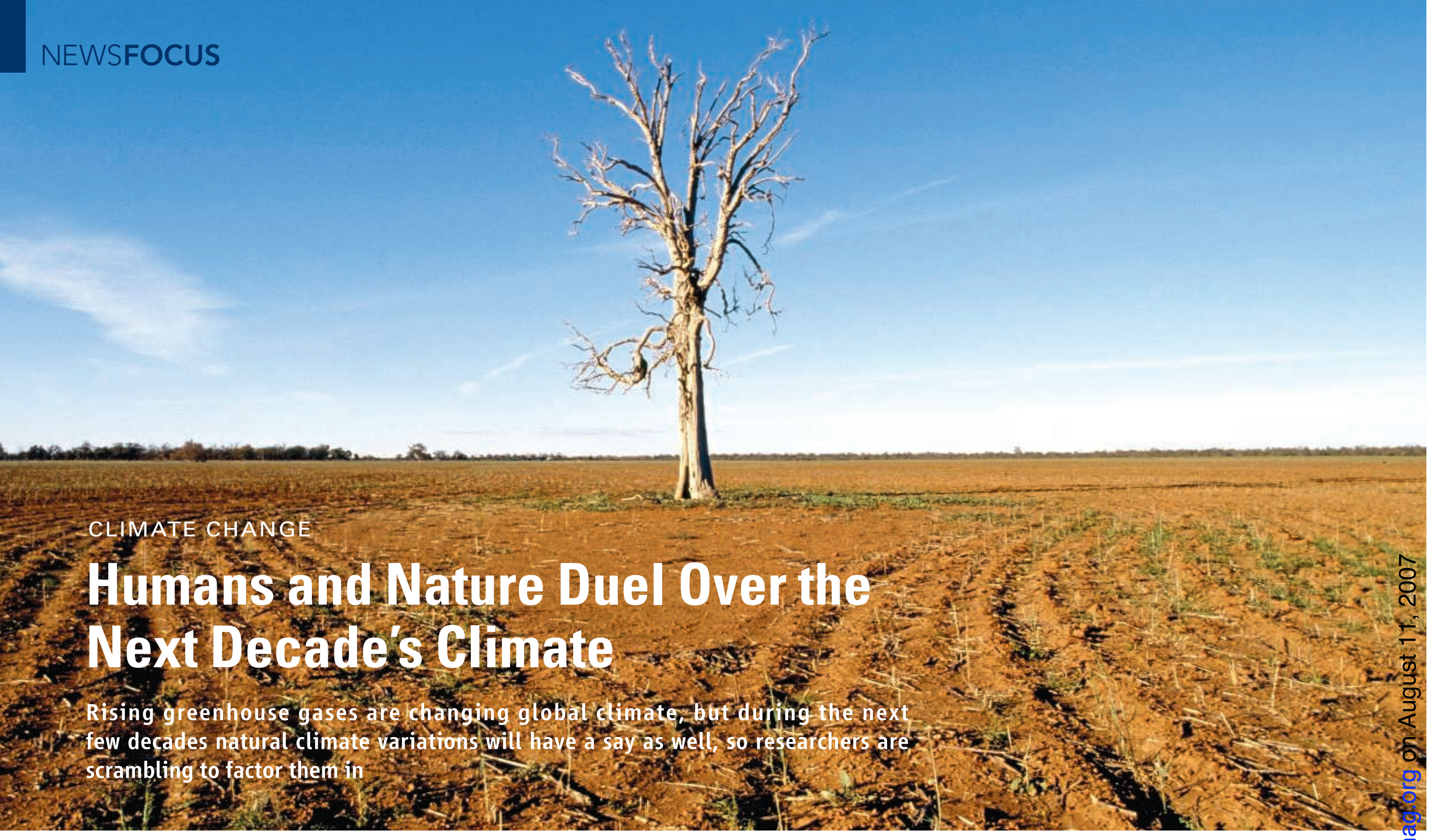


CLIMATE CHANGE

Humans and Nature Duel Over the Next Decade's Climate

Rising greenhouse gases are changing global climate, but during the next few decades natural climate variations will have a say as well, so researchers are scrambling to factor them in

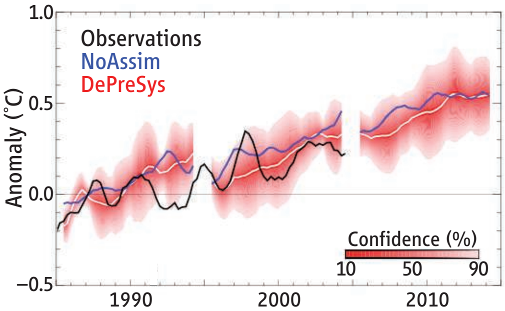
For a century or more, meteorologists have known the secret to weather forecasting: To glimpse tomorrow's weather, one must know today's. And lately they have realized that the same precept applies to predicting climate years or decades ahead. Stirrings in the North Atlantic Ocean today that have nothing to do with the strengthening greenhouse—just natural jostlings of the climate system—could lead to drought in Africa's Sahel in a decade or two, they recognized. Ignore today's ocean conditions, and your 2020 global-warming forecast could be a bust. And such natural variability can be far-reaching. In a recent study, researchers found that when the Atlantic Ocean swung from one state to another, it apparently helped trigger a decade-long climate shift in the late 1960s that sprang from the Atlantic and reached as far as Australia.

But until now, climate forecasters who worry about what greenhouse gases could be doing to climate have ignored what's happening naturally. Most looked 100 years ahead, far enough so that they could safely ignore what's happening now. No more. In this week's issue, researchers take their first stab at forecasting climate a decade ahead with current conditions in mind. The result is a bit disquieting. Natural climate variability driven by the ocean appears to have held greenhouse warming at bay the past few years, but the warming, according to the forecast, should come roaring back before the end of the decade.

"This is a very valuable step forward," says meteorologist Rowan Sutton of the University of Reading, U.K. "It's precisely on the decadal time scale and on regional scales that natural variability and anthropogenic effects have comparable magnitudes." So improved climate forecasting of the next few decades could help decision-makers focus on where and when the most severe climate change will be happening. Or, conversely, they could recognize when the looming threat of global warming will be masked—temporarily—by natural variability.

Jiggly climate

No one ever said Earth's atmosphere was a boring place. Air is in continually shifting motion, from the wafting of innumerable summer breezes to a few roaring jet streams. But forecasters have long recognized that certain parts of the chaotic atmosphere are better behaved than others. Over the North Atlantic, for example, atmospheric pressure over Iceland and Portugal tends to "seesaw" over the weeks and months, rising at one site while it falls at another. This North Atlantic Oscillation (NAO) in turn switches winds to and fro across the Atlantic, guiding storms into or away from western Europe. Other modes of natural variability—atmospheric jigglings that lack an external cause such as added greenhouse gases—tend to cause atmospheric reorganizations over the North Pacific and the high latitudes of both hemispheres. The tropical warmings and coolings of the El Niño–La Niña cycle can also hold sway in various regions around the globe.



Better. A model starting from current conditions (white) came closer to reality (black) than one without (blue).

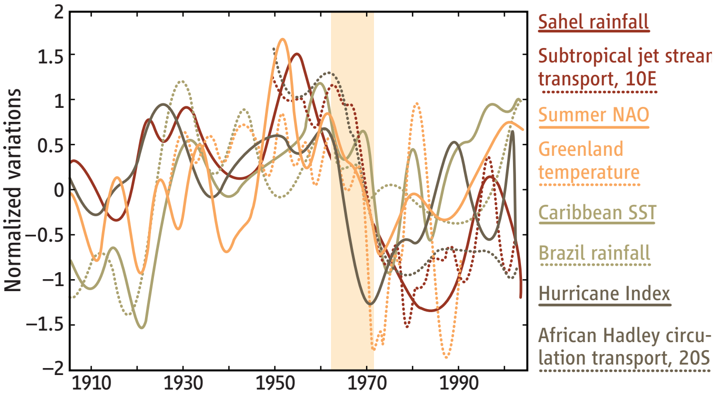
Once meteorologists recognized that natural variability offered hope of predicting out a few months, climate researchers began to see that the same or similar modes might improve forecasting a decade or more ahead. On a regional scale, the NAO seesaws over the decades as well. Its dramatic strengthening in winter between the 1960s and 1990s pumped extra heat into Northern Europe on top of greenhouse warming, according to a new analysis in press at the *Journal of Geophysical Research* by climate researcher

Published by AAAS

David Parker of the Hadley Centre for Climate Prediction and Research in Exeter, U.K., and his colleagues.

On a broader scale, natural variability over decades is clearly rooted in the oceans. A warm-cool cycle that spans the Pacific, both North and South, has lately swung back and forth on a time scale of 30 to 50 years. By Parker and his colleagues' data and model analysis, this so-called Interdecadal Pacific Oscillation seems to be driven by interactions between the tropical ocean and atmosphere much like those that drive El Niño; the IPO could be the multidecadal expression of the El Niño cycle, they say.

Over in the Atlantic, there's the Atlantic Multidecadal Oscillation (AMO) of sea surface temperature. It is apparently driven by the acceleration and slowing of the great ocean conveyor that carries warm surface water into the northern North Atlantic (*Science*, 1 July 2005, p. 41). The AMO's vacillations have been linked to everything from triggering drought in the Sahel and the central United States to alternately suppressing and—in the past decade—firing up hurricanes (*Science*, 10 November 2006, p. 910).



Doin' the shift. All sorts of regional climate—from African rainfall to hurricane activity—changed in the late 1960s, especially around the Atlantic.

SOURCE: P. G. BAINES AND C. K. FOLLAND/JOURNAL OF CLIMATE

A global reach

Lately, researchers are finding that the AMO may have a stronger influence and a longer reach than they once thought. They knew that the oscillation affected climate around the Atlantic, but some suspected it had also caused a mid-century warming of the Northern Hemisphere or even the globe.

This past January in *Geophysical Research Letters*, climate modeler Rong Zhang and colleagues at the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, showed how the AMO might have warmed at least the one hemisphere. They varied the warmth of the North Atlantic in their model to mimic the way the temperature of the real North Atlantic varied under the AMO during the 20th century. In the model, the Northern Hemisphere warmed to mid-century and then cooled slightly through the 1950s and 1960s, as it did in the real world.

In work accepted at the *Journal of Climate*, climate researchers Sergey Kravtsov and Christopher Spannagle of the University of Wisconsin, Milwaukee, extract what looks like an AMO temperature signal from not just the hemispheric but the global record as well. To gauge the effect of natural variations, they took 20th century temperature records from around the globe and subtracted the warming due to rising greenhouse gases, as simulated by 16 climate models. The difference—a strong warming over southern Greenland, a warming North Atlantic, a cooling South Atlantic, and a weak warming in the far North Pacific—looks like the pattern and timing attributed to the AMO. Kravtsov and Spannagle conclude that the shifting ocean circulation behind the AMO has global effects on global warming.

The AMO may have had a hand in a more dramatic global climate event, according to meteorologist Peter Baines of the University of Melbourne, Australia, and climatologist Chris Folland of the Hadley Centre, writing in the 15 June issue of the *Journal of Climate*. Their climate shift rattled the circum-Atlantic region over a decade starting in the early 1960s and reached around the globe.

First, Baines and Folland pulled together a range of regional changes in temperature, rainfall, and atmospheric circulation around the Atlantic that could all be tied back to a cooling of the North Atlantic. The AMO presumably cooled the ocean—perhaps with the help of sun-shielding pollutant hazes—as the warm conveyor slowed. Greenland cooled, Brazilian rainfall swelled, hurricane activity dropped, and the Sahel dried to the most catastrophic drought in more than a century. These changes, which are most evident in the northern summer, can all be linked to the reduction and relocation of the ocean's transfer of heat into the atmosphere, Baines and Folland say. Those shifts, in turn, led to changes in atmospheric circulation and precipitation over adjacent continents.

Searching for the most remote limits of this climate shift, Baines and Folland looked out along the atmospheric circulations ultimately driven by tropical ocean heating in the Atlantic. There they found changes in subtropical jet streams in both hemispheres and poleward shifts in storm paths. In southwest Australia, for example, the shift reduced the rains and brought long-term drought. Baines and Folland's explication of a globe-girdling late-'60s climate shift only reinforces the view that "the AMO does affect global climate," says meteorologist Mojib Latif of the University of Kiel, Germany. "It's not just regional climate."

Anticipating nature

Appreciating the power and reach of natural climate variations is a major step. To put that information to use, however, climate forecasters must find a way to model the future course of the variations themselves, starting from current conditions. Climate researchers from the Hadley Centre, led by Douglas Smith, are the first to try that, as they report on page 796.

The Hadley group tested the usefulness of their new prediction model by "hindcasting" the climate of two past decades. Starting from the observed distribution of ocean heat content, the model outperformed its own forecasts that lacked observed initial conditions. Errors in predicting global temperature declined by 20% or 36%, depending on the type of error. The model successfully predicted the warming of El Niño and the effect of unusually warm or cold waters around the world. An actual forecast starting in June 2005 correctly predicted that natural variability—the appearance of cooler water in the tropical Pacific and a resistance to warming in the Southern Ocean—would offset greenhouse warming until now. But beyond 2008, warming sets in with a vengeance. "At least half of the 5 years after 2009 are predicted to be warmer than 1998, the warmest year currently on record," the Hadley Centre group writes.

"Smith *et al.* is an important first step in setting out the method," says meteorologist Tim Palmer of the European Centre for Medium-Range Weather Forecasts in Reading, U.K. Now researchers need to amass more computing power, more past observations to test the method better, and more future observations to feed the models, he says. And time is of the essence. If the AMO in fact played a substantial role in the rapid warming and enhanced hurricane activity of the past decade or two, says Sutton, "there will in all probability be a turnaround [of the AMO], possibly in the next decade." It would be nice to know for sure.

–RICHARD A. KERR