They’ve said it before, but this time climate scientists are saying it with feeling: The world is warming; it’s not all natural, it’s us; and if nothing is done, it will get a whole lot worse.

Scientists Tell Policymakers We’re All Warming the World

THE LAST TIME THE INTERGOVERNMENTAL Panel on Climate Change (IPCC) assessed the state of the climate, in early 2001, it got a polite enough hearing. The world was warming, it said, and human activity was “likely” to be driving most of the warming. Back then, the committee specified a better-than-60% chance—not exactly a ringing endorsement. And how bad might things get? That depended on a 20-year-old guess about how sensitive the climate system might be to rising greenhouse gases. Given the uncertainties, the IPCC report’s reception was on the tepid side.

Six years of research later, the heightened confidence is obvious. The warming is “unequivocal.” Humans are “very likely” (higher than 90% likelihood) behind the warming. And the climate system is “very unlikely” to be so insensitive as to render future warming inconsequential.

This is the way it was supposed to work, according to glaciologist Richard Alley of Pennsylvania State University in State College, a lead author on this IPCC report. “The governments of the world said to scientists, ‘Here’s a few billion dollars—get this right,’ ” Alley says. “They took the money, and 17 years after the first IPCC report, they got it right. It’s still science, not revealed truth, but the science has gotten better and better and better. We’re putting CO₂ in the air, and that’s changing the climate.”

With such self-assurance, this IPCC report may really go somewhere, especially in the newly receptive United States (see sidebar, p. 756), where a small band of scientists has long contested IPCC reports. Coordinating lead author Gabriele Hegerl of Duke University in Durham, North Carolina, certainly hopes their report hits home this time. “I want societies to understand that this is a real problem, and it affects the life of my kids.”

Down to work
Created by the World Meteorological Organization and the United Nations Environment Programme, the IPCC had the process down for its fourth assessment report. Forty governments nominated the 150 lead authors and 450 contributing authors of Climate Change 2007: The Physical Science Basis. There was no clique of senior insiders: 75% of nominated lead authors were new to that role, and one-third of authors got their final degree in the past 10 years. Authors had their draft chapters reviewed by all comers. More than 600 volunteered, submitting 30,000 comments. Authors responded to every comment, and reviewers certified each response. With their final draft of the science in hand, authors gathered in Paris, France, with 300 representatives of 113 nations for 4 days to hash out the wording of a scientist-written Summary for Policymakers.

The fact of warming was perhaps the most straightforward item of business. For starters, the air is 0.74°C warmer than in 1906, up from a century’s warming of 0.6°C in the last report. “Eleven of the last twelve years rank among the 12 warmest years in the [150-year-long] instrumental record,” notes the summary (ipcc-wg1.ucar.edu). Warming ocean waters, shrinking mountain glaciers, and retreating snow cover strengthened the evidence.
So the IPCC authors weren’t impressed by the contrarian argument that the warming is just an “urban heat island effect” driven by increasing amounts of heat-absorbing concrete and asphalt. That effect is real, the report says, but it has “a negligible influence” on the global number. Likewise, new analyses have largely settled the hullabaloo over why thermometers at Earth’s surface measured more warming than remote-sensing satellites had detected higher in the atmosphere (Science, 12 May 2006, p. 825). Studies by several groups have increased the satellite-determined warming, largely reconciling the difference.

This confidently observed warming of the globe can’t be anything but mostly human-induced, the IPCC finds. True, modeling studies have shown that natural forces in the climate system—such as calmer volcanoes and the sun’s brightening—have in fact led to warming in the past, as skeptics point out. And the natural ups and downs of climate have at times warmed the globe. But all of these natural variations in combination have not warmed the world enough, fast enough, and for long enough in the right geographic patterns to produce the observed warming, the report finds. In model studies, nothing warms the world as observed except the addition of greenhouse gases in the actual amounts emitted.

From studies of long-past climate, including the famous hockey-stick curve of the past millennium’s temperature (Science, 4 August 2006, p. 603), the IPCC concludes that the recent warming is quite out of the ordinary. “Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years,” the report concludes, “and likely the highest in at least the past 1300 years.”

Contrarians have conceded that greenhouse gases may be warming the planet, but not by much, they say. The climate system is not sensitive enough to greenhouse gases to overheat the globe, they say. For the first time, the IPCC report directly counters that argument. Several different lines of evidence point to a moderately strong climate sensitivity (Science, 21 April 2006, p. 351). The eruption of Mount Pinatubo in 1991 thickened the stratospheric haze layer and cooled climate, providing a gauge of short-term climate sensitivity. Paleoclimatologists have determined how hard the climate system was driven during long-past events such as the last ice age and how much climate changed then. And models have converged on a narrower range of climate sensitivity.

The IPCC concludes that both models and past climate changes point to a fairly sensitive climate system. The warming for a doubling of CO₂ “is very unlikely to be less than 1.5°C,” says the report, not the less than 0.5°C favored by some contrarians. A best estimate is about 3°C, with a likely range of 2°C to 4.5°C.

What next?
Looking ahead, the report projects a warming of about 0.4°C for the next 2 decades. That is about as rapid as the warming of the past 15 years, but 50% faster than the warming of the past 50 years. By the end of this century, global temperatures might rise anywhere between a substantial 1.7°C and a whopping 4.0°C, depending on the amount of greenhouse gases emitted. In some model projections, late-summer Arctic sea ice all but disappears late in this century. It is very likely that extremes of heat, heat waves, and heavy precipitation events will continue to become more frequent. Rain in lower latitudes will decrease, leading to more drought.

On some hot topics, the IPCC comes down on the conservative side. It sees evidence of more intense hurricane activity in the North Atlantic, something many researchers contest, but paints a murky picture elsewhere, in line with doubters’ reservations (Science, 10 November 2006, p. 910). As to the so-called meridional overturning circulation (MOC)—the conveyor belt of currents that delivers warm water to the far North Atlantic—there is not enough evidence to say whether it has slowed under global warming, according to the IPCC, contrary to a high-profile report of a 30% slowing (Science, 17 November 2006, p. 1064). But...
This time around, issuing yet another international assessment of the planet’s climatic health (see main text) might look like throwing gasoline on a fire. Even in the United States, where skepticism about human-induced climate change has long dominated government policy, public concern about global warming was already as high as it ever had been. U.S. media had been at fever pitch on climate for a year and more. And local, state, and national politicians from both of the country’s major political parties were pushing or even implementing their own proposals for reining in greenhouse gas emissions.

“It takes a sudden jolt sometimes before we become aware of a danger,” former vice president Al Gore says in his Oscar-nominated global warming documentary An Inconvenient Truth. If so, the shock to public and political perceptions this time may have come in large part from Mother Nature. There has been “a chronic drip of [media] stories about weather effects that are hard to control,” notes geoscientist Michael Oppenheimer of Princeton University, from raging hurricanes such as Katrina and melting Arctic sea ice to mid-January daffodil blooms in Washington, D.C.

Will the weird weather drive the body politic to eventual action on global warming? Some observers believe so. “Probably it’s robust,” says Oppenheimer. The sentiment toward U.S. action “is just not going to go back.” But many of the jolting climate events may themselves gave away, at least temporarily. Ice-melting warmth in the Arctic and surges of deadly hurricanes in the Atlantic, among other climate trends, are also subject to natural swings that could temporarily slow or even pause some of global warming’s more dramatic effects.

The first American surge in attention to global warming started with a similarly combustible mix of climate science and weird weather. On one of the hottest days of 1988 in muggy Washington, D.C., with drought gripping much of the American West and huge wildfires racing through a tinder-dry Yellowstone National Park, leading climate researcher James Hansen of NASA’s Goddard Institute for Space Studies testified on Capitol Hill. This was greenhouse warming, he told Congress confidently.

News coverage, at least, took off, according to a new accounting by political scientists Maxwell Boykoff of the University of Oxford and Jules Boykoff of Pacific University in Forest Grove, Oregon. It peaked again in 1992, when the first President George Bush signed the United Nations Framework Convention on Climate Change. Then media attention promptly plummeted. It perked up only briefly, the Boykoff brothers note, in response to political events, such as when President George W. Bush rejected the Kyoto Protocol limiting greenhouse gas emissions in 2002.

Nevertheless, global warming never entirely vanished from the American consciousness. In the past couple of years, “the whole issue has moved up the agenda” again, says political communications researcher Matthew Nisbet of American University in Washington, D.C., and it did not without the usual boost from a single, triggering political event. The public still hasn’t elevated global warming to its highest levels of environmental concern, Nisbet notes, but the subject has permeated television, movies, and books, segued onto the business, style, and gardening pages, and broken into daily conversation. Media attention reached an all-time high in 2006, Nisbet has found, as gauged by the number of articles in elite newspapers. And the mutualistic relation between the media and politicians was cranked way up as reporters fed off the policy debate and politicians drew strength from media coverage.

So what got the pot boiling so high in the United States this time around? Many observers see global warming moving to the front burner much the way the IPCC goes on to project a very likely reduction in MOC flow by the end of the century, perhaps on the order of 25%. Contrary to the climate catastrophe movie The Day After Tomorrow, however, a slowing of the MOC would not freeze up the North Atlantic. The region won’t even cool off, thanks to greenhouse warming. And it’s very unlikely the MOC will abruptly shut down this century, the report says.

The IPCC is overly conservative, in the opinion of some newly outspoken scientists, when it comes to the fate of the world’s great ice sheets—on Greenland and Antarctica—and the likely rise in sea level. The facts are not in much dispute. The ocean is warming and therefore expanding, mountain glaciers are melting into the sea, and Greenland is melting around its edges as well. That drove up sea level as fast as 3 millimeters per year lately. The IPCC projects that sea level will continue to rise 28 to 43 centimeters in this century, depending on emissions.

It is also generally agreed that the IPCC calculation leaves out a potentially important factor. Some glaciers draining ice from Greenland and West Antarctica have sped up in the past 5 to 10 years, some of them doubling their speed (Science, 24 March 2006, p. 1698). But this glacier acceleration is not included in the IPCC sea-level projection “because a basis in published literature is lacking,” according to the report.

That didn’t sit well with some researchers,
ozone destruction did in the 1980s. Theoretical predictions were prompting some governments to begin to curtail chlorofluorocarbon (CFC) emissions. Then researchers recognized the springtime ozone hole hovering over the Antarctic, galvanizing international negotiations on eliminating CFCs.

Global warming may never have the equivalent of the ozone hole, but the cumulative effect could be the same. Americans “are starting to see changes in the weather,” says Eileen Claussen, president of the Pew Center on Global Climate Change in Arlington, Virginia. There was the 2004 hurricane season, with four hurricanes wreaking havoc across Florida, followed by Katrina in 2005; year after year of record-breaking shrinkage of Arctic sea ice, accompanied by images of hungry polar bears; glaciers accelerating their rush to the sea in Greenland and Antarctica, driving up sea level; and those daffodils in the nation’s capital.

Political and economic factors have also helped fuel the fire. Many alternatives to expensive oil, for example, would also ease greenhouse warming. But to the extent that dramatic climate events have heightened interest, global warming activists have a sometimes unreliable helper, researchers note. The climate system swings from warm to cool and back, from wet to dry. El Niño’s unusual warmth in the tropical Pacific is just one of many natural climate variations. And the climate system does it all quite on its own.

Such natural variability could temporarily reinforce or rein in global warming effects. In a study in press at the Journal of Climate, for example, modeler Gabriele Hegerl of Duke University in Durham, North Carolina, and colleagues reconstructed past Northern Hemisphere temperature from records such as tree rings and then apportioned the warming using a simple climate model. They found that rising levels of greenhouse gases account for about one-third of the large, rapid warming over the first half of the past century, but another third must have been a natural warming.

What warms the hemisphere can also cool it, according to a modeling study reported 30 January in Geophysical Research Letters. Modeler Rong Zhang and his colleagues at the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, found that oscillations in the flow of warm currents into the North Atlantic could have added substantially to the early–20th century warming, contributed to the mid-century pause in warming, and bolstered the obvious greenhouse-fueled warming of the past few decades. If what has been going up and down for at least a century goes down again, the ongoing warming that took off in the ’70s could noticeably slow in the next 10 or 15 years.

Natural variability is even stronger in places such as the Arctic (Science, 5 January, p. 36), one of two climatic “canaries in the coal mine” Gore cites in his film. In the 1930s to 1940s, the Arctic warmed to even higher temperatures than now, only to cool back down by the 1970s. Drawing on 12 climate models, Arctic researcher James Overland of the National Oceanic and Atmospheric Administration’s Pacific Marine Environmental Laboratory in Seattle, Washington, sees the recent rapid Arctic warming “as a fairly strong natural variability signal on top of long-term [humanmade] change. It’s very likely we could have a 5-year period of colder temperatures, and people could say, ‘Aha, we don’t have global warming.’ ”

Other worrying climate trends could pause or moderate as well. Part of the surge in powerful Atlantic hurricanes since 1995 is attributable to a natural cycle in the proportion of major storms, according to meteorologist Gregory Holland of the National Center for Atmospheric Research in Boulder, Colorado (Science, 10 November 2006, p. 910). So the Atlantic could quiet down a bit, he says, although perhaps not until 2020 or later. Another climate threat—the collapse of the climate-modulating currents of the Atlantic—seems to have receded already. Late in 2005, oceanographers reported measuring a sizable 30% slowdown in the so-called meridional overturning circulation only to concede late last year that their record was so noisy that they couldn’t reliably detect any change after all (Science, 17 November 2006, p. 1064).

Just how natural climate variability will interact with political divisiveness, the public’s mood swings, and the cyclic economics of energy is unclear at this point. Some say, however, that the mix of bizarre weather and politics boosted by the media now ensures there’s no turning back. Even if the climate craziness fades for a while, “I think national legislation is inevitable in 4 years,” says Claussen. Others, however, think such confidence may be misplaced. Science historian Naomi Oreskes of the University of California, San Diego, recalls the energy craze of the late 1970s, when soaring oil prices drove dreams of energy independence through conservation and alternative fuels. That passed as soon as prices fell. “We got excited for a while, but we didn’t take the serious steps.”

—R.A.K.