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Assessing variability of particle size distributions in experimental plots by multifractal scaling

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Soil particle size distributions measured by laser diffraction have been found to show well defined multi-scaling behaviour. Multifractal analysis captures the intrinsic variability of the measure, allowing discrimination among densities. Subsequently, a multifractal formalism gives insight into the heterogeneity of particle size distributions and express then in the shape of a multifractal spectrum. This information may be used for a quantitative characterization of differences of soil particle size distributions belonging to the same textural class. The aim of this study was to describe soil particle size distributions employing multifractal concepts for assessing between plot variability of soil texture.

A field experiment with two tillage treatments and two cropping systems was conducted on the experimental field of the Centre for Agricultural Research (CIAM) at Mabegondo, Coruña province, Spain (latitude 43º14' N and longitude 08º15' W). Tillage treatments included conventional tillage (CT) to a depth of 30-35 cm and no tillage (NT). Each plot had a size of 276m^2 (12 m width, 23 m length). The crop rotations were ryegrass-sorghum (RS) and ryegrass-corn (RC). The experimental design was a completely randomized split-block with four replications. Two soil samples were taken at the 0-6 cm depth in each plot, given a total of 32 individual samples.

Particle size distribution was routinely analyzed by laser diffraction in a range of scales varying from 0.390 to 2000 μm. The laser diffraction technique also provided the amount of data needed for multifractal analysis. All the particle-size distributions exhibited multifractal behaviour. Both, Rényi dimension spectra, D$_q$, and singularity spectra, f(α), showed good multifractal scaling trends. However, Rényi spectra were more sensitive than singularity spectra, as D_q appeared defined with R^2greater than 0.95 within a significant range of *q´s*. Singularity and Rényi spectra were far from homogeneous allowing distinguishing different quantitative characteristics of the particle size distributions studied that belonged to the same textural class. The capacity dimension, D_0, was between 0.92 and 1.00. Values for the entropy dimension, D_1, ranged between 0.86 and 0.92. The correlation dimension, D_2, varied from 0.77 to 0.86. Concave parabolic f(α) spectra had different patterns of symmetry/asymmetry. Likewise, the concave left part of the Rényi spectra showed various degrees of heterogeneity. In this way, the width of the f(α) spectra showed two main patterns of multifractal behaviour: in most of the examined cases the left hand side of the f(α) spectra, $\alpha_0 - \alpha_{min}$, was larger than the right hand side , $\alpha_{max} - \alpha_0$, but the opposite was true in 4 out 32 cases.

These evidenced the usefulness of scale independent multifractal parameters for characterizing differences in particle size distributions from the same textural class. Statistical analysis of variance showed that Hölder exponent of order 0, α_0, and left hand side of the f(α) spectra, $\alpha_0 - \alpha_{min}$, were significantly different between plots with the crop rotations ryegrass-sorghum (RS) and ryegrass-corn (RC).

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