Mass fractal dimension and spectral dimension to characterize different horizons in La Herreria (Sierra de Guadarrama, Spain)

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EGU General Assembly
Vienna, Austria, April 2016

1. Influence of soil structure

Knowledge on three dimensional soil pore architecture is important to improve our understanding of the factors that control a number of critical soil processes as it controls biological, chemical and physical processes at various scales. Computed Tomography (CT) images provide increasingly reliable information about the geometry of pores and solids in soils at very small scale with the benefit that is a non-invasive technique.

Fractal formalism has revealed as a useful tool in these cases where highly complex and heterogeneous meda are studied. One of these quantifications is mass dimension (Dm) and spectral dimension (d) applied to describe the water and gas diffusion coefficients in soils (Tarquis et al., 2012).

Figure 1. Detail of the different soil horizons characterized in the EG010-La Herrería trench.

2. Study area and Image Adquisition

In this work, intact soil samples were collected from the first three horizons of La Herreria soil (see Fig. 1). The first layer (Horizon A) is the result of biological alteration with roots resulting in fertile soil. Second layer (Horizon C1) is a deposit of medium-sized boulders due to river floods of little intense character. The third layer (Horizon C2) is the result of deposits of boulder larger size river due to avalanches stronger character.

This station is located in the lowland mountain area of Sierra de Guadarrama (Santolaria et al., 2015) and it represents a highly degraded type of site as a result of the livestock keeping.

The 3D images, of 45.1 micro-m resolution (256x256x256 voxels), were obtained (Fig. 2) and then binarized following the singularity-CA method (Martín-Sotoca et al. 2016). Based on these images Dm and d were estimated.

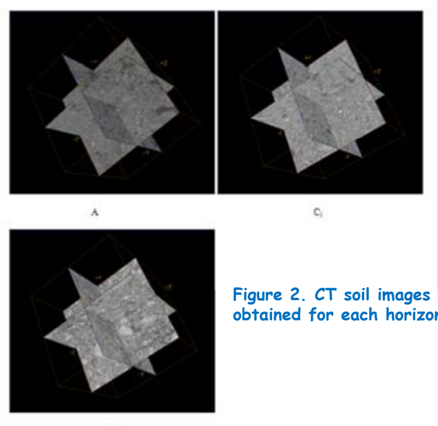

Figure 2. CT soil images obtained for each horizon.

3. Soil as a network

The rate of movement of a particle moving randomly through a fractal network (soil) is related to the mass fractal dimension (Dm) and the spectral dimension or fracton (*d*) of that network.

Dm is associated with the heterogeneity and space-filling properties of a soil, while the spectral dimension *d* reflects the connectedness of a fractal network.

4. Spectral dimension and mass dimension

Sn = number of new places visited

n = number of steps

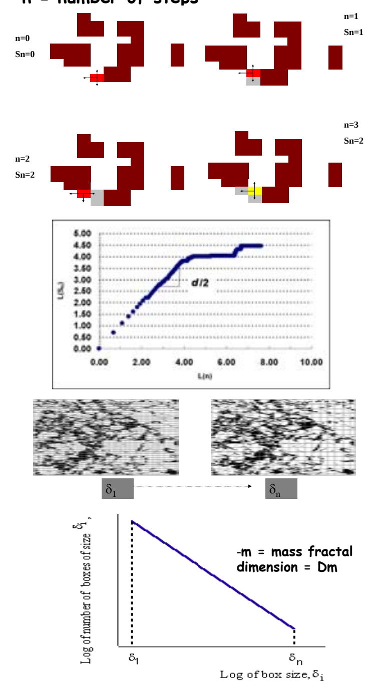

Figure 3. Graphics to explain how to calculate the spectral dimension (*d*) and mass dimension (Dm).

References

·Martin Sotoca; J.J. Ana M. Tarquis, Antonio Saa Requejo, and Juan B. Grau (2016). Pore detection in Computed Tomography (CT) soil 3D images using singularity map analysis. Geophysical Research Abstracts, 18, EGU2016-829.

·Santolaria-Canales, Edmundo and the GuMNet Consortium Team (2015). GuMNet - Guadarrama Monitoring Network. Installation and set up of a high altitude monitoring network, north of Madrid. Spain. Geophysical Research Abstracts, 17, EGU2015-13989-2.

·Tarquis, A. M., Sanchez, M. E., Antón, J. M., Jimenez, J., Saa-Requejo, A., Andina, D., & Crawford, J.W. (2012). Variation in spectral and mass dimension on three-dimensional soil image processing. Soil Science,177(2), 88-97.

5. Results

Horizon	Porosity	D_m	R^2	*d*	R^2
A	13.348	2.798	0.997	1.620	0.892
C_1	8.749	2.703	0.994	1.400	0.893
C_2	6.950	2.538	0.996	1.170	0.893

Table 1. Mass fractal dimension (Dm) and spectral dimension (*d*) at samples of horizon A, C1 and C2.

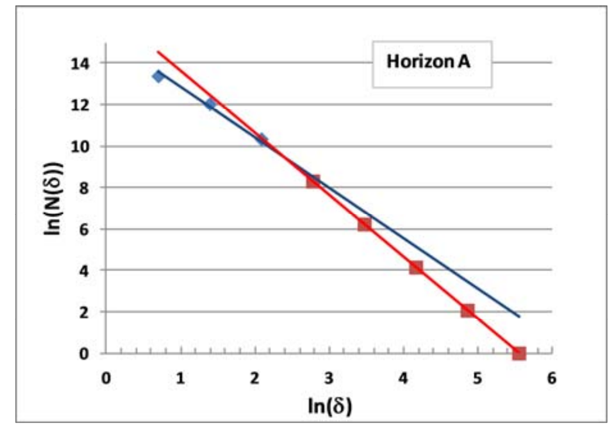

Figure 4. Variation of mass fractal dimension (Dm) depending on the scales selected for horizon A.

6. Remarks

The results showed difference in porosity, Dm and d for each horizon. This fact has a direct implication in diffusion parameters for a pore network modeling based on both fractal dimensions. These soil parameters will constitute a basis for site characterization for further studies regarding soil degradation; determining the interaction between soil, plant and atmosphere with respect to human induced activities as well as the basis for several nitrogen and carbon cycles modeling.