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Melting Tundra Releases Carbon Dioxide Quickly

Previous estimates of how fast greenhouse gases get to the atmosphere from melting permafrost underestimated the work of soil bacteria

By Christa Marshall and ClimateWire | Tuesday, February 12, 2013 | 6 comments

Sunlight is speeding up the conversion of Arctic soil carbon into carbon dioxide, raising the possibility that future warming could occur at a much faster pace, according to a new study.

LEAKING CO2: Soil bacteria are rapidly converting thawing permafrost into carbon dioxide emissions.
Image: Flickr/subarcticmike

Scientists generally agree that higher temperatures increase the likelihood of collapses of long-frozen Arctic ground, or permafrost, creating large holes in the tundra and landslides. But there has been less understanding of how long-buried carbon in the permafrost behaves when suddenly exposed to the sun's rays after such collapses, which are caused by the melting of ice-rich soils.

"We once thought that maybe permafrost soils would just kind of thaw quietly in place," said Rose Cory, an environmental sciences and engineering assistant professor at the University of North Carolina, Chapel Hill, and co-author of the study, published yesterday in the *Proceedings of the National Academy of Sciences*.

Previously, it was unknown whether permafrost carbon would react little to sunlight when finally released from its resting spot, and would instead flow to the Arctic Ocean with little immediate impact on the atmosphere, she said.

"The conversion to CO2 is going much faster than previously thought," she said.

It is important to understand the dynamic, she said, because permafrost is such a rich potential source of the greenhouse gas. If all the world's permafrost melted, it could double the amount of heat-trapping carbon dioxide in the atmosphere, she said.

The study demonstrates another feedback caused by warming -- high temperatures melt Arctic soil, which then releases even more carbon dioxide, helping create additional warming, the researchers said.

Sunlight and bacteria at work

The scientists sampled 34 sites in Arctic Alaska, including places where the land surface has collapsed, exposing long-buried soils. They found that sunlight increases the bacterial conversion of soil carbon to carbon dioxide by at least 40 percent compared to soil that remains in the dark.

Similarly, sunlight exposure increases the conversion of ancient permafrost carbon to CO2 by as much 40 percent in comparison to

carbon already in the landscape system, Cory said. That existing carbon typically comes from annual thawing of the thin, active layer of soil resting on top of the permafrost, she said.

The collapses of Arctic soil, also known as thermokarst failures, are at the root of the process.

By stirring up the landscape, those failures cause carbon long stored in permafrost to be "mixed up" from depth, according to Cory. The Arctic is warming about twice as fast as the global average, according to scientists.

"We know that these thermokarst failures are going to be more and more common as time goes on," she said.

At the surface, the exposed soil carbon then absorbs sunlight, which breaks it down into compounds easily respired as carbon dioxide by bacteria. Most of this carbon-to-CO_2 process via bacteria occurs in water pathways -- small streams, rivers and ponds -- fanning out from the large, erosional holes in the ground created from melted soil, she said.

One hypothesis of why ancient carbon is so sensitive to sunlight is that bacteria prefer carbon to be "somewhat baked," but not "excessively baked," said Cory. If organic carbon is in surface waters for too long, it becomes less susceptible to sunlight, she said.

'Huge stocks' of carbon remained untapped

The conversion to CO_2 occurs via ultraviolet radiation, meaning it can still occur on cloudy days, she said. It doesn't require what the average person thinks of as "sunny," she said.

Laurence Smith, a geography professor at UCLA who did not participate in the research, said the paper is an "interesting addition" to existing knowledge of Arctic soil carbon.

It will be particularly relevant in the "near term" of the next century or so, when it is likely that warming will increase pools of water on the Arctic surface, he said.

At the same time, he said, the biggest fears about a ticking climate bomb in the Arctic lie around stored carbon that is very deep underground, out of the reach of many surface waters.

That deep carbon is unlikely to be influenced by the same sunlight conversion process caused by thermokarst failures, he said. In many places, less than 10 percent of the Arctic surface is water, noted Smith. While the paper reveals an important process with a significant impact on warming, it is not pointing to a tipping point for the Arctic, he said.

"In the face of this threat, the [release] of CO_2 from surface waters is small relative to the overall huge stocks of soil carbon frozen in the permafrost," he said.

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