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A preliminary study of multifractality from microprofiles of soil penetration resistance

Jorge Paz-Ferreiro (1), Jose Garcia Vivas Miranda (1), Laura F.S. da Silva (1), Edson Eiji Matsura (1), and Mara de Andrade Marinho (2)

(1) FEAGRI. Universidade Estadual de Campinas (UNICAMP), Brazil, (2) University of Coruña, La Coruña, Spain (jpaz@udc.es)

Soil strength is an important characteristic affecting many aspects of agricultural soils, such as the performance of cultivation implements, root growth, trafficability features, etc. The soil strength results from cohesive forces between soil particles and their frictional resistance. Characterization of soil strength is usually made by measuring the resistance to penetration (RP) of a metallic plunger with a particular shape, usually a cone. Field penetrometers have been widely used for estimating resistance to root growth in soil, because soil RP is roughly indicative of the pressure required for soil penetration by roots. However, plant growth is not only affected by RP, but also by soil water content and soil aeration. The least limiting water range (LLWR) is an index of structural quality for plant growth, which takes into account those three soil physical properties. LLWR was defined as "the range in soil water content within which limitations to plant growth imposed by water potential, aeration and mechanical impedance are minimal". For LLWR assessment, RP is currently recorded in laboratory conditions using micropenetrometers. The objective of this study was to explore the effect of soil bulk density on soil PR microprofiles using multifractal analysis. The studied soil was a *Rhodic Hapludox* (Latossolo Vermelho Distroférrico típico in the Brazilian Soil Classification System) sampled in Campinas, SP, Brazil. Remolded soil core samples were prepared using air-dried fine earth (< 2.0 mm), obtained from disturbed soil samples, repacked in volumetric steel rings (5 cm diameter, 5 cm length).The remolded soil core samples were built applying seven levels of bulk density, i.e., 1000, 1100, 1200, 1300, 1400, 1500 and 1600 kg m^{-3}. After saturation with water, samples were put in a pressure plate extractor under a pressure of 750 kPa. At equilibrium, when the outflow has ceased, the soil RP was measured using a computer-controlled penetrometer having a cone with a semi-angle of 30º, a base area of 0.1256 cm^2(about 4 mm diameter), and a penetration speed of 1 cm min^{-1}. For each bulk density value, three replicated cores were studied and three microprofiles per core were recorded. Multifractal analysis of each experimentally obtained RP microprofile was performed using the box-counting based moment method. PR profiles were partitioned into subsequently smaller segments, following a multiplicative cascade procedure and they were normalized in order to have a probability mass function. Next, partition functions have been calculated for all the study data sets. Plots of the normalized measure versus measurement scale for moments q = 10 to q = -10 obeyed power low scaling, showing linear behaviour over 8 regression data points. Moreover, PR microprofiles behave like a multifractal system. At the imposed soil water potential, multifractal parameters extracted from the central part of the generalized dimension and the singularity spectra were not significantly affected by bulk density. In contrast, width of the left part of the singularity spectra showed a trend to decease as the bulk density increased, so that parameters derived from this portion of the spectra best discriminate between RP for successive bulk density values. Consequences of RP multifractal behaviour for LLRW assessment are outlined.