CLIMATE CHANGE

Major Challenges for Bush's Climate Initiative

The president's drive to reduce the uncertainties about global warming faces daunting obstacles both scientific and institutional

When President George W. Bush yanked support for the Kyoto Protocol last month and called for more research to reduce the "uncertainties" about global warming, many policy-makers and scientists worldwide let out a collective groan. Bush's stance, they said, was just another excuse for inaction. Many climate scientists believe that, despite the admittedly large uncertainties, their current knowledge merits action (*Science,* 13 April, p. 192). But political disagreements aside, scientists do see a silver lining in Bush's call for a "science-based approach" to global climate change: the opportunity to focus climate science on key research and rein in the country's sprawling research enterprise.

Neither task will be easy, says David Evans, an assistant administrator of the National Oceanic and Atmospheric Administration (NOAA), who suspects that tightening the coordination of federal agency activities may prove even harder than setting scientific priorities. Indeed, Bush's father already tried. In 1990, he set up the U.S. Global Change Research Program (USGCRP) to coordinate research among 10 federal agencies. Although the country has since spent $18 billion on the program—"three times as much as any other country," the president pointed out—researchers and managers agree that it needs an overhaul.

"We have lots of talent and capabilities [in the United States], but they aren't as coordinated as they need to be," says atmospheric science program director Jay Fein of the National Science Foundation, one of the leading USGCRP agencies. One problem is that "the agencies' priorities have taken precedence over the coordinated needs of the program," agrees climate modeler Maurice Blackmon of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. "In tight budgetary times, the agencies have a tendency to protect their own interests."

Another problem, in the view of some, is a loose interpretation of "global change." For example, NASA claims the lion's share—69%—of USGCRP spending, which it uses to support costly satellites examining everything from stratospheric ozone to tropical forest clearing to the algae coloring the ocean. Some of the satellite data are crucial to monitoring long-term trends and verifying climate models, says meteorologist J. Michael Wallace of the University of Washington, Seattle, a member of the recent National Research Council (NRC) committee that reviewed climate change science (*Science*, 15 June, p. 1978). But "how much of that is really dedicated to climate?" he asks. "If NASA wants to, they say it's part of climate."

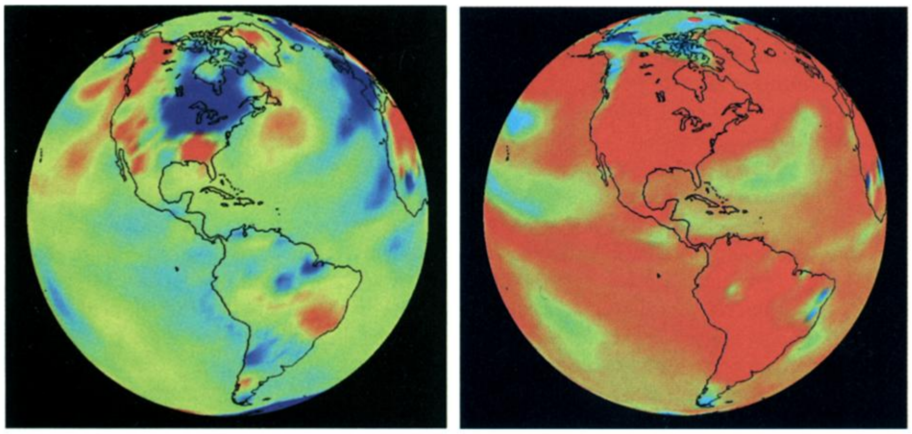
To address such problems, President Bush said in June, he will "establish the U.S. Climate Change Research Initiative to study areas of uncertainty and identify priority areas where investments can make a difference." He mentioned no dollar amounts, only "additional investments in climate change research." The president gave the secretary of commerce (home to NOAA) lead responsibility for setting priorities and improving coordination among the various agencies. "We have really just begun," says Evans, who is organizing the effort for the secretary. He expects that, under this new umbrella, climate research will be more responsive to "a wider range of policy needs."

The secretary of commerce may have his hands full deciding where to give climate change research a policy-oriented tweak. In the realm of climate change processes, "we want everything, we need it all," says NRC study committee member Thomas Karl of NOAA's National Climatic Data Center in Asheville, North Carolina, only slightly tongue-in-cheek. But when pressed hard to go beyond the lengthy laundry lists of research needs that study committees have produced of late, some other climate scientists identify the role of clouds and pollutant hazes as the biggest and perhaps most recalcitrant uncertainties in projecting future climate.

Fast, but not the fastest. U.S. climate-modeling supercomputers like NCAR's are not the best for the job.

In a warming climate, clouds will morph to reflect more or less solar energy back into space—but no one is sure which it will be or how much warming or cooling that process will add. Similarly, depending on their composition, pollutant hazes made up of aerosol particles will either reflect solar energy and cool their surroundings or absorb solar energy and warm the region. And aerosols can modify clouds themselves so that they cool more, but the magnitude of this indirect effect is so uncertain that it might be large enough to counteract most of the greenhouse warming to date.

"We have made some progress since 1990 understanding what we don't understand" about clouds and related processes such as



Red-hot scenario. With more on their plates than greenhouse warming simulations like this one from NCAR's model, U.S. researchers have not contributed as much to assessments as Europeans have.

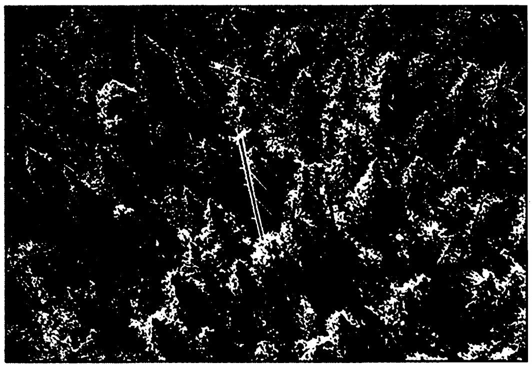
CREDITS: (TOP TO BOTTOM) NCAR; TIM SCHEITLIN/NCAR

Scientists Shower Climate Change Delegates With Paper

LONDON, U.K.—A group of prominent European academics this week released a trio of reports aimed at reviving the stalled international talks on climate change. Their advice comes on the heels of a report by the U.K.'s Royal Society that questions the value of carbon sinks in absorbing greenhouse gas emissions, one of the major sticking points to those talks. The torrent of words reflects the vigorous debate over the fate of the Kyoto Protocol, which delegates will take up next week during a follow-up meeting in Bonn, Germany.

The first set of reports comes from Climate Strategies, a new pan-European network of senior climate researchers and social scientists formed to shape the post-Kyoto debate by keeping policy-makers abreast of relevant climate data. "We've come up with great ideas in the past, but it's been too late," says Benito Müller, an expert on the Kyoto Protocol at the Oxford Institute of Energy Studies and a founding member of the group, which announced its formation at a press briefing here on 9 July. "The idea is to coordinate research so that it comes out on a timely basis."

Funded by a seed grant from the Shell Foundation, Climate Strategies argues in two reports that U.S. opposition to Kyoto should not torpedo the 1997 agreement. "Kyoto is a huge investment in intellectual and research effort, and renegotiating a new protocol would not necessarily give a better product —and would waste another 10 years," says Michael Grubb, a professor of climate change and energy policy at Imperial College and leader of the group. A third report looks at ways to tap carbon sinks for energy.



Up a tree. A Royal Society report warns against overstating the value of carbon sinks in mitigating global warming.

Carbon sinks were also the subject of a report last week by the Royal Society, the U.K.'s most prestigious scientific body. It warned against overreliance on carbon sinks as an alternative to slashing carbon dioxide emissions. "Carbon sinks may help to reduce greenhouse gas levels during the short term, but the amounts of carbon dioxide that can be stored are small compared to emissions from the burning of fossil fuels," says David Read, an ecologist at the University of Sheffield, U.K., and leader of the panel that prepared the report. Countries such as Japan, Australia, and the United States have been arguing for a larger role for sinks in meeting emissions targets. The report, however, says the role of sinks is small and finite.

One big uncertainty, the report says, is their estimated life-span. "Land sinks are not stable for long periods of time. Carbon locked up in trees and soils can also be released," says John Shepherd, a climate modeler at the Southampton Oceanography Centre. Another major issue involves the techniques required to monitor, quantify, and verify sinks. "Current techniques are not good enough operationally for something as important as this," says Shepherd.

Climate change experts not involved in any of the reports are divided on their value in shaping the negotiations to be held in Bonn from 16 to 27 July. "[The reports] will have some visibility, but I don't think the primary driver will be scientists or policy analysts," says Mike Hulme, director of the Tyndall Centre for Climate Change Research in Norwich, U.K. But Darren Goetze, a senior policy adviser on carbon sinks for the Canadian Environment Ministry in Ottawa, says the Royal Society's report "in large part confirms what the IPCC [Intergovernmental Panel on Climate Change] has been saying" and, thus, may steer debate away from carbon sinks and toward more lasting solutions to anthropogenic global warming.

As with greenhouse gases, there is no shortage of greenhouse analyses. Climate Strategies hopes to feed government officials throughout Europe a steady stream of reports that will help them take definitive action, and Frank Biermann, a political scientist not affiliated with the group, thinks that it can play a valuable role. "European [research] institutes are too small, and it makes sense that they join forces," says Biermann, who is with the Potsdam Institute for Climate Impact Research in Germany. "Europe needs a united position on climate change policy, which is sometimes lacking."

Even so, Grubb and others readily admit that a problem as complex as climate change won't be solved overnight. "Countries need to focus on completely restructuring their generation and use of energy," says Read. "These measures may be socially and politically more painful to implement. ... But they provide the ultimate solution."

—**JOHN PICKRELL**

aerosols, says climate modeler John Mitchell of the Hadley Center for Climate Prediction and Research in Bracknell, U.K. "But we've probably not progressed at all as far as decreasing uncertainty." Indeed, the estimated range of climate's sensitivity to increasing greenhouse gases—a measure of just how warm it could get—hasn't shrunk since it was first officially estimated in 1979.

To narrow these uncertainties, researchers call for many more targeted field investigations like INDOEX, the 1998–99 study of pollutant aerosols over the Indian Ocean. They also urge dramatic improvements in the most computationally demanding sort of climate modeling and in the collection of global climate data used to verify the models. "A sustained network of global observations is required if we're going to believe what's coming out of the models," says climate modeler Jeffrey Kiehl of NCAR. "We don't have that, and what we do have is deteriorating."

After a decade of planning and construction, NASA's space-based Earth Observing System satellites, such as Terra, are beginning to return the data on changing seasons and year-to-year climate variations that are needed to validate models of atmospheric behavior, Kiehl says. But for the long-term records that are also needed, climate researchers have had to depend on data collected for daily weather forecasts, a poor substitute. "A climate observing system really has always been lacking," says atmospheric chemist Ralph Cicerone of the University of California, Irvine, who chaired the NRC review of climate change science. "We're limping by with observations from platforms that were never designed for climate studies."

Nor is all of U.S. climate modeling up to world standards, researchers say. "I find it extraordinary that England does more focused and more extensive climate modeling than the United States," says oceanographer Edward Sarachik of the University of Washington, Seattle, who headed a recent NRC study on improving the effectiveness of U.S. climate modeling. "In the United States, our top two centers together don't amount to one-fifth of the European effort." When the U.S. global change program assessed the prospects for greenhouse warming in various regions of the country, it had to rely on two foreign models, one Canadian and one British (*Science*, 23 June 2000, p. 2113). No U.S. center with a top-of-the-line climate model had the spare computer time to run the needed simulations. And when the U.N.–sponsored Intergovernmental Panel on Climate Change compiled its regular 5-year report on the state of climate science, U.S. researchers were embarrassed

CREDIT: CAROLINE NICHOL/IERM/UNIVERSITY OF EDINBURGH because the U.K.'s Hadley Center and the Max Planck Institute for Meteorology in Hamburg, Germany, supplied the bulk of the needed simulations.

The crunch in U.S. climate computing "is not a matter of talent," says Cicerone, "it's focus, emphasis, and computer resources." U.S. researchers have long felt at a disadvantage because a trade dispute with Japan has prevented them from buying "vector" supercomputers from Japanese companies like Fujitsu and Hitachi. Instead, U.S. firms have concentrated on massively parallel supercomputers that, despite their much ballyhooed promise, have failed to provide the promised boosts, at least when computing climate change, says Kiehl.

Perhaps more crucial, say U.S. researchers, is the lack of focus on climate modeling. NCAR, NOAA's Geophysical Fluid Dynamics Laboratory, and several other institutions have developed sophisticated global climate models. But at each center, climate change modeling must vie for available computer time with other research on atmospheric science. "It's a matter of dedicating computer hardware to climate modeling," says Kiehl. "We don't do that here. There's also a cultural issue. The competition [among many centers] is viewed as a healthy way to stimulate research. I agree, but the climate modeling field has reached such a level of complexity that we have to change the way we've been working." Both the NRC study and a December 2000 USGCRP report recommend that the country create a center for U.S. climate modeling. The USGCRP report even suggests a "Climate Service," modeled on the Weather Service, that could perform climate modeling and run a climate observing system.

Given the push from the White House, climate scientists are optimistic that the field will get a needed boost. A new 10-year plan for USGCRP that would tighten up management is working its way to Congress, but all eyes are now focused on the Commerce Department. "The secretary is very engaged," says Evans, "and everyone's taking it very seriously, so something is likely to happen."

—RICHARD A. KERR

SUPERCOMPUTING

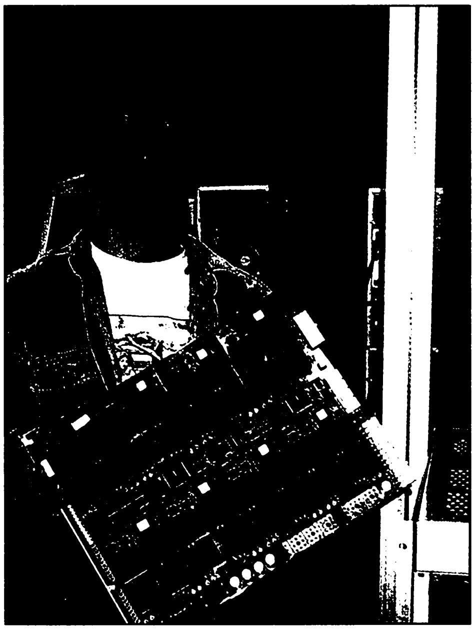
High-Powered GRAPEs Take On the Cosmos

An astrophysicist's dream machine, the GRAPE-6 supercomputer can put virtual galaxies through their gravitational paces

TOKYO—The world's fastest supercomputer is an unimpressive-looking machine with a name like a fruit drink and a price tag to warm a lab director's heart. Meet GRAPE-6, perhaps astrophysicists' most anticipated tool.

Unveiled earlier this week at a symposium* here, GRAPE-6 is the latest in a line of machines that has been quietly revolutionizing astrophysical simulation. Developed on a shoestring budget by a small team of researchers at the University of Tokyo, GRAPEs have become the machines of choice for simulating the formation of planets, the evolution of star clusters, and the collisions of galaxies. They have earned this distinction by being exquisitely tailored to do just one thing: computing the gravitational attraction between two bodies. GRAPEs run through this calculation so quickly that researchers have been able to begin simulating these astrophysical phenomena using realistic numbers of celestial bodies, a task that chokes conventional supercomputers. And GRAPEs are so affordable that even modestly funded groups can buy their own. Many groups have several.

"This is the democratization of supercomputing," says Mordecai-Mark MacLow, an astrophysicist at the American Museum of Natural History in New York City. Simon White, a theorist at the Max Planck Institute for Astrophysics in Garching, Germany, adds that work on stellar dynamics "has been much more lively than it would have been without [GRAPEs]." At least 32 research groups around the world now use them, and the tangle of collaborative work is so thick that Piet Hut, an astrophysicist at the Institute for Advanced Study in Princeton, New Jersey, has to think long and hard to name theorists without some connection to GRAPE simulations. The impact of GRAPE "has been revolutionary," says Hut, who himself collaborates with the GRAPE developers. Despite their limitations—GRAPES alone cannot calculate the effects of temperature, radiation, or magnetism—over the past decade their knack for gravitational number-crunching has helped resolve long-standing questions about planet formation, the behavior of globular clusters, and the collision of galaxies.



Hot item. Astrophysicist Jun Makino shows off a circuit board from the just-unveiled GRAPE-6.

CREDIT: D. NORMILE

And the best may be yet to come. GRAPE-6 debuts as the fastest computer in the world, with a theoretical peak speed of 30 trillion floating-point operations per second —teraflops or Tflops, for short. IBM still claims to hold the record for general-purpose computers, with its ASCI White supercomputer, which operates at 12.3 Tflops.

The GRAPE project grew out of dissatisfaction with available computers. In the mid-1980s, Daiichiro Sugimoto, an astrophysicist at the University of Tokyo, and Jun Makino, one of his grad students, were using so-called *N*-body simulations to study the evolution of star clusters. Makino recalls that simulations involving a few thousand stars took hundreds of hours of supercomputing time. And they wanted to scale up to hundreds of thousands of stars. "We really needed a computer much faster than what was available," Makino says.

The calculation is elementary, equaling the product of the masses of the two bodies and the gravitational constant divided by the square of the distance between the bodies. The problem is that increasing the number of bodies for greater realism increases the number of computations quadratically, because every body interacts with every other body.

Sugimoto's group was unaware that a problem similar to theirs had already been solved just across town. In 1983, Yoshihiro Chikada, an astronomer at Japan's National Astronomical Observatory, completed a special-purpose computer that processed the raw signals gathered by the battery of antennas at the Nobeyama Radio Observatory into usable data. The key idea was to hardwire the routine calculations as

* Astrophysical Computing Using Particle Simulations, 10–13 July.