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Determination of multifractal spectra in void/solid soil aggregate images

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Multifractal methods have a potential to be useful tools for characterizing spatial distributions of soil pores from microtomographic images of undisturbed soil cores and soil aggregates. The objective of this study is to examine the limitations of the multifractal analyses in binary (void/solid) soil images and to explore conditions under which multifractal spectra can be obtained. Multifractal characteristics of binary soil images are bounded within certain limiting values corresponding to non-fractal scaling. In this study we, first, examined the non-fractal scaling boundaries in multifractal calculations by the method of moments. Then we developed boundary conditions for multifractal calculations by the direct method. Examining behavior of the multifractal characteristics revealed that potentially fractal scaling is possible only at a relatively narrow range of cell sizes restricted by the non-fractal scaling boundaries. Moreover, the range of cell sizes where potentially fractal scaling is possible varies with pore sizes. That is, in a course of multifractal calculations it changes continuously with change of q value. For the soil aggregates examined in this study the range of potentially fractal scaling varied from 2-8 pixels for low q values to 2-128 pixels for high q values. Varying range of cell sizes for potential fractal scaling makes calculations of true multifractal spectra for the binary soil image data impossible. However, based on the analysis of the experimental data and on the review of literature results, we suggest that application of multifractal formalism can generate “pseudo-multifractal spectra” that might still be useful for summarizing pore distribution information and comparing pore data among different agricultural managements and soil types.