Climate projections don't accurately reflect soil carbon release

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A new study concludes that models may be predicting releases of atmospheric carbon dioxide that are either too high or too low, depending on the region, because they don't adequately reflect variable temperatures that can affect the amount of carbon released from soil.

The study points out that many global models make estimates of greenhouse gas emissions from soils based on "average" projected temperatures. But temperatures vary widely from those averages. That variability, along with complex biological processes, makes the issue far more complicated.

Researchers said that climate projections, in general, don't effectively incorporate into their calculations a major component of global warming – the enormous amounts of carbon found in dead, decaying organic matter, which represent up to three times the amount of carbon in the Earth's live vegetation.

The study was just published in the journal *Biogeosciences* by scientists from the College of Forestry at Oregon State University and other institutions.

"We've done a pretty good job of determining how much carbon is getting absorbed by growing trees and vegetation, how much is coming in," said Mark Harmon, professor and holder of the Richardson Chair in Forest Science at OSU, and one of the world's leading experts on the effect of decomposition on the Earth's carbon cycle.

"However, we know much less about how carbon is released to the atmosphere through the process of decomposition, how much is going out," he said. "This is half of the equation, and there's just a huge amount we don't know about it."

These findings don't change the fact that atmospheric carbon dioxide and other greenhouse gas levels are increasing and global warming is a reality, Harmon said. But they do suggest that some of the projections, particularly those made by older models that incorporate even less variability into their analysis, may be flawed.

"This work is important because it brings attention to a component of climate change that was often ignored in the past," said Carlos Sierra, previously an OSU doctoral student, lead author on the study and now a researcher with the Max-Planck-Institute for Biogeochemistry in Germany. "We can make better projections if we add changes in temperature variability to the equation."

Researchers have understood, and have been concerned for some time, that warmer temperatures will speed up the rate of decomposition of stored organic matter in soils, a process that ordinarily is slow. This faster rate of decomposition, in turn, could further increase carbon released to the atmosphere and cause even greater global warming.

"This feedback loop is one of our biggest worries with global warming, simply because the amount of carbon stored in soil is so huge," Harmon said. "Increased release of that soil carbon could offset much of what we're trying to accomplish with increased growth of live vegetation in forests. And this is a special concern in northern latitudes."

In the past, estimates of that process were usually based on average temperature increases that were expected, Harmon said. But in the real world, temperatures vary greatly, from day to night, season to season,

through heat waves and cold spells. And that variability, researchers say, changes the biological equation considerably and can make averages misleading.

"If the response of soil respiration to temperature was a straight line, then temperature variability would not be important," Harmon said. "However, the response is curved, which means that as temperature variability increases, so does the average response. This general phenomenon is known as Jensen's inequality, but it had not previously been applied to soil respiration."

In simple terms, less variability will equate to less soil carbon release. In the new analysis, considering the effects of variability, scientists found that temperature variability may be reduced in northern latitudes, in particular, and result in carbon releases that are lower than have been projected in one of the areas of the world where this phenomenon is of greatest concern.

The research was not able to precisely quantify this phenomenon and more work needs to be done in that area, the researchers said.

The study reports that:

- The amount of carbon stored in soils worldwide exceeds the amount of carbon in the atmosphere by a factor of two to three.
- There is concern that a large portion of this carbon will be released to the atmosphere as global average temperatures increase.
- Too little attention has been paid to the effect of temperature variability in this process.

- In high latitudes of the Northern Hemisphere, temperature variability is expected to decrease, and release of soil carbon will probably be lower than that predicted by changes in average temperature.

- At lower latitudes, where both average temperature and variability are expected to increase, the release of soil carbon will probably be higher than that predicted by changes in average temperature.

"The findings of this study can greatly modify past predictions about the effects of future average temperatures on ecosystem respiration," the scientists wrote in their conclusion. "Changes in both temperature and precipitation variance would likely produce complex behaviors not incorporated in current model predictions."

The research was done by scientists from OSU, the U.S. Geological Survey, and the National Ecological Observatory Network. The study used data from the Long Term Ecological Network Program of the National Science Foundation.

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