Carbon degradation and potential greenhouse gas production in a changing Arctic thermokarst landscape

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Abstract

Permafrost carbon pools are vulnerable to a warming climate and bear the potential to alter the terrestrial carbon cycle. In the extensive drained lake basins that span across Arctic lowlands, enhanced degradation of organic-rich deposits upon permafrost thaw could lead to greenhouse gas emissions to the atmosphere. Yet, little is known on the geochemical properties of the sediments in these basins and on the rate of release of greenhouse gases. This study investigates processes and intensity of organic matter decomposition and associated potential greenhouse gas production in thawed sediment from drained lake basins on the Yukon Coastal Plain in the western Canadian Arctic. We conducted a three-month low temperature (4 °C) incubation experiment, during which we measured carbon dioxide (CO_2) and methane (CH_4) production in thawed sediment from two permafrost cores from adjacent drained lake basins. To simulate current and near future greenhouse gas production potential we incubated material from the active layer as well as from the transition layer and permafrost to account for projected active layer deepening. Four replicates of each sample were incubated under aerobic and anaerobic conditions, respectively. CO_2 and CH_4 concentrations were measured by gas chromatography. The experiment was supplemented by a comprehensive lipid biomarker analysis of the same sample material before and after the incubation covering n-alkanes, n-fatty acids, triterpenoids and hopanes. Biomarker concentrations and indices (average chain length, carbon preference index, higher-plant fatty acid index) gave insights on the origin and degradation state of organic matter as well as changes to carbon accompanying the incubation experiment. In a multi-proxy approach, findings are further aligned with biogeochemical and sedimentological parameters. Results will reveal organic matter vulnerability to decomposition and potential greenhouse gas production in sediments after thawing, both of which are key elements in assessing future trajectories of carbon dynamics in drained lake basins.