Individual climate models may not provide the complete picture

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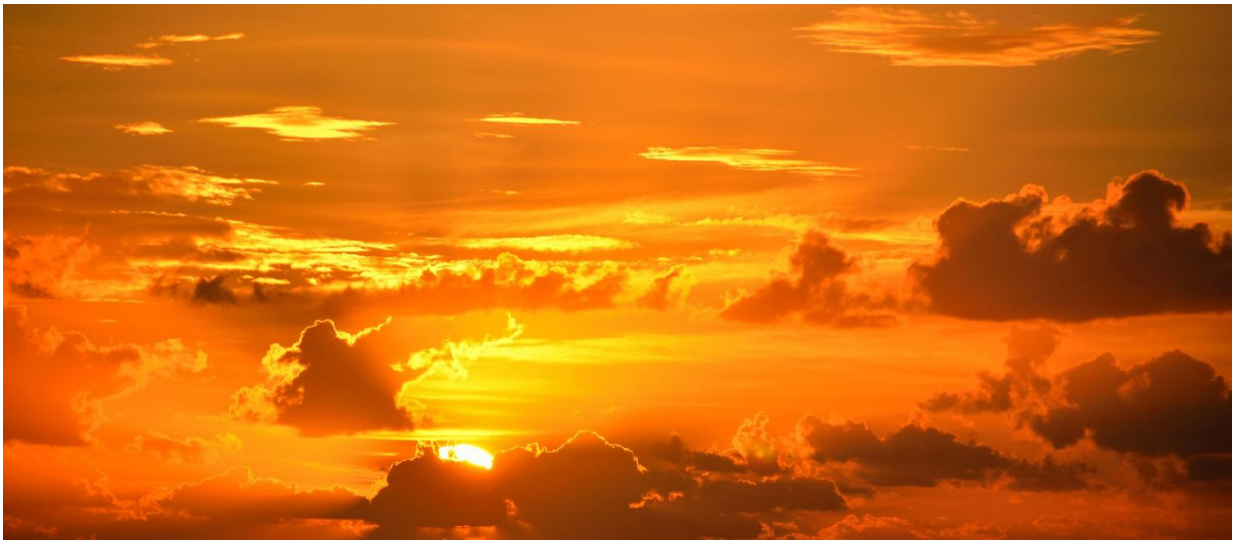

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Equilibrium climate sensitivity—how sensitive the Earth's climate is to changes in atmospheric carbon dioxide—may be underestimated in individual climate models, according to a team of climate scientists.

"Probabilistic estimates of climate system properties often rely on the comparison of model simulation to observed temperature records and an estimate of the internal climate variability," the researchers report in *Geophysical Research Letters*. If the internal climate variability is wrong, then the probabilistic estimates will be wrong and climate predictions

could miss the mark.

"We're looking at temperature changes in the tropics and in the temperate northern hemisphere at higher latitudes," said Chris E. Forest, professor of climate dynamics at Penn State. "We're focusing on simple single equations and using time series analysis because for this to work, we need to make thousands of runs of the models."

That requirement of thousands of model runs also requires large amounts of computing power, and Forest is an associate of the Penn State Institute for Computational and Data Sciences.

How changes in the way the climate reacts to changes in carbon dioxide in the atmosphere is important because carbon dioxide as a heat-trapping greenhouse gas causes warming of the atmosphere and the Earth.

"Overall, we have two choices: We can adapt or start reducing emission," said Forest. "We are going to have to do better to provide long-term predictions because increased warming will raise the oceans due to melting ice. We are already seeing the results of warming in crops and health and water availability. All of these risks are already driving our decisions, our choices. We must be able to plan for the next 20 years or the next 50 years."

What Forest and his team want to do is be able to make a statement of what we can expect 50 years from now.

This type of prediction is not simple because the Earth is not warming at the same rate equally around the globe. What happens in the tropics is not what is happening at the northern latitudes.

The researchers used the Massachusetts Institute of Technology Earth System Model to test the sensitivity of probability distributions for three

climate system properties, including equilibrium climate sensitivity. They included results from 25 different state of the science Earth system models, where each one is configured differently.

"Each modeling group has to determine what criteria they use to assess a model's quality, and that is often unclear," said Forest. "In one, cloud feedback might be higher, in another they might consider other components."

Not all models are run the same length of time for calibration purposes or during the set up phase. Most are tested with a 200- to 300-year interval and only a few groups ran simulations for more than 1,000. The individual model results all differ, and no single model spans the full range of internal variability.

The researchers took the estimated internal climate variability from these 25 models and compared observed climate change from the historical period against the MESM simulations. They then used results from similar, combined internal climate variability estimates in the same Earth system model.

They found that the uncertainty from individual models generally leads to a non-robust narrow estimate of climate sensitivity, while combining the uncertainty from multiple models provides wider distributions.

The researchers want to use these new results and look at the Intergovernmental Panel on Climate Change scenarios and see the full uncertainty that is embedded in those estimates of future climate.

"We would like to be able to ask what happens if we do nothing, what can we expect," said Forest. "How effective will the scenarios be to getting us to meet the 1.5 or 2 degree Celsius (2.7 or 3.6 degree Fahrenheit) targets for maximum warming?"

More information: Alex G. Libardoni et al, Underestimating Internal Variability Leads to Narrow Estimates of Climate System Properties, *Geophysical Research Letters* (2019). DOI: 10.1029/2019GL082442