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Separating soil organic carbon dynamics in the rhizosphere and the mineral soil to model depth profiles of organic carbon, δ13C and Δ14C

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Over the past decades, our understanding of soil organic carbon (SOC) cycling has evolved to one where its persistence is mainly due to physical and chemical protection mechanisms, while soil microbes are now acknowledged as being the main precursor of stabilized OC. In line with this understanding, microbial-driven SOC models that explicitly account for these mechanisms have been developed during the past years. While 14C has been widely used to calibrate and validate SOC models, stable carbon isotopes (δ13C) have to date not been used for the calibration of a mechanistic SOC model. The change in these isotopic ratios is, however, caused by fundamentally different mechanisms: the Δ14C value of SOC provides an indication of how long C has been in the soil, while the δ13C value provides information about the intensity with which this C has been processed by soil microorganisms. If the δ13C value of SOC can be mechanistically simulated, this might improve confidence in model calibration and the modeled residence time of SOC substantially.

Therefore, we developed a microbial-driven SOC model that simulates depth profiles of total SOC, δ13C and Δ14C. The novelty of this model is that it separates SOC processes in the rhizosphere (with fast OC cycling due to high C inputs and limited protection mechanisms) and the mineral soil (with slow OC cycling due to the protection by organo-mineral interactions). Furthermore, the physical protection of OC in aggregates is simulated while microbial residues are stabilized on mineral surfaces. The simulated depth profiles of δ13C reflect the increasing contribution of microbial residues to SOC with depth, while this isotopic signal is influenced by heterotrophic CO_2 assimilation by microorganisms. The model has been used to simulate depth profiles of OC, δ13C and Δ14C of stable landscape locations under forest in western Europe.