

Dear Dr. Subke,

We really appreciate your time and effort on improving our manuscript. We have revised these issues point by point as follow. Please note that the comments are in italic gray followed by our replies in black.

**Comment 1:** *Page. 2, Line. 2: Please capitalize first letter of all words in Earth System Models.*

**Response:** Done. the first letter of all words in Earth System Model has capitalized through the whole text.

**Comment 2:** *P. 2, L. 3: “mean age” of C atoms is not correct. Please change to “mean residence time”.*

**Response:** Thanks for the suggestion. We have carefully double checked the differences in the concepts of transit time, residence time and mean age. The recent book *Radiocarbon and Climate Change* wrote by Schuur et al. (2016) has clearly summarized their difference. Below is the table on the Page 71 of that book:

**Table 3.2** Terms used to infer C dynamics using biogeochemical box models.

Term	Concept
Turnover time	An inventory divided by either the input or the output flux.
Age	Time since a C atom in a system entered the it. Integrating over all atoms present in the system at a given time, one can calculated a mean age.
Transit time	Time it takes a C atom to move through (transit) the system, which is equivalent to the age of the atoms at the time they leave it. Integrating over all atoms in the output flux, one can calculated the mean transit time.
Residence time	Variably defined in the literature, sometimes equivalent to age, sometimes to transit time. The use of this term depends on the scientific discipline and the context where it is applied.
Conventional radiocarbon age	Time since C in a system was fixed from the atmosphere as determined by the radiocarbon dating method using Libby’s half-life, and assuming a closed system for C.
Calibrated radiocarbon age	Calendar year in which the C in system was fixed from the atmosphere, assuming a closed system and using a stated calibration curve.

Note that only in single-pool, homogeneous systems in steady-state (one for which the probability of every atom leaving is equal), are *turnover time*, *mean age*, *mean transit time*, and *mean residence time* equal.

It shows that the residence time is variably defined in different studies. Another recent study of Serria et al. (2016) also suggest the research community of soil carbon to avoid using the concept of “residence time”. Thus, in this version, we kept the definition as same as that used in the book of Schuur et al. (2016) as:

“... soil carbon (C) transit time ( $\tau_{\text{soil}}$ ), which quantifies the age of the C atoms at the time they leave the soil.”

**Comment 3:** P. 2, L. 7: Please change: “(median of 4 years, with interquartile range of 1 to 25 years)”.

**Response:** Done. “(median of 4 years, with interquartile range of 1 to 25 years)” has revised as “(4 with 1 to 25 years)” in *Abstract* and *Results* section.

**Comment 4:** P. 2, L 11-14: Make 2 sentences, with full stop after “temperature” (end of line 12).

**Response:** This long sentence has revised to two sentences in *Abstract* section (P. 2, L. 11-13) as:

“We then found a significant and negative linear correlation between the *in-situ* measured  $\tau_{\text{soil}}$  and mean annual air temperature. The underestimations of modeled  $\tau_{\text{soil}}$  are mainly located in cold and dry biomes, especially tundra and desert.”

**Comment 5:** P. 2, L. 13: Comma needed after “biomes”.

**Response:** Done.

**Comment 6:** P. 2, L. 17: Please change to: “... soil C dynamics in regions limited by temperature or moisture”.

**Response:** Done. The sentence has rephrased in *Abstract* section (P. 2, L. 15-17) as:

“These findings indicate that the spatial variation of  $\tau_{\text{soil}}$  is a useful benchmark for ESMs, and we recommend more observations and modeling efforts on soil C dynamics in regions limited by temperature and moisture.”

**Comment 7:** P. 3, L. 3: As above, please use capitals for each of the words “Earth System Models”.

**Response:** Done.

**Comment 8:** P. 3, L. 9-10: Please rephrase to: “It is difficult to reduce or even diagnose this uncertainty, as many processes...”

**Response:** Done. This sentence has rephrased in *Introduction* section (P3, L 9-11) as:

“It is difficult to reduce or even diagnose this uncertainty, as many processes collectively affect the time of C atoms transit the soil system (i.e., transit time;  $\tau_{\text{soil}}$ )”

**Comment 9:** P. 3, L. 19/20: Please rephrase: “..., and the construction of a benchmarking database of available observation is urgently needed (Koven et al., 2017).”

**Response:** Done. This sentence has rephrased in *Introduction* section (P. 3, L. 17-20) to:

“Therefore, identifying the locations of such underestimations is critical to improve the predictive ability of ESMs on terrestrial C cycle, and the construction of a benchmarking database of available observations is urgently needed (Koven et al., 2017).”

**Comment 10:** P. 3, L. 24: Rephrase: “...commonly defined as “turnover time”, calculated by dividing SOC stock by C fluxes such as ...”.

**Response:** Done. This sentence has rephrased in *Introduction* section (P3, L 23-25) to:

“The first approach commonly defined as “turnover time”, calculated by the division of SOC stock by C fluxes such as net primary productivity (NPP) or heterotrophic respiration ( $R_h$ ).”

**Comment 11:** P. 4, L. 5: “mean residence times” rather than “mean ages”.

**Response:** Thanks for the suggestion. Please see **Comment 2**. we kept the definition as same as that used in the book of Schuur et al. (2016).

**Comment 12:** *P. 4, L. 20-22: This sentence is not clear. I suggest making it into 2 sentences: “ $\tau_{\text{soil}}$  was calculated under the homogenous one-pool assumption at steady state for all studies. Data from observations and CMIP5 ensemble were then used to calculate the  $\tau_{\text{soil}}$  based on both one-pool and three-pool models.*

**Response:** Done. This sentence has separated two sentences to made it clearer in *Introduction* section (P 4, L19-21) as:

“The SOC  $\tau_{\text{soil}}$  was calculated under the homogenous one-pool assumption at steady state for all studies. Data from observations and CMIP5 ensemble were then used to calculate the  $\tau_{\text{soil}}$  based on both one-pool and three-pool models.”

**Comment 13:** *P. 5, L. 4/5: Use active voice; “We constructed a database...”*

**Response:** Done.

**Comment 14:** *P. 10, L. 14: Text in brackets: “(median of 60 years, with interquartile range of 8 to 29 years)”. For subsequent results, simply state “(X with Y to Z years)”*

**Response:** Done. The subsequent results were simply state as “(X with Y to Z years)” in the main text.

**Comment 15:** *P. 11, L. 11: adjust spaces: “0.5° x 0.5°” (i.e. spaces either side of x, but not before degree sign).*

*P. 11, L. 14: delete “was” at end of line*

*P. 12, L. 5: “show”, not “shown”. Delete “both” at end of line.*

*P. 12, L. 18: delete “the” before “equation (12)”. Change “showed” to “show” at end of the line.*

*P. 12, L. 19: delete “the” before CLM4.5”. Change “Fig. 6” to “Fig. 5”*

**Response:** Done.

**Comment 16:** *P. 12, L. 24: Rephrase: “Higher NPP values simulated by ESMs...”*

**Response:** Done. This sentence has rephrased in section 3.4 (P. 12, L.24-25) as

“Higher NPP values simulated by ESMs in the cold and dry regions have been reported by previous studies (Shao et al., 2013, Smith et al., 2016, Xia et al., 2017)”

**Comment 17:** *P. 13, L.4-6: However, other processes such as the microbial dynamics, SOC stabilization and nutrient cycles could affect  $\tau_{\text{soil}}$ , but are so far not fully considered by CMIP5 models (Luo et al., 2016).*

**Response:** Done. This sentence has rephrased in section 3.4 (P. 13, L. 4-6) to

“However, other processes such as the microbial dynamics, SOC stabilization and nutrient cycles could affect the estimation of  $\tau_{\text{soil}}$ , but are so far fully considered by the CMIP5 models (Luo et al., 2016).”

**Comment 18:** *P. 13, L. 23: Is it fair to say that the model data base “is” a useful tool (rather than “could be”)?*

**Response:** Done. Yes, “...is a useful tool...” is better. This sentence has revised as

“Thus, model database, such as the bgc-md (<https://github.com/MPIBGC-TEE/bgc-md>), is

a useful tool to improve the integration of observations and soil C models.”.

**Comment 19:** *P. 13, L. 24: Delete “Thus”.*

**Response:** Done.

**Reference:**

Schuur, E. A., Druffel, E. R., & Trumbore, S. E. (2016). *Radiocarbon and climate change*. Cham, Switzerland: Springer.

Sierra, C. A., Müller, M., Metzler, H., Manzoni, S., & Trumbore, S. E. (2016). The muddle of ages, turnover, transit, and residence times in the carbon cycle. *Global change biology*, 23(5), 1763-1773.