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Local to Global Hydrobiogeochemical Impacts of High-Frequency Stage Fluctuations

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This element of the PNNL SFA seeks to understand the hydrobiogeochemical impacts of high frequency stage fluctuations from local-global scales through a research consortium and new sensors. While our understanding of dynamic river corridors is increasing, there is uncertainty in the hydrobiogeochemical impacts of high-frequency stage fluctuations, and such influences are omitted from current models. These deficiencies undermine predictions of feedbacks among energy-water systems, water quality, and river corridor health. The Worldwide Hydrobiogeochemical Observation Network for Dynamic River Systems (WHONDRS) aims to overcome these limitations. WHONDRS partners with researchers to use standardized methods across field sites to systematically collect and synthesize hydrobiogeochemical data in dynamic river corridors. By galvanizing a global community around understanding these impacts, WHONDRS will provide the scientific basis for improved management of dynamic river corridors throughout the world.

A key aspect of WHONDRS is the deployment of consistent instrumentation across field sites that is capable of estimating hydrologic exchange fluxes in very dynamic systems. Estimating these fluxes is essential for understanding and predicting hydrobiogeochemical processes, and requires understanding of pore velocity and mass flux. Current monitoring approaches estimate either transient pore fluid velocity or mass flux rate at the surface water/groundwater interface, but not both. To address this limitation, we developed a multi- sensor probe that continuously monitors the vertical distribution of pore fluid conductivity, temperature, pressure, and bulk electrical conductivity. Combined with fluid conductivity, bulk electrical conductivity estimates the vertical distribution of porosity, which links pore fluid velocity to mass flux. We developed the capability to simulate all time-series data from the probe using PFLOTRAN-E4D, and a joint Occam's inversion for estimating the simplest vertical distribution of porosity, permeability, and dispersivity that honor the data. We have also developed a companion stochastic analysis to investigate uncertainty in parameter estimates and corresponding flux rates. Once parameters are estimated, transient pore fluid velocity and mass flux can be monitored using pressure boundaries at the top and bottom of the sensor probe.

The multi-parameter sensor rod is being developed, in part, to support WHONDRS efforts across globally distributed field sites. WHONDRS members will have access to this unique instrumentation and analytical software. WHONDRS, in collaboration with EMSL, is also supporting high resolution metabolomics to be paired with hydrologic exchange flux estimates. Collating hydrologic and metabolomic data across systems will reveal hydrobiogeochemical impacts of sustained high-frequency stage fluctuations from local to global scales.