Biogeosciences Discussions

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Comment on bg-2021-336

Anonymous Referee #1

Referee comment on "Stable isotope profiles of soil organic carbon in forested and grassland landscapes in the Lake Alaotra basin (Madagascar): insights in past vegetation changes" by Vao Fenotiana Razanamahandry et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-336-RC2, 2022

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.

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.

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?

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 13C results? Why do you think they were similar? Are the textures similar?

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)?

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.
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?

Specific comments are as follows:

L 26: 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?

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?)

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

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

L93: again, a word is missing here “allow to assess”

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?

L108: lavaka need to be better addressed specifically 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.

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.

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.

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 13C 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.

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.

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?

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

L357: what does “10Be in-situ topsoil samples” mean? I am more familiar with “in situ 10Be” which means cosomogenic 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 13C values based on the erosion rates indicated by the 10Be analyses.

L358-9: This is very hard to see in figure 5. It is much easier to see in figure 3 for the 13C. 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.

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.

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.

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?

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.