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The effect of vegetation type and fire on permafrost thaw: An empirical test of a process based model

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As conditions become more favourable for plant growth in the high latitudes, most models predict that these areas will take up more carbon during the 21st century. However, vast stores of carbon are frozen in boreal and arctic permafrost, and warming may result in some of this carbon being released to the atmosphere. The recent inclusion of permafrost thaw in large-scale model simulations has suggested that the permafrost feedback could potentially substantially reduce the predicted global net uptake of carbon by terrestrial ecosystems, with major implications for the rate of climate change.

However, large uncertainties remain in predicting rates of permafrost thaw and in determining the impacts of thaw in contrasting ecosystems, with many of the key processes missing from carbon-climate models. The role that different plant communities play in insulating soils and protecting permafrost is poorly quantified, with key groups such as mosses absent in many models. But it is thought that they may play a key role in determining permafrost resilience.

In order to test the importance of these ecological processes we use a new specially acquired dataset from sites in the Canadian arctic to develop, parameterise and evaluate a detailed process-based model of vegetation-soil-permafrost interactions which includes an insulating moss understory. We tested the sensitivity of modelled active layer depth to a series of factors linked to fire disturbance, which is common in boreal permafrost areas. We show how simulations of active layer depth (ALD) respond to removals of (i) vascular vegetation, (ii) moss cover, and (iii) organic soil layers. We compare model responses to observed patterns from Canada. We also describe the sensitivity of our modelled ALD to changes in temperature and precipitation. We found that four parameters controlled most of the sensitivity in the modelled ALD, linked to conductivity of organic soils and mosses.