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Model structure uncertainty of SOC dynamics studied in a single modeling framework

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The aim of our study is the source of uncertainty in soil organic carbon (SOC) models which comes from the model structure. For that we have developed a family of mathematical models for SOC dynamics with switchable biological and physical mechanisms. Studies mechanisms include microbial activity with constant or dynamic carbon use efficiency (CUE) and constant or dynamic microbial turnover rate; priming effect: decay of stable SOC pool in the presence of labile SOC pool; temperature and moisture dependencies of SOC decomposition rates; dynamic adsorption strength and occlusion. Model SOC cycle includes measurable C pools in soil size and density fractions, each comprised of two estimated theoretical C pools (labile and stable - biochemical C cycle). Reaction rates of the biochemical cycle are modified according to its physical state: decay accelerates with size, accelerates with the amount of adsorbed C (density: heavy to light) and decelerates with soil microaggregation (occluded state). The models family was tested on C and 13C dynamics detailed data of a long-term bare fallow chronosequence.

Analysis of SOC models family with different combinations of mechanisms showed that the best (estimated by BIC) description of SOC dynamics in physical fractions was with microbially-explicit models only in case of a feedback via dynamics of microbial turnover and CUE. First, we estimated uncertainty of all mechanism-specific parameters for every model in the family. We calculated density distributions for parameters characterizing functional properties and stability of soil components (such as energy of activation, adsorption capacity, CUE, 13C distillation coefficient) for the models family weighted with models likelihoods. These parameter values were then compared with common experimental values.

We discuss the use of the study results to estimate relevance of observed parameter and structural uncertainties for global SOC projections obtained using different model structures.