Poster #21-80

Quantifying Magnitude and Age of Groundwater Flux from Topographically Complex Watersheds Using a MODEX Approach

Rosemary Carroll[1*], Kenneth Williams[2], Zhufeng Fang[1], Andrew Manning[3], Reed Maxwell[4], Erica Woodburn[2], Markus Bill[2], and Mark Conrad[2]

[1]Desert Research Institute, Reno, NV
[2]Lawrence Berkeley National Laboratory, Berkeley, CA
[3]U.S. Geological Survey, Lakewood, CO
[4]Colorado School of Mines, Golden, CO

Contact: Rosemary.Carroll@dri.edu

BER Program: SBR
Project: Berkeley Lab Watershed Function SFA
Project Website: watershed.lbl.gov

The magnitude and age of groundwater contributions to watershed outflows in snow-dominated, mountainous watersheds are poorly understood due to difficulty in characterizing complex surface and subsurface geospatial characteristics and their tight coupling with recharge and associated groundwater connectivity. We explore the hypothesis that deeper, older groundwater is hydrologically active in headwater basins underlain by fractured shale and igneous bedrock through a modeling-experimental (MODEX) framework. Specifically, we highlight three individual studies that can inform one another and update the conceptual model of groundwater flux in these systems. All three studies are conducted within the East River, a headwater basin of the Colorado River and the study site of Berkeley Lab's Watershed Function Science Focus Area (SFA). The first study investigates the lag of snowmelt to stream discharge combining observed mass flux of $\delta^{18}O$ with numerically simulated hydrologic boundary fluxes and inverse techniques applied to analytically-derived transient travel time distributions. Results indicate that snowmelt during wet years transports a greater fraction of younger water (< 1 year) to streams but simultaneously activates older and potentially deeper groundwater contributions in comparison to dry years. The second study combines measurements of multiple dissolved gas tracers (SF_6, CFCs, N_2, and noble gases) and ^3H to constrain age distributions in groundwater samples across key watershed sub-components including shallow and deep groundwater, springs and baseflow. The resulting age information and associated uncertainties are addressed with respect to sampling protocols, excess air and recharge temperature corrections, choice of distribution (e.g. piston flow, exponential, bi-modal), and solution uniqueness. Lastly, a newly developed Lagrangian particle tracking code is applied to an integrated hydrologic model to explore changes in source waters and age distributions of watershed outflows as functions of variable climate. The comparison of results acquired from these three studies provides insight into the age, magnitude, and circulation depth of hydrologically active groundwater in mountainous watersheds and will help guide future observation and modeling strategies performed as part of the SFA project.