Understanding Composition and Decomposability of Arctic Soils by Integrating Laboratory Incubations with Spectroscopy Measurements and Models

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Project Abstract: In the permafrost region, the relative importance of mechanisms affecting soil organic carbon (SOC) mineralization rates differ from those of other ecoregions. Thus, the composition and potential decomposability of soil organic matter (SOM) are key uncertainties in models projecting the amount of SOC that might be released to the atmosphere from this region. In past studies, we demonstrated that the mid-infrared (MIR) spectra of bulk soils are sensitive to the degradation state of SOM and can predict short-term carbon mineralization from arctic tundra soils. Here, we explore the decomposability of soils collected from ice-wedge polygons formed on glaciomarine sediments near Utqiaġvik, Alaska. The soils were incubated aerobically at 15°C and 5°C for more than two years, and CO_2 production was measured periodically and modeled. Soil physicochemical properties including particle density, total organic carbon, total nitrogen, and SOM composition were also determined. We derived very good partial least square regression (PLSR) models of cumulative CO_2 production (expressed on the basis of soil mass) from the MIR spectra of these soils. Analysis of the beta coefficients for the PLSR models suggest that the amounts of clay minerals, silicates, and the organic functional groups indicative of aliphatics and polysaccharides were the primary drivers of differences in SOC mineralization. Although the cross validation PLSR models had R^2 values ranging from 0.93 to 089 for incubation periods of 6 to 24 months, the PLSR models tended to underestimate CO_2 production after 6 months. Thus, we are currently evaluating whether other chemometric or machine learning algorithms can improve predictions of long-term mineralization. Nevertheless, the overall success of the PLSR models demonstrates the predictive potential of MIR spectra, which is derived from the ability of this analytical tool to integrate information on the amounts of both SOC and soil minerals, as well as the types of organic compounds in each soil. The ultimate goal of our research is to link geo-referenced estimates of SOM composition and potential decomposability with environmental co-variates to create geospatial assessments and maps, which can serve as benchmarks for process models at landscape, regional, and global scales.