Response to Dr. C.A. Sierra (referre)

Response to the general comments

First, we would like to thank Dr. Sierra for his constructive remarks and reassure him about the interpretation of radiocarbon data. We used the F_a radiocarbon data for modelling. In order to compare the Bh between profiles, we calculated a conventional, uncalibrated apparent age from the F_a radiocarbon values. The paragraph from line 86 to 91 is actually confusing: the Poznań Radiocarbon Laboratory has indeed provided both the values of F_a and calibrated ages, the latter having not been used. Regarding the topsoil horizons, the bomb carbon should not be neglected so that we retrocalculated a pre-1950 F_a value that we used for modelling. The paragraph has been modified (lines 90-97), as well some column legends in Table 1 that were incorrect, and we added the reference to Sierra, 2014 because of the good synthesis given in this paper. The F_a values were added in Tables 1 and 2.

Regarding the second concern, and as was pointed out by the reviewer, we used the concept of minimum time and time to steady-state to compare the different soils within the context of this analysis.

- The value we used for the minimum time ($\beta_{Bh} = 10^{-10}$) is not arbitrary: we used a value different from zero for numerical reasons, in order to avoid denominators equal to zero (see for example equ. 12). We checked that the difference between the minimum times obtained using $\beta_{Bh} = 10^{-10}$ and $\beta_{Bh} = 10^{-20}$ is negligible (lower than 0.0005%). We clarified this point in the new version of the manuscript (lines 227-229).
- We agree with the reviewer that the proportion of the steady-state value set to 99% is arbitrary. Values closer to 100% would give a dramatic increase of the time needed to form the profile, as shown on Fig. 8. We used 99% because, as shown on Fig. 8, this value gives a result sufficiently close to the horizontal asymptote to give a reasonable evaluation of the time necessary to reach a steady state. This is now explained on lines 207-208.

Response to the technical comments.

Reviewer comments are given in bold, our response in normal font

• The ^{14}C ages presented in the abstract are misleading because you do not meet the closed system assumption. I would rather not present these values, or if you decide to present them, mention that you calculated them even though you do not meet the assumptions of the dating method.
We specified in the abstract that the given ages are calculated apparent ages.

• Line 63. What database? Is it publicly available? Can you provide a reference or a doi?
This is a database of 80 podzol profiles which have been studied in detail and of which 11 have been dated, this database will be the subject of a further publication. This is now indicated on lines 63-65.

• Line 75. 'Conventional age calibration' is a contradiction. Conventional radiocarbon age is the age assuming Libby's half life, and does not use a calibration curve. What you probably mean is 'age calibration', but as I mentioned above, this step is not needed for your modeling setup so you may consider eliminating this section from your methods.
This was corrected – see response above.

• Line 112. I had problems understanding this step and the corresponding Fig 5. You may need to provide additional details.

We explained better this step: in eq (7), we give the expression of the $F_{a\,t_i}$ value (F_a value of the topsoil OM on year *i*) as a function of the $F_{a\,t_{i+1}}$ value (F_a value of the topsoil OM on year I +1), and we explained on lines 139-141 the iterative retrocalculation.

• Section 2.3. It is not clear from the description of the simulation setup what is the calendar year corresponding to t = 0. In other words, did you always started your simulations at a specific calendar year or did this varied for the different soils. This information is important because the atmospheric radiocarbon value corresponding to t = 0 influence the forward trajectories for the soil radiocarbon values.
The simulations did not started at a specific year. We used the present day atmospheric carbon value to simulate the Bh formation. This is an approximation, as it is known that atmospheric radiocarbon value was higher than at present (see for example Kitagawa and Van der Plicht, 1998), which likely leads to a systematic underestimation of development durations, although this underestimation remains low compared to uncertainty.

• Equation 8. Why is P a subscript of _ and C? Is this a typo?
It was a "copy and paste" error and was corrected.

• Line 171. These numbers are in reverse order. Curve 1 in Fig 7 has a time required to reach 99% of the steady state of 43 10$_3$, while curve 2, 345 10$_3$. This also makes sense since Montes et al. suggests a much higher value of vertical C C3 transfers than Sierra et al., therefore the values from Montes et al. should reach the steady-state faster.
OK, this was corrected.

• Line 184. This is a very arbitrary definition of minimum time. if β_{Bh} is 10$_{-20}$, or 10$_{-30}$, the 'minimum time' would change drastically, and there is not any relevant reason for why it should be 10$_{-10}$. I would recommend not using this concept of minimum time.
See explanation above – this minimum time is really significant, we used 10^{-10} in place of 0 for numerical reasons but the result is the same as if 0 is used. We also checked this using equations rewritten for $\beta_{Bh} = 0$.

• Line 189. What is this maximum absolute error propagation? Did you define this before?
This is the maximum absolute error, this was corrected in the text (line 241).

• Lines 247 and 252. Are these decimal numbers? Change comma for point.
This was corrected.

• Tables. I'm missing a table with the obtained values of the parameters of the model of Fig 4 obtained for the four different soils. This information is somehow imbedded in Fig 12, but as total stocks and fluxes, and not with the values of the parameters used to obtain these numbers.
We added a table to give the values of the parameters (Table 4).

• Figures. Figure captions are very poor. Please provide enough information in the caption to better interpret the figures.
This problem corresponded to a poor framing of the figures, which cut some of the informations. It was corrected in the new version.