How do post-thaw hydrologic changes affect carbon cycle during the degradation process of a palsa in northern Finland?

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Abstract

With climate change, discontinuous permafrost is thawing rapidly and is predicted to reach a "tipping point" in the next decade. Permafrost affected peatlands store about 185±66 Pg C. Due to permafrost thaw, the landscape topographies and hydrologic conditions could change quickly and thus, release carbon (C) stored in soils. However, there is a current lack of understanding regarding the C lability post- thaw and how the microbial community will affect methane (CH_4) and carbon dioxide (CO_2) fluxes. Here, we quantified and qualified the effect of hydrologic changes on CH_4 and CO_2 emissions and production during the thawing process of a palsa (peaty permafrost mounts, mainly in discontinuous permafrost areas). We used a chronosequence approach along a thawing transect from an intact palsa to a thawed wetland site during fall and measured CH4 and CO_2 emissions. Additionally, we experimentally simulated palsa degradation by incubating 1 m soil cores from the palsa and the wetland sites. The CO_2 and CH_4 emissions were continuously measured for 60 days. The field measurements showed that the intact palsa and the intermediate site were net CH_4 sinks while the thawed wetland site had the highest CH_4 emissions. Furthermore, we showed that a top-down sequential thawing incubation setup is an efficient and robust way to study C cycle dynamics and upscale laboratory results to the field. With permafrost thaw and former permafrost areas turning into wetlands, bridging scales to understand processes underlying greenhouse gas production is necessary to better estimate the future C emissions.