Radiocarbon measurements to assess soil carbon vulnerability in Arctic coastal tundra

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Permafrost soils contain large, old carbon stores, protected from decomposition by frozen, cold, and waterlogged conditions. If climate change causes high latitude soils to warm and dry, carbon emissions from permafrost soils could be an important atmospheric greenhouse gas source. There is no consensus, however, on how high latitude soil carbon decomposition will respond to soil thaw and warming, due to environmental heterogeneity, complex controls on microbial processes, uncertain carbon stocks and flux rates, and poorly understood soil carbon stabilization mechanisms. To address these knowledge gaps, we are using radiocarbon measurements to estimate soil carbon turnover times and temperature sensitivities in polygonal tundra in Barrow, Alaska. Specifically, we ask: (1) how do soil carbon residence times vary with depth across distinct soil features, and (2) what are the relative temperature sensitivities of different age soil carbon pools? Old radiocarbon ages of soil organic matter in perennially frozen soils and deep portions of the seasonally thawed active layer reflect slow historic decomposition rates, and variations in the radiocarbon content of respired CO_2 indicate variable contributions of this old carbon to total decomposition flux. At five times in 2012 and 2013, we sampled soil organic matter and respired CO_2 from low-centered, flat-centered, and high-centered polygons characteristic of a permafrost degradation cycle. We measured the radiocarbon content of CO_2 in surface fluxes and soil pore space from 3 depths in the soil profile, concurrently incubating active layer soils to resolve the 14C-CO_2 signatures of individual soil layers. Additionally, we incubated soils at 2 temperatures, using radiocarbon measurements of respired CO_2 to determine relative temperature sensitivities of old and recently fixed carbon. Preliminary data show that CO_2 ages increase with depth from modern radiocarbon ages to as old as 3115 BP, and high incubation flux rates indicate availability to microbes. Preliminary results from the temperature manipulation show slight shifts in Δ14C-CO_2 between temperature treatments, indicating different temperature sensitivities of old and recently fixed carbon. These shifts are particularly pronounced in well-drained, upland soils, suggesting variable stabilization mechanisms across an environmental gradient. This research is part of the Next Generation Ecosystem Experiment (NGEE-Arctic), a multi-institutional collaboration that has the goal of improving models of Arctic greenhouse gas fluxes through combined observational, experimental, and modeling studies. Results from this study will be integrated with a broad range of measurements from the cm- to the landscape-scale spanning biogeochemistry, geophysics, vegetation, microbiology, micrometeorology, and hydrology.