A Mechanistic Model of Climate Sensitivity Hysteresis of Soil Organic Matter Dynamics

Jinyun Tang[1*] and William J. Riley[1]

[1]Earth & Environmental Science Area, Lawrence Berkeley National Laboratory, Berkeley, CA Contact:

(jinyuntang@lbl.gov)
Project Lead Principle Investigator (PI): Stan Wullschleger BER Program: TES
Project: NGEE Arctic
Project Website: https://ngee-arctic.ornl.gov

Empirical observations have indicated that the climate sensitivities—temperature and moisture— of soil organic matter (SOM) decomposition are very likely hysteretic. However, most existing models of SOM dynamics assume these climate sensitivities as deterministic, leading to predictions that are lacking observed temporal variability, and degrading the credibility of projected long-term SOM dynamics. We here use first-principle-based theories to assemble a SOM model that explicitly resolves the interactions between microbes, substrates, enzymes, mineral surfaces, and physical transports. The model makes predictions of hysteretic responses of SOM decomposition to changing temperature and moisture conditions that are consistent with a range of empirical observations. Since our model also predicts important emergent parameters (e.g., carbon use efficiency, substrate affinity, etc.) that are treated as constant in other models, it allows us to demonstrate that it is the lack of parametric variability that makes the traditional response function-based models to underestimate the climate sensitivities of SOM dynamics, and overestimate the predictive uncertainty resulting from the parametric equifinality. We further discussed how our approach can be extended to improve the modeling of other climate sensitive soil biogeochemical processes.