Reviewer #2 Comment Response sheet

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

Major comments

Comment: *The authors are trying to present this effort as directed towards answering a research question related to the driver of the transition of Australian vegetation from Eucalyptus to C4-grass dominated savannas in the South. In my opinion, they did not answer to any specific new research question, as it seems to me that most results are just reasonable model outcomes. Possible solutions to this issue that come to my mind are i) rephraming the paper as a new-model description ii) performing model experiments to answer clearer research questions. If choosing i): the validation against flux tower data is very good; however, a validation of model outcomes in terms of functional type distribution, LAI etc is lacking and should be added if possible.*

Response: We disagree that our study does not answer new research questions. The role of stress, competition and disturbance are a key theme in savanna research but the hypothesised underpinning mechanisms of how these factors control savanna structure and function have rarely been explored using process-based vegetation models that explicitly represent those mechanisms. We argue that our study is a new and unique contribution in demonstrating how these mechanisms play out for Australian savannas, thereby validating the assumptions as encoded in our model. Regarding the reviewer's suggestion to reframe the paper as a 'new-model description', 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. We argue that the incorporation of empirical data on the local savanna ecosystems 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.

Adding functional type distribution: We will include the result of PFTs (table/figure) distribution along the rainfall gradient in Section 3.2, under 'PFTS composition shift with rainfall'. Similarly, we will 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.

Adding (observed) LAI: We will include the model-derived LAI from the MODIS or Bureau of Meteorology as a secondary Y-axis in Figure 6, based on their availability, showing how simulated and observed total LAI vary along the rainfall gradient. We will also add the tree and grass LAI components from this dataset as a line plot in Figure 8, enabling validation of the simulated partitioning of LAI between woody and grassy components along the gradient.

Comment: *If choosing ii): I completely agree with the other reviewer that the effect of fire should be taken into account explicitly, given these are well-known to be fire ecosystems. In this respect, I would add the remark that post-fire response traits, such as resprouting (not currently mentioned in the section describing traits) should be included in the definition of plant functional types in Australia (see e.g. Harrison et al 2021, Kelley et al. 2014, Venesky et al 2019). Furthermore, given the focus the authors put on disentangling the importance of rainfall gradients in these Australian woodlands and savannas, I would highly Recommend reading Holdo and Nippert 2023 excellent New Phytologist review on the subject.*

Response on forest fire: We confirm that the role of fire was indeed included in the simulations using the BLAZE fire module (Rabin et al., 2017), which explicitly simulates fire occurrence, spread, and impacts on vegetation based on climate and fuel conditions. This is stated in the manuscript, but we will revise the Methods and Discussion sections to clarify the role of fire disturbance. We will add a brief result highlighting the simulated fire dynamics along the gradient for the BLAZE model to analyze its active role in shaping vegetation along the rainfall gradient of the savanna. 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.

Response on adding resprouting: We agreed that post-fire recovery traits, particularly resprouting capacity, are ecologically important in the Australian savanna system. However, implementing resprouting as a dynamic process would be a significant model development quest and is also limited by observational and knowledge gaps regarding details such as the phenology of carbohydrate storage under different conditions and remobilisation in response to different disturbances. While relevant to the overall topic, this would be well beyond the scope of this study. We will add mention of the role of resprouting in the ecology of Australian savanna trees in the Introduction and Method sections, noting this is an ecological characteristics of the existing vegetation not explicitly accounted for in our modelling approach.

Adding suggested references: We will add suggested references (Harrison et al., 2021; Kelley et al., 2014; Venesky et al., 2019 Hodo and Nippert (2022)) in the discussion of limitations in the treatment of fire in the Introduction and Discussion section.

Specific comments

Comment: *The abstract lines 'We hypothesise that biotic competition and abiotic stress exhibit opposing patterns along the NATT rainfall gradient and aim to disentangle these effects on vegetation structure and productivity. Using a trait-based dynamic vegetation model, we simulated vegetation responses to varying competition and stress along the NATT.' I did not see how and where this hypothesis was tested given the model-centered approach.*

Response: This hypothesis was formulated as a conceptual framework to interpret signals emerging from model simulations and capture the existing knowledge about the system. The LPJ-GUESS model integrates both competition and abiotic stress mechanisms by simulating resource acquisition, growth, and mortality at the cohort level, based on functional trait differences. The emergent vegetation dynamics in the model simulations are influenced by these representations and their underpinning assumptions. In this way, they express the interaction of biotic (e.g., light competition, asymmetric growth) and abiotic (e.g., water limitation) constraints along the NATT rainfall gradient. Our approach uses the model as a 'digital twin' to explore how simulated structural, compositional, and functional patterns vary along the rainfall gradient and evaluate whether these patterns align with ecological expectations derived from the model. We will revise the Introduction to bring out such reasoning and explain our study's inferential approach more clearly.

Other minor comments

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