

Biogeosciences Discuss., author comment AC2  
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## Reply on RC2

Elisa Bruni et al.

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Author comment on "Additional carbon inputs to reach a 4 per 1000 objective in Europe: feasibility and projected impacts of climate change based on Century simulations of long-term arable experiments" by Elisa Bruni et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2020-489-AC2>, 2021

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**We thank the reviewer for the positive comment. We modified the abstract to better show the limits of the study.**

**The end of the abstract was reformulated as follows: "This means that the C inputs required to reach the 4 per 1000 target might actually be much higher. Furthermore, we estimated that annual C inputs will have to increase even more due to climate warming, that is 54% more and 120% more, for a 1°C and 5°C warming, respectively. We showed that modeled C inputs required to reach the target depended linearly on the initial SOC stocks, raising concern on the feasibility of the 4 per 1000 target in soils with a higher potential contribution on C sequestration, that is soils with high SOC stocks. Our work highlights the challenge of increasing SOC stocks at large scale and in a future with warmer climate."**

Specific comments:

- The introduction is interesting, but sometimes strays from the subject of the study.

78-89: This paragraph is too detailed and could be halved in length, especially given it is not the focus of the paper.

**We removed L. 84 to L.89 and cited Chenu et al. (2019), who already developed these concepts.**

90-108: Again, this paragraph is too detailed and could be halved in length, given it is not the focus of the paper.

**We removed L.95-L.102.**

L109: In contrary, this paragraph is the focus of the paper and needs to be expanded. E.g. the concepts of feasibility and applicability of the 4p1000 need to be introduced; is there doubt that the 4p1000 cannot be reached / maintained ? Why? Are there indications that there is not enough available biomass to reach the 4p1000 aim? State that this study focuses on C inputs only and not on reducing C loss (decreasing mineralisation through cover crops, otherwise reducing erosion).

At the moment there is little justification why this study is necessary.

**We rephrased the part stating the objectives, better introducing the context of this work, as follows:**

**“The feasibility and applicability of a 4‰ increase target depend on biotechnical and socio-economic factors. As we mentioned earlier, a number of practices are known to increase SOC stocks in agricultural systems. However, it is still debated whether they will be sufficient to reach the 4p1000 objective. Minasny et al. (2017) described opportunities and limitations of a 4‰ SOC increase in 20 regions across the world. Several authors (e.g. Baveye et al., 2018; van Groenigen et al., 2017; VandenBygaart, 2018) argued that some of the examples described in Minasny et al. (2017) were not representative of wide-scale agriculture and suggested that a 4‰ rate is not attainable in many practical situations (Poulton et al., 2018). Implementing new agricultural practices that allow the maintenance and increase of SOC stocks might require structural land management changes that not all farmers will be willing to adopt. Incentivizing and sustaining virtuous practices to increase SOC stocks should be a strategy for policymakers to overcome socio-economic barriers (e.g. Lal, 2018; Soussana, 2017) and in order to do that, they need to be correctly informed. Recent works have assessed the biotechnical limitations of a SOC increase, studying the required and available biomass to reach a 4p1000 target in European soils (Wiesmeier et al., 2016; Martin et al., 2021; Riggers et al., 2021).**

**Our work was set up in this context with the objectives to: 1) estimate the amount of C inputs needed to increase SOC stocks by 4‰ per year; 2) investigate if this amount is attainable with currently implemented soil practices (i.e. organic amendments and different crop rotations) and 3) study how the required C inputs are going to evolve in a future driven by climate change. We used the biogeochemistry SOC model Century, which is one of the most widely used and validated models (Smith et al., 1997) to simulate SOC stocks in 14 different agricultural LTEs around Europe. We set the target of SOC stocks increase to 4‰ per year for 30 years, relative to the initial stocks in the reference treatments. With an inverse modeling approach, we estimated the amount of additional C inputs required to reach a 4p1000 target at these sites. Finally, we evaluated the dependency of the required additional C inputs to different scenarios of increased temperature.”**

- The methods are generally clearly described, with one exception: I have only a basic understanding of the CENTURY model, but as far as I understand from the manual and from Parton et al. (1993), plant C inputs into the soil are based on plant production, as simulated by the model. The authors however calculated plant C inputs based on allometric equations (the approach first described by Bolinder), using user-given yield data as inputs. Is this an alternative version of the CENTURY model? If so, this needs to be explained.

**Yes, we used a version of Century that only simulates SOC, we add this information in the description of Century model as follows:**

**“In the version used, only SOC is modeled and plant growth is directly accounted as variations of C inputs.”**

- This study asks how much C inputs are needed to reach the 4p1000 target i.e. in the future. Because recent climate data were used for the simulations, the result has probably been underestimated, as SOC decomposition rates in a warmer world might be higher than at current. Indeed, this has been demonstrated by similar studies (e.g.

Riggers et al 2021, 10.1007/s11104-020-04806-8; Wiesmeier et al. 2016, 10.1038/srep32525). The authors are aware of this and addressed the issue with the so-called 'sensitivity analysis'. This is good, but the outcome of this analysis needs to be related more closely to the main results, especially in the abstract. I therefore suggest that the sentence of L50-51 be moved to the end of the previous paragraph in the abstract, as follows: At the end of the sentence on L 48, add: "This means that the C inputs required to reach the 4p1000 target might actually be much higher. Furthermore, we estimate that annual C inputs will have to increase even more due to climate warming, that is 54% more and 120% more, for a 1°C and 5°C warming, respectively."

Furthermore, I recommend the two studies mentioned above be cited in the discussion.

**The sentence was added, as indicated. We added the citations of Wiesmeier et al. 2016 and Riggers et al 2021 both in the introduction and in the discussion:**

**L.115: "Recent works have assessed the biotechnical limitations of a SOC increase, studying the required and available biomass to reach a 4p1000 target in European soils (Wiesmeier et al., 2016; Martin et al., 2021; Riggers et al., 2021)."**

**L.491: "Riggers et al. (2021) found that in 2095, a minimum increase of C inputs by 45% will be required to maintain SOC stocks of German croplands at the level of 2014. However, they found that to increase SOC stocks by 4‰ per year, a much higher effort will be required. That is, C inputs in 2095 will have to increase by 213% relative to current levels."**

**L.595: "Moreover, inaccuracies in simulations outcomes, such as those found in this study, need to be reduced. As discussed in subsection 4.2.3, a better representation of C inputs dynamics and management practices could improve the simulation of SOC stocks."**

**We suggest to consider multi-model analysis for this type of work in the future (Farina et al., 2021), to acknowledge different representations of SOC and reduce the effect of single models' uncertainties. Furthermore, the likely increase of SOC mineralization due to future climate change (Wiesmeier et al., 2016) needs to be taken into account."**

- L361-363: Isn't this increase in temperature an overestimate? The 1 and 5 degree increases refer to increases between 1996 (roughly half way between 1986 and 2005) and 2090 (roughly half way between 2081 and 2100), i.e. 94 years. The simulations for the study are however run only for 30 years, meaning such temperature increases should not be expected to occur.

**We agree that a +1 °C and +5 °C are likely overestimations of the temperature increase for a 30 years simulation period. However, our objective was not to apply climate change scenarios, rather understanding the sensitivity of the model to temperature. To better show this point, we reformulate the following points:**

- **We change the "Sensitivity analysis to temperature" section (2.3.3), as follows:**

**"We tested the sensitivity of model outputs to temperature, running two simulations with increased temperatures. We considered two representative concentration pathways (RCPs) of global average surface temperature change**

**projections (IPCC, 2015). The first scenario (RCP2.6) is the one that contemplates stringent mitigation policies and predicts that average global land temperature will increase by 1 °C during the period 2081-2100, compared to the mean temperature of 1986-2005. The second scenario (RCP8.5) estimates an average temperature increase of +4.8 °C, compared to the same period of time. We ran two simulations of increasing temperature scenarios with Century. We considered the same initial conditions as the standard simulations, hence running the spin-up with the average soil temperature and relative humidity of the 30 years preceding the experiments. Then, we increased daily temperature by 1 °C (AS1) and 5 °C (AS5) for the entire simulation length, to assess the sensitivity of modeled C inputs to increasing temperatures. Nevertheless, it must be noted that our simulations are running over a 30 years period not the entire 21st century. Thus, the temperature sensitivity analysis should not be considered as a test of climatic scenarios but like a classical sensitivity analysis where the boundaries were defined following RCP2.6 and RCP8.5 predictions of increased temperatures.”**

- **We changed section 3.3 title to: “Carbon input requirements with temperature increase”**
- **We added a sentence in the sensitivity analysis discussion, stating that:**

**“Although these scenarios (+1 °C and 5 °C) are calculated over ~100 years, we used these values over a 30 years’ simulation to assess the sensitivity of Century to temperature increase.”**

- L496: “farmers may have difficulties in producing or buying high quantities of EOMs” Surely this is not the point: Even if farmers are able to source additional EOMs, these EOMs will then be lacking from other sites (from whence they came), meaning that there is no net removal of CO<sub>2</sub> from the atmosphere -> no C-sequestration. Only if these EOMs would otherwise be mineralised (e.g. burnt) can these be considered sequestration.

**We rephrase our sentence to take this into account:**

**“First of all, the amount of organic fertilizers is limited at regional scale. If farmers source additional EOMs elsewhere, only those EOMs that otherwise would be mineralized (e.g. burnt) and not applied to land account as sequestration. Second, farmers may be prevented from applying high amounts of EOM because of the risk of nitrate and phosphate pollution (Li et al., 2017; Piovesan et al., 2009). Moreover, producing additional animal manure implies larger GHG emissions through animal digestion and manure decomposition. Consequently, even if more manure is returned to the soil, it will not necessarily result in climate change mitigation.”**

- L632-633: “indicating that lower amounts of carbon inputs might be sufficient to reach the 4p1000 target where SOC stocks are low.” Is this effect (1) merely a calculation effect? i.e. Soils with high SOC stocks need more to reach the 4p1000 target simply because 0.4 % of a higher value is higher (than 0.4 % of a lower value); or (2) is there additionally a ‘true’ effect e.g. the application of 1 t C / ha of EOMs to soils with lower SOC stocks results in a higher SOC gain than 1 t C / ha of EOMs to soils with high SOC stocks?

If the answer is (2), this means that the addition of EOMs to soils with low SOC is much more efficient. This is very important, given that EOMs are a finite resource. In this case, I would also suggest rephrasing the sentence. A suggestion, “indicating that the 4p1000 target can be more efficiently met, i.e. using fewer EOMs, in soils with lower SOC stocks”

or "indicating that more C can be stored, and the 4p1000 target more efficiently met, i.e. using fewer EOMs, in soils with lower SOC stocks"

**We believe this is mainly a modeling effect, because a similar trend was not found in field treatments. However, it is hard to make conclusions in this sense, because only one site had very high initial SOC stocks.**

Technical comments:

L30-31: I recommend removing «to promote better agricultural practices». Firstly, it distracts from the focus of the paper and secondly, this is strictly speaking not the aim of the initiative but rather how the aim can be achieved.

**We removed "to promote better agricultural practices".**

L32: The term "straightforward" is ambiguous. Please be more precise.

**We changed this term and rephrased the sentence saying: "One way to enhance SOC stocks is to increase C inputs to the soil."**

L36-37: "Initial simulated stocks were computed analytically assuming steady state". I think "initial stocks were simulated assuming steady state" would suffice. Alternatively, consider removing the whole sentence (too much detail for the abstract?).

**We rephrased this sentence as suggested.**

L40: control plot -> control plots (otherwise it is implied the model was calibrated to the control plot of a single experiment)

**We specified "control plots".**

L 40-41: "conventional management without additional carbon inputs" Additional to what? Is the term 'no exogenous carbon inputs' meant here? The authors need to be more precise, because in some countries, conventional management does include adding EOMs, e.g. farmyard manure.

**We specified: "conventional management without additional carbon inputs from exogenous organic matter or changes in crop rotations"**

L47-48: why "on the variation of SOC stocks"? Is not simply "the SOC stocks" meant here? I assume that the SOC stocks are modelled as increasing by 0.25 %? Please specify.

**We rephrased as follows: "However, Century might be overestimating the effect of additional C inputs on SOC stocks. In the experimental sites, we found that SOC stocks in treatments with additional carbon inputs were increasing by 0.25% on average."**

L56: "Strategies of conservation and expansion of existing SOC pools may be necessary but not sufficient to mitigate climate change" The word "are" needs to be inserted before "not sufficient".

**The word "are" was inserted before "not sufficient"**

L68: "resilience face to changes in climate" -> resilience to changes in the climate.

**We changed "resilience face to changes in climate" to "resilience to changes in**

**the climate”.**

L71: assessed -> demonstrated (otherwise, depletion of SOC could have been assessed, but have been found to not be the case).

**We changed the word “assessed” to “demonstrated”**

L74: “carbon in the soil” -> “C in the soil” or simply “SOC”

**We changed “carbon in the soil” to “SOC”**

L78: The word ‘balance’ is inappropriate (they could be unbalanced and SOC stocks would still be present). A suggestion: “SOC stocks are a function of C inputs and C outputs.”

**We changed “balance” to “SOC stocks are a function of C inputs and C outputs.”**

L86-89: I understand what the authors mean to say, but fear that this sentence is unclear for readers unacquainted with the literature / concept of C-sequestration. I suggest inserting ‘at a given location’ between “SOC stocks over time” and “and is not necessarily”. It would also be useful to give an example “for example, EOM added to one site is not an example of C-sequestration if it results in loss of EOM at another site”.

**This sentence was entirely removed to take into account comment #1.**

L90: “for estimating” -> to estimate and “evaluating” -> evaluate

**We changed “for estimating” to “to estimate” and “evaluating” to “evaluate”.**

L96: kept on -> maintained L98: In fact, -> For example,

**Both sentences were removed to take into account comment #2.**

L104: allow estimating the evolution of SOC stocks and their future trends to assess the potential gain of SOC at global scale -> allow the evolution of SOC stocks and their future trends to be estimated, enabling the potential gain of SOC at a global scale to be assessed, also following changes in agricultural practices.

**We rephrased the whole sentence to take into account this comment and comment #2, as follows:**

**“Combining measurements of SOC with models provides a wider applicability of the information collected in field trials, as it allows SOC stocks and their future trends to be estimated.”**

L127: one control plot -> one control plot in each experiment.

**We changed “one control plot” to “one control plot in each experiment”.**

L131: “experiments with a duration of at least 10 years,” Surely this is redundant if the experiments all ran for at least 11 years? If this phrase is necessary, please explain what is meant here.

**We removed “with a duration of at least 10 years”**

132: except from Foggia -> except for Foggia. It needs to be made clear here that control plots also receive no EOM. I suggest: “C inputs in all sites except for control plots, and all

plots in Foggia included...”

**We rephrased as suggested: “C inputs in all sites except for control plots, and all plots in Foggia included exogenous organic matter (EOM) addition”**

L138: remove ‘found’

**We removed “found”**

Table 1: Please specify whether ‘N’ represents the addition of nitrogen or of mineral fertiliser (obviously including nitrogen).

**It is specified in the bottom notes: “\*\*Optimal amounts of mineral fertilizers added to the control plot and to all other treatments in the experiment”**

L151: a part -> apart

**We corrected a part -> apart**

L154: ratio: should this not be ‘rate’?

**We corrected ratio -> rate**

153-157: I presume the values here all pertain to Table 1. If so, can the authors please recount: the I get only 18 (including the 0.40 score in Arazuni) treatment cases with a SOC annual variation of > 0.4 %. I counted 6 cases where the increase is less than 0.4 % and 22 times where there is decrease in SOC stocks.

**We recounted and corrected these values, as suggested.**

Figure 1 is not referenced in the text. Please add where appropriate.

**Referenced at L.126**

L167: Why not give a range for humidity (as for temperature)? This is more useful to know.

**We added the range for humidity.**

L173: Table legend should begin with: “Information about experimental sites” (or something like this).

**We changed the table legend as follows: “Information about experimental sites, including: mean annual temperature (C°) and soil humidity to approximately 20 cm depth ( $\text{kg}_{\text{H}_2\text{O}} \text{m}^{-2}_{\text{soil}}$ ) simulated with the ORCHIDEE model at each experimental site, measured pH, bulk density ( $\text{g cm}^{-3}$ ), clay (%) and initial SOC stocks in the control plots ( $\text{MgC ha}^{-1}$ ) at the experimental sites. Reference papers for each site are indicated.”**

L197: Please define the term ‘SOC(t)’ in text

**We added “and SOC evolution with time (SOC(t))”**

L199: space required between “(t)” and “of”

**Space added**

L235: consists in -> consists of

**We changed "in" to "of"**

L243: "By enhancing the computational performance of the simulations". What does this mean? Please be more precise. Or omit.

**We changed "By enhancing the computational performance of the simulations" to "By speeding up the performance of the simulations"**

L244: "this technique enables the analysis of system properties and facilitates studying model behavior." I think this phrase is redundant. Omit? (in which case add "also" between "It and "allowed" in the next sentence.)

**We removed this sentence.**

L346: please specify what "s is the size of the experiment" means. This is unclear to me.

**We changed "size" to "length"**

L369: "fitted quite well the observed SOC stocks" -> fitted the observed SOC stocks well

**We changed "fitted quite well the observed SOC stocks" -> fitted the observed SOC stocks well**

L370: remove comma in "Fig 4.a, provides"

**We removed comma**

Figure 4: The colour scheme is nice, but colours need to be more saturated as they are difficult to distinguish from one another if the computer screen is dim.

**The colours of the picture were changed to make it more saturated and Fig 4.c was added to the figure to take into account a comment from Referee #3 (see Fig\_4.pdf in supplement)**

L383: Could the term 'optimized' be specified here ? e.g. minimum C input additions needed / required to reach the 4p1000 target? Both terms are used elsewhere (e.g. L 422, L451) and make more sense than 'optimized'.

**The term "optimized" was changed into "required"**

L389: why 'globally'? Is this word necessary here? L394: per year) -> per year respectively)

**We changed the term "globally" into "on average among the studied sites"**

L399-400: The absolute increases of the active and passive pool need to be given (so that the 2.7 MgCha-1 can be compared to something).

**This info was added: "(against an increase of 0.1 and 0.06 MgC ha<sup>-1</sup> in the active and passive compartments, respectively)".**

L410-412: This sentence belongs in the discussion.

**This sentence was moved in the discussion, to L.578**

L414: How can it be that the TOT C pool requires a lower C input change than all the other pools? I would have expected this pool to be a weighted average of the other pools and thus have an intermediate value.

**TOT C is the average total carbon input change among the sites. It was not calculated as the weighted average of the other pools, but as the percentage change between total initial C inputs and "final" C inputs (i.e. C inputs after the 4p1000 optimization)**

**We add a sentence in Figure 5 caption to clear this out: "N.B: Total change of carbon inputs (TOT) was calculated as the percentage change between the amount of carbon inputs before and after the 4p1000 optimization, averaged across all sites."**

L452: "increase on average by 54%": please specify what this is compared to. Compared to the C inputs required to meet 4p1000 (CURR) or compared to the control plots of CURR (I

**We add ", relative to current C inputs in the control plots"**

L454: "business as usual situation" is this referring to the CURR climate? This is stated in the legend to Fig. 9 but also needs to be stated in the main text.

**We add "(CURR)" to the end of the sentence in the main text**

Figure 9: The y-axis label needs to be changed; at present it implies the average C input change required to reach 4p1000 is a decrease in C inputs (circa 50 %)

C inputs change (%) -> C inputs increase (%)

**The y-axis label was changed: C inputs change (%) > C inputs increase (%)**

L466-468: This allowed us: 1) taking into account the average carbon quality of the litter pools in the different crops rotations and 2) correctly estimating the initial values of SOC stocks on the majority of the sites. -> This allowed us to: 1) take into account.... and 2) estimate correctly....

**We corrected this sentence as suggested.**

L468: On the other side -> On the other hand

**We changed the term "side" to "hand"**

L469: why 'redistribution' ? Is simply 'distribution' meant here?

**"Redistribution" is meant here because it refers to the allocation of C in the different pools, after the 4p1000 optimization. Hence, while there might be some initial predicted distribution, we refer here to the redistribution after the optimization.**

L468-469: If this is mentioned here, it needs to be discussed in more detail. For example, is there any evidence that this impacted the main outcomes of this study, e.g. the amounts of C inputs required?

**We added figure C2 in the appendix C (see Fig\_C2.pdf in the supplement) to show that the optimization does not affect model outputs for current values of**

temperature in our modeling exercise. We added a few sentences to discuss the optimization effect on modeling results: "Figure C2 shows that the optimization of temperature sensitive parameters did not affect significantly the required C input estimation for the current temperature scenario. This means that, although parameter optimization improved the simulation of SOC stocks in the control plots, the final results are not affected by it."

[Figure C2: Effect of the optimization of the  $Q_{10}$  and reference temperature ( $T_{ref}$ ) parameters on the additional carbon inputs to reach the 4p1000 predicted by Century (mean standard deviation).]

L470: Initializing -> initialize L471: on -> regarding

**These two terms were corrected**

L472: we decided to optimize -> we optimized

**We changed "we decided to optimize" to "we optimized"**

L478-479: It is unclear what is meant by "simulate SOC stocks variation". Is simply "simulate SOC stocks" meant here?

**We removed "variation"**

L478-483

L502: different whether -> different depending on whether

**We added "depending on"**

L507: "The additional carbon is essentially slow" Carbon is not 'slow'. Please rewrite more precisely.

**We changed "is essentially slow" to "is mainly stored in the slow pool"**

L510-511: we might consider implementing new strategies of additional carbon later on -> new strategies of additional C could be implemented later on.

**This sentence was corrected, as suggested.**

L512: residues -> residue

**This term was corrected**

L535: I recommend a sentence such as "Thus, Century seems to be over-predicting the effect of adding C inputs in the virtual simulations" after the word "experiments." It would make the paragraph much easier to read.

**This sentence was added.**

L540: in -> for

**This term was corrected**

L542-543: What is meant by this sentence ("The calculation method...")? Please expand.

**We rephrased this sentence as follows: "The method used to estimate C inputs (i.e. the allometric functions from Bolinder et al. (2007) in our case) also influences the simulation of SOC stocks"**

L543: relatively -> relative

**This term was corrected**

L546: A value of N inputs is given. Why is the term 'proportion' used to describe this amount (in the line above)?

**We changed the term "proportion" into "amount"**

L552: inputs -> input

**This term was corrected**

L552: I recommend: need -> requirement ('need' is correct but because this is also a verb, the is sentence difficult to understand)

**The term "need" was substituted with the term "required"**

L557-571: This section of text is not very focussed and I did not understand what the authors are trying to say. The values cited are important for the discussion of EOMs and agricultural soils, but how does this text relate to the rest of the paragraph?

**We rephrased this part to better link it to the rest of the paragraph:**

**"Pellegrini et al. (2016) reported the amounts of sewage sludge disposed on landfill in Europe (EU26) from Eurostat (2014b). In 2010, this was 0.914 Tg DM. Using the Van Bemmelen factor (1.724) to convert OM to OC (McBratney and Minasny, 2010; Rovira et al., 2015), we estimated that the sewage sludge disposed on landfill in Europe was around 0.004 MgC ha<sup>-1</sup> per year in 2010. If applied to cropland, this could potentially increase C inputs to the soil and decrease GHG emissions associated to landfilled waste. However, in some countries social acceptability of spreading EOM such as sewage sludge is very low, limiting its actual potential. In Europe, landfilled municipal waste was 0.3 MgC ha<sup>-1</sup> in 2019 (estimated from Eurostat (2020) considering a C content in household waste of 71% (Larsen et al., 2013)). This is higher than the amount of municipal waste currently composted in Europe (i.e. 0.22 MgC ha<sup>-1</sup> in 2019, according to Eurostat (2020)), showing that additional efforts to improve the reutilization of municipal waste could help to increase C inputs in agriculture."**

L573: Is the term 'decreases' meant here instead of 'increases'? Please check.

**Yes, we changed the term "increases" to "decreases"**

L577: As we could expect -> As expected (or 'As we expected')

**We changed "As we could expect" to 'As we expected'**

L593-595: This sentence is important, but it needs to be expanded. Most importantly, inaccuracies / biases in the outcomes of simulations – such as that found in this study – need to be reduced. The authors could incorporate suggestions from L535-538 (e.g. we need to represent the dynamics / timing of C inputs more accurately). Furthermore, the (probable) additional reduction of SOC due to future climate needs to be taken into

account.

**We rephrased and expanded subsection 4.2.5 (cf comment below)**

L594-545: The term 'cut out model uncertainty' is awkward. Multi-model analysis does not strictly speaking omit model uncertainty, but rather acknowledges it and reduces the effect of extreme model outcomes. Please reword.

**We take into account both comments by rephrasing and expanding subsection 4.2.5 as follows:**

**"Also, inaccuracies in simulations outcomes – such as those found in this study – need to be reduced. As discussed in subsection 4.2.3, a better representation of C inputs dynamics and management practices could improve the simulation of SOC stocks. We suggest to consider multi-model analysis for this type of works in the future, to acknowledge different representations of SOC and reduce the effect of single models' uncertainties. Furthermore, the likely increase of SOC mineralization due to future climate change (Wiesmeier et al., 2016) needs to be taken into account."**

L601-602: This sentence lacks a context and needs to be written more precisely. I presume the authors mean that SOM will increase decomposition under future (warmer) climates because its decomposition rate is affected – in general increased – with increasing temperatures.

**We rephrased this sentence as follows:**

**"We know that the decomposition rate of SOM is affected – in general increased – with increasing temperatures."**

L602-603: remove 'from SOC stocks' L603: of -> by

**We removed 'from SOC stocks'**

**We changed "of" into "by"**

L603-604: This sentence needs to be explained. I presume the authors would like to say that there is a diversity of compounds and therefore a diversity of changes that can be expected. As well as the diversity of strength of sensitivity of decomposition rates to future climates, there might also be increases as well as decreases in decomposition rates in the future (e.g. water limitation will reduce some decomposition rates).

**We expanded this sentence with the following explanation:**

**"In fact, a diversity of responses of decomposition rates to future climates can be expected, including increases due to higher temperature as well as decreases due to water limitation"**

L613: inputs -> C inputs

**We added "C"**

L619: The Davidson and Janssens paper addresses this. If there is space, I recommend to cite this paper again here, and briefly mention how moisture change is important.

**We added the following: ", with consequences on root respiration and microbial**

## **decomposition (Davidson and Janssens, 2006)."**

L627-628: I would recommend removing this sentence. It is not a generalizable finding but rather is how the authors came to the conclusion that Century over-estimated the effects of the C inputs.

**We consider this sentence important because it compares current practices to model simulations of additional C inputs, which was one of the objectives of this study. This finding (see Fig. 8) does not show that Century over-estimates the effects of C inputs on SOC stocks. It rather shows that current practices use higher amount of C inputs than those predicted by Century. In a further analysis we showed and discussed that the model might over-estimate the effects of C inputs, hence additional C inputs to reach the 4p1000 might be actually higher than those predicted. This was pointed out in the results, discussion and conclusion parts.**

L628-629: might be overestimating -> might have overestimated L635: The required amount -> Furthermore, the required amount L636: to substantially increase -> to increase substantially

L636: rising concern on -> raising concern about

L637: SOC stocks -> SOC stock

### **These sentences were corrected**

L638-640: The matter covered in this sentence is not a conclusion reached from this study and it does not fit into the rest of the conclusion. I recommend removing it.

### **This sentence was removed**

L641: largely depends -> depends largely L642: only considered -> considered only L644: is worthwhile to -> should

### **These sentences were corrected**

L645: "to allow for a correct estimation of the uncertainties related to model-specific assumptions" This is too simplistic. Though it would allow the influence of extreme model outcomes to be reduced, if all simulations are biased (e.g. over-estimate the effects of C inputs) then the results of the multi model analysis will also be biased. A more urgent research priority would be to address the cause(es) of the bias(es). See above (response to L593-595). Additionally, EOMs need to be accurately represented in models. The decomposition of biochar for example – the use of which might become more widespread in the future – has very different decomposition dynamics than other EOMs and models need to be adjusted to account for this.

### **We replace this sentence with the following:**

**"Causes of biases in model simulations should be addressed in future studies and the representation of C inputs should be improved. We also suggest that future research should include multiple models to reduce the influence of extreme model outcomes on the representation of SOC stocks."**

General technical comments:

- The authors use the terms 'site' and 'experiment' interchangeably. I presume these terms relate to the same thing. If so, please use one term only throughout the manuscript

(I would suggest 'site').

**We changed "experiment" to "site" throughout the manuscript.**

- Likewise the terms control plots and reference plots (e.g. L473 and in table 1)

**We changed "reference plot" to "control plot" throughout the manuscript.**

- The abbreviation 'SOC' is not used everywhere (e.g. L 418) but should be.

- Likewise, 'C' (carbon).

**We added the abbreviations "SOC" and "C" throughout the manuscript.**

Please also note the supplement to this comment:

<https://bg.copernicus.org/preprints/bg-2020-489/bg-2020-489-AC2-supplement.zip>