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Variation in spectral and mass dimension on 3D soil image processing

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Knowledge on three dimensional soil pore architecture is important for understanding soil processes as it controls biological, chemical and physical processes on various scales. Recent advances in non-destructive imaging, such as X-ray Computed Tomography (CT), provide several ways to analyze pore space features mainly concentrating on the visualization of soil structure. Fractal formalism has revealed as useful tool in these cases where highly complex and heterogeneous medium are studied. One of these quantifications is mass dimension (Dm) and spectral dimension (d) applied for water and gas diffusion coefficient in soil. At the same time that these techniques give a unique opportunity to quantify and describe pore space, they presents steps in their procedures on which the results depend.

In this work, intact soil samples were collected from four horizons of a Brazilian soil and 3D images, of 45.1 micro-m resolution (256x256x256 voxels), were obtained. Four different threshold criteria were used to transform CT grey-scale imagery in binary imagery (pore/solid), based on the frequency of CT units. Then the threshold effect on the estimation of Dm and d, as well as their ratio was studied.

Each threshold criteria had a direct influence on Dm as it has been previously reported [1], through the increase on porosity obtained. Meanwhile Dm showed a clear logarithmic relation with the apparent porosity in the image obtained for each threshold, d showed an almost linear one. In any case the increase of each one of them respect to porosity was different for each horizon.
The Dm/d ratio was practically constant through all the porosity achieved in this study when Dm was estimated using all the scale range available. On the other hand, when Dm was estimated based on smaller scales this ratio depended on the threshold criteria applied to the image. This fact has a direct implication in diffusion parameters for a pore network modeling based on both fractal dimensions.

[1] A.M. Tarquis, R.J. Heck, J.B. Grau, J. Fabregat, M.E. Sanchez, and J.M. Antón. Nonlin. Processes Geophys., 15, 881-891, 2008.