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Evaluating permafrost thaw vulnerabilities and hydrologic impacts in boreal Alaska (USA) watersheds by integrating field data and cryohydrogeologic modeling

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Permafrost environments undergo changes in hydraulic, thermal, chemical, and mechanical subsurface properties upon thaw. These property changes must be considered in addition to alterations in hydrologic, thermal, and topographic boundary conditions when evaluating shifts in the movement and storage of water in arctic and sub-arctic boreal regions. Advances have been made in the last several years with respect to multiscale geophysical characterization of the subsurface and coupled fluid and energy transport modeling of permafrost systems. Ongoing efforts are presented that integrate field data with cryohydrogeologic modeling to better understand and anticipate changes in subsurface water resources, fluxes, and flowpaths caused by climate warming and permafrost thawing. Analyses are based on field data from several sites in interior Alaska (USA) that span a broad north-south transition from continuous to discontinuous permafrost. These data include soil hydraulic and thermal properties and shallow permafrost distribution. The data guide coupled fluid and energy flow simulations that incorporate pore-water liquid/ice phase change and the accompanying modifications in hydraulic and thermal subsurface properties. Simulations are designed to assess conditions conducive to active layer thickening and talik development, both of which are expected to affect groundwater storage and flow. Model results provide a framework for identifying factors that control the rates of permafrost thaw and associated hydrologic responses, which in turn influence the fate and transport of carbon.