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# Effects of modeling decisions on cold region hydrological model performance: snow, soil and streamflow

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Cold regions are characterized by intense spatial gradients in climate, vegetation and soil properties that determine the complex spatiotemporal patterns of snowpack evolution, frozen soil dynamics, catchment connectivity, and streamflow. These spatial gradients pose unique challenges for hydrological models, including: 1) how the spatial variability of the physical processes are best represented across a hierarchy of scales, and 2) what algorithms and parameter sets best describe the biophysical and hydrological processes at the spatial scale of interest. To address these topics, we apply the Structure for Unifying Multiple Modeling Alternatives (SUMMA) to simulate hydrological processes at the Caribou - Poker Creeks Research Watershed in the Alaskan sub-arctic Boreal forest. The site is characterized by numerous gauged headwater catchments ranging in size from 5 sq. km to 106 sq. km with varying extents (3% to 53%) of discontinuous permafrost that permits a multi-scale paired watershed analysis of the hydrological impacts of frozen soils. We evaluate the effects of model decisions on the skill of SUMMA to simulate observed snow and soil dynamics, and the spatial integration of these processes as catchment streamflow. Decisions such as the number of soil layers, total soil column depth, and vertical soil discretization are shown to have profound impacts on the simulation of seasonal active layer dynamics. Decisions on the spatial organization (lateral connectivity, representation of riparian response units, and the spatial discretization of the hydrological landscape) are shown to be as important as accurate snowpack and soil process representation in the simulation of streamflow. The work serves to better inform hydrological model decisions for cold region hydrologic evaluation and to improve predictive capacity for water resource planning.