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Quantifying Mountain Aquifer Recharge Rates Using Storage-Discharge Functions in the Sierra Nevada, California

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Mountain System Recharge (MSR) is one of the main components of recharge in many arid and semi-arid aquifers, yet the mechanisms of MSR in high-elevation mountain ranges are poorly understood. The complexity of recharge processes and the lack of groundwater observations in mountain catchments contribute to this problem. MSR consists of two distinct pathways: 1) mountain bedrock aquifer recharge (MAR) consists of snowmelt or rainfall derived infiltration into the mountain bedrock, which either discharges to streams as baseflow or reaches an alluvial aquifer in an adjacent valley via lateral subsurface flow referred to as mountain block recharge (MBR), and 2) Mountain front recharge (MFR) consists of streamflow infiltration at the mountain front. Here, we apply streamflow recession analysis across 11 anthropogenically unaffected catchments in the Sierra Nevada to derive seasonally distinct storage-discharge functions and quantify MAR in response to changes in precipitation. Median annual recharge efficiencies (ratio of annual MAR to precipitation) range from 4 to 28% and can reach up to 60% during the wettest years on record. We implement a global sensitivity analysis to identify parameters that significantly impact MAR rates. Results illustrate that MAR estimates are mostly sensitive to the filter parameters for streamflow data selection used during the recession analysis, and the number of dry days after a rain event where streamflow data are excluded has the greatest impact. Our results demonstrate that storage-discharge functions are useful for quantifying groundwater recharge in mountainous catchments under perennial flow conditions. However, estimated MAR rates are impacted by the uncertainty in streamflow data, filtering of streamflow time series and model structure. Future work will be focused on quantifying uncertainty in MAR estimates caused from various sources.