

Interactive comment on “Long residence times of rapidly decomposable soil organic matter: application of a multi-phase, multi-component, and vertically-resolved model (TOUGHREACTv1) to soil carbon dynamics” by W. J. Riley et al.

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Received and published: 25 April 2014

We thank B. Ahrens for his insightful comments on our manuscript, and attempt to address his three points below (his comments in italics and our responses in normal font).

1. You very openly discuss that under the current parameterization your model gives negative $\Delta^{14}\text{C}$ values in the first centimeters (P.835–L.12; P.839–L.27). Visual inspection of Fig. 6 d-f would suggest $\Delta^{14}\text{C}$ values of $-100\pm 25\%$ in the first centimeters. I

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would have expected that the modeled $\Delta^{14}\text{C}$ in the first centimeters would easily reflect that litter inputs have had a $\Delta^{14}\text{C} > +69\%$ from 1957–2003 (“bomb-peak”). Could you elaborate which mechanisms in the model are right now responsible for negative $\Delta^{14}\text{C}$ values in the first centimeters, corresponding to conventional ^{14}C ages of around 900 years BP? Sorption processes? Very fast turnover of litter inputs? Could that also be related to the vertical resolution of the model?

As you mention, the model predictions did not match expected enriched $\Delta^{14}\text{C}$ values in the near-surface soil, which we believe indicates underlying mechanisms not represented in the model. As we discuss in the Discussion section:

“However, for context, we estimated that an increase of about 30 percent in SOC concentrations resulting from plant inputs over the past several decades would lead to a close agreement with observations. Thus, an additional young and protected carbon pool of small size (Fig. 3), and effectively not in equilibrium with the aqueous phase, can explain the difference between our predicted and commonly observed $\Delta^{14}\text{C}$ values near the soil surface. Our model allows for an additional non-equilibrium carbon pool that could be tuned to match these $\Delta^{14}\text{C}$ and SOC profiles, but we have avoided that type of tuning here. Processes that may be good candidates for this level of protection include aggregation and formation of colloids, which have been shown to substantially affect chemical mobility and carbon decomposition rates in soils (Daynes et al., 2013; Kausch and Pallud, 2013; Six et al., 2000).”

To clarify these points, we have indicated in the Results section that this discussion follows.

2. Throughout the text you use the $\Delta^{14}\text{C}$ notation, but the $\Delta^{14}\text{C}$ notation in Fig. 6d-f. Is this by accident? In my opinion, the $\Delta^{14}\text{C}$ notation should be preferred because it is independent of isotopic fractionation (Stuiver and Polach, 1977). Because one probably does not include isotopic fractionation due to photosynthetic fixation and microbial processing into the model, the $\Delta^{14}\text{C}$ notation should be more appropriate for model

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output.

It was not by accident, but by error from the typesetters. Our submitted text used the $\Delta^{14}\text{C}$ notation, and we will ensure that this problem is corrected in the final version of the paper.

3. The distribution coefficient K_d is very helpful to get an idea about the sorption affinity of the different compounds (Table 2), you note, however, that you use a dynamic approach because of competing sinks and sources (e.g., microbial consumption). How do the adsorption and desorption rates k_f and k_r compare to the maximum specific consumption rates μ_i ?

In the baseline version of the model, k_f is $6.6\text{e-}8$ per second and k_r is scaled by the factors shown in the last column of Table 2. The maximum specific consumption rates are given in Table 3. Note that this comparison is not particularly helpful to understand the relative rates between these processes, since the maximum specific consumption rates are modified by the Michaelis-Menten kinetics (equation 1) and are therefore often much lower than the maximum values. We have added text to Section 2.6 to clarify the sorption rate values.

Interactive comment on Geosci. Model Dev. Discuss., 7, 815, 2014.