Author's response to reviewer comments, followed by MS in track-change mode

Reviewer 1

This paper addresses an important issue with regards to modelling soil carbon dynamics. The inclusion of some measure of experimental uncertainty in such models is vital in informing the level of confidence one should have in their output. The approach taken by the authors to determine how the experimental error compares to the measurement error and how it is affected by experimental parameters such as soil treatment and sample depth appears to be straightforward and effective. Whilst the experimental approach seems sound, I have a number of large concerns with the manuscript itself.

In many places, the written English is such that the sentences are overly convoluted and their meaning is often unclear (e.g. lines 22 to 26, 61 to 63).

Response: no page numbers are given for these lines or they do not exist, hence it is not clear what part of the text the reviewer is referring to. We went through the whole text, tried to clarify and formulate more to the point. Further, we will make use of English language copy-editing offered by the publisher.

My major concern, however is not with the quality of the data itself, or the interpretation, but that it appears that there has been a transcription error in many of the values given for the coefficients of variation in Table 2. These are the main parameters from which many of the conclusions are drawn and if this transcription error occurred before the data were interpreted and analysed, this could have a significant effect on the discussion and conclusions. I would strongly recommend that the authors rectify the issues with the data and the clarity of the writing before resubmitting.

Thanks for this point. As already mentioned in our online-response, there has indeed been a transcription error. The revised manuscript contains the corrected data. The average CV of our pMC data did not change and, consequently, Figs. 2 and 3 remain as they were. Hence, the revision does not alter our conclusions.

Specific Comments

- The sentence on lines 41-43 needs referencing. It may also be prudent to very briefly explain how stable isotopes have been used to investigate C storage changes over time and how fast new C replaces old C.
We added two references and briefly introduced the topic. Given the nature of our MS (short communication), these three sentences are not considered all-encompassing.

- The authors talk about in-field variability, but in this context, this term may be misleading. This field contains 60 different experimental plots. A large amount of variability across the field is very likely. I would argue that the individual experimental plots within the field are experimental replicates, and the variability the authors are discussing is an experimental error rather than a measure of soil heterogeneity, or in-field variation. If the issue were variation in a field due to soil heterogeneity, the authors should discuss the issue of representative sampling in the introduction section. If a sample is truly representative of a field, the within-field variability becomes irrelevant. This would be an important area of discussion, because if a representative sample is taken then it could be argued that the only error term of importance is the measurement error. The current experiment employed replicated treatment plots (n=5). This replicate error is another matter; it gives a measure of confidence in the experiment itself, i.e. repeatability, the influences of surrounding plots etc.

As already indicated in our online response, we agree with the reviewer’s view and changed the terminology to ‘experimental error’ accordingly throughout the MS.

- Table 2 contains a worrying error whereby the wrong CV values are given for the majority of the samples in this study. The CV values reported by the authors and the values I calculated from the data presented are given in Attachment 1. It is unclear how this error will affect the interpretation of the data in this paper, but the authors urgently need to address this issue.

The reviewer detected a transcription error, thanks for this. We corrected and checked all data in the MS. The interpretation does not change because the average CV of our pMC values does not change.

This is what Figs. 2 and 3 built on.

- In lines 126, it is not fair to say that there was no change with depth. The authors must at least say that there was no significant change, i.e. there was no change at a p=0.05 level of significance. The data shows that statistically, with a p value of 0.16, there is a significant difference at an 84% confidence level. This is not high enough to say that there is a significant change, but it is certainly not fair to say that there was no change. Similarly, line 132.

Changed to ‘no significant’ and ‘not significantly’

Technical corrections

There are many linguistic and grammatical errors throughout the manuscript and I would suggest professional editing might be required.

If accepted, the MS will be copy-edited by the publisher.
Reviewer II

General comments The paper by Leifeld & Mayer is a very good short communication on the important and timely subject of using 14C to estimate turnover times of soil C. The authors make good use of an established long-term experiment and make a convincing argument for caution when converting pMC values to MRT values due to inherent soil variations. I recommend that this paper be published subject to minor revision outlined below.

Specific comment (referred to page (P) and line (L) number in the version I downloaded)

C147

P219 L11 It is more typical to refer to 13C/12C (rather than 12C/13C).

Agree, changed.

P219 L18-19 Use 14C rather than radiocarbon (you have already introduced this).

done

P219 L22 Change ‘constraints’ to ‘constrains’.

done

P219 L24 Change ‘extent’ to ‘extend’.

done

P223 L6-11 As another referee may have already commented, I was a little unsure as to how the confidence intervals were derived. There appeared to be a contradiction (‘outer band, 3.6% of the measured pMC. This CI represents the 3.1% CV above’). To calculate confidence intervals, one requires the standard error of the mean (SEM) and the appropriate Student’s t-value. I was a little unsure as to whether one single SEM had been calculated for the total 45 data (3 treatments x 3 depths x 5 field replicates) in Table 2, or whether some kind of ‘average’ SEM had been calculated based on individual SEMs for the 9 treatments (3 treatments x 3 depths). Please could the authors clarify this?

As already explained in our online-response, calculation of confidence intervals for each set of n=5 was done exactly as described here by the reviewer (using SEM and t-value). Because the 14C-variability was not dependent on treatment or depth, we used a generic 14C variability, given by the average variability of the nine treatment x depth combinations. Hence, we act on the assumption that the CV of 3.15 % (SD/mean*100) is the same over the simulated range of 70 – 105 pMC and, hence, the confidence interval (i.e., SD/sqrt [n]*t) is calculated for every single pMC value in Figs. 2 and 3 using the same CV. We adopted our text accordingly.

P224 L 26 Ellert et al. (2006) reference should use upper case for 13C, 14C and 15N.

changed
Table 2 caption. Please state that ‘sigma’ is the standard deviation (assuming that it was it is).

Done. The radiocarbon convention always use sigma, sigma = SD now as table footnote.

Figure 2 I recommend that the y-axis (MRT) goes up to 4500 years to show the full deviation at 70 pMC.

Good point, done
$^{14}$C in cropland soil of a long-term field trial – experimental in-field variability and implications for estimating carbon turnover

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Abstract

Because of their controlled nature, the presence of independent replicates, and their known management history long-term field experiments are key to the understanding of factors controlling soil carbon. Together with isotope measurements, they provide profound insight into soil carbon dynamics. For soil radiocarbon, an important tracer for understanding these dynamics, in-field experimental variability across replicates is usually not accounted for, hence, a relevant source of uncertainty for quantifying turnover rates is missing. Here, for the first time, radiocarbon measurements of five independent field replicates, and for different layers, of soil from the C050 years old controlled field experiment ZOF in Zurich, Switzerland, is used to address this issue. 14C variability was the same across these three different treatments and for three different soil layers between surface and 90 cm depths. On average, in-field experimental variability in 14C content was 12 times the analytical error but still, on a relative basis, smaller than variability in that of soil carbon concentration. Despite a relative homogeneous variability across the field and along the soil profile, the curved nature of the relationship between radiocarbon content and modelled carbon mean residence time suggests that the absolute error, without consideration of in-field variability, introduced too high calculated soil carbon turnover time calculations increases with soil depth. In our field experiment findings on topsoil carbon turnover variability would, if applied to subsoil, tend to underweight turnover variability even if in-field experimental variability of the subsoil isotope concentration is not higher the same. Together, in-field experimental variability in radiocarbon is an important component in an overall uncertainty assessment of soil carbon turnover.

1 Introduction

Long-term agricultural field trials have long been recognized as important sources for understanding long-term management effects on soil parameters such as soil organic carbon content and turnover (Jenkinson, 1991). Their special value lies in their controlled nature, the long-term record of management activities, reliable soil and crop parameter records as well as site climate data. Many experiments have indicated that soil carbon responds sensitively to agricultural management and have allowed to identify sustainable management practices. Hence, these data sets are valuable sources of information also for developing or testing soil and ecosystem carbon models (Smith et al. 1997; Franko et al. 2011).

Soil carbon feedback to management is controlled by organic matter input as well as turnover and hence loss. Isotopes play an important role for unraveling soil carbon turnover rates. In complementation to records on carbon storage change over time, they deliver information on how fast new carbon replaces old carbon (e.g., Trumbore 1993). When the isotopic signature, i.e. 13C/12C or 14C/12C ratio, of the input material to soil is not constant over time, it induces a directed shift in the soil’s isotopic signature. For a known input signature, the subsequent change in the soil’s isotopic signature allows estimating the replacement rate of old by new carbon. For example, changes from C3 to C4 vegetation or vice versa alter the 13C/12C ratio of the input and allow for estimating turnover rates (Balesdent et al. 1988). Besides stable 13C/12C, also the radioactive isotope 14C has a long history of application in soil carbon studies (Harkness et al. 1986; Jenkinson et al. 1992; Trumbore 1993). The introduction of extra 14C to the atmosphere via nuclear bomb testing in the 50ies and 60ies of the last century and the subsequent diffusion of that label into terrestrial
2 Material and Methods

The Zurich Organic Fertilization Experiment ZOFE was commenced in 1949 at the Swiss federal research institute for agriculture, Agroscope in Zurich. It is located at 420 m asl, receives an annual precipitation of 1040 mm and has a mean annual temperature of 9°C (1949–2009). The soil is a well-drained, carbonate-and-stone-free, homogeneous haplic Luvisol (IUSS 2006) (texture: clay 14%, silt 27%, sand 54%). ZOFE comprises 12 different fertilization treatments with five replicates each (Fig. 1), applied to a 8-years crop rotation. The experiment is arranged in a systematic block design. A detailed experiment overview is provided by Oberholzer et al. (2014).

Here we present data from three treatments (Fig. 1) that were analyzed for their radiocarbon content. Treatment ‘Null’ received no fertilizer since 1949, treatment ‘FYM+PK’ receives 2.5 t farmyard manure (dry organic matter) every second year plus annually 235 kg K and 35 kg P as mineral fertilizer. Treatment ‘N2P2K2Mg’ receives 56/139 kg N (before/after 1981), 318/167 kg K (before/after 1991), 61/38 kg P (before/after 1991), 12/6 kg Mg (before/after 1991), and no organic fertilizer. All mineral fertilizer units are in kg ha⁻¹ a⁻¹. Differences in crop productivity resulted in different residual plant carbon input of 556 (Null), 1085 (FYM+PK), and 1255 (N2P2K2Mg) (kg ha⁻¹ a⁻¹) (Oberholzer et al., 2014).
Soil samples were taken in April 2012 from the center of each plot using a powered rotating soil auger (Humax, Burch AG, Rothenburg, Switzerland) down to depth of 90 cm. The auger is equipped with an outer shaft hosting a PVC inlet that gets filled with a volumetric soil sample of diameter 5.0 cm during drilling. Samples were pooled into segments 0-20, 20-30, 30-60, and 60-90 cm. For the present study, samples from the plough pan 20-30 cm were not analyzed. After extraction, samples were sieved < 2 mm, dried at 105 °C, roots were removed by hand, and an aliquot was finely ground.

Prior to radiocarbon analysis, samples were pretreated using acid fumigation with 0.5M HCl to remove possible remnants from liming or traces of pedogenic carbonate. Soil radiocarbon content was measured by accelerator mass spectrometry at two different facilities, the radiocarbon laboratory of ETH Zurich, and the radiocarbon laboratory of the University of Bern, Switzerland. Both systems operate following the protocol of Synal et al. (2007). Radiocarbon concentrations are given as percent Modern Carbon (pMC) as defined by Stuiver and Polach (1977).

To study effects of experimental \(^{14}C\) variability on soil carbon dynamics, we applied a common, time-dependent steady-state soil carbon turnover model. This model has been first described by Harkness et al. (1986) and later been used as single or multiple pool version in various studies (e.g. Baisden et al. 2013; Gaudinski et al. 2000; Harrison 1996; Trumbore et al. 1996). The model gives mean residence times (MRT's) of soil carbon. Because we have no \(^{14}C\) time-series available the most simple version of that model is applied representing a single-pool assumption as described in Leifeld et al. (2013). Although soil carbon time-series are better described by multiple pool approaches (Baisden et al. 2013), the assumption followed here is sufficient to discuss possible consequences of \(^{14}C\) variability for the interpretation of soil carbon dynamics. Because our data represent a single point in time, they do not allow adequate parameterization of a more complex model. Hence, we do not claim the presented turnover estimates to represent the most realistic in situ situation but rather to allow discussion of variability effects.

The effect of depth on pMC and carbon mean residence time was tested by univariate ANOVA separately for each treatment and for the aggregated sample across treatments.

### 3 Results and Discussion

Radiocarbon contents in the ZOFE plots average 100.2 (± 1.8 (1 SD)), 88.0 (± 3.00), and 76.5 (± 4.2) pMC for 0-20, 30-60, and 60-90 cm, respectively (Table 2). Across all 15 plots as well as when grouped by treatment, the depth effect was highly significant (p<0.001). Declining pMC values with soil depth are indicative for longer carbon mean residence times in the deeper layer of soil and have been reported frequently for soils that were not prone to substantial inputs from fossil carbon (Budge et al. 2011; Gaudinski et al. 2000; Jenkinson et al. 2008; Toyota et al. 2010).

Table 2 also indicates that the coefficient of variation (CV) of pMC for five independent plots, representing mostly experimental \(^{14}C\) variability, lays between 1 – 7 percent (mean over nine of all treatments: layer combinations and layers: 3.15 %). This is, for the present data set, 3 – 23 times the CV of 0.3% pMC of the analytical precision of the AMS measurement. Notably, the CV for soil organic carbon concentration is, per treatment and layer, on average 9.5 % (data not shown), thus three times that of the radiocarbon content. There was no significant depth effect on the coefficient of variation (p=0.16), hence, \(^{14}C\) variability does neither increase nor decrease with depth. At the same time, the CV grouped by treatment was statistically not different between ‘Null’, ‘FYM+PK’, and
247 'N2P2K2Mg' (p=0.64). The latter implies that experimental $^{14}$C field variability as measured in ZOFE is
248 related to site – or soil inherent properties rather than to agricultural management.
249
249 Although $^{14}$C variability did not significantly change with depth, it influences the variability of the
250 derived soil carbon MRT’s differently in the three layers. This can be studied by calculating turnover
251 for the range of pMC data expressed by their average confidence interval (CI). Here, we calculate the
252 CI of MRT’s from the average coefficient of variation of i) 0.30 % of pMC (analytical error) and ii) 3.15
253 % of pMC (experimental variability, average of nine individual sample sets with each n=5) over the
254 measured data range. We use these average CV’s for calculating CI’s over the whole data range
255 because neither treatment nor depth significantly influenced pMC variability in the field. Owing to
256 the combination of i) a non-constant atmospheric radiocarbon concentration as a result from long-
257 term and short-term $^{14}$CO$_2$ fluctuations and ii) exponential radioactive decay in the soil, the
258 relationship between pMC and MRT is non-linear. This is illustrated for a series of homogeneous soil
259 pools of different age. Radiocarbon signatures of such a pool series with range from 70 – 105 pMC
260 (resembling the span found in the soil data, Table 2), convert to MRT’s of between 3891 and 156
261 years (Fig. 2). The pMC-age curve becomes steeper at smaller radiocarbon concentrations. Whereas
262 the central curve in Fig. 2 gives results for the mean pMC, the inner and outer bands represent the
263 95% CI of i) the average variability owing to measurement-analytical error only (inner band) and ii) the
264 average in-field experimental variability in the soil (outer band, 3.1 % of the measured pMC. This
265 CI represents the 3.1 % CV above). These bands give upper and lower probability limits for the
266 calculated MRT and they deviate the further from their mean the older the carbon is. For example, a
267 MRT of 3891 (CI 3392 - 4453) years is assigned to a soil carbon pool with signature pMC = 70 (CI
268 67.50 – 72.50 pMC), whereas the same relative uncertainty for a mean pMC of 105 (CI 101.26 - 108.74 pMC) converts to a MRT of 156 (CI 92 – 268) years.
269
270 Fig. 3 further illustrates the principle. Soil carbon from 60 – 90 cm, carrying a signature of e.g. 75
271 pMC, has a calculated MRT of 2947 years with deviations of + 477 and – 428 years, referring to the
272 variability among five independent field replicates. The uncertainty range is reduced to +193 and -
273 129 years (mean MRT 321 years) for a pMC of 100, roughly representing the current topsoil. While
274 the absolute uncertainty declines the younger the soil becomes, the relative uncertainty increases in
275 the opposite direction (Fig. 3, right). Fig. 3 also exemplifies the wider uncertainty band, over the
276 calculated pMC range, when in-field experimental variability and not only measurement error is
277 accounted for. At pMC 70, the uncertainty range of MRT’s considering in-field experimental variability
278 is 4.2 times that of measurement error only. This factor increases to 6.5 at pMC 105, indicating that
279 for younger soil carbon the omission of in-field experimental variability introduces a larger relative
280 uncertainty than for older soil carbon.

281 4 Conclusions

282 Soil radiocarbon dating from a long-term agricultural experiment indicates that in-field experimental
283 variability of this parameter is many times the analytical error. in-field/Experimental variability seems
284 neither controlled by management nor by soil depth. Conversion of relative uncertainty in
285 radiocarbon content to relative uncertainty in carbon turnover reveals a higher sensitivity of carbon
286 turnover to $^{14}$C variability in deeper soil layers that contain older carbon. Consequently, when soil
287 samples from a long-term field trial are pooled per depth and treatment for $^{14}$C analysis, the
underestimation of the actual in-field experimental variability of soil carbon turnover is larger for subsoil samples where long-lived C pools are more abundant.

Acknowledgments. We thank Irka Hajdas and Lukas Wacker, ETH, and Sönke Szidat, Oeschger Center University of Bern, for AMS measurements and the Swiss Federal Office for the Environment for financial support, contract L482-0519.
References


Ellert, B. H., and Janzen, H. H.: Long-term biogeochemical cycling in agroecosystems inferred from 


Table 1. Long-term agricultural field experiments where radiocarbon was used to derive soil carbon turnover estimates.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Country</th>
<th>$^{14}$C time series</th>
<th>$^{14}$C available from independent and randomized treatment reps.</th>
<th>$^{14}$C measured in &gt; 1 layer</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lethbridge</td>
<td>Canada</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>Ellert and Janzen (2006)</td>
</tr>
<tr>
<td>Askov</td>
<td>Denmark</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>Bol et al. (2005)</td>
</tr>
<tr>
<td>Bad Lauchstädt</td>
<td>Germany</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>Ludwig et al. (2007)</td>
</tr>
<tr>
<td>Halle</td>
<td>Germany</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>Rathemeyer et al. (2007); Flessa et al. (2008)</td>
</tr>
<tr>
<td>Rotthalmünster</td>
<td>Germany</td>
<td>no</td>
<td>no</td>
<td>yes</td>
<td>Rathemeyer et al. (2007); Flessa et al. (2008)</td>
</tr>
<tr>
<td>DOK</td>
<td>Switzerland</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>This study</td>
</tr>
<tr>
<td>ZOFF</td>
<td>Switzerland</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Rothamsted</td>
<td>UK</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>Jenkinson et al. (2008)</td>
</tr>
<tr>
<td>Morrow Plots</td>
<td>USA</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>Hsieh (1992)</td>
</tr>
<tr>
<td>Sanborn Field</td>
<td>USA</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>Hsieh (1992)</td>
</tr>
</tbody>
</table>
Table 2. Percent modern carbon (%) (±1 sigma uncertainty) of organic carbon in soil samples from the ZOFE trial taken in 2012 for three treatments and three soil layers. Lines ‘CV’ indicate the coefficient of variation for each treatment/depth combination. Plot number according to Fig. 1. Sign ‘x’ refer to lab ETH, sign ‘o’ to lab Bern.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plot number</th>
<th>0-20 cm</th>
<th>30-60 cm</th>
<th>60-90 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null</td>
<td>1</td>
<td>97.54 (0.36)x</td>
<td>84.24 (0.32)x</td>
<td>73.52 (0.33)x</td>
</tr>
<tr>
<td>Null</td>
<td>19</td>
<td>102.33 (0.22)o</td>
<td>85.44 (0.34)x</td>
<td>77.17 (0.32)x</td>
</tr>
<tr>
<td>Null</td>
<td>28</td>
<td>101.01 (0.36)x</td>
<td>84.74 (0.33)x</td>
<td>74.75 (0.33)x</td>
</tr>
<tr>
<td>Null</td>
<td>46</td>
<td>101.00 (0.22)o</td>
<td>89.90 (0.20)o</td>
<td>74.03 (0.17)o</td>
</tr>
<tr>
<td>Null</td>
<td>51</td>
<td>100.69 (0.22)o</td>
<td>83.48 (0.19)o</td>
<td>74.90 (0.39)x</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>1.77</td>
<td>2.9638</td>
<td>1.8746</td>
</tr>
<tr>
<td>FYM+PK</td>
<td>6</td>
<td>100.78 (0.22)o</td>
<td>91.26 (0.21)o</td>
<td>78.98 (0.18)o</td>
</tr>
<tr>
<td>FYM+PK</td>
<td>24</td>
<td>99.80 (0.22)o</td>
<td>89.55 (0.20)o</td>
<td>78.52 (0.18)o</td>
</tr>
<tr>
<td>FYM+PK</td>
<td>33</td>
<td>101.20 (0.22)o</td>
<td>90.05 (0.20)o</td>
<td>73.11 (0.17)o</td>
</tr>
<tr>
<td>FYM+PK</td>
<td>39</td>
<td>102.33 (0.38)x</td>
<td>90.52 (0.20)o</td>
<td>86.10 (0.19)o</td>
</tr>
<tr>
<td>FYM+PK</td>
<td>53</td>
<td>96.08 (0.21)o</td>
<td>88.95 (0.20)o</td>
<td>75.37 (0.18)o</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>2.3995</td>
<td>0.948</td>
<td>6.2732</td>
</tr>
<tr>
<td>N2P2K2Mg</td>
<td>12</td>
<td>100.13 (0.37)x</td>
<td>88.36 (0.33)x</td>
<td>74.93 (0.18)o</td>
</tr>
<tr>
<td>N2P2K2Mg</td>
<td>18</td>
<td>100.49 (0.22)o</td>
<td>85.36 (0.20)o</td>
<td>76.11 (0.18)o</td>
</tr>
<tr>
<td>N2P2K2Mg</td>
<td>27</td>
<td>97.79 (0.37)x</td>
<td>93.88 (0.35)x</td>
<td>85.01 (0.34)x</td>
</tr>
<tr>
<td>N2P2K2Mg</td>
<td>45</td>
<td>101.55 (0.46)x</td>
<td>86.52 (0.33)x</td>
<td>71.40 (0.31)x</td>
</tr>
<tr>
<td>N2P2K2Mg</td>
<td>59</td>
<td>101.06 (0.22)x</td>
<td>87.84 (0.20)o</td>
<td>73.16 (0.17)o</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>1.4582</td>
<td>3.72627</td>
<td>6.9844</td>
</tr>
</tbody>
</table>

1 sigma = standard deviation
Fig. 1. Spatial arrangement of the ZOFE field trial in Zurich indicating twelve treatments à five replicates arranged in five blocks (I. – V.). Plot numbers in lower left corner are listed together with measurements in Table 1. Treatments in bold (Null, FYM+PK, N2P2K2Mg) were used for the present study. For a detailed description of all treatments, please see Oberholzer et al. (2014).

Fig. 2. Relationship between percent modern carbon (pMC) and calculated carbon mean residence time (MRT) using a time-dependent steady-state single pool turnover model. The inner line refers to mean values; the inner, dashed band to the 95% uncertainty range related to the average $^{14}$C measurement analytical error, and the outer, solid band to the 95% uncertainty range related to the average experimental $^{14}$C variability in the field.

Fig. 3. Comparison of absolute (left) and relative (right) deviation of calculated MRT’s from the mean, expressed as 95% confidence interval of i) average measurement analytical errors (inner, dashed line) and ii) average in-field experimental variability in the field (outer, solid lines). In the ZOFE trial MRT’s of below 200 years resemble topsoil 0-20 cm, of c. 1200 years to 30 – 60 cm, and of c. 2600 years to 60 – 90 cm.
Table 1. Experiment design for the study.

<table>
<thead>
<tr>
<th>N</th>
<th>NIPK2</th>
<th>N2P2K2</th>
<th>Sludge</th>
<th>FYM+PK</th>
<th>FYM</th>
<th>Compost</th>
<th>Compost + PK</th>
<th>Compost + PK + Peat</th>
<th>Peat</th>
<th>Peat +PK</th>
<th>Sludge + PK</th>
<th>NIPK2</th>
<th>N2P2K2 Mg</th>
<th>N2P2K2</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Fig. 1.
Feldfunktion geändert
Fig. 3