ANL Terrestrial Ecosystem Science SFA: Characterizing organic matter quality and lability of Alaskan soils using mid infrared spectroscopy

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Soils in Arctic and sub-Arctic regions contain large amounts of organic matter that has been preserved in a relatively undecomposed state due to cold and often wet conditions, but the potential vulnerability of this organic matter to climate change is largely unknown. We are developing empirical tools for predicting the potential decomposability of organic C stored in these soils and for informing model development. In this study, we used diffuse-reflectance Fourier-transform mid-infrared spectroscopy (MidIR) to investigate soil organic matter (SOM) quality along a latitudinal gradient (78.79° N to 55.35° N) in Alaska and, in combination with soil incubations, to assess the lability of active-layer and upper permafrost SOM. The gradient encompassed 29 sites representing 10 vegetation types and 7 soil parent materials. Multiple soil horizons from each site were scanned to obtain MidIR spectra and were analyzed for organic and inorganic C, total N, particle size distribution, pH, cation exchange capacity, and exchangeable cations. Principal component analysis (PCA) of the MidIR spectra identified 20 bands that varied across vegetation type and parent material, with PCA axis one explaining 75.8% and 70.7% of the variation, respectively. Most of the identified bands were correlated with soil C concentrations. We found that single spectral bands could be relatively strong predictors of total organic C (2925), inorganic C (2512), Ca (1725), K (1226), and clay content (3675). Ratios of characteristic bands have been proposed in the literature as indicators of SOM quality or relative degradation state. We compared a suite of these band ratios and found that several were also indicative of SOM quality for the Alaskan soils. We also incubated active-layer organic and mineral soils and upper permafrost soils from selected tundra sites for 60 days at -1, 1, 4, 8 and 16 °C. Characteristic MidIR bands and band ratios identified via the latitudinal gradient were correlated with total CO_2 mineralized during the incubations. Several bands and band ratios (e.g., the ratio of lignin amides to lignin phenols) were significantly correlated with cumulative respired CO_2 as a function of incubation temperature, suggesting they might serve as useful lability indicators. Further investigation of these characteristic bands and band ratios for additional soils and for longer term incubations are needed to fully assess their utility as indicators of the relative degradation state and potential decomposability of permafrost-region soils.