Response to Reviewer 1 (Sonja Keel)

We are grateful for the time you dedicated to a thorough reading of our manuscript and for the valuable comments and suggestions provided. We believe that your suggestions help improve the presentation and discussion of the study's results. In this document, we have included each of your suggestions and have attempted to address them as best as possible (text in blue following each comment). All these comments will be taken into account and incorporated into the revised version of the manuscript.

"general comments"

In this study González-Sosa et al. measured the effect of an agricultural management change on a large set of variables related to soil organic carbon in a long-term experiment in Uruguay established in 1963. At two points in time (2008 and 2021), samples were collected at 10 to 20 cm intervals down to 80 cm depth. Two types of fractionations were used (physical and density), and for each fraction the C content, the stable C isotope ratio and radiocarbon was measured. The results were used to test whether vertical transfer of C explains the age distribution in the profile using a model. The main conclusion of this study is that introducing grassland in a crop rotation leads to lower C losses at depth.

A lot of hard work has been invested in this study and the results presented are interesting and novel. Subsoil organic C and 14C analysis are still rare although they both provide important information to understand the soil C cycle. However, I have three main points to consider. Overall, the article is well written. Some sentences are a bit long and you may want to consider splitting them.

We appreciate the general comments provided by the reviewer. In particular, regarding the following comment:

"Some sentences are a bit long and you may want to consider splitting them."

We will try to keep the sentences short wherever possible.

"specific comments"

- Your main aim is to test the effect of two different types of agricultural management on soil organic C (SOC) storage in depth. To do this, you need to compare the results against a baseline (or a business-as-usual scenario see e.g. Don et al. 2023; DOI: 10.1111/gcb.16983). Currently only data for two years are shown, and already in the first year (2008) there are huge differences in SOC stocks. Because no information of previous years is presented it remains unclear when the SOC stocks started to diverge or whether they were different already from the start. Based on a quick look into your previous publication (González-Sosa et al. 2024, SOIL) a SOC stock record for the entire experimental period is available (at least for the topsoil). This information is essential for the interpretation of your results and needs to be included here.

This study explicitly states that it builds upon the findings presented in González-Sosa et al. (2024). That study already analyzes, through the fitting of dynamic compartmental models, the dynamics of SOC and radiocarbon at the surface soil only. For this reason, we felt it was unnecessary to repeat information derived from that other study and instead present it here as supporting context.

Perhaps the description of this previous study should be expanded in the introduction, but we are hesitant to further lengthen a paper that is already sufficiently dense in terms of information and figures. We will add a clear description of the SOC dynamics of the two treatments. Briefly, both treatments started from the same SOC stock (they share the same baseline) given that they were established in an experiment designed on the same soil and at the same site. The integrated crop-pasture rotation system (R) was able to maintain a relatively constant SOC stock throughout the LTE period, while the continuous cropping system (CC) SOC stock declined steadily over the entire study period.

- On top of the treatment differences a relevant management change was introduced in 2008. Soils were no longer tilled (and the crop rotation changed). It is well known that no-tillage changes the depth distribution of C (see e.g. reviews by Luo et al. 2010; doi:10.1016/j.agee.2010.08.006). This is an aspect that received no attention but could have influenced your results.

We appreciate the reviewer's suggestion, and we agree that it is highly relevant. Based on the reference provided and a more extensive review of the subject, we will incorporate these elements into the discussion of the results.

- I think you present too much information. You have 10 figures and 2 tables each including a lot of information. Please consider moving part of this to the supplement. I added some further suggestions related to the figures below. The modelling results are interesting but did not provide a lot of new information. I would therefore shorten this part in the discussion.

We fully agree with the reviewer's suggestion. The manuscript indeed presents a substantial amount of information, and moving part of the results to a Supplementary Material could help improve readability. In addition, we will aim to shorten the section of the Discussion focused on the results of the modelling exercise.

"technical corrections"

L12: Based on your SOIL article this is not true. There is no accumulation of C, but a prevention of C losses.

That is a valid point, and we will revise the text to address this suggestion.

L63: "aggregate formation"

Thank you for pointing this out. We will correct this in the revised manuscript.

L74: please double check if the name is correctly spelled.

The suggestion is correct. We will change this in the revised manuscript.

L78: "agricultural sequences" are usually referred to as crop rotations.

Thank you for pointing this out. We will correct this in the revised manuscript.

L79: I think it would be good to add a reference here.

Thank you for pointing this out. There should indeed be a reference in that sentence, we will include it in the revised manuscript.

L81: If pastures are in a rotation they are typically referred to as leys. Since your grassland includes clover, you could refer to it as “grass clover ley”.

We agree with the reviewer’s suggestion. Since the pastures are part of a rotation and include both grasses and legumes, we will change the terminology in the revised manuscript to "mixed grass-legume leys."

L105: please replace by “conservation management”

Thank you for pointing this out. We will correct this in the revised manuscript.

L155: I understand that this has been described elsewhere but it would be helpful to add just a bit more (everything that is relevant for C inputs): what type of fertilizer (organic/synthetic), residues left on the field or not.

We appreciate the comment, it is very pertinent. In both production systems, inorganic fertilizers (N and P) are applied to both crops and pastures in accordance with agronomic recommendations based on soil and plant analyses. As a general management practice, crop and pasture residues are left on the site. However, to ensure better pasture growth, sporadic hay harvests have been carried out during this phase of the rotation since 2009. We agree that these factors contribute to the interpretation of the production system’s characteristics and its impact on the analyzed variables, so they will be included in the revised manuscript.

L168: Add latin names of crops.

We will correct this in the revised manuscript.

L172: Could the historic changes affect C inputs? If yes, then I think it would be important to mention this

Yes, it is possible that this had some effect. One example we already discussed in González-Sosa et al. (2024) is the replacement of sunflowers with soybeans in 2009, a crop that generates C inputs with a lower C/N ratio which may have caused changes in the dynamics of both systems. You are correct in noting that it is worthwhile to incorporate these elements into this study as elements to the discussion. Therefore, we appreciate the suggestion and will incorporate it both into the methodology (with a more detailed description) and into the discussion section.

L295 : I would rephrase this sentence as follows: “the SOC stock of the R system in the 20-80 cm layer (80.66 Mg ha-1) was 46% higher than that of the CC system (p value < 0.010)”

We agree with the change, it will be incorporated into the revised manuscript.

Fig. 3a: This might be a detail, but I honestly had difficulty understanding the figure(s) at first. I suggest changing the order of the dark and light grey label explanation (first the older one, then the newer one when reading from left to right). Additionally, please consider changing the order of the treatments so it aligns with the figure. Furthermore, the letters indicating the statistical results are barely visible and the tests are not mentioned in the legend. The same holds for Fig. 3b (and others).

Thank you for these suggestions. We will incorporate these modifications in the revised manuscript.

Fig. 5: Text on the right is too small.

Thank you for pointing this out. We will correct this in the revised manuscript.