Towards a Paradigm Shift in the Modeling of Soil Organic Carbon Decomposition for Earth System Models

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BIO

I obtained my bachelors in Environmental Science and Engineering in 2010, undergrad thesis was on multivariate analysis of the odor component from livestock farms. I decided to apply for phD program in ecosystem modeling because I felt learning how the nature works is very intriguing. I started my phD at EAPS in 2010 fall and started off with 2 side projects on the application of terrestrial ecosystem model in paleoecology and model sensitivity analysis. After that, I became very interested in systematic analysis of model formulations, such as sensitivity analysis, conceptual formulation, and data-model assimilation. Belowground ecology is always a research hot-spot and is relatively under-studied comparing to above-ground processes. In addition, current modeling of soil carbon dynamics is overly simplified and lagged behind current advances in soil science. These all helped me formulate my final dissertation topic.

Abstract

Soils are the largest terrestrial carbon pools and contain approximately 2200 Pg of carbon. Thus, the dynamics of soil carbon plays an important role in the global carbon cycle and climate system. Earth System Models are used to project future interactions between terrestrial ecosystem carbon dynamics and climate. However, these models often predict a wide range of soil carbon responses and their formulations have lagged behind recent soil science advances, omitting key biogeochemical mechanisms. In contrast, recent mechanistically-based biogeochemical models that explicitly account for microbial biomass pools and enzyme kinetics that catalyze soil carbon decomposition produce notably different results and provide a closer match to recent observations. However, a systematic evaluation of the advantages and disadvantages of the microbial models and how they differ from empirical, first-order formulations in soil decomposition models for soil organic carbon is still lacking. This study consists of a series of model sensitivity and uncertainty analyses and identifies dominant decomposition processes in determining soil organic carbon dynamics. Poorly constrained processes or parameters that require more experimental data integration are also identified. The critical role of microbial life history trait, such as microbial dormancy, in the modeling of microbial activity in soil organic matter decomposition models is also demonstrated through ablation analysis. Finally, this study also surveys and synthesizes a number of recently published microbial models and provides suggestions for future microbial model developments.