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Environment

Warmer winters mean world's highest places may store less carbon

At high altitudes, global warming is having its strongest effect on winter temperatures – and that might mean soils there store can less carbon than we expected

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The Tibetan plateau
Nicolas Marino/mauritius images GmbH/Alamy

Climate change is raising winter temperatures faster than those of summer, especially in high-altitude areas. This "asymmetric" warming could spell trouble for the vast amount of carbon stored in soils there by altering microbial activity more than expected.

The planet's soils store more carbon than any ecosystem other than the oceans, and could store much more https://www.nature.com/articles/s41598-017-15794-8 if better managed. But soil carbon is threatened by climate change. Researchers expect warmer temperatures will boost the amount of soil carbon lost to the atmosphere as greenhouse gases, largely due to changes in the behaviour of soil microbes. However, the scale of this warming feedback remains uncertain.

Ning Ling https://www.researchgate.net/profile/Ning-Ling at Lanzhou University in China and his colleagues heated soils in an experimental grassland on the Tibetan plateau to test how different patterns of warming might change microbial activity. Some of the soils were kept at ambient temperatures, while others were exposed to a "symmetric" warming of 2°C throughout the year. A third group was exposed to warming of 2.5 to 2.8°C during winter and 0.5 to 0.8°C during the rest of the year, a more realistic simulation of actual warming patterns.

After a decade of this treatment between 2011 and 2020, the researchers tested microbial activity of samples from the different soils. They focused on two measures in particular: growth rate and an indicator of how the organisms are using carbon, known as carbon use efficiency. This has been shown to be a major determinant https://www.nature.com/articles/s41586-023-06042-3 of the amount of organic carbon stored in soils.

"When a microbe eats carbon, it can do one of two things with it: it can break it down for energy and breathe that carbon as CO2, or it can use it to make new body structures," says Daniel Rath https://www.nrdc.org/bio/daniel-rath at the Natural Resources Defense Council, an environmental non-profit organisation based in New York. A higher growth rate means microbes are using more carbon, and higher carbon use efficiency means more of that carbon is being made into body structures, rather than respired as CO2, he says.

Ling and his colleagues found both warming patterns substantially reduced microbial activity. Soils under symmetric warming saw growth rate decline 31 per cent and carbon use efficiency decline 22 per cent relative to soil exposed to ambient temperatures. Under asymmetric warming, this effect was even stronger, with growth rate lowered by 58 per cent and carbon use efficiency lowered by 81 per cent relative to soils exposed to ambient temperatures. They ascribed the differences to factors including a change in the nutrients available to the microbes.

"Their findings suggest that soil carbon storage likely will decrease, reducing the capacity of terrestrial ecosystems to sequester carbon and degrading the soil's efficacy for nature-based solutions to climate change," says Yiqi Luo https://cals.cornell.edu/yiqi-luo at Cornell University in New York.

Rath says the fact that current models don't take asymmetric warming into account means we are probably underestimating soil carbon losses due to climate change. However, he says the findings may only apply to soils from frigid ecosystems, and more research is needed to understand exactly what these changes in microbial activity mean for carbon. For instance, despite the significant change in microbial activity, the total amount of carbon stored in the soil didn't change over the course of the experiment.