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Net drainage effects on CO_2 fluxes of a permafrost ecosystem through eddy-covariance measurements

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Permafrost landscapes in the Northern high latitudes with their massive organic carbon stocks are critically important for the global carbon cycle, yet feedback processes with the atmosphere under future climate conditions are uncertain. To improve the understanding of mechanisms and drivers dominating permafrost carbon cycling, we established a continuous observation program in moist tussock tundra ecosystem near Cherskiy in North-eastern Siberia (68.75°N, 161.33°E). The experiment has been designed to monitor carbon cycle fluxes at different scales with different approaches, including e.g. the eddy-covariance technique, and their environmental drivers. Recent observations started mid July 2013 and are still ongoing, while 'historic' measurements are available for the period 2002-2005. Since 2004 part of the observation area has been disturbed by a drainage ditch ring, altering the soil water conditions in the surrounding area in a way that is expected for degrading ice-rich permafrost under a warming climate. With parallel observations over the disturbed (drained) area and a reference area nearby, respectively, we aim to evaluate the disturbance effect on the carbon cycle budgets and the dominating biogeochemical mechanisms.

Here, findings based on over 1.5 years of continuous eddy-covariance CO_2 flux measurements (July 2013 - March 2015) for both observation areas are presented. Results show systematic shifts in the tundra ecosystem as a result of 10 years of disturbance in the drained area, with significant effects on biotic and abiotic site conditions as well as on the carbon cycle dynamics. Comparing the net budget fluxes between both observations areas indicates a reduction of the net sink strength for CO_2 of the drained ecosystem during the summer season in comparison to natural conditions, mostly caused by reduced CO_2 uptake with low water levels in late summer. Regarding the long-term CO_2 uptake dynamics of the disturbance regime (2005 vs. 2013/14) the drained area has strongly rebounded from a strong reduction in NEE sink strength immediately following the disturbance. The observed significant increase in summertime uptake, has been caused mostly by an overall increase in the gross primary production. Based on the analysis of environmental drivers derived by in situ measurements and remote sensing products, this increase in summertime uptake is not linked to corresponding increases in air temperature, while there are some links to a greening of the ecosystem as observed in MODIS NDVI data. Finally, we present results on the role of the flux patterns during the non-growing season for the annual carbon budget, with a particular focus on the contributions of the shoulder seasons.