Use of Environmental Tracers for Multi-Scale Investigation of Hydrologic Mixing and Connectivity in the Arctic Coastal Plain, near Barrow, Alaska

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As part of the US DOE, Office of Science, Next Generation Ecosystem Experiment-Arctic project, we have been using environmental tracers (naturally occurring stable isotopes and geochemical species) to understand the hydrology within polygonal ground and the broader landscape in a continuous permafrost area near Barrow, Alaska. Field sampling in late May to early June (2013) during the snowmelt period showed broad hydrologic connectivity of surface water up to the landscape scale. However, the importance of snowmelt water was short lived and by early June, rainfall and the thawing active layer were the dominant sources of water. Broad-scale synoptic sampling in July and September, 2013 revealed a great deal of hydrological heterogeneity between interlake basin areas, drained thaw lake basins, and major drainages. By mid- to late-summer, isotope and chemical data suggest that stagnant or low flow parts of the landscape are common, with little active connection to larger scale drainages. High depth- resolution, passive sampling of active layer saturation in polygonal ground in 2012 and 2013 using diffusion cells often showed well developed and sometimes substantial geochemical gradients for multiple analytes within saturated zones that were less than 50-cm thick. Such gradients imply a lack of vertical mixing within the active zone. Reductions in permeability with depth and lack of strong hydrological gradients likely limit vertical mixing. These results have implications for understanding spatial variability in methane and carbon dioxide production, and surface water evaporation. Hydrological models should reflect the observed rapid loss of snowmelt water, a summer landscape with limited lateral connectivity, and a lack of mixing with depth. Environmental tracers will also be useful for examining the degree and timing of hydrologic connectivity in landscapes with discontinuous permafrost (e.g., Seward Peninsula) or significant topography.