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Nested EMMA to Identify Stream Sources in a Colorado River Headwater Catchment

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Stream concentration-discharge relationships represent an integrated hydrologic response of the individual catchment with a direct link to contributing sources, associated flow paths and groundwater residence times. We employ the empirical approach of end-member mixing analysis (EMMA) using a suite of natural chemical and isotopic observations within the East River, CO; a snow-dominated, headwater catchment of the Colorado River and recently designated as the Lawrence Berkeley National Laboratory Watershed Function Science Focus Area study site. EMMA relies on eigenvector and residual analysis and is used to estimate mixing model dimensionality and identify contributing end-members of the furthest downstream (84.7 km^2) and most heavily characterized stream gauge in the study site. Model development using this gauge helps minimize uncertainties related to sampling frequency, temporal variability, and possible data gaps. Results are then applied to 10 nested sub-catchments (ranging from 0.38 km^2 to 69.9 km^2). The mixing space will scale if the seasonal ratios among solutes are maintained. In contrast, lack of a common mixing subspace will occur if water originates with a different chemical signature, contacts and exchanges solutes with different mineral assemblages, or experiences dissimilar hydrologic partitioning. We discuss similarities and differences in the predictive power of EMMA among sub-catchments in terms of first-order geospatial characteristics and with reference to processes that potentially violate underlying assumptions of linearity in mixing and conservative behavior of tracers. Nested EMMA is an initial step to elucidate source contributions to streamflow and address scalability and applicability of mixing processes in a complex, highly heterogeneous, snow dominated catchment. Work will aid hydrologic conceptualization of the East River, guide future observation, and inform numerical model development over a range of scales and across key system subcomponents, such as hillslopes, floodplains, and deep groundwater.