The LBNL Sustainable Systems Subsurface Biogeochemistry SFA 2.0: Overview

Susan Hubbard (sshubbard@lbl.gov) - Lawrence Berkeley National Laboratory (PI), Jillian F. Banfield (UCB/LBNL), Harry R. Beller (LBNL), Eoin Brodie (LBNL), Phillip E. Long (LBNL), Peter Nico (LBNL), Carl Steefel (LBNL), Tetsu Tokunaga (LBNL), Kenneth H. Williams (LBNL), Deb Agarwal (LBNL); and the SFA 2.0 Team; (Co-PIs).

The LBNL Sustainable Systems SFA 2.0 is advancing approaches for quantifying and simulating genome-through-watershed scale interactions that govern biogeochemical cycling in terrestrial environments. The terrestrial environment is an especially complex component of the Earth System: it is the host for a multitude of interactions among plants, animals, microorganisms, minerals, migrating fluids, and dissolved constituents that occur within a heterogeneous framework and across a wide range of scales. There are significant uncertainties associated with the predictive understanding of terrestrial environment biogeochemical cycling relevant to carbon cycling, contaminant mobility and biofuel crop sustainability.

The SFA 2.0 is developing approaches to quantify how climate or land-use-induced changes in hydrology and vegetation affect subsurface carbon inputs, spatial and temporal distribution of flow and transport, biogeochemical cycling, and microbial metabolic activity in terrestrial environments; how will these processes change over time; and what effect these interactions have on overall watershed biogeochemical functioning. These questions are being addressed through iterative and multi-scale experiments and observations tied to the development of a Genome-Enabled Watershed Simulation Capability (GEWaSC). GEWaSC will provide a community predictive framework for exploring how genomic information stored in a subsurface microbiome affects biogeochemical watershed functioning, how watershed-scale processes affect microbial functioning, and how these interactions co-evolve.

Development of approaches and initial investigations are being carried out at the Rifle, CO subsurface biogeochemistry community field study site, which is located in a Colorado River floodplain. At this site, seasonal snowmelt and perturbation experiments are being used to explore how hydrological changes in moisture and dissolved oxygen affect subsurface carbon transport, biogeochemical transformations, and metabolic potential across the floodplain, as well as to test developing GEWaSC capabilities for predicting metabolic and geochemical in the presence of vertical and lateral heterogeneity.

Launched in October of 2013, the LBNL SFA 2.0 project has already made substantial progress along several critical and linked research fronts. Examples include: metagenomic analysis revealing the extraordinary genomic diversity of aquifer microbiomes and their roles in terrestrial system biogeochemical cycling; new soil, vadose zone and groundwater biogeochemical instrumentation and monitoring that has revealed high spatiotemporal variability of DOC in response to hydrological pulses; new approaches for quantifying organic-mineral associations; new approaches for remotely identifying hotspots of microbial activity in the Rifle floodplain, field manipulation experiments to probe metabolic and geochemical responses; and progress in developing a genome-enabled watershed simulation capability.