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Modelling soil physical properties based on XCT scans processed using state-of-the-art local and machine learning based segmentation approaches

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With the recent progress in soil structure imaging it is now possible to assess the properties of soil samples using pore-scale modelling. In this contribution we focus on saturated hydraulic conductance which can be easily modelled by solving Stokes equation in 3D pore geometry with the help of FDMSS software (Gerke et al., 2018) or pore-networks (Miao et al., 2017). We chose three soil images as obtained using microtomography device which were sampled in Russian Federation (Karsanina et al., 2018). As these are the gray-scale images representing attenuation of X-rays within the studied sample, before performing any modelling we need to classify all gray-scale voxels into pores and solids. Current state-of-the arts methods are represented by local segmentation methods which has two thresholds: 100% pores and 100% solids, the voxels in between are assigned to either pores or solids based on some considerations such as neighbors or by growing pore/solid phases from these 100% areas until they fill the whole space. We utilized such local binarization converging active contours (CAC) method (Sheppard et al., 2004) to segment soil images with manually chosen thresholds. Next, the same images were segmented using convolutional neural network (CNN) with U-net architecture. We compared the simulated saturated hydraulic conductances for images obtained by two different binarization approaches to show that if CNN is trained based on CAC segmentations the resulting physical properties are close to that of the CAC itself. This means that if the true data for CNN segmentation would be available, the conundrum we believe can be solved using multi-scale structure modelling techniques (Gerke et al., 2015; Karsanina and Gerke, 2018), our flow simulations based on CNN binarization would be of high accuracy and would require no operator input. We discuss critical implications of machine learning based segmentations for soil images and what it means as related to pore-scale modelling.

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