ANL Terrestrial Ecosystem Science SFA: Soil Carbon Response to Environmental Change

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The Argonne TES SFA conducts fundamental research to quantify and characterize carbon stored in soils and evaluate its potential responses to environmental change. SFA research is currently focused on soils of the northern circumpolar permafrost region, where one of Earth's largest carbon reserves is being held in a state of disequilibrium because of the perennially frozen conditions. Global warming is expected to release significant amounts of carbon dioxide and methane from circumpolar permafrost soils to the atmosphere, potentially creating a positive feedback that will accelerate the rate of climatic change. Confidence in model predictions of this mineralization response is limited by knowledge gaps concerning the distribution and potential vulnerability of permafrost-sequestered carbon stocks.

Hence, our SFA aims to quantify the carbon currently preserved in soils of the permafrost region, determine its spatial and vertical distributions, and assess how susceptible this carbon is to decomposition and release to the atmosphere. Interpretation of soil forming processes will be used to iteratively identify under-sampled locations, obtain new data, characterize spatial and vertical heterogeneity, and generate geospatial extrapolations of soil carbon stocks at landscape and regional scales. Empirical tools will be developed to characterize existing forms of organic matter in permafrost-region soils and evaluate their intrinsic potential for mineralization. SFA products will reduce the uncertainties in regional and global simulations produced by coupled carbon-climate models by informing model calibration and by providing observational references for model validation.

Currently, our research is focused on:

1. Characterization of the spatial heterogeneity of soil carbon stocks in polygonal soils. We are studying the distribution of carbon stocks of low-, flat-, and high-centered polygons in the context of the microtopography associated with troughs, rims, and centers. Polygons representing latitudinal and longitudinal gradients across the North Slope of Alaska are being compared to determine if the heterogeneity of soil carbon stocks can be described and generalized by using a super-pedon approach at the scale of individual polygons.

2. Development of mid-infrared (MidIR) spectroscopy as a tool for characterizing the relative degradation state of organic carbon stored in permafrost-region soils. We are building a circumpolar database of MidIR spectra for active layer and permafrost soil horizons. A variety of multivariate statistical techniques will be used to interpret spectra in the context of applicable metadata to enable development of a relative degradation index for mapping the potential vulnerability of permafrost soil carbon stocks.