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Nonlinear Processes in Geophysics Discussions

Interactive comment on "Multiscale analysis of nitrogen adsorption and desorption isotherms in soils with contrasting pedogenesis and texture" *by* J. Paz-Ferreiro

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(1) Comments from Referee # 2 (29 February 2016)

Review of npg-2015-79 This manuscript presents multifractal analyses of nitrogen adsorption and desorption isotherms obtained on soil samples from 6 different soil profiles in São Paulo State, Brazil. There is very little that is new here, and the manuscript essentially repeats the study by Paz-Ferreiro et al. (2013), but in a different geographic area and with some less clayey soils. Although it lacks originality, I suppose there is some incremental new knowledge gained on the effects of soil texture on these types of multifractal analyses. Therefore, I recommend acceptance following minor revisions. My specific comments are itemized below (page #, line #):

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Discussion paper

1,12 & 4,27 – If SSA implies Euclidean geometry & method of moments analyses indicate multifractal geometry is it valid to present both sets of results for the same samples. Surely, the soil pore space is either Euclidean or multifractal, but not both. I am not sure that correlating SSA with generalized dimensions and Hölder exponents, as is done in Table 6, is a useful exercise.

1,18 – If the nitrogen adsorption and desorption isotherms are indeed multifractal, what are theimplications for soil pore size distributions? We have well-established physical models for Euclidean (e.g., random packing of uniform spheres) and monofractal (e.g., randomized Menger sponge) soils. Physically, what would a multifractal model for soil pore space geometry look like?

2,3 – Artificial is spelled incorrectly.

2,31 – Paz-Ferreiro and Vidal Vázquez (2012) does not appear in the references.

5,1 & Fig. 1 – It would be preferable to show the differential results rather than the cumulative plots in Fig. 1, which are very smooth and give absolutely no indication of multifractality.

6,5 – How many data points are needed to perform a robust multifractal analysis? Are 41 to 52 data points acceptable, and if so, according to what criteria?

6,6 – Report R2 values for the log-log linear regression analyses. Also, the residuals should be examined for the absence of trend.

6,7 – For a true multifractal the normalized measure versus scale is always linear on a log-log scale regardless of the subdivision level (k). Does the observation that these plots were non-linear for $k < 1$ imply that this is a pre-multifractal system operating over a limited range of scales, or is it due to the limited number of data points used in the analyses? 6,7 – Why was the range $-5 \leq q \leq +5$ chosen? Did the linearity of the plots change with q, and if so what are the implications of this? Again, for a true multifractal, linearity should not be a function of q.

(2) author's responses We appreciate your comments, as they raise an essential point related to the reliability of the multifractal method used to analyze the complex behavior of Nitrogen adsorption and desorption isotherms, and even the pertinence of our methodology. Referee # 2 contributed with a general comments and several specific comments itemized by: page #, line #. Author's responses have been organized following this scheme. General comment. A similar comment, about the novelty of our manuscript has been posted by reviewer # 3. We agree with reviewers #2 and #3 in that the analysis presented in not new, given that multifractal analysis from Nitrogen adsorption (and some times also Nitrogen desorption isotherms) has been carried out previously by several authors, as referenced in our manuscript. Note, however that the data set and the aims in the previous work published by Paz- Ferreiro et al. (2013) and the present work are different. In the former work the data set contained mainly clayey textured soil samples with a relatively wide range of organic matter content, which allowed assessment of the effect of organic matter. The main novelty of the present work, is the contrasting texture of two groups of soil sample, i.e. medium versus clayey textured soils. So, the sampling strategy was chosen to evaluate texture effects and to the best of our knowledge this is a new issue; this is explicitly stated at the end of the Introduction section and in the objectives. Also we focused in agronomical and environmental characterization of the two soil types selected using multifractal analysis, which not addressed previously.

Specific comments (by: page #, line #) - 1,12 & 4,27. This comment is very pertinent ad we totally agree with you in that the soil pore space is "either Euclidean or multifractal, but not both". Please, note that soil specific surface area (SSA) was obtained from the first part of nitrogen adsorption isotherms, i.e. for relative pressure (p/p0) values below 0.30, (as in this range a linearization has been proven to be possible); however multifractal analysis was performed for a wider range of relative pressures, i.e. $0 < p/p0 <1$. Therefore data sets used for estimating SSA and to perform multifractal analysis are very different. This issue has been also addressed in Page 2, Lines 21 to 27. On the other hand, the exercise of correlation between SSA and multifractal parameters in

Table 6 (now Table 4 in the revised version of the manuscript), could be useful given the association between SSA and a number of soil physical and chemical properties.

- 2,3. The spelling mistake has been corrected.

- 2,31. Mistake has been corrected. Correct was Vidal Vázquez and Paz-Ferreiro, instead of Paz-Ferreiro and Vidal Vázquez.

- 5,1 & Fig. 1. Authors agree that cumulative plots of N2 isotherm “give absolutely no indication of multifractality”. Indeed, differential curves are more irregularly distributed, and therefore may suggest multifractal behaviour. In fact, in previous work, differential plots NAIs as a function of either relative pressure (p/p0), (in Paz-Ferreiro et al., 2009) or as a function of pore sizes (Paz-Ferreiro et al., 2010) have been presented. However, in this particular manuscript we prefer to show and compare examples of the cumulative NAIs and NDIs for clayey and medium textured soils, because this better illustrate differences in the hysteresis loop between the two soil types. In our wok, the hysteresis loop has been found to be associated to the main differences in multifractality of the soils groups with contrasting textures studied.

- 6,5. Again, this is also a very important comment and also the question of the number of data points needed to perform a robust multifractal analysis also has been posed reviewer # 3. Next, we address this point and, please see also our answer to reviewer # 3. We are aware that that ideally and as recommended by Turcote 1992), for mutifractal analysis, the scale should be at least three orders of magnitude of the sampling intervals.(Turcotte, D.L. 1992. Fractals and Chaos in Geology and Geophysics. Cambridge University Press, Cambridge, 221 p). The larger the measurement scale and the number of data points available, the more reliable the results of mulifractal analysis. However in practice many data sets used for multifractal analysis in several disciplines such as Geochemistry or Soil Sciences are much smaller. Indeed, reliability of multifractal analysis depends on the number of points, but also on the range of q-moments used. Please, see additional comments in 6.7.

- 6,6. This is also a very valuable comment. A new Table showing R2 for the linear relationship of the partition function ïĄčïĂĺqïĂňïĄďïĂľïĂăversus the scale, ïĄďïĂňïĂăhas been included (now, Table S3). This issue is now briefly addressed in the Methods (Page 6, Line 6) and in the Results and Discussion Sections (Page 7, Lines 22 to 27).

- 6.7. a) Does the observation that these plots were non-linear for k < 1 imply that this is a pre-multifractal system operating over a limited range of scales, or is it due to the limited number of data points used in the analyses?. In our opinion the answer to this question would need a review of the previous work on MFA of NAIs and NDIs published until now and also additional work. For example Paz Ferreiro et al. (2009) and Lado et al. (2013) reported non-linearity for k < 1, while Paz-Ferreiro et al.(2010) found linearity for 0 < k < 5. In the present manuscript we performed MFA for 32 horizons (64 adsorption and desorption isotherms) and for most of them we also found linearity for 0 < k < 5, but this was not the case at 3 of the studied data sets. however, in order to compare all the data sets studied we choose non-linearity for k < 1. This issue has been now briefly addressed in the Results and Discussion section. b) Why was the range -5 $\leq$ q $\leq$ +5 chosen?. In Literature this aspect is very discussed Again, the q-moments choice depends from the number of data points available. Again, using a smaller range of q moments results in reduction of large statistical errors, especially for q <0. Using a wider range of q moments better identifies differences between subsets. In previous papers dealing with multifractality of NAIs and NDIs, also different q moments ranges have been reported. We think that in our context q=+/-10 moments would be excessive, because of the small number of data points available.

(3) author's changes in manuscript - We edited the revised manuscript and corrected a large number of spelling and other language errors, in addition to the mistakes that reviewer # 2 showed in 2.3 and 2.31.

- We reported R2 values for the log-log linear regression analyses between partition function and scale, for several q moments, at the Supplementary Digital Content.

- Additional details about the way in which multifractal analysis has been performed (given the limited number of points in the available data sets) have been provided.

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