Geophysical Research Abstracts,
Vol. 10, EGU2008-A-07121, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-07121
EGU General Assembly 2008

Multifractal scaling of soil surface mireorelief under different tillage tretament

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Increased attention has been drawn to the variation of soil surface characteristics on a micro-scale. This is because soil surface constitutes the interface between soil and atmosphere and, consequently, it has implications for understanding water and heat fluxes, emission, and also when using remote sensing for soil evaluation. Soil surface microrelief may undergo rapid changes due to tillage and in tilled soil it may decay considerably under rainfall. As many natural and anthropogenic fractal-like structures, soil surface roughness is determined by a large number of generating processes operating at different scales. Such structures, termed multifractals, are characterized by fractional dimensions that vary in scale, and so require an infinite number of scaling exponents for their description, called a distributional spectrum.

Previous studies have shown that multifractal formalism was appropriate for analyzing point elevation data sets acquired by high resolution laser scanning. The main objective of this work was to assess the feasibility of applying multifractal analysis to soil surface roughness data sets obtained by pin-meter. In addition, we investigated the effect of tillage treatment and cumulative rain on parameters derived from Rényi dimension spectra of these data sets.

The samples were collected from a field tillage experiment at the Experimental Sta-

tion of the Agronomic Institute of Campinas (IAC), São Paulo State, Brazil. The soil was an Oxisol. The field experiment consisted of six tillage treatments, namely: disc harrow, disc plow, chisel plow, disc harrowing + disc level, disc plow + disc level and chisel plow + disc level. Measurements were made four times, firstly just after tillage and subsequently after cumulative natural rainfall. Duplicated measurements were taken per treatment and date, yielding a total of 48 experimental data sets of soil surface roughness. A pin microrelief meter was used for this purpose. The plot area was 135 cm by 135 cm and the sample spacing was 25 mm, yielding a total of 3025 data points per measurement. Because pin-meter is a destructive device, data sets obtained during successive rain stages for a given tillage treatment were measured at different places within an experimental plot. Before multifractal analysis, linear trend and the periodical tillage effects were removed from the experimentally measured point elevation data sets.

Multifractal analysis carried out using the box count algorithm showed well defined scaling properties of these point elevation data sets obtained by pin-meter on a 25 x 25 mm^2 grid. Rényi dimension spectra followed the typical sigmoidal non-increasing shape of theoretical multifractal measures, which also have been previously found in experimental data sets with higher horizontal resolution, obtained by laser scanning on a 2 mm x 2 mm^2 grid. A wide variety of Rényi dimensions spectra was found for the studied data sets. Microrelief peculiarities of each data set were reflected on the distribution of the highest or the lowest point elevation values. Consequently, Rényi spectra could be regarded as measures of soil microrelief heterogeneity. However, the effect of tillage treatment and cumulative rain on multifractal parameters was somewhat obscured by the spatial variability of soil surface microrelief conditions, leading to important differences of Rényi spectra for duplicate data sets acquired during a given rain stage in each of the six tillage treatments. On the other hand, the vertical microrelief component of microrelief measured by the statistical index random roughness and parameters derived from multifractal analysis showed little or no association. This result suggests that changes in vertical and horizontal configuration of the random component of soil surface microrelief do not rely on each other.

Acknowledgements. This work was financed by MEC (Spain) under project CGL2005-08219-C02-01 (Spain).