CLIMATE CHANGE

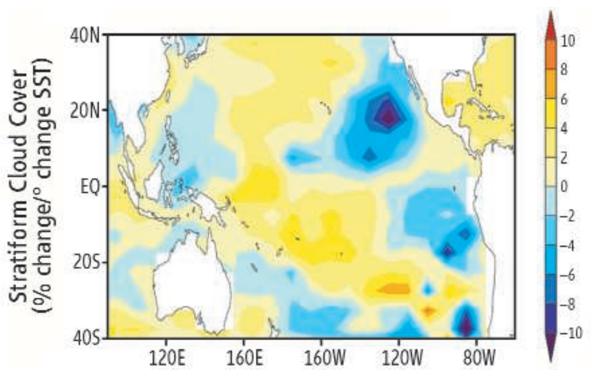
Clouds Appear to Be Big, Bad Player in Global Warming

Climate researchers have long viewed clouds' reaction to greenhouse warming as the key to understanding the world's climatic fate. As rising carbon dioxide strengthens the greenhouse, will some clouds thicken and spread, shading the planet and tempering the warming? Or will they thin and shrink, letting in more sunshine to amplify the warming? The first reliable analysis of cloud behavior over past decades suggests—but falls short of proving—that clouds are strongly amplifying the warming. If that's true, then almost all climate models have got it wrong.

The new study "confirms with observations that low clouds are critical for the climate system's response," says climate modeler Gerald Meehl of the National Center for Atmospheric Research in Boulder, Colorado. But "it's really a challenge for models" to simulate that response, he adds. If real-world cloud amplification works the way the study indicates, researchers say, global warming could be even worse than the typical model predicts.

Clouds have been a climate conundrum in part because no one has been keeping an eye on them the way the weatherman has been recording temperature for more than a century. On page 460, climate researcher Amy Clement of the University of Miami in Florida and colleagues consider the two best, long-term records of cloud behavior over a rectangle of ocean that nearly spans the subtropics between Hawaii and Mexico. Other researchers had compiled one of the records from eyeball estimates of cloud cover made by mariners who passed through the region from 1952 to 2006. The other record, which runs from 1984 to 2005, came from satellite measurements, which Clement and her colleagues adjusted to account for calibration shifts from one satellite to the next.

Between them, the observations recorded the two major climate shifts that roiled the North Pacific during the periods they covered. In a warming episode that started around 1976, the ship-based data showed that cloud cover—especially low-altitude cloud layers—decreased in the study area as ocean temperatures rose and atmospheric pressure fell. One interpretation, the researchers say, is that the warming ocean was transferring heat to the overlying atmosphere, thinning out the low-lying clouds to let in more sunlight that further warmed the ocean. That's a positive or amplifying feedback. During a cooling event in the late 1990s, both data sets recorded just the opposite changes—exactly what would happen if the same amplifying process were operating in reverse. "All of the elements of a positive feedback are there," Clement says.



Leaky clouds. Decades-long records show that when sea surface temperature (SST) warms, cloud cover—especially from low clouds (*bottom*)—decreases (blues, *top*), letting in more sunlight.

Even so, positive low-cloud feedback was only a supposition until the group looked at another sort of satellite measurement of the second natural climate shift. That showed that when decreasing cloud cover let the sun leak through, the additional solar heating was large enough to account for much of the ocean warming. A positive feedback operating in the decades-long climate shifts "is real," Clement concludes. And other studies link cloud changes in the northeastern tropical Pacific to atmospheric changes across the Pacific.

But is such a feedback actually working to amplify global warming? To get some indication, Clement and her colleagues checked the archives of a study in which the international Coupled Model Intercomparison Project compared the results of 18 global climate models run under standardized conditions. Clement and her colleagues tested whether each model was properly simulating each element of the positive cloud feedback they had found in the northeastern Pacific.

When the results were in, only two models showed low clouds producing a positive feedback as observed. One of them stood out from the pack. The HadGEM1 model from the U.K. Met Office's Hadley Center in Exeter produced patterns of warming and circulation changes during greenhouse warming that resembled those of all 18 models averaged together—the best guide available. The group also concluded that HadGEM1's simulation of meteorological processes in the lowermost kilometer or two of the atmosphere—where the key low-lying clouds reside—is particularly realistic.

As it happens, the HadGEM1 model is among the most sensitive of the 18 models to added greenhouse gases. When carbon dioxide is doubled, the model warms the world by 4.4°C; the median of the models for a doubling is 3.1°C. That gap raises a red flag for Clement. "We tend to focus on the middle of the range of model projections and ignore the extremes," she says. "I think it does suggest serious consideration should be given to the upper end of the range."

Climate researchers agree that Clement and her colleagues may be on to something. "There's been a gradual recognition that this rather boring type of [low-level] cloud is important in the climate system," says climate researcher David Randall of Colorado State University, Fort Collins. "They make a good case that in [decadal] variability there is a positive feedback. The leap is that the same feedback would operate in global climate change." The study tends to support an important role for marine low clouds in amplifying global warming, he says, but it doesn't prove it.

One clear contribution of the study, Randall says, is to point the way toward more reliable climate models. The paper "is definitely a reasonable approach to deciding which models to pay the most attention to," he says. In its previous international assessments, Randall notes, the Intergovernmental Panel on Climate Change assumed that all models are created equal. "I think we have to get away from that."

–RICHARD A. KERR

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