Environmental Controls on Observed Spatial Variability of Soil Pore Water Geochemistry in Small Headwater Catchments Underlain with Permafrost

Nathan Conroy,[1*] Jeffrey Heikoop,[1] Emma Lathrop,[1,2] Dea Musa,[1] Brent Newman,[1] Chonggang Xu,[1] Rachael McCaully,[3] Carli Arendt,[3] Verity Salmon,[4] Amy Breen,[5] Vladimir Romanovsky,[6] Cathy Wilson,[1] and Stan Wullschleger[4]

[1]Earth and Environmental Sciences Division, Los Alamos National Laboratory, Bikini Atoll Road, Los Alamos, NM;
[2]Center for Ecosystem Science and Society, Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ;
[3]Department of Marine Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC;
[4]Biological and Environmental Systems Science Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN;
[5]International Arctic Research Center, P.O. Box 757340, University of Alaska, Fairbanks, AK;
[6]Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK

Contact: (nconroy@lanl.gov)
BER Program: ESS
Project: NGEE Arctic
Project Website: https://ngee-arctic.ornl.gov/

Permafrost thaw in the Arctic is causing significant changes to landscape structure, hydrology, vegetation, and biogeochemistry. The integrated hydrogeochemical effect of these environmental changes are already apparent in the chemistry of the large Arctic rivers, where fluxes of carbon and nutrients are increasing, leading to enhanced nutrient loadings, with strong implications for the global carbon cycle. While the watershed areas of large Arctic rivers are vast, recent studies suggest that solute concentrations in these large rivers are likely controlled by solute generation processes occurring at much smaller scales. In this sense, changes in hydrogeochemistry in small Arctic catchments not only impact hydrogeochemistry at much larger scales, but also prognosticate the future hydrogeochemistry of larger Arctic rivers. While there is a rapidly growing body of literature focused on observing and understanding the impacts of Arctic warming on landscape structure, hydrology, vegetation, and biogeochemistry, relatively few studies directly address the existing spatial variability. In this study, we quantitatively evaluate the spatial variability of soil pore water geochemistry within two distinct catchments underlain with permafrost, and then seek to identify the source of the observed spatial variability. The soil pore water geochemistry of 18 locations spanning two small Arctic catchments were examined for spatial variability and its dominant environmental controls. The primary environmental controls considered were vegetation, soil moisture/redox condition, water/soil interactions and hydrologic transport, and mineral solubility. The sampling locations varied in terms of vegetation type and canopy height, presence or absence of near-surface permafrost, soil moisture, and hillslope position. As source areas for geochemical fluxes to the broader Arctic hydrologic system, geochemical processes occurring in these environments are particularly important to understand and predict with regards to such environmental changes.