Title: How does deep warming of a peatland affect methane production?

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Abstract: Despite covering <3% of the Earth's surface, peatlands contain one-third of total global soil carbon (C) and are responsible for approximately 10% of global methane (CH_4) flux. Methane has a radiative potential 28-times greater than carbon dioxide (CO_2), and the accuracy of Earth system model projections hinges on our mechanistic understanding of peatland CH_4 cycling in the context of environmental change. The objective of this study was to determine, under in situ conditions, how heating of the peat profile affects ecosystem-level anaerobic C cycling. We assessed the response of CO_2 and CH_4 production, as well as the CO_2:CH_4 ratio, in a boreal peatland after four (September 2014) and thirteen (June 2015) months of deep peat heating as part of the Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) project. The study utilizes a regression-based experimental design including five temperature treatments that warmed the entire 2 m peat profile from 0 to +9 °C above ambient temperature beginning in June of 2014. Soil cores were collected at 25, 50, 100, 150 and 200 cm depths from each experimental chamber at the SPRUCE site and anaerobically incubated at in situ temperatures. Rates of CO_2 and CH_4 production were then measured over the course of 1-2 weeks. Methane and CO_2 production in surface peat were positively correlated with seasonal and experimentally elevated temperature ($p < 0.001$), but no consistent temperature response was observed at depth (50-200 cm). Surface peat had greater CH_4 production rates than deeper peat (GLM, $p < 0.001$), implying that the increased CH_4 emissions observed in the field were largely driven by surface peat warming. Additionally, the CO_2:CH_4 ratio was inversely correlated with temperature in the surface and 100 cm depth increments ($p \leq 0.01$), indicating that surficial anaerobic respiration becomes more methanogenic with warming. While SPRUCE will continue for many years, our initial results suggest that the vast C stores at depth in peatlands will be less responsive to warming than surface peat.