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Hillslope Characterization, Measurements, and Modeling

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Important segments of the hydrologic and elemental cycles reside between the soil surface and impermeable bedrock, where subsurface biogeochemical transformations are depth distributed and coupled to the atmosphere and river via dynamic fluxes of gases, water and solutes. We have begun a set of integrated studies to elucidate these processes through characterization, experiments, and modeling of a lower montane hillslope that drains into the East River, Colorado.

A 200 m long transect was instrumented at four stations where 10 m deep boreholes were drilled to provide samples and measurements within soil, saprolite, and fractured shale. Surface and depth-resolved subsurface measurements are being obtained of aqueous and gas phase compositions, pressures, and temperatures. Hydraulic potential measurements show strong evapotranspiration influence within the upper 2 m, underlain by baseflow through the fractured shale. Pedotransfer functions developed based on measured unsaturated/saturated hydraulic properties combined with meteorological data/drivers (temperature, rainfall, solar radiation, snow and soil water content) from field meteorological stations will be used to estimate infiltration and groundwater recharge. These datasets will be used as inputs for predictive modeling of East River hydrological and biogeochemical conditions.

Spanning broader scales encompassing the hillslope transect and floodplain, electrical resistivity tomography (ERT) and seismic refraction were used to delineate the major lithological units including weathered and fractured bedrock. An automated time-lapse ERT system and point-scale sensors to monitor changes in water content and fluid conductivity were also deployed to provide information on vertical and lateral dynamics in vadose zone and groundwater.

Carbon inventories from the soil surface down through fractured shale bedrock are being quantified through a suite of solid, aqueous, and gas phase analyses. Combining these analyses with field gas flux measurements, laboratory soil/sediment incubation studies, depth-profiled metagenome and metatranscriptome analyses from five sites along the transect, and determination of pore water fluxes will help develop a comprehensive understanding of hydrologic and biogeochemical controls on the hillslope carbon cycle and its exports to the atmosphere and river.

Geochemical and integrated hydrologic modeling activities are being designed along the hillslope transect to better predict partitioning of water, carbon and nutrient fluxes at the site. Preliminary results from modeling show the impact of subsurface heterogeneity on the water energy balance. Next steps in modeling will involve incorporating more field observations and detailed characterization into reactive transport models and resolving rates and fluxes under temporal perturbations (e.g., storm events).

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