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Simulating Future Distributions of Northern Permafrost Peatlands

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Northern permafrost peatlands represent one of Earth's largest terrestrial carbon stores and are highly sensitive to climate change. Whilst frozen, peatland carbon fluxes are restricted by cold temperatures, but once permafrost thaws and saturated surficial conditions develop, emissions of carbon dioxide (CO_2) and methane (CH_4) substantially increase. This positive feedback mechanism threatens to accelerate future climate change globally. Whilst future permafrost distributions in mineral soils have been modelled extensively, the insulating properties of organic soils mean that peatland permafrost responses are highly uncertain. Peatland permafrost is commonly evidenced by frost mounds, termed palsas/peat plateaus, or by polygonal patterning in more northerly regions. Although the distribution of palsas in northern Fennoscandia is well-studied, the extent of palsas/peat plateaus and polygon mires elsewhere remains poorly constrained, which currently restricts predictions of their future persistence under climate change.

Here, we present the first pan-Arctic analyses of the modern climate envelopes and future distributions of permafrost peatland landforms in North America, Fennoscandia, and Western Siberia. We relate a novel hemispheric-scale catalogue of palsas/peat plateaus and polygon mires (>2,100 individual sites) to modern climate data using one-vs-all (OVA) binary logistic regression. We predict future distributions of permafrost peatland landforms across the northern hemisphere under four Shared Socioeconomic Pathway (SSP) scenarios, using future climate projections from an ensemble of 12 general circulation models included in the Coupled Model Intercomparison Project 6 (CMIP6). We then combine our simulations with recent soil organic carbon maps to estimate how northern peatland carbon stocks may be affected by future permafrost redistribution. These novel analyses will improve our understanding of future peatland trajectories across the northern hemisphere and assist predictions of climate feedbacks resulting from peatland permafrost thaw.