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Tracing the catchment-scale hydrology of polygonal tundra and implications for lateral fluxes of carbon and nitrogen, Lena River Delta, Siberia

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Surface-water hydrology changes the thermal regime of permafrost, carries varying amounts of nutrients depending on its flowpath, and provides a fuel for biogeochemical reactions, including the biological production of methane and carbon dioxide by soil microbes. In this work we present the findings of hydrological investigations in the ice-wedge polygon tundra of the Samoylov Research Island in Russia's Lena River Delta. We compare the catchment-scale behaviour of two adjacent watersheds through stable isotope analysis conducted over two years of sampling (2012-13). This work also incorporates the use of conservative natural tracers such as silica concentration and sheds light on mechanisms for the transport of dissolved organic carbon into the Lena River system.

Hydrological discharge measurements taken over three years (2011-13) reveal generally similar patterns in rainfall response and permafrost thaw between two adjacent watersheds – one smaller (0.02 km2) and dominantly comprised of the characteristic polygonal tundra and the second larger one (0.6 km2) also containing two large surface-water reservoirs, namely a degraded ice-wedge network and a lake. However, stable isotope measurements of hydrogen (δD) and oxygen (δ18O) reveal that the latter watershed maintains a significant surface-water isotopic signature throughout the summer period, with greater influence of evaporation on watershed dynamics. The smaller, characteristic polygon catchment shows ever-increasing influence of deeper flow paths as the thaw depth increases over the season. These small catchments release low amounts of dissolved organic carbon and nitrogen both in terms of concentration (< 10 ppm and < 1 ppm, respectively) and as proportion of the watershed's annual carbon budget (< 1 % of CO_2 uptake).

These findings will interest permafrost researchers studying polygonal tundra, Arctic floodplains, interactions between the water, carbon, and energy cycles. Furthermore, modeling strategies will benefit from simpler process-based representations of landscape processes when upscaling to examine regional landscape-atmosphere interactions.