiation must be relatively small during the present interglacial period. Satellite measurements show some small variations, less than one-tenth of a percent, in concert with the 11-year sunspot cycle. But for the years before 1978, when satellite measurements began, scientists must estimate the variations from proxy indicators like sunspots. These estimates say that solar irradiance did not increase by more than 1 percent from 1908 to 1952.

In the recent Tett study, the British scientists fed into a computer model of the climate system varying estimates, based on different proxy studies, of past solar irradiance. They also fed in the observed and estimated changes in greenhouse gas concentrations and aerosols from both volcanoes and industrial sources. They ran many simulations of the effect of each of these forcings and then averaged them together to see if they explained the observed global temperature rise — and to determine what weight each should be given. Since the 1970's, the simulations revealed, global warming cannot be explained without a large impact from greenhouse gases.

Dr. Schlesinger, the University of Illinois climatologist, says he has "a couple of problems" with the study. First, he says, the data on solar variability before 1978 are unreliable. Second, the climate system's natural internal variability, apart from external forcings, is quite large relative to the observed warming and has not been well quantified. For example, he says, there is a growing body of evidence that the warming in the early part of the century resulted from a natural oscillation in the surface temperature of the North Atlantic Ocean.

The larger point, Dr. Schlesinger says, is that the climate system's internal variations may be so large that they render the Tett findings' statistical significance weaker. Nonetheless, Dr. Tett says he believes the findings strengthen the United Nations panel's 1995 conclusion about a human impact on climate.

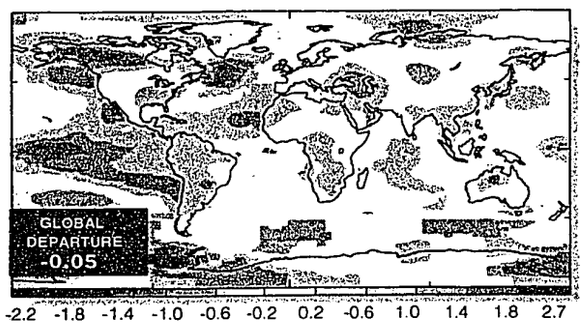
The struggle to gauge that impact goes on. "The important question," Dr. Prinn says, "is numbers" — precise estimates of the relative weight of natural and human factors. "It could be there are big environmental issues involved here," he says, "or relatively modest ones.

## Tracking the Globe's Hot Spots

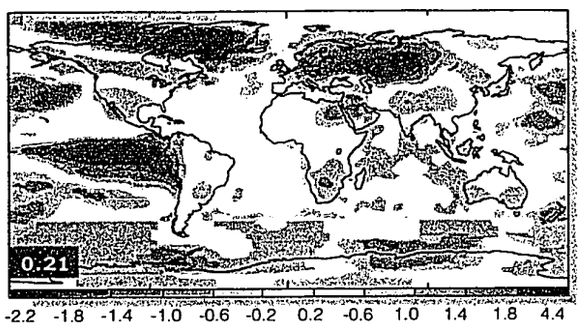
While the earth's average surface temperature has warmed over the last century, the warming has not been geographically uniform, and many influences combined to produce different temperature profiles at different times. Here are illustrative snapshots from the last 25 years. In each case, the snapshot presents an average for the 12 months ended with July of the year shown.

**Global Warming Since 1974**

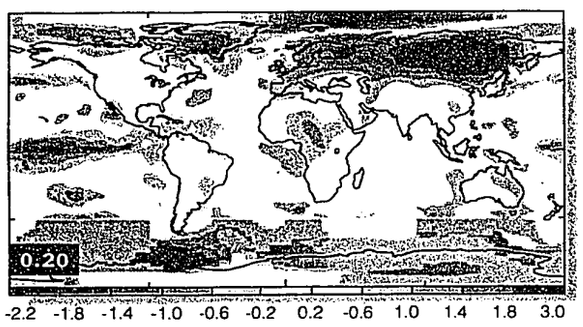
*Maps show temperature departure in degrees Celsius from a benchmark average of 1951-1980*



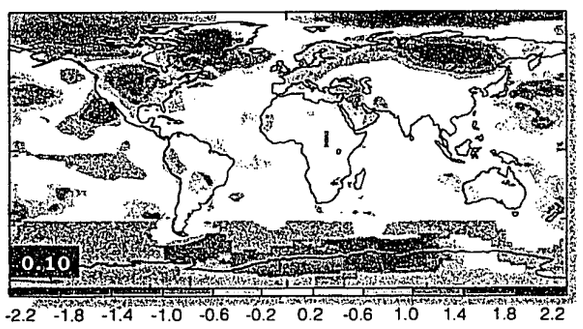

**1973-74**
This was one of the last years of a relatively cool period beginning in the 1950's.



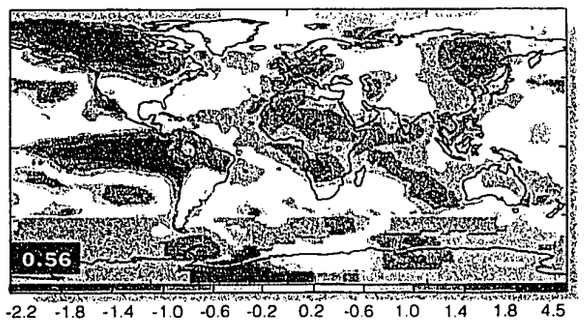

**1982-83**
A combination of global warming and El Niño (exceptionally warm area off South America) pushed this year above average.




**1988-89**
Global warming was moderated by the cooling impact of La Niña (cool area of tropical Pacific west of South America).




**1992-93**
Global haze of sun-reflecting sulfate droplets from eruption of Mount Pinatubo volcano interrupted global warming trend.




**1997-98**
Combination of global warming and El Niño pushed average surface temperature to all-time record.

*Source: NASA Goddard Institute for Space Studies*

The New York Times