



Permafrost and Global Climate Change

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KEY SCIENCE POINTS

- Permafrost contains almost twice as much carbon as the atmosphere.
- As the Earth warms, permafrost thaws, releasing carbon dioxide and methane to the atmosphere.
- The amount and rate of this carbon release will greatly impact Earth's climate trajectory.

Carbon emissions from thawing arctic permafrost will become substantial within decades, likely exceeding current emissions from fossil fuel combustion in the United States. This will greatly complicate efforts to keep global warming below 2°C and adds urgency to limiting anthropogenic emissions. Unlike fossil fuel emissions, emissions from thawing permafrost build on themselves, because the warming they cause leads to even greater emissions. For this reason, emissions from permafrost could lead to out-of-control global warming.



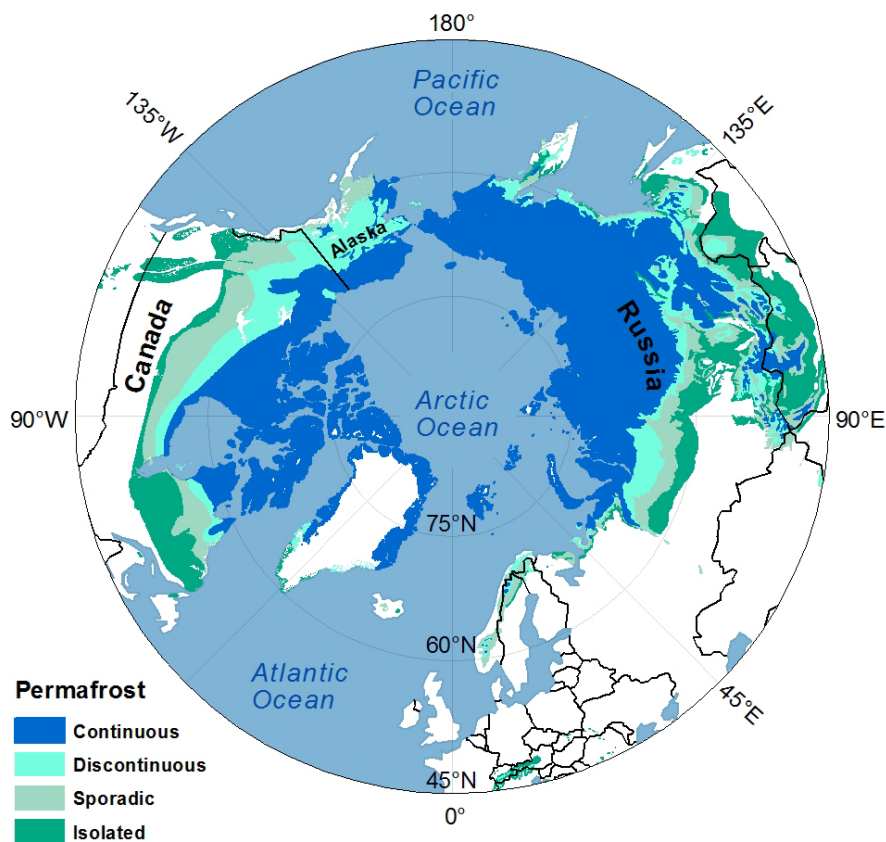
June 2015 White Fish Lakes fire in the Yukon Delta National Wildlife Refuge in southwest Alaska. Photo: Alaska Division of Forestry

BACKGROUND

- Permafrost is “permanently” frozen ground, generally thousands of years old.
- Permafrost soils in the Arctic contain ~1500 petagrams (Pg) of carbon, almost twice as much as is currently in the atmosphere.
- As the Earth warms, permafrost thaws.
- When permafrost thaws it releases carbon to the atmosphere, in the form of carbon dioxide or methane.
- A recent analysis¹ suggests that 130-160 Pg of carbon might be released from thawing permafrost between now and 2100. Emissions from thawing permafrost will continue, or even accelerate, after 2100 unless climate change is controlled.
- For perspective, in 2013 the entire United States emitted 1.4 Pg of carbon from fossil fuel combustion and cement production.
- Global climate models do not adequately account for carbon loss from thawing permafrost, so current projections of future climate tend to be too optimistic.

IMPLICATIONS

- Permafrost carbon emissions will likely account for a large share of the remaining emissions allowable globally if we are to keep global warming below 2°C.
- Carbon emissions from thawing permafrost accelerate climate warming, so the potential exists for a catastrophic, self-reinforcing cycle of warming and thawing permafrost.
- It is unknown at exactly what level of warming this “tipping point” occurs; if less than 2 degrees, then the oft-cited 2-degree target would be too lenient.
- International scientific cooperation is essential to reduce uncertainties about the rate of carbon loss from thawing permafrost, because most arctic permafrost is in Russia.
- Permafrost thaw will also dramatically alter arctic and subarctic landscapes, impacting human infrastructure including building, roads, and pipelines, as well as impacting plant and animal communities.



Northern hemisphere permafrost extent.
Data from Brown, et al. 2001 NSIDC

RECOMMENDATIONS

GREATLY REDUCE GLOBAL CARBON EMISSIONS from fossil fuel use and deforestation, and take steps to limit black carbon deposition in the Arctic.

LOCATE THE TIPPING POINTS Undertake a large-scale effort to understand at what level of warming a self-reinforcing cycle of warming and permafrost thawing occurs. This should involve modeling, field measurements, and analysis of paleoclimate data.

COMMUNICATE about the threat of arctic permafrost thaw to policymakers and the public.

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FURTHER READING

¹Schuur, E. A. G., A. D. McGuire, C. Schadel, G. Grosse, J. W. Harden, D. J. Hayes, G. Hugelius, C. D. Koven, P. Kuhry, D. M. Lawrence, S. M. Natali, D. Olefeldt, V. E. Romanovsky, K. Schaefer, M. R. Turetsky, C. C. Treat, and J. E. Vonk. 2015. Climate change and the permafrost carbon feedback. *Nature* 520:171-179, doi:10.1038/nature14338.

Schaefer, K., H. Lantuit, V. E. Romanovsky, E. A. G. Schuur, and R. Witt. 2014. The impact of the permafrost carbon feedback on global climate. *Environmental Research Letters* 9, 085003, doi:10.1088/1748-9326/9/8/085003.



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