Reviewer #1 comments responses sheet

Reviewer comments are in *Italics,* and questions raised are highlighted in yellow. Our responses are in normal type.

Major comments

Reviewer comment: *First, the authors validate their model by comparing simulations done using their newly parameterised version of LPJ-GUESS to flux tower-derived GPP and evapotranspiration measurements. The ET comparisons (Fig. 2) look good. The GPP comparisons, with the exception of Stuart Plain, look okay. However, there is no control to compare the results of this new model parameterisation with. How should a reader assess whether the presented new version is an improvement compared to the standard version of LPJ-GUESS?*

Response: We would like to clarify that our study does not involve developing a new version of the LPJ-GUESS model or introducing fundamentally new model components. Instead, we utilize the existing LPJ-GUESS framework and modify specific parameters, particularly by integrating regionally relevant PFT trait data. Whether this improves the performance relative to the standard global model or not, we argue that the incorporation of empirical data on the local savanna ecosystems that we are simulating is necessary and relevant to represent that system in the most realistic way. Following validation, this allows us to apply the model with confidence to investigate ecological processes related to competition, productivity, and community composition along the NATT rainfall gradient. We will clarify this logic in the Introduction and Methods sections to make the objectives and approach of the study clearer.

Reviewer comment: *Second, the authors acknowledge that "Good model performance in terms of replicating compositional patterns along environmental gradients may then provide confirmation of assumptions as to the eco-evolutionary basis of plant traits as encoded in the model." (line 61). Yet, the authors have not dedicated any formal analysis to assess whether their model does indeed perform well in terms of replicating the compositional patterns along the environmental gradient. I also find very little text which* *discusses matches or mismatches. It should be possible to add observed PFT lines to Figs. 4, 5, and 6 and provide a map of simulated vs observed PFTs.*

Response: Field observations of tree species composition are available from the flux tower sites along the transect, reflecting compositional and abundance patterns along the rainfall gradient. However, the model is designed to simulate landscape average vegetation whereas local ecosystems are affected by local microenvironments, disturbance history and stochasticity which is not feasible for a model to replicate based on first principles. We will add observed and simulated PFT distributions (table/figure) along the gradient in Section 3.2 (PFT composition shift with rainfall) and further expand the discussion section to elaborate on how the simulated vegetation composition aligns with the observed patterns at flux tower sites, providing a more nuanced interpretation of matches and mismatches.

Reviewer comment: *Lastly, and most crucially for the current conclusions presented in the manuscript, LPJ-GUESS includes fire and its impacts on vegetation structure. Based on the simulation protocol it appears the BLAZE fire module was used for this study and fire was turned on for these simulations. The vegetation of this region has evolved with fire. Fire is a regular event in the study area. There is an extensive literature documenting this. How can the authors claim to have identified the mechanisms underlying the distribution of vegetation when they do not consider fire? How well does simulated fire (burnt area, fire return interval) match observations? Does fire and fire frequency, in combination with precipitation reductions, perhaps influence the change in the dominance of PFTs from tall eucalypts to C4 grasses along the gradient?*

Response: We confirm that the role of fire was indeed included in the simulations using the BLAZE fire module (Rabin et al., 2017), which simulates fire occurrence, spread, and impacts on vegetation based on climate and fuel conditions. This is stated in the manuscript, but we will add further detail to the Methods and Discussion sections to clarify model assumptions regarding the role of fire disturbance in vegetation assembly. We will also add some results illustrating the simulated fire dynamics along the gradient. However, we also note that fire in these systems is a complex phenomenon influenced by multiple interacting drivers, including natural ignitions, vegetation structure, climate variability, and cultural practices such as Indigenous burning. Accurately analyzing and attributing fire impacts, including disentangling them from climate-vegetation interactions, would require a dedicated analysis with further fire-specific simulations and data inputs, which is beyond the scope of the current study.

Specific comments

Reviewer comment: Tables 1 and S1 are the same? Why duplicate them?

Response: Table 1 in the main text presents a summarized version of the PFT parameter values used in the model simulations, focusing on the final parameter values applied during the model simulation process. In contrast, Supplementary Table S1 provides a more detailed breakdown, including the original empirical trait data compiled from literature and databases, as well as the adjusted values used for model input. While there is some overlap, we believe that keeping both tables serves complementary purposes: Table 1 offers a concise overview for general readers, while Supplementary Table S1 provides transparency for those interested in the derivation and variation of trait values among species. We will clarify this distinction in the table captions and main text.

Other minor comments

Response: We will incorporate and correct in the specified sections.