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Impact of thresholding techniques on X-ray soil microtomogram analyses

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Using X-ray microtomography, 3D soil structure can be visualised and analysed through useful factors like pore size distribution, shape, connectivity, orientation, etc. X-ray scans yield grey-level 2D images, which can be recombined to form 3D structures. Treatments of the grey-level images can consist of either a binarization -distinguishing soil and pores- or a permeability level attribution directly linked to the grey-level values. The latter leads to problems in order to assign a permeability for each point (in soil a same grey level value can be assigned to points with a different permeability), as well as to analyse the 3D structure. On the other hand, treatment of black and white 3D structures is well-handled. However, the impact of the choice of one thresholding technique on the resulting images has already been demonstrated. Moreover, thresholding methods are various and numerous. Many of them are based on the image histogram analysis. But because of the soil complexity, the relevance of these techniques becomes debatable, with a risk of producing non reliable images. We propose to palliate this with a simple new algorithm based on physical measurements: it uses a loop fixing the threshold value in order to match the measured porosity for each sample. In this communication, our point is to highlight the impact of different thresholding techniques on the analysis and interpretation of our soil microtomograms. The underlying questions could be: Does the thresholding method influence our conclusions? Are the results depending on the sample itself or on the methodology?
In order to answer these questions we tested the Otsu technique and our physically based algorithm.

Soils samples were removed from the upper layer (Ap horizon) of a silty soil (Gentinnes, Brabant Walloon, Belgium) in plots with different management practices. In fact, since 2004, the field has been cultivated in conventional tillage (CT) or reduced tillage (RT). In order to empty the meso- and macroporosity, samples were placed under a 1.5 MPa pressure (Richards apparatus). Samples were then scanned by X-ray microtomography using a Skyscan-1172 high-resolution desktop micro-CT system (Skyscan, Kontich, Belgium). The cone beam source operated at 100 kV, using an aluminium filter. The detector configuration, i.e. 1048×2000 pixels with a 16-bit X-ray camera, and the distance source-object-camera were adjusted to produce images with a pixel size of 17 μm. Porosity was measured for each scanned sample. Then the threshold methods -the Otsu technique on one hand and our developed algorithm on the other - were applied, and morphological factors were calculated for both methods.

A comparison of the first results shows a threshold influence on average porosity and number of pores, but also on connectivity factors and size distribution. The apparent porosity of the images, as well as connectivity, is underestimated with the Otsu technique. Despite the fact that the changes induced by thresholding are more important for RT than CT, global conclusions about the comparison of these agricultural practices are approximately the same in this case. However, differences between tillage systems are less important with the Otsu method, confirming the impact of choosing the adapted threshold method.