

Biogeosciences Discuss., referee comment RC2  
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## Comment on bg-2022-65

Anonymous Referee #2

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Referee comment on "Exploring the impacts of unprecedented climate extremes on forest ecosystems: hypotheses to guide modeling and experimental studies" by Jennifer A. Holm et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-65-RC2>, 2022

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"Exploring the impacts of unprecedented climate extremes on forest ecosystems: hypotheses to guide modeling and experimental studies" by Holm et al.

This study investigates carbon dynamics in response to unprecedented climate extremes (UCEs), specifically droughts as well as in combination with warming and CO<sub>2</sub> fertilization, using two dynamic vegetation demographic models (VDMs), ED2 and LPJ-GUESS. It illustrates 1) conceptual frameworks and hypotheses on potential ecosystem response to UCEs, 2) VDM simulations to present potential ecosystem response, and finally 3) the limits of the current understanding of these responses. It is clearly written and will be an interesting topic to the readers of Biogeosciences. However, I fear that some important components are missing to make this study complete or original. For example, it is not clear whether the main focus of this study is to introduce the newest model development or review what is missing in the current VDMs and suggest future directions, or even the combination of both. In any case, model simulations need to be compared with the observation/data, at least partially, to describe the limitation of the current VDMs.

If process-based modeling is a great tool for studying the response of ecosystems to extreme drought events, which cannot be easily conducted with in-situ manipulation experiment (line90), I expect optimized or calibrated model simulations for specific study sites using historic drought events for the justification of the projections and to define the limitations of the current VDMs. Even if UCEs haven't occurred at the study site (line228), validating the model with some historic drought events (that the models are sensitive to drought events, and the directions and magnitudes of the responses are reasonable) will be necessary to support the conclusion. Of course, it is not easy to track the effects of a certain drought event in reality because not only single event occurs during a certain time period, while controlling other factors. In addition, ecosystem responses to extreme droughts will be different from those to less intense droughts as the responses can be nonlinear. Yet, providing the evidence that the model performance is reasonable is critical. As one example, LPJ-GUESS showed large swings in LAI at EucFACE site (line476) – is it reasonable? If not, is it because of some parameters too sensitive specifically for this site or the model structure that needs to be modified? In this regard, another question arises: why two specific study sites are selected? Models were not tuned specifically for each site

(line290), and comparison between the model simulation and observation was not made because data lack (line228; no observations in C change or no drought events?). If the model is not tuned for each site because of the lacking data, how about selecting other sites, where observations are available, at least for aboveground C? Or can any observations from FACE experiment be used for validating the model, such as the response to CO<sub>2</sub> fertilization? Adding this information and validating the model simulations will make the results more plausible and this study very unique.

In the discussion, what is missing in the current VDMs are thoroughly reviewed. It can be nicer if there was a tighter connection between the simulation results and discussion by providing more detailed descriptions of the two models. Some parts are discussed based on the simulation results but mostly shortcomings are written based on literatures, which can be done without modeling exercises. Providing more details will make the story more coherent, what the current VDMs can do based on the simulation results, what are still missing, and what needs to be done. Another important point to address is, despite multiple missing processes in the current VDMs: how the results of the VDM simulations are different from conventional ESM simulations?

Some other comments:

Line77: 'moderate treatments' is vague. How can you differentiate moderate drought from unprecedented drought? Also, where can you draw the line between moderate and unprecedented droughts in the figures?

Line213: can you provide climatology of the sites, e.g., what are the mean and interannual variability of temperature and precipitation?

Line434: 'multiple mechanisms that vary among ecosystem types' – if the model was not tuned for each site, what drives the variations between the two sites, climate or the number of PFTs?

Line483: 'further explored' can be more specific or explored in this study