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Impact of hydrology on methane flux patterns in a permafrost-affected floodplain in Northeast Siberia

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A large fraction of organic carbon stored in Arctic permafrost soil is at risk to be decomposed and released to the atmosphere under climate change. Thawing of ice-rich permafrost will re-structure the surface topography, with potentially significant effects on hydrology: water table depth (WTD) of depressed areas will increase, while that of the surrounding area will decrease. Changes in hydrology will trigger modifications in soil and vegetation, e.g. soil temperature, vegetation and microbial community structure. All of these secondary effects will alter carbon cycle processes, with the magnitude and even sign of the net effect yet unknown.
The objective of this study is to investigate effects of drainage on methane fluxes in a floodplain of the Kolyma River near Cherskii, Northeast Siberia. The study site is separated into two areas, one that has been drained since 2004, and a nearby reference site. Methane flux was measured for $\sim$16 weeks during summer and early winter of 2013, and summer of 2014. In addition, to separate different methane emission pathways, plant-mediated methane transport (through aerenchyma) as well as the proportion of ebullition were measured in 2014. Vegetation and microbial community structures were investigated and compared.
After a decade of drainage history that lowered WTD by about 20cm in the drained area, Eriophorum (cotton grass) that previously dominated have to a large part been replaced by Carex (tussock-forming sedge) and shrub species. While WTD primarily influenced the methane flux rate, this vegetation change indirectly altered the flux as well in a way that sites with Eriophorum emitted more methane. Concerning the microbial community structure, the relative abundance of methanogen and ratio of methanotrophs to methanogens were well correlated with methane flux rates, implying that the methane flux is highly influenced by microorganisms. As a consequence of these changes, in the drained area less amount of methane was produced in the first place due to less anaerobic condition, and subsequently most of it was oxidized while being transported to the atmosphere through diffusion. In fall, however, methane emission was higher in the drained site, potentially originating from stored methane during growing season or freshly produced methane in deep, relatively warmer soil layers. To summarize all effects of WTD, the drainage changed vegetation and microbial community structure, which in turn altered net methane emissions in growing season with significantly less amount of methane emission in drained site.