IGCC POLICY BRIEF

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Climate Change Science

Part II of VI: Predicting 21 st Century Climate

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The United States must not lag in dedicating national resources to trustworthy climate prediction.

Full recommendations, page 4.

Summary: Thanks to recent developments in climate modeling, our ability to predict severe storms, El Niño, and La Niña effects is improving. But climate models are not yet accurate enough to predict regional or global climate change with confidence. Accurate predictions require solid data, realistic simulations, and super-computer access. If climate changes, clouds are likely to change as well, and have important feedback on the change process. Thus, treating clouds accurately is especially critical. Long-term, sustained, global scale observations are necessary. Governments must commit resources and develop cooperative strategies to fill in gaps in current observing systems. Current computer simulation do not model clouds well, and have rarely been tested against observations. Observational and modeling research to show how clouds behave in the actual atmosphere is key to making future climate projections reliable, detailed, and useful to policymakers. It should be supported. ❖

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 10–11 May 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 Scripps Institution of Oceanography. We wish to thank the University of California Office of the President Office of Research for generous support of this work.

GOOD SCIENCE CAN OFTEN provide the needed foundation to under gird good policy. Unless scientists provide a clear and comprehensive understanding of climate, how is the policy maker to judge whether serious climate change due to human activity is a bleak certainty or a remote possibility or something in between? When weighing choices with potentially serious economic and societal consequences, political leaders deserve the results of the best relevant research, presented intelligibly and neutrally. And scientists, whose research is often supported by tax dollars, ought to provide helpful input to policy makers who need it.

Advances in Science

As it happens, environmental science today is well enough advanced to be highly useful to policy makers, although it is far from being able to answer all the questions put to it. We know that in many ways people are beginning to rival Mother Nature as factors causing global environmental change. The main underlying reasons are the rapid increase in human population, the chemicals we dump into the environment, and the ways we use energy, which we mainly obtain from coal and oil and natural gas. People cause air pollution and acid rain. People cause the ozone hole. People are adding to the natural greenhouse affect. These are demonstrable facts, not in dispute among reputable scientists.

Cloudy Futures

The increased greenhouse effect due to human activities will eventually cause climate change, although we still have much more research to do in order to say authoritatively how quickly the change will arrive and what forms it will take. Meanwhile, we must realize that the popular phrase "global warming" is deceptive. The most important aspects of climate change are likely to be neither global nor confined to warming. They may involve changes in the normal patterns of storms and precipitation, for example, or they may affect specific climate phenomena such as the Indian monsoon or El Niño. (Incidentally, nobody knows for sure whether the just-past El Niño event is connected in any way to long-term climate change.) We ought not to trivialize climate change by asking only whether doubling atmospheric carbon dioxide levels will produce an average warming of two or four or eight degrees Fahrenheit. Climate is complex. It is much more than just averages. It is, in fact, the sum total of weather.

Seen from space, the Earth appears as a mainly blue ocean planet flecked with constantly changing intricate patterns of white clouds. The clouds, which cover about half the surface of the planet, are critical to climate. They cool the Earth by reflecting away sunlight. At the same time, they warm the Earth by trapping the Earth's heat, thus contributing to the natural greenhouse effect. Of course, clouds are also a source of water in the form of rain and snow, critical to all aspects of life and central to agriculture and thus to the well-being of humankind. If climate changes, whether for natural or man-made reasons, clouds are likely to change as well and have important feedbacks on the climate.

Physical Models

In computer modeling of the global climate system, which is our main technique for forecasting future climate, we first have to understand climate science well enough to build crucial physical processes into our models realistically. Among the key science areas, treating clouds accurately is an especially critical issue, because clouds have such important effects on climate. However, clouds are much too small and short-lived to be modeled explicitly in a global simulation, and the physical processes involved in clouds are still imperfectly understood. Nevertheless, clouds and their consequences are much too important to be ignored, and so their effects are treated by simple rules.

Climate models are solved numerically on global grids with a typical resolution of a few hundred miles horizontally. When the model values of climate variables at this resolution are used to prescribe clouds, the resulting rules are often highly simplistic. For example, a typical rule might make the cloud amount in a model grid area proportional to relative humidity. However, the behavior of rules of this sort often bears little resemblance to the way clouds actually vary in space and time in the present atmosphere, let alone as to how they will change and feed back on any future climate which differs from the present one. These rules are rarely well-founded theoretically and have almost never been tested observationally in any thorough and satisfying way.

Getting Real

It is crucial that observational and modeling research be done to show how clouds behave in the actual atmosphere. Only recently have appropriate observations begun to be available to tackle this task. These observations provide invaluable information for the development of improved models. Supporting the research to obtain and use these data optimally is a key to progress in making future climate projections reliable, detailed and useful to policymakers.

A major goal of current research is to provide climate information on regional scales smaller than the domain of a global model grid volume. This can be accomplished by a variety of techniques, including statistical downscaling and nesting finer resolution models inside the global models. However, much research remains to be done before these techniques are fully developed and adequately realistic and reliable for policymakers and for other applications.

Supporting Science

Even with physically realistic models, developing trustworthy climate scenarios requires coordinated research, inter-agency cooperation, scientific and political leadership, and adequate supercomputer resources. In recent years, the United States has lagged in these areas. The scientific community has now assessed these shortcomings and has made strong recommendations as to needed changes in the way climate research is organized and supported. In particular, the glaring shortcomings in computer power available to climate research have now been well documented, and initiatives for solving this problem have been proposed.

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

The National Research Council's 1998 Report, *Capacity of U. S. Climate Modeling Capabilities to Support Climate Change Assessment Activities*, finds that in the United States, "there is no integrated national strategy" for climate modeling research. The report also concludes that, "insufficient human and computational resources are being devoted to high-end, computer-intensive, computational modeling" and that, "the United States lags behind other countries in its ability to model long-term climate change." The report calls upon Federal agencies to agree on a set of national goals, to establish a coordinated national strategy, and to provide adequate resources, including greatly improved supercomputing capability. From the viewpoint of the scientific community, it is now up to the Congress and the agencies to implement these recommendations. ❖

Richard C. J. SOMERVILLE is professor of meteorology at the Climate Research Division of the UCSD Scripps Institution of Oceanography. He received his Ph.D. in meteorology from New York University in 1966, and is an expert on global climate change and a specialist in computer modeling of the climate system. Author of *The Forgiving Air: Understanding Environmental Change* (University of California Press, revised paperback edition, 1998), an award-winning account of global change science written clearly and accessibly for the lay reader, Somerville has lectured widely on climate change; his research results have been published in more than one hundred technical papers.

This is the second of a six-part series titled Climate Change Science. *See also* PB 12-1: Bridging Science to Policy *by Richard Carson*; PB 12-3: Critical Omissions for Critical Emissions *by Mark Thiemens*; PB 12-4: Soil Carbon Sinks *by Susan Trumbore*; PB 12-5: Abrupt Climate Change *by Jeff Severinghaus; and* PB 12-6: Practical Implementation *by Michael Molitor.*

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How to develop good climate change predictions:

1. **Earth's climate can change for both natural and human-related causes. First, improve understanding of key physical processes, such as those related to clouds.**
2. **Measure. Model. Dedicate resources to make key observations; use these to improve computer simulations.**
3. **Dedicate more computer power, inter-agency coordination, and political leadership to turning observations and simulations into climate predictions useful to policymakers.**

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