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Seasonal Oxygen Dynamics in a Thermokarst Bog in Interior Alaska: Implications for Rates of Methane Oxidation

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Methane is a potent greenhouse gas, and wetlands represent the largest natural source of methane to the atmosphere. However, much of the methane generated in anoxic wetlands never gets emitted to the atmosphere; up to >90% of generated methane can get oxidized to carbon dioxide. Thus, methane oxidation is an important methane sink and changes in the rate of methane oxidation can affect wetland methane emissions. Most methane is aerobically oxidized at oxic–anoxic interfaces within wetlands where rates of oxidation strongly depend on methane and oxygen concentrations. In wetlands, oxygen is often the limiting substrate. To improve understanding of belowground oxygen dynamics and its impact on methane oxidation, we deployed two planar optical oxygen sensors (40–cm wide x 60–cm deep) in a thermokarst bog in interior Alaska. Previous work at this site indicated that, similar to other sites, rates of methane oxidation decrease over the growing season. We used the sensors to track spatial and temporal patterns of oxygen concentrations over a growing season. We coupled these *in-situ* oxygen measurements with periodic oxygen injection experiments performed against the sensor to quantify belowground rates of oxygen consumption. We found that over the season, the thickness of the oxygenated water layer at the peatland surface decreased. At the start of the season (June) the oxygenated layer was, on average, 4–cm thick. By the end of the season (August) the oxygenated layer decreased to, on average, 0.5–cm thick. We also saw intermittent ~1-cm increases in the thickness of the oxygenated water layer after rainstorms. Previous research has indicated that in sphagnum-dominated peatlands, like the one studied here, rates of methane oxidation are highest at or slightly below the water table. It is in these saturated but oxygenated locations that both methane and oxygen are available. Thus, a seasonal reduction in the thickness of the oxygenated water layer could restrict methane oxidation. The decrease in thickness of oxygenated layer coincided with an increase in the rate of oxygen consumption during our oxygen injection experiments. We infer that this increase was due to a temperature enhancement of microbial reaction rates and/or an increase in substrate available for oxygen consuming reactions. Together, the data provide an explanation for the seasonal decrease in methane oxidation: rates of oxygen consumption increase over the season, which decreases the amount of oxygen dissolved in porewater at the peatland surface and reduces rates of methane oxidation.