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Implementation of mycorrhizal mechanism into a soil carbon model improves the prediction of long-term processes of plant litter decomposition

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Mycorrhizae, a plant-fungal symbiosis, is an important contributor to below ground-microbial interactions, and hypothesized to play a paramount role in soil carbon (C) sequestration. Ectomycorrhizae (EM) and arbuscular mycorrhizae (AM) are the two dominant forms of mycorrhizae featured by nearly all Earth plant species. However, the difference in the nature of their contributions to the processes of plant litter decomposition is still understood poorly. Current soil carbon models treat mycorrhizal impacts on the processes of soil carbon transformation as a black box. This retards scientific progress in mechanistic understanding of soil C dynamics.

We examined four alternative conceptualizations of the mycorrhizal impact on plant litter C transformations, by integrating AM and EM fungal impacts on litter C pools of different recalcitrance into the soil carbon model Yasso15. The best performing concept featured differential impacts of EM and AM on a combined pool of labile C, being quantitatively distinct from impacts of AM and EM on a pool of recalcitrant C.

Analysis of time dynamics of mycorrhizal impacts on soil C transformations demonstrated that these impacts are larger at the long-term (>2.5yrs) litter decomposition processes, compared to the short-term processes. We detected that arbuscular mycorrhizae controls shorter term decomposition of labile carbon compounds, while ectomycorrhizae dominate the long term decomposition processes of highly recalcitrant carbon elements. Overall, adding our mycorrhizal module into the Yasso model greatly improved the accuracy of the temporal dynamics of carbon sequestration.

A sensitivity analysis of litter decomposition to climate and mycorrhizal factors indicated that ignoring the mycorrhizal impact on the decomposition leads to an overestimation of climate impacts. This suggests that being co-linear with climate impacts, mycorrhizal impacts could be partly hidden within climate factors in soil carbon models, reducing the capability of such models to mechanistically predict impacts of climate vs vegetation change on soil carbon dynamics.

Our results provide a benchmark to mechanistic modelling of microbial impacts on soil C dynamics. This work opens new pathways to examining the impacts of land-use change and

climate change on plant-microbial interactions and their role in soil C dynamics, allowing the integration of microbial processes into global vegetation models used for policy decisions on terrestrial carbon monitoring.