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Transport and degradation of permafrost and peat carbon in large Siberian rivers

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Permafrost and peat deposits of northern high latitudes contain large amounts of organic carbon that will be increasingly thawed and remobilized as temperatures rise. Part of the carbon may be degraded to CO_2 and CH4 at the site of thaw, potentially amplifying climate warming. Another part will be released into aquatic systems, removed from active cycling by sediment sequestration or degraded during transport, thereby inducing a carbon-climate feedback translocated up to thousands of kilometers away from its origin. This lateral carbon transfer is difficult to constrain, but represents an important component of the high latitude carbon cycle and an opportunity to monitor permafrost thaw across heterogeneous catchments in a warming climate.
In a recent study, we used long-term records of 13C and 14C in the four largest Siberian rivers Ob, Yenisey, Lena and Kolyma to show that permafrost- and peat-derived carbon represents on average only 17% of total fluvial dissolved and particulate organic carbon (DOC, POC). Considering the vast extent of permafrost and peat deposits in the river catchments, these findings may indicate rapid degradation of terrestrially derived carbon during river transport. In this follow-up study, we employed a high-spatial resolution dataset of POC, DOC and dissolved inorganic carbon (DIC) to assess the fluvial transport and degradation of permafrost- and peat-derived carbon along the Ob and Lena rivers. Both rivers showed decreasing POC concentrations towards the river mouths and increasing offsets between the 13C contents of POC and potential carbon sources, supporting the degradation or sedimentation of a large POC fraction. In the Ob, DIC concentrations decreased while DOC concentrations and CO_2 oversaturation of surface waters compared to the atmosphere increased. The Lena in contrast showed no consistent change in DOC or DIC concentrations and only slight CO_2 oversaturation. Taken together, these findings support the degradation of terrestrially derived carbon during river transport and release of the resulting CO_2 to the atmosphere, but also indicate substantial differences in land-river-atmosphere carbon fluxes between river catchments, possibly related to differences in climate, permafrost extent or soil properties. Our data will be combined with atmospheric observations of CO_2 along the rivers as well as 14C source apportionment of DOC and POC to quantify the contribution of different organic carbon sources to both rivers across their heterogeneous catchments and assess its fate during transport.