Responses to reviewers' comments

We thank both reviewer for their constructive comments and suggestions which allowed us to improve our methodological description, the overall manuscript structure, and the data analysis/interpretation. Below we have listed the main changes we made in the revised version of our manuscript:

- We extended the introduction section, by adding some background on the use ^{14}C and ^{13}C to study the impact of deforestation or vegetation changes.
- We provided more detailed information on our study area and our soil characteristics:
    - Lavaka and erosion processes
    - Lateritic horizon
    - Type of soil and soil rock basement
    - Topographical characteristics (slope length, elevation and gradient) of the forested and grassland transects
    - soil texture data are now included
    - The occurrence of endemic C3 grasses
- The discussion section was improved based on the comments received, and new statistical analyses are included.
- Inconsistencies in figure captions, references, equations and units were corrected.

These changes are described in detail below, where you can find our point-by point response to the reviewer 'comments. For clarity, the comments of the reviewers are in *italics* while our response is given normal font, with an indication of the lines and references in the revised MS track-change indicated in **bold.**

Author response referee#1

In this paper the authors present SOC concentration and stock, 13C, and 14C depth profiles from hillslope transects with forest and grassland vegetation cover in the highlands of Madagascar. The authors use these data to address a debated question – whether current grasslands are grasslands because of bioclimatic and edaphic factors (ie. they are "natural" grasslands") or if they are the consequence of deforestation by humans hundreds of years ago. They argue that 13C depth profiles indicate a shift from C3 (possibly forest) to C4 (current grasses). They further argue that conversion from forest to grassland has caused the sustained loss of SOC since this time as current grasslands store about half as much carbon as intact forests. These data and findings are interesting, but I find that the manuscript could use some improvements and corrections prior to publication.

REPLY: First, we would like to thank referee #1 for his/her positive evaluation and comments on our manuscript. All comments were helpful to improve the presentation of our results and manuscript.

Reviewer #1 General concerns are as follows:

1) *Though there is some consideration of erosion, this could be better explained and addressed in the abstract and discussion sections. This needs to be fully considered as an alternative explanation to the differences in SOC especially considering the presence of gully erosion (lavaka) and lateritic horizons in some grassland areas.*

   REPLY: Indeed, erosion rates are considered to be higher after a change in vegetation (from forest to grasslands), and this, therefore, could contribute to the higher $\delta^{13}C$ and OC at the valley position compared to the upper hillslope position for the grassland profiles (Top - Upper middle-Middle – Lower middle and Bottom). We have now mentioned this in the abstract and discussed the possible effect of erosion in more detail in the revised Discussion.

Abstract. L31-38.
4.3 Effect of erosion following natural vegetation change in the grassland transects. L620-633.

2) There is no other discussion of alternative sources of carbon. At least indicate you've considered carbonate and geogenic OC. What would their presence mean for your findings and conclusions? Why do you think you do not need to consider them?

REPLY: It should first be noted that the data presented only refer to organic carbon: all carbonates were eliminated when preparing our soil for analysis, by acidification after weighing subsamples in Ag cups (see Materials & Methods, L203-204). According to the World Reference Base for Soil Resources (2006), the soils in our study area are classified as ferralsols. In addition, the basement rocks on the site we sample our soil are metamorphic and igneous (Du Puy and Moat, 1996). Therefore, we did not consider geogenic OC to be substantial, in contrast to subsoils developed from sedimentary rocks where this might be more important (Graz et al., 2010). We now mentioned this explicitly in the revised version.

2.1 Study area: Lake Alaotra region. L140; L152-154.

3) Inferring that the conversion to grassland is what caused the large discrepancy in SOC stocks between the grassland and forest transects is interesting but requires consideration of how similar or different the soils are independent of the vegetation cover now – if erosion is a factor now, could it have been before *when the vegetation was C3 dominated according to the ^{13}C results? Why do you think they were similar? Are the textures similar?*

REPLY: We agree that our soils should be comparable before testing our hypothesis: soil type, topography, slope gradient, and texture. We have now mentioned in the manuscript that we did not observe significant differences in the texture of soils under grassland and forest. We added a new figure presenting the soil texture data and the topographical gradient as a supplementary Figure (S3 and S5). Regarding the possible effect of erosion under C3 vegetation: the $\delta^{13}C$ data collected along our forest transects do not show substantial differences according to the position along the hillslope. This suggests that erosion might not play a major role in the variation of $\delta^{13}C$ in a C3-dominated landscape (in this case, forest) as significant erosion would invariably have led to signs of OC accumulation in the valley position. Water erosion is likely to be more important under grassland: this explains the fact that there is clear accumulation of SOC in the valley positions under grassland. This line of discussion has been added to the revised manuscript.

2.2 Sampling transect. L178-180,
2.3.3 Soil texture analyses : L269-L275,
3.1 Soil texture for grassland and forest soils. L286-L296,
4.3 Effect of erosion following natural vegetation change in the grassland transects. L620-630.

4) is it possible that previous C3 vegetation may not have been forest (possibly savanna or C3 grassland, which is common in other parts of the tropics)?

REPLY: Endemic C3 grass species that have been inventoried in Madagascar belong to the "forest shade clade" (Paniceae: Boivinellinea) and bamboos (Hackel et al., 2018). Their diversification since the Miocene is reported to be favored by the expansion of the *Sambirano* rainforest (in the North of Madagascar) (Hackel et al., 2018; Yoder and Nowak, 2006). Therefore, if C3 grasses had existed in our study area, it would have been within a forest ecosystem. We clarified this in the revised version of our manuscript.

2.1 Study area: Lake Alaotra region. L162-L165

5) The introduction needs some background on the use of 13C and 14C in this context (for vegetation shifts and erosion) as well as context for why these differences in SOC stocks are relevant. There is a lot of good literature on the impacts of agriculture (from the beginning of agriculture, not limited to contemporary studies) on SOC to draw from here.

REPLY: Thank you for this suggestion; a background paragraph on the use of ^{13}C and ^{14}C has been added in the introduction and the impact of deforestation/conversion to grassland as presented in the literature is now also included.

Introduction. L96-L106.

6) there are no statistical analyses included in this manuscript. It seems the work could benefit from some relatively simple correlation, regression, and ANOVA to address whether it is appropriate to average all of the hillslope positions, for example. Is there no difference in the valleys or are the valleys just more similar than the other hill slope positions?

REPLY: A summary table showing the results of the statistical analyses has been added in the supplementary materials, and we refer to this accordingly in the revised manuscript.

2.4 Statistical analyses. L276-284

Specific comments from referee #1:

-L26: what about geogenic C, which could have a 13C value similar to C3 vegetation. How confident are you this is trees and not C3 savanna or grassland?

REPLY: As outlined in response to previous general comments: in Madagascar, C3 grasses had existed only within a forest ecosystem; all open grasslands are characterized by C4 vegetation. Geogenic OC is not considered as a significant source of OC because the basement rocks are metamorphic and igneous, and all carbonates were eliminated when preparing our soil for analysis.

2.1 Study area: Lake Alaotra region. L152-154; L162-164.

-L31: What do you mean by "recent expansion" and why do you think this is 1) recent and 2) expansion? Why not just high productivity in the valleys or erosional deposition of C from the surface up slope? This would also explain why the SOC stocks in the valleys are so high and similar to the forest more so than a recent expansion (I think, but maybe I am missing something?)

REPLY: We agree with the reviewer that these mechanisms may also be important in explaining the characteristics of the valley profiles and our wording has been changed to include these mechanisms as a possible explanation for the high OC content of the valley soils and the young SOC age there.. The sentence has been changed as follows:

"At the valley positions under grassland, the upper 80 cm contains higher amounts of recent grass-derived OC in comparison to the hillslope positions. This is likely to be related to the higher productivity of the grassland valleys (due to higher moisture and nutrient availability), and deposition of OC that was eroded further upslope may also have contributed".

Abstract. L30-L38

-L75: a word is missing here "do not allow assess how"

REPLY: We changed to "do not allow us to assess".

Introduction. L93

-L85-6: 13C, 14C, and SOC stock relevance need to be presented earlier in the introduction.

REPLY: Some background on the use and relevance of ^{13}C and ^{14}C data, as well as SOC stocks have been added to the introduction.

Introduction. L96-L106

-L93: again, a word is missing here "allow to assess"

REPLY: We have corrected this as suggested.

Introduction. L121

-L105: If at many locations there are lateritic horizons, you need to indicate whether you sampled in any of these areas later. What does this mean for your findings?

REPLY: The lateritic soil horizon is usually between 0.5 to 2m thick (Voarintsoa et al., 2012). Our soil samples have been sampled in the lateritic soil horizon, this is now specified in the revised Material and Methods sections. The lateritic soil horizon is considered to be relatively impermeable, thus favoring surface runoff erosion, especially if there is no or little vegetation and if no cracks are present (Wells and Andriamihaja, 1993). These have been clarified in the revised manuscript.

2.1 Study area: Lake Alaotra region. L143-154
2.2 Sampling transect. L173

-L108: lavaka need to be better explicitly addressed in the context of erosion in the current grassland areas – what impact can their presence have on your results? How old are they – do they predate human deforestation or are they possibly a consequence of humans using these areas for grazing? Land cover conversion and land use may be conflated here or not independently addressed adequately. They seem used interchangeably.

REPLY: An important point is that we did not sample inside lavaka, we consider the presence of lavaka but sampled along a transect outside of the actual lavaka present. By choosing a slope with and without lavaka we wanted to investigate whether soils on slopes that have lavaka development may differ from slopes that do not have them. We found that the OC content and $\delta^{13}C$ values did not differ significantly (at the surface) and our profiles showed similar trend for GLP and GLA. A statistical analysis of this is now provided. In addition to the lavaka and their development, we have clarified their initiation process in the revised version of the manuscript.

Previous research has shown that some lavaka can be directly associated with human activities such as trenches, tracks, steep fields and the construction of canals and paddies (Riquier, 1954; Wells and Andriamihaja, 1993). However, other lavaka are tens of thousands of years old, predating the permanent settlement of humans in the highlands, which is estimated to have taken place between 1600 and 100 years ago (Douglass et al., 2019; Mietton et al., 2014; Wells and Andriamihaja, 1993). Recent research has shown that lavaka in the Lake Alaotra region are on average ca. 400 years old. Lavaka became far more numerous since ca. 1000 years ago and lavaka formation rates have increased dramatically over the last 200 years. This timing and the rapid increase in lavaka erosion rates has been confirmed by floodplain sedimentation data in the same area (Brosens et al., 2022). Brosens et al. (2022) links this increase in lavaka erosion to increased environmental pressure due to growing human populations and intensified grazing based on scenario modelling and on the absence of significant climatic variations in the period considered. The mechanisms that lead to the initiation of lavaka, which typically occurs at the hillslope between upper middle and lower middle position, are not well understood. Different theories have been developed to explain their initiation, where both surface runoff processes and groundwater sapping are hypothesized to play an important role (Wells and Andriamihaja, 1993). However, the fact that excessive pressure on the land plays a critical role in lavaka initiation suggests that changes in surface properties related to overgrazing/overuse such as soil compaction and the decrease in vegetation cover and the increase of surface runoff caused by these changes play a crucial role. We have briefly re-inserted the main findings of Brosens et al. (2021) in the revised version of the manuscript.

2.1 Study area: Lake Alaotra region. L134-139

Table 1: Reported errors are > 1 so you should not report decimal places as they are within your uncertainty. Is it appropriate to present the data this way by averaging across landscape position? The presence of a large difference between the forests and grasslands except in the valleys suggests that maybe it is not appropriate as does the statement that the grassland hillslopes may be different from one another. This table is redundant with Figure 4, isn't it? The figure is much more informative, and you provide these values in the text – they do not need to be reported in the main paper so many times. If you find value in the table, move it to the supplement.

REPLY: The table is now presented in the supplementary material, and the number of decimals has been adjusted. We do indeed average across landscape positions. Given that profiles at different landscape positions are very similar and that their variation is not in any way related to landscape position, we believe this is justified. Also the data are simply used to make a comparison of SOC inventories under forest vs grassland and we believe that this approach is suitable for such a comparison.

3.4 Soil organic carbon stocks for grassland and forest soil profiles. L361-364
Supplementary table 3

L345-6: this suggests the surface young C has been eroded, which would explain why the valley has more SOC and younger C but this does not seem adequately discussed as an important part of the story for the grassland transects.

REPLY: As suggested, a section on the effect erosion that follows the vegetation change has been added to the discussion on the grassland transect data.

4.3 Effect of erosion following natural vegetation change in the grassland transects. L620-630.

L269: This paragraph is correct but the way the logic is presented is a little confused in my opinion. Important to this explanation but only implied, is that respiration would be depleted in ^{13}C relative to the organic matter because the light isotope is preferentially converted to CO2 and diffused to the surface – this is based on mass-dependent fractionation and is why the heavy isotope remains behind in the microbial biomass and byproducts. This is why the leaves that are taking up CO2 in soil respiration may be depleted relative to leaves taking up CO2 from well mixed air higher in the canopy. Also important is that mass-dependent fractionation causes the light isotope to be transported within the plants, so roots and root respiration are also quite depleted in 13C relative to the classic values for C3 plant leaf tissue of -25 permil. Similarly within a tree leaves growing closer to the ground may be more depleted that leaves in the upper canopy.

REPLY: As the reviewer explains, the understory effect or canopy effect found in tropical forest is mainly related to the gradient in $\delta^{13}C$ of ambient CO_2 along the vertical gradient: $\delta^{13}C$-CO_2 is lower close to the ground, due to elevated CO_2 concentrations via the contribution of soil respiration. Higher up in the canopy, the $\delta^{13}C$-CO_2 values are closer to the average atmospheric CO_2 composition. We have tried to express this more clearly in the revised version.

4.1 Difference in carbon sources between grassland and forest soils. L423-426

L278: Figures 3a and 3c look the same. Only 3 d looks like it may be different. Is this a mistake? There are no statistics again to assess what differences are statistically significant, making ecological significance questionable.

REPLY: We apologize for this error; the right figure is corrected. Statistical analyses are now provided in the manuscript and in the supplementary materials.

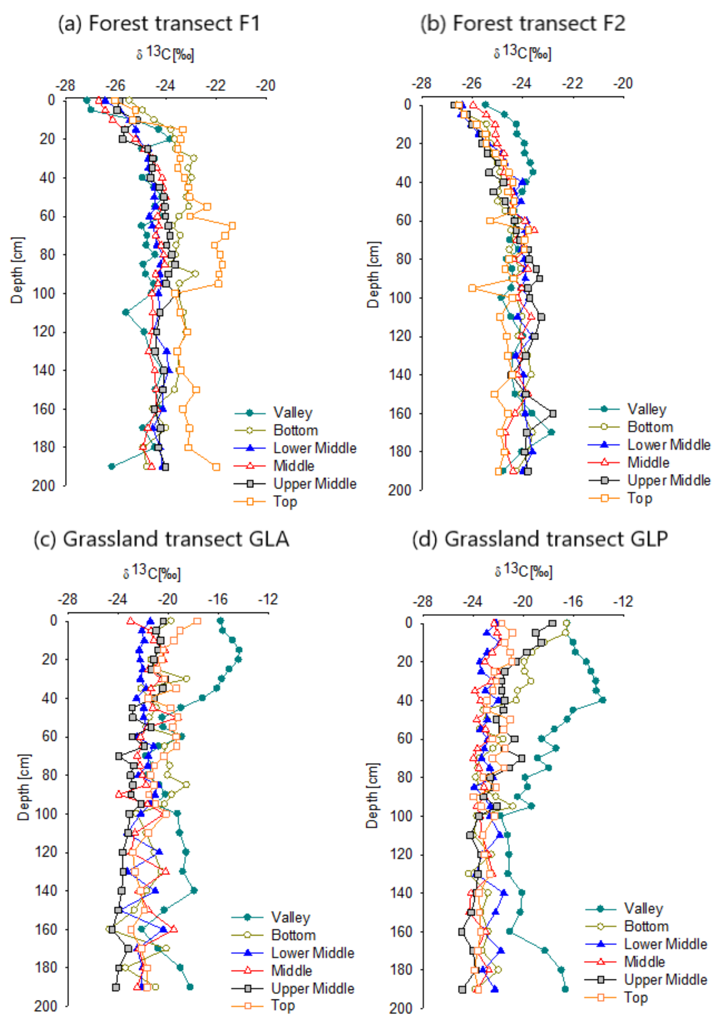


Figure 3: Depth profiles of $\delta^{13}C$ for each sampling location (Top-Upper Middle-Middle-Lower Middle-Bottom-Valley) of the four transects including F1 (a), F2 (b, GLA (c) and GLP (d).

Figure 3.L893

L296: Could this be because of deposition from soil that originated upslope via erosion? Could this explain why topsoils don't have more enriched 13C values on the slopes?

REPLY: We considered all alternatives that might explain the higher value of $\delta^{13}C$ in the valley. We suggested that the $\delta^{13}C$ values of the top position could be due to vegetation changes, which induce higher erosion rates on the upper slope positions. In addition, we observed a higher vegetation density in the valley positions – this has been included in the revised version.

4.1 Difference in carbon sources between grassland and forest soils. L512-513;L515-516.

L355: Rephrase for clarity – something like "Surface erosion is expected to be variable across topographic positions along the hillslope transect, with minimal…."

REPLY: Thank you for this suggestion; the sentences has been changed as suggested.

4.1 Difference in carbon sources between grassland and forest soils. L535-L534

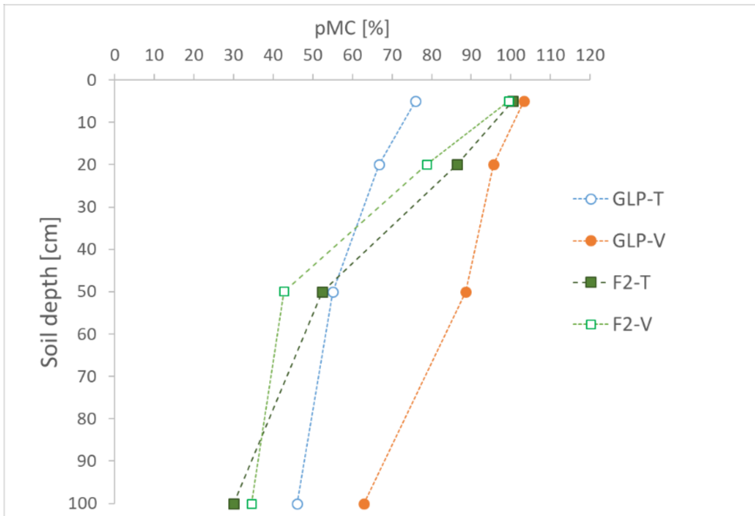
L357: what does "10Be in-situ topsoil samples" mean? I am more familiar with "in situ 10Be" which means cosmogenic formation of 10Be when surfaces are exposed in rock or sediment. This is an analysis so again this phrasing does not make sense to me. Try "erosion rates from in-situ 10Be analysis of the topsoil samples" perhaps? Also, please clarify what you would expect in terms of variation in the pMC and ^{13}C values based on the erosion rates indicated by the ^{10}Be analyses.

REPLY: We apologize for the confusion; the sentences has been modified to clarify. With the data that we have now, we could not really have a specific expectation for pMC and $\delta^{13}C$ values based on the erosion rates indicated by the 10Be analyses. However, the fact that we saw an increase in OC, $\delta^{13}C$ and pMC values at the valley-position under grasslands seems to indicate that at this position soil that has been eroded from upslope position is deposited. This is not observed in the forest transect, which is consistent with low erosion rates, with minimal deposition taking place at the forest valley position.

4.1 Difference in carbon sources between grassland and forest soils. L528-531

L358-9: This is very hard to see in figure 5. It is much easier to see in figure 3 for the ^{13}C. Please provide a similar figure as Figure 3 to show the 14C value. If it is only useful for this statement, put it in the supplement. I would very much appreciate seeing this figure along with the depth profiles for SOC and 13C as you have shown.

REPLY: Thank you for this suggestion, we now included a new figure (see below) in the supplementary figures:



Supplementary Figure S6: Depth profile of pMC for GLP-T, GLP-V, F2-T and F2-V.

4.1 Difference in carbon sources between grassland and forest soils. L537-538
Supplementary Figure S6

L360: Again, some statistics would be great and could strengthen your story. Correlation or regression would be very simple but quantify the relationship you see between the isotopes in the grassland transects. On figure 5, drawing a regression line on this plot for the grasslands (and also perhaps for the forests) would also drive home your point about how the grassland values converge with the forest ones at depth and make it easier to identify the depth labels on the different datapoints, which are quite difficult to read. Also, figure 5 would be easier to digest if the grassland points had the same symbols and color, with one open and one closed like the forests. This would make the figure feel less cluttered and make it easier to pick out the labels for the depths and transects. I am unsure why the hillslopes and valleys are marked using different symbols – I do not see a pattern. Is there one? If so this plot should be further improved to make it easier to see. I see the grasslands falling on one regression line and the forests on another.

REPLY: Thank you for this suggestion. We used different symbols for the valley to show the difference between pMC values found in the valley position of forest and grassland transects. In this figure (Figure 5), we highlighted that OC in the upper 50 cm of the grassland valley profiles is mainly modern (pMC≥100%), which is not the case of the OC in the forest valley position. In addition, we also highlighted that there is a clear trend in the 14C data, whereby the grassland reaches the pMC values of the forest SOC in the subsoil. Therefore, this figure has been improved as suggested, and regression lines have been added:

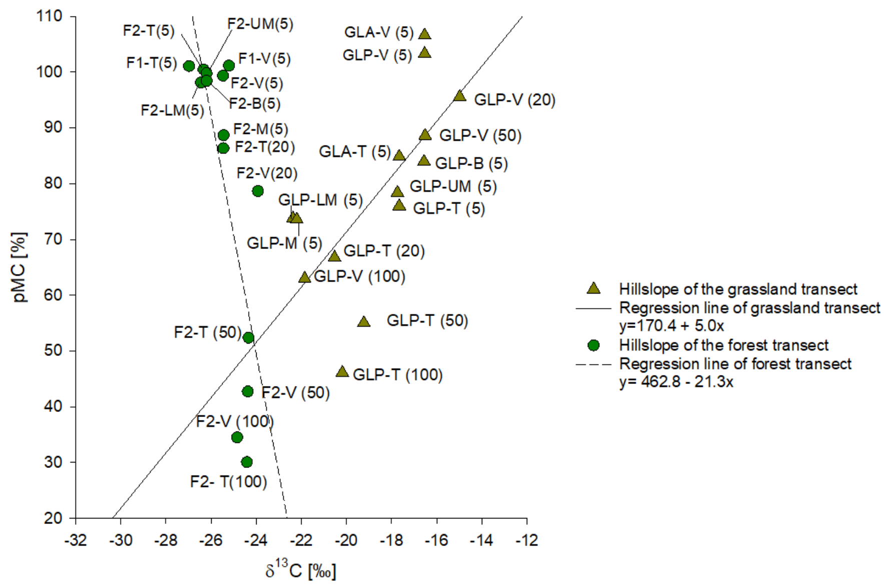


Figure 1: Comparison of the average value of pMC of bulk SOC plotted against $\delta^{13}C$ of SOC of grassland and forest soils. Each point is labelled by the transect position and the top depth interval. Continuous and dotted black lines represent the regression lines of grassland soil samples and forest soil samples, respectively.

Figure 5. 903

L365-378 This section should be significantly shortened to just a few sentences about how your findings are similar to other similar studies. There is no introduction or context about why the stocks or distribution of stocks are important so it is very out of place in a manuscript so focused on vegetation shifts and erosion across hillslopes. What about how similar these soils were prior to when humans may have deforested the current grasslands? What else could explain your results? What about the laterite? What about the lavaka – when did it form and what influence does it have on your findings? What other things may explain your findings other than human deforestation? I very much like the suggestion in this section that there may be long sustained loss of C and I think this is consistent with what long term global evidence for a massive loss of C since the dawn of agriculture has been. But this needs to be better substantiated in the paper through consideration of alternative explanations.

REPLY: Thank you for this suggestion, as outlined in response to other comments, we have (i) introduced the importance of SOC stocks in the introduction, and (ii) added more context on the laterite horizon depth and lavaka.

1.Introduction. L96-L106
2.1 Study area: Lake Alaotra region. L133-154.

Figure 6: Is averaging the grassland profiles like this valid? There is no effect of the lavaka? Are some of these sites influenced by laterite?

REPLY: We collected all our soil samples on the hillslope and did not find any significant difference between the hillslope with and without lavaka: we have confirmed this statistically in the revised version. The two grassland transects that we analyzed do not show any statistical difference in terms of $\delta^{13}C$ and

OC content at the surface, and they show the same trend with depth. We therefore think it is justified to combine the data here.

2.2 Sampling transect L176-180
Supplementary Table 1

Figure 7: This is redundant with figure 3, no? chose which one best shows your results (I think figure 3 but it is difficult to tell as it seems to have a mistake). If you like both plot types, move the less impactful one to the supplement.

REPLY: Figure 3 mainly compares the values in each transect. Figure 7 compares $\delta^{13}C$ of forest and grassland for each position and shows that $\delta^{13}C$ become similar at a lower depth. We agree that the underlying results we present are the same – but feel it is still useful to present them both ways; however we moved Figure 7 to the supplement as suggested.

Supplementary figure S7

Response to reviewer #2

GENERAL COMMENTS

I have read with interest this paper, which describes the consequences of vegetation change and erosion processes on SOC dynamic and stocks. It is an interesting research objective, and the purposes of this work would fall within the aims of this journal. In general, I think the paper is interesting and has potential. However the manuscript needs some improvements, outlined in the specific comments, but its main shortcoming is outlined below. The study is based on the comparison of toposequences under forest and grassland and the assumption that the soils under these different vegetations were identical or at least very similar before the vegetation change. However, the paper gives almost no information on these soils, either from a chemical or physical aspect. Some parameters, such as texture, have a strong link with the dynamics and stocks of organic matter. How can we be sure that the very large decreases in C stocks observed under pasture is indeed due to deforestation and the erosion it induces, if we do not know that the soils are really comparable? A presentation of the main characteristics of the soils (if only in the supplementary material) is necessary before we can put forward the hypotheses set out in the discussion. This manuscript, after the necessary improvements and corrections, would be acceptable for publication.

REPLY: We thank the reviewer for their overall positive evaluation and the detailed suggestions to improve the manuscript. To test our hypothesis whether the differences in SOC and $\delta^{13}C$ between grassland and forest profiles are linked to vegetation changes, we agree that additional information on our soil transects would be valuable. Therefore, additional information on the slope gradient of all transects will be provided in the revised manuscript. We found that slope gradients are similar for all transects, even though the lengths of grassland transects are slightly shorter than the forest ones. We will also include information on soil texture data, which are available and show no significant differences between soils under grasslands and forest. Other specific comments have been addressed point-by-point in our replies below.

SPECIFIC COMMENTS

Abstract

Lines 17-18: the time span allowed by the $\delta^{13}C$ to study the past dynamic of soil carbon ranges from years to millennia (rather than centuries)

REPLY: Thank you for this, we modified “centuries” to millennia as suggested.
Abstract. L18

Line 20: the SOC is low, not extremely low.

REPLY: Thank you for this, “extremely low” has been changed to “low”.

Abstract. L20

Line 23: “…which show typical profiles under C3 vegetation, with a slight increase with depth.”

REPLY: Thank you for this suggestion, the sentence has been rephrased.

Abstract. L23

Line 30-31: “…suggesting a recent expansion of grass vegetation, and/or that the valleys are depositional areas from organic matter eroded from the hillslopes.”

REPLY: Thank you for this suggestion, the sentence has been changed.

Abstract. L30-38

Lines 31-33: "Our approach, based...determine changing vegetation cover". This is true, but it has already been done in different parts of the world and published in many publications in the last 40 years. As this sentence is written, it sounds like a new approach.

REPLY: We agree that this approach has been previously applied in different parts of the world, however not yet in Madagascar. We have therefore rephrased this sentence as follows "The method we applied, which is based on the large difference in $\delta^{13}C$ values between the two major photosynthetic pathways (C3 and C4) in (sub)tropical terrestrial environments, provides a relatively straightforward approach to quantitatively determine changing vegetation cover, and we advocate for its broader application across Madagascar to better understand the islands' vegetation history."

Abstract. L39-42

Introduction

Lines 87-90: "The stable carbon isotope ratio…show a different degree of isotope fractionation". It is necessary to cite references

REPLY: The following reference is added: Cerling and Harris (1999).

Introduction. L119

Materials and methods

Line 101: the rainfall is not very high; many tropical regions have average annual rainfall between 1500 and 3000 mm or more.

REPLY: We agree - the term "high" has been removed.

Materials and Methods . L130

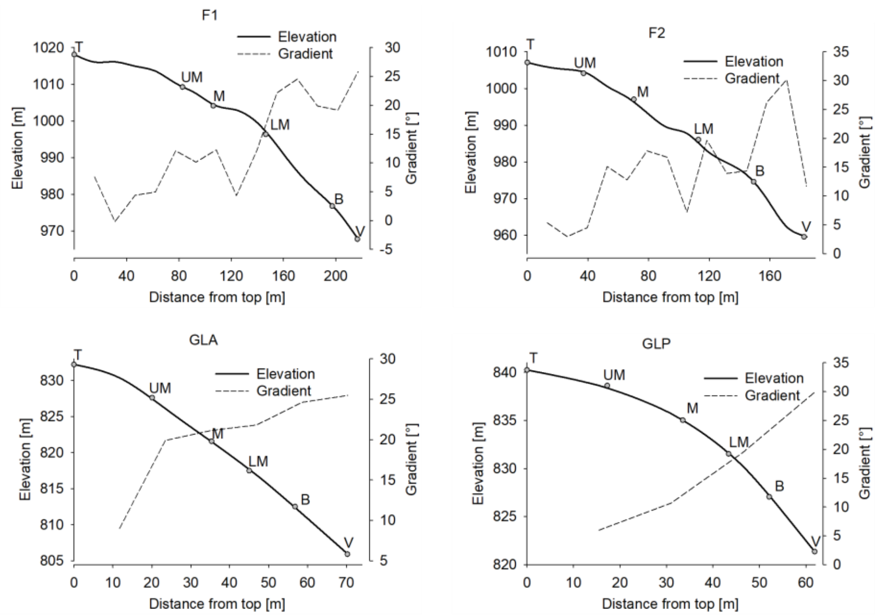
Line 103: "the mean annual temperature varies between 18 and 24°C" Really? Not the mean monthly temperature?

REPLY: We thank the reviewer to notice this, we have corrected this statement accordingly: "The mean annual temperature is 20.6°C, ranging between 11°C in July and 28°C in January (Ferry, 2009)".

2.1 Study area : Lake Alaotra . L131-L132

Line 118-120 AND Figure S3: the length and the gradient of the hillslopes are different under forest and grassland. Could this have an effect on erosion processes?

REPLY: We agree that the sampled hillslope transects under forest are longer (217 and 184 m) than the sampled grassland profiles (62 and 70 m). However, the slope gradients (derived from the 12 m resolution TanDEM-X DEM) of the four transects are comparable, with maximum slope gradients of 30° and 25° for the forest transects and 29° and 25° under grassland. In the revised manuscript, supplementary Figure S3 has been improved.



S3: Sampling locations along the hillslope transect, plotted together with the elevation profiles (left vertical axis) and slope gradient (right vertical axis). T (Top), UM (Upper middle), M (Middle), LM (Lower Middle), B (Bottom) and V (Valley). Elevation data are extracted from the TanDEM-X DEM.

The two main types of soil erosion on hillslopes are water erosion and diffusive erosion. Water erosion rates typically increase with increasing slope length and gradient (Govers et al., 1994). Diffusive erosion fluxes are approximately proportional to the slope gradient (Heimsath et al., 2005; Pelletier and Rasmussen, 2009; Roering et al., 1999).

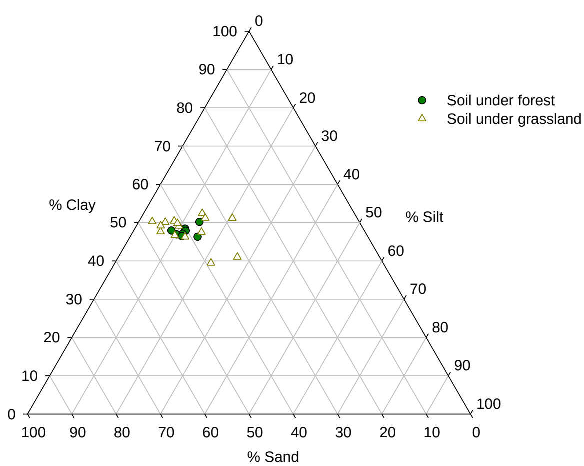
Based on the topographical characteristics only (i.e., assuming the same vegetation cover) of our hillslopes, we can thus expect diffusive soil erosion fluxes to be similar for all four transects which would result on lower diffusive erosion rates on the forested slopes as they are longer. Similarly, one might expect higher water erosion rates on the lower half of the forest transects when considering topography only as these are longer than the grassland profiles. However, the effect of slope length on water erosion rates is non-existent under dense, natural vegetation (Cerdan et al., 2010) and it is therefore unlikely that there would be significant differences in erosion rates between the grassland and forest slopes if they would only have a different topography. The differences in erosion rates due to differences in topography are more than likely far less important than those related to differences in vegetation cover. A grass cover that is well below 100% offers far less protection, however: consequently, water erosion rates may be expected to be significantly higher on the grassland slopes in comparison to the forest slopes (Carroll et al., 2000; Silburn et al., 2011).

Supplementary figure S3

Line 123-126: Why is there such a large distance (about 60 km) between the soil profiles under the forest and those under the grassland? Were there no adequate situations for the grassland soils closer to the forest? Important information about the soils is missing, which could be in the supplementary material: are the soils under forest and under grassland really similar, in chemical and physical terms. One of the objectives of the paper is to assess the effect of vegetation change on carbon stocks. Several soil parameters, such as texture, can influence organic matter stocks, so it is important to know whether the soils are similar.

REPLY: We agree with the reviewer that the distance between the forest and grassland profiles is relatively large. The main rationale behind the site selection was that (i) grasslands on the western side of Lake Alaotra were the main focus, as these represent a large and continuous/homogeneous area with characteristic vegetation cover, for which we hypothesized that vegetation changes (deforestation) may have occurred long enough in the past to result in differences in SOC inventories and characteristics. The nearest zone of pristine forest is located on the eastern side of Lake Alaotra – given the wide alluvial plain that results in a fairly high distance between sites. While grasslands area are also present on the eastern side of the lake, they represent a much more narrow strip of land which may have been deforested relatively recently so that SOC inventories might still reflect the forest cover that was present until recently. However, we paid careful attention to ensure that the topography of the transects was as equivalent as possible.

We agree that the chemical and physical characteristics of our soil should be comparable in order to verify our hypothesis of a shift in vegetation. The soils at both the forested and grassland sampling site are defined as ferralsols (World Reference Base for Soil Resources , 2006). We further verified the assumption of comparable soils by analysing the texture of the soil under forest and grassland. These results are now included, we did not observe significant differences in texture of soils under grassland and forest (p-value =0.663 (sand); p-value=0.723 (silt) and p-value= 0.232 (clay)). In the revised version of the manuscript, we added the soil texture diagram (see below) to the supplementary figures, added a paragraph describing the methods used to derive the soil texture, and report the results of the texture analysis in the text.



Supplementary Figure S5: Texture triangle (clay, silt and sand) of soil under forest and grassland.

2.2 Sampling transect. L140,
2.3.3 Soil texture analyses : L269-L275,
3.1 Soil texture for grassland and forest soils. L286-L296,
Supplementary figure S5

Results

Line 207-208: The description of the C profiles is too brief and even wrong! For example, for the F1UM profile the SOC content varies from 60 to 200 cm, between 0.3 and 0.9 %, not 0.1 and 0.2 %.

REPLY: We apologise for the error. We have verified and corrected these numbers and have further elaborated the description of these results.

3.2 Organic carbon content and stable carbon isotope of forest soil and vegetation. L298-304

Line 210-211: The description of the $\delta^{13}C$ profiles is too brief.

REPLY: The description of the $\delta^{13}C$ has been extended.

3.2 Organic carbon content and stable carbon isotope of forest soil and vegetation. L305-L311

Line 218-219: It would be better to say that in the first few decimeters, these two profiles have lower SOC values than the other profiles.

REPLY: Thank you for your suggestion, we have changed this accordingly.

3.3 Organic carbon content and carbon isotope ratios of grassland soil and vegetation. L316

Line 236: The sentence "However, the cumulative…on the GLP hillslope" is unnecessary.

REPLY: We have removed this.

3.4 Soil organic carbon stocks for grassland and forest soil profiles. L363

Figure 3c: THIS IS NOT THE GOOD ONE!

REPLY: Thank you for pointing out this error. We corrected the sub-plot, and verified the corresponding text, and checked the full manuscript for correct Figure and Table references.

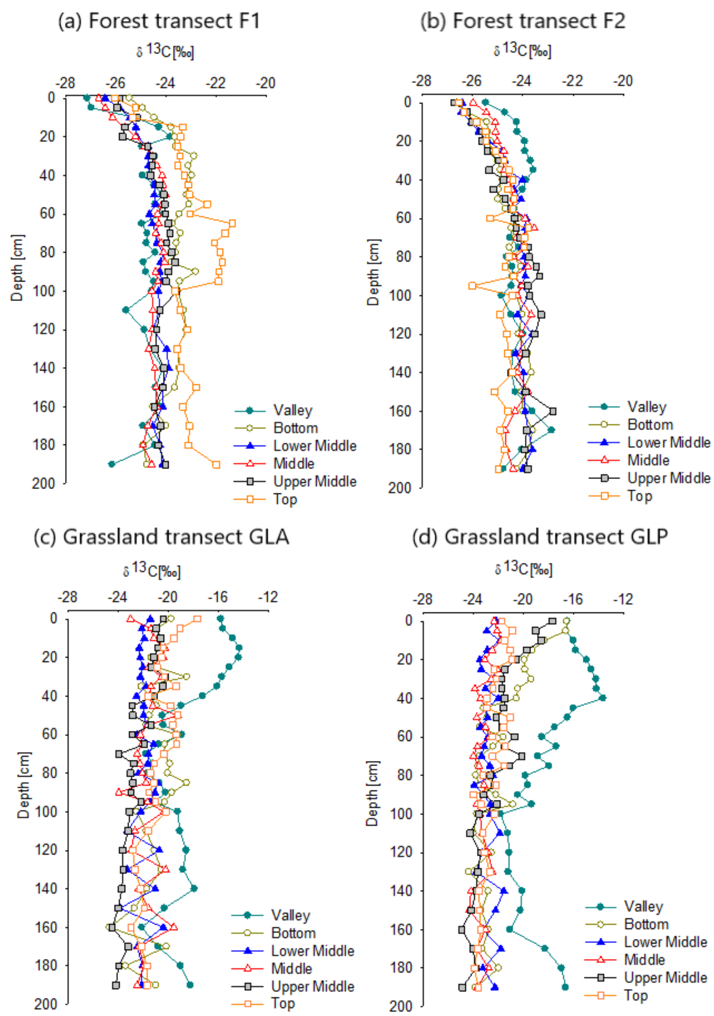


Figure 2: Depth profiles of $\delta^{13}C$ for each sampling location (Top-Upper Middle-Middle-Lower Middle-Bottom-Valley) of the four transects including F1 (a), F2 (b, GLA (c) and GLP (d).

Figure 3.L893

Discussion

Lines 253-277: All these explanations of the evolution of δ 13C values under C3 forest vegetation are excessively long. Since the end of the 80's, many articles have detailed this. This does not provide decisive information to answer the objectives of the paper.

REPLY: We had elaborated on this topic to provide the reader with the necessary background information to frame the observed decrease in $\delta^{13}C$ that we observed under forest, and to be able to properly compare this with the trends we found under grassland that are described from line 278. However, we agree this might be considered too extensive, and reduced the length of this part by removing few sentences in the revised version of the manuscript.

4.1 Difference in carbon sources between grassland and forest soils. L380-427

Lines 293-295: I do not agree, in the topsoil (what depth exactly?), the C3 contribution is much lower than 70%! See the figure 6.

REPLY: This was indeed not clearly formulated, the profile interval we refer to here is the upper 0-55 cm, and we excluded the values in the valley profile. We clarified this by changing the sentence as follows: " the contribution of C3 plant material to the SOC present in the upper 0-55 cm of these grassland soil profiles is estimated at ca. 70%, with the exception of the valley position."

4.1 Difference in carbon sources between grassland and forest soils. L444-445

Lines 297: for GLP-V the δ13C value increases between the surface and 50 cm.

REPLY: We have corrected his.

4.1 Difference in carbon sources between grassland and forest soils. L472

Lines 356-358: repetition of the lines 348-350

REPLY: Thank you for noticing this repetition. Lines 348-350 mainly point out the difference between of erosion which occurred in transects under forest vegetation and grassland vegetation, whereas lines 356-358 refer to differences in erosion between along the transects, i.e. that the erosion rates increase from the top towards the lower slopes. To clarify this, we combined these 2 sections in the new version of the manuscript as follows: " This is confirmed by soil erosion rates derived from in situ ^{10}Be concentrations of the topsoil samples (5-15 cm) which indicates that both under grassland and forest erosion rates increases from the top towards the valley position, where the erosion rates are consistently higher under grassland when compared to forest."

4.1 Difference in carbon sources between grassland and forest soils. L528-531

Line 380: "…, while the outputs include CO2,…" or "…, while the outputs include CO2 emissions,…"?

REPLY: Thank you for your clarification. We mean here the CO_2 emission, this has been corrected.

4.2 Response of SOC stocks to vegetation transition. L582

Line 397-398: It is not true that all the studies cited found strong differences in SOC stocks between savannah and forest situations. Moreover, the stocks are not calculated and commented on.

REPLY: We apologize for the confusion due to missing references - we had intended to refer here to Rabetokotany-Rarivoson et al. (2015) and Razafindrakoto et al., (2018) who have investigated the SOC change due to land use change by following the different stages of deforestation that occurred in the humid rainforest of Madagascar. They indeed found that the SOC stocks in the soil under the final stage of deforestation (grasses) are always much lower than the SOC stock under the initial forest. We rephrased this sentences as follow: " Rabetokotany-Rarivoson et al. (2015) and Razafindrakoto et al. (2018) found a strong difference in SOC stocks between the initial forest vegetation and the final stage of deforestation (i.e. a landscape dominated by grasses)".

4.2 Response of SOC stocks to vegetation transition. L610-611

Lines 400-401: That is true, but what does it add to the discussion, at this point. It would be better to delete this sentence.

REPLY: This has been removed.

4.2 Response of SOC stocks to vegetation transition. L614

Line 411: "The δ13C values of the forest profiles increased with depth, which is expected for soils developed for soils developed under C3 vegetation". It would be better to say that these 13C profiles are typical of soils under C3 vegetation for a very long time.

REPLY: Thank you for the suggestion. We rephrased this sentence.

5.Conclusions. L637

Lines 417-418: you cannot say that organic carbon input from the new grassland vegetation is not significant: it represents almost a third of the carbon stock!

REPLY: This description might have been somewhat unfortunate - the fraction of SOC from the grass vegetation indeed represents one third of the total SOC stock. What we aimed to communicate here, is that (i) total OC stocks in the grasslands are substantially lower than in forests, and (ii) that despite the absence of substantial new inputs from C3 vegetation, the bulk of the SOC stocks is still largely dominated (70%) by (old) C3-derived carbon.

To clarify our point, we have rephrased this sentence to make this point more clear and avoid misinterpretations.

5.Conclusions. L652-654

Line 429: "This indicates that the response time to deforestation depends on the rate of depletion of the old C3 pool." What does this sentence mean?

REPLY: What we referred to here is that the time since deforestation is likely to be reflected in the fraction of the C-OC pool that has been mineralized / lost. We agree that the sentence might be unclear for readers and therefore rephrased this.

5.Conclusions. L664-665

Technical corrections

Introduction Line 42: Voarintsoa et al., not Voarintsoa and Cox

REPLY: Thank you for pointing this out, this has been corrected.

Introduction. L50

Materials and methods Figure 1a: in the caption, it is written "dotted black line", but it is a "dotted white line".

REPLY: This has been corrected.

Figure 1. L882

Line 121: The supplementary material S3 does not show vegetation

REPLY: Thank you for pointing out this error; this has been corrected in the revised manuscript.

2.2 Sampling transect. L172

Line 148: in the equation, δ13C, not δ13.

REPLY: This is now corrected.

2.3.1 OC content, $\delta^{13}C$ and ^{14}C measurements. L212

Line 197: for D(i), the unit of measurement is missing.

REPLY: We added units for D(i) (cm) as well as for the bulk density (g/cm^3).

2.3.2 Dry bulk density and estimation of carbon stock. L262

Results

Figure 2: in the caption: "middle" not "middles"

REPLY: We have corrected this.

Figure 2 caption. L889

Line 207: the topsoil samples are 0-5 cm not 0-10 cm

REPLY: This has been changed.

3.2 Organic carbon content and stable carbon isotope of forest soil and vegetation. L299

Line 209: "…between -25.5 and - 27.1‰ …"

REPLY: We agree that number format should be one number after the decimal point and it should be -27.1 and -25.5‰ (from low to high values). We changed this in the manuscript and keep our number format consistent.

3.2 Organic carbon content and stable carbon isotope of forest soil and vegetation. L305

Line 225-226: verify the profiles which show gradual decline: GLP-B, GLP-UM, GLA-T (not GLA-M)

REPLY: It has been verified and changed accordingly in the revised manuscript.

3.3 Organic carbon content and stable carbon isotope of grassland soil and vegetation. L324-325

Line 240: "at different depths" appears two times

REPLY: This is corrected in the new revised manuscript.

3.5 ^{14}C analyses of bulk SOC. L366

Line 280: "…values of -20 down…" The symbol ‰ is missing.

REPLY: The symbol ‰ is now added in the revised manuscript.

4.1 Difference in carbon sources between grassland and forest soils. L430

Line 350: In the references, Brosens et al. is indicated as published in 2022.

REPLY: The discussed in-situ ^{10}Be data have not yet been published and are not part of the Brosens et al. (2022) paper. Therefore, we will keep this reference as non-published.

4.1 Difference in carbon sources between grassland and forest soils. L531

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