

Confronting the Bogeyman of The Climate System

The threat from an abrupt circulation switch in the North Atlantic and resultant climatic chaos seems to be receding, but researchers are still worried

ASPEN, COLORADO—Scientists have been warning us for a quarter-century that the climate system has some surprises up its sleeve. By the 1990s, as paleoclimatologists discovered the whiplash history of recent climate, attention turned to the far North Atlantic. There, as the world emerged from the last ice age more than 8000 years ago, the supply of warm water to high Atlantic latitudes appeared to shut down in mere decades. The collapse of the warm circulation chilled and dried surrounding lands back to near-glacial conditions for centuries, skewing regional climate around the world.

A precipitous shift in climate could happen again, say researchers, 25 of whom gathered here last summer to discuss abrupt climate change.* But the prime menace no longer lies in the North Atlantic. Instead, a growing contingent of scientists now sees the North Atlantic as no more of a threat than accelerating sea level rise, megadroughts, and monsoon failures. “A few years ago, people thought the [Atlantic circulation] could collapse almost like *The Day After Tomorrow*,” said paleoclimatologist Julia Hargreaves of the Frontier Research Center for Global Change in Yokohama, Japan. “But a very rapid collapse now seems fairly unlikely under global warming.”

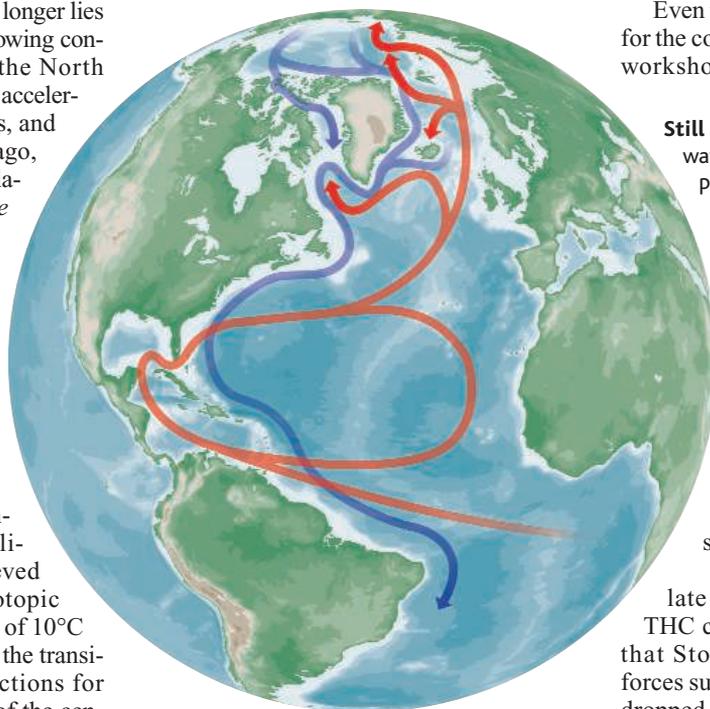
Shifty climate

Paleoclimatologists have certainly turned up worrisome examples of abrupt North Atlantic climate change. In ice cores retrieved from the Greenland ice cap, isotopic studies showed temperature shifts of 10°C during the last ice age and during the transition out of glacial times. Projections for greenhouse warming by the end of the century are running about 1.5°C to 2°C. And other ice-core studies showed that 10° shifts took only a few years—50 at most, which is abrupt by anybody’s standard.

Some of these sudden events began to look disquietingly familiar from recent events. Apparently, melting ice sheets during

* “Abrupt Climate Change: Mechanisms, Early Warning Signs, Impacts, and Economic Analyses,” held 9 to 15 July in Aspen, Colorado; organized by the Aspen Global Change Institute.

the last glaciation had sent meltwater gushing into the far northern North Atlantic to form a surface layer of relatively fresh and, therefore, less dense seawater. That would have thrown a monkey wrench into the far end of the ocean “conveyor belt” that carries warm surface water northward, according to the story developed by paleoceanographers. The less-dense freshwater lid would have prevented surface water from sinking at the northern end of the conveyor and returning southward. That would have jammed the conveyor and shut it down. With no added warm water from the south, the North Atlantic and surrounding land would have chilled (*Science*, 10 July 1998, p. 156).



In recent years, researchers have reported freshening seawater in the far north similar to that of the last ice age in pattern, if not in magnitude. Rivers have been dumping more fresh water into the Arctic Ocean, perhaps as the strengthening greenhouse increases high-latitude precipitation. At the same time, high-latitude Atlantic surface waters have been freshening (*Science*, 2 January 2004, p. 35). And at least one cog in the northbound

conveyor—the subpolar gyre—has slowed of late (*Science*, 16 April 2004, p. 371). All the while, the conveyor circulations collapsed in one climate model after another when the North Atlantic was flooded with fresh water.

Not so simple

These discoveries commingled with the idea that humans tinkering with Earth’s greenhouse could in theory drop temperatures around the North Atlantic. Some media found the result irresistible. European newspapers have carried dramatic headlines such as “Global Warming May Freeze Out British Isles,” and even the sedate National Academy Press selected *Climate Crash* this year as the title of a journalist-written book on abrupt climate change. And although an alarmist headline or two might not seem far out of line, some scientists are beginning to doubt that a North Atlantic shutdown is looming. Physical oceanographer Carl Wunsch of the Massachusetts Institute of Technology, for one, contends that the North Atlantic Ocean simply can’t determine climate single-handedly.

Even the commonly used technical name for the conveyor is misleading, he said at the workshop. “The ocean flow is a compli-

Still circulating, for now. Dumping fresh water on the far North Atlantic could, in principle, shut down the northward flow of warm surface waters (red) and the deep return of cold water (blue).

cated beast,” he said. Calling the ocean conveyor the thermohaline circulation (THC) has come to imply that only differences in temperature and salt content drive it. In fact, “the crucial element for knowing what the ocean is doing is knowing what the wind is doing,” he said.

His graduate school adviser, the late Henry Stommel, introduced the THC concept in 1958. But Wunsch says that Stommel included crucial driving forces such as the wind that have since been dropped. As long as the wind blows, essential parts of the THC such as the warm Gulf Stream will continue to flow, Wunsch said, “and I don’t know how to stop the wind.” A safer label for the ocean conveyor might be the meridional (north-south) overturning circulation (MOC, pronounced “mock”), many at the workshop concluded.

Another complication is ice—in particular, the dearth of it around the North Atlantic. At the workshop, geophysicist Richard Peltier of the University of Toronto, Canada, argued

that abrupt shifts “have something to do with ice,” noting that all of the Northern Hemisphere’s glacial ice melted away shortly after the last abrupt climate event 8200 years ago. Ice might have done its work by producing fresh meltwater fast enough to put a lid on the North Atlantic. Or, as Wunsch suggests, the mountains of it sticking up into the prevailing winds at high latitudes could have skewed atmospheric circulation the way the Rockies do today. In either case, vast amounts of it seem to have been required.

Unmoved models

If the past is not a good analog for the future, computer models might serve as guides to global warming’s effect on the MOC. Lately, the most sophisticated and realistic model simulations of a warmer world have failed to drive the MOC anywhere near collapse. For example, climate modeler Peter Gent of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, told the workshop how the latest version of the NCAR climate model responded to greenhouse gas increases like those expected in the next century or two. Over a range of rates of greenhouse strengthening, the model’s MOC slowed by an average of 25% to 30%. “That is not a collapse,” said Gent.

Modeler Jonathan Gregory of the University of Reading, U.K., and 17 colleagues got similar results in an international comparison of models. They ran 11 different models—six of the most sophisticated sort, including an earlier version of NCAR’s, and five “intermediate complexity” models—for 140 simulation years, quadrupling the concentration of greenhouse gases in the process. None led to a collapse of the MOC; instead, they slowed it gradually by 10% to 50%.

Not that model MOCs can’t collapse. “If you really hit the North Atlantic with fresh water,” says Gent, “you can make it collapse.” But the flow needs to be something like 10 times faster than current greenhouse simulations, says Gent. That’s also the only way to chill Europe in greenhouse models. None of the models in Gregory’s inter-comparison showed a cooling anywhere; greenhouse warming always prevailed.

Not everyone is ready to consign the MOC collapse threat to the back burner, however. Climate modeler Michael Schlesinger of the University of Illinois, Urbana-Champaign, an organizer of the workshop, notes that model simulations are not entirely realistic. For one, they have yet to include meltwater from a warming Greenland. And, as geochemist Daniel

Hedging Your Climate-Change Bets

The prospects for sudden shifts in climate are highly uncertain. For some, that’s justification for further study. But some economists disagree. To them, uncertainty is itself a reason to take action, and right away.

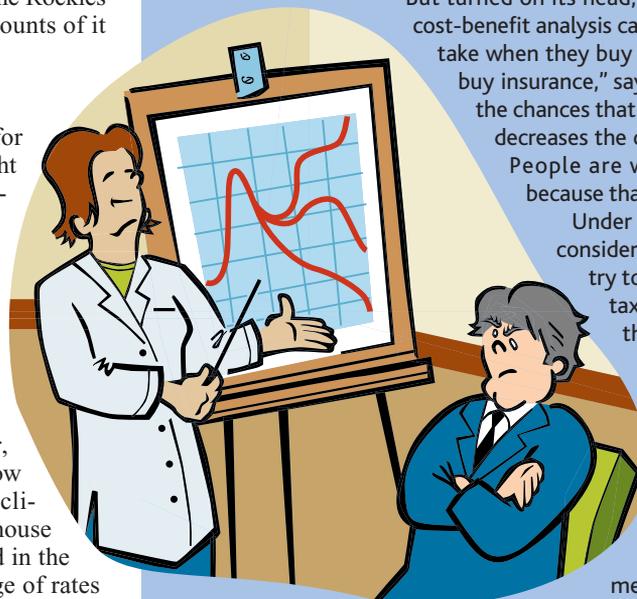
In a classic cost-benefit analysis, the immediate costs of dealing with profound uncertainty can be considerable. Unless decision-makers have a clear view of the future, economist Gary Yohe of Wesleyan University in Middletown, Connecticut, told workshop participants, the cost-benefit approach is likely to discourage any action.

But turned on its head, uncertainty can justify an alternative to cost-benefit analysis called risk management, an approach people take when they buy insurance. “Uncertainty is the reason you buy insurance,” says Yohe. Insurance does nothing to reduce the chances that your house will catch fire, he notes, but “it decreases the consequences should the bad event occur. People are willing to pay premiums for insurance because that spreads the risk.”

Under risk management, decision-makers would consider the range of possible outcomes and then try to avoid the worst by, for example, levying a tax on the carbon in fossil fuels that becomes the greenhouse gas carbon dioxide. The tax would reduce the urgency of making more sweeping decisions. At the same time, it would keep in play more ambitious goals such as holding greenhouse gases to even lower levels. All the while, scientists would be learning more about the risks of global warming.

Without much formal acknowledgment, decision-makers seem to be adopting risk management as they tackle global warming. Under the Kyoto Protocol, says Yohe, “the European approach to thinking about climate is based in large measure on risk management.” And in announcing goals for reducing greenhouse-gas emissions, the governor of California and a consortium of New England states seem to be thinking along the same lines. Perhaps the answer to climate uncertainty is doing what comes naturally.

—R.A.K.



Getting unstuck. Treating climate-change mitigation as a form of insurance would buy time for scientists to sort out the risks.

“Schrag of Harvard University has pointed out, models cannot yet simulate other climate extremes known from the geologic record, such as the extreme warming that occurred 55 million years ago.

By the end of the workshop, the threat of a MOC collapse seemed to have receded, at least relative to other climate threats. “The [scientific] community is way, way over-focused on the MOC,” said ice core geochemist Jeffrey Severinghaus of the Scripps Institution of Oceanography (SIO) in San Diego, California. Tropical oceanographer George Philander of Princeton University agreed: “The last 6 months, every computer center has been tied up pouring fresh water on the North Atlantic. That’s not good. How do we get off this bandwagon?”

A looming MOC collapse “has inspired a Hollywood movie and a lot of fear,” said statistical economist Richard Tol of Hamburg University in Germany. “It’s everyone’s favorite bogeyman, but they may be barking up the wrong tree.” Tol would direct more

attention toward the prospect of rising sea levels, possibly sharply rising if the ice of West Antarctica accelerates its slipping into the sea (*Science*, 24 September 2004, p. 1897).

Others pointed to the possibility of sudden “regime shifts.” In these, the slowly strengthening greenhouse could abruptly snap climate patterns into new configurations. Such climatic switches have happened in the past, Severinghaus noted. The central United States seems to go through centuries-long intervals of longer and more frequent droughts separated by periods of less drought-prone climate. And there are signs that the recent western U.S. drought was intensified by the warming of tropical waters (*Science*, 31 January 2003, p. 636). Other climate regimes, such as the monsoons, might be susceptible to greenhouse-triggered shifts as well, noted physical oceanographer Lynne Talley of SIO. Abrupt surprises, it seems, may yet be found far beyond the North Atlantic.

—RICHARD A. KERR