Soil Carbon Response to Environmental Change – Argonne Soil Dynamics SFA Overview

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Project Abstract: The Argonne Scientific Focus Area (SFA) on soil dynamics conducts fundamental research to quantify and characterize soil carbon stocks, evaluate their potential responses to environmental change, and develop data products that can inform model development. We envision our role in the DOE integrated model-observation-experiment paradigm (ModEx) as translating an understanding of the processes and mechanisms driving the distribution, composition, and dynamics of soil organic carbon stocks into (1) informed collection of new observations, (2) characterization of soil organic matter (SOM) pools and factors affecting their dynamics and persistence, and (3) development of products to benchmark, constrain, and validate process models at multiple scales.

At present, research focuses on soils of the northern circumpolar permafrost region, where climatic changes are causing widespread permafrost thawing, hydrologic changes, and related disturbances that are accelerating SOM decomposition rates and increasing greenhouse gas emissions from one of Earth's largest organic carbon reserves. Current SFA objectives are (1) provide reliable assessments of the spatial and vertical distributions of soil carbon stocks in permafrost regions, and (2) develop empirical tools for predicting the potential decomposability of carbon stored in permafrost region soils. Our approach to these objectives integrates focused field campaigns and new sample collection, archived soil resources, laboratory/spectroscopic analytical tools, and geospatial modeling. To reduce observational uncertainties caused by the unique cryo-pedogenic processes occurring across permafrost-affected landscapes, our field campaigns are targeting how soil carbon distributions are influenced by development of ice-wedge polygons on lowland coastal plains, topographic position within hillslope landscapes, and formation of river deltas. To evaluate the relationships between the composition and potential decomposability of SOM pools preserved in permafrost-region soils, we are coupling physical/chemical fractionation and spectroscopic approaches with standardized incubation bioassays. Multivariate calibration models are being developed to predict these laboratory measurements from the mid infrared (MIR) spectra of bulk soils representing different circumpolar soil types and ecoregions. Ultimately, the calibration models will be applied to the MIR spectral library we are building for soils collected by the SFA and its collaborators from across the northern circumpolar region to enable widespread geospatial interpolation and assessments of SOM composition and potential decomposability at landscape to regional scales.