Understanding the gas exchange mechanisms between permafrost soils and the atmosphere in Daring Lake (Canada): Implications to the climate change.

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The carbon pool in permafrost soils is estimated at about 1600 Gt, almost twice the concentration of carbon in the atmosphere (Turetsky et al., 2020; Miner et al., 2022). In northern high latitudes, climate warming is responsible for several environmental changes leading to the decomposition of soil organic matter (SOM) and emissions of greenhouse gases (GHG) from the soil into the atmosphere (Szymański et al., 2022). The main aim of this study is to investigate the thermal properties of the SOM in permafrost-affected soils and evaluate the relationship between SOM stability and in-situ gas emissions. In this study, three different ecosystem zones were defined near the Tundra Ecosystem Research Station (TERS) at Daring Lake (Canada) according to the predominate vegetation, soil moisture conditions, and relief as follows: 1) mixed tundra (dwarf shrub/sedge tundra), 2) wetlands, and 3) shrub tundra (Humphreys et al., 2011; Atlas of Canada). An integrated analytical approach was tested here combining in-situ measurements as well as laboratory analysis. During the field campaign, CO_2 and CH_4 fluxes were continuously measured using a Flair box™ device in the mixed tundra and wetland zones. At the laboratory scale, soil samples collected from the active layer (~60 cm thickness) were analyzed using the thermal Rock-Eval® method, whereas carbon isotopic analysis of methane gases sampled from soils were examined using a Picarro® device.

Results indicate that both wetland and mixed tundra zones are mainly dominated by thermolabile organic carbon forms. This is also consistent with high measured atmospheric CO_2 and CH_4 concentrations, suggesting that these zones can be considered the main GHG source in the studied area. Results also suggest that the SOM in shrub tundra zones is probably more resistant to the thermal degradation due to a predominance of thermostable organic carbon forms. In general, the results also suggest that the stabilization of the SOM in these permafrost soils takes place by geochemical interactions between the mineral and organic horizons, and probably under these conditions the SOM is less susceptible to decomposition and to release additional GHG in a warming climate. This geochemical data will be used to develop a soil respiration model that considers thawing of permafrost soils and SOM mineralization.