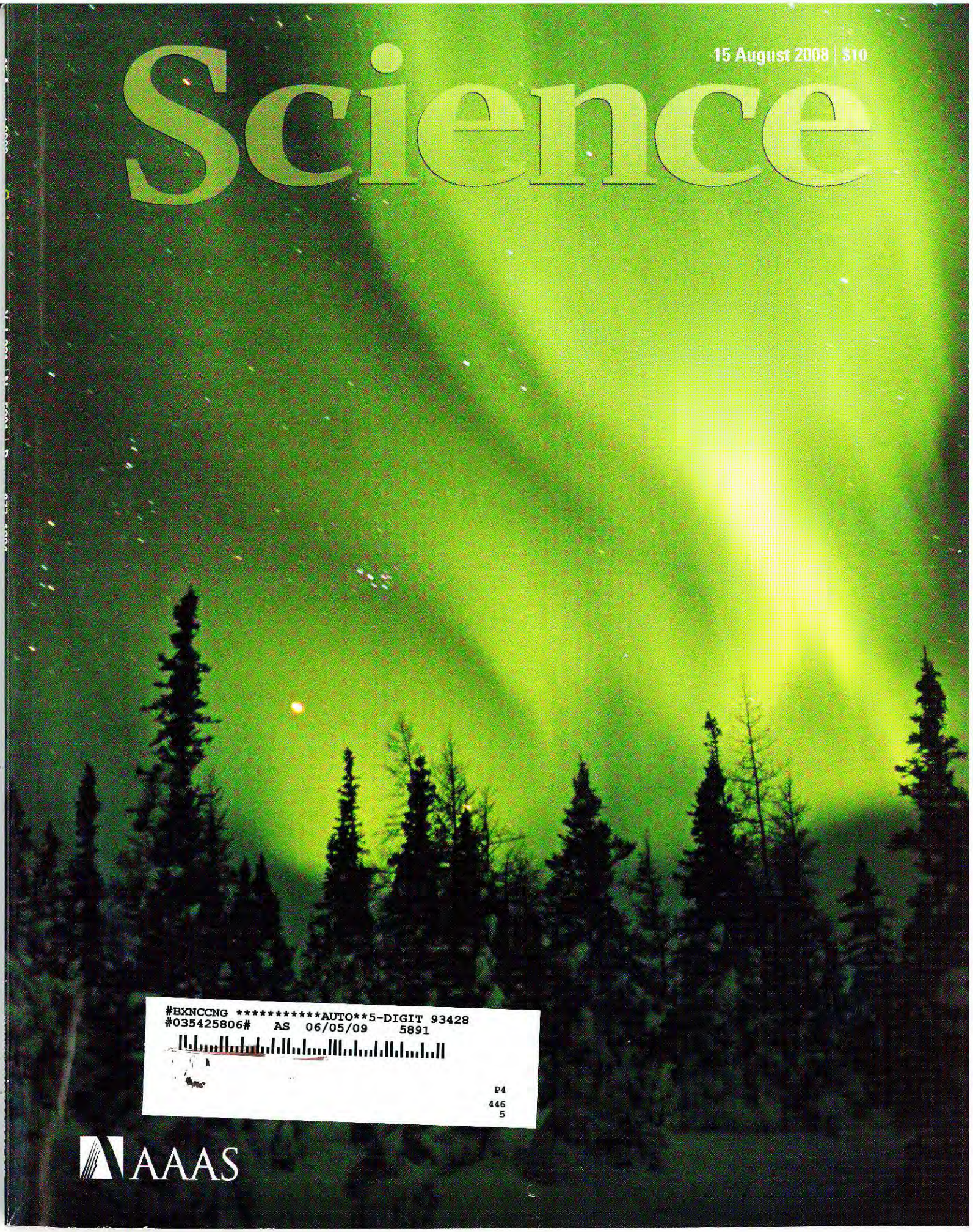


AAAS

GLOBAL WARMING

Climate Change Hot Spots Mapped Across the United States

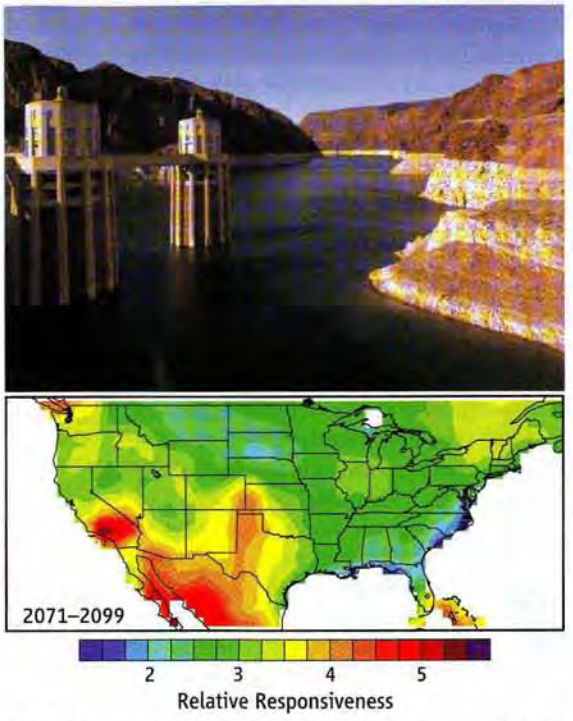
Taking some of the fuzziness out of climate models is revealing the uneven U.S. impact of future global warming; the most severely affected region may be emerging already

Now that almost everyone expects a certain amount of global warming by the end of the century, attention can turn to more local climate change. What's going to happen in our own backyards? Researchers can't go that far yet, but in an effort to squeeze the maximum detail out of notoriously fuzzy climate models, they are pooling results from some of the most sophisticated simulations available.

The latest regional climate effort points up the uneven burden climate change will place on the United States. "It highlights that there are regions where climate changes will be bigger than others," says climate modeler Gerald Meehl of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. The American Southwest looks to be hardest hit by far, but the work also highlights a dramatic increase in year-to-year climate variability contributing to hot spots.

The new work is in press in *Geophysical Research Letters* (*GRL*). As climate modeler Noah Diffenbaugh of Purdue University in West Lafayette, Indiana, and his colleagues lay out in the paper, regional climate modeling in the wake of last year's report from the Intergovernmental Panel on Climate Change has come a long way since the previous IPCC report in 2001. For that report, researchers divided the contiguous 48 states into 1300-kilometer-wide west, central, and east regions, including a good bit of Canada in the west. Drawing on IPCC simulations of future greenhouse climate generated by nine then–state-of-the-art global climate models, they concluded that each broad region could expect slightly more warming and in the winter slightly more precipitation than the global average.

In the *GRL* paper, Diffenbaugh and his colleagues offer a much sharper picture of climate change. They combine forecasts from 15 new, state-of-the-art global models run for last year's IPCC report. These models individually paint a more detailed picture than their predecessors did and have more realistic renditions of the physical processes in the climate system. The group also formulates a new gauge of climate change—climate responsiveness—by combining projected changes in temperature and precipitation as well as changes in variability of those climate properties from year to year. High values of this climate responsiveness mark "hot spots" where the models say climate will be changing the most.



More of the same? Models predict that the U.S. Southwest and northern Mexico will be most responsive (reds and yellows) to the strengthening greenhouse; Lake Mead (*top*) may have responded already.

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According to the 15-model consensus, the strongest U.S. hot spot by far stretches across the Southwest from southern California to west Texas and intensifies even more over northern Mexico. By another statistical analysis technique, the American Southwest hot spot extends northward into Nevada, Utah, and Colorado. By either technique, the U.S. Southeast is a distinct "cool spot," a region relatively less responsive in changing temperature and precipitation, although Diffenbaugh cautions that "we need to be careful to not overinterpret these areas as 'safe' or 'immune.' " Other studies have suggested that these less responsive regions may be at risk of other sorts of greenhouse changes, such as increased severe weather in the Southeast.

Two higher resolution models not included in the consensus—one global, the other an extremely high-resolution model of the continental United States—suggest a similar pattern but also identify a milder climate change hot spot in the Midwest.

Most surprising to Diffenbaugh, the better part of a hot spot's strength came not from progressive warming or a long-term rise or fall in precipitation but from increased variability from one year to the next, especially in precipitation. Models have predicted that a strengthening greenhouse would make the climate more variable, but "I'm not sure what that means," says regional climate modeler Linda Mearns of NCAR. "More attention should be given to how variability is going to change."

"Needless to say, this work is only the beginning of a possible new avenue ... towards a clearer picture of where regional climate change matters," regional modeler Jens Christensen of the Danish Meteorological Institute in Copenhagen writes in an e-mail. It was good that the group checked the combined global models against the higher resolution models, he explains. But the work points up the need for combining results from multiple regional models, not just the global models. Such an approach might help address concerns that the models still aren't very good at replicating climate change across the United States during the past 50 years, as meteorologist Kevin Trenberth of NCAR notes in an e-mail. That may be in part because the models have trouble simulating natural climate changes induced by slow changes like El Niño, he says.

Shortcomings or not, the IPCC models may have found a hot spot that is already developing. The predicted Southwest hot spot of climatic change looks much the same during the next 30 years as at the end of this century. And that future hot spot bears a strong resemblance to the drying and warming of the Southwest during the past decade or so. Says Diffenbaugh: "We may already be seeing some emerging hot spot patterns."

–RICHARD A. KERR