Response to Review #1

Comment: This study tested the sensitivity of the parameters of a plant hydraulics model coupled in a demographic vegetation model (FATES-Hydro). This is an important step for model development and also helpful for understanding model behavior. The simulation experiments and analysis are solid, and the paper is generally well written. However, some places are not clear to me. I expect the authors can improve the description of the design of simulation experiments and the analysis of the results.

Response: Thank you for your time to review our manuscript and we will address your comments in the revised manuscript as detailed below.

Major questions/suggestions:

Comment 1. For the key parameters in Table 1, is it possible to list the key equations of this model that are related to these parameters? An analytical analysis of these equations would help to understand the sensitivity of these parameters.

Response: In the revised manuscript, we will add specific equations related to parameters in Table 1 and add these key equations to section 2.1 as well.

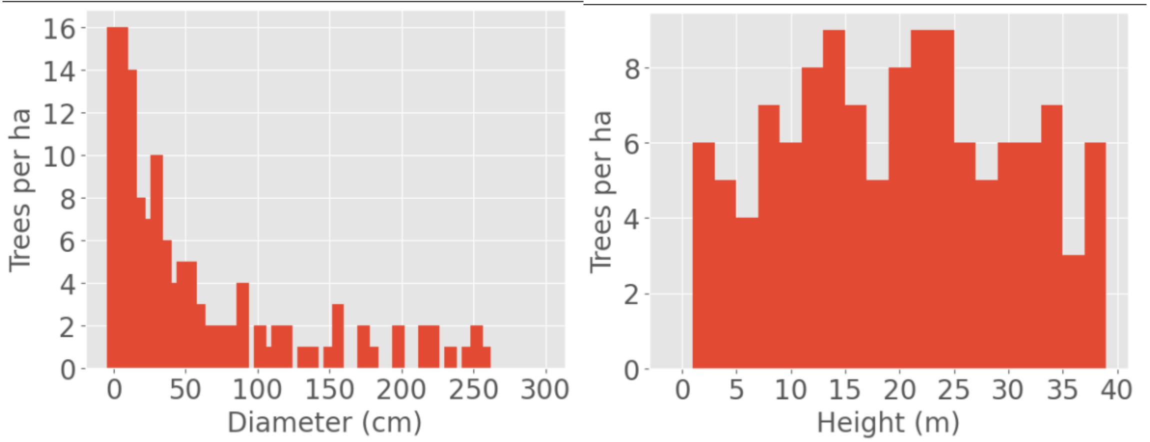
Comment 2. If I understand it correctly, the plant traits data of different species in the tropical forest of BCI are used to define the parameter ranges and distribution, from which the ensembles are sampled. This means a mean PFT is defined in each parameter combination. However, there are trade-offs in these parameters. How is this considered in the design of ensembles?

Response: Because our goal is to understand the model behaviors as determined by different hydraulic traits, we assumed independence among traits. Thus, we did not consider the tradeoff between traits. We will add caveats on the importance of trade off among hydraulic traits in discussion for future studies focusing on the uncertainty of model outputs.

Comment 3. The authors set the vegetation static (no growth, no reproduction and mortality). Please list the details of vegetation. Such as how many cohorts? what are the sizes of these cohorts?, etc.

If there was only one cohort in these tests, what is the size? Does the parameter sensitivity change with tree size? For example, the most important parameter according to this test, taper factor, may relate to the tree sizes.

Response: Thanks for these good points. The forest has 137 cohorts with diameters ranging from 10 cm to >2 meters. See the figure below for the size distributions. In the model output, we aggregated cohort information into different tree size class bins . In this paper, we focused on the outputs for the size >60 cm bin, in view that they are most sensitive to canopy environmental conditions. Per your suggestion, we will add the sensitivity analysis to the size below 60cm in the revised manuscript.



Comment 4. In the discussion, some claims and opinions can be evidenced by recent research. Please add those references.

Response: We have added references in the discussion per our response to the detailed comments below.

Details comments:

Comment: Lines 36~38: about the statistical distribution of plant traits, please also clarify that they are used in parameter sampling (if they are).

Response: Yes, these traits are used in the parameter sampling. We will revise it as "... determined the best-fit statistical distribution for each trait, which is used in model parameter sampling to assess the parametric sensitivity".

Comment: Line 101: "we describe the implementation of a hydrodynamic scheme within FATES,": to me, this paper only tested parameter sensitivity, did not "describe the implementation of a hydrodynamic scheme". Am I wrong? If yes, please provide a detailed description of the hydro model.

Response: This manuscript is mostly focused on sensitivity analysis. The hydro code is based on Christoffersen et al.,(2016), but with modifications made to be implemented in FATES. We did provide detailed implementation of the codes in FATES in the supplementary file [MODEL DESCRIPTION: updates made to TFS-HYDRO for FATES-HYDRO].

Comment: Line 102: "assess the importance of different hydraulic traits". I think it is about sensitivity. if it is "importance", then an index should be defined.

Response: We agree with your opinion here and will change 'importance' to 'sensitivity'.

Comment: Lines 115~116: "FATES simulates growth by integrating photosynthesis across different leaf layers for each cohort." From somewhere else, I learned that FATES does not have multiple leaf layers in a crown. Otherwise PPA principles cannot be applied. Please clarify.

Response: The PPA is applied based on the crown area to determine whether cohorts are positioned in the canopy and understory. For trees in both the canopy and understorey, there are indeed different layers of leaves. We hope this clarifies the confusion and we will add this to the revised manuscript.

Comment: Line 151: "we used the static stand structure mode of FATES": Please provide a detailed description of the static cohorts and tree sizes.

Response: We will add the number of cohorts and the size distribution of trees in the revised paper.

Comment: Lines 166~167: "here we focused on hydrodynamic behaviors for trees of diameter more than 60 cm.". Detailed cohorts and tree sizes please.

Response: We will add the number of cohorts and the size distribution of trees in the revised paper.

Comment: Line 169: "We identified 36 parameters for the FATES-HYDRO model (Table 1).". Please also provide the relevant equations.

Response: We will add a new column to add the relevant equations to the table. We will also add the relevant equations in the 2.1 and supplementary file.

Comment: Lines 181~194: I am not quite clear about this section. do authors use the multiple trees' traits to define a "mean state" tree?

Response: Each model ensemble member consists of a community of trees with identical traits (one PFT), but does not necessarily represent a "mean state" tree because we resampled from the observed distribution of trait values. We will reword the lines 179-184 for clarity as follows: "This trait dataset consisted of anywhere from 1 - 323 observations for each trait, where each observation corresponds to a different species (multiple observations for the same species are first averaged; see above). Before fitting distributions to these data, some traits were first transformed to be positive (e.g., P50) or normalized within [0, 1] when upper and lower bounds were well-defined (Table 1). Then, for each trait separately, we used the fitdistr package in R to estimate best-fit parameters for uniform, beta, normal, lognormal, and gamma statistical distributions in order to estimate central tendencies and spread for each trait. The distribution with the largest log likelihood and best-fit parameters are given in Table 1. Each model simulation consisted of a single PFT: all trees (across all cohort sizes and patches) had the same traits. The plant hydraulic traits in each simulation were assigned using a random draw from each trait's distribution, and an ensemble of 1000 simulations were used to sample the observed plant hydraulic trait space for sensitivity analysis (see Section 2.3 Sensitivity analysis below)."

Comment: Lines 195~208, Section 2.3. I think an "important index" should be defined here. Or, make it clear that the most sensitive parameter is most important. (Though I don't think it is always true.)

Response: Agreed and we will add the following sentence to this section:

The parametric sensitivity index is calculated based on the ratio of the partial variance in the model output attributed to a specific parameter to the total variables in the model output.

Comment: Line 230 "during August compared to February". Please also note "wet' and "dry" season.

Response: We will add the wet/dry season in the parenthesis for each month in the revised manuscript.

Comment: Line 244: "1000 ensembles" should be defined in the method section. In the total 36 parameters, how many samples for each of them and how they combined?

Response: 1000 parameter values are sampled for each parameter and they are randomly combined. We will add this information to this section in the revised manuscript.

Comment: Lines 261~263: I guess p_taper is related to tree size. A test with different tree sizes can show if I am wrong.

Response: We will add the results of how p_taper will change with size in the revised manuscript.

Comment: Also p_taper comes with strong assumptions on plant development. Please cite some papers about that. There are some research on the changes in xylem structure with tree age.

Response: We will add the following sentence and citation to the revised manuscript:

The p_taper parameter determines the xylem architecture and it could change in response to age and development stages (Rodriguez-Zaccaro et al. 2019), which is not considered in this study. Future studies evaluating the importance of this change to hydraulic functions could be useful to guide size-dependent growth and mortality.

Rodriguez-Zaccaro, FD, Valdovinos-Ayala, J, Percolla, MI, Venturas, MD, Pratt, RB, Jacobsen, AL. Wood structure and function change with maturity: Age of the vascular cambium is associated with xylem changes in current-year growth. *Plant Cell Environ*. 2019; 42: 1816– 1831. https://doi.org/10.1111/pce.13528

Comment: Lines 270~271. Citation?

Response: We have rewritten it as follows:

While xylem taper exponent (p_taper), is a balance between maximizing conductance and hydraulic safety, it various through species and is additionally the product of maximizing carbon capture through leaf architecture and architectural and biochemical constraints (Savage et al., 2010).

Savage, V. M., Bentley, L. P., Enquist, B. J., Sperry, J. S., Smith, D. D., Reich, P. B., & Von Allmen, E. I. (2010). Hydraulic trade-offs and space filling enable better predictions of vascular structure and function in plants. Proceedings of the National Academy of Sciences, 107(52), 22722-22727.

Comment: Line 278 “interaction between root, fungi and bacteria.”: citations are required here. I know there are some good review papers published in this area.

Response: We will add the following reference to the revised manuscript. We would appreciate any additional suggestions.

Bhagat, N., Raghav, M., Dubey, S. and Bedi, N., 2021. Bacterial exopolysaccharides: Insight into their role in plant abiotic stress tolerance,31(8): 1045-1059