Effect of belowground warming on surface methane and CO_2 fluxes from a boreal black spruce peatland

High latitude peatlands represent a major terrestrial carbon store sensitive to climate change, as well as a globally significant methane source. While elevated atmospheric carbon dioxide concentrations and warming temperatures may increase peat respiration and C losses to the atmosphere, reductions in peatland water tables associated with increased growing season evapotranspiration may alter the nature of trace gas emission and increase peat C losses as CO_2 relative to methane (CH_4). As CH_4 is a greenhouse gas with twenty times the warming potential of CO_2, it is critical to understand how factors associated with global climate change will influence surface CO_2 and CH_4 fluxes. We used an automated soil respiration system at the SPRUCE (Spruce and Peatland Responses Under Climatic and Environmental Change) Experiment to assess the effect of belowground warming on peat CO_2 and CH_4 production throughout the first year of experimental treatment. We use the continuous flux record to assess seasonal and diel flux patterns across the five warming treatments (+0^{o}C, +2.25 ^{o}C, +4.5 ^{o}C, +6.75 ^{o}C, +9 ^{o}C), and separate the influence of physical (i.e., plant species composition, microtoporaphy) and environmental (i.e., peat temperature, water table position, oxygen availability) factors on observed rates of CH_4 and CO_2 loss. We find that both CO_2 and CH_4 fluxes increased significantly across belowground warming treatments, although CH_4 responded more strongly to temperature increases than CO_2. Peat microtopography strongly influenced trace gas emission rates, and peat hollow locations showed consistently higher CH_4:CO_2 ratios than peat hummocks. Hollow locations also responded more strongly to elevated temperatures throughout the belowground warming component of the experiment. Trace gas production in was also more sensitive to warming than hollow locations than hummocks. While there was no difference in the isotopic composition of the methane fluxes between hollow and hummock locations, $\delta^{13}CH_4$ was more depleted in the early and late growing season, indicating a transition from hydrogenotrophic to acetoclastic methanogenesis during periods of high photosynthetic input. The measurement record demonstrates that belowground warming has measureable impacts on the nature of peat greenhouse gas loss within one year of treatment onset and highlights the vulnerability of high-latitude wetlands to future temperature increases.