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GREENHOUSE EFFECT AND GLOBAL CLIMATE CHANGE

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

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ON THE

GREENHOUSE EFFECT AND GLOBAL CLIMATE CHANGE

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PART 2

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FORECAST FOR DISASTER

Man-made pollutants are producing changes in the earth's climate that may prove catastrophic

BY ROBERT H. BOYLE

LOOKING AHEAD

A WARMING WORLD:

Rising global temperatures could disrupt wheat farmers, electric utilities, and military strategy. Which companies win or lose depends on how well they plan ahead. ■ *by Anthony Ramirez*

A PHYSICAL CHILL settled on the 14th century at its very start, intimating the miseries to come. The Baltic Sea froze over twice, in 1303 and 1306-7, years followed of unseasonable cold, storms, and rains, and a rise in the level of the Caspian Sea. Contemporaries could not know it was the onset of what has since been recognized as the Little Ice Age ... lasting until about 1700. Nor were they yet aware that, owing to the climatic change, communication with Greenland was gradually being lost, that the Norse settlements there were being extinguished, that cultivation of grain was disappearing from Iceland and being severely reduced in Scandinavia.

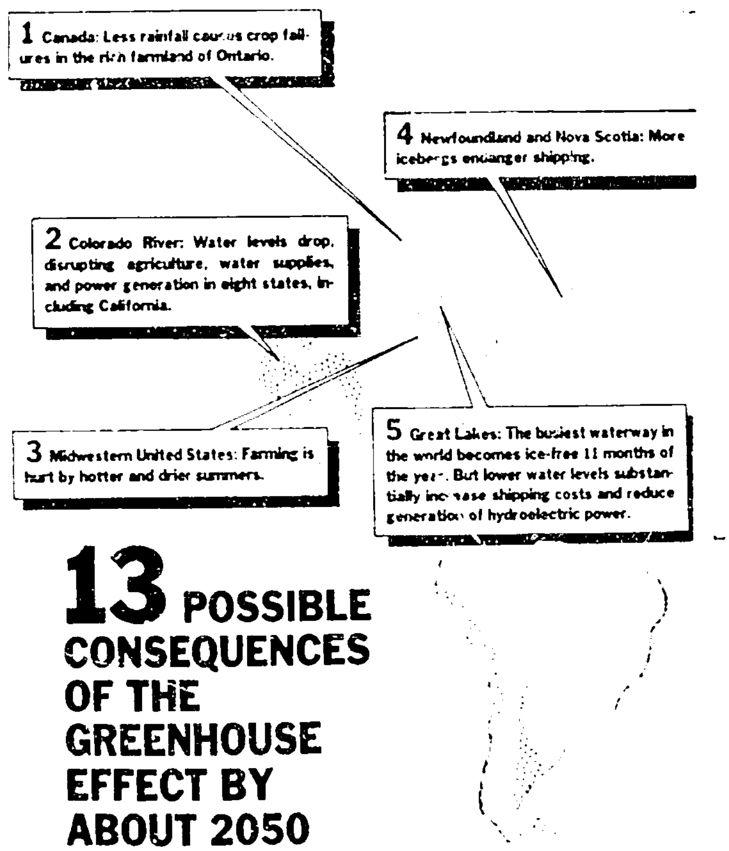
– Barbara Tuchman, A Distant Mirror

Like the 14th century, the 21st century is in for nasty weather—but of the opposite kind. Although the earth has undergone periods of warming and cooling in the past, scientists are now generally agreed that it is about to heat up more—and faster—than ever. By the likeliest scenario, the resulting climatic changes will bedevil farming, shipping, international trade, energy policy, and military strategy. Coping with dramatic global warming will not be easy, but ignoring it would be foolish. The best bets: conserving energy and using alternative energy sources, including nuclear power.

The threat is clear. Carbon dioxide from the burning of fossil fuels like oil, coal, and gasoline is rapidly accumulating in the atmosphere. So are gases like chlorofluorocarbons (CFCs), which are far less abundant but equally devastating. CO_2, CFCs, and the other gases come almost entirely from a variety of man-made sources like vehicle exhausts and industrial solvents. Only a modest amount derives from natural sources like microbes in the soil. In the earth's atmosphere the gases act like the glass in a greenhouse, which lets in sunlight but traps heat. By absorbing rather than reflecting the infrared radiation that produces heat, they are bringing about the relentless warming of the planet known as the greenhouse effect (see box, page 104).

"My feeling is that there's no way to stop it," says Walter Roberts, president emeritus of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and an organizer of a year-long United States–Soviet Union conference on global warming that started meeting in May. "It may be a little bit smaller or it may be a little bit larger. But the greenhouse effect is going to come." He thinks global dependence on fossil fuels is so vast that it makes

REPORTER ASSOCIATE *Alicia Hills Moore*



13 POSSIBLE CONSEQUENCES OF THE GREENHOUSE EFFECT BY ABOUT 2050

Center in Woods Hole; Dr. Manabe from NOAA, Geophysical Fluid Dynamics Laboratory in Princeton; Dr. Dudek, a senior economist with the EDF; and finally Dr. William Moomaw, Senior Associate of WRI, World Resources Institute.

All of your statements will be included in full in the record, and we would ask you to summarize in the way that you think would be most beneficial. And after you have all had a chance to testify, we will then go to questions and discussions with the members of the Senate. So, gentlemen, thank you very much for being here. Dr. Hansen, if you would start us off, we'd appreciate it.

STATEMENT OF DR. JAMES HANSEN, DIRECTOR, NASA GODDARD INSTITUTE FOR SPACE STUDIES

Dr. HANSEN. Mr. Chairman and committee members, thank you for the opportunity to present the results of my research on the greenhouse effect which has been carried out with my colleagues at the NASA Goddard Institute for Space Studies.

I would like to draw three main conclusions. Number one, the earth is warmer in 1988 than at any time in the history of instrumental measurements. Number two, the global warming is now large enough that we can ascribe with a high degree of confidence a cause and effect relationship to the greenhouse effect. And number three, our computer climate simulations indicate that the greenhouse effect is already large enough to begin to effect the probability of extreme events such as summer heat waves.

My first viewgraph, which I would like to ask Suki to put up if he would, shows the global temperature over the period of instrumental records which is about 100 years. The present temperature is the highest in the period of record. The rate of warming in the past 25 years, as you can see on the right, is the highest on record. The four warmest years, as the Senator mentioned, have all been in the 1980s. And 1988 so far is so much warmer than 1987, that barring a remarkable and improbable cooling, 1988 will be the warmest year on the record.

Now let me turn to my second point which is causal association of the greenhouse effect and the global warming. Causal association requires first that the warming be larger than natural climate variability and, second, that the magnitude and nature of the warming be consistent with the greenhouse mechanism. These points are both addressed on my second viewgraph. The observed warming during the past 30 years, which is the period when we have accurate measurements of atmospheric composition, is shown by the heavy black line in this graph. The warming is almost 0.4 degrees Centigrade by 1987 relative to climatology, which is defined as the 30 year mean, 1950 to 1980 and, in fact, the warming is more than 0.4 degrees Centigrade in 1988. The probability of a chance warming of that magnitude is about 1 percent. So, with 99 percent confidence we can state that the warming during this time period is a real warming trend.

The other curves in this figure are the results of global climate model calculations for three scenarios of atmospheric trace gas growth. We have considered several scenarios because there are uncertainties in the exact trace gas growth in the past and especially in the future. We have considered cases ranging from business as usual, which is scenario A, to draconian emission cuts, scenario C, which would totally eliminate net trace gas growth by year 2000.

The main point to be made here is that the expected global warming is of the same magnitude as the observed warming. Since there is only a 1 percent chance of an accidental warming of this magnitude, the agreement with the expected greenhouse effect is of considerable significance. Moreover, if you look at the next level of detail in the global temperature change, there are clear signs of the greenhouse effect. Observational data suggests a cooling in the stratosphere while the ground is warming. The data suggest somewhat more warming over land and sea ice regions than over open ocean, more warming at high latitudes than at low latitudes, and more warming in the winter than in the summer. In all of these cases, the signal is at best just beginning to emerge, and we need more data. Some of these details, such as the northern hemisphere high latitude temperature trends, do not look exactly like the greenhouse effect, but that is expected. There are certainly other climate change factors involved in addition to the greenhouse effect.

Altogether the evidence that the earth is warming by an amount which is too large to be a chance fluctuation and the similarity of the warming to that expected from the greenhouse effect represents a very strong case. In my opinion, that the greenhouse effect has been detected, and it is changing our climate now.

Then my third point. Finally, I would like to address the question of whether the greenhouse effect is already large enough to affect the probability of extreme events, such as summer heat waves. As shown in my next viewgraph, we have used the temperature changes computed in our global climate model to estimate the impact of the greenhouse effect on the frequency of hot summers in Washington, D.C. and Omaha, Nebraska. A hot summer is defined as the hottest one-third of the summers in the 1950 to 1980 period, which is the period the Weather Bureau uses for defining climatology. So, in that period the probability of having a hot summer was 33 percent, but by the 1990s, you can see that the greenhouse effect has increased the probability of a hot summer to somewhere between 55 and 70 percent in Washington according to our climate model simulations. In the late 1980s, the probability of a hot summer would be somewhat less than that. You can interpolate to a value of something like 40 to 60 percent.

I believe that this change in the frequency of hot summers is large enough to be noticeable to the average person. So, we have already reached a point that the greenhouse effect is important. It may also have important implications other than for creature comfort.

My last viewgraph shows global maps of temperature anomalies for a particular month, July, for several different years between 1986 and 2029, as computed with our global climate model for the intermediate trace gas scenario B. As shown by the graphs on the left where yellow and red colors represent areas that are warmer than climatology and blue areas represent areas that are colder than climatology, at the present time in the 1980s the greenhouse warming is smaller than the natural variability of the local temperature. So, in any given month, there is almost as much area that is cooler than normal as there is area warmer than normal. A few decades in the future, as shown on the right, it is warm almost everywhere.

However, the point that I would like to make is that in the late 1980's and in the 1990's we notice a clear tendency in our model for greater than average warming in the southeast United States and the midwest. In our model this result seems to arise because the Atlantic Ocean off the coast of the United States warms more slowly than the land. This leads to high pressure along the east coast and circulation of warm air north into the midwest or the southeast. There is only a tendency for this phenomenon. It is certainly not going to happen every year, and climate models are certainly an imperfect tool at this time. However, we conclude that there is evidence that the greenhouse effect increases the likelihood of heat wave drought situations in the southeast and midwest United Stats even though we cannot blame a specific drought on the greenhouse effect.

Therefore, I believe that it is not a good idea to use the period 1950 to 1980 for which climatology is normally defined as an indication of how frequently droughts will occur in the future. If our model is approximately correct, such situations may be more common in the next 10 to 15 years than they were in the period 1950 to 1980.

Finally, I would like to stress that there is a need for improving these global climate models, and there is a need for global observations if we're going to obtain a full understanding of these phenomena.

That concludes my statement, and I'd be glad to answer questions if you'd like.

[The prepared statement of Dr. Hansen follows:]