Reply to reviewer 2

General comments:
Axel Don et al. have submitted an original, well written and very interesting draft to BG. They investigated the effect of wild boar bioturbation on soil organic carbon (SOC) dynamics in a 6 year study in two forests of Germany (focusing on coniferous plots in one forest and coniferous + deciduous plots in the second forest), both on acidic and sandy soils.
The experimental design is nice and sound, the authors have manually simulated wild boar bioturbation (each year, which is a high frequency). They discuss in a clear way the advantages and limitations of the chosen design. Yet, I think that in many sentences of the manuscript and also in the draft title, the fact that wild boar were not part of the game should be more clearly stated (see below my specific comment 1 on this topic).
Reply: We very much appreciate all comments and suggestions from the reviewer and took all of them into account. We agree and added “simulated” wherever wild boar bioturbation is mentioned.

SOC dynamics is studied in paired-plots (control vs. bioturbation) by focusing on SOC stocks (using equivalent soil mass for litter + 0-5/5-10/10/15 cm soil layers) and SOC physical fractionation to separate particulate SOC from mineral associated SOC (0-5/5-10 cm soil layers + C content of the mineral fraction of the O layer of bioturbed plots). The results show that SOC stocks were not affected by bioturbation but that the fate of litter SOC was affected by bioturbation: 1/ a part remains in the litter (as litter), 2/ a part is incorporated as particulate/light organic matter in the mineral topsoil layer, 3/ a part remains in the litter layer, but is associated to minerals.
The authors finally state that the part of the litter SOC that has been associated to minerals (in the litter layer) has been "stabilised" by bioturbation. I suggest that this statement on carbon "stabilisation" should be avoided. We indeed lack evidences regarding the residence time of mineral-associated SOC above the topsoil (i.e. in the litter layer; see below my specific comment 2 on this topic).
Reply: See reply below.

Specific comments:
1/ Wild boars were not involved in this study :)
I suggest to state more clearly in the title and in the text that bioturbation by wild boar was simulated. - "Simulated wild boar bioturbation..." for the title. - in the text this could be done for instance p5 line 17 "[simulated] wild boar bioturbation" and in many other sentences of the draft.
Reply: We agree and added “simulated” wherever wild boar bioturbation is mentioned.

2/ Mineral-associated C in the litter layer (above-ground) cannot be called "stabilised" C
First, I would like to remind that in (mineral) soils, a large part of mineral-associated SOC is not stabilised. This has been clearly shown in e.g. long term bare fallows trials where the fine soil fraction looses SOC at a relatively high rate. So transfering litter SOC to the mineral-associated SOC fraction does not mechanistically imply that all of it has been stabilised. A part of it may be stabilised if this transfer would have taken place in the mineral soil layer (i.e. below the soil surface). Indeed the mean residence time of mineral-associated SOC is generally higher that the one of the particulate organic matter SOC in mineral soil layers. But here the bioturbation transfer of SOC from litter to

the mineral-associated C fraction occurred in the litter layer (i.e. above the soil surface), where there is no evidence that this above-ground mineral-associated C would have a slower turnover than litter C from the F/H O layers. This should be acknowledged in the manuscript.

Reply: We will add in the material and method section to define the term “stabilised” by adding the following sentence: We refer to SOC associated with minerals (MOM) as stabilised SOC since its turnover is slower compared to non-mineral associated POM. “Stabilised” does not mean “inert” but only refers to the fact that organic compounds attached to mineral surfaces are more difficult for microorganisms to use as substrate. There is a large number of studies showing that under different environmental conditions (also in aquatic systems) the mineral association of organic compounds reduces its turnover (e.g. Eusterhues et al. 2003 Organic Geochemistry, Six et al. 2002, Plant and Soil, Kleber et al. 2007 Biogeochemistry, von Lützow et al. 2006, European Journal Soil Science). Bioturbation leads to a complete mixture of organic layer and mineral soil and it is not possible to distinguish both compartments anymore. Moreover, in forests with intensive bioturbation (by earthworm) only temporarily forest floor can be found and litter is incorporated into the mineral soil. This is a similar situation like in the investigated plots with simulated bioturbation. Thus, from an ecological and biogeochemistry point of view there is no reason to assume that attachment of organic compounds will not lead to stabilisation in the sense to decreased turnover.

- The title of the manuscript should be changed, avoiding the confusing term (and not properly measured for litter layers) "stability". The expression "increases mineral C loading" should be preferred and would better represent the findings of the study.
Reply: We do not agree that the term “increased mineral C loading” will be more clear and easy to understand compared to “increases the stability of forest soil carbon”. Here we only refer to a gradient change in stability/turnover. Thus, this is not misleading but reflects the fact that more SOC is incorporated into the mineral soil making it less prone to disturbances such as forest fires and also more SOC is mineral associated (see above).

- The title of section 2.2 should be changed. Stability of SOC was not assessed, but "SOC distribution in physical soil fractions".
Reply: We will change the title accordingly into “Distribution of organic carbon in physical soil fractions”

- The title of section 2.3 should be changed to "Associating C on minerals with bioturbation".
Reply: We propose to delete this heading and include the section into the previous one with an introductory sentence.

- The title of section 3.2 should be changed to "Contact [...] facilitates the association of litter C with minerals in the litter layer"
Reply: We will revise the heading and deleted the word “soil” in order to emphasis the transitional character of the new compartment in which litter layer and mineral soil is mixed together. However, as explained above, we do not see any reason to assume that mineral association of organic carbon does not lead to slower turnover and thus higher C stability. We propose as new heading “Contact between litter layer carbon and minerals facilitates carbon stabilisation”.

- The abstract/conclusion should be re-written: bioturbation has a positive effect on "C association to minerals" or on "mineral C loading in the litter layer", not on C stability, we do not know of this C is "more stabilised", it is more linked to minerals, and research on the turnover of mineral-associated C in the litter layer is therefore needed.
Reply: See reply above.

3/ The effect of wild boar on plant biodiversity and forest ecosystem C cycle is questionable
In the introduction section, the authors insist on the "mainly positive effects in forests" (p2 line 15) of wild boar bioturbation. However, other studies are questioning this statement, presenting the effect of ungulate populations as :
- "jeopardiz[ing] forest regeneration process"
- "detrimental to the peculiarity of forest plant communities"
- leading to "lanscape-level biotic homogeneization" (see e.g. Boulanger et al., 2017 in Global Change Biology)
If forest regeneration process is actually jeopardized by wild boar invasions, then the fate of the global ecosystem C stock and cycle is not clear... This should be acknowledged in the manuscript.
Reply: We acknowledge that the effects of wild boar on biogeochemical processes and forest ecology are not fully understood and may also be negative.
Reply: We agree that studies on wild boar effects are not uniform in their results. Therefore, we will include a sentence acknowledging that wild boar may also have negative effects: “However, other studies also found negative wild boar effects on forest regeneration or understory biodiversity (Siemann et al., 2009; Barrios-Garcia and Ballari, 2012)”. Since Boulanger et al., 2017 did not find any effect of wild boar on species richness for any vegetation layer, we refrain from citing this paper as example for negative wild boar effects.

4/ No positive grubbing effect on total SOC stocks were found
Please correct this mistake at p8 lines 9-10
Reply: We will correct this and change it to: “supporting our finding of no SOC loss with bioturbation".

Technical corrections:
p1 l26: "an[d]" ?
Reply: Thank you for noticing. It will be corrected.

p5 l17: "due [to] six"
Reply: Thank you for noticing. It will be corrected.

p7 l2: "significant[ly]
Reply: Will be changed accordingly.

p8 l20: please replace "mainly" with "only"
Reply: Will be changed accordingly.

p9 l16: please reverse "forest floor" and "mineral soil" : "mineral soil" : mineral soil mixed into the forest floor almost doubled the C load (not the opposite)
Reply: Will be changed accordingly.