IGCC POLICY BRIEF

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Climate Change Science

Part V of VI: Abrupt Climate Change

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Climate change may occur abruptly, within a decade—not gradually, over several lifetimes—with continued warming.

Full recommendations, page 4.

Summary:

Climate change may not be a smooth, gradual phenomenon, but can occur in abrupt jumps. There can be abrupt climate change within a period of ten years. This suggests that climate change acts more like a switch than a dial, and jumps from one relatively stable state to another. Economic studies and policy recommendations based upon the assumption that there will be gradual increases in temperature may be seriously flawed. While climate models are not yet accurate enough to predict exactly how close we are to dangerous triggers, the more climate is altered, the greater the risk of sudden change. ❖

This brief is the product of the *Climate Change–Science Policy Interface* panel to the UNFCC COP-4 meetings held in Buenos Aires, Argentina 12-13 November 1998, and the 10–11May 1999 *Global Climate Change: Recent Science Developments* briefing to the U.S. Congress, held at the invitation of U.S. Senator Diane Feinstein. Both events were co-sponsored by IGCC and the UC Scripps Institute of Oceanography. We wish to thank the UC Office of the President, the Muskie Foundation, and the Hewlett Foundation for generous support of this work.

BUBBLES OF GASES TRAPPED in ice cores can be used to track changes in ancient climate. Following research on ice core bubbles in Greenland, the author recently reported that the Earth went through a period of rapid warming at the end of the ice age. This research raises the question: Contrary to the slow, steady rise many computer models have predicted, will the addition of carbon dioxide to the atmosphere through the fossil fuel burning also produce a rapid change in climate?

Rapid Warming

Recent discoveries from the Greenland ice core drilling program, and from sediment cores in much of the world, have demonstrated that some 11,000 years ago, during and at the end of the last ice age, the earth's climate warmed abruptly—in less than a decade, and perhaps as little as three years,

Indeed, abrupt warming events punctuated the end of cold periods both 15,000 and 11,500 years ago. During the 15,000-year event, air temperature at the summit of Greenland rose sixteen degrees Fahrenheit over several decades. Tropical temperatures and/or rainfall rose at the nearly the same time, underscoring the near-global nature of these warming trends.

These results have a high degree of confidence. Such events have occurred some twenty-two times in the last 100,000 years, and thus must be considered characteristic and recurring features of our Earth's climate.

Climate Switch, not Warming Dial

The new view that is emerging from these studies is that the earth's climate system can behave more like a "switch" than a "dial." For example, just as a light switch responds only after one pushes it for some distance, when it flips all at once, climate appears to jump abruptly from one relatively stable state to another. The general message, then, is that the Earth's climate system may vary at discreet thresholds. If climate changes, it may change quickly when a specific level is reached—not necessarily in proportion to the amount of greenhouse gases added to the atmosphere.

Unpleasant Surprises

This fast speed of change stands in marked contrast to the gradual pace that is generally discussed in the context of greenhouse warming over the next fifty to one-hundred years. Indeed, models used to predict future climate fail to simulate these abrupt changes. The gradual warming in response to rising carbon dioxide concentrations over the next century that is predicted by these models therefore must be taken with a grain of salt. We should expect some climate surprises in the next 50-100 years.

Our adaptation to a change in temperature and rainfall is critically affected by the speed of the change. Agriculture and infrastructure can adapt to changes that occur over the century time scale, but not to events that happen in a few years. If for some reason such an abrupt event were to happen now, it would be far more destructive to society than the greenhouse-gas induced warming that is generally expected. Some modeling studies suggest that human greenhouse gas emissions may in fact trigger such a surprise, although most of the abrupt events occurred during the cold ice ages, and not during the warm interglacial period in which we now live.

Certain Surprises

While the possible effect of human emissions remains speculative, there is no doubt that these abrupt events did occur in the past, and are a regular and characteristic feature of the climate system. In that sense, they are certain to occur again, though we cannot predict when. And while climate models are not yet accurate enough to predict exactly how close we are to dangerous triggers, obviously the more climate is altered, the greater the risk of sudden change.

Uncertain Solutions

In light of these findings of natural changes, it may seem that it is beyond our power as humans to do anything to reduce the risk of disruption to our food production and life support systems. Furthermore, it may seem to be too late to take preventative actions such as reductions in greenhouse gas emissions. However, some models suggest that the rate at which we subject the Earth to change is as important as the total amount of change. Thus we may be able to 'buy some time' by reducing the speed with which the concentration of heat-trapping gases increases in the atmosphere. In general, climate policy prescriptions need to be made with an extra margin to allow for the unexpected, which we can expect.

THE IGCC CLIMATE CHANGE PROGRAM

is a University of California system-wide initiative that brings leading climate scientists directly in touch with key national and international policy-makers. Bringing objective, timely scientific expertise directly to bear in ongoing negotiations, IGCC sent a delegation of eminent climate change scientists to the November, 1998 (fourth) meeting of the Conference of the Parties (COP-4) of the United Nations Framework Convention on Climate Change (UNFCCC), held in Buenos Aires, Argentina. Through three panel presentations on abrupt climate change, carbon sinks, and the science–policy interface, UC scientists advised UN national delegations, intergovernmental organizations, industry representatives, environmental agencies, and international media about current, relevant implications of recent research.

IGCC was the only academic organization with a substantial presence at the conference, where there were otherwise few scientists. According to Michael Molitor, IGCC Climate Change Program Coordinator, "Our fundamental understanding of the climate system is evolving rapidly. There are some basic scientific assumptions that underlie the Kyoto protocol negotiating process that need to be reexamined in light of recent advances." The importance of these latest discoveries was not lost on UN delegates. Thereafter, on 10–11 May 1999, IGCC Climate Change Program held briefings for policymakers in the nation's capitol. IGCC's delegation comprised:

Sandra BROWN, Winrock International
Richard CARSON, IGCC
Michael MOLITOR, IGCC
Stephan RAHMSTORF, Potsdam Institute for Climate Impact Research
Jayant SATHAYE, Lawrence Berkeley National Laboratory
Stephen SCHNEIDER, Stanford University
Jeff SEVERINGHAUS, Scripps Institution of Oceanography, UCSD
Lisa SHAFFER, Scripps Institution of Oceanography, UCSD
Robert SHELTON, UC Office of the President
Richard SOMERVILLE, Scripps Institution of Oceanography, UCSD
Mark THIEMENS, UCSD Center for Environmental Research and Training
Susan TRUMBORE, UC Irvine
Ray WEISS, Scripps Institution of Oceanography, UCSD

Jeff P. SEVERINGHAUS is an assistant professor in the geosciences research division of the UCSD Scripps Institution of Oceanography. He is an expert in stable isotope geochemistry. Severinghaus received a Ph.D. in geological sciences from Columbia University's Lamont Doherty Earth Observatory in 1995.

This is the fifth of a six-part series titled Climate Change Science. See also PB 12-1: Bridging Science to Policy *by Richard Carson;* PB 12-2: Predicting 21st Century Climate *by Richard C.J. Somerville;* PB 12-3: Critical Omissions for Critical Emissions *by Mark Thiemens;* PB 12-4: Soil Carbon Sinks *by Susan Trumbore;* and PB 12-6: Practical Implementation *by Michael Molitor.*

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Surprising climate changes:

1. **Abrupt warming events—some over less than a decade—occurred some 22 times in the last 100,000 years. They are characteristic and recurring features of our Earth's climate.**
2. **These are global phenomena.**
3. **Earth's climate may behave more like a "switch" than a "dial." The climate system varies at discreet *thresholds*.**
4. **If climate changes, it may change quickly when a specific level is reached—not in proportion to the amount of greenhouse gases added to the atmosphere. Doubling future greenhouse gas emissions might not produce only twice the warming.**
5. **Models used for predicting future climate do not simulate abrupt changes. Therefore, gradual warming predicted by current models must be taken with a grain of salt.**
6. **Expect some climate surprises in the next 50-100 years.**

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