Reply on RC1

This study presents the modelling of forest responses to extreme climate conditions (i.e., droughts), using the dynamic vegetation model LPJmL-FIT. The research focuses on an area in eastern Germany, applying custom climate scenarios to simulate increased probabilities of the 2018 drought event. Two model configurations were used: one representing a monoculture temperate needleleaf evergreen forest and another representing a mixed forest ecosystem with temperate and boreal needleleaf and broadleaf plant functional types.

This manuscript presents a valuable test case for the vegetation modeling community by showcasing the capability of vegetation demography models within a scenario-testing framework. Such kind of studies are important because illustrate the critical role in defining optimal forest management strategies under climate change conditions.

We thank the reviewer for valuing our study. We agree that by applying a scenario-testing framework one can test the impacts of increasing frequency of climate extremes, here drought, on monocultures vs. natural mixed temperate forests.

However, I believe there are aspects where the manuscript could be improved to better convey its message to the community. Below, I provide a list of suggestions:

- *Authors focused their attention on the response of mixed forest ecosystems based on the PFT classification. However, reliance on PFTs may inadequately capture the diversity of the different tree species defining the resilience of a forest ecosystem. I think authors should address this issue when introducing/justifying the need of their work and when discussing some of the limitations of their study.*

  We thank the referee for his/her comment. We want to emphasize the fact that we use PFTs with variable traits and that the model simulates different functional tree strategies within a PFT (Thonicke et al., 2020). In our opinion, the diversity of tree species is included in the functional trait space defined by the PFTs. The model approach focuses on capturing functional diversity. We clarify this by writing
  "The potential trait space is defined by these four PFTs and results from all temperate and boreal needle-leaved and broad-leaved trees according to the trait ranges provided in the TRY database. Via environmental and competitive filtering, however, this trait space can be smaller or change (as a result of changing environmental and demographic conditions) but still consists of different tree strategies composing the with-in PFT trait space. The simulated trait space therefore stands for the diversity of all relevant tree species." in line 206.

  Some recent works (e.g., Forzieri et al., 2022) reported on an emerging signal of declining forest resilience based on trend analysis of remotely sensed information. It would be interesting to apply a similar analysis framework using numerical simulation output presented in this study. In so doing authors would be able to summarize the whole set of model results into more "practical" indicators of ecosystem status.

We thank the referee for his/her helpful remark. We like his/her idea to use the framework of assessing forest resilience based on temporal autocorrelation of simulated vegetation variables. We will keep it in mind for future work, but it would go beyond the scope of this manuscript.

The study is based on the pure analysis of numerical simulation results without any level of benchmarking with direct observations and/or forest inventory information. This limitation should be somehow addressed or at least better discussed.

The model has been validated using observation and remote sensed data products with regard to GPP, biomass, plant height, wood density and SLA (Billing et al., 2022; Thonicke et al., 2020). Due to lack of observation data for the long-term adaptation to droughts in natural temperate forests, no validation could be used for this study specifically. We will discuss that better in the manuscript. Starting in line 233 we now write

"Due to lack of observation data for the long-term adaptation to the occurrence of hot-dry compound events like 2018 in unmanaged temperate forests and from unmanaged temperate forests in general, no benchmarking of our model results with direct observations was possible. Instead we discuss our results qualitatively and where possible also quantitatively referring to the findings of empirical studies from similar environments."

Minor comments:

- *I am fine with the creation of ad-hoc drought years in a scenario-testing framework. However, I am not convinced by the arguments used by authors between lines 105-109. lines 105-109:*
  "However, climate models most likely underestimate the frequency of hot dry compound events like the 2018 drought (Zscheischler and Fischer 2020; van der Wiel et al. 2021) that were much more rare in the past. As a result, vegetation models using these data cannot accurately simulate the impact of increased drought frequency. To overcome this problem, we take a simplistic approach of designing climate scenarios with artificially increased drought frequency for the area of Berlin and Brandenburg in Germany."

  We agree that the statement "climate models most likely underestimate the frequency…" might be too strong and will change into "climate models might underestimate the frequency…", which is shown to be true in the both citations given to that statement. Especially the sentence "Thus, projections based on climate model simulations may underestimate the risk of co-occurring hot and dry extremes." in Zscheischler and Fischer 2020 clearly supports our statement. The text now reads:

"However, climate models might underestimate the frequency of hot dry compound events like the 2018 drought (Zscheischler and Fischer 2020; van der Wiel et al. 2021) that were much rarer in the past. Because the realism of the frequency and intensity of such extreme compound events can vary in climate models the resulting simulated impacts on vegetation and tree demography might be blurred and miss out on possible abrupt changes. Therefore, we take a simplistic approach of designing climate scenarios with artificially increased drought frequency for the area Berlin and Brandenburg in Germany."

- *The color scheme used in Figure 2 makes difficult to easily identify the model response for the different scenarios.*

  We thank the reviewer for this comment and will increase the contrast in colors for the different scenarios.

- *Please check the statement between lines 277-278. It should be the opposite.*
  We agree and will correct the mistake in the manuscript.
- *The first sentence of the Conclusions section does not really apply for mixed forest ecosystems.*
  We thank the reviewer for this comment. Figure 2 shows a reduction in biomass also for mixed forest in the first century of the simulations. In the less severe drought scenarios this reduction in biomass is less than in scenarios with higher drought frequencies. For the scenarios with moderate drought frequency using the expression "drastic reduction in biomass" might be exaggerated and therefore we will simply write "reduction in biomass" instead.

We would like to make further adjustments on our own initiative:

1. In Figure 3g, 3h, 5b the wood density values are wrongly plotted in units of kgC/m³ (although the label says kg/m³). We now display the values in units of kg/m³.
2. We now acknowledge the funding by the Fachagentur für Nachwachsende Rohstoffe (FNR) under grant agreement 2219WK39A4.. In the Acknowledgements we now write:

   "This research was funded through the Einstein Research Unit 'Climate and Water under Change' from the Einstein Foundation Berlin and Berlin University Alliance (ERU-2020-609) and by the "Waldspektrum Projekt" funded by the Fachagentur für Nachwachsende Rohstoffe (FNR) under grant agreement 2219WK39A4."

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