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Modelling the dynamics of soil structure and water in agricultural soil

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The impact of agricultural management on soil functions is manifold and severe. It has both positive and adverse influence. Our goal is to develop model tools quantifying the agricultural impact on soil functions based on a mechanistic understanding of soil processes to support farmers and decision makers.
The modeling approach is based on defining relevant soil components, i.e. soil matrix, macropores, organisms, roots and organic matter. They interact and form the soil's macroscopic properties and functions including water and gas dynamics, and biochemical cycles. Based on existing literature on soil processes we derive functional interactions between soil components and combine them in a dynamic network approach.
In agricultural soils, an important feature is the temporal change in soil structure and the related impact on water and gas dynamics. While compaction processes are well studied, our knowledge on the recovery of compacted soil due to root growth and the activity of soil organisms is limited. We simulate structural dynamics based on interactions between soil organic matter, root growth and biological activity. Its impact on water and gas dynamics is described using a lumped model concept that is both coarse enough to allow extensive model runs while still preserving some important, yet rarely modeled phenomena like preferential flow, hysteretisis and hydraulic non-equilibrium.
For simulating water dynamics, at each depth, the model assumes water at different binding energies depending on soil structure, i.e. the pore size distribution. When water enters the soil it has to be redistributed to the different pore classes. This is driven by the gradient between the matric potential and the binding energies of the partially saturated pore classes and by the conductivity of the pores. Hence, bigger pores are filled first across an infiltration front followed by a redistribution. The matric potential is obtained from the mass balance for water flow between soil layers and the inner redistribution in the pores.
Based on this concept, the dynamics of soil structure can be directly linked to soil water dynamics as a main driver for other soil processes. Further steps will include integration of temperature and solute leaching as well as defining the feedback of the water regime on the structure forming processes.