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Hydrologic sensitivity of headwater catchments to climate and landscape variability

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Headwater streams cumulatively represent an extensive portion of the United States stream network, yet remain largely unmonitored and unmapped. As such, we have limited understanding of how these systems will respond to change, knowledge that is important for preserving these unique ecosystems, the services they provide, and the biodiversity they support. We compare responses across five adjacent headwater catchments located in Tenderfoot Creek Experimental Forest in Montana, USA, to understand how local differences may affect the sensitivity of headwaters to change. We utilize global, variance-based sensitivity analysis to understand which aspects of the physical system (e.g., vegetation, topography, geology) control the variability in hydrologic behavior across these basins, and how this varies as a function of time (and therefore climate). Basin fluxes and storages, including evapotranspiration, snow water equivalent and melt, soil moisture and streamflow, are simulated using the Distributed Hydrology-Vegetation-Soil Model (DHSVM). Sensitivity analysis is applied to quantify the importance of different physical parameters to the spatial and temporal variability of different water balance components, allowing us to map similarities and differences in these controls through space and time. Our results show how catchment influences on fluxes vary across seasons (thus providing insight into transferability of knowledge in time), and how they vary across catchments with different physical characteristics (providing insight into transferability in space).