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Elaborating consequences of variation in microbial carbon-use efficiency for soil organic carbon storage and turnover using the COMISSION model

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The carbon-use efficiency (CUE) of the microbial community is describing the partitioning of carbon uptake into respiration and growth (building of microbial biomass and extracellular compounds). In most soil carbon models, CUE is an important, time-invariant parameter, which strongly affects the build-up and persistence of organic carbon (OC) in soils. However, a number of studies have shown that CUE is not constant, but sensitive to environmental and biological drivers like substrate composition and stoichiometry, microbial community structure, and temperature. Yet, the sensitivity of soil carbon models to varying CUE has so far only rarely been addressed.

In conventional soil carbon models, SOC stocks are scaling with litter input. A decline in CUE is leading to a decline in SOC storage, as more OC is being respired and less transferred to other pools. Recent years have seen the development of a new generation of soil carbon models, in which microbial biomass is explicitly represented with its twofold role as decomposer of SOC and potential source for SOC via microbial residues. Also in these microbially-explicit models, a decline in CUE increases CO_2 emissions per unit microbial biomass and accordingly potentially decreases SOC storage. However, since the corresponding smaller microbial biomass is also reducing soil OC decomposition, the net effect of variation in CUE on soil OC storage is not as straightforward as in conventional models. Some microbial model studies suggested for example that the negative effect of increasing temperatures on soil OC storage can be offset or even be reversed into net carbon gains when it is accompanied by a decline in CUE (Wieder et al. 2013, Li et al. 2014). When looking in contrast at stoichiometric constraints, reduced nutrient availability is assumed to reduce CUE. However, this nutrient-related CUE effect is a odds with the often observed increase in litter layer thickness with reduced litter quality.

The net effect of variation in CUE on SOC storage of microbial carbon models will depend in the way the feedback mechanisms and the fate of microbial necromass are implemented and parameterized in the models. With COMISSION, we have developed a soil carbon model, where not only feedbacks between microbial biomass and decomposition are considered, but also sorption of OC to minerals, which reduces OC availability, and we recently also added the nitrogen and phosphorus cycle. We will use this model to elaborate the role of CUE and corresponding microbial feedbacks and their parameterization for SOC storage and turnover using examples of varying litter input, temperature, or substrate stoichiometry. We hypothesize that mineral sorption will dampen the feedback loops in microbial models, resulting in simulation results more similar to conventional models.