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Quantitative morphology of soil porosity based on X-ray tomography

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X-ray tomography is an attractive non-invasive tool to measure soil structure. It allows to distinguish between soil pores larger than a given threshold and the porous soil matrix. The threshold depends on the spatial resolution of the CT system which is typically in the range between a few microns for synchrotron and industrial micro-CT systems and some millimeter for medical CTs. Below this threshold the measured value of X-ray absorption is directly related to the local bulk density of the soil matrix.

We present a general approach to quantify the entire pore space in terms of pore size and connectivity which operates across the resolution threshold of the specific CT device used. It is based on the assumption that for a given soil material which is homogeneous in terms of the particle size distribution, the local bulk density is directly related to the local pore size distribution in that the maximum pore size decreases with increasing bulk density. Hence, pore size can be used as a continuous variable for the entire range of x-ray absorption. Above the threshold pore size can be measured explicitly, below the threshold it is represented by a maximun pore size which can be interpreted as a local air-entry value

The quantification of the measured structure is based on integral geometry using the well defined Minkowski functionals in combination with mathematical morphology to capture the spatial correlation. The resulting morphological material functions are expected to be closely related to hydraulic properties, transport characteristics, the accessibility of the soil material by plants and soil organisms and to characteristic diffusion lengths for compounds of chemical interactions.