Poster #59

Resolving Conflicting Physical and Biochemical Feedbacks to Climate in Response to Long-Term Warming

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The acceleration of global warming due to terrestrial carbon (C)-cycle feedbacks is likely to be an important, though poorly defined, component of future climate change. Both the sign and magnitude of these feedbacks in the real Earth system are still highly uncertain due to gaps in basic understanding of terrestrial ecosystem processes. This research takes advantage of an ongoing long-term soil warming experiment in which soils at the Harvard Forest LTER in Massachusetts have been heated for 24 years. By examining this long-term climate warming manipulation, this research targets two of the biggest questions in soil carbon response to climate warming: how will carbon use efficiency and physical protection of carbon altered in a warming world?

Long-term warming has caused the soil system to act as a positive feedback to climate, but our studies show microbes acting to promote negative feedbacks to climate. Over 24 years of warming has resulted in a 16% loss of the soil C in the top 60 cm of the soil, with a quarter of this loss happening in the last 5 years. This positive feedback is in contrast to evidence that microbes are promoting negative feedbacks, including increased simple (monomeric) C use efficiency (CUE) in heated compared to control plots, reduced microbial biomass, and thermal acclimation of microbial respiration. In other systems, CUE of complex C, which requires extracellular processing, tends to be lower than that for simple C. To account for the increased C lost as CO_2 with long-term warming, we expect to find that warming has decreased the CUE of complex (but not simple) C, which may account for the large loss of soil C over time. Physical protection is afforded to SOM by adhesion to mineral surfaces as well as by occlusion in aggregates, and these experiments will quantify both. We have also observed altered physical protection with long-term warming, where the SOM pool in the mineral soil is less processed in the heated compared to control plots. Modeling and sensitivity analysis will test the relative magnitude and interactions of physical protection and CUE for substrates of varying complexity, which will also be validated in lab studies of CUE of whole versus crushed aggregates. This work will improve the integration physical protection and C complexity into climate models, and scale measured biological, chemical and physical parameters to improve predictions of global C cycle feedbacks in a warmer world.