Above and Below-Ground Geophysical Characterization of Watershed Structure and Functioning

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Predictive understanding of watershed function and dynamics is hindered by lack of means to quantify complex interactions between plants, minerals, microbes, dissolved constituents, and migrating fluids. These multi-scale interactions and feedbacks occur from bedrock-to-canopy, and variably within the watershed as a function of landscape position and environmental gradients. A key aspect of the Berkeley Lab Subsurface Biogeochemistry SFA is to develop new characterization and monitoring methodologies to quantify complex watershed systems, using new sensing, inversion, and data assimilation approaches. In particular, we aim to (a) tractably identify the regions that have unique suites of properties that influence watershed subsystem behavior (b) provide unparalleled insights about the interactions between above and below-ground processes and their responses to disturbances; (c) provide unprecedented understanding of in-situ fine-scale processes, such as microbially-mediated root zone functions and dynamics. We have developed and tested several approaches at the Genomes-to-Watershed Rifle CO site, and are extending and expanding our methods to the new East River SFA Watershed Study Site. Examples include:

- In situ electrical resistance tomography (ERT) imaging to investigate root-zone dynamics, including: (1) identifying important plant root traits and their adaptation to environmental conditions, (2) tracking root zone water and nutrient dynamics regulated by hydraulic redistribution and (3) understanding how below ground root trait dynamics impact above ground plant growth and productivity.
- A new autonomous sensing methodology to jointly collect subsurface measurements (using ERT and point sensors) and land surface measurements (sensors mounted on poles and unmanned aerial system) to, for the first time, 'watch' bedrock-through-canopy interactions, particularly in response to perturbations.
- New inversion approaches that can incorporate streaming field data to estimate the spatiotemporal dynamics of subsurface properties important for microbial activity, such as heat, water and nutrient fluxes. The new inversion framework has been tested at the Rifle, CO site with autonomously collected above-and-below ground datasets to explore responses to snowmelt and infiltration/evaporation processes.
- Statistical approaches to quantify hot spots and functional zones in the landscape, using multi-scale datasets. The zonation approach provides a tractable approach to capture co-variability among various subsurface and surface properties (such as plant functional types and dynamics, geomorphology, soil thickness and soil biogeochemical properties), and to distribute those properties for parameterizing watershed-scale ecosystem models.

These and other Watershed Function SFA geophysical activities are leading to the development of a 'Digital Watershed'.