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Modeling the effects of litter stoichiometry and soil mineral N availability on soil organic matter formation

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Microbial decomposition of plant litter is a crucial process for the land carbon (C) cycle, as it directly controls the partitioning of litter-C between CO_2 released to the atmosphere versus the formation of new soil organic matter (SOM). Land surface models used to study the C cycle rarely considered flexibility in the decomposer C use efficiency (CUE_d) defined by the fraction of decomposed litter-C that is retained as SOM (as opposed to be respired). In this study, we adapted a conceptual formulation of CUE_d based on assumption that litter decomposers optimally adjust their CUE_d as a function of litter substrate C to nitrogen (N) stoichiometry to maximize their growth rates. This formulation was incorporated into an empirical soil biogeochemical model (CENTURY) and a microbial explicit model (the MIcrobial-MIneral Carbon Stabilization (MIMICS) model). Then the two models with new CUE formulation were evaluated based on data from laboratory litter incubation experiments and large-scale *in situ* observations of present-day soil organic C (SOC) stock in Europe and China. Results indicated that the CENTURY model with new CUE_d formulation was able to reproduce differences in respiration rate of litter with contrasting C:N ratios and under different levels of mineral N availability, whereas the default model with fixed CUE_d could not. Using the CENTURY with flexible CUE_d, we also illustrated that litter quality affected the long-term SOM formation. Litter with a small C:N ratio tended to form a larger SOM pool than litter with larger C:N ratios, as it could be more efficiently incorporated into SOM by microorganisms. Both the CENTURY and MIMICS model with flexible CUE can reasonably capture the observed present-day SOC stocks at European and China forest sites, although a large bias between the observed and simulated SOC stock, which was potentially caused by the uncertainties in litterfall inputs, historical land use change, soil erosion and some other factors (e.g. soil structure) that has not been considered in these two tested models, have been observed. This study provided a simple but effective formulation to quantify the effect of varying litter quality (N content) on SOM formation across temporal scales. Optimality theory appears to be suitable to predict complex processes of litter decomposition into soil C, and to quantify how plant residues and manure can be harnessed to improve soil C sequestration for climate mitigation.