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Carbon dynamics of permafrost-affected peatlands in the Siberian Arctic

Permafrost-affected soils (cryosols) are long-term repositories for large amounts of organic carbon (~1000 Gt within the upper 3 m), which accumulated over millennia due to cold and often water-saturated soil conditions under arctic or boreal climates. However, the arctic and boreal zones face the most pronounced climate warming on Earth, which is expected to lead to permafrost degradation, enhanced soil organic matter mobilization and higher emissions of CO_2 and CH_4. The magnitudes of these effects are still highly uncertain due to an insufficient understanding of interacting hydrological and biogeochemical processes that control the water and carbon balance of permafrost-affected landscapes.

In this contribution, I exemplify our interdisciplinary approach to study the coupled water and carbon dynamics of permafrost-affected landscapes by presenting results from an arctic polygonal peatland in the Lena River Delta, northern Siberia. The study site is characterized by a polar and distinctly continental climate, very cold and ice-rich permafrost, the formation of thermal contraction polygons, and gleyic organic matter-rich soils. Vertical land-atmosphere fluxes of H_2O, CO_2 and CH_4 were measured by the eddy covariance method during nine campaigns between 2002 and 2013. Lateral export fluxes of water and dissolved organic carbon from a polygonal peatland catchment were quantified by means of V-notch weirs and hydrochemical analyses of discharge water samples.

In the majority of the investigated years (7 out of 9), the polygonal peatland was a robust carbon sink. However, warm and dry summers caused a reduction of photosynthesis capacity of the vegetation, probably by inhibiting moss growth. Also, heat spells caused strong ecosystem respiration which could switch the tundra peatland to a carbon source even during the vegetation period. Thus, the cumulative CO_2 emissions in autumn, spring and winter can exceed CO_2 uptake during dry and warm summers making the tundra peatland a whole-year net carbon source. The CH_4 fluxes were found to be not decisive for the carbon balance, whereas they are important for its greenhouse gas balance. While the lateral export fluxes were relevant for the water balance, they caused only low carbon exports (one order of magnitude smaller than CH_4 fluxes) due to low dissolved matter concentrations.

The carbon cycle of Siberian tundra peatlands appears less affected by the observed climate warming than the tundra ecosystems of Alaska. This might be due to the deep, very cold and ice-rich permafrost in Siberia that acts as a thermal buffer preventing the carbon cycle from more drastic changes. However, massive changes can be expected when the buffering capabilities of the permafrost-tundra-climate system will be exhausted.

Die Vorträge sind öffentlich. Um rege Teilnahme, insbesondere auch durch Studierende, wird gebeten. Die Veranstaltungen sind im Studiengang MSc Lök, Modul M2/M1 anrechenbar.