BACKGROUNDER

Assessing Future Climate Change

CONFRONTING CLIMATE CHANGE IN THE U.S. MIDWEST

CLIMATE MODELS AND EMISSIONS SCENARIOS

In order to project changes in temperature and other climate variables over the coming decades, scientists must address two key uncertainties. The first is directly related to human activity: how much carbon dioxide (CO_2) and other heat-trapping emissions will our industrial and land-use activities produce over the coming century? The second is scientific in nature: how will the climate respond to these emissions (e.g., how much will temperatures rise in response to a given increase in atmospheric CO_2)?

To address the first uncertainty, the Intergovernmental Panel on Climate Change (IPCC) has developed a set of possible futures, or scenarios, that project global levels of emissions of heat-trapping gases based on a wide range of development variables including population growth, energy use, and other societal choices. Analyses in this series of reports use the IPCC's A1fi and B1 scenarios to represent possible higher- and lower-emissions choices, respectively, over the course of the century.

The higher-emissions scenario represents a world with fossil fuel-intensive economic growth. Atmospheric CO_2 concentrations reach 940 parts per million (ppm) by 2100—more than triple pre-industrial levels. The lower-emissions scenario assumes a relatively rapid shift to less fossil fuel intensive industries and more resource-efficient technologies. This causes CO_2 emissions to peak around mid-century, then decline to less than our present-day emissions rates by the end of the century. Atmospheric CO_2 concentrations reach 550 ppm by 2100—about double pre-industrial levels.

To address the second uncertainty—how the climate will respond to increasing emissions—and estimate the range of potential changes in the Midwest's climate, researchers used the IPCC's higher and lower-emissions scenarios as input to three state-of-the-art global climate models, each representing different climate "sensitivities." (Climate sensitivity, defined as the temperature change resulting from a doubling of atmospheric CO_2 concentrations relative to pre-industrial times, determines the extent to which temperatures will rise under a given increase in atmospheric concentrations of heat-trapping gases). The greater the climate sensitivity of the global climate model, the greater the extent of projected climate change for a given increase in CO_2.

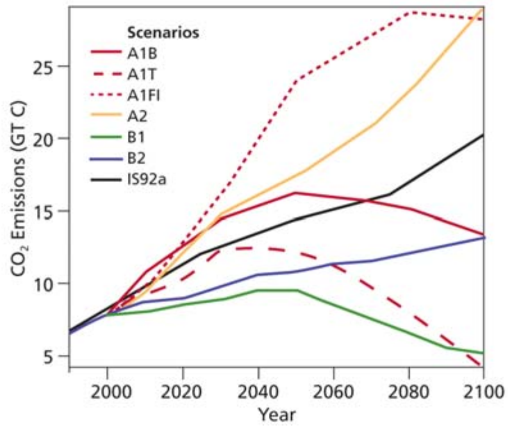

FIGURE 1: IPCC Emissions Scenarios
Projected carbon dioxide emissions for the IPCC SRES scenarios. The higher-emissions scenario (A1fi) corresponds to the dotted red line while the lower-emissions scenario (B1) corresponds to the green line.

The three climate models used to generate the projections described in this study were the U.S. National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory (GFDL) CM2.1 model, the United Kingdom Meteorological Office's Hadley Centre Climate Model version 3 (HadCM3), and the National Center for Atmospheric Research's Parallel Climate Model (PCM).

The first two climate models have medium and medium-high climate sensitivities, respectively, while the third has low climate sensitivity. These three are among the best of the latest generation of climate models. Confidence in using these global models to assess future climate is based on results from a detailed analysis that indicates they are able to reproduce not only key features of the regional climate but also climate changes that have already been observed across the Midwest over the last 100 years.

Uncertainties in climate modeling and the workings of the earth-atmosphere system remain, and several lines of evidence suggest that the climate-model projections used in this assessment may be relatively conservative. The models do not, for instance, capture the rapid winter warming observed in the Midwest over the past several decades. Projections of sea-level rise discussed in this report may also be quite conservative because they do not account for the rapid rate of decay and melting of the major polar ice sheets currently being observed, nor for the potential for further acceleration of this melting.

Many other changes in climate over short timescales (on the order of 10 years or less) may not be adequately resolved from these models. Climate researchers use projections over spans of 30 years or more to ensure they represent long-term averages and not short-term fluctuations in climate. Some of the well-known short-term fluctuations are due to changes in the strength of the El Niño Southern Oscillation (or its counterpart La Niña) and other patterns of variability in the ocean and atmosphere.

Global climate models produce output in the form of geographic grid-based projections of daily, monthly, and annual temperatures, precipitation, winds, cloud cover, humidity, and a host of other climate variables. The grid cells range in size from 50 to 250 miles on a side. To transform these global projections into "higher-resolution" regional projections (which look at changes occurring across tens of miles rather than hundreds), scientists used well-established statistical and dynamical downscaling techniques. As with global climate models, how well the downscaled models reproduce climate over the past century allows scientists to determine the performance of the models in projecting future climate.

State specific reports titled *Confronting Climate Change in the U.S. Midwest* and the underlying technical papers are available online at www.ucsusa.org/mwclimate.

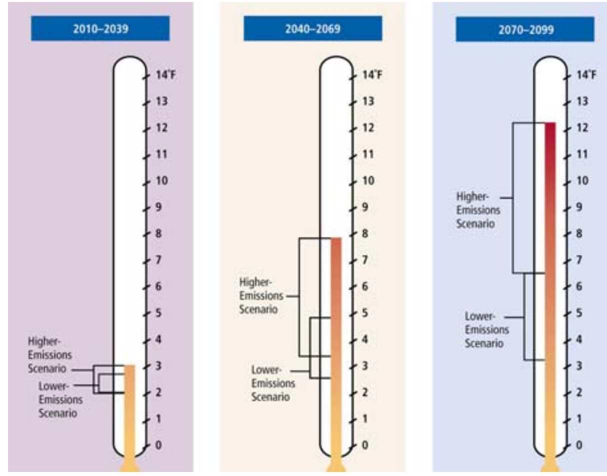

FIGURE 2: Projected Temperature Change for the U.S. Midwest above 1961-1990 average
The Midwest is already experiencing rising temperatures, with potentially dramatic warming expected later this century, especially if emissions of heat-trapping gases continue along the path of the higher-emissions scenario. These "thermometers" show projected increases in regional average annual temperatures for three time periods: early-, mid-, and late-century.

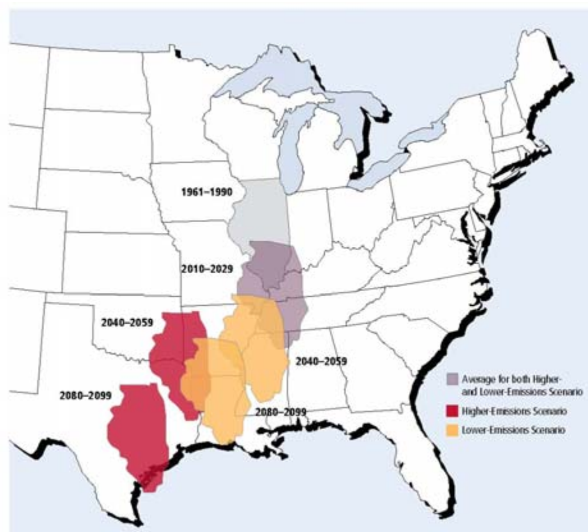

FIGURE 3: State Climates Migrate South
Changes in average summer "heat index"-a measure of how hot it actually feels based on a specific combination of temperature and humidity-could strongly affect Midwesterners' quality of life in the future. For example, the red arrows track what summers in Illinois could feel like over the course of the century under the higher-emissions scenario; the yellow arrows track what summers could feel like under the lower-emissions scenario.

NOTE: Throughout this report, except where otherwise noted, "historical" refers to the baseline period of 1961–1990; "over the next several decades" is used to describe model results averaged over the period 2010–2039; "mid-century" and "late century" refer to model results averaged over the periods 2040–2069 and 2070–2099, respectively.

This backgrounder is available online at *www.ucsusa.org/mwclimate*

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