

Biogeosciences Discuss., author comment AC1
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Reply on RC1

Eva Kanari et al.

Author comment on "A robust initialization method for accurate soil organic carbon simulations" by Eva Kanari et al., Biogeosciences Discuss.,
<https://doi.org/10.5194/bg-2021-246-AC1>, 2021

Dr. Andriulo (Referee 1): The work aims to solve and reduce the main source of uncertainty of the AMG model, the Cs pool size estimation. This goal is greatly fulfilled without appealing both to the soil ^{13}C abundance technique (when is possible to apply it) or adjusting other parameters at the same time. It is remarkable the possibility to work in non-equilibrium conditions at the initialization of the modelling, simplifying its use. Furthermore, the method could be easily adopted due to its relatively low cost.

Next, some things and questions are highlighted in order to improve the presentation of the manuscript:

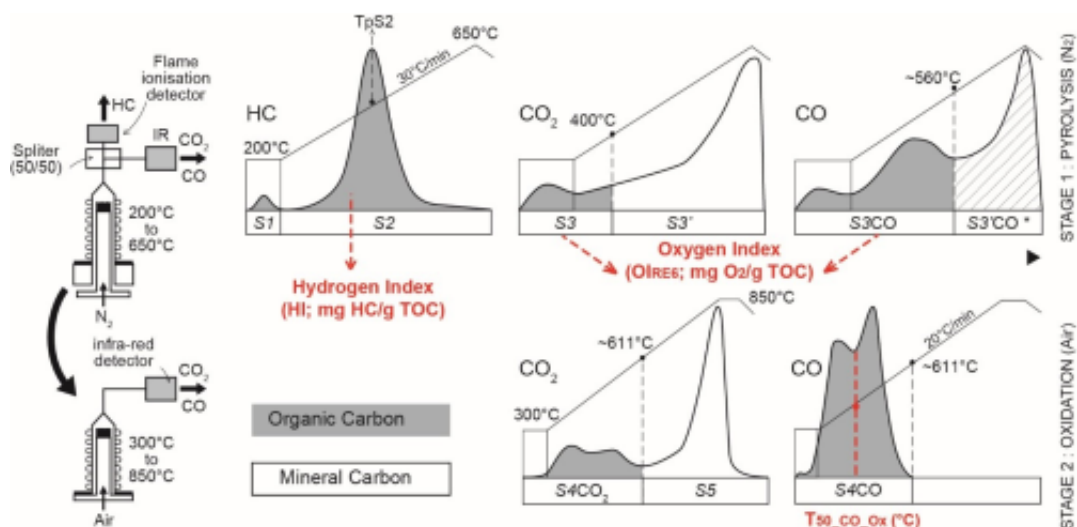
Reply: We deeply thank Dr. Andriulo for his positive and thorough review of our manuscript. We greatly appreciate his comments as we consider that they will help improve our manuscript.

R1: 1) Rock-Eval analysis of soil samples

- In the method description it is not explained what happens in the sites with CaCO_3 presence (Colmar, Grignon-Folleville, Auzeville) and its impact on total C released during the process.

Reply: We thank Dr. Andriulo for his comment. It is briefly explained in the manuscript (lines 157–160) that for the calculation of total organic carbon content and thermal parameters only the part of the signal corresponding to organic carbon is used. We suggest reformulating lines 157–160 to make sure that this point is clear: "It is important to note that **no pre-treatment of CaCO_3 -containing samples was necessary before Rock-Eval® analysis. The slow pyrolysis and oxidation steps of the Rock-Eval® method allow distinguishing carbon of organic and mineral form, since the latter is released above a given temperature.** For the calculation of all of the above-mentioned parameters, only the part of each thermogram corresponding to organic carbon was taken into account. For this purpose, upper temperature integration limits **for Rock-Eval® temperature parameters** were set at 560 °C for the CO and CO_2 pyrolysis thermograms, and at 611 °C for the CO_2 oxidation thermograms (Cécillon et al., 2018).".

Moreover, we suggest adding the following figure describing the Rock-Eval method, in the supplementary material (a better quality figure is provided as supplement to this reply).



R1: - Pyrolyzed organic carbon (PC), line 149: If the pyrolysis was carried out under an inert N₂ atmosphere how CO and CO₂ could be released during this step?

Reply: We thank Dr. Andriulo for this question. Even though the carrier gas of the pyrolysis step is N₂, some water and oxygen are present in soil organic matter and even in soil clay minerals that can undergo dehydration reactions at high temperatures (up to 650 °C). Generally, the amount of CO and CO₂ generated during the pyrolysis step is relatively small (~by one order of magnitude) compared to the amount of carbon released as HC during pyrolysis or as CO₂ during the oxidation step.

R1: - Should be detailed how is finally estimated the proportion Cs/C₀ with the PartySOC model.

- It is not clear how does the Cs pool size is finally estimated. Is the Cs obtained by the difference between TOC and the sum of all C released or is it an integrated prediction?

Reply: From these two comments (as well as from the third comment of anonymous referee 2) it is clear that there is some confusion around the origin of the PARTY_{SOC} predicted centennially stable SOC proportion and its use for AMG pool partitioning. We propose reformulating the description of the steps that lead to the Rock-Eval-based AMG initialization in lines 220–227 as follows:

"The Rock-Eval®-based initialization of C_s/C₀ was based on Rock-Eval® measurements of initial topsoil samples from each LTE. The proportion of centennially stable SOC was estimated using the following simple 4-step procedure: First, topsoil samples from the LTE's onset were analysed with Rock-Eval® and the 18 thermal parameters described in Sect. 2.3 were calculated for each sample. Second, the thermal parameters were used as input for the PARTY_{SOC} machine-learning model described in Sect. 2.4 which was run for this sample set resulting in a sample-specific prediction of the centennially stable SOC proportion. Third, the obtained values were averaged per LTE. Fourth, the site mean of the centennially stable SOC proportion was used to initialize simulations of

SOC stocks for the various treatments of every site (the site standard deviation is reported on Fig. 1 and in Supplementary Material Table 2). Supported by the evident common land-use history shared by the multiple treatments of each site before the onset of simulations and as the SOC stocks and centennially stable SOC content were very homogeneous amongst each site, we also performed simulations of 17 treatments for which soil samples from the onset of the LTE were not available. In these cases, we considered that the centennially stable SOC proportion of the treatment was equal to the mean value of the respective site (Supplementary Material Table 1 and 2).

Finally, from the proportion of centennially stable SOC for a given site, the actual content of the stable SOC pool was estimated through multiplication with by total SOC content or SOC stock at a given date (e.g., for the onset of an LTE where $t=0$: $C_s = C_s/C_0 * C_0$ and $QC_s = C_s/C_0 * QC_0$, where C_s is the stable SOC content ($gC\ kg\ soil^{-1}$), C_0 is the total SOC content ($gC\ kg\ soil^{-1}$) at time $t=0$, ($gC\ kg\ soil^{-1}$), QC_s is the stable SOC stock ($MgC\ ha^{-1}$), and QC_0 is the total SOC stock ($MgC\ ha^{-1}$) at time $t=0$)."

R1: - Line 153: Please change mgHC•gTOC-1 by mgCH•gTOC-1.

Reply: We thank Dr. Andriulo for noticing and reporting this inconsistency. We appreciate this suggestion but we would like to reformulate all occurrences of hydrocarbon abbreviation (CH) to HC instead to be consistent with the relevant literature.

R1: 2) AMG model results presentation:

- Supplementary Material - Table 1: Why a unique bulk density value is shown? Is it the initial mean value for each LTE? Please, describe in the Table.

- It is not shown if changes in bulk density were found in the treatments. If these changes happen should be convenient to express the results for an equal soil mass, affecting the considered soil depth. In these cases, is valid to use the same C_s concentration?

Reply: We appreciate this comment and we recognise the importance of this information. The soil bulk density (BD) indicated in Table 1 is the mean BD of the considered soil layer at each site. Unfortunately, very few bulk density measurements were available at most LTEs (Auzeville, Doazit, Grignon-Folleville, Kerbernez, Mant and Tartas), so the assumption was made that BD did not vary with time. In the case of Boigneville, Colmar and Feucherolles BD measurements were available at each SOC measurement date and were used to calculate SOC stocks at equivalent soil mass. We propose adding an asterisk to the BD column of Table 1 to clarify this point. Moreover, we suggest adding a line to Table 1 including information on the considered soil mass for each site.

R1: - Supposing that the soil arable layer is 0-30 cm, TOC and C_s concentrations are available. Now, 0-10, 10-20 and 20-30 cm C_s concentrations are required. Is valid to obtain them multiplying by the same proportion from 0-30 cm or is necessary to Rock-Eval analysis for each depth.

Reply: We thank Dr. Andriulo for this interesting question. The question is if it is possible to predict C_s contents of sublayers based on a soil layer. We suppose it would be meaningful to consider that if the "soil arable layer" is ploughed then the mixing should

homogenize both SOC content and C_S distribution. Otherwise, since C_S content is expected to change with depth individual sample characterization would be necessary. In the contrary case it is possible to combine sublayer data (0-10, 10-20 and 20-30 cm) to obtain information on a single soil layer (0-30 cm) (see Kanari et al., 2021).

R1: 3) Other manuscript aspects:

Reply: - Lines 335-345: Results and Discussion are separated. However, in lines 335-345 the results are discussed.

We appreciate the comment by Dr. Andriulo but we would like to keep this separation as is, since the content of lines 335-345 is closely related to Figure 2 (presented just above these lines), while the content of the discussion section is far more general.

R1: - Supplementary Material - Figure 4: Discussion and Hypothesis are included in the figure legend.

Reply: We suggest stating the discussion of Supplementary Material Fig.4 just above the figure instead and keeping only the figure description in the legend.

R1: - Please, change the expression t ha⁻¹ by Mg ha⁻¹ along with the manuscript.

- Line 165: change (Cécillon et al., 2021) by Cécillon et al. (2021).

- Line 391: change Cconclusions by Conclusions

Reply: We thank the reviewer for their thorough attention to detail and we agree with these corrections.

References:

Kanari, E., Barré, P., Baudin, F., Berthelot, A., Bouton, N., Gosselin, F., Soucémariadin, L., Savignac, F., Cécillon, L. (2021) Predicting Rock-Eval® thermal analysis parameters of a soil layer based on samples from its sublayers; an experimental study on forest soils, *Organic Geochemistry*, 160, <https://doi.org/10.1016/j.orggeochem.2021.104289>