Scientists find Earth's carbon cycle accelerating

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Soil is slowly releasing more carbon into the atmosphere in response to warming temperatures associated with climate change, according to study published in the journal *Nature*.

The carbon stored in soil is far more abundant than the amount stored in the atmosphere as carbon dioxide. In the boreal and sub-Arctic permafrost lies about 1,600 gigatons of carbon in the form of organic matter or soil. The atmosphere has, in comparison, about 750 gigatons of carbon.

The potential of the carbon to escape from the soil into the atmosphere has been called the ticking time bomb of climate change.

The latest study, by Ben Bond-Lamberty and Allison Thomson of the Energy Department's Pacific Northwest National Laboratory and the University of Maryland, shows, using empirical evidence rather than just theory, that the soils over the globe have been releasing more carbon.

"It is the first observational evidence that the major part of the global carbon cycle is accelerating," said Bond-Lamberty.

But whether it is the old stores of soil carbon that are being released or just soil bugs chomping away on newer plant growth due to warmer temperatures is unknown.

Carbon is a major part of all organic matter, including plant biomass. It gets shuttled around as plants take in carbon from the atmosphere during photosynthesis. They also respire, giving out carbon dioxide.

And upon death, plants return to the soil, where soil bacteria decompose the organic matter. In doing so, the bacteria respire and release the carbon back into the atmosphere. This is the terrestrial carbon cycle, and over the past 20 years, the rate of this overall shuttling of carbon has been accelerating, according to Bond-Lamberty.

Sifting 45 years of data

Measuring the overall respiration of the soil -- which includes the respiration by plants and soil bacteria -- can be difficult to observe globally. In this study, the researchers assembled 45 years of scientific literature that had measured respiration at local geographies. They used those data to construct a regression analysis to show that respiration has been increasing over the last 20 years, together with air temperatures.

"The correlation is reasonably strong at the global level, and very strong at biome [sub-global] scales," said Bond-Lamberty.

The researchers say that respiration has increased by 0.1 petagram of carbon per year (1 petagram is 1 billion metric tons, or 10 to the power of 15 grams). They give a value of 98 petagrams of carbon as being released into the atmosphere every year by soil respiration. In comparison, burning fossil fuels puts 8 petagrams of carbon into the atmosphere every year.

"But just because the carbon cycle is accelerating doesn't necessarily imply a feedback effect," said Bond-Lamberty. There could be greater respiration because there are just more plants. Plants grow better in warmer

temperatures and in the presence of more photosynthesis -- promoting carbon dioxide. The soil microorganisms could just be decomposing newer organic matter rather than carbon-rich soils stored underground over millions of years.

"Right now, the carbon cycle is well balanced," said Charles Rice, a professor of soil microbiology at Kansas State University. "Respiration is balanced by photosynthesis and carbon inputs."

More questions than answers about Arctic soils

The most carbon-rich soils lie beneath the permafrost in the yedoma soils of Siberia. Thawing soils can rapidly decompose. They have the potential to release not only carbon but also methane into the atmosphere and contribute to climate change.

But counterintuitively, the current study shows that warming temperatures do not increase soil respiration in the Arctic regions. Bond-Lamberty attributed this to the limited amount of data he had for northern latitudes. Fewer data points can make it difficult to draw strict conclusions, he said. Removing a few data points shows that there is no relationship between temperature and soil respiration in the North, he said.

But even having no relationship is not good enough. Theory so far has dictated that there should be a positive relationship between temperature and soil respiration, especially in the carbon-rich northern regions.

"This was the first thing that jumped out at me when I saw the paper," said Pete Smith, a soil researcher at the University of Aberdeen in the United Kingdom who commented on the Bond-Lamberty paper in *Nature*. "Even if there is no relationship, the fact that there is no positive relationship hints that some other effect is going on."

This raises more questions than it answers about the Arctic carbon stores, said Smith. And given the large stores of carbon under permafrost, it is important to study soil respiration and temperature in greater detail, he said.