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Spatial and temporal nitrogen dynamics in a mountainous watershed

Nicholas Bouskill (1), Taylor Maavara (1), Markus Bill (1), Eoin Brodie (1), Rosemary Carroll (2), Mark Conrad (1), Michelle Newcomer (1), Patrick Sorensen (1), Carl Steefel (1), Tetsu Tokunaga (1), Jiamin Wan (1), Erica Woodburn (1), and Kenneth Williams (1)

(1) Lawrence Berkeley National Laboratory, Earth & Environmental Sciences Area, Berkeley, United States (njbouskill@lbl.gov), (2) Desert Research Institute, Division of Hydrologic Sciences, Reno, NV

Mountainous watersheds are characterized by substantial heterogeneity in geomorphology, soil texture, and vegetation that determine hydrological flow paths and residence times through distinct catchment subsystems. Despite advances in understanding the spatial and temporal drivers of biogeochemical cycling within snowmelt-dominated ecosystems, knowledge gaps remain. Here we describe ongoing work employing a combination of field and laboratory measurements alongside multi-scale modeling to characterize and quantify the sources, transformations, and sinks of nitrogen, a major limiting nutrient within the pristine East River (CO) watershed. This work focuses on two distinct spatial scales, a hillslope to floodplain transect, and scaling up to the whole watershed. At the hillslope scale, we employ a combination of geochemistry, isotope geochemistry and molecular microbiology to identify and quantify specific mechanisms regulating the input (e.g., nitrogen fixation, Mancos shale weathering, or atmospheric deposition), retention (plant and microbial accumulation), transformation (mineralization, nitrification) and loss (denitrification or hydrological export) of nitrogen across temporal aridity gradients (capturing baseflow, snowmelt, drought, and monsoonal precipitation). At the scale of the watershed we have built a semi-distributed, coarse scale mechanistic model to characterize how broad features of the landscape (e.g., topography, geology, river sinuosity, soil properties) and biology (vegetation, microbiology) determine the export of nitrogen (as nitrate or organic nitrogen) during distinct periods of the hydrograph. Our model output is benchmarked against high-resolution nitrate and organic nitrogen flux data collected along the East River and major tributaries over 4+ years. Overall, this work intends to improve understanding of the feedback between hydrological perturbation (in the formation and loss of snowpack) and biogeochemical processes to improve predictions of nitrogen export at the watershed scale.