Abrupt Permafrost Thaw and Greenhouse Gas Exchange in Northern Peatlands

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The current literature supports that abrupt permafrost thaw will lead to surface inundation and create anaerobic landscapes. This may increase the release of CO_2 but may at some stage dominantly release methane during the decomposition process. Over time, natural succession and vegetation growth may decrease methane release and increase net carbon uptake. We investigated how rapid permafrost thawing and subsequent natural succession over time affect greenhouse gas exchange (CO_2, CH_4, and N_2O). We used a natural gradient of permafrost thaw and natural succession in northern Norway and observed greenhouse gas exchange for 3 years. We show that abrupt permafrost thaw and land surface subsidence increase net annual carbon loss. Permafrost thaw accelerated CO_2 release greatly in thaw slumps (177.5 $gCO_2\ m^{-2}$) compared to intact permafrost peat plateau (59.0 $gCO_2\ m^{-2}$). During the growing season, peat plateau was a small sink of atmospheric CH_4 (-2.5 $gCH_4\ m^{-2}$), whereas permafrost thaw slumping and pond formation increased CH_4 release dramatically (ranging from 9.7 to 36.1 $gCH_4\ m^{-2}$). Furthermore, CH_4 release continues to increase even in natural succession likely due to aerenchyma transport of CH_4 from deeper soil. Beyond thermokarst formation, carbon uptake from the natural succession of vegetation, but we show that greenhouse gas emissions continue to increase beyond abrupt permafrost thaw event towards natural succession.

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