Woods Hole Research Center POLICY BRIEF

Permafrost and Global Climate Change

Susan Natali, Robert Max Holmes, Brendan Rogers, and Philip B. Duffy

KEY MESSAGES

- 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 of carbon dioxide and methane that will be released by thawing permafrost is not yet well understood and as a result it is not incorporated into global climate models. The amount and rate of this carbon release will greatly impact Earth's climate trajectory.
- The risks of permafrost thaw are amplified by fire, which is becoming more frequent across the Arctic.

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 contribute to out-of-control global warming.

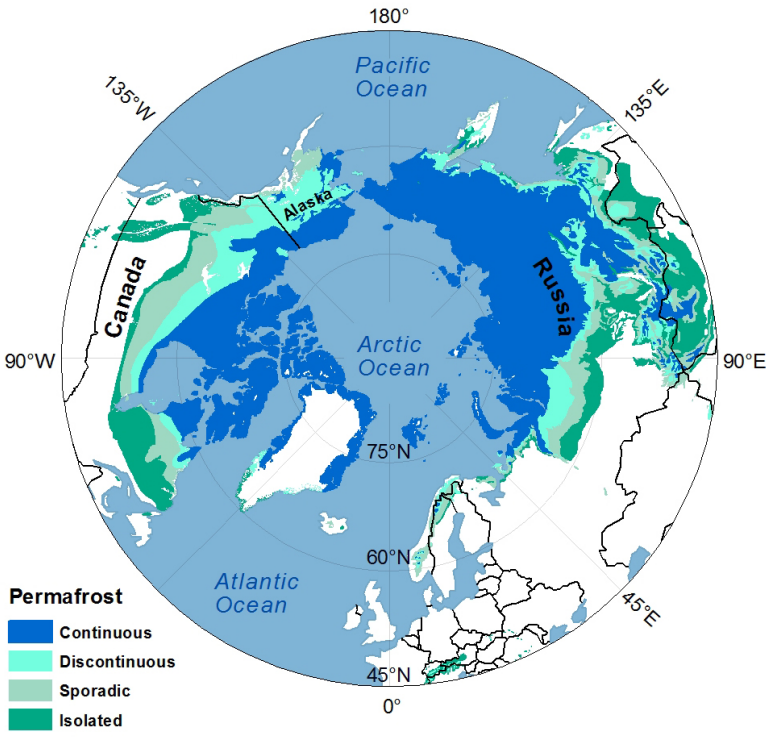
June 2015 White Fish Lakes fire in the Yukon Delta National Wildlife Refuge in southwest Alaska. Photo: Alaska Division of Forestry

BACKGROUND

- Permafrost is "permanently" frozen ground, generally thousands of years old.
- Permafrost soils in the Arctic contain ~1500 billion tons of carbon, almost twice as much as is currently in the atmosphere.
- As the Earth warms, permafrost thaws. With 2°C increase in global warming, 6.6 million km2 of permafrost will be lost (44% of the global total). If we can limit warming to 1.5°C, 4.8 million km2 of permafrost will be lost.[1]
- When permafrost thaws it releases carbon to the atmosphere, in the form of carbon dioxide or methane.
- A recent analysis[2] suggests that 130-160 billion tons 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 billion tons 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.
- Permafrost thaw will also dramatically alter arctic and subarctic landscapes, impacting human infrastructure including buildings, roads, and pipelines, as well as impacting human, plant, and animal communities.
- Carbon release from thawing permafrost will substantially increase the economic cost of climate change.



Map by Greg Fiske.
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.

INTEGRATE PERMAFROST SCIENCE into global climate change models.

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

WHRC EXPERTS

Susan Natali
508-444-1560 • snatali@whrc.org

Robert Max Holmes
508-444-1548 • rmholmes@whrc.org

Brendan Rogers
508-444-1507 • brogers@whrc.org

Philip B. Duffy
508-444-1504 • pduffy@whrc.org

FURTHER READING

[1] S. E. Chadburn, E. J. Burke, P. M. Cox, P. Friedlingstein, G. Hugelius & S. Westermann (2017) An observation-based constraint on permafrost loss as a function of global warming. Nature Climate Change 7, 340–344.

[2] Schuur, 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.

Woods Hole Research Center is an independent research institute where scientists investigate the causes and effects of climate change to identify and implement opportunities for conservation, restoration and economic development around the world.

WOODS HOLE RESEARCH CENTER 149 Woods Hole Road, Falmouth, MA 02540 508-540-9900 whrc.org