Sea Change in the Atlantic

Greenhouse warming may be accelerating the cycling of water through the Atlantic Ocean, with uncertain effects on everything from polar ice to European climate

SAN FRANCISCO, CALIFORNIA—All eyes are on the global thermometer these days: 2003 was the third-warmest year on record, probably one of the warmest in the past millennium. But there's more to global climate than temperature. At the fall meeting of the American Geophysical Union here last month, a group of physical oceanographers announced that a grand compilation of oceanic observations that nearly spans the Atlantic Ocean from pole to pole reveals a decades-long shift in the cycling of water through the climate system. The hydrologic engine that pumps fresh water from Atlantic tropical seas to high latitudes has been cranked up, possibly by global warming.

The resulting surge of fresh water into polar latitudes could ultimately disrupt the climate system, with diverse effects such as a counterintuitive chilling of the far North Atlantic region or the melting of Arctic ice. The study "is another piece of evidence that there really are large-scale changes going on," says physical oceanographer Sydney Levitus of the National Oceanic and Atmospheric Administration in Silver Spring, Maryland. The question now is whether the changes persist and how dire any ramifications will be.

Oceanographers made no new observations to gauge the speed of the Atlantic's hydrologic cycle. Levitus and his colleagues originally gathered millions of temperature and salinity measurements made during the past century from around the world (*Science*, 24 March 2000, p. 2126). Physical oceanographer Ruth Curry of the Woods Hole Oceanographic Institution in Massachusetts has further checked the Levitus data from the Atlantic for quality and consistency. "You can slice through the Atlantic from pole to pole to see how things have changed," she says. That's what she and physical oceanographers Robert Dickson of the Centre for Environment, Fisheries, and Aquaculture Science in Lowestoft, U.K., and Igor Yashayaev of the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, have done. As they reported in the 18/25 December 2003 issue of *Nature*, they compared the change in Atlantic conditions between two 14-year periods centered in 1962 and 1992.

Curry and her colleagues found changes of "remarkable amplitude" over the 30-year interval. The tropical ocean shallower than about 1000 meters had become warmer and saltier, while waters at high latitudes to the north and south had become fresher, right down to the bottom. That's a pattern that makes physical sense, they say. The tropics warmed enough to account roughly for the additional evaporation—about an extra 2 meters of water evaporated during the past 40 years—needed to increase the salinity of tropical waters as observed. That extra evaporated water would have eventually traveled poleward and precipitated into the sea or fallen onto the land and run into the sea, helping explain the polar freshening. Based on more limited surveys, a similar pattern of increasing salinity in the tropics and freshening of higher latitudes has been reported in the Pacific.

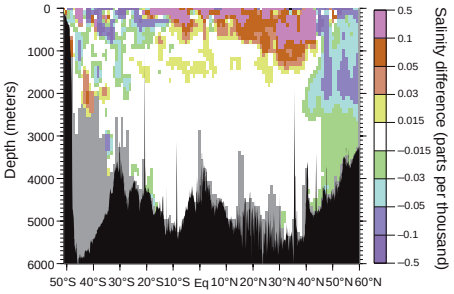
To Curry and her colleagues, it's looking as if something has accelerated the world's cycle of evaporation and precipitation by 5% or 10%, and that something may well be global warming. Climate models of the intensifying greenhouse predict such an acceleration, the expected pattern is showing up in both the Pacific and Atlantic, and it's been going on as greenhouse warming has been kicking in, they note. If so, the consequences could be as broad and enduring as those of greenhouse warming. For example, add too much fresh water too quickly to the surface of the far northern North Atlantic, and the fresh water could slow or even stop the Gulf Stream's delivery of warm water to the far north Atlantic that helps moderate climate there (*Science*, 27 September 2002, p. 2202). Such shutdowns during the last ice age were nearly catastrophic, with Greenland chilling 10°C in a decade, although the slow freshening that Curry and her colleagues have observed would likely have less dramatic effects. And the extra evaporated water leaving the tropics carries large amounts of heat that could eventually help melt polar ice or shift storm tracks.

Oceanographers are welcoming the new analysis. "It's a very appealing story," says physical oceanographer Harry Bryden of the Southampton Oceanography Centre in the United Kingdom. "It clearly shows there is this consistent pattern" of changing salinity, but "whether it's a long-term trend or not remains to be seen." Experience has made him leery of snap decisions about the ocean. Climate modeling had suggested that a freshening in the southern Indian Ocean between the 1960s and 1987 had been induced by anthropogenic climate change. But a new survey by Bryden showed that the freshening had since reversed and the southern Indian Ocean had gotten saltier since the 1980s (*Science*, 27 June, p. 2086). As a result, Bryden is "skeptical these days about 'trends,' " he says.

Given the limited observations, oceanographers are answering the oft-heard call for more data. Curry is extending her database to the Pacific. Levitus is continuing to forage around the world for neglected data sets, in hopes of extending the useful record back in time. And ocean surveys continue, by both oceanographers and robots. So perhaps more attention to the water cycle will help us understand what a warmer world will be like.

–RICHARD A. KERR





A changing ocean. The Atlantic's shallow, tropical waters have become more saline (reds and yellows) while its high latitudes became fresher (blues and greens).

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