Biogeosciences Discuss.,
doi:10.5194/bg-2016-11-AC1, 2016

Biogeosciences Discussions
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EGU

Interactive comment on "Which are important soil parameters influencing the spatial heterogeneity of ^{14}C in soil organic matter?" *by* S. John et al.

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Received and published: 20 May 2016

First of all, we would like to express our thanks for the review. We considered all comments carefully, which significantly improved the general quality and structure of the MS. Below, we will provide a point-to-point reply to the comments.

Sincerely, Stephan John

Comments on anonymous referee (RC#1); published on 8 March 2016

1) The study is rather descriptive and misses a sound statistical analysis. The approach makes it difficult to identify driving factors for 14C variability because many explanatory variables are cross-related. For example, soil depth, pMC, root biomass and silt/clay content correlate significantly with each other, hence, assignment of unique factors to

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pMC variability is hampered. Authors should consider using a general linear model for their analysis.

We agree that driving factors for 14C are difficult to identify only by PCA and added linear regression models with 14C as dependent variable. However, the PCA should be maintained, because it is a multivariate statistical approach that makes it possible to identify the interaction of highly correlated soil parameters (Reimann et al., 2008) and contain important information in such a complex (sub-) soil system.

2) It is not clear why authors explicitly excluded A-horizons from their study.

This study was performed in the framework of a larger research project on subsoil carbon dynamics which uses a comparable sampling scheme (starting in 10 cm) at different sites excluding the A horizons (5 cm). We consider the A horizon of being of minor importance since this study should solely focus on subsoil.

3) Without any estimate of C input from aboveground and belowground litter, i.e., without adding a dynamic component to the study, the explanation of 14C distributions remains vague.

Unfortunately, we were not able to estimate C inputs from above- and belowground litter. In contrast to cultivated sites with known C inputs, the determination of C input under natural forest is a parameter, which is extremely difficult to determine. Estimations of C inputs and dynamics in subsoil under forest were widely unknown (Rumpel et al., 2012). Furthermore, natural 14C contents do not only reflect short term dynamics but integrate over longer time scales. Thus, the input of the surface soil is not essential in this study.

4) Further, grammar and syntax are partially poor and I recommend copy-editing of the text.

We improved the grammar and syntax.

Detailed comments

5) Title: The title should reflect that only one single gradient at different distances from a beech tree was studied. Hence, at least the word ‘forest’ should appear in the title.

We changed the title accordingly.

6) Line 38. Why does sentence begin with ‘however’?

The sentence has been changed.

7) Line 58. The description of parameters influencing the soil’s 14C content is not well structured. The 14SOC content is in principal determined by i) input rates, ii) turnover or loss rates, iii) radioactive decay, and iv) changes in atmospheric 14CO2, i.e., changes in 14C of the input material over time. Soil or vegetation or climate properties modulate some of these principal factors. Authors are requested to put their list of factors into a logical order following these drivers.

The input of C is the most important factor determining the 14C content of bulk OC. This general statement should be maintained (it includes potential changes over time). We added a remark on the radioactive decay and changes of the atmospheric 14C content. We modified the following sentence listing soil properties and environmental factors, which ’modulate’ 14C contents.

8) Line 64. Is heterogeneity of SOM age meant?

We agree that the sentence was written in a rather unclear way. Therefore, we modified the sentence.

9) Line 65 and later. Input from roots is called root litter, from living roots rhizodeposition. This is not in contrast to being ‘fresh’.

We agree with the reviewer and use the suggested terms.

10) Line 72 .There are studies on spatial variability of 14C in soils, e.g. Leifeld and Mayer (2015), Budge et al. (2011); Schoning et al. (2013). Results in these publications revealed also different patterns as compared to the current study.

We are thankful for the suggested literature and added some of the suggested manuscripts.

11) Line 75-82. Again, the argumentation is not stringent. All listed factors just reflect a change in SOM turnover rates, albeit caused by different mechanisms.

Unfortunately, this remark is not clear. We listed factor that change SOM dynamics and don't want to go into more detail by naming parameter that modulate these factors. We consider this to be not necessary for a paper, which investigates factors affecting the 14C distribution of SOM.

12) Line 84 and elsewhere. Authors are requested to explain what 'apparent 14C age' and, later 'apparent MRT' refers to.

Apparent means that SOM was defined by Trumbore (2009). It is the 'apparent' age or MRT of the complex mixture of various compounds turning over on different time scales. This explanation can be found in the introduction.

13) Line 99. I suggest adding 'of a forest soil' behind 'subsoils'.

Changed according to your comment.

14) Line 183 ff. It is not clear why soils were treated with 0.5 % HCl before AMS. This removes part of SOM of a particular but unknown signature. If amount and signature of the dissolved C is not the same for all samples, the resulting 14Csample may lead to biased conclusions.

In radiocarbon dating this is a standard procedure to remove any inorganic C from soil samples that may bias its 14C content. This acid treatment does not remove significant amounts of OC as most fulvic acids are removed after alkali treatment which was not applied (see Bräuer et al., 2013). Moreover, we used a more diluted HCl as normally done (0.5 instead of 1%) as suggested by the Groningen AMS lab (presented at the 14C Conference in 2010). Thus 14C contents are not biased because of this treatment.

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15) Line 336. Strictly spoken, the root biomass does not tell very much about the input from roots because root turnover and rhizodeposition may change with depth. Also the correlation between % SOC and root biomass must not be conclusive. Higher SOC in topsoils is, at least partially, resulting from aboveground litter input, and this explains much of the typically found difference in the mass-depth slope between depth and % SOC on the one hand and depth and root biomass on the other (see e.g. Jackson et al. (1996); Jobbagy and Jackson (2000).

We agree that the upper 35 cm are still significantly influenced by aboveground OC and this was already stated in the text and is reflected by unpublished lipid biomarker analyses. However, in the subsoil horizons below soil OC contents and 14C contents are strongly affected by the root distribution. Unfortunately, we don't have any data on rhizodeposits and root turnover but our data give enough evidence for our statements given in this chapter. Moreover they confirm results of a previous study by Rasse et al., (2005). We improved the text by making some changes (chapter 4.1).

16) Line 354. This conclusion is difficult to draw without consideration of carbon input rates. Chapter 4.2. I think the attempt to explain 14C by microbial biomass parameters is highly misleading. The measured microbial biomass reflects the current situation and its turnover time is in the range of months whereas 14SOC integrates processes that took place over centuries and millennia. The authors implicitly assume that the Cmik distribution in their profiles is representative for much longer timescales, which they do not know.

Line 354: We listed several parameters that may - in addition to the root mass - affect the 14C distribution. This is no final conclusion but just a speculation which could not be improved by C input data because more detailed studies are required to verify our assumptions.

Chapter 4.2: We agree that Cmic represent the present situation (i.e. viable microbes) and thus is difficult to be compared with 14C data. However, Cmic has already been used to identify ‚hot spots, of microbial biomass Bundt et al. (2001), which could probably have strong effects on 14C, e.g. due to utilization of labile (young) OC. However, there is no other parameter that can easily be measured representing the microbial biomass over longer timescale (lipid biomarkers are also difficult because of selective degradation). Thus we keep on using Cmic as an indicator for the current situation assuming no significant changes in the mature beech forest. We added a comment to this in the text and replace the word 'effect' to 'interaction' in caption 4.2.

17) Line 366. Authors may also consider that DOC ages during its journey through the soil column; this may increase its 14C age substantially.

Unfortunately, DOC fluxes were not included in this study. DOC fluxes were determined in another project in an adjacent study site. They were found to be extremely low and their 14C ages were modern at all depth intervals (unpublished data). This result is comparable to previous studies which determined low DOC fluxes in sandy soils under forest (e.g. Dosskey and Bertsch, 1997; Fröberg et al., 2007; McDowell and Likens, 1988). Thus we assume that DOC has a minor effect on the 14C contents of bulk soil OC.

18) Line 385. Sentence unclear.

We modified this sentence. We compare our result, suggesting that microbial derived OC is enriched in fine particle size fractions, with a study by Rumpel who found - in contrast to our result - that 'microbial-derived polysaccharides were enriched in the mineral fraction (>2 g cm-3).

19) Line 437-444. I would argue that, in addition, the smaller topsoil variability reflects the important role of aboveground litter inputs, which may be similar among the three sites.

We added this argument in chapter 4.4

20) Line 456. This is in some contradiction to line 383.

We rewrote this part to clarify that abundances or content of microbial derived C do not promote 14C contents but that higher abundances of microorganisms can utilize fresh (young) OC, resulting in lower 14C contents.

21) Line 461. OC input has not been estimated in this study, which is a major shortcoming. Hence, authors should not refer to input as a driving force for 14SOC unless they do a proper input estimate.

According to comment 3, we were not able to estimate C input rates. Therefore, we decided to replace the word 'source' inputs by 'source' derived OC.

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Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-11, 2016.