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Multi-scale study of soil structure from different genetic horizons: from meter to nanometer

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Soil structure is extremely diverse, has numerous relevant scales, e.g., important pore hierarchical levels, such as intra and inter aggregate porosity, cracks and others. None of the existing imaging techniques is capable of catching all scales within one single image due to sample size/resolution limitations. The only way to experimentally obtain soil structural information from all important scales is to utilize multi-scale scanning using different imaging approaches.

In this study we use macro X-ray tomography (with resolution of 100 um), micro X-ray tomography (with resolution range of 3-16 um) and SEM with nanoscale resolutions to obtain a vast multi-scale structural data from meter to nanometer. Two one meter long undisturbed soil columns extracted from soddy-podzolic and grey forest soils were used as objects of our multi-scale study. At first macrotomography was used to make the coarsest 3D image of the whole column. Afterwards, the column was carefully sliced to obtain smaller undisturbed samples for microtomography scanning. Some undisturbed soil pieces were also imaged using SEM to obtain sub-micron images of the soil structure.

All resulting 2/3D images were segmented using up-to-date image processing and segmentation techniques to obtain solid material and pore space binary phases. Directional correlation functions were utilized to characterize multi-scale soil structures and compare/differentiate them from each other. We extensively show how such powerful structural descriptors as correlation functions can results in better soil structure characterization and classification. Combined with multi-scale image fusion and/or pore-scale modelling techniques 3D multi-scale images can used to assess scale dependant flow and transport properties.

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