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Exploring the heterogeneity of the soil pore system using multifractal analysis from Mercury injection and Nitrogen sorption

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The soil pore space is composed of a continuum of pores extremely variable in size, which range from equivalent diameters smaller than nanometres to an upper limit that may reach the order of centimetres. Thus, the soil pore space commonly displays a size range of more than a factor of 10^6 in scale. Because of the big array of pore sizes, there is not a unique method to record the pore size distribution (PSD) across the entire size range of soil pores. PSDs over a range of lineal scales larger than 10^4 (about 150 μm to 50 nm) can be determined indirectly by mercury injection porosimetry. Nitrogen sorption (adsorption and desorption) isotherms provide additional information for equivalent diameters in the order of one magnitude smaller (about 2-100 nm), partially overlapping mercury injection curves. This study follows previous work, which found that multifractal analysis was a suitable tool to characterize nitrogen adsorption and desorption isotherms (Paz-Ferreiro et al., 2010a), as well as mercury intrusion porosimetry (Paz-Ferreiro et al., 2010b). The goal was to compare PSDs obtained by mercury injection, nitrogen adsorption and nitrogen desorption. Soil samples were collected in two series of a Typic Argiudoll located in the north of Buenos Aires and in the south of Santa Fe provinces, Argentina. Two treatments and three sampling depths have been considered. The box counting method was used to carry out multifractal analysis of Nitrogen sorption and Mercury intrusion. Mercury intrusion curves as well as Nitrogen adsorption and desorption isotherms exhibited a well defined scaling and behave like a multifractal system. On average, the entropy dimension, D_1, ranged as follows: Mercury porosimetry > Nitrogen desorption > Nitrogen adsorption. The width of the singularity spectra, f(α) also followed the former rank. In general, our results showed different averaged values of the entropy dimension and other fractal parameters depending on the technique used and the corresponding pore size range appraised. Such differences could be the result of nonuniform probability distributions of soil porosity for specific size ranges. We conclude that parameters derived from multifractal analysis are useful to characterize the heterogeneity of the pore system at successive scales within primary soil aggregates, allowing distinction between different patterns of PSDs with various degrees of clustering. Also multifractal spectra are a powerful tool to differentiate between the local scaling properties of each experimental PSD.

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References

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