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Changing hydrological connectivity in the Arctic

Alexa Hinzman (1), Ylva Sjöberg (2), Steve Lyon (2), and Ype van der Velde (3)

(1) Department of Earth and Climate, Vrije Universiteit Amsterdam, Amsterdam, Netherlands (a.m.h.hinzman@vu.nl), (2) Department of Physical Geography, Stockholm University, Stockholm, Sweden, (3) Department of Earth and Climate, Vrije Universiteit Amsterdam, Amsterdam, Netherlands

In regions where subsurface flow is controlled by seasonally frozen ground or permafrost, identifying where and when hydrological connectivity increases during thawing periods is necessary to understand source areas, flow pathways and river flows. The degree of connectivity (i.e. water flow between surface, subsurface and between stores of water within the subsurface) controls water chemistry and streamflow dynamics. With current anthropogenic climate change, Arctic and sub-Arctic regions will continue to warm, frozen grounds will thaw and flow paths open to allow increased subsurface flow. This increase in connectivity is expected to result in a change of the storage-discharge relationship of watersheds. As spring snowmelt occurs earlier, subsurface connectivity is predicted to establish earlier and continue later into the summer. However, it is still unclear if the increase in temperatures actually deepen hydrologic connectivity or create a shift of unfrozen extent of connectivity to earlier in the year?

We use recession flow analysis on 16 watersheds to determine when and how much of a shift in storage-discharge relationships has occurred within Northern Sweden. Our research shows a wide-spread trend of significant increase in non-linearity of the storage-discharge relationship which we relate to an increase in hydrologic connectivity, in arctic watersheds over the last 50 years. Moreover, we find that during this period, cold winter temperatures affect the storage-discharge relationship differently than warm winters. The relationship is more nonlinear in warm winters than cold winters and cold winters effect the hydrologic connectivity to start increasing later into spring. These results strengthen our hypothesis that trends in storage-discharge relationships are valuable indicators for persistent changes in hydrological connectivity induced by thawing in a warming Arctic. Our results lead to a better understanding of how streamflow in arctic watersheds have changed as seasonal freezing of grounds diminishes.