Methane Oxidation in Boreal Peatlands: A Joint Field, Laboratory and Modeling Investigation

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Natural wetlands currently contribute 20-39% of global methane emissions; but their response to changing climate conditions is unknown because feedback between climate and wetland methane emissions is highly uncertain. Our objective is to improve predictions of methane emissions and constrain climate-methane feedback by focusing on the oxidation side of the methane emission equation. Specifically, we will advance understanding and modeled representations of methane oxidation within the unsaturated zone and soil zone surrounding roots of wetland plants (the rhizosphere). Rhizospheric oxidation, in particular, represents an important sink for methane, capable of oxidizing ~90% of the CH4 produced in wetlands; however, the process is not well captured by large-scale wetland models where oxidation of CH4 is usually simply set to a constant percentage of that transported by plants. Our approach involves fieldwork, laboratory experiments, and modeling. We are augmenting fieldwork conducted in Alaskan boreal peatlands that span hydrochemical and permafrost-thawing gradients with controlled laboratory experiments and mechanistic modeling. Results from this effort will inform the development of a dynamic representation of methane oxidation appropriate for large-scale models.

In the first year of the project, we have harnessed porewater data on concentration and isotopic composition of methane and carbon dioxide to determine rates of methane production, methane oxidation and methane loss from a subsurface profile in a boreal bog. Model fits to the data indicate that a large fraction of produced methane was not present in the porewater, suggesting it escaped to the atmosphere. However, the modeled rate at which methane was lost from the porewater far exceeded measured rates of atmospheric methane emission at the site, implying that a majority of the "lost" methane was oxidized once it left the porewater (e.g., in the unsaturated zone or in plant aerenchyma). The results indicate that methane oxidation is a key process at the site, responsible for reducing potential methane emissions by up to 98%.

Ongoing and planned field and lab work build upon these initial results by further quantifying rates of methane production, oxidation and loss within the subsurface, linking these rates to oxygen concentrations measured within the subsurface using optical oxygen sensors, and identifying factors that control subsurface oxygen concentrations. We are concurrently developing a root-scale mechanistic model that we will use to test hypotheses, aid in the quantitative assessment of field and laboratory data, and as a means for discerning the dominant controls over methane oxidation.