Alaskan permafrost warming experiment produces surprising results

Enlarge / The study took place near Denali National Park, pictured here.

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Emissions from burning fossil fuels, cutting down forests, and agricultural practices aren’t the only things that control how high atmospheric CO_2 will go in the future. There are also feedbacks in the Earth’s climate system, where warming temperatures cause the release of carbon into the atmosphere. One of these is the release of carbon from permafrost as it thaws and decays.

Unlike emissions, which we can control through actions like retiring a coal-burning power plant, humans can only indirectly change the behavior of these feedbacks—the sooner we halt warming, the smaller their emissions will be. Figuring out exactly how much (and how fast) those feedbacks will emit is a major challenge for climate science.

A striking new study led by César Plaza works on the first step of this challenge: measuring how much carbon is being lost from permafrost right now.

Not-so-perma frost

It sounds simple enough to measure, but measurements are complicated by the fact that permafrost sort of compacts as the ice within it melts. So if you measure, say, the amount of carbon in a 3-meter-thick sample, any later samples can be denser, packing in more carbon and masking losses. To get around potential discrepancy, the researchers measured something that stays put: volcanic ash in the soil.

By referencing the carbon measurements against the ash content, you can work out how much carbon is lost from a cube of soil even as that cube gets squashed since the ash squashes along with it.

Working at a site near Denali National Park in Alaska, the researchers collected samples to measure carbon between 2009 and 2013. Some sample sites were outfitted with snow fences and accumulated wind-blown snow on one side and insulating the ground beneath. This had the effect of making the ground at these sites warmer than in the open spots without snow fences, which simulated future warming. While the open sites warmed about 1°C over the five years of the study, the sites with snow fences were almost 1°C warmer than that.

Similar to past studies, traditional depth-based measurements showed no significant change in carbon content over the five years. The ash-referenced measurements, however, showed a remarkable loss of about five percent per year at all the sites. Less than half of this carbon was released as CO_2 by microbial decomposition, so the rest must have disappeared by another route.

Because the ground is frozen solid at a certain depth, surface water can’t simply percolate downward. Instead, it ends up flowing horizontally through the soil and into streams. The researchers think the rest of the carbon went along for the ride. Without studying the movement of carbon through those

streams, it’s impossible to say how much ended up released as CO_2 or if some got bound up in sediment.

What about warming?

Somewhat counterintuitively, there was no real difference in carbon loss between the warmed and open sites. The depth of the unfrozen “active layer” did increase more in the warmed sites, as you would expect, but this didn’t seem to result in more carbon being released. It could be that the bottom of the active layer contained much less ready-to-decay organic matter, such that deeper thaw was a small effect compared to the amount of carbon being released in the shallower soil.

But the real upshot of this study is simply how rapidly carbon was being lost. The researchers say there’s a good chance they’re looking at an area going through a phase of rapid change that may not be true everywhere or at all times. Still, projecting a plausible diminishing rate of loss into the future would mean that something like 70 percent of the soil carbon would be lost by 2100. Contrast that with prevailing estimates of 5 to 15 percent by 2100 and it’s clear that the new results are raising eyebrows.

Lawrence Berkeley National Laboratory researcher Charles Koven, who was not involved in the new work, told Ars:

> *This is a really interesting study for a few reasons. We don’t know how representative or widespread these types of carbon loss are, but their results suggest we need to be doing a much better job of both monitoring and experimenting on these ecosystems that are undergoing permafrost loss. There is huge uncertainty in the models we use to try to estimate climate feedbacks from ecosystems, particularly in the permafrost, and this result underscores that.*
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> *The other reason this paper is so interesting is that they saw almost as large carbon losses from their control plots as*

> *from their experimentally warmed ones. This suggests that they've found an ecosystem that is undergoing rapid change that is driving the carbon losses, beyond even what they are doing with their experiment. This is a very troubling result if their ecosystem is representative of larger scale dynamics that are underway, and this type of thing is turning up more often.*

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