Global Change Fights Off a Chill

The multibillion-dollar U.S. effort to understand Earth's climate system has long angered political conservatives. But now the program's supporters are urging scientists to take a new approach to the subject

The floods, droughts, and freakish weather associated with the recent El Niño brought disaster to millions around the world. But these calamities represented a scientific triumph for the U.S. Global Change Research Program, which tapped into data from a network of ground-, water-, and space-based instruments plus computer models for a dead-on prediction of the latest version of this cyclical global phenomenon. This week that prowess even earned the personal kudos of Vice President Al Gore in a speech highlighting the researchers' capabilities (see p. 1684).

NASA

Heavy lift. Technicians prepare EOS-AM spacecraft for December launch.

Such easily measured success, however, is rare for the U.S. program, which has spent $15 billion over the past decade on understanding Earth's climate. Long a target of conservative legislators, it is now under scrutiny from a coalition of its friends in the Clinton Administration and the scientific community. They are quietly taking it to task for neglecting pivotal scientific questions, poor coordination, and an emphasis on space hardware over research. "It's time to get serious, to collaborate across agencies, and to make sure the money is put on hot topics," says Berrien Moore, a mathematician at the University of New Hampshire, Durham, who is leading a National Research Council (NRC) review of the program.* In response, program managers have pledged to draw up clear priorities, set out measurable goals, and find a way to tie together more closely the work of more than a half-dozen agencies.

The climate program was launched in 1989 with great fanfare as a multidisciplinary effort (see pie graph on p. 1684). It poses horrendously complex challenges—in gathering data, crossing traditional academic boundaries, and linking different government bureaucracies. Atmospheric chemists, sociologists, geophysicists, oceanographers, and forestry experts are drawing on data beamed from space, retrieved from polar ice cores, and collected from the ocean depths. Scientists are successfully mapping ozone, building a global plankton database, and analyzing the effects of tropical forest fires. Researchers are also using increasingly sophisticated computer programs to tame this flood of data and create sound models for predicting climate fluctuations in the near- and long term, such as the recent El Niño.

Although the effort was begun under the Bush Administration, it has been a longtime favorite of Gore's, who championed it in the Senate and became its patron after the Democrats won the White House in 1992. Partly as a result of that affiliation, the program came under intense fire in the mid-1990s from some Republican lawmakers, who scoffed at the idea of global warming and proposed emission curbs to counter the threat. But attacks on the program have since waned, and its annual budget of $1.8 billion is stable.

Now the complaints are coming from ideologically friendly troops. "There is a general discontent with the program," says one Administration official about the mood within the White House's Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). The worry is that, El Niño notwithstanding, the program has generated too little in the way of concrete results and needs a more focused direction. "It's time to reassess what research is going on," agrees Rosina Bierbaum, OSTP's acting environment chief. "We really need to make some choices."

They also want the program to come up with ways to quantify its progress, in accord with a 1993 law requiring agencies to measure their performance. But such a task poses a formidable challenge for this sprawling research effort. In addition, policy-makers complain about what they see as the research community's insatiable appetite for money. "The program has spent most of its time whining that the budget is not going up," the Administration official adds. "But it should quit dreaming. That's not going to happen."

Left vulnerable

Such criticism is becoming more common among scientists as well. Late last month, a 15-member panel led by Moore released a report that chastises program officials for neglecting key scientific questions, focusing too much on expensive satellites, and failing to create a cohesive effort that crosses agency boundaries. In a 59-page overview of a yet-unreleased 600-page document, the report concludes that the program's desire to understand Earth as a system, although still intellectually compelling, "has made the program too diffuse and left it vulnerable. A more sharply focused scientific strategy ... is urgently required."

Such a strategy, committee members say, might include clarifying Earth's water and carbon cycles (see sidebar), understanding the interaction between solar radiation and atmospheric dynamics and the resulting effect on climate, and providing climate change predictions on human timescales of a generation or so. "If you say everything is connected to everything else, then it's hard to make progress," says Moore. "We're at the point where we have to choose priorities."

But priorities require flexibility to trade in existing efforts for newer activities. That's not easy when some 60% of overall funding is devoted to hardware projects—mostly NASA satellite systems to gather data—that are far along in the pipeline. The first of the agency's major Earth Observing System (EOS) spacecraft, for example, is slated to go up before the end of the year after technical problems delayed a launch scheduled for this month. A second platform is planned for 2000, and a third in 2002. The agency also envisions orbiting a series of smaller and cheaper satellites during and after that period. The NRC panel acknowledges that such spacecraft provide critical data. But it makes the case for spending more on research and on upgrading the network of ground-based instruments that can gather local data on temperature, humidity, and other conditions.

One obstacle to such changes is the difficulty of transferring money from one agency to another. Although the global change effort

* "Overview of Global Environmental Change: Research Pathways for the Next Decade," available from the NRC at www.nap.edu/readingroom/reader.cgi?auth=free&label=ul.book.0309061385

Research Limelight Falls on Carbon Cycle

Eight billion tons of carbon spew out of factories, cars, power plants, and deforested land every year. That massive release, up more than a billion tons in less than a decade, is the primary culprit in the rise of atmospheric greenhouse gases. When politicians tackled this problem last year in Kyoto, they proposed a carbon-release accounting system to encourage nations to reduce their emissions. Such an accounting system would require accurate measurements of the carbon being released and ways to verify those totals. But scientists are far from ready to provide detailed and accurate information—much less verification—on the sources and sinks of carbon emissions.

The disconnect between policy and science is pushing carbon cycle research to the top of the list of priorities for the U.S. Global Change Research Program. "We need to focus more attention on this, and it involves serious hard work," says Tony Janetos, a NASA specialist in land cover. To succeed, program managers must create a team out of a mix of scientists from a host of disciplines with funding by a half-dozen U.S. agencies. Agency managers don't even know how much is now being spent on the topic. "The federal government really doesn't have its act together in this area," admits David Goodrich, executive director of the office that coordinates the global change program.

That could soon change, however. With funding from several agencies, a team of 16 researchers led by Princeton University biogeochemist Jorge Sarmiento is hammering out a scientific framework to support the program's proposed budget for 2000 that will be submitted to the White House this fall. "There's been no real consensus on what needs to be done" in carbon cycle research, says Sarmiento.

The panel hopes to set a course to untangle the complicated threads that carbon weaves through forests, soil, and water. Nearly half of the 8 billion tons released annually—primarily through the burning of fossil fuels—remains in the atmosphere. About 2 billion is absorbed by the oceans, and a half-billion goes into northern forests, which absorb more carbon than tropical forests. Scientists aren't sure what happens to the remaining 1.5 billion tons, although evidence points to additional absorption by the northern stands of trees. "This is among our hardest problems," says Berrien Moore, a mathematician at the University of New Hampshire, Durham, who chaired a recent National Research Council study on the global change program.

The problem was relatively esoteric a decade ago when the global change program began. But the Kyoto agreement has catapulted the carbon cycle into a critical issue that could have a dramatic impact on the global climate and economy. Sarmiento's panel likely will recommend that scientists can best contribute to the policy debate by defining carbon sources and sinks in the past, present, and future, identifying the mechanisms behind carbon transfer, modeling future sources and sinks, and providing the scientific basis for carbon verification. The researchers are also expected to push for a more local approach to understanding the cycle. "Everyone has come to the conclusion that the focus needs to move from the global scale to the regional one," he says.

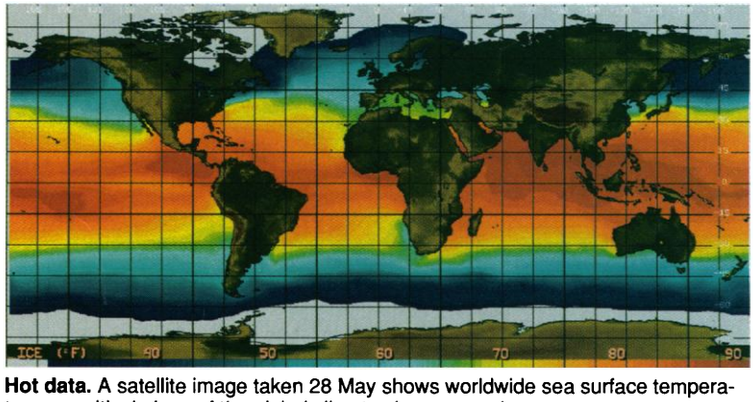
Toward that end, the panel likely will propose a long-term carbon observation network to gather data and a modest increase in funding for understanding and predicting the processes involved in carbon transfers. It may also suggest formation of a National Academy of Sciences committee to oversee U.S. carbon cycle research and give it higher visibility.

Although a final version of the study is not due until December, Sarmiento expects this summer to be able to provide guidance to an interagency team, one of five panels aimed at revamping the global change effort. The team, led by Elliot Spiker, an Interior Department geologist, is rushing to come up with a clear strategy for carbon cycle research in time to affect the 2000 budget request. "The feeling is that most pieces are there," says Spiker. "The main thing we need is coordination." A clearer scientific direction, say Spiker, Sarmiento, and other researchers, will lead to improved coordination and help unlock the secrets of the carbon cycle. Then the scientists may be ready to give politicians the data they need. –A.L.

set up a central office to coordinate its many pieces, the report concludes that the program lacks "an enforceable mandate [so that agencies] cooperate in a manner necessary to be successful." For example, the Department of Energy (DOE) chopped its 1997 budget for global ocean carbon-cycle research, restoring it only after the National Oceanic and Atmospheric Administration (NOAA) warned that the result could be disastrous to the program as a whole. The report also notes that NOAA and the Air Force have failed to coordinate their weather satellite efforts with NASA, and that it's not clear whether the Air Force will agree to add global change instruments to those spacecraft. With each agency jealously guarding its own budget, the report concludes, "the desired 'virtual agency' has been quite far from reality."

Right time

Global change managers say they have gotten the message and plan to address the problems. "I sense a real disappointment from old-time players in the program that we haven't delivered on some things as we should have," says David Goodrich, executive director of the program's coordinating office. "We should have made more progress on the carbon cycle, there is an imbalance toward satellite hardware, and it is hard to move money between agencies. Our job now is to see how we can change the program." Adds Robert Corell, National Science Foundation geosciences chief and chair of the National Science and Technology Council's global change research panel: "The project is 10 years old, so the timing is right" for a new look.



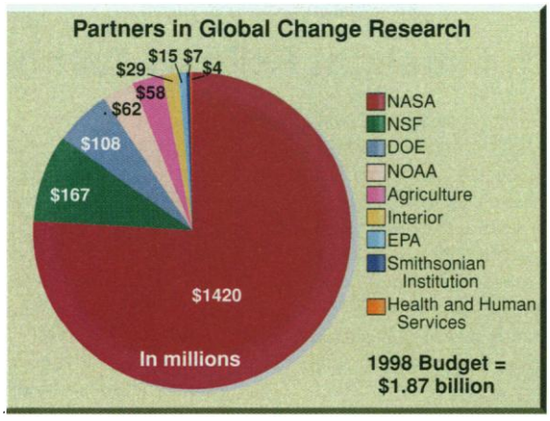
SOURCE: NASA

Hot data. A satellite image taken 28 May shows worldwide sea surface temperatures, a critical piece of the global climate change puzzle.

The first step on this path came during a sometimes contentious retreat last month in rural Virginia for members of the NRC panel, White House staffers, and agency managers. Moore laid out the NRC's concerns, while White House officials made it clear that budget increases

are not a possibility. "They also told us to take a hard look at the program [to decide] what's in and what's out," says Goodrich.

In response, program officials are assembling five groups to review global change priorities and set criteria for inclusion in the proposed 2000 budget that is to be compiled in the fall. A draft plan will be readied by 15 August and submitted to the White House 2 weeks later. The goal is to plug research gaps, eliminate overlap, and coordinate the work of the various agencies.



NASA will lead a group examining global change observations, including the balance between satellites and a NOAA ground network that in some cases "is decaying pretty badly," says Goodrich. Those instruments, notes the NRC report, also require better calibration to avoid contentious debates over data comparisons. A DOE-chaired panel will consider modeling needs. "There must be a considerably expanded commitment of resources to modeling" and to the advanced computing necessary to build better models, the NRC study states. A third panel, headed by the Department of Agriculture, will look at ecosystem issues, while a fourth, led by Interior, will focus on the carbon cycle. A fifth DOE-led team will examine ways to link seasonal and interannual climate change with longer trends.

Program managers admit they are a long way from being able to come up with clear and identifiable measures of their progress, and that working in a more coordinated fashion is easier said than done. "There is tremendous potential for coordination, but that hasn't yet come to fruition," adds Ghassam Asrar, NASA earth sciences chief.

Despite those hurdles, program critics say the initial response to their concerns makes them optimistic that the situation will improve. "At the retreat, I felt they were more or less heading in the right direction," says Moore. Bierbaum says she feels that program officials are responding properly, and another White House official called the actions "a good step." So while global climate change managers and researchers keep an eye on future El Niños and other climate phenomena, their efforts are certain to be watched closely by their political and scientific colleagues.

–Andrew Lawler

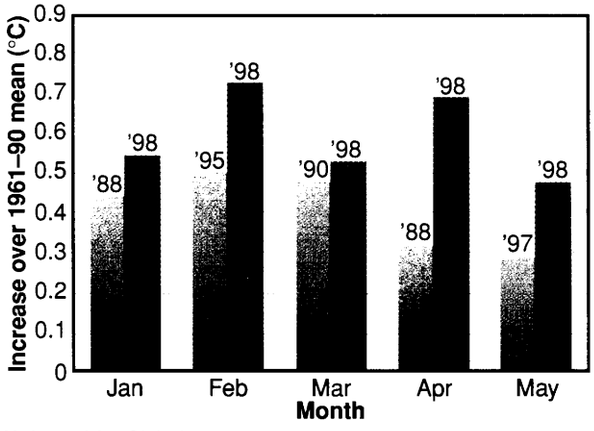
GLOBAL WARMING

Hot Year, But Cool Response in Congress

Boosted by El Niño, 1998 is in the lead position to be the warmest year of the millennium. Vice President Al Gore and scientists from the National Oceanic and Atmospheric Administration (NOAA) announced on 8 June that the global average temperature "far exceeded" previous records for every one of this year's 5 months. Although El Niño has been waning in the last few weeks, scientists say the heat so far is enough to make 1998 a very good bet to surpass 1997, the current record holder (*Science*, 16 January, p. 315).

Gore used the NOAA data as ammunition in the Administration's uphill battle to convince a reluctant Congress to back its efforts to reduce greenhouse gases. "This report is a reminder once again that global warming is real and that unless we act, we can expect more extreme weather in the years ahead," he said during a hastily organized meeting of the White House that included NOAA chief James Baker and leading global change researchers.

Most climate researchers agree with Gore that a gradual warming trend contributed to this year's heat and that if 1999 turns out to be cooler, it is only because it will lack an El Niño. Defined by unusually warm surface waters in the tropical Pacific, El Niños typically lead to warmer-than-average global temperatures. But this year's was exceptional. Based on measurements from weather stations, satellites, ships, and buoys, NOAA researchers calculated that combined land and ocean temperatures were 0.25 degrees Celsius warmer than in any previous recorded January-through-May period. It was the hottest spring in a decade that tree rings and other indirect evidence suggest is the hottest of the last 1000 years. The jump is well outside the 0.05 degrees of estimated error in such global averages, implying that the warming is real, says climatologist Philip Jones of the University of East Anglia in Norwich, England.



Unbeatable. Global average temperature has exceeded the previous record (crosshatched bars) in every month so far this year.

The NOAA report also suggested that global warming might be exacerbating El Niño's effects on weather. The underlying warming provides extra energy for evaporation, says atmospheric scientist Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colorado. That could both worsen droughts on land and also put more moisture into the air to strengthen storms and floods associated with El Niño.

But so far, bad news about global warming has not convinced Congress to act. Last week the Senate Appropriations Committee rejected the White House request to boost spending in 1999 on Department of Energy–funded research into cleaner, renewable energy sources. That move earned a rebuke from Gore: "It's time for Congress to wake up to the mounting evidence and help us meet this challenge head on." However, congressional staffers say that extraordinarily low gasoline prices make additional spending on alternative energy technology untenable.

Senate leaders have also made it clear that they will not even debate whether to ratify the Kyoto treaty signed by more than 150 nations last year, which would reduce greenhouse emissions. Industry executives and politicians from both parties worry that such reductions could harm economic growth.

The third leg of the Administration's global change strategy—the global change research program—is less controversial and is likely to reap the full $1.8 billion 1999 request, staffers say (see p. 1682). But the global heat wave seems unlikely to warm prospects for greenhouse spending on Capitol Hill.

–Gretchen Vogel and Andrew Lawler