

Biogeosciences Discuss., community comment CC1  
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## Comment on bg-2022-78

Katrin Fleischer

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Community 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-CC1>, 2022

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### General remarks

The paper by Kronnäs et al. describes a timely issue of climate interactions with weathering rates under future climate change. Weathering is an important process for nutrient supply and limits plant growth in some ecosystems, and I read the manuscript with great interest. The authors present a model application for Swedish sites along an environmental gradient, which is a suitable study setup to better understand and model weathering dynamically. Current and future rates of weathering are reported for two future scenarios, considering seasonal variation of weathering rates. I appreciate the conclusion that we need dynamic modelling of weathering in space and time, however, I am not fully convinced that the presented study, in its current format, is advancing our understanding of the mechanistic drivers of weathering and how they are affected by climate change. I recommend the authors adopt a more ecosystem-level approach in the analysis and include interactions with plants, and fully explain, analyze, and discuss the underlying mechanisms that lead to the model outcome in terms of weathering.

The paper presents results on seasonal ambient weathering, and effects of a hypothetical drought in future scenarios. The presentation of results lacks important details and needs to be improved by providing clearer visualization items, and correct and clear presentation of quantitative results. E.g. statistics on mean weathering rates, in absolute terms, are not reported in the results section and are not adequately compared to other estimates. The underlying modelled processes in regards to weathering need to be fully explained in the paper, for the reader to interpret the model outcome and better follow the discussion. Also, the underlying soil texture and mineralogy effects are not well explained. Other small details such as units and explanations in captions and headers need to be carefully checked.

While the focus of the paper is clear, the scope of the results seems too narrow, given the presented scientific problem and the model tool ForSAFE. The paper does not present results in its main section on how weathering interacts with nutrient availability from other nutrient-mineralizing processes, nor how seasonal changes in weathering interact with the timing of plants' requirements for soil nutrients. All of which can be modelled by ForSAFE, and also the introduction leads the reader to believe that these interactions are subject of the study. The scope of the study should be clearly communicated in the introduction and abstract. The paper would improve its scientific depth if these aspects would be addressed within the analysis of the paper. In its current format, results on modelled plant-

weathering interactions are reported in the discussion, without visual items or quantifications. Most parts of the discussion are actual material for the results section, and there is little scientific discussion of the model results.

I recommend the authors consider extending the scope of the paper and review the current structure and discussion of the manuscript.

#### Abstract

L12 Unclear what a climate change base scenario is, and what a drought scenario is.

L9 Why is the 2018 drought event singled out here? How is it relevant for the study?

L17 Present weathering as absolute rates for better context. Also, in the sentences presenting results afterward.

L25 Coarse soils respond quicker in which regard?

#### Introduction (page 2)

Methodology of weathering process in the model not well explained. General background knowledge on process-based weathering is not well explained. Too many unreferenced arguments and an unbalanced argument structure.

L8-14 this paragraph is not well balanced in explaining the different drivers for nutrient scarcity in terrestrial ecosystems.

L15-23 this paragraph is not well structured to follow a common argument. It is unclear what is currently known and where are the unknowns in e.g. how climate change will interact with weathering, and many statements lack an appropriate reference.

L28 if it is not possible to measure weathering in situ, how is the knowledge derived until now? Explain process knowledge on weathering.

L29 consider rewording here to express actual value of modelling, project into the future, derive hypotheses, etc.

#### Methods (page 3)

L3 why use 5 consecutive years, please justify

Consider removing the small section 1.1 and move aims to introduction.

Consider removing small text after methods and move it to 2.1 and 2.2

Section 2.1 Please explain in detail how ForSAFE models the process of weathering, and explain briefly how ForSAFE models other relevant processes that influence the rate of weathering, such as nutrient interactions and plant growth, in order to understand and interpret the modelling outcome.

L18 please specify which research objectives (if you mention that) and which aspects are being improved. This helps understanding the strength and limitations of the model.

#### (page 4)

L1 How were the sites chosen, on which data requirement, environmental representation?

L2 what does "relatively low weathering rates" mean? Compared to other soils the same age? Can this be more specific?

(page 6)

Why is the A1B scenario chosen? And which climate data is used for the 1990-2019 values? Units of climate variables missing, e.g. mean temperature, annual precipitation sum

(page 7)

Please explain why the base cation content was not matched, or speculate. It is unclear what the implications of this fix are.

L16 Do you investigate the effect of forest management on weathering rates? Or the effect of vegetation on the modelled weathering rates?

(page 8)

L1 It would be interesting to quantify the difference in dry deposition due to clear cutting. And also, what is the effect of base cation deposition on forest growth, and how does that interact with weathering in the model simulations?

L8 why use 5 consecutive years, please justify

(page 9)

L2-6 Please show the seasonal variation of precip/T/PAR for the future scenarios.

L7-9 Due to which factor have they transitioned into another climate zone?

L11 please define "extreme drought" with quantitative measure, e.g. X reduction in mean precipitation during summer months. I also wonder how often such conditions were projected by the climate models?

Figure 2

What is the absolute difference in precipitation between the scenarios? Please quantify the water deficit in meaningful ways, e.g. mean precipitation, monthly MCWD, etc.

The difference in temperatures between scenarios is hardly visible on this plot and scale. Also, for precipitation, it would be nice to visualize the summer months, where the actual reduction took place.

(page 11)

Results

L9 How is weathering dependent on the texture and mineralogy? Please explain before.

(page 12)

Table 3. Instead or additionally, can the response of weathering to warming be plotted? So, the relative control of temperature on weathering can be seen across season, or across mineralogy, etc.?

L15-17 Nice result, this could also be visualized and calculated per site, etc.

Figure 3 – why is weathering not increased more in some sites after 2030-59 ? or why is the effect larger or smaller per time frame? Please explain the underlying model drivers and processes.

Table 4 – this table is not easily comprehensible. What is the difference in base and drought scenario referring to in %? Is it soil moisture saturation? How long is summer now? It would be better to show % reduction of weathering, in my view. And why show yearly change in weathering, while the drought impacts summer weathering only? Is it possible to depict these results in an informative figure, and perhaps move the data table to the supplement? I am not sure for what kind of patterns I am supposed to look for in the table in its current format.

Figure 4 – same as above, it is hard to see differences in weathering, perhaps use a different line size or time-smooth data a little to better visualize.

Results section lacks an evaluation of the model's performance in regards to weathering.

Results section lacks reporting of actual modeled weathering rates.

Discussion

(page 17)

L3-15 This discussion on plant-weathering interactions should be part of the results in my view. The discussion starts with a summary of climate and weathering interactions, and they are now represented more as general remarks and speculations in the discussion, however, since nutrient supply for forest growth can be modelled with ForSAFE, I wonder why the effect on plants was not further looked into in this study? I see in L. 26 that forest growth is changing dynamically. And in L. 26-29 effects on plant nutrition are actually reported. Please explain how forest growth is treated in ForSAFE in the methods, and consider quantifying nutrient requirements versus nutrient supply via weathering, across the scenarios, sites, etc. I wonder what effect does vegetation have on weathering in your model?

The importance of using dynamic modelling is highlighted only for climate and weathering impacts in this study. The link to plant nutrition is not directly made, if I understand the study/model correctly.

L20-24 This is rather a result again, the difference in soil temperature and the underlying drivers.

L26 consider rewording, "faster ... than today in this modelling"

(page 18)

L23-25 This is material for the results section. It is necessary to analyze the effect of soil texture on the model results.

L26- 32, this is also material for the results section, not the discussion.

(page 19)

L7-9 Evaluation of model results need to be done in the results section, and actual measurements and observational-based estimates or model-based estimates need to be

included here. A simple statement that they are comparable is not enough.

L15-17 So if weathering has been analyzed with a very comparable approach before, what is the added value of this study? How does this study take us further to what we have previously known?

(page 20)

L17-20 now this opens up many questions here, the immediate one is, can you test the effect of CO<sub>2</sub> fertilization in your results, simply by keeping CO<sub>2</sub> constant in a control scenario. Consider the effect of different CO<sub>2</sub> scenarios. That would allow estimating the effect of eCO<sub>2</sub> directly. At the very least, the mentioned processes need to be analyzed, e.g. how did soil moisture change or any other driver of weathering due to CO<sub>2</sub>?