

Floodplain biogeochemistry at the molecular to pore scale and why it matters at ecosystem scales

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Alluvial floodplains exhibit a multitude of juxtaposed sediment layers with sharply contrasting physicochemical and hydrologic properties, which in turn shapes distinct geochemical conditions and microbiological metabolic niches. Typically, the biogeochemical implications of this complexity have been approached by studying the end-member situations (e.g., fine-grained vs. coarse grained sediments, anoxic vs. oxic conditions, saturated vs. unsaturated water content) at “steady state” and/or transitioning from one to the other. However, increasing evidence suggests that highly impactful biogeochemical processes driving the fate of e.g., C, plant nutrients, and contaminants, rely on the non-steady state exchange of water, solutes, gasses, and colloids across the interfaces between these end-member layers and conditions.

To gain knowledge of these transitional conditions and their impacts on environmental outcomes, the SLAC Floodplain Hydro-Biogeochemistry SFA has developed field- and lab-based observational and experimental approaches that inform and are informed by modeling activities, including sensitivity analyses, uncertainty quantification, identification of unexplained anomalies in the model parameterization/reaction network, through re-iterative exchanges and refinements both on the observational/experimental side and within the modelling framework. To date, these efforts have rendered several important insights that are re-shaping our views of what controls the biogeochemical processes within floodplains and the resulting exports to the atmosphere and ground-/surface waters. For example, we have shown that 1) large (>0.15 μm) organic colloids, probably including live microbial cells, can drive outsized establishment of anoxic biogeochemical reactions in otherwise oxic conditions in saturated sediments, and 2) aeration (due to drying) does not necessarily increase the export of contaminants that are mobile in oxidated states (e.g., U).

In this presentation, we will challenge the validity of some of the generally accepted conceptual models for hydro-biogeochemical process pathways in complex subsurface environments, as well as the established porewater sampling and analysis strategies. We will further provide evidence and ideas of how to re-shape our understanding of these environments to