

## ***Interactive comment on “Spatial variability and sampling density of chemical attributes in archaeological black earths under pasture in southern Amazonas, Brazil” by Alan F. L. de Lima et al.***

### **Anonymous Referee #1**

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#### General comments

The authors sampled a plot in the Brazilian state of Amazonas and analysed the samples on chemical composition, to assess the spatial variability and thereby recommend a sampling density for everyday agricultural use. The topic is relevant, and the data seems abundant and interesting; however, from my – rather theoretical geostatistical - viewpoint, I see possibilities for improvement, especially with a clearer explanation and use of geostatistical concepts. I advise the authors to draw inspiration from a geostatistical textbook or for example from the summary paper by Oliver and Webster,

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2014 (<https://doi.org/10.1016/j.catena.2013.09.006>), rather than rewording the somewhat crudely presented theory as shown in very applied papers such as Gomes et al. (2017). For example, please make a clear distinction between 1) an experimental variogram, which follows directly from the data, but where perhaps a decision about bin width etc. has to be taken, 2) The variogram model, or mathematical variogram model, with a chosen covariance model and estimated parameters and 3) the prediction (or kriging). For example, on page 4, lines 21-24, it is not clear to me what you mean by “choosing” an experimental variogram model, and I suppose the R<sup>2</sup> has to do with mathematical model fit, and cross-validation has to do with the kriging phase? Please make clear what is meant.

In the discussion or in the conclusion, I would expect some reflection on the main finding about the required sampling density. Do the authors expect the same spatial variability in similar soils with the same history, in similar soils with a different history, etc.? In how far can the findings be generalised?

Note that I am not qualified to say anything meaningful about soil chemistry and its agricultural consequences, so I will refrain from that topic.

General textual remark: In my pdf, several would-be subscripts in the text are actually normal, in the chemical formula as well as in the mathematical variables.

#### Specific comments and textual remarks

Page 1, line 20 and also page 3, line 2: Perhaps use “required sampling density” rather than just “sampling density”.

Page 2, line 33: “, Mapping” should not have a capital

Page 3, Figure 1: Please explain why DEM is shown. As I understood it, it is not used as explanatory variable.

Page 3, line 17: To maintain which quality? Of the crop, or the soil?

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Page 3, line 19: An GPS accuracy up to 15 m, when the sample locations are supposed to be 8 m apart, seems quite problematic. Perhaps elaborate in the discussion which influence this might have on the results and conclusions, or explain better what it actually means.

Page 4, line 15/16: The line “Based on the assumption of stationarity of the intrinsic hypothesis..” is a bit vague, which hypothesis is meant?

Page 5, line 3-8, and also page 9, figure 3: I am sorry, but I don't understand what is meant here. With scaling, the nugget-sill ratio will not change. Please elaborate, also because the referred paper [Vieira (1997)] seems to be in Portuguese.

Page 5, equation (3): As this leads to the central conclusion of this paper, please explain where this formula comes from, and perhaps also when it is applicable and which are the underlying assumptions.

Page 5, line 21-22: Which “Values close to..” are meant?

Page 7, line 21-23: I am not sure about the assumed short distance differences between a spherical and an exponential variogram model. Perhaps the authors confused “Gaussian” with “spherical”, based on the comparison in Isaaks & Srivastava (1989), page 303?

Page 7, line 23: Firstly: what is meant by “these” models? Exponential, or spherical? Secondly, it is quite a strong statement that a certain model “best fits soil properties”. How is this information extracted from the paper of Gomers at al. (2017) – as I could not find it - , and in which context is this statement valid? Also note that a spherical variogram model has a range which is equal to the range parameter, but an exponential variogram model has a so-called “effective range” being 3x the range parameter; this should be taken into account when comparing

Page 7, line 26-30: The words “.. has a random distribution” might give confusion, as “random” does not mean “not correlated”. Also the sentence “In general, .... used”

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can be phrased more to the point. A pure nugget variogram indicates that there is no spatial structure found with the given sampling scheme. And why would one expect to find a spatial dependence in increased grid spacing? This might happen, but perhaps rather with smaller grid spacing, or perhaps not at all.

Page 11, figure 4: Perhaps, also mention the kriging error uncertainty (the kriging variance), as that is a substantial part of geostatistics.

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