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High frequency flow and solute dynamics in an alpine discontinuous permafrost catchment

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Permafrost and frozen ground play a critical role in the transfer of water and solutes from the landscape to the stream, and in biogeochemical cycling by acting as a cold season or semi-permanent aquitard. Conceptual models of permafrost hydrology have been well defined for over 40 years, yet renewed interest in the face of climate change and rapid degradation of frozen ground has provided an opportunity to revisit previous paradigms. At the same time, new instruments and techniques to understand coupled hydrological and biogeochemical processes have emerged, providing a more nuanced view of northern catchments. In this presentation, multi-year high frequency data sets of water, specific conductance (SpC) and chromophoric dissolved organic matter (CDOM) from Granger Creek, an instrumented alpine watershed with discontinuous permafrost within the Wolf Creek Research Basin, Yukon Territory, Canada, is presented. Snowmelt and rainfall-runoff events were delineated over multiple years and sub-hourly data was used to generate hysteresis loops for several dozen events. The direction and magnitude of these loops for Q-SpC and Q-CDOM suggest strong seasonal controls on the mechanisms of solute export, which vary for weathering ions compared with dissolved organic matter. Dissolved solutes (as represented by SpC) are largely diluted during freshet and storm events, with Q-SpC hysteresis being greatest during period of low-flow in mid-summer when SpC was large. In contrast, CDOM largely exhibited a mobilization signal with large event and inter-annual variability in hysteresis patterns. In both cases, there were unique signals related to season: freshet, mid-summer low flow and fall wetting. High-frequency and hysteresis direction and magnitude suggest changing proximal and distal sources of solutes and organic material in response to active layer thickening, soil moisture and precipitation intensity; highlighting spatial connections among landscape units not previously reported. Evaluation of these patterns at the headwater scale provides alternate hypotheses for how permafrost landscapes may respond to a changing climate.