Poster #21-72

Field Observations of Hydrologic Exchange Flows and Biogeochemical Impacts

Timothy C. Johnson[1*], Matthew Kaufman[1], James Stegen[1], Yue Zhu[1], Jon Thomle[1], Chris Strickland[1], Kenton Rod[1], and Xuehang Song[1]

[1] Pacific Northwest National Laboratory, Richland, WA

Contact: TJ@pnnl.gov

BER Program: SBR
Project: PNNL SBR SFA
Project Website: https://sbrsfa.pnnl.gov/

This element of the PNNL SFA seeks to gain new understanding of coupled hydrologic and biogeochemical processes in the hyporheic zone through novel instrumentation linked to numerical models. Quantifying the spatial and temporal pattern of hyporheic respiration remains a key gap in field studies as well as river reach-scale reactive transport modeling. Accurate simulation and prediction biogeochemical function within the hyporheic zone (HZ) of dynamic, regulated river systems is dependent on corresponding understanding of the distribution of physical properties that govern hydrologic exchange fluxes (HEFs) and the metabolic reactions that take place within the HZ. To better inform coupled hydrological and biogeochemical models of HZ function, we are developing novel tools and analytic techniques that enable simultaneous monitoring of dynamic fluxes and HZ respiration rates: the flux tool and the optode-based oxygen sensor.

The flux tool consists of a vertical array of sensors deployed in the riverbed. The sensors record time series of pressure gradient, temperature, fluid electrical conductivity, and bulk electrical conductivity. Collectively, these time series provide adequate information to estimate the vertical distribution of porosity and permeability using a companion high-performance hydrogeophysical joint inversion software. Once the system is 'calibrated' using the flux tool and software, the tool is removed and long term monitoring of dynamic flux is accomplished using only dynamic pressure, temperature, or fluid conductivity measurements.

Dynamic river flows lead to HZ conditions that vary the ratio between oxygen consumption and resupply in reactive transport models. Understanding these coupled flow and biogeochemical processes requires knowledge of both reaction and transport timescales. The flux tool provides the flow physics half of this equation, but existing methods for measuring in-situ HZ respiration are inadequate. To fully link hydrology and biogeochemistry, we require a sensor able to measure oxygen concentrations in the HZ at high spatial and temporal resolution. Previous work has shown limited success using off the shelf fiberoptic oxygen sensors combined with custom optode-coated tubes. We pursue that avenue, while simultaneously developing a more robust and compact system with no moving parts to measure and log a linear profile of oxygen concentration. Using these tools together, we test the hypothesis that the evolution of the oxygen profile will lag behind perturbations in vertical flux, leading to complex responses in highly dynamic rivers. Understanding these interactions is critical to properly parameterizing large- scale GW/SW interaction models.