Investigating Soil Organic Matter Composition and Degradation State Across Hillslope Positions in the Arctic Foothills of Alaska

Roser Matamala[1], Nicolas Jelinski[2], Irfan Ainuddin[2], Chien-Lu Ping[3], Julie Jastrow[1]

[1]Argonne National Laboratory, Lemont, IL
[2]University of Minnesota, Twin Cities, MN
[3]University of Alaska Fairbanks, Palmer, AK

Contact: (matamala@anl.gov)
Project Lead Principal Investigator (PI): Julie Jastrow
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Project Abstract: In the permafrost region, the soil organic carbon (SOC) stocks of hilly terrains are highly uncertain. In particular, frozen hill-toe soil deposits are one of the highest uncertainties at the circumpolar scale. The vulnerability of SOC stocks to warming depends on ice contents and the amount and composition of soil organic matter (SOM) occurring at different depths across the landscape. In addition to erosion and other processes, hillslopes in the Arctic are impacted by permafrost-affected solifluction and other lateral mass movements, cryoturbation, and patterned-ground formation. These processes might differently affect the accumulation, distribution, and decomposition of SOM across hillslope toposequences. We investigated the composition and degradation state of SOM at different landscape positions across two toposequences formed on differing land surface ages in the Arctic Foothills of Alaska. The soil profiles of seven hillslope positions (summit, shoulder, upper and lower backslope, upper and lower footslope, and basin) were sampled by soil layers to depths of 1-3 m. We determined SOC stocks and water/ice contents at comparable hillslope positions for each toposequence. We also evaluated profile variations in SOM composition (organic functional groups and minerals) and indicators of SOM degradation state by analyzing the mid-infrared spectra of the soil. Both hillslopes contained large SOC stocks to 1-m depth across the toposequence. Volumetric ice content was high at all hillslope positions with pore ice and ice lenses forming a range of soil cryostructures. Ice-wedges were observed at summit, shoulder, lower footslope, and basin positions. A principal component analysis indicated similar SOM composition occurred across all slope positions with the exception of the basin areas, where greater accumulation of non-polar methyl group compounds dominated over other organic functional groups. Indicators of SOM degradation state, such as high ratios of carboxylates to polysaccharides, were negatively correlated with SOC content suggesting that SOM associated with mineral soil layers were more degraded than organic or mixed organic/mineral layers. Next steps will focus on understanding how SOM degradation state varies with the depth distribution of different soil layers across each toposequence — with the aim of generating spatially explicit local and regional estimates of SOM degradation state and potential decomposability for hillslope-dominated arctic landscapes.