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What controls inter-basin variation in cold-season river flow recession in permafrost basins in sub-Arctic Siberia?

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Cold-season river discharge during the period of ice cover and snow fall in northern high latitudes, provides a unique window on the role of subsurface hydrology in permafrost settings as direct surface runoff contributions are largely inhibited. Several recent studies have brought to light positive temporal trends in cold-season discharge totals for the past several decades to one century, and have interpreted these trends to reflect permafrost degradation and associated increased subsurface water transport in response to climate warming. While these are significant and compelling findings of hydrological change, there is a clear need to better understand the hydrology of cold-season flow and the discharge-generating processes themselves.

We present results of an inter-basin comparison of cold-season (October – April) river flow characteristics for 17 catchments in Siberia that are not disturbed by artifical reservoirs/dam influences. Streamflow data for the period 1980 – 1998 were studied. Flow and recession metrics for each basin and mean annual cold season catchment-averaged drainage depth, CSDD (in mm equivalent water depth) were compared/correlated with various basin attributes in order to evaluate the significance of these attributes as potential controls. Preliminary findings include a marked behavioural distinction between (11) basins on continuous permafrost and (6) basins with reduced permafrost coverage (discontinuous/sporadic). The latter are characterized by slow recession, relatively high discharge in April before spring freshet, and high CSDD values up to about 80 mm corresponding to more than 10% of total annual rainfall. Although positive correlations with several attributes (annual precipitation; peat land fraction) are found, higher abundance of through-taliks and greater active layer depth (ALD) appear to be the most prominent controls of the distinctive behaviour. Cold-season flow behaviour of the (11) basins on continuous permafrost also show conspicuous inter-basin differences, with some rivers exhibiting very fast recession and cessation of flow for 3 to 4 months, while others show strongly reduced, but continuous discharge throughout the cold season. An interesting question is if the latter behaviour signals contributions from intra- and/or sub-permafrost groundwater flow. Comparison with investigated catchment attributes suggests that ALD, soil properties and vegetation cover do not account for these differences, while lake area fraction and peat land fraction may play a role in favouring prolonged cold-season flow, although correlation is weak. It is anticipated that river valley and stream channel characteristics may be important, but this remains to be evaluated.