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Accounting for microbial habitats in modeling soil organic matter dynamics

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The extreme heterogeneity of soils constituents, architecture and inhabitants at the microscopic scale is increasingly recognized. Microbial communities exist and are active in a complex 3-D physical framework of mineral and organic particles defining pores of various sizes, more or less inter-connected. This results in a frequent spatial disconnection between soil carbon, energy sources and the decomposer organisms and a variety of microhabitats that are more or less suitable for microbial growth and activity.
However, current biogeochemical models account for C dynamics at the macroscale (cm, m) and consider time- and spatially averaged relationships between microbial activity and soil characteristics. Different modelling approaches have intended to account for this microscale heterogeneity, based either on considering aggregates as surrogates for microbial habitats, or pores.
Innovative modelling approaches are based on an explicit representation of soil structure at the fine scale, i.e. at μm to mm scales: pore architecture and their saturation with water, localization of organic resources and of microorganisms. Three recent models are presented here, that describe the heterotrophic activity of either bacteria or fungi and are based upon different strategies to represent the complex soil pore system (Mosaic, LBios and μFun). These models allow to hierarchize factors of microbial activity in soil's heterogeneous architecture.
Present limits of these approaches and challenges are presented, regarding the extensive information required on soils at the microscale and to up-scale microbial functioning from the pore to the core scale.