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Describing soil structure using parameterized universal spatial correlation functions

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In order to parameterize flow and transport continuum-scale models a detailed spatial information on soil physical properties is needed [1]. Obtaining the latter is not a simple task due to laborous and time-consuming field sampling and laboratory measurement campaigns. This gave rise to indirect statistical parameterization methods such as pedotransfer functions. Their concept can be reshaped into more widespread so-called structure-property relationships [2] relevant to a multitude of research areas. Typically the main aim is to relate soil structure to its physical properties. As 3D (multiscale) structural information can be readily obtained using XCT imaging, stochastic reconstructions [3] or multiscale image fusion [4,5] based on the superposition of different methods, the major challenge lies in finding a way to relate such large 3D datasets and soil properties in rigorous and computationally efficient way. With the rise of modern machine learning techniques it is not clear if building such relationships should be based on images themselves or their structural/geometrical descriptors [6]. Moreover, without first describing soil structure it is not possible to accurately address statistical inhomogeneity and representativity issues. For these reasons we start to attack the problem by reducing the number of parameters. To do so, we computed directional correlation functions for a library of processed soil images [2] and then described them by a limited number of parameters. This was done by fitting experimental correlation functions from images with superpositions of classical basic functions. Our results clearly show the possibility to reduce or "compress" soil structural information. In addition, correlation functions seem to be much more much sensitive to scale variations [7] than max pooling in e.g., convolutional neural networks. Whether this is the most efficient way to represent soil structure is the topic for future research (as should be checked by relating it against, for example, tensorial flow and transport properties).

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