Like it or not, uncertainty and climate change go hand in hand

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Despite decades of ever more-exacting science projecting Earth's warming climate, there remains large uncertainty about just how much warming will actually occur.

Two University of Washington scientists believe the uncertainty remains so high because the climate system itself is very sensitive to a variety of factors, such as increased greenhouse gases or a higher concentration of atmospheric particles that reflect sunlight back into space.

In essence, the scientists found that the more likely it is that conditions will cause climate to warm, the more uncertainty exists about how much warming there will be.

"Uncertainty and sensitivity have to go hand in hand. They're inextricable," said Gerard Roe, a UW associate professor of Earth and space sciences. "We're used to systems in which reducing the uncertainty in the physics means reducing the uncertainty in the response by about the same proportion. But that's not how climate change works."

Roe and Marcia Baker, a UW professor emeritus of Earth and space sciences and of atmospheric sciences, have devised and tested a theory they believe can help climate modelers and observers understand the range of probabilities from various factors, or feedbacks, involved in climate change. The theory is contained in a paper published in the Oct. 26 edition of *Science*.

In political polling, as the same questions are asked of more and more people the uncertainty, expressed as margin of error, declines substantially and the poll becomes a clearer snapshot of public opinion at that time. But it turns out that with climate, additional research does not substantially reduce the uncertainty.

The equation devised by Roe and Baker helps modelers understand built-in uncertainties so that the researchers can get meaningful results after running a climate model just a few times, rather than having to run it several thousand times and adjust various climate factors each time.

"It's a yardstick against which one can test climate models," Roe said.

Scientists have projected that simply doubling carbon dioxide in the atmosphere from pre-Industrial Revolution levels would increase global mean temperature by about 2.2 degrees Fahrenheit. However, that projection does not take into account climate feedbacks -- physical processes in the climate system that amplify or subdue the response. Those feedbacks would raise temperature even more, as much as another 5 degrees F according to the most likely projection. One example of a feedback is that a warmer atmosphere holds more water vapor, which in itself is a greenhouse gas. The increased water vapor then amplifies the effect on temperature caused by the original increase in carbon dioxide.

"Sensitivity to carbon dioxide concentration is just one measure of climate change, but it is the standard measure," Roe said.

Before the Industrial Revolution began in the late 1700s, atmospheric carbon dioxide was at a concentration of about 280 parts per million. Today it is about 380 parts per million and estimates are that it will reach 560 to 1,000 parts per million by the end of the century.

The question is what all that added carbon dioxide will do to the planet's temperature. The new equation can help provide an answer, since it links the probability of warming with uncertainty about the physical processes that affect how much warming will occur, Roe said.

"The kicker is that small uncertainties in the physical processes are amplified into large uncertainties in the climate response, and there is nothing we can do about that," he said.

While the new equation will help scientists quickly see the most likely impacts, it also shows that far more extreme temperature changes -- perhaps 15 degrees or more in the global mean -- are possible, though not probable. That same result also was reported in previous studies that used thousands of computer simulations, and the new equation shows the extreme possibilities are fundamental to the nature of the climate system.

Much will depend on what happens to emissions of carbon dioxide and other greenhouse gases in the future. Since they can remain in the atmosphere for decades, even a slight decrease in emissions is unlikely to do more than stabilize overall concentrations, Roe said.

"If all we do is stabilize concentrations, then we will still be risking the highest temperature change shown in the models," he said.

Source: University of Washington

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