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ABSTRACT: According to current estimates, permafrost soils store more than two times the carbon as the carbon in atmospheric CO_2. With climate change causing high latitude soils to warm and dry, this soil carbon will likely become more available to decomposition. The magnitude of these predicted carbon emissions as CO_2 and methane (CH_4) are poorly constrained due to several factors, including fine-scale environmental heterogeneity, unknown and complex controls on microbial processes, and uncertainty in carbon stocks and current emissions rates. This work aims to improve our ability to predict Arctic greenhouse gas fluxes from the cm- to the landscape-scale by investigating the biological and environmental controls on CO_2 and CH_4 production, consumption, and emissions. On the Arctic coastal plain in Barrow, Alaska, we combine a suite of biogeochemical measurements beginning in 2012 and extending through 2013. We measure in situ trace gas fluxes using static chambers and eddy covariance towers across a range of landscape features; greenhouse gas concentrations in soil pore space and stable and radioisotopes throughout the soil depth profile; soil physical data such as temperature and moisture at depth; and vegetation greenness using normalized difference vegetation index (NDVI). In laboratory experiments with soils collected on site and incubated at two temperatures, we measure CH_4 and CO_2 flux and the radiocarbon content of respired CO_2 and bulk soil. Initial results from 2012 indicate that landscape polygon feature, soil water content, soil temperature, and sampling location all influence CO_2 and CH_4 fluxes. Soil CO_2 fluxes measured with static chambers decreased toward the end of the growing season, whereas CH_4 fluxes remained constant or increased. From half-hourly eddy covariance data between September and October 2012, net ecosystem exchange ranged between -0.02 and 0.10 g C m^{-2}, and maximum evapotranspiration and CH_4 flux were 0.03 mm, and 50 mg CH_4 per half hour respectively. NDVI values correlate well with microtopographical polygon features. Stable isotope measurements indicate methane production in deeper and wetter soils, with increasing methane oxidation toward the soil surface, dependent on polygon feature. ^{14}C data show that CO_2 respired from deep soils is very old relative to surface soils. Taken together, along with ancillary microbial, geophysical, hydrological, and vegetation data from collaborative research teams, our results suggest that soil moisture is a major control on carbon cycling processes, with interacting environmental and biological effects. Continued research through 2013 will further investigate the vulnerability to climate change of this region's old carbon stores.