How important is the hyporheic zone for biogeochemical cycling?

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The interaction between hydrological, ecological, and biogeochemical processes in the hyporheic zone significantly influences nutrients and coupled carbon and nitrogen cycling. Upwelling of nutrient-rich water and downwelling of higher pH and dissolved oxygen rich water lead to distinct biogeochemical gradients within the hyporheic zone. These biogeochemical gradients impact local riverine fluxes of carbon, nitrogen, and metals; local fluxes affect the larger scale biogeochemical cycling. The objectives of this study are to (a) identify biogeochemical zonation of key chemical constituents due to hyporheic exchange and (b) quantify local riverine fluxes of carbon, nitrogen, and metals in tight meanders of the lower East River floodplain. To understand the effects of hyporheic exchanges on hydrological and biogeochemical fluxes at the meander scale, we develop a biogeochemical reaction network and integrate it with a reactive transport solver – PFLOTRAN.

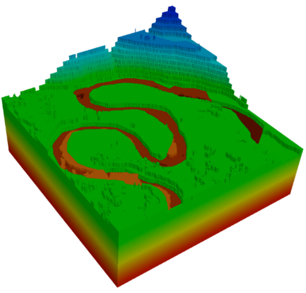

Figure 1: 3-D modelling domain for lower East River meanders. Domain size is approximately 175m by 175m by 25m with a lateral grid resolution of 0.5 m.

The model includes representations of microbially mediated redox reactions, aqueous speciation, mineral precipitation/dissolution reactions, and sorption. Simulation results demonstrate that the intra-meander hyporheic flow paths and biogeochemical reactions cause the lateral redox zonation, which considerably impact the carbon and nitrogen fluxes into the stream system. Also, the meander-driven hyporheic flow paths enhance denitrification because of relatively longer residence times of nitrate in the organic carbon-rich sediments. An important conclusion from this work is the need for high resolution spatial datasets that can delineate meanders at exact locations (up to the meter scale).