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Quantifying watershed storage dynamics using long duration, high frequency measurements of precipitation, runoff, and evapotranspiration

S. Carlson, K. Jencso, and B.L. McGlynn
Montana State University

Quantifying water storage and redistribution in mountain watersheds is critical for water resources planning and improving fundamental catchment hydrology understanding. Previous studies have estimated watershed storage, but have often been poorly constrained, relying on modeled evapotranspiration (ET) for calculation. Vegetation and landscape heterogeneity often make modeling of ET complex and uncertain. In this study we calculated dynamic catchment storage using a direct, fully measured water balance approach. We utilize ET measurements from an eddy covariance tower located in Tenderfoot Creek Experimental Forest, Montana. Measured ET was combined with hourly precipitation (P) and runoff (Q) to calculate ΔS, using the mass balance equation $\Delta S = P - (Q + ET)$. Relationships between S, ET, and Q measurements elucidate the relative influence of vegetation and topographically mediated soil water redistribution on changes in watershed S. Topographic controls on lateral soil water redistribution and S dynamics were corroborated with water table data from 30 hillslope – riparian – stream well transects (180 recording wells). This study provides new insights into the interplay between vegetation and soil water redistribution and their influence on watershed scale storage and runoff through time. This understanding is valuable for prediction of watershed scale response and for understanding water resources sensitivity in the context of climate change.