The GEWaSC Framework: Multiscale Modeling of Coupled Biogeochemical, Microbiological, and Hydrological Processes

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In order to improve our ability to predict the effect of climate change on carbon and nutrient cycling, we are developing a genome-enabled multiscale reactive transport framework (GEWaSC) that couples microbial composition, competition, and activity to biogeochemical processes and the hydrologic cycle at the watershed scale. The model will capture flow of water and flux of carbon and nutrients from the surface through the vadose zone and saturated zone, while simulating the dynamics of microbial community evolution and consequent changes in carbon and nutrient fluxes and aquifer biogeochemistry as a result of climate perturbations or other changes in the surface and subsurface environment.

This new simulation capability goes beyond conventional watershed models by ultimately integrating surface processes (e.g., those taking place in the soil and surface waters) with the subsurface flow and transport in a formal manner to provide a complete description of carbon, biogeochemical, and nutrient cycles within a catchment. A novel feature of the modeling approach is to couple microbial functional distributions inferred from trait-based models that are parameterized using site-specific 'omic data with a comprehensive simulation of biogeochemical networks. An important requirement of the framework is that it is capable of upscaling hydrologic, biogeochemical, and microbiological data from smaller to larger scales (up to the watershed scale), and in some cases downscaling processes and parameters to more focused, smaller scale simulations.

Initial model application is to biogeochemical and microbial dynamics within the Rifle Flood Plain system, a component of the greater Colorado River system. Scientific questions to be addressed include 1) What are the primary factors regulating redox status in aquifers and watersheds? 2) What are the effects of climate change influences, both gradual and abrupt relative to seasonal (baseline) variability, on carbon and nutrient cycling at the watershed scale?