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Biogeosciences Discussions

Interactive comment on "Soil carbon stock increases in the organic layer of boreal middle-aged stands" *by* M. Häkkinen et al.

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Reply to referee #1

We appreciate the comments from Referee #1 that clearly specify some points of our manuscript where further clarification is needed. In addition to the responses to each comment, we propose below the intended changes in the manuscript whenever the comment indicates a need for it.

Referee's general comments

1) Authors assume that spatial variation of carbon is unchanged over time which is probably not true.

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Interactive Discussion

Discussion Paper

In general, we may expect changes in the spatial variation of soil properties after major disturbances, scarification after final harvesting or trampling with heavy machinery, but changes in the spatial variation of forest soil in the middle-aged forest stands without any external influence are not reported (as far as we know). In our analysis, this assumption of unchanged spatial variation was used when soil carbon changes were tested at plot scale. We observed statistically significant change on six plots out from 38. In the case that spatial variation would have changed over time we might have had wider or narrower confidence intervals of the plot level carbon stocks at the time of the first sampling and few more (or less) statistically significant changes might have been detected. Anyhow, overall conclusion would have been the same that at plot scale only a few changes are significant.

2) They apply spherical variogram models but this is not always supported by their data.

See reply on point 18

3) Moreover information on the number of replicates in different lag distance classes of the variograms should be given.

We shall report that in the revised version of the manuscript.

Specific comments:

4) Line 53: Why does a positive autocorrelation enlarge the variance of the mean of single plots?

Because i) the variance of a sum of random variables is equal to the sum of the variances of these variables plus the sum of covariances between all pairs of variables, ii) positive autocorrelation implies positive covariances between some pairs, and iii) the variance of the mean is simply equal to the variance of the sum divided by the square of the number of variables in the sum.

5) Line 70: Usually, the organic layer comprises several soil horizons (Oi, Oe, Oa). You

should clearly indicate which ones were studied here.

We will clarify this by adding one sentence to page 1020, line 20 'The organic layer consist both partially decomposed matter whose origin can be spotted on sight and well-decomposed organic matter, the origin or which is not readily visible'.

6) Line 76: How were the 38 sampling points selected? By random?

Yes, we add this information on page 1020 line 20-22, rephrased text is 'The sample plots used in this study were a random sample that represented. . ...'

7) Line 113: Soil samples are usually dried at temperatures <40_C.

Yes, 40oC was drying temperature also in our case, but since we know that there is some variation in the actual temperature within our heating chamber (due to generation and circulation of warm air) we prefer to report range of potential temperatures (35-44 oC) that may take place during drying of our samples. If this is confusing, our expression can be changed into 40oC.

8) Line 128: Did you use distance classes for the variogram analysis and how many replicates per distance class were available?

The distance classes and the number of replicates will be reported in the revised version of the manuscript.

9) Line 139: This is only true for the spatial scale you studied. This means it is true for a forest inventory plot of 300 m2.

Right, this point will be added into revised version on page 1021 line 23 'The spatial autocorrelation within a plot of 300 m2 is strong if. . .'

10) Line 141: I am not sure if the assumption of the similarity of variances at both sampling dates can be made, since forest structure is changing over time.

See, reply on point 1.

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11) Line 158: What exactly did you use as covariance? Did you take the sill variance? Then you would overestimate the real covariance at plots with a high spatial autocorrelation. This might explain the very high standard deviations in Table 1.

This was based on the actual locations x1ki of the sub-samples in the first measurement, which were inserted into equations 6 and 7, and the corresponding covariances were obtained using the variogram fitted to the observations of the second measurement of the same plot k, specifically the value of that variogram at the distance between the two points appearing in equations 6 and 7. We shall aim to clarify this in the revised manuscript.

12) Line 193: An annual carbon accumulation cannot be calculated since the increase might not be linear.

Agree, calculated annual change will be removed from page 1025 line 10. Revised version will state 'The mean change of all the 38 plots was 412+-44 gm-2. The amount. . .'

and in the discussion on page 1025 line 14 we rephrase as follows 'The average rate of increase in. . ..'

13) Line 227: It is important to mention that you discuss only the carbon stock of the organic layer but not of the complete soil.

Yes, in the revised version this is clarified on page 1026 line 24 by saying '. . ..may result in an increase in the soil carbon stock of organic layer'.

14) The spelling of references should be carefully checked (e.g. Peltoniemi et al., 2007)

We have checked spelling of references and Peltoniemi is correctly spelled.

15) Table 1: Why is the standard deviation of carbon stocks at the first sampling systematically higher than at the second sampling? This has to be proved.

By using equations 5 and 10, we implicitly took into account the fact that at the time of the first sampling the number of subsamples per plot was m1=30, whereas at the time

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of the second sampling we had m2=40 sub-samples per plot.

16) Fig. 2: I do not completely understand the sampling scheme. I do not understand how a grey sampling point could be 0 m away from a black one. Please provide a more detailed description of the sampling.

Description clarified in the revised version. Revised legend of Fig. 2 states '. . ... The fourth sample point is located consecutively at one of the three grey points shown in the square, either side by side with a black one or 0.2 m or 0.4 m away from it'.

17) Fig. 3: This figure could be deleted without loss of information.

OK, deleted from revised version.

18) Fig. A1: In many of the variograms one could argue that a pure nugget effect is obvious. Is there any reason why a spherical model is applied in most of the variograms.

The spherical model is one of the most frequently used models in geostatistics (Webster and Oliver 2001, p. 115). The 'pure nugget' model is a special case of the spherical model (when it contains the nugget as in our analyses) with sill=0 as, for example, in our model for plot 417702. In that case, we get exactly the same result as by using the pure nugget model. But the spherical model (with non-zero sill) is naturally more general and more appropriate for most of the plots. Furthermore, we judged that the amount of data does not allow for a data-driven choice of the parametric form of the variogram separately for each plot, and therefore simply applied for all plots the spherical model, which appeared reasonable for most plots.

19) The extremely high small scale variation of carbon stocks might indicate that the number of replicates you took in the present study is not appropriate.

Yes, the spatial variation of the soil properties is high and with the number of soil samples we took per plot (40) we were able to detect a change in the soil carbon stock only on 6 plots out from 38. Thus, this number of samples is not appropriate for monitoring changes at stand scale, but >20 samples per plot is considered to be

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appropriate sample size for regional scale analyses where plot means are used (e.g. Mäkipää et al. Boreal Environment Research 13(supp.B): 120-130.).

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