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Rhizodeposition, *i.e.* the release of any organic material by roots, has been recognized as a major process that controls the short-term dynamics of carbon in the soil and the biological activity in the rhizosphere. The various rhizodeposits emitted by roots over their lifetime (*e.g.* soluble exudates, secreted mucilage, sloughed cells, or volatile organic compounds) can be used by microorganisms as a substrate for growth and metabolism, which may either drive the build-up of stable soil organic matter (SOM) from the accumulation of microbial residues and/or stimulate an increase in SOM mineralization through the so-called rhizospheric *priming effect*. So far, our understanding of such processes has been hindered by the lack of reliable estimations of the amount and composition of the organic materials released by roots, because of the technical challenges associated to the measurement of rhizodeposition fluxes and the absence of any mechanistic soil-plant models that explicitly integrate such fluxes. RhizoDep is a new functional-structural plant model (FSPM) that simulates the development of a 3D root system together with physiological processes such as root respiration and rhizodeposition, depending on the allocation of photoassimilates from the shoots to the roots. By coupling this plant model to models describing SOM dynamics at various spatial scales, it has now become possible to recreate a plausible evolution of soil organic carbon accumulation, CO_2 respiration or nitrogen mineralization at various soil depths. Examples of such outputs in the context of wheat growth will illustrate how this modeling approach can greatly improve our understanding of the influence of root-soil interactions on C and N cycling.