Long Hot Future: Warmer Earth Appears Inevitable

The planet earth will be a warmer place in the 21st century, and there is no realistic strategy that can prevent the change. Scientists and societies should instead concentrate their efforts on learning how to adapt to a warmer world—and to the new climate's likely effects on agriculture, water resources and sea level.

That, in broad paraphrase, is the central conclusion of two independent studies, both released this week, of the so-called "greenhouse effect"—the effect, that is, of rising levels of atmospheric carbon dioxide on global climate. Carbon dioxide, which is released into the atmosphere primarily through burning coal, oil and gas, is the most abundant of the greenhouse gases — gases that absorb the earth's radiated energy and create a thermal blanket around the globe. Both studies — one requested by Congress and the other by the administration—address the question of whether or not changes in energy policy might prevent or delay changes in climate. Both conclude that some warming is probably inevitable and that even very forceful policies—such as heavy taxing of fossil fuel use by industry — are unlikely to significantly delay the heat.

The greenhouse theory has been known and debated since the 19th century, but only in recent years have scientists developed the mathematical modeling techniques that make it possible to predict future climate. Both studies make use of such models. This week's report to Congress, prepared by the National Research Council (NRC), predicts that the level of atmospheric carbon dioxide will double (to approximately 600 parts per million) by the year 2065. Such an increase, the report concludes "with considerable confidence," will be accompanied by an increase in the earth's surface temperature and the temperature of the lower atmosphere—probably in the range of 1.5 to 4.5 degrees centigrade. A change in the lower end of that range is more probable, the report states; but in order to underscore the significance of even a small global temperature change, the report adds that the earth's temperature has changed only 2 degrees centigrade over the last 1,000 years and only 6 to 7 degrees in the past million years. The changes predicted for the next century, the authors say, "carry our planet into largely unknown territory."

What is unknown is how a 2 degree temperature change would affect weather conditions, which in turn affect water supply, agriculture, regional welfare and world politics. Although the authors speculate wildly — Arctic melting might make possible the old dream of a "Northwest Passage"—they emphasize that their inferences about regional changes are offered "with much less confidence." They suggest that the temperature rise will be relatively greater at the poles; that a 3 to 4 degree temperature increase would cause the sea level to rise about 70 centimeters; that summers will be drier in the middle latitudes (where the United States is situated). Precipitation, water supply and agriculture may be affected differently in different regions of the world, the report says.

While the report of the NRC (part of the National Academy of Sciences) concludes that the worldwide problem is "intractable," it is a "reason for caution, not panic." The predictive model, the report emphasizes again and again, contains many "enormous uncertainties": It requires estimation of the future economy, patterns of fuel use, the carbon dioxide sent into the atmosphere by fossil fuels, the amount of the carbon dioxide that actually stays in the atmosphere, and the effect of the gas (and all other greenhouse gases) on climate—all processes that are not well understood. It is not likely that the worst scenario will occur, the report states, so any immediate action to cut back on use of fossil fuels is unjustified. While society should be prepared to switch from fossil fuels to other energy sources if necessary, the report states, it is more prudent to study ways of adapting to environmental change.

That, too, is the conclusion of the second report, prepared by Stephen Seidel and Dale Keyes for the Environmental Protection Agency (EPA), which was designed specifically to determine if a change in energy policy regarding fossil fuels could help control carbon dioxide emission enough to prevent the predicted warming. The study used three models—estimating future energy use, levels of atmospheric carbon dioxide, and the ultimate effects of gases on temperature—to evaluate the effects of public policy innovations on the climate 60 and 120 years from now. Using the estimate that a 2 degree change will occur by the year 2040 and a 5 degree change will occur by 2100, they found that only a total ban on coal use by the end of the century would significantly delay the temperature rise — pushing it back 15 years. Even a worldwide tax of 300 percent on the cost of fossil fuels, the authors report, would delay the 2 degree rise by only five years. The timing and magnitude of the coming temperature change is more likely to be affected by such unknowns as the role of other greenhouse gases and the sensitivity of the atmosphere to these gases, than by changes in economic growth and energy demand, the report notes. The EPA report concludes that an international ban on coal use is politically unfeasible, and that research on national adaptive strategies is the best course.

—*W. Herbert*

Bugs in the termite gas estimates?

By some accounts concentrations of atmospheric methane, a long-lived trace gas and a contributor to global warming, have doubled in the last 150 years and are still rising at a rate of nearly 2 percent per year. One proposed source of as much as half of this yearly contribution is termites. Billions of them worldwide gnaw through wood and plant fiber, their guts providing a plush abode for the microbes that break the cellulose down into organic compounds the insects can use.

It has been known for several decades that termites produce methane. But a year ago when researchers from the National Center for Atmospheric Research (NCAR) in Boulder, Colo., published their startling assertion that termite gas comprises a major portion of the annual flux of atmospheric methane (SN: 11/6/82, p. 295), other scientists hustled to their laboratories or to the field to reproduce or challenge the results. The latest of these retorts was presented last week in Santa Fe, N.M., at the Sixth International Symposium on Environmental Biogeochemistry. Ralf Conrad of the Max Planck Institute for Chemistry in Mainz, West Germany, described work performed with colleague Wolfgang Seiler. They measured methane and carbon dioxide emissions from termite mounds in a savanna in Transvaal, South Africa, and found that while "termites are definitely a significant source of methane," they contribute far less of the gas to the atmosphere than proposed by NCAR researchers Patrick Zimmerman, James Greenberg and colleagues.

The original report proposed that the insects release about 150 teragrams, or 150 million tons, of methane to the atmosphere each year. (The atmosphere is said to hold about 4,000 teragrams of methane; 14 million people weigh about one teragram.) Seiler and Conrad estimate that the termites contribute about 10 million tons. Reinhold Rasmussen and M.A.K. Khalil of the Oregon Graduate Center in Beaverton, who first demonstrated the increase in atmospheric methane (SN: 12/11/82, p. 375), propose that termites supply 15 to 30 million tons of the gas per year. These latter amounts still constitute sizable quantities of the gas, but leave room for large contributions by other known methane sources — ruminant animals such as cattle, which produce methane as a by-product of digestion; stagnant water bodies such as rice paddies and swamps; and leakage from natural gas pipelines.

The debate is certain to continue. Greenberg, speaking for the NCAR group, says that they are confident in their figures but adds that any estimate of global methane production by termites is undermined by the lack of good termite population figures, and by the difficulty of determining how much total carbon the insects consume. Conrad, for instance, told SCIENCE NEWS that the reason his calculations differ so notably from those of the NCAR group is that they used different figures in computing the amount of biomass eaten by the termites each year. The equation is complicated further because different termite species and termites in different ecological systems do not necessarily produce equal quantities of gas.

The controversy is of practical interest because the implications of the rising methane concentrations will be better understood when the sources for the gas are identified. The problem also highlights the difficulties inherent in any effort to extrapolate a local measurement to a global scale. Not only is agreement lacking over sources of the gas, but no one knows for sure what happens to methane once it is produced.

As the NCAR group suggests, methane may enter the atmosphere as soon as it escapes from the termite mounds or other sources. Or, as some other researchers, including Seiler and Conrad, believe, it may be taken up by other micro-organisms, such as those that so densely populate the soils.

In related research, the German scientists took measurements of methane uptake by soils in the same geographic region where they conducted their termite studies. They estimate that the annual methane consumption in the tropics and subtropics is 21 million tons, exceeding their estimate of the methane emitted by the termites and "indicating that these areas may act as a net sink of atmospheric methane." *—C. Simon*

Integrated optics: On a hot trail

Modern integrated electronics can do many things that would have seemed magical only a few decades ago. However, integrated optics are hot on their trail and may soon provide more versatile and lower-power alternatives. An example of such a development, representing worldwide efforts at optical signal processing, is an optical analog-to-digital converter developed at the Lincoln Laboratory of the Massachusetts Institute of Technology in Lexington, Mass., by R. A. Becker and F. J. Leonberger. Their paper on the subject presented this week at the meeting in New Orleans of the Optical Society of America was intended to show, among other things, that "optics can do some things you can't do with silica."

An analog signal is a continuous signal that mimics the shape of something — it may be the acoustical wave produced by a person's voice or the variation of light and dark across a picture. For most kinds of present day computer processing, analog signals, which naturally arise in many data gathering procedures, must be converted to digital signals, sequences of numbers. The converter works by repeated fast sampling of the passing analog signal. It then measures at intervals whatever quality of the analog signal is changing, usually either the amplitude or the frequency of an electromagnetic wave, and puts out a sequence of numbers representing the values it measures as it samples again and again. The computer does whatever calculating it has to do with these numbers and then the signal is converted back to analog.

Thus the smoothly varying analog signal is converted to what amounts to a series of steps. The faster the sampling rate, the narrower the steps, and the more faithfully the analog signal is coded. The optical converter samples much faster than silicon ones can, Becker and Leonberger say, at rates of 100 million to even a billion samples a second. Furthermore, its optical properties have a periodicity that matches that of the Gray code, a widely used digitizing method. In the Gray code each decimal number is translated to a series of 1s and 0s. The decimal is arranged so that a change of one unit in the decimal number changes only a single 1 or 0 in the digital code and does it in a cyclic way as the digital numbers rise or fall. The operative element in the optical converter, an array of Mach-Zehnder interferometers, cycles in the same way, facilitating the coding procedure.

The Mach-Zehnder interferometer takes an incoming laser light pulse, splits it in two and sends the parts down two paths in an electro-optic material. Electrodes bracket both paths. A potential difference across the electrodes causes the material to change the speed of the light through it. One path is biased to slow the light, the other to speed it. The incoming analog signal controls these biases. When the light pulse is reunited at the end of the interferometer, the pulse difference between the two halves represents the data sample. Very short laser pulses make high sampling rates possible.

The interferometers can be fabricated in an integrated way out of titanium-doped lithium niobiate. Work is underway on developing a fully integrated converter and optical readout components as well.

—D.E. Thomsen

Clark nominated for Interior job

President Reagan's quick and surprising nomination of White House National Security Adviser William P. Clark as Department of Interior secretary to replace James Watt (SN: 10/15/83, p. 247) has sent Senate staff and many environmental groups digging into Clark's past record on environmental issues. Much attention is focussing on Clark's rulings when he was a justice of California's Supreme Court from 1973 to 1981.

Reagan's announcement last week, just three days after Watt's resignation, described Clark as "a God-fearing westerner, a fourth-generation rancher, a person I trust." Whether or not those qualifications are sufficient for the job and whether Clark intends to continue Watt's policies will be the subject of confirmation hearings before the Senate Energy and Natural Resources Committee. Sen. James A. McClure (R-Idaho), committee chairman, said he saw no difficulty in confirming Clark, and said confirmation may come before Congress recesses on Nov. 17.

However, several senators, including Sen. Dale Bumpers (D-Ark.), expect to question Clark closely because of Clark's apparent inexperience in dealing with environmental matters. Groups like the National Audubon Society are hoping that the hearings will also be a forum for looking at the Reagan administration's environmental policies and for getting an idea of what direction the Interior Department may take in the next year.

Although some groups like the Wilderness Society have already condemned the Clark nomination, others like the National Wildlife Federation and the Sierra Club are awaiting meetings with Clark to get a better sense of where he stands on particular issues. One important concern is whether Clark will consider replacing some Interior Department officials dedicated to carrying out Watt's policies. Another worry is access. A National Audubon Society representative says, "We will again try to open some of the doors that have been closed at the Interior Department."

Based on Clark's California record — for instance, he favored limiting government land-use restrictions — most environmentalists are not optimistic about a change in policy, but they are hoping Clark will listen and show more flexibility than his predecessor.

One issue Clark would face immediately is the administration's long-delayed acid rain policy. The present cabinet debate seems to center on the great cost of measures to reduce sulfur dioxide emissions versus the apparent benefits of "saving a few fish" and the issue's potential for dividing the country because of strong regional differences. A decision may not be made until late November. *—I. Peterson*