Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-80-AC1, 2020

Biogeosciences Discussions

Interactive comment on "Vegetation modulates the impact of climate extremes on gross primary production" *by* Milan Flach et al.

Milan Flach et al.

mflach@bgc-jena.mpg.de

Received and published: 30 May 2020

Response on the

Interactive comment on the interactive comment by Anonymous Referee #1

Received and published: 15 April 2020

Reviewer: The study deals with the role of vegetation for the effects of climate extremes on gross primary production (GPP). This is by analysing a selection of different observational data sets for the last 15 years or so. Although I find the subject of the study interesting and highly relevant, I don't find its presentation in the manuscript meets the quality standard, making it suitable for publication in its current form. Therefore, in my opinion, the manuscript should undergo a major revision before being published in

Biogeoscienes. I will further explain my reservations in the following:

Response: We are pleased that the reviewer is considering our manuscript highly relevant and are confident that we are able to present the manuscript in a form meeting the reviewers expectations as well as the quality standard of the journal. Please find the responses to the individual comments below.

General comments:

Reviewer: 1. In the study, forests are combined over the whole globe, providing estimates of the impacts of droughts and/or heatwaves on GPP at a global scale. I wonder, whether it would add value to the study, if also different categories of trees or different climate ranges (which typically also have a dominating type of trees) were distinguished. Different types of trees in a different background climate might be affected by the extreme events in different ways.

Response: We would like to thank the reviewer for this comment. Differente climate ranges are distinguished in this study so far by using growing season temperature and growing season surface moisture as drivers of the statistical models explaining the impacts of the extreme events. Figure 3 shows the impact of the extreme events using temperature and surface moisture during the event. To further distinguish these impacts in different climate ranges, we will add a similar second plot showing the extreme events in climate space opened up by growing season temperature and growing season surface moisture. We will add a paragraph on different climate ranges to the result section. Regarding the second aspect, distinguishing more different categories of trees, we would like to note here, that although forests are combined over the whole globe, the ecosystem type forests provides an astonishing homogeneous response pattern globally. We further differentiated forests into their different land cover classes (such as evergreen needleleaf forest, mixed forest, . . .) in Figure 4b and will provide more details on the specific land cover classes in the result section. However, further splitting different tree categories up to a species level is not possible so far to the best

of our knowledge by the means of globally available remote sensing products as used in this study.

Reviewer: 2. I find that the presentation of the results (Section 3) only makes up a relatively small part of the paper, certainly as compared to the introduction and the section on the methodology. I think this section needs to be extended to have a more balanced paper.

Response: We will extend the presentation of the results in a revised version of the paper. Therefore, we will add a second figure similar to Figure 3 and a paragraph on the climate space. Furthermore, we will add more details on specific land cover types in the results section (see also 18.) and provide more details on our findings on spatial vs. temporal contrasting anomalies (see also 20.).

Reviewer: 3. I find that the conclusions (Section 5) of the paper a bit weak. I think they could be extended in several ways, e.g. what the findings of the study mean for the terrestrial carbon budget and carbon dioxide concentrations under climate change.

Response: We would like to thank the reviewer for the suggestions on how to improve the conclusions (see also 22.). We will add a summarizing paragraph of the main results at the beginning of the conclusion and we will add a paragraph of our findings with respect to climate change and the carbon cycle (on p.12, l. 204): "[...] lagged impacts in forest ecosystems. Our findings imply for future climate that forest ecosystems may be crucial for mitigating immediate negative impacts on the carbon cycle of an increasing number of heatwaves (Seneviratne et al. 2012, Coumou & Robinson 2013). However, longer lasting heatwaves, drying in continental climates (Meehl et al. 2000) or a disproportionate increase in summer drought–heat events due to mutual dependencies (Zscheischler & Seneviratne 2017) may lead more frequently to critical moisture conditions for which we observe negative impacts for forests and to which forests are not well adapted to (Isaac-Renton et al. 2018). This is particularly critical as forest recovery times are multi-decadal. However, the lack [...]"

Reviewer: 4. I am a bit confused that some of the dots in Fig. 1 seem to be assigned to different types of ecosystems. Unless this is related to the way of presentation, it needs to be explained that grid points can comprehend different types of ecosystems and that in the analysis all (my assumption) types of ecosystems are included rather than the dominating type. I also wonder, whether, if in fact different types are considered, there should be a lower limit on the extent/fraction of the area covered by each type in a grid point.

Response: We would like to thank the reviewer for pointing us to this possible source of misunderstanding. We will extend the explanation of Fig. 1: it encompassed all grid cells affected by the extreme event. In many cases one extreme event affects adjacent grid cells which may each be dominated by a different ecosystem type. However, each grid cell (at the resolution of 1/12 degree) has still one dominating ecosystem type.

Reviewer: 5. I miss information on the types of ecosystem that are considered in the study in various places. Actually, it seems the only place, where this information can be obtained, is in Fig 4b. The information could easily be provided in a table in Section 2, where the ecosystems could also be grouped in the three main categories: forest, agriculture and others.

Response: We will provide the requested table in section 2 (methods) and will provide more information on the different types of ecosystems (see 18.).

Reviewer: 6. I miss a discussion of the limitations and potential biases of the data used in the study. This is only done for the FLUXNET data in the discussion (Section 4).

Response: We thank the reviewer for this important note. Indeed, we specifically discussed the limitations and potential biases of FLUXCOM-RS data as we consider this for the findings of our study to be particularly important. We will add a section to the Discussions on the limitations of temperature and radiation (from ERA5) as well as surface moisture (from GLEAM).

Specific comments:

Abstract

Reviewer: 7. Page 1, lines 10-11: “On the other hand. . . droughts and heatwaves.” – That would actually mean a limitation of the data, which to my understanding hasn’t been discussed in the paper.

Response: We would like to thank the reviewer for this comment. We would like to note that the limitations of FLUXCOM-RS are discussed as already mentioned earlier (6., see above) on p. 12, l.191-200. However, the discussion does not explicitly mention the lack of sensitivity to droughts and heatwaves. We will extend the discussion to explicitly mention the lack of sensitivity to droughts and heatwaves and we will add a paragraph discussing the limitations of temperature, radiation and surface moisture data as outlined above (6.).

Introduction

Reviewer: 8. General: I would find a short paragraph on the structure of the paper at the end of the introduction really helpful.

Response: We will add a short paragraph on the structure of the paper at the end of the introduction as suggested.

Reviewer: 9. Page 2, line 27: “the crucial role of timing” – I assume this refers to the timing of the extreme events. Please clarify.

Response: Yes, indeed. We will clarify it to be “crucial role of timing of the extreme event”

Reviewer: 10. Page 2 line 31: “the least understood aspect” – I wonder whether there is a review paper on this or another suitable reference to support this statement.

Response: We apologise for this statement being a bit speculative and change it into “one important aspect”.

Reviewer: 11. Page 2, line 39: ”in some meteorological. . . in ecological processes” – I am not sure, what this statement means. Please clarify.

Response: We clarify it as follows: “One option is to use values over some global thresholds to detect extremes e.g. to detect temperatures above 25 or 30 degree Celsius and to investigate the associated anomaly in vegetation productivity.

Reviewer: 12. Page 2, lines 95-96: “extreme relative to their expected value” – I am not sure that I understand this. In any case, considering a global absolute threshold would not make much sense, while it would make sense to use locally varying thresholds based on the same percentile, e.g. the 95th percentile, would.

Response: We fully agree with the reviewer. We will change it into: “Another option is to define extreme events relative to some locally varying threshold, e.g. defined by the 95th percentile of the distribution of the data. Here, we rely on the latter definition, and refine the definition by taking also a joint multivariate distribution of the data with regionally varying thresholds into account.”

Method

Reviewer: 13. General: I think it would be nice to properly introduce the acronyms of the various datasets.

Response: Yes, we will properly introduce the acronyms of the data sets as requested.

Reviewer: 14. Page 3, line 55: “ERA5” – I think it need to be mentioned that in ERA5 vegetation doesn’t vary but is prescribed via some climatological value. That has an effect on the turbulent energy fluxes at the land surface and, thus, might also affect the near-surface temperature.

Response: We would like to thank the reviewer for this important comment and will mention it in the extended discussion of the data limitations.

Reviewer: 15. Page 3, line 57: “GLEAM model-data integration framework” – It would

be interesting to know how and to which extent these data are constrained by observations.

Response: This is indeed an important aspect. GLEAM is driven by precipitation and microwave satellite observations to estimate soil moisture. Surface net radiation and near surface air temperature are used to estimate evaporation.

Reviewer: 16. Page 3: line 62: "2003-2018 period" – The choice of this particular time period for the study is not motivated at all.

Response: This choice represents the common time period of all data sets used. It is mainly constrained by GLEAM v3.3.b (starting 2003, ending 2018) and FLUXCOM-RS (starting 2001, ending 2018). We will add the following sentence: "The time period is chosen as it represents the common period of all data sets used at the time of the analysis."

Reviewer: 17. Page 3, line 71: "for more details see the B" – It is not clear, what this means and what it refers to. Appendix B, maybe (see also my comment below)?

Response: We will add the word appendix, which we unfortunately missed in the current version of the manuscript.

Results

Reviewer: 18. Page 6, line 115: "non-forested land-cover types" – This is one of the (many) places, where information on the types of ecosystems is missing. See also my comment above.

Response: We will specify the non-forested land-cover types ("savannas, grasslands, open and closed shrublands, permanent wetlands") as well as the agriculture land cover type ("C3 and C4 croplands as well as C3 and C4 fractions croplands / natural vegetation mosaics"). Furthermore, we will extend the description of Figure 4(b) on p.8 l. 140-144 with more details of the results with respect to the different land cover types.

Reviewer: 19. Page 8, lines 136-137: "the most important. . . model" – I find it interesting to note that according to this statistical model soil moisture doesn't seem to play a role. This is, however, in contrast to the results presented in Fig. 4b, where soil moisture receives a rather large weight. I wonder, how these – at first sight – contrasting results can be reconciled.

Response: We thank the reviewer to point us to this important aspect. We apologise that this aspect can be misunderstood. We do not state nor do we want to state that soil moisture does not play a role. Soil moisture is one important variable in the statistical model, which we definitely should mention. We will mention that surface moisture is the fourth most important variable after land cover type, as can be seen from Fig. 4(a) in line 137. Furthermore, we will tone down the first sentence of the paragraph to "Figure 3(a) shows that temperature and soil moisture have some effect on the direction of the impact, but does not consider other potentially important variables. Thus, we refine our understanding of the observed patterns using a statistical model."

Reviewer: 20. Page 8, lines 148-149: "but enhanced productivity. . . contrasting anomalies)" – I am not sure what this statement means. Please clarify.

Response: We will reformulate and extend the statement as follows: ". . . (spatial contrasting anomalies). Apart from an extreme event simultaneously affecting adjacent ecosystems with different or even contrasting impacts, it is also possible that one ecosystem shows contrasting impacts over time. During startup of the extreme event enhanced productivity may be observed which can turn into a contrasting reduced productivity at a later stage of the extreme event. This temporal difference in the response with a longer lasting extreme event is considered to be a temporally contrasting anomaly. To explicitly quantify . . . "

Discussion

Reviewer: 21. General: I think it would be important to also discuss the potential implications of the effects of extremes on net ecosystem productivity (NEP), given the

effects on GPP, to the extent possible.

Response: We will add a sentence on the implications for net ecosystem exchange on p. 12, l 190.

Conclusions

Reviewer: 22. General: I think the conclusions need to fill more than the one short paragraph (see my comment above). I also wonder, whether it would be helpful with a short summary of the main results of the study.

Response: We will add a paragraph with a short summary of the main results to the conclusions and will add a sentence on our findings with respect to climate change and the carbon cycles as stated above (3.)

Appendix

Reviewer: 23. General: I find the appendix unnecessary. This is because, in my view, Fig. A1 should be part of the section on the results (it is discussed quite a bit and is needed to give a complete picture) and Fig. B1 doesn't provide much relevant information (and is not really referred to).

Response: We will include Figure A1 into the result section as requested. However, we would like to leave Figure B1 in the Appendix, as it illustrates the found regions with similar seasonal cycles which are used to obtain similar thresholds in the multivariate extreme event detection procedure.

Figures

Reviewer: 24. Figure 1: One of the prominent extreme events ("Russia 2010") is not linked to a dot in the figure. Is this a mistake or doesn't exist a particular grid point that can be assigned to this event?

Response: We apologise that the linking line of Russia 2020 is hidden behind "Siberia 2011" at the very beginning. We will ensure that the link is visible in a revised version

of the manuscript.

Also, I think this figure should be extended with the panel representing "other ecosystems", now Fig. A1 in the appendix.

Response: We will move Figure A1 ("other ecosystems") to the results section.

Supplementary material

Reviewer: 25. General: An introduction into the structure of the figures, i.e. what the different panels show and how they relate to each other. Also, I think it would be helpful to give the "identification" of the extreme period and the type of extreme (drought, heat wave or a compound even) in a headline. I understand the rational for presenting mean values for temperature and soil moisture, but presenting anomalies instead might highlight some of the regional details and would indicate the soil moisture/temperature coupling. Also, an indication of the colours/numbers of the different ecosystem types shown in the figures would be helpful. That could also be part of the introduction to the supplementary material. See also my comment above.

Response: We will revise the Supplementary material. Specifically, we will add a general introduction for the structure of the figures and we will add the type of the extreme in a headline. However, we would like to present the figures with mean values as they currently are. The rationale behind presenting mean values instead of relative anomalies is to illustrate the range of global temperatures and surface moisture during extreme events (which are already detected by a relative approach).

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-80, 2020.