Poster #174

Quantifying Reach-Scale Hydrological Exchange Flows and Their Influences on Biogeochemistry, Contaminant Mobility, and Land-Surface Fluxes

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This element of the PNNL SBR SFA seeks to quantify the cumulative effects of hydrological exchange flows (HEFs) on reach-scale phenomena (i.e., water quality, nutrient dynamics, and ecosystem health) in dynamic river corridor systems, based on rigorous upscaling of mechanistic process understanding developed at hydromorphic units. HEFs in rivers play vital roles in watershed ecological and biogeochemical functions due to their strong capacity to attenuate contaminants and process significant quantities of carbon and nutrients. Recent PNNL SBR SFA studies, using a combination of numerical simulations and field observations, have revealed complex spatial and temporal dynamics in km-scale HEFs and their significant impacts on contaminant plume mobility, hyporheic thermal regimes, and land surface energy fluxes at a few km-scale sites along the Hanford Reach. The coupling between massively parallel flow and reactive transport code PFLOTRAN and the Community Land Model (CLM), PFLOTRAN_CLM, provides a key capability for studying the interactions between river water, groundwater, and land surface processes.

Expanding on these previous research, we propose to conduct field and numerical experiments to evaluate the influence of HEFs on riparian-zone biogeochemistry, land surface fluxes, and contaminant mobility at the scale of the entire Hanford Reach (10s of km). This activity will develop reach-scale flow and reactive transport (PFLOTRAN) model using unstructured variable-resolution grids, incorporating reduced-order models of HEFs and nitrogen cycling developed from high-resolution mechanistic models at hydromorphic units. The nitrogen cycling will be informed by spatially distributed carbon stocks mapped from remotely sensed measurements and the ultra-high resolution carbon characterization. The resulting model system will be applied to quantify carbon/nitrogen dynamics and contaminant transport and transformation at the Hanford Reach scale, as a representative example of influences of HEFs on system-scale biogeochemistry. The flow and reactive transport model will be calibrated against both site-wide contaminant monitoring data and new spatially distributed HEF measurements. The coupled PFLOTRAN_CLM model, informed by eddy-covariance measurements of latent heat and carbon fluxes from three flux towers distributed across the Hanford Reach, will be used to assess the impacts of HEF on riparian vegetation and land surface fluxes. This activity will be heavily informed by a combination of high-resolution mechanistic models and process studies across the SFA project. The upscaling of mechanistic processes from the hydromorphic scale to reach scale will fill in a critical need in bridging the gaps between hydromorphic-scale process understanding and robust predictions of the watershed hydrobiogeochemical function.