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Biogeosciences Discussions

Interactive comment on "Stable isotopic constraints on global soil organic carbon turnover" *by* Chao Wang et al.

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A. SUMMARY OF THE REVIEW The topic is fully relevent for publication in Biogeoscience. The study confirms the correlations between 13C enrichment down the depth in soil profiles and environmental variables, that bave been already reported by several authors on smaller datasets. The title makes sense. But the manuscript requires significant revisions for two major reasons. - The first concern the consistency of the dataset itself, i.e., some erroneous attribution of data to biomes, omission of true tropical savannas profiles and profiles that reveal paleo C4-vegetations. The contribution of past C4 vegetation (delta13C -10 to 13 ‰ in such profiles is misunderstood. This leads to (i) non representative values of beta and (ii) overestimation of temperature dependence of 13C enrichments. - The second point concerns interpretation beyond this bias. The discussion tends to maximize the importance of kinetic fractionation by microbes as an explanation of beta's variance, but without providing results supporting it. I suggest reducing the section of discussion on this point. These comments are detailed in point "C. Extended review". Finally, the "Stable isotopic constraints on global soil organic carbon turnover " is there, but has to be recalculated after database correction. Interpretation of the correlations in terms of processes should be minored. I suggest to correct the database by restrict it to pure C3 ecosystems, and furthermore make the proposition to merge this database with another one, therefore doubling the number of observations (see B. below).

B. ONE UNUSUAL PROPOSITION TO IMPROVE THIS STUDY. In line with the philosophy of Biogeoscience Discussion, which stimulates interactive and cooperative research more than competitive research, I make the proposition to provide 155 additional profiles worldwide. In the frame of the COST (European COoperation in Science and Technology) action SIBAE (Stable Isotopes in Biosphere-Atmosphere-Earth System Research; 2009-2013), a group of 10 scientists (10 institutions) has built and analyzed an exactly similar database of 196 World 13C/C profiles and beta values under pure C3 ecosystems. 43 are common to yours, 99 in other peer-reviewed articles, and 56 in non peer reviewed literature (Figure 1). This dataset shows significant multiple regressions with climate and clay, which are similar to those presented in the present manuscript BGD 2017-338, but with less predictive value. This less predictive value is in accordance with the above-mentioned biases, with more profiles exhibiting less negative beta values (including some positive) and more varied environments. If the authors of MS BG2017-338 accept this proposition, a final dataset merging the present dataset (after correction) with SIBAE's one, would provide a stronger view of the stable isotopic constraints on global soil organic carbon turnover.

C. EXTENDED REVIEW.

1. Consistency of the database

Almost all so-called "tropical savannas" profiles in the database refer to afforestation or tree encroachments in C4 savannas. In published "real" tropical savannas profiles, delta13C decreases with depth, with values close to -12 -15 ‰ in surface and lower than - 20‰ in deep layers because of the presence of millenary-old forest-derived carbon. These have therefore POSITIVE beta values (of course non log transformable). If not log transformed, they would draw the "tropical beta" toward the opposite direction. In the so-called "tropical savannas" (profiles # 85, 86, 87, 106-112), reforestation leads to a strong gradient from C3 signature in the top, and predominant C4 signature below. These systems were precisely chosen by the authors to analyse C dynamics through 13C signature change, and are not representative of world savannas. In some of the cited papers, profiles with positive beta were omitted. Interpretations of highest ln(-beta) in this "expansive and dynamic biome" (line 149) are therefore based on forest expansion data! As a result Figure 3 is wrong: either real savannas should be included (positive beta) or tropical savannas and these C4 to C3 conversions should be removed from the database. The latter is my suggestion.

Beyond the case of "savannas", several profiles under tropical forests are marked by ancient C4 vegetations (profile numbers 78, 82-84, 115-121). They have been studied for this reason and are therefore not representative of world tropical forests. In both cases, beta is not linked to C turnover, but paleoclimate, as in many regions of the world. Almost all profiles with beta < -5 in the database are concerned. This overestimation of tropical ln(-beta) strongly affects Figure 4, the correlation with MAT or MAP (Figure 5), and Table 1, i.e., the main results.

2. Discussion of the relationships between beta and other variables (beyond paleo C4 vegetation) The discussion might sometimes be confusing. A "kinetic isotope fractionation" associated to biodegradation process (decay) would not directly imply a dependence on the rate (speed) of decay, i.e., the turnover rate. In the Rayleigh distillation equation, beta is typically independent on the rate. A partial explanation of the variance in beta by the turnover rate rely on complex processes (e.g., Acton,

Garten, Schlesinger), and should not neglect other sources of 13C variations, such as the change in plant isotopic composition with time, post-photosynthetic fractionation in plants, bioturbation, isotope composition of nitrogenous compounds, etc., which can also be involved in the correlation of beta with carbon turnover rate. On the contrary, the discussion tends to minimize these processes (lines 215 to 234). Furthermore, the magnitude of a kinetic fractionation by heterotrophic respiration in soils is still debated (e.g., Breecker et al., 2015). Since the results provide no new demonstration, I suggest minoring this part of the discussion. Since the dataset includes turnover rate (k), some hypotheses of factors affecting the "turnover rate" (e.g., MAP > 3000 mm) might be discussed also on the basis of k, and not only ln(-beta). The apparent decrease of ln(-beta) under climates with MAP > 3000 mm is probably linked to overestimated -beta in moderately moist tropical areas (C4 zone).

3. Details. Precise when defining beta that you used the decimal logarithm ("log" is ambiguous). Table 1 and Figure 5 legend: indicate that N(%) and Clay (%) refer to topsoil. Table 1 Add one digit to the regressor of MAP. Figure S1 is after Acton et al. 2013

Breecker, D. O. et al. 2015. Minor stable carbon isotope fractionation between respired carbon dioxide and bulk soil organic matter during laboratory incubation of topsoil BIOGEOCHEMISTRY 123, 83-98.

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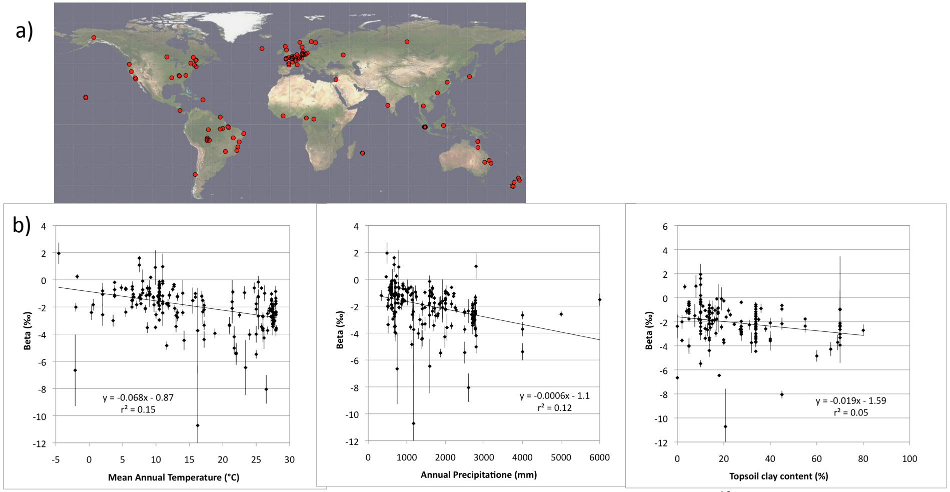

In each profile *beta* is defined as the slope of the logarithmic regression of SOM $\delta^{13}C$ (‰ VPDB) vs carbon concentration (C in g. kg^{-1}) according to:

$$\delta^{13}C = a + beta.\log_{10}(C)$$

a) Location of profiles. b) Relationship between *beta* and MAT, Annual Precipitations and topsoil clay content. Vertical bars stand for one standard deviation of *beta* as determined by profile individual regression.. After Balesdent J., Ågren G., Braakhekke M., Chadoeuf J., Derrien D., Gessler A., Hatté C., Kayler Z., Kuzyakov Y., and Wynn J. SIBAE Working group report. The carbon stable isotopes composition of organic matter down soil depth : a meta analysis. .

Fig. 1. Relationship between world soil organic matter delta13C gradient down the depth and environmental variables over 196 published soil profiles under C3 vegetation.

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Discussion paper