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Soil thaw effects on river discharge recessions of a subarctic catchment

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Thawing permafrost in circumpolar regions is likely to change subsurface hydrology. In high latitude areas continuous permafrost is expected to partially thaw leading to sporadic permafrost with deeper groundwater flow paths. Moreover, freeze-thaw cycles of the shallow subsurface are likely to increase. River discharge recession analysis can be particularly useful to understand the hydrological effects of a thawing Arctic. Here we examine river discharge recessions of the Abiskojokka, a 560 km2 watershed with sporadic permafrost, using a river discharge record of 30 years (1985 – 2015). Snow observation records were used to separate river recessions in snowmelt and snowfree periods. We found significant differences between recessions during the snowmelt and snowfree seasons. During the snowmelt, recessions were close to linear (b=1.11), while during the snowfree period, recessions were more non-linear (b=1.54). Typically, non-linearity has been found to increase with discharge magnitude, while we observed the opposite (snowfree periods tend to have lower discharges than the snowmelt periods). We explain these contrasting results by hypothesizing that increased connectivity (increasing magnitude and number of water flow paths) between groundwater and stream leads to higher non-linearity. In temperate catchments without frozen soils, connectivity tends to increase with increasing discharge. In contrast, in Arctic systems, where soils are frozen, connectivity between groundwater and stream is limited. Therefore, thawing of frozen soils is expected to increase connectivity and thus non-linearity of river discharges. We tested this hypothesis with a detailed analysis of all spring flood recessions. Years with cold soil temperatures (b=1.08) and years with a below median snowpack depth were found to have progressively linear slopes (b=1.08 and 1.01 respectively). On the other hand, years with warm soil conditions show increasingly non-linear recessions (b=1.67). Although limited in spatial extent, these results further support our connectivity hypothesis, which predicts increasing non-linearity of river discharges (higher discharge peaks and lower low flows under the same precipitation regime) as permafrost thaws.