GREENHOUSE WARMING

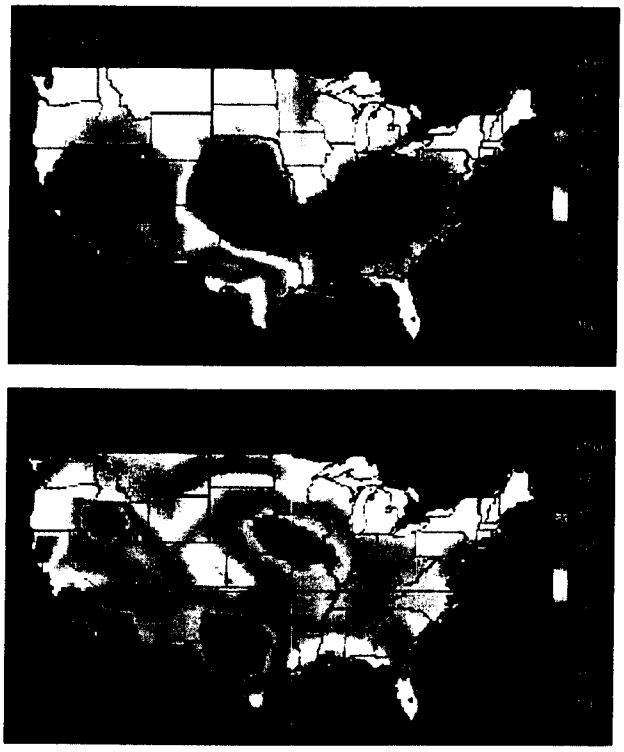
Dueling Models: Future U.S. Climate Uncertain

When Congress started funding a global climate change research program in 1990, it wanted to know what all this talk about greenhouse warming would mean for United States voters. Ten years later, a U.S. national assessment, drawing on the best available climate model predictions, concludes that the United States will indeed warm, affecting everything from the western snowpacks that supply California with water to New England's fall foliage. But on a more detailed level, the assessment often draws a blank. Whether the cornfields of Kansas will be gripped by frequent, severe droughts, as one climate model has it, or blessed with more moisture than they now enjoy, as another predicts, the report can't say. As much as policy-makers would like to know exactly what's in store for Americans, the rudimentary state of regional climate science will not soon allow it, and the results of this 3-year effort brought the point home.

"This is the first time we've tried to take the physical [climate] system and see what effect it might have on ecosystems and socioeconomic systems," says Thomas Karl, director of the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center in Asheville, North Carolina, and a co-chair of the committee of experts that pulled together the assessment report "Climate Change Impacts on the United States" (available at www.nacc.usgcrp.gov). "We don't say we *know* there's going to be catastrophic drought in Kansas," he says. "What we do say is, 'Here's the range of our uncertainties.' This document should get people to think." If anything is certain, Karl says, it's that "the past isn't going to be a very good guide to future climate."

By chance, the assessment had a handy way to convey the range of uncertainty that regional modeling serves up. The report, which divides the country into eight regions, is based on a pair of state-of-the-art climate models—one from the Canadian Climate Center and one from the U.K. Hadley Center for Climate Research and Prediction—that couple a simulated atmosphere and ocean. The two models solved the problems of simplifying a complex world in different ways, leading to very different predicted U.S. climates. "In terms of temperature, the Canadian model is at the upper end of the warming by 2100" predicted by a range of models, says modeler Eric Barron of Pennsylvania State University, University Park, and a member of the assessment team. "The Hadley model is toward the lower end. The Canadian model is on the dry side, and the Hadley model is on the wet side. We're capturing a substantial portion of the range of simulations. We tried hard to convey that uncertainty."

On a broad scale, the report can conclude: "Overall productivity of American agriculture will likely remain high, and is projected to increase throughout the 21st century," although there will be winners and losers from place to place, and adapting agricultural practice to climate change will be key. Where the models are somewhat consistent, as in the far southwest, the report ventures what could be construed as predictions: "It is likely that some ecosystems, such as alpine ecosystems, will disappear entirely from the region," or "Higher temperatures are likely to mean ... a shorter season for winter activities, such as skiing." Where the models clash, as on summer soil moisture over the eastern two-thirds of the lower 48 states, it explains the alternatives and suggests ways to adapt, such as switching crops.



A cloudy crystal ball. One climate model calls for mostly drier soil in summer *(top)*, another mostly wetter *(bottom)*.

CREDIT: "CLIMATE CHANGE IMPACTS ON THE UNITED STATES," PUBLIC REVIEW DRAFT, JUNE 2000

The range of possible climate impacts laid out by the models "fairly reflects where we are in the science," says Karl. But he notes that the effort did lack one important input: Congress mandated the assessment without funding it. "You get what you pay for," says climatologist Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colorado. "A lot of it was done hastily." Karl concedes that everyone involved would have liked to have had more funding delivered more reliably.

Even given more time and money, however, the assessment may not have come up with much better small-scale predictions, given the inherent limitations of the science. Even the best models today can say little that's reliable about climate change at the regional level, never mind at the scale of a congressional district. Their picture of future climate is fuzzy—they might lump together San Francisco and Los Angeles because the models have such coarse geographic resolution—and the realism of such meteorological phenomena as clouds and precipitation is compromised by the inevitable simplifications of simulating the world in a computer.

"For the most part, these sorts of models give a warming," says modeler Filippo Giorgi, "but they tend to give very different predictions, especially at the regional level, and there's no way to say one should be believed over another." Giorgi and his colleague Raquel Francisco of the Abdus Salam International Center for Theoretical Physics in Trieste, Italy, recently evaluated the uncertainties in five coupled climate models—including the two used in the national assessment—within 23 regions, the continental United States comprising roughly three regions. Giorgi concludes that as the scale of prediction shrinks, reliability drops until for small regions "the model data are not believable at all."

Add in uncertainties external to the models, such as population and economic growth rates, says modeler Jerry D. Mahlman, director of NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, and the details of future climate recede toward unintelligibility. Some people in Congress and the policy community had "almost silly expectations there would be enormously useful, small-scale specifics, if you just got the right model. But the right model doesn't exist," says Mahlman.

Still, even though the national assessment does not offer the list of region-by-region impacts that Congress might have hoped for, it does show "where we are adaptable and where we are vulnerable," says global change researcher Stephen Schneider of Stanford University. In 10 years, modelers say, they'll do better. –RICHARD A. KERR

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