Spatiotemporal patterns in hydrologic connectivity within a semi-arid montane headwater catchment in central Colorado

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Abstract

Climate projections suggest that snowfall-dominated areas will decline substantially in the coming decades. Such climate impacts are already being observed in Colorado where the dominant source of annual peak discharge is shifting from snowmelt to rainfall, altering the paths by which water flows through a landscape and is ultimately delivered to streams. Observed climate driven shifts in stream flow dynamics and permanence highlight the increasing importance of understanding the hydrologic connectivity of uplands to streams in lower elevation, montane ecoregions. We collected geochemical and hydrometric data over three years to quantify hydrologic connectivity of uplands to a montane headwater stream at the Manitou Experimental Forest in central Colorado. We use a combined approach of concentration-discharge relationships and end-member mixing analysis, paired with high resolution measurements of soil moisture, precipitation, and groundwater levels to characterize source areas to the stream in 3-dimensions: longitudinal, lateral, and vertical. Samples were collected and measurements were recorded along the stream profile (longitudinal), from groundwater wells and soil lysimeters installed with increasing distance from the stream (lateral), and from shallow versus deep groundwater wells and soil moisture measured at different depths (vertical). Results indicate distinct differences in stream chemistry along the longitudinal stream profile, with highest concentrations at the most upstream sites and lowest concentrations at the most downstream sites. Stream solute concentrations increased with decreasing stream discharge values from spring to late summer. However, the stream remained chemostatic during all recorded rain storms, suggesting a difference in flow pathways during individual summer storm pulses. End member mixing analysis suggests spatiotemporal differences in shallow and deep vertical source areas, and between riparian and upland sources to the stream. These results provide a promising step towards quantifying the expansion and contraction of runoff source areas to a montane headwater stream.

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