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Hydrological patterns in warming permafrost: comparing results from a control and drained site on a floodplain tundra near Chersky, Northeast Siberia

Sandra Boelck (1), Mathias Goeckede (1), Anke Hildebrandt (2), Jorien Vonk (3), and Martin Heimann (1)

(1) Max Planck Institute for Biogeochemistry, Department of Biogeochemical Systems, Hans-Knoell-Straße 10, 07745 Jena, Germany (sboelck@bgc-jena.mpg.de), (2) Friedrich-Schiller-University Jena, Institute of Geoscience, Burgweg 11, 07749 Jena, Germany, (3) Vrije Universiteit, Department of Earth Sciences, Faculty of Earth and Life Sciences, De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands

Permafrost areas represent a major reservoir for organic carbon. At the same time, permafrost ecosystems are very susceptible to changing climate conditions. The stability of this reservoir, i.e. changes in lateral and vertical carbon fluxes in permafrost ecosystems, largely depends on groundwater level, temperature and vegetation community. Particularly during summer when the soil thaws and a so-called active layer develops, fluctuations in carbon flux rates are often dominantly driven by water availability. Such dry soil conditions are expected to become more frequent in the future due to deepening active layers as a consequence of climate change. This could result in degradation of polygonal tundra landscape properties with channelled water transport pathways. Therefore, water table depth and the associated groundwater fluxes are crucial to understand transport patterns and to quantify the lateral export of carbon through an aquatic system. Consequently, a fundamental understanding of hydrological patterns on ecosystem structure and function is required to close the carbon balance of permafrost ecosystems.

This study focuses on small-scale hydrological patterns and its influencing factors, such as topography and precipitation events. Near Chersky, Northeast Siberia, we monitored (i) a control site of floodplain tundra, and (ii) a drained site, characterised by a drainage ring which was constructed in 2004, to study the effects of water availability on the carbon cycle. This experimental disturbance simulates drainage effects following the degradation of ice-rich permafrost ecosystems under future climate change. Continuous monitoring of water table depth in drained and control areas revealed small-scale water table variations. At several key locations, we collected water samples to determine the isotopic composition (δ18O, δD) of surface water, suprapermafrost groundwater and precipitation. Furthermore, a weir at the drainage ditch was constructed to directly measure the discharge of the drained system. This hydrological sampling programme was complemented by continuous monitoring of atmospheric vertical turbulent carbon fluxes and meteorological conditions by two eddy-covariance towers on each site.

Our results from the hydrological sampling campaign of summer 2016 indicate that total discharge through the drained system was mainly driven by precipitation events as well as modified evaporative loss due to temperature changes. The distributed network of groundwater gauges allows deriving lateral, local scale groundwater flow direction and its spatial variability, as well as the response to precipitation events within different parts of this ecosystem. Isotopic analysis of water samples showed the contribution of specific end member water sources, and how these vary across the season while the active layer deepens. Future research will focus on carbon fluxes, distribution and sources in relation to hydrological patterns.