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Modeling soil processes - are we lost in diversity?

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Soils are among the most complex environmental systems. Soil functions - e.g. production of biomass, habitat for organisms, reactor for and storage of organic matter, filter for ground water - emerge from a multitude of processes interacting at different scales. It still remains a challenge to model and predict these functions including their stability and resilience towards external perturbations. As an inherent property of complex systems it is prohibitive to unravel all the relevant process in all detail to derive soil functions and their dynamics from first principles. Hence, when modeling soil processes and their interactions one is close to be lost in the overwhelming diversity and spatial heterogeneity of soil properties.
In this contribution we suggest to look for characteristic similarities within the hyperdimensional state space of soil properties. The underlying hypothesis is that this state space is not evenly and/or randomly populated but that processes of self organization produce attractors of physical, chemical and biological properties which can be identified. (The formation of characteristic soil horizons is an obvious example). To render such a concept operational a suitable and limited set of indicators is required. Ideally, such indicators are i) related to soil functions, ii) are measurable and iii) are integral measures of the relevant physical, chemical and biological soil properties. This would allow for identifying suitable attractors. We will discuss possible indicators and will focus on soil structure as an especially promising candidate. It governs the availability of water and gas, it effects the spatial distribution of organic matter and, moreover, it forms the habitat of soil organisms and it is formed by soil biota.
Quantification of soil structural properties became possible only recently with the development of more powerful tools for non-invasive imaging. Future research need to demonstrate in how far these tools can be used to identify functional soil types (i.e. attractors) allowing for modeling soil processes at an integral level. We provide an example from the 100-years fertilization experiment in Bad-Lauchstädt.