Reviewer #1:

The TREED model is a vegetation model designed to simulate global vegetation dynamics and biodiversity potential outputting GPP, NPP, evapotranspiration, average plant height, below, and above ground biomass storage. These variables are simulated on an average grid point bases by applying eco-evolutionary optimality principles. The plants in the model adapt to maximize fitness under a steady state or transient climates. Evolving the plants to maximize their fitness lets TREED simulate average plant traits in the grid point without making assumptions with regards to the climate niche. This framework offers a method for understanding how biological systems reorganize during different climates.

The paper is well written and explains the technical parts of the paper in detail. The authors have taken the time to go over all the equations used in the model and describe how and why they are implemented. The paper can benefit from more Thurow evaluation to show where the limitations are, please see comments below. In addition, the authors have carefully provided a limited sensitivity study appropriate for this paper. I hope to see a follow up sensitivity study further exploring the trait evolutions of the plants in different paleo climates, but this would be too much for this paper. I have some minor comments and recommend this paper for publication:

We thank the reviewer for taking the time to evaluate our manuscript, the positive feedback and the constructive comments, which have helped to clarify the manuscript and the purpose of the TREED vegetation model.

Line 178: I think "ration" should be "ratio"

Corrected.

Table 1: would it be possible to add citations for the values (where applicable) or an indicator, something like "this study" for where you have made your own estimates. In addition, an indicator for the sensitivity level? I understand that this might be subjective at the moment and needs to be further investigated but as a potential user of this model that would help assess if I can/should/want/need to change this value or not.

We have extended Table 1 in line with the reviewer's comments. We now include a column including references for all used parameters. Most of the values were adopted from other dynamic vegetation models (particularly from the LPJ model family; Schaphoff et al. 2018, Sitch et al. 2003). The parameters describing allometric relationships were calibrated in this study as now explained on L223-226. Regarding sensitivity levels, we now indicate parameters in bold for which we expect the model reaction to be particularly sensitive, following the sensitivity studies from Oberpriller et al. 2022 and Pappas et al. 2013 conducted for the LPJ vegetation model family from which the photosynthesis and respiration physiology, as well as the allometric equations were adopted.

Schaphoff et al., LPJmL4 – a dynamic global vegetation model with managed land – Part 1: Model description, Geosci. Model Dev., 11, 1343–1375, https://doi.org/10.5194/gmd-11-1343-2018, 2018

Sitch et al. Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model, Global Change Biology, 25, 2003.

Oberpriller et al. Climate and parameter sensitivity and induced uncertainties in carbon stock projections for European forests (using LPJ-GUESS 4.0), Geosci. Model Dev., 15, 6495–6519, https://doi.org/10.5194/gmd-15-6495-2022, 2022.

I think "fumeroot" should be "fine root" and "Rubisco specifity" should be "Rubisco specificity"

Thank you - corrected accordingly.

Section 5.3: Please expand this analysis to include a more regional evaluation of where the model does well vs. where the model is lacking. In addition, the reasons given for the mismatched between the model and data are too brought and should be more mechanism specific where possible. For example, "Reduced height growth under high NPP levels indicates carbon turnover processes that are not currently represented in TREED and its height optimization." Which processes are not represented and how does this effect the model? Is this region specific or a global problem? Do this for all three variables, NPP, GPP, and AET. This will help understand when the model is appropriate to use and the model limitations.

We have extended the regional analysis of the model biases. Particularly, we have now included a spatial bias plot for GPP, NPP, AET, H, AGB, and BGB in figures 3 and 5, clarifying regional differences in model performance. We have also extended the regional bias discussion in the text for carbon and water fluxes (L572-593) and carbon storage (L606-630). We clarify main limitations, including that the limited temporal resolution of the model (monthly) likely does not capture non-linear productivity dynamics in regions with pronounced changes in temperature and water availability, for example in the subtropics or savannah climates. For height and biomass carbon storage, we clarify which carbon turnover processes may play a role that are currently not represented, for example environmental disturbances due to fires, heat or cold spells that could increase mortality and increase annual carbon turnover or carbon investments into biotic interactions.

Figure 7: A contour plot will work better here showing the density of the points

Changed accordingly (now Figure 6).

Figure 8c: Please use a density plot here

Changed accordingly (now Figure 7c).

Figure 8d: Try to see if a density plot works, it might not because of the

Here, we did not apply a density plot due to the low density of observations.

Figure 11: What alphas and dispersal rates are used? (Add numbers to slow, fast, and intermediate)

We have added the respective information in the plot (now Figure 10a).

Section 7: It would be nice to add a section on model limitations. Several limitations are already stated in the appropriate sections however, I think the paper can benefit to list them again and address them in a more systematic way.

We have revised the discussion section following the reviewer's suggestion. From the previous version we have kept three sections focusing on the main functionalities of the model, including the modelling of carbon fluxes and vegetation traits (7.1), the application of the model using eco-evolutionary adaptation dynamics (7.2), and the modelling of biodiversity dynamics

(7.3), including a discussion of important limitations for each functionality separately. We have now introduced and extended an additional section (7.4) summarising the main limitations of the model and combined it with an outlook of future developments that may address some of these limitations (L901-935).

Section 9: Please add the GitHub tag (or release name) also in the text, this makes it easier to check out the specific version

We have included a github release tag (Release TREED v1.0) in the code availability section (L953).