Scientists Develop New Method to Quantify Climate Modeling Uncertainty

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(PhysOrg.com) -- Climate scientists recognize that climate modeling projections include a significant level of uncertainty. A team of researchers using computing facilities at Oak Ridge National Laboratory has identified a new method for quantifying this uncertainty.

The new approach suggests that the range of uncertainty in climate projections may be greater than previously assumed. One consequence is the possibility of greater warming and more heat waves later in the century under the Intergovernmental Panel on Climate Change's (IPCC) high fossil fuel use scenario.

The team performed an ensemble of computer "runs" using one of the most comprehensive climate models--the Community Climate System Model version 3, developed by the National Center for Atmospheric Research (NCAR)--on each of three IPCC scenarios. The first IPCC scenario, known as A1F1, assumes high global economic growth and continued heavy reliance on fossil fuels for the remainder of the century. The second scenario, known as B1, assumes a major move away from fossil fuels toward alternative and renewable energy as the century progresses. The third scenario, known as A2, is a middling scenario, with less even economic growth and some adoption of alternative and renewable energy sources as the century unfolds.

The team computed uncertainty by comparing model outcomes with historical climate data from the period 2000-2007. Models run on historical periods typically depart from the actual weather data recorded for those time spans. The team used statistical methods to develop a range of temperature variance for each of the three scenarios, based on their departure from actual historical data.

The approach's outcome is roughly similar to the National Weather Service's computer predictions of a hurricane's path, familiar to TV viewers. There is typically a dark line on the weather map showing the hurricane's predicted path over the next few days, and there is a gray or colored area to either side of the line showing how the hurricane may diverge from the predicted path, within a certain level of probability. The ORNL team developed a similar range of variance--technically known as "error bars"--for each of the scenarios.

Using resources at ORNL's Leadership Computing Facility, the team then performed ensemble runs on three decade-long periods at the beginning, middle, and end of the twenty-first century (2000-2009, 2045-2055, and 2090-2099) to get a sense of how the scenarios would unfold over the twenty-first century's hundred years.

Interestingly, when the variance or "error bars" are taken into account, there is no statistically significant difference between the projected temperatures resulting from the high fossil fuel A1F1 scenario and the middling A2 scenario up through 2050. That is, the A1F1 and A2 error bars overlap. After 2050, however, the A1F1 range of temperature projections rise above those of A2, until they begin to overlap again toward the century's end.

Typically climate scientists have understood the range of uncertainty in projections to be the variance between high and low scenarios. But when the error bars are added in the range between high and low possibilities actually widens, indicating greater uncertainty.

"We found that the uncertainties obtained when we compare model simulations with observations are significantly larger than what the ensemble bounds would appear to suggest," said ORNL's Auroop R. Ganguly, the study's lead author.

In addition, the error bars in the A1F1 scenario suggests at least the possibility of even higher temperatures and more heat waves after 2050, if fossil fuel use is not curtailed.

The team also looked at regional effects and found large geographical variability under the various scenarios. The findings reinforce the IPCC's call for greater focus on regional climate studies in an effort to understand specific impacts and develop strategies for mitigation of and adaptation to climate change.

The study was published in the *Proceedings of the National Academy of Sciences*. Co-authors include Marcia Branstetter, John Drake, David Erickson, Esther Parish, Nagendra Singh, and Karsten Steinhaeuser of ORNL, and Lawrence Buja of NCAR. Funding for the work was provided by ORNL's new cross-cutting initiative called Understanding Climate Change Impacts through the Laboratory Directed Research and Development program.

More information: The paper can be accessed electronically here: www.pnas.org/content/106/37/15555

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