Geophysical Research Abstracts
Vol. 17, EGU2015-2806, 2015
EGU General Assembly 2015

In situ contribution of old CO_2 and CH4 released from soils in burnt and collapsed permafrost in Canada

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Permafrost degradation is associated with an aggradation of the active layer thus exposing previously frozen soil carbon (C) to microbial activity. This may increase the generation of greenhouse gases and potentially increase rates of climate change. However, the rate of C release remains highly uncertain, not least because few in situ studies have measured the rate at which previously frozen C is released from the soil surface, post thaw. We quantified the contribution of this “old” C being released as CO_2 and CH4 from permafrost degraded soils in sporadic and discontinuous permafrost in Yukon and Northwest Territories, Canada. Firstly, we studied the effect of fire on black spruce forests as the removal of vegetation, especially mosses, may play a key role on thaw depth. Secondly, we investigated the collapse of peatland plateau after permafrost thaw which resulted in the formation of wetlands. We combined radiocarbon measurements of respired CO_2 and CH4 with a novel collar-design that either included or excluded respiration from deeper soil horizons. Our results from the first field campaign show that, while excluding deeper layers did reduce the average age of the C being released from the soil surface, more than 90% of the CO_2 and CH4 came from contemporary sources, even after burn and permafrost plateau collapse. Furthermore, soil cores dated using 210Pb show that the rapid accumulation of sedge peat after plateau collapse may more than compensate for any C losses from depth. Additional incubation experiments quantified the effect of temperature on respiration rates and assessed the vulnerability of permafrost soil C. Our results from the Canadian boreal contrast strongly with findings from other geographical areas emphasising the complexities of predicting the impact of permafrost thaw on the carbon balance of northern ecosystems.