

Biogeosciences Discuss., referee comment RC1
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Comment on bg-2021-191

Martin De Kauwe (Referee)

Referee comment on "The effects of varying drought-heat signatures on terrestrial carbon dynamics and vegetation composition" by Elisabeth Tschumi et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-191-RC1>, 2021

Tschumi et al. explore the timely topic of the impact of combined drought/heat extremes on terrestrial carbon dynamics, using the LPX model. The authors construct a suite of potential forcings and use a factorial approach to examine the follow-through impact on carbon/tree dynamics. I found the paper well written, the methods are well constructed and the analysis broadly interesting. I did feel that more could have been done to explain key assumptions (see below) and in particular to leverage these assumptions in the discussion text when discussing impacts/broadening how transferable the results are across models. I think the equilibrium analysis needs more motivation in the paper, currently, 2 of the 9 figures relate to this and there is no mention in the abstract.

The first major issue relates to what LPX assumes, particularly with respect to temperature. The manuscript lacks information on the assumed bioclimatic limits and that photosynthesis and respiration estimates are simply down-regulated if temperature bounds are exceeded (I'm going off what I know about LPJ-GUESS, so please correct me). I think this information should be in the methods (a table by PFT) as it is likely to impact on how transferable the results are across models. For example, how much of the impact of the hot (or hotdry) is due to the assumed upper bounds of the model? Are these sensible in all geographic locations (see Australia, for example, where I also note the model has a continent of grasses - <https://bg.copernicus.org/articles/18/2181/2021/>). I would anticipate some return to this in the discussion when the authors try to contextualise their results. I want to be clear though, I'm not suggesting this invalidates anything the authors have done, but I would nevertheless anticipate a degree (a lot) of sensitivity to the assumptions of the DGVM. Similarly, some text on how well the model simulates the impact of drought.

This point about assumptions can be extended when the authors discuss how competition changes fractional cover with scenarios. I think the C4 grass component of the model will have assumed bioclimatic limits, in some places (Australia I know for certain), these are likely to bias interpretations ...

The second major issue relates to missing insight into how realistic the output from EC-Earth is? Is it biased warm/cold, wet/dry. The model will clearly have biases and I'm not suggesting that these biases would warrant the paper not being accepted; however, they do affect the subsequent analysis through LPX. It is really important that some text is

added about this I feel. Having personally been recently looking at the mean and variability bias in future precipitation data over Australia, I think this is a significant issue.

Finally, I think it would be great to add some figure (timeseries) that shows a case study of one of these very extreme summers to see how the model is behaving, for some region. I might be alone here, but I'd appreciate seeing how the model dynamics in terms of uptake/respiration play out across an extreme scenario vs one without events. It is quite hard to get this message from the maps.

Minor

- Line 23: Allen et al. isn't an appropriate citation for CO₂-induced changes in WUE.
- I think the scenarios sound well thought through and I note what I suspect is a deliberate naming choice to call one of the "dry" rather than drought. I think this is the right choice as the authors can't be sure it indeed does sample a drought (unless they check). However, the text surrounding Table 1 talks in terms of "drought". I think it would be better to be consistent with the language of the scenarios (?). I note further on they talk about checking for drought using SPI. Could they perhaps add a few sentences to explain a bit more about how they did this, it is currently unclear for me.
- I thought the equilibrium text was interesting but I'm not sure that the context was really given? If I missed it, I apologise but I would have liked to have seen more in the intro/methods to explain motivation. I also wonder whether each change in Fig 7 would be better on the same y-axis so the reader can compare relative impacts.
- With the maps, consider chopping off Antarctica to show more of the land surface.

Martin De Kauwe