

Abrupt permafrost thaw found to intensify warming effects on soil CO₂ emission

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Thermokarst landscape on the Tibetan Plateau. Credit: Wang Guanqin

According to a recent study published in *Nature Geoscience*, scientists have found that soil carbon dioxide (CO₂) emissions are more sensitive to climate warming in permafrost-collapsed areas than in non-collapsed

areas.

This study, based on field warming experiments combined with laboratory incubation of soils from a large-scale sampling, provides new insights about [permafrost](#) carbon–climate feedback in the context of future climate warming.

Warmer temperatures have led to rapid permafrost thawing in high-latitude and high-altitude permafrost regions. Abrupt permafrost thaw, known as thermokarst, occurs in approximately 20% of the northern permafrost region, but this region stores about half of all below-ground organic carbon. This type of thawing can restructure land surface morphology, causing abrupt changes to the soil biotic and abiotic properties, which may significantly alter ecosystem carbon cycling.

Since both thermokarst and non-thermokarst areas are simultaneously experiencing ongoing warming, an important but so far overlooked consideration is whether the warming effects on soil CO₂ flux might differ between these two distinct landforms.

To fill this [knowledge gap](#), a collaborative research group led by Prof. Yang Yuanhe from the Institute of Botany of the Chinese Academy of Sciences has investigated how thermokarst formation influences the responses of soil CO₂ fluxes to climate warming, using multiple approaches.

In a well-replicated warming experiment conducted simultaneously in thermokarst and non-thermokarst areas, the researchers found that the warming-induced increase in soil CO₂ release was about 5.5 times higher in thermokarst features than in adjacent non-thermokarst landforms.

They then analyzed over 30 potential drivers of the warming effects on CO₂ release using soil physicochemical analyses, solid-state ¹³C [nuclear](#)

[magnetic resonance](#), and metagenomic sequencing. They found that the greater warming response was mainly due to the lower soil substrate quality and higher abundance of microbial functional genes related to [organic carbon](#) decomposition in thermokarst-affected soils.

Furthermore, by incubating soils from six additional thermokarst-affected sites along a 550-km permafrost transect, the team found that thermokarst formation significantly increased the temperature sensitivity of CO₂ release, providing additional evidence for the stronger soil CO₂ response to warming in thermokarst landscapes.

"As a preliminary exploration of its global importance, extrapolating the warming response of soil CO₂ flux to all upland thermokarst regions in the Northern Hemisphere, there could be an additional 0.4 Pg C year⁻¹ of soil carbon release, which is about a quarter of the projected permafrost soil carbon losses by the end of the 21st century," said Prof. Yang, corresponding author of the study.

This study provides multiple lines of evidence that warming-induced soil CO₂ loss is stronger under thermokarst formation. These findings may help to more accurately project the future trajectory of permafrost carbon–climate feedback.

More information: Enhanced response of soil respiration to experimental warming upon thermokarst formation, *Nature Geoscience* (2024). [DOI: 10.1038/s41561-024-01440-2](https://doi.org/10.1038/s41561-024-01440-2)

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