Response to Referee #2

We would like to thank Referee #2 for the constructive comments on our manuscript. Below, we address the comments, with the referee comments written in italics.

Why did the authors use rooting depth in the vegetation optimality model? Since the conceptual models, e.g. FLEX, used the root zone storage capacity as the term in modeling. What is the relationship between the rooting depth and the root zone storage capacity? Since root zone storage capacity is a more meaningful term to describe the interaction between ecosystems and hydrology in catchment scale, like previous studies (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL061668; https://hess.copernicus.org/articles/20/1459/2016/hess-20-1459-2016.pdf), rather than their depth. I'd like to hear the authors' thoughts. And this part needs more clarification.

Thank you for bringing this up, we will add more discussion in the revised manuscript about the differences between the models and their parameters. Indeed, these models are extremely different in their concepts, but this makes it only more interesting that we found similar results. In the VOM, the plants are optimized for net carbon profit, linked to actual vegetation properties as rooting depths and vegetation cover. As a result, this leads to an effective root zone storage capacity, which is not specifically quantified. The conceptual models lump this behavior directly in the model parameters related to the root zone storage capacity. Since the parameters in the conceptual models were calibrated, we did not undertake a comparison between the effective root zone storage capacities. However, we will point the reader to alternative approaches of estimating root zone storage capacities, also based on the given references.

There are lack of equations described the vegetation model. For readers who did not have enough background about this model, it is very necessary to give some equations, illustrating how the model describes the core processes. Adding a table showing the equations might be a good idea.

Thank you for this idea, we will add a table with the main equations of the VOM to the SI.

I found the experiment design are hard to follow. And the VOM and three hydrological models are not well linked. A workflow chart might be helpful.

Thank you for this suggestion, we will add a scheme with the experimental design as also requested by Referee #1.

The Budyko equations are not the same as we widely used. This brings in much difficulty to review this manuscript. I did not see a clear reason to use Rn rather than potential evaporation (Ep) in the traditional Budyko equation.

Please note that the original Budyko framework (Budyko, 1974) was also formulated in terms of net radiation, which we adopted here as well. We also decided to use Rn, as this is a more general form of defining the energy for evaporation, which is consistently used by the different models. For example, the VOM does not use potential evaporation in terms of water (i.e. in mm/day), but only downwelling radiation for photosynthesis. Also the form of the equation is rather common, it was originally defined by Mezentsev (1955) and later, among others, Choudhury (1999) and Roderick and Farquhar (2011).

The authors conducted the study for 37 years (1-1-1980 until 31-12-2017). I am curious to know whether there were any changes during these 37 years. This needs more clarification and discussion.

Thank you for this comment. The flux tower sites are relatively undisturbed, but only suffer occasionally from fires. We will mention recently documented trends at Howard Springs over time in the revised manuscript, see also Hutley et al. (2022). For the catchments and additional locations along the transect, we can, unfortunately, not state with certainty that there were no changes. However, since we only use the full time series of the climate data as input for a numerical experiment, any trends in the fluxes would not make a difference to our results.

In Section 2.3.2, what does this mean "a permeable soil block with layers of 0.2 m thickness, and a total thickness of 30 m"?

The VOM schematizes the soil as a block with layers of 0.2 m. In total, there are 150 layers, leading to a soil depth (to impermeable bedrock) of 30 m. Vertical flow between the layers is possible down to the last impermeable layer. Lateral drainage is simulated from the bottom saturated layers. We will clarify this in the manuscript.

The equations used in TUWmodel and FLEX to estimate evaporation are the same, although with a bit different term definition. That is why all three conceptual models have very similar performance. It seems not necessary to use three conceptual models in this study.

Indeed, these models have quite some similarities, but also differ at several points. Especially the GR4J-model has a rather different formulation of the actual evaporation (Equation 6), but Equation 5 and 7 of the TUW and FLEX model are basically the same. Nevertheless, these models still differ in other aspects that results in different outflows, storages and a resulting evaporation. The configuration of the conceptual reservoirs is different, as well as the definitions of fast flow components and the simulation of interception evaporation.
We also decided to use multiple models here, in order to assess the robustness of our results. We will add more discussion about the differences and similarities of the models, as well as the robustness of our findings.