Modeling the Effects of Warming, Water Cycle Acceleration and Permafrost Thaw on Arctic Rivers

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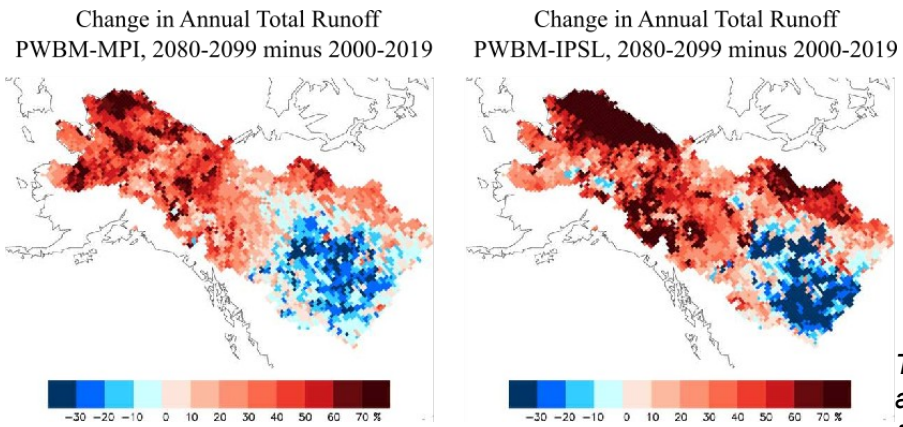

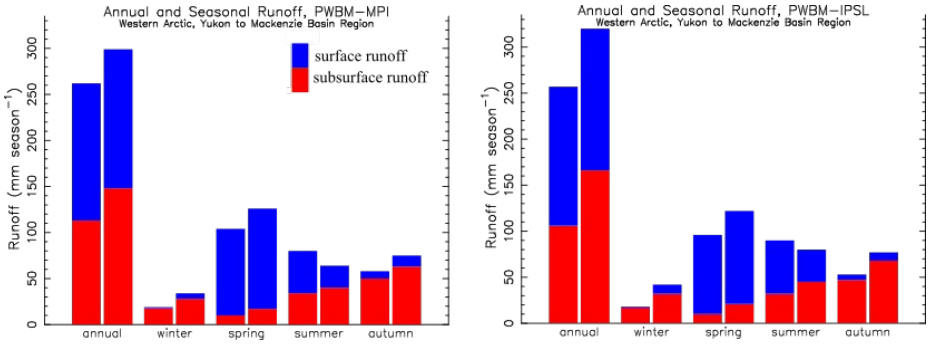

Two simulations bracket projected changes this century. Left and right bars above for early century and late century periods respectively. Results shown for the project's western Arctic's Yukon to Mackenzie drainage region.

Problem: Observations over the recent past capture how warming, water cycle intensification, and permafrost thaw are altering Arctic terrestrial hydrology. Numerical models capable of capturing the myriad effects are needed to investigate how river flows of freshwater and materials will be altered.

Method: The Permafrost Water Balance Model was driven with data from atmospheric reanalysis and two CMIP6 coupled climate models. Simulations across the pan-Arctic basin to 2100 were parameterized with remote sensing estimates of surface water extent and validated against RS-based evapotranspiration and gridded active layer thickness fields derived from observational data. Low model-data biases were found.

Finding: The simulations point to an increase in annual total runoff of 17–25%, while the proportion of runoff emanating from subsurface pathways is projected to increase 13–30%. Runoff contributions to river discharge shift to northern parts of the Arctic basin that contain greater amounts of soil carbon, which will be leached from soils, transferred to growing channel networks, and transported downstream. Each season sees an increase in sub-surface runoff, higher surface runoff is noted in spring only, and summer experiences a decline in total runoff despite increased subsurface flows.

Impact: Changes in runoff and, in turn, river discharge will alter the amount of land-to-ocean freshwater and materials transports, with impacts to coastal ecosystems, ice dynamics, and ocean biogeochemistry.