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Temperature and moisture controls on non-growing season CO_2 emissions in laboratory incubations with soils from northern peatlands

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Canada has extensive peat deposits in northern high latitude wetlands and permafrost ecosystems. Peat accumulation represents a natural long-term carbon sink attributed to the cumulative excess of growing season net ecosystem production over non-growing season net mineralization. However, near-surface peat deposits are vulnerable to climate change and permafrost landscape transition. One specific concern is a potential rapid increase in the non-growing season carbon loss through enhanced organic matter mineralization under a warming climate. Our experimental study explores the response of peat CO_2 exchanges to (1) temperature, using the conventional Q_{10} parameter, and (2) moisture content. The observed responses are expected to reflect, at least in part, differential soil microbial adaptations to varying wetland conditions, across two northern ecoclimatic zones. Laboratory incubations were carried out with shallow peat samples from different depths collected at seven Canadian wetland sites and adjusted to five moisture levels. For each subsample (varying by site, depth and moisture content), CO_2 fluxes were measured at 12 sequential temperature settings from -10 to 35˚C. For each subsample, the data were fitted to an exponential equation to derive a Q_{10} value. In general, boreal peat samples were more temperature sensitive than temperate peat. The optimum moisture level for CO_2 release was determined for all the subsamples and related to variations in wetland vegetation and landform types. As a general trend, increasing water saturation reduced the CO_2 release rate from a given subsample. We further tested a flexible curve-fitting equation, as recently proposed on a theoretical basis, to recompile the data by ecoclimatic peat type and to account for the non-growing season dynamics. These findings will contribute to Canada's national carbon budget model by guiding the development and calibration of the peatland module.