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Comment on bg-2022-78

Anonymous Referee #1

Referee comment on "Effect of droughts on future weathering rates in Sweden" by Veronika Kronnäs et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-78-RC1, 2022

Review for "Effect of droughts on future weathering rates in Sweden"

Submitted to *Biogeosciences* by Veronika Kronnäs, Klas Lucander, Giuliana Zanchi, Nadja Stadlinger, Salim Belyazid, Cecilia Akselsson

General comments:

The manuscript "Effect of droughts on future weathering rates in Sweden" by Kronnäs et al. presents model results on how climate change will affect soil weathering across different locations in Sweden. The authors compare the results of different climate change scenarios and identify seasonal weathering dynamics that differ for the various locations. While the general focus of the manuscript is valid and interesting, it is not yet mature enough to be considered for publication. This concerns both the necessity for some language editing, including text organization, and mostly content organization and argumentation.

More specifically, text organization is suboptimal, since the information hierarchy is often not considered. It is also not helpful that line numbering starts from 1 with every single page. There are quite a few oversimplifications, e.g. "increasing temperatures increases evapotranspiration…" (line 16, p 2). This is only true as long as there are no drought conditions. Since the manuscript targets Sweden, the general statements in the introduction (and conclusion) should also target Sweden and be backed by references. Some statements appear not-justified, e.g., the shortcut from elevated calcium concentrations in rocks to related higher Ca concentrations in soils. There are various Ca-bearing minerals that do not weather easily. Only with carbonates could such a statement be made. This, more in-depth discussion and argumentation is needed (line 12ff, p 4). Lastly, Figures with multiple graphs of similar content, e.g. figures 3 and 4, should bear the same scales to make a direct comparison easier. Normalizing the absolute weathering

rates would make a direct comparison of the relative changes in weathering easier across sites.

Specific comments:

Title: You are not only looking at the effect of droughts, but more general on the effect of climate change. This should probably be addressed in the title and also that you are focusing on soil weathering.

Abstract: In general, try to focus on your main findings. The abstract contains a lot of descriptive text and it is not always that easy for the reader to extract the main findings. Additionally, try to give some more context, it is not always that clear to what you exactly are referring to (e.g., stronger compared to what, less compared to what...)

Line 12, p 1: What do you mean with "climate change base scenario"? Could you give some more context in the abstract already?

Line 13, p 1: Either there is a geographical gradient or not. Later you say, that there are clear differences in the response of weathering rates between north and south Sweden.

Line 15, p 1: More variable compared to what? Compared to weathering rates during winter or across sites? Try to use less descriptive words and be more precise, e.g. using numbers from your models.

Line 18, p 1: "Changes in seasonal dynamics due to climate change differ between regions." This is obvious given the large area your sites cover. In addition, what do you mean with "seasonal dynamics"? Seasonal dynamics of the weathering rate or the climate in general?

Line 20, p 1: What do you mean with "high"? Please provide some numbers here.

Line 24, p 1: Grammar. Use events instead of occurs?

Line 25, p 1: Quicker compared to what? Fine-textured soils? Try to be more precise and clearly state where and why weathering is lower/higher compared to what.

Line 25, p 1: Weathering rates of 78% still seems to be fairly high to me. It is difficult to put relative numbers in context without knowing the sites and the absolute values.

Line 26, p 1: "In the north, the soils do not dry out as much despite the low precipitation, …" Why? Is it because of less evapotranspiration?

Introduction: As stated earlier, the introduction could be improved by focusing more on Sweden and by mirroring what is presented and discussed in the result, discussion and conclusion sections. In the introduction you focus a lot on the responses of forests, but in the main text you write mostly about soil weathering.

Line 11, p 2: Better "in contrast" instead of "moreover"?

Line 13, p 2: I cannot really follow your argumentation here. At the beginning of this paragraph you write that forest cover will decrease which will results in a decrease in soil nutrients and here you write that there will be increased forest growth in the future that need more nutrients. Could you please add some more background information and references? In addition, your manuscript focusses more on changes in weathering than the future of forests. So maybe, you should focus more on this and less on the future of forests which are not only driven by weathering (as you also write).

Line 15f, p 2: "Weathering rates increase with temperature, but also with soil moisture." This is only true if enough moisture is available. Try to be more precise here and explain the importance of the different factors in more detail for Sweden, since this is the geographic focus of your study.

Line 19f, p 2: This is not part of the effect of climate change on weathering. So maybe, this fits better when you talk about trees and how they might response to changes. In addition, to which minerals are you referring here and on which weathering products to they depend?

Line 20ff, p 2: This is a really general sentence which does not add much information/context. Please give some more context and say under which conditions you expect to have higher weathering rates and under which you expect to have lower weathering rates.

Line 22f, p 2: Also, this sentence does not really contain information that help the reader to follow your argumentation.

Line 26, p 2: What do you mean with "this kind"? You have not defined this kind of drought. Please give some context what was so extreme about the drought in Sweden in 2018. How likely is a drought like this in the future?

Line 26, p 2: "nutrient situation" – awkward phrasing

Line 2-5, p 3: This section should be part of the abstract and introduction to define the goal of the study for the reader early on.

Line 3, p 3: A1B scenario – you have not explained this abbreviation yet and which climate scenario it is.

Methods: This section lacks some more information to fully understand what has been done and why.

Line 8, p 3: For how many years have the sites been monitored?

Line 9, p 3: What do you mean with "sites' development"? Soil weathering or also other factors?

Line 12–22, p 3: The description of the model is really general. What are the assumptions you have to make in order to run the model? What are the input variables? Please provide more context (this could also be part of the supplement). A flow chart could also help here.

Line 1 – 3, p 4: Missing reference. What do you mean with low weathering rates and "for their ages"?

Line 7, p 4: Which soil water chemistry variables did you measure and how?

Line 9, p 4: At which sampling depth? Is your model also depth explicit?

Line 9, p 4: Why do you measure the organic layer? This layer should not be of relevance for soil weathering? Later you write that you use the mineral content of the first mineral

layer for the organic layer – this seems to be an oversimplification.

Line 9, p 4: What means “most”? Is this variable needed for the model? If so, you should have this measurement for each site. Or explain, why and how you can use the same values across sites.

Line 10, p 4: What do you mean by 'few times'?

Line 10f, p 4: Can you give some more context? What do you mean it cannot be matched? If the site is so heterogeneous, how can you model it then and how can it be representative for the region?

Line 11, p 4: Better: “… soil water chemistry. This…”?

Line 12f, p 4: See my comment in the general section. I do not agree with your argumentation here and maybe you need to investigate this specific site better before you can use it for model exercises.

Line 14, p 4: You already write in the previous sentence that it is likely that there is variability in soil composition. You could easily test this by taking more soil samples, water chemistry and/or rock samples. This should probably be first addressed before modeling your site. Perhaps, your lysimeter and/or soil pit is not representative for the site.

Line 15, p 4: Maybe start a new paragraph after “…soils at the site too.”, since you are now writing about the other sites and the land use history.

Line 15, p 4: What do you mean with “recently”?

Line 16, p 4: What do you mean by “strong”?

Line 17, p 4: Which elements exactly?

Line 18, p 4: This is really descriptive and does not help to really understand the land use history of the sites (Why does the reader need to know that the sites were also described

in another study?). Give all the necessary information for your study in this manuscript: Why did you selected clear-cutted sites and non-clear cutted sites? How can you compare the different sites in terms of their response to climate change if they have such a different land-use history? Try to provide a more comprehensive description of the sites (focus on the key things that are important for this study) and why you selected these sites - what are you trying to compare among sites? Different climate, land-use etc.?

Table 1, p 5: Are the reported values mean or median values? What about standard deviation or the range of the variables? What about detection limits and accuracy? The table is not well integrated in your text.

Figure 1, p 5: This is a very helpful overview figure and should probably come earlier in the text. Why are you providing information about PAR here? You have not discussed it before. How does it influence the weathering rates?

Line 2, p 7: Which ions are you referring to?

Line 7, p 7: Please provide this information also in your publication and do not only refer to another publication.

Line 8, p 7: What do you mean with "possible mineralogy"?

Line 8, p 7: What do you mean by "total chemistry"? Did you measure all elements?

Line 9, p 7: What kind of model is this? What are the input variables? How does it work?

Line 9, p 7: This sentence does not make sense to me. What do you mean by "average mathematical solution"?

Line 10, p 7: As written earlier, why do you need the organic layer for your model? Using the next (mineral layer) does not sound appropriate. Please provide more background to justify your assumption.

Line 11, p 7: Again, how do you know that this is representative for your site, if it does not match with the other measurements?

Line 11, p 7: As an average for what?

Line 12, p 7: This seems to be a lot to me. Are you sure this is justified? I think you really need to have a better understanding of this site before modelling it.

Line 12, p 7: What do you mean by 'has been seen'? Since when can we 'see' mineral content?

Line 14, p 7: Awkward phrasing. I would actually argue that all of your sites have a coarse texture and that you cannot really say much about fine-textured soils. To me, your data does not allow you to make assumptions about the effect of soil texture. You could do some simple statistical tests to see if the sites differ significantly in their soil texture (if you do so, you should consider the compositional nature of your soil texture data). In addition, please provide the cut-offs you used to define clay, silt and sand. Furthermore, are the gravel class part of the sand class? Sand, silt and clay should add up to 100%. You can then also use the soil texture classification to say something about the differences (e.g. if there are real differences in soil texture).

Line 16f, p 7: What do you mean with "increasing intervals to the north"? Why?

Line 21, p 7: Why? Please describe the input variables in brief at the beginning (when you describe the model and what you are exactly trying to model) and explain their role/why they are needed.

Line 26, p 7: Please describe it also briefly here. It is not good practice just to refer to another publication that did it the same (or almost the same).

Line 27, p 7: Check grammar.

Line 27, p 7: For how many years was it kept constant? What are the time intervals?

Line 31, p 7: This information is not needed. Maybe delete: "were SMHI was a partner organization."?

Line 1, p 8: Are these assumptions you made or are they justified by any measurements or other studies? Please clarify and provide references.

Line 4–6, p 8: Again, why are these measurements needed and what is their specific role?

Line 11, p 8: What do you mean by bias correction of data from CLEO?

Line 13, p 8: Is this commonly done? If so, please provide references, if not, explain why you did it this way.

Line 26, p 8: "right level" - Awkward phrasing.

Line 27, p 8: I am not sure if your approach is better, since you have to make a lot of assumptions and without a more detailed description your exact methods, it is not possible to varify your assumptions and corrections. Why did you make all this effort, if you don't have the data from the sites? Using global products what probably just be fine – as you also write (since your results are similar to earlier approaches).

Line 31, p 8 to line 21, p 9: This information should probably be moved up. It would help the reader to have this information earlier in the method section to know what you mean with "climate base scenario" and "drought scenario".

Line 14f, p 9: Why are the drought years depending on the year of clear-cutting? I think you really have to make sure that you clearly state what you are modelling, which input variables are need and what are the output variables. I am missing the link between the forest management, and soil weathering and climate change in your manuscript.

Line 20, p 9: Why are the numbers in Table 2 are only based on two sites? What about the other sites?

Figure 2, p 10: Since the differences are not that big between the two scenarios, you could try to plot the differences instead of the absolute values for the two scenarios. Similar to your Table 2, but instead of showing % use the actual units. Yet, I am not sure if this will actually improve the figure or not. In your legend you only need to show the color for the two scenarios once; I don't see any squares in the figure, so you could delete this legend.

Results: The findings are quite interesting, yet, the structure of the text needs to be improved. You may also consider presenting your results in a different value. At the

moment, a direct comparison between the sites is difficult, due to their large differences in absolute weathering rates – normalizing the values might help which would allow to directly compare the relative changes across sites.

Line 9, p 11: Are you showing these results somewhere? Without any numbers it is difficult to verify these statements. As I said, your texture gradient is not that big, so I'm not sure if you can actually say that weathering is driven by soil texture. But, I might be wrong, so seeing the data what help here.

Line 14, p 11: Under which conditions will we see the largest increase in 1990–2019 and 2030–2059, and between 2030–2059 and 2070–2099? Also, didn't you model until 2100?

Line 16, p 11: Awkward phrasing: "In absolute values, Ammarnäs has by far the largest increase in weathering, as it has by far the largest weathering." What are the absolute values and what do you mean by "largest increase in weathering because of largest weathering? This sentence does not make sense to me. Same is true for the first sentence in the next paragraph (line 18, p 11). Maybe you should present your results in a different way, to account for the large differences in the absolute weathering rates which influences your relative values. You could normalize your weathering rates which would make it easier to compare the changes in the weathering rates across sites.

Line 18ff, p 11: Check sentence structure. If I understand it correctly, you are saying that in southern Sweden there is an increase in soil weathering in all four seasons, with winter showing the smallest increase?

Table 3, p 12: Add explanation of the acronym BC to your table. A table should stand alone without the text, so all acronyms used in the table should be explained below the table.

Figure 3, p 13: In the text you refer usually to southern and northern sites. Maybe you can add this information also to your figures to make it easier for the reader to know which site belongs were. You could use a color code for this or describe it briefly in the figure caption.

Line 2–13, p 14: Very nice description of the drought scenario and how these changes effect soil weathering in general. It might be useful if you provide some of the information already earlier in the text.

Line 20f, p 14: Could you provide some more context? Which minerals are causing the differences? This is the first time that you are talking about differences in mineral

weathering. You should probably provide some background information for this in the introduction and/or method section.

Table 4, p 15: "Averages, with standard deviation around the average in parenthesis." Check sentence structure. Maybe better: Average values with standard deviation in parenthesis. In addition, did you check the data distribution. Median values and median absolute deviation might be better to summarize your data.

Figure 4, p 16: Legend is missing and see comment about Figure 3.

Discussion: The discussion contains interesting thoughts, yet the structure of the text is not ideal. Some of the results discussed in the discussion section have not been presented in the result section. Part of the discussion reads like a result and/or method section.

Line 4, p 17: Again, I don't think you can support your finding that the highest weathering increase will be in summer with the fact that weathering is highest in summer.

Line 9, p 17: What are the implications for plant nutrition? Please support your discussion with references.

Line 13, p 17: Same as above: what are the implications for the ecosystems? Please provide some more background here. I think your discussion goes in the right direction and contains interesting thoughts, yet they need to be supported by references and also stated more clearly with more information.

Line 16, p 17: Have you really tested this? I cannot remember reading anything in your result section about this. Is this your own finding or is this statement based on literature? If the latter case is true, provide references.

Line 16–26, p 17: This should be part of the result section or when you describe the differences between sites. In my opinion, it does not really fit in the discussion here since you have not presented results about soil temperature. This section comes a little bit unexpected and needs to be integrated into the rest of the manuscript. Same is true for the following paragraph about soil acidification. In general, you can only discuss results that are presented in the result section.

Line 29–32, p 17: This sentence does not really contain information that help the reader to follow your argumentation. Under which condition does soil acidification decreases soil

weathering and under which conditions does it increase soil weathering? This could be part of your introduction and in the discussion, you can discuss what you find for Sweden and why it might be different (or not) and what this tells us.

Line 26ff, p 18: This reads more like a method section.

Line 4–17, p 19: Not sure what this comparison is supposed to tell me. If understand it correctly, the other models show similar annual values, but do not provide seasonal results. Personally, I don't think you need a separate section for this. You can just point this out, when you present the annual values for your study, saying that these results are similar to other model approaches across Sweden.

Line 19, p 19: Accept for Västra Torup, your model does not seem to be capable to capture the variation in ANC. Yet, you have not really discussed the role of ANC for your study.

Line 22ff, p 19: This is an important finding and I think you need to discuss this more. I acknowledge that you have this section about limitations in the main text of the manuscript. Yet, I am wondering if your model structure is appropriate, since it looks like that your model is not capable of capturing site-specific properties.

Conclusion: This section summarizes the main findings well. Yet, I am not fully convinced that soil texture is among the main drivers of soil weathering in this study. I would like to see some more statistical tests to back-up this conclusion.

Line 23, p 20: "A1B climate change scenario"

Line 29, p 20: Again, I think for this conclusion you need to perform a few more tests. Firstly, do the sites significantly differ in their soil texture, secondly, can the results actually be linked to soil texture?

Code/data availability: I highly encourage the authors to publish their data and code in a repository. This can be done independently of publishing the code for the model.

Line 13, p 21: The code is not freely available, if it needs to be requested.

References: The doi is not reported in a consistent way and sometimes it is completely missing.