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Towards a new global soil organic carbon model representing microbial interactions, sorptive stabilization, DOC leaching, and bioturbation

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Most Earth System Models represent soil organic carbon (SOC) as zero-dimensional pools of organic matter decaying according to first order kinetics with decomposition rates which vary solely with soil temperature and moisture. These simplistic representations are inconsistent with understanding of the mechanisms underlying soil carbon cycling. SOC stabilization and mineralization are controlled by a range of processes that depend on climate, vegetation, and soil properties, and respond differently to environmental forcing. Furthermore, the vertical dimension plays a central role in SOC cycling since the relevance of different processes varies along the profile.
We have developed a new SOC model which includes all processes thought to be relevant for carbon dynamics in well-drained soils but is sufficiently parsimonious for global application. Rather than relying on pools with intrinsic decomposition rates, the model explicitly represents stabilization due to adsorption to minerals and energy limitation of microbes. Furthermore, the vertical distribution of organic matter over the organic layer and the mineral soil is explicitly simulated based on representations of bioturbation, dissolved organic carbon transport, and the vertically distributed root litter input. The model is calibrated and tested based on site level data. In order to apply it at global scale it has been coupled to the ecosystem model JSBACH, which is the land surface component of the MPI Earth system model. We will show first global results of the new model under contemporary climate.
Additionally, we will explore the relevance of considering vertical heterogeneity for SOC cycling at global scale, by running the model in a multi-layer as well as a single-layer configuration. Reduction of decomposition due to limited availability of fresh substrates for microbes is an important mechanism for SOC stabilization, particularly in the deep soil. Since this mechanism is (partially) relieved by ignoring vertical heterogeneity, we hypothesize that this will lead to lower soil carbon stocks and shorter residence times.