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Influence of permafrost disintegration on wetland carbon fluxes in Abisko, Sweden

The northern permafrost regions are experiencing a rapid warming as surface temperatures are rising, causing a disintegration of permafrost and a deepening of the active layer (AL). This releases previously frozen carbon, making it available for decomposition by microbes. The combination of the high microbial activity and overall wetter soils may cause anoxic conditions and in turn methane (CH_4) and carbon dioxide (CO_2) release into the atmosphere, further contributing to warming of the climate. The main drivers, and therefore, the magnitude of CO_2 and CH_4 fluxes may vary spatially (CO_2/CH_4). Thus, the aim of this study is to investigate the influence of spatial variability of site-specific conditions such as vegetation composition, AL depth, water table depth (WTD) on the magnitude of carbon fluxes (CO_2/CH_4) between and within sites. Multiple replicate measurements of CO_2 and CH_4 concentrations, WTD, AL depth, air temperature (T_{air}) and soil temperature (T_{soil}) were taken from three different locations in Abisko, Sweden. The three study sites had varying stages of permafrost degradation: Storflaket had a relative stable permafrost, Kursflaket is currently undergoing permafrost degradation and Katterjokk has undergone a complete permafrost loss over last few decades. The results showed significant differences in CO_2 and CH_4 fluxes between and within the sites. The CH_4 emissions and CO_2 uptake were significantly higher in the site with completely disintegrated permafrost (Katterjokk), compared to the other two sites with permafrost presence. CH_4 fluxes were also significantly higher for wet plots, compared to dry plots. The CH_4 emissions were shown to be mainly driven by the WTD and AL depth as well as the abundance of aerenchymateous vegetation. No significant relationship between the investigated variables and CO_2 fluxes could be found. However, there was a significant difference in ecosystem respiration (R_{eco}) between the wet and dry plots, indicating that there may be a relationship between WTD and CO_2. The results demonstrated that even within the Abisko region, there were considerable variations in carbon fluxes as well as drivers of the fluxes between and within the sites. The differences in carbon fluxes and the site-specific conditions are important to take into consideration when extrapolating and generalising for larger areas. Furthermore, a continued disintegration of permafrost and deepening of the AL, may further alter the sub arctic ecosystem of Abisko and thereby enhance the spatial variability, as site-specific conditions continue to change. Moreover, further permafrost disintegration on a global scale may lead to even more CH_4 emissions, amplifying the initial warming.

Keywords: Physical Geography, Ecosystem Analysis, Permafrost, CH_4 flux, CO_2 flux, Abisko, Wetlands

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