Strong changes in the relationship between storage and discharge during a period of thawing soils and climate warming in Northern Sweden

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The Arctic is warming at an unprecedented rate. This warming affects not just ecosystems, but also permafrost, landscape configuration, and water availability in watersheds. One relatively under researched process is how seasonally frozen soils and changes thereof affect the water cycle. As frozen soils thaw, flow pathways within a catchment open, allowing for enhanced hydrologic connectivity between groundwater and rivers. As the connectivity of flow paths increase, the storage-discharge relationship of a watershed changes, which can be perceived within a hydrograph. More specifically, previous studies hypothesized that storage-discharge relationships are relatively linear when soils are frozen and become increasingly non-linear as the landscape thaws.

The objective of our research is to expand on the assumption that soil thaw leads to increasingly non-linear storage-discharge relationships by quantifying trends and spatio-temporal differences of this relationship. We will present our analysis of sixteen watersheds within Northern Sweden throughout the years of 1951 and 2018. We focus on spring and summer storage-discharge relationships and show how they are affected by preceding winter conditions.

We found a clear increase in non-linearity of the storage-discharge relationship over time for all catchments with twelve out of sixteen watersheds (75%) having a statistically significant increase in non-linearity. For twelve watersheds, spring relationships were significantly more linear compared to summer, which supports the hypothesis that seasonally frozen soils have less hydrologic connectivity leading to more linear storage-discharge relationships. Winter conditions that allow deep soil frost lead to more linear storage-discharge relationships for ten watersheds. Overall, we show that thawing soil leads to a more non-linear storage-discharge relationship which implies river runoff in the Arctic becomes more unpredictable.