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Soil hydraulic behaviour at different bulk densities

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Soil structure may be defined as the spatial arrangement of soil particles, aggregates and pores. The geometry of each one of these elements, as well as their spatial arrangement, has a great influence on the transport of fluids through the soil. Fractal geometry has been increasingly applied to quantify soil structure, using fractal parameters, due to the complexity of the soil structure, and thanks to the advances in computer technology. The value of fractal parameters can be derived directly through image analysis being D (mass dimension) and d (spectral dimension) the most used ones.

In this work we describe the transport of a fluid particle through a soil simulating its movement through voxel-thick images of the soil. For this purpose, we introduce a constraint to compute the d imposing a downwards movement as a fluid particle randomly delivered from the top of a soil image. To describe hydraulic behaviour of the soil, the frequency distribution of random walk time (expressed as number of simulation steps) was obtained.

For this analysis, an arable sandy loam soil was packed into polypropylene cylinders of 6 cm diameter and 5 cm high at four different bulk densities: 1.2, 1.4, 1.5 and 1.6 Mgm−3. At each bulk density the air-filled pore volume was 0.17. The soil samples were imaged using an mSIMCT at 155keV and 25 mA. To minimize beam hardening an aluminium filter (0.25 mm) was applied, and reconstruction process also implied several corrections. The image stacks of 260x260x260 with voxel-thick slices were generated from the 3D volumes by using VGStudioMax v.1.2.1. Porosity connectivity was described applying a threshold value based on the analysis of the histogram region corresponding to 5 voxels. From each image, corresponding to a bulk density, fractal parameter as well as random walk time were estimated and related to the water transport through these soils.