Poster# 103

Modeling the Response of Soil Carbon Decomposition and Stocks to Warming with a Focus on Minerals and Microbes

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Climate warming may reduce soil organic carbon (SOC) stocks if higher temperatures increase decomposition rates. It is uncertain, however, how vulnerable SOC is to warming, or what processes– abiotic and biotic – determine SOC stocks over long timescales. In this poster, we will present results of the Berkeley Lab Terrestrial Ecosystem Science SFA aimed at improving our ability to predict SOC cycling. Comparing observed SOC stocks along a 4,000 km transect in South America to model predictions of SOC using a sorption isotherm, we found that mineral sorption capacity was the dominant control over steady-state SOC stock, and that mineral-bound C is vulnerable to warming. Further, our model suggests that soil can gain or lose C after warming, independent of NPP, depending on assumptions about microbial acclimation and sorption. The type of sorption equation used in soil decomposition models has large implications for SOC stock and its temperature sensitivity. Thus, we compared different model formulations of SOC sorption to mineral surfaces, such as Langmuir, linear, and Freundlich, motivated by the diversity of chemical associations between organic and mineral surfaces.

Biotic interactions such as community-level regulation also affect decomposition rates. We evaluated four archetypal microbial models that range in complexity, finding that insufficient limitations on microbial activity result in unrealistic oscillations and insensitivity of C stocks to plant inputs, diverging from observations. We show that a density-dependent formulation of microbial turnover, motivated by community-level interactions, constrains oscillatory behavior. Comparing model predictions to 24 long-term C-input field manipulations reveals that the density-dependent formulation reproduces soil C responses to long-term C-input changes. C inputs also affect decomposition via effects on microbial nitrogen (N) limitation. Using a metaanalysis of carbon-use efficiency (CUE) observations to constrain the modeled effect of N limitation on decomposition, we found that modeled CUE declined with microbial N limitation due to C-overflow and -acquisition strategies that favor N immobilization. Further, competition between two or more microbial populations for N affected the apparent CUE of the modeled community. These model-development activities are part of ongoing efforts to scale abiotic and biotic controls on soil decomposition for inclusion in earth system models. LBNL