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It's the little things that count – how microbial dynamics affect simulation results of the systemic soil model BODIUM

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Mechanistic simulation models are essential tools for predicting soil functions such as nutrient cycling, water filtering and storage, productivity, and carbon storage as well as the complex interactions between these functions. Most soil functions are driven or affected by soil microorganisms. Yet, biological processes are often neglected in soil function models or only implicitly considered in form of unspecific, effective rate parameters. This can be explained by the high complexity of the soil ecosystem with its dynamic and heterogeneous environment, and by the range of temporal and spatial scales at which these processes take place.

We integrated different microbial processes and feedbacks into our systemic soil model BODIUM (König et al., 2023) and tested the sensitivity of soil functions such as productivity and nutrient cycling to these microbial aspects at the scale of soil profiles. This includes flexible C:N ratios, carbon use efficiency, nitrogen fixation, feedback with root exudation, and the dynamics of different functional groups such as fungi and bacteria. We observed a high sensitivity of our simulation outcomes to microbial parameters related to the microbial component, such as the exudation rate or fungal/bacterial resistance to environmental conditions. This shows the high relevance of microbial processes for soil functions at the field scale, but also indicates that the process description should be further improved. In process-based models, a high sensitivity of parameters is often a sign for an instable process description relying too much on site-specific calibration instead of mechanistic understanding.

We will discuss how to improve this, but also further extensions, including an approach that accounts for the spatial distribution of microorganisms within the pore space.

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