Hydrologic response along the intermittent-persistent snow transition of the Western U.S.

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Abstract. In mountain regions, both snowpack trend analyses and modeling studies suggest that snowpacks are most sensitive to climate change at their lower elevation boundaries, yet we still lack understanding of where these snow-sensitive elevation ranges are located and how snow changes within them affect hydrologic response. Comparing runoff ratios across persistent and intermittent snow zones raises questions about how climate mediates the role of snow persistence (SP) in runoff generation. The central hypothesis guiding this research is that loss of a persistent winter snowpack triggers a loss in runoff generation, but the magnitude of this loss is higher in more arid climates. Snow affects hydrologic response by shifting the timing and magnitude of water input. All other factors being equal, two factors may lead to higher runoff in the persistent snow scenario, (1) concentrated input during melt, and (2) decreased evapotranspiration (ET) due to snow cover. Using a total of 159 USGS reference catchments across five mountainous regions of the Western U.S., annual snow persistence and discharge were calculated for the water years 2001 to 2015. Results show strong positive relationships between annual SP and annual runoff ratio in the Southern Rockies, and Basin and Range, where annual precipitation ranges from 0.20 m at low elevations in the Basin and Range to 1.7 m at high elevations in the Southern Rockies. No relationships between annual SP and runoff ratios are evident in the wetter North Cascades, and weaker relationships are present in the Sierra Nevada and Northern Rockies, where annual precipitation ranges from 0.33 m in the low elevation Sierras to 4.8 m in the high elevation Cascades. Streamflow generation in arid regions may be most sensitive to loss of persistent winter snow, whereas precipitation is a stronger predictor of runoff ratio in wetter climates.