Response to RC2

We are very grateful to this referee for the thoughtful critique and suggestions, which we believe have improved the readability of the manuscript.

Review of Modelling the topographic influence on aboveground biomass using a coupled model of hillslope hydrology and ecosystem dynamics by Yilin Fang et al

The study combines hillslope hydrological processes and ecosystem demography within an Earth system model framework. This is done by coupling a land component (ELM) of an earth system model (E3SM) using the FATES model as the vegetation demography component with a 3-D hydrology model (ParFlow). The model is applied and evaluated at BCI, Panama using hidrological and vegetation observations from the study site. The scientific aim is to investigate the influence of topography via hydrological processes on AGB. The paper presents a series of model sensitivities to model structure, plant traits, soil properties and hydraulic failure representations.

Combining 3-D hydrology, ecosystem demography and testing of various drought mortality functions on an ESM framework and testing it at site level is worth of publication in GMD. The work is overall well written and mostly clear. Unfortunately, the site selection was not ideal for testing impacts of hillslope water availability on AGB due to the low elevation at the site which could have been known a priory with the digital elevation model information.

Thanks for the positive comments. We selected this site as it has some relevant observations and meteorological forcing available for our model development and testing. ELM-FATES-ParFlow is being applied to another tropical forest region with ongoing measurements of hillslope flow, groundwater table, and vegetation dynamics.

There are various minor comments are important to improve comprehension of the analysis, discussion and conclusion.

The results and discussion section need to make a clearer differentiation of text referring to predictions and to observations. This is not clear in many parts. I was unable to find the figures and tables that refer analysis related to AGB observations. A suggestion is that sections that are only model sensitivity analysis and do not use the observations need to be separated from the section dealing with observations.

Thanks for the suggestion. We clarified in each section that has only model sensitivity analysis. The following sentences are added in section 3.1 and 3.3, respectively:

This section focuses on model sensitivity analysis as no spatial observations are available for comparison to the model simulations.

As there is no spatial observation of the relationship between AGB and WTD at the site, this section is for model comparison only.

Section 3.2 refers to spatial variability of simulated and observed variables with various model configurations , yet it shows temporal figures (fig 4 and 5). Spatial variability of the observations (ABG for example) is no shown, for other variables I understand that only a time series at a single location is available, but maybe should not refer to spatial variability if the comparison is to a single point observation. Some of the work done in this section is new to the results section, i.e not mentioned in the methods (Vcmax sensitivity)

Thanks for the comment. The spatial variability of the model was used to compare the effect of topography on water availability at different elevations and consequentially on the variables of interest. It can help us infer under what conditions the model can better match the observations. We showed spatial variability of variables when available. The Vcmax experiment was removed from the text and Fig. 5 to avoid confusion and replaced with

AGB can be further increased by parameter tuning for better agreement with observations, but we don't expect it to significantly change the AGB variability.

The discussion on factors that could explain observed AGB variability is succinct and vague, this section needs to elaborate further, for example it should include discussion possible variability of wood density.

Thanks for the suggestion. We added some discussions in section 3.2:

Based on the model results, species competition also cannot explain the observed variance of AGB at the 50-ha plot without accounting for the spatial heterogeneity of soil properties, nutrient availability, plant traits, etc. in the model. For example, wood density can contribute to the observed variability as it is a parameter used to define the allometry function (Eq. 10).

Eq. 10 was added in the text. It is a functional form in Chave et al. (2014):

$$C_{agb} = \frac{1}{c2b} p_1 (\rho D^2 h)^{p_2} \quad (10)$$

where C_{agb} is the target stem aboveground biomass, p_1 and p_2 are allometry parameters, c2b is carbon to biomass ratio, ρ is the plant wood density, D is stem diameter, and h is tree height.

Reference:

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., Duque, A., Eid, T., Fearnside, P. M., Goodman, R. C., Henry, M., Martínez-Yrízar, A., Mugasha, W. A., Muller-Landau, H. C., Mencuccini, M., Nelson, B. W., Ngomanda, A., Nogueira, E. M., Ortiz-Malavassi, E., Pélissier, R., Ploton, P., Ryan, C. M., Saldarriaga, J. G., and Vieilledent, G.: Improved allometric models to estimate the aboveground biomass of tropical trees, Glob. Change Biol., 20, 3177–3190, 2014.

The study concludes that data needs to be collected to support findings of this study but does not elaborate (L700). There is a need to inform the ecological/plant physiology community on what is needed to be able to represent these processes/and or parameters needed in Earth System Models. L701-L702 are equally vague, authors need to be more specific on what is needed.

We added the following for elaboration:

For example, soil moisture, WTD, AGB, and plant traits across hydrologic gradient (from low land to high land).

Future modeling research should also account for spatial heterogeneity of soil resource (i.e., water and nutrients) and plant functional traits (e.g., mortality, growth, rooting depth etc.), as well as anthropogenic factors (habitat loss due to deforestation, degradation, and fragmentation [Miranda et al., 2017]) on the structure of plant communities.

Reference:

Miranda, A., Altamirano, A., Cayuela, L., Lara, A., Gonzalez, M., 2017. Native forest loss in the Chilean biodiversity hotspot: revealing the evidence. Reg Environ Change 17, 285-297.

Section 3.4 is full of statements that miss a figure or a table supporting the text.

Figure and table are now cited to support the text. Please see the response to the specific comments below.

Specific comments

L73, Clark et al 2015 is missing in the reference list, if this refers to JULES, that might be Clark et al 2011,doi:10.5194/gmd-4-701-2011 which focuses on the carbon cycle, Best et al 2011, doi:10.5194/gmd-4-677-2011 has more focus on the energy balance probably more appropriate. Jules has been used to represent ecosystems along topographic gradients,

See Hsi-Kai Chou, Boris F. Ochoa-Tocachi, Simon Moulds & Wouter Buytaert (2022): Parameterizing the JULES land surface model for different land covers in the tropical Andes, Hydrological Sciences Journal, DOI: 10.1080/02626667.2022.2094709

Thanks for the references. We were referring to:

Clark, M. P., Fan, Y., Lawrence, D. M., Adam, J. C., Bolster, D., Gochis, D. J., Hooper, R. P., Kumar, M., Leung, L. R., & Mackay, D. S. (2015). Improving the representation of hydrologic processes in Earth System Models. Water Resources Research, 51, 5929–5956. https://doi.org/10.1002/2015WR017096

Table 1 legend, what is K ?

K refers to the case where soil hydraulic parameters from Kupers et al. 2019 were derived. It's now defined in the Table caption as "K in the experiment name of Case 5 indicates soil property derived from Kupers et al. [2019b] is used."

Most of the end part of section 3.4 needs to use table and figures to support the all statements in the text (text is not using panels from figure 8 which I imagine needs to be included) Here two examples

Thanks! We added table and figures to support the statements in the text of section 3.4.

L582 -587 results presented here need to cite figures or tables where the information contained in the text is shown

Thanks! We cited Fig. 8 in this section.

L594, indicate in the text where is it shown that inclusion of VWC can explain more than 80% of the variance

Thanks! We cited Table 2 in this sentence.

L605 -615 -needs figures or tables to support text

As the model is not good, only performance scores were reported in lines 607 and 608 of the original submission. Figure is not shown as indicated in line 609 of the original submission.

I could not find (figure and table) on which the model is trying to explain the observations.

We clarified in sections where there is only model comparison. Please see our response above in the general comments.

Section 3.4 unclear where the sensitivity is trying to explain spatial variation of modelled AGB or observed AGB.

We now cited tables and figures where appropriate.

The paper has many abbreviations some of which are not defined. Please carefully check they are all explained (including those in tables, i.e table 2) or include a table with all abbreviations.

Thanks! We checked to make sure all abbreviations are defined. Those in Table 2 are added in the caption of Table 2 as shown in the response below.

Table 2: the authors might want to add extra explanation to the reader on how to interpret this busy table.

The caption of Table 2 now reads:

Table 2. Random Forest Model Performance on the simulated above ground biomass (AGB) and water table depth (WTD) from the site wide and 50-ha locations, respectively. Model performance is quantified by mean absolute percentage error (MAPE (%)) and percent of variance explained (VAR_{ex} (%)). The paired data separated by "/" in each column are metrics for training data (left) and unseen test data (right). Subscript RF1 indicates models using topographic features while subscript RF2 indicates model using simulated soil moisture as predictor in addition to the predictors used in RF1 models.