Poster #22-2

Coupled Investigation of Hyporheic Transport and Transformation Dynamics in Headwater Streams: Preliminary Findings and Experimental Design

Adam Ward[1*] and Marie Kurz[2]

[1] Indiana University, Bloomington, IN
2 Drexel University, Philadelphia, PA

Contacts: adamward@indiana.edu and marie.kurz@drexel.edu

BER Program: SBR
Project: ORNL Critical Interfaces Scientific Focus Area
Project Website: https://www.esd.ornl.gov/programs/rsfa/

Improving the representation of key hydrological processes, such as evapotranspiration (ET), that influence discharge and exchange fluxes in streams is essential to developing a more robust predictive understanding of mercury cycling in low-order streams globally. For example, ET on hillslopes can cause discharge in low-order streams to fluctuate on a diurnal basis. At certain locations and times, the net result can produce spatially intermittent stream discharge— specifically the diurnal presence or absence of surface discharge along a fixed study reach. We expect ET-driven (de)activations of stream flow, more generally, the diurnal variation in hydraulic gradients that link the stream and subsurface, to alter exchange fluxes and transit times along a stream reach. These alterations would result from changes in the geometry of some flow paths, including (de)activation, and changes in the relative flux along flow paths that do not change over time. Variations should both be continuous as discharge rises and falls in response to ET, and exhibit threshold behavior as the stream and/or subsurface pathways activate and deactivate. Associated with these changes, a number of other system states fluctuate on a diurnal basis, including changes in exchange flux, reach scale transit times, and locations oscillating between saturated and unsaturated. Given the changes in both biogeochemical forcing (e.g., saturated to unsaturated conditions) and physical transport (e.g., changing timescales and relative fluxes along flow paths, activation of new flow paths) we expect diurnal variation will be observable in reach-scale ecosystem function, including respiration and nutrient spiraling. We present results of a series of four injections of both conservative and reactive tracers along a study reach with diurnal fluctuations in discharge, including two locations where flow is completely subsurface along the stream. We interpret physical transport by analyzing conservative solute tracer breakthrough curves using both time-series analyses and fitting of a time-variable StorAge Selection (SAS) function; and we infer ecosystem function using resazurin-to-resorufin transformation rates (both modeled and based on field observations).

Finally, we generalize our findings as a series of challenges facing existing and emerging models of transport and transformation in the river corridor. We conclude with a proposed experimental design to measure the spatially heterogeneous and time-varying reactive transport relationships that were identified in our field campaign.