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The Impact of Scale: Iterative Approach to Understanding Soil Heterogeneity in Actively Thawing Permafrost Watersheds in Alaska

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Across the arctic, permafrost degradation is reshaping northern ecosystems through substantial changes in soil water content, elemental fluxes to soil porewaters and surface water, and oxidation-reduction (redox) processes. Unprecedented climate warming is adding rapid spatial and temporal change to an already highly heterogeneous system. Mechanical, physical, and biogeochemical soil measurements for arctic soils are time-intensive to collect and field sites are difficult to access. As such, input parameters for models tend to be derived from single observations that may not be temporally or spatially representative or representative of the complicated subsurface environment. Additionally, uncertainties associated with sample heterogeneity, collection procedures, and laboratory processing remain understudied, yet they are integral for assessing the overall impact of permafrost thaw on biogeochemical processes in arctic terrains. In this new study, we couple highly-controlled laboratory measurements with bulk site-scale measurements to understand soil biogeochemical variability related to soil moisture across different scales and assess predictive power using geostatistical regression methods. Key measurements include soil temperature, soil moisture, soil strength, hydraulic conductivity, wettability, respiration, and redox across multiple sites. Preliminary results show seasonality plays a significant role in redox processes and permafrost thaw is directly contributing to mobilization of elements to soil porewaters. However, overall concentrations remain intricately tied to soil type, which changes at a sub-meter scale. Changes in soil type within a catchment and differences in soil water content across redox boundaries (i.e. the active layer transition zone) may be detectable by non-invasive geophysical techniques, potentially making geophysical applications sensitive enough to map geochemical gradients both at the plot- and landscape-scale. With this work, soil estimations may be more accurately and statistically scaled to the catchment, which will aid in quantifying the impact permafrost thaw has on biogeochemical processes in the arctic.