How Urgent Is Climate Change?

Having issued their fair and balanced consensus document, many climate scientists now cite oft-overlooked reasons for immediate and forceful action to curb global warming

THE LATEST REPORTS FROM THE NOBEL Prize–winning Intergovernmental Panel on Climate Change (IPCC) were informative enough. Humans are messing with climate and will, sooner or later, get burned if they keep it up. But just how urgent is this global warming business?

IPCC wasn't at all clear on that, at least not in its summary reports. In the absence of forthright guidance from the scientific community, news about melting ice and starving polar bears has stoked the public climate frenzy of the past couple of years. Climate researchers, on the other hand, prefer science to headlines when considering just how imminent the coming climate crunch might be. With a chance to digest the detailed IPCC products that are now available (www.ipcc.ch), many scientists are more convinced than ever that immediate action is required. The time to start "is right now," says climate modeler Gerald Meehl of the National Center for Atmospheric Research in Boulder, Colorado. "We can't wait any longer."

What worries these researchers is the prospect that we've started a slow-moving but relentless avalanche of change. A warming may well arrive by mid-century that would not only do immediate grievous harm—such as increase drought in vulnerable areas—but also commit the world to delayed and even more severe damage such as many meters of sea-level rise. The system has built-in time lags. Ice sheets take centuries to melt after a warming. The atmosphere takes decades to be warmed by today's greenhouse gas emissions. And then there are the decades-long lags involved in working through the political system and changing the world energy economy. "If you want to be able to head off a few trillions of [dollars of climate] damages per year a few decades out," says glaciologist Richard Alley of Pennsylvania State University in State College, "you need to start now."

Bad things, soon

The disturbing message on the timing of global warming's effects comes in the IPCC chapters and technical summaries quietly posted online months after each of three working groups released a much-publicized Summary for Policymakers (SPM). An overall synthesis of the working group reports was released Saturday at the 27th session of IPCC. Earlier this year, only the SPMs went through the wringer of word-by-word negotiations with governments, which squeezed out a crucial table and part of another (*Science*, 13 April, p. 188). That information—which was always in the full reports—along with other report material, makes it clear that substantial impacts are likely to arrive sooner rather than later.

Early target. Some mountain-dwelling amphibians are already feeling the heat.

Table TS.3 of Working Group II's technical summary, for example, lays out projected warmings. The uncertainties are obvious. Decades ahead, models don't agree on the amount of warming from a given amount of greenhouse gas, and no one can tell which of a half-dozen emission scenarios—from unbridled greenhouse-gas production to severe restraint—will be closest to reality. But this table strongly suggests that a middle-of-the-road, business-as-usual scenario would likely lead to a 2°C warming by about the middle of this century.

Lined up beneath the projected warmings in the table are the anticipated effects of each warming. Beneath a mid-century, 2°C warming is a litany of daunting ill effects that had previously had no clear timing attached to them: increasing drought in mid-latitudes and semiarid low latitudes, placing 1 billion to 2 billion additional people under increased water stress; most corals bleached, with widespread coral mortality following within a few decades; and decreases in low-latitude crop productivity,

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A goner? Time may have run out to prevent the disappearance of summertime Arctic sea ice.

as in wheat and maize in India and rice in China, among other pervasive impacts.

At the bottom of the same table is a category of effects labeled "Singular Events," most dramatically sea level rise. The table shows a "Long term commitment to several metres of sea-level rise due to ice sheet loss" falling between the middle-of-the-road 2°C warming and a 3°C warming, which without drastic emissions reductions might well come by the end of the century. The report calls it a "commitment" because although the temperatures needed to melt much of the Greenland ice sheet might be reached in the next 50 to 100 years, the ice sheet, similar to an ice cube sitting on a countertop, will take time to melt even after the surrounding air is warm enough. Its huge thermal inertia means a lag of at least several centuries before it would largely melt away, flooding much of South Florida, Bangladesh, and major coastal cities.

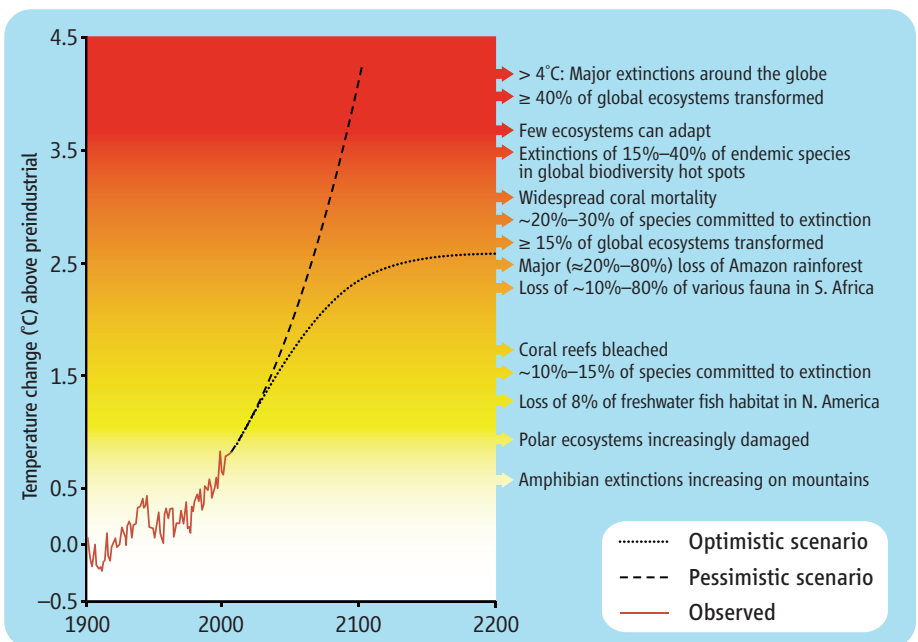
A laggard system

Ice sheets aren't the only thing that stretches out the time between an action—say, building a coal-fired power plant—and a global warming impact. For example, the atmosphere is slow to warm because the oceans are absorbing some of the heat trapped by the strengthening greenhouse. IPCC estimates that even if no greenhouse gases were added after the year 2000, the oceans' heat would warm the atmosphere 0.6°C by the end of the century, or as much as it warmed in the last century. So the world is already committed to almost one-quarter of the warming that can be expected late in the century. And half the warming of the next couple of decades will be carried over from emissions in the past century.

Then there are the lags that come into play ahead of the climate system. The technological infrastructure that does most of the emitting—the gasoline-fed cars and coal-fired power plants, primarily—will have to be radically altered if greenhouse emissions are to be drastically reduced. The speed at which infrastructure can be changed depends on the perceived urgency, says energy-climate analyst James Edmonds of the Pacific Northwest National Laboratory's office in College Park, Maryland. Past transitions from one energy source to another—say, wood to coal—took upward of 50 to 100 years, he notes. But even with a Manhattan Project imperative—something nowhere in sight—weaning cars off oil, building nuclear power plants, and rigging coal power plants to shoot the carbon dioxide into the ground will take decades, not years.

And there's the lag while governments crank up the will to fundamentally alter the global energy system. "The biggest lag is in the political system," says geoscientist Michael Oppenheimer of Princeton University. A couple of decades have already passed discussing the seriousness of the threat, as he sees it, and at the present rate it could be another 20 years before a worldwide program up to the task is in place.

Yet another lag would enter the calculation for taking action if policymakers waited for more research to narrow the scientific uncertainties. In the 1980s, for example, the biggest uncertainty in climate science was clouds and how they would react to climate change.



SOURCE: MODIFIED FROM IPCC WORKING GROUP II'S 2007 TECHNICAL SUMMARY, FIGURE TS.6

Fifteen years later, "we are essentially where we were then," says atmospheric scientist Robert Charlson of the University of Washington, Seattle. Clouds are still poorly understood, as are pollutant hazes, another collection of microscopic particles with a highly uncertain effect on future climate.

With all these known time lags adding up to many decades, a lot of climate scientists say that the time for serious action is now. "We can't really afford to do a 'wait and learn' policy," says Oppenheimer. "The most important question is, when do we commit to 2°? Really, there isn't a lot of headroom left. We better get cracking."

Fear of the unknown

Physics and socioeconomics may make piloting the ponderous ship of climate a cumbersome business, but researchers are also worried about navigating around the hazards they fear may be lurking unseen beneath the surface. They've hit hidden obstacles before. Back in the 1970s, atmospheric chemists were worrying that pollutant chlorine might be destroying stratospheric ozone over their heads. Yet all the while, that chlorine was teaming up with ice-cloud particles over Antarctica to wipe out stratospheric ozone through a mechanism that scientists had overlooked.

Prestigious committees have been warning for 25 years that similar surprises could spring from the climate system. A few may be starting to show themselves. Arctic sea ice took a nosedive last summer, prompting concerns that feedbacks not properly included in models are taking hold and accelerating ice loss (*Science*, 5 October, p. 33). Glaciers draining both southern Greenland and West Antarctic have suddenly begun rushing to the sea, and glaciologists aren't sure why (*Science*, 24 March 2006, p. 1698). And theorists recently reminded their colleagues that they will never be able to eliminate the small but very real chance that the climate system—contrary to most modeling—is hypersensitive to greenhouse gases.

The uncertainties are adding up. "You can hope the uncertainties are going to break your way," says policy analyst Roger Pielke Jr. of the University of Colorado, Boulder. "There have been times they did. But if you play that game often enough, you're going to lose some pretty big bets sometimes." In the case of global warming, Pielke says, "we don't have a lot of time to wait around." Edmonds agrees. If avoiding a 2°C warming is the goal, "the world really has to get its act together pretty damn fast. The current pace isn't going to do it."

–RICHARD A. KERR

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