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Distinct periods of organic carbon and mineral element supply from soils to rivers during the Arctic spring

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The spring is the key period for organic carbon (OC) and mineral element (ME – here referring to calcium, iron, aluminium, and manganese) supply from permafrost soils to rivers. The OC and ME interact in permafrost soils and river waters and these interactions promote (e.g., by photo-oxidation) or mitigate (e.g., by mineral stabilisation) organic carbon degradation along the aquatic continuum. To fingerprint the initial OC-ME association in soils and understand its fate in the river, we need to disentangle the sources of these constituents during the spring. Previous studies have mainly focused on the OC supply to larger Arctic rivers during this key period of the year. Large Arctic rivers integrate waters from a multitude of tributaries and the sources of OC and ME during spring encompasses riverbank erosion, in-river particle dissolution, vegetation during snowmelt, surface soils during snowmelt. Taken separately, each source could supply OC-ME with distinct interactions resulting in different OC fates along the continuum.

The aim of this study is to identify the distinct periods of OC and ME supply to a smaller Arctic River during the spring. To achieve this aim, we sampled soil waters (0-30 cm depth) and river waters every one to two days between May 8th to June 21st 2022 from Panguingue catchment, Interior Alaska, USA. To assess the impact of permafrost degradation (here referring to increased early season thaw depth) on the source of OC and ME we sample soil waters from sites where soils had undergone manipulated winter warming and sites where soils had undergone no additional warming. We observe four periods where OC and ME are supplied from a distinct source and show distinct interactions: i) before river ice break-up and snowmelt; ii) river ice break-up; iii) the period between river ice break-up and snowmelt secession and iv) after snowmelt. We show that soil waters from sites of increased early season thaw depth supply an increased contribution relative to controlled sites of OC and ME to the river immediately after snowmelt.