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How representative is the conventional undisturbed soil core sample in terms of fllow properties?

Kirill Gerke and Marina Karsanina
Schmidt Institute of Physics of the Earth of Russian Academy of Sciences, Moscow, Russian Federation
(kirill.gerke@gmail.com)

Classic soil physics relies heavily on the concept of representative elementary volume (REV), which is necessary to perform upscaling from the studied soil samples and parameterize continuum scale hydrological models (e.g., based on Richards equation). In this paper we explore the boundaries of the classic REV concept and conventional representativity studies that claim REV for a given physical property if its values converge to a steady value with increasing sample's volume. We chose two conventional undisturbed soil samples from Ah and B horizons and performed pore-scale flow simulations based on their X-ray microtomography scans. The volumes of the simulation domains were 729 million of voxels with a physical volume within the order of magnitude of the whole soil core. Based on 3D pore geometry images and resulting flow velocity and pressure fields we performed REV analysis for saturated hydraulic conductivity and porosity. To further facilitate the REV analysis, we also evaluated the stationarity of pore structures by computing directional correlation functions for studied images. We concluded that neither of the studied samples can be considered to be representative due to its structural non-stationarity, which reflects on the behavior of Ksat values within the subcubes of different volume within the samples. In this contribution we extensively discuss the implications of such results. While it was possible to show that studied soil samples are not REVs for saturated hydraulic conductivity, we were unable to establish any relevant domain length scale. The latter may require tensorial flow property analysis with correct boundary conditions (Gerke et al., 2019), multi-scale soil structure imaging (Gerke et al., 2015; Karsanina et al., 2018; Karsanina and Gerke, 2018) and pore-scale simulations on fused multi-scale images (Miao et al., 2017; Gerke et al., 2018).

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