ESS abstract

Geochemical constraints on water, carbon, and nitrogen cycling at different scales in the tundra environment of Barrow, Alaska

Arctic tundra contains large carbon stocks stored in active layer soils and permafrost, and may be an important source of carbon dioxide and methane over the next century due to a rapidly changing climate, degrading permafrost, and redistribution of water across high latitude landscapes. The DOE Office of Science Biological and Environmental Research Program has funded the Next Generation Ecosystem Experiment (NGEE) Arctic project to quantify biogeochemical and biogeophysical processes and to develop model representations of terrestrial climate feedbacks from these systems. This presentation synthesizes geochemical and isotopic data and examines vertical and lateral factors and processes critical to predicting the carbon, nitrogen, and water balance of tundra ecosystems. Stable water isotope analyses (dD and d18O) indicate recharge of higher elevation microtopography and shallow saturated pore waters during summer thaw season from recent precipitation events, with stronger winter and seasonal ice melt contribution to deep pore waters in saturated troughs, ponds, and low-centered polygons. Microtopography and water table effects on geochemistry were also apparent from a comprehensive spatial examination of active layer biogeochemistry, showing a number of significant differences in the concentrations of cations and anions for polygonal type (i.e., high- versus low-centered ice wedge polygons), microtopographic features (polygonal centers versus troughs), and with depth. These results have implications for future nutrient availability. For example, permafrost degradation has the potential to produce a shift from low- to high-centered polygons. Our results showed higher concentrations of oxyanions (sulfate, phosphate, and nitrate) in high centered polygons versus low-centered polygons, suggesting potentially greater availability of these limiting nutrients with projected future microtopographic evolution. Nitrate isotopes (dN15 and d18O) indicated a predominantly microbial source for nitrate in high centered polygon active layers. However, there appears to be a greater component of atmospheric nitrate in permafrost that may serve as a potential indicator of permafrost degradation. Additionally, our results suggest that older, deeper carbon sources may be promoting a shift in methanogenic pathway, from predominantly acetoclastic to hydrogenotrophic. This mechanistic shift is attributed to the source and quality of available organic substrate. Overall, results showed substantial lateral and vertical variability in biogeochemical, biogeophysical, and hydrological processes across microtopographic- to landscape scales that needs to be accounted for in fine and intermediate scale models.