Author Responses to Reviewer Comments

We would like to thank the reviewer for taking time to make comments and suggestions. We have revised the manuscript based on the feedback and have answered questions raised. We hope these revisions are satisfactory for the further processing of this paper.

In this response document, Orange is the quoted comment/question while dark blue is response text. *Italicised text is text extracted from the manuscript after implementing suggested changes.*

Reviewer 1

The authors used two experiments of CC and LULCC scenarios to evaluate their results. Yes, this is good to use but my concern is that what about the consideration of other factors that are interlinked to the oceans' atmospheric pressures as they may affect the precipitation distributions.

We thank the reviewer for raising this concern. In our study, the scenarios (Climate Change (CC) and Land Use and Land Cover Change (LULCC)) were informed by General Circulation Models (GCMs). These GCMs inherently account for interlinked processes that tie together oceanic conditions and atmospheric pressures, affecting precipitation distributions and even include those that pertain to ocean-atmosphere feedback loops, and the role of land use and land cover (Boucher et al., 2020; Flato et al., 2013; Mortier et al., 2020). In our study's context, these factors were considered as integral components of the underlying models, ensuring a comprehensive representation of precipitation distribution influenced by oceanic conditions.

The authors simulate the historical (1975 - 2005) and the far future (2070 - 2100) periods. I think it would have been better if they could produce the near (2021-2040) and midterm (2041-2070) results for better preparation of the societies for the climate variabilities that may evolve as the climate changes in the near future.

We appreciate the insightful comment raised here. We do acknowledge that near and midterm analyses have their merits, especially for operational planning and immediate adaptation strategies. Ideally, a comprehensive study would include both, but given the scope and focus of this study, we prioritized the end-of-century timeframe. The decisions made in areas such as infrastructure and land use planning often have consequences that last many decades. End-of-century projection data is crucial for these kinds of decisions.

In addition, some of the most significant impacts of climate change on catchments may not be readily apparent until later in the century. Our timeframe allows us to capture these longer-term transformations and understand the cumulative impacts of climate change and land use, which often have nonlinear effects that accelerate over time. Furthermore, focusing on the end of the century underscores the long-term consequences of current actions or inaction as emphasised a study by Thiery et al. (2021), reinforcing the ethical responsibility we have to future generations.

That said, we believe that our work can be complemented by other studies focusing on shorter-term impacts, thereby providing a full spectrum of data for decision-making.

Regarding model calibration, it is good that the authors have used NSE values. But some NSE values are still below the threshold values in some stations. Would have been added some other model performance measures would be good to crosscheck the results and see the outputs.

Large-scale models are often not adapted and evaluated at very large scales due to high computation time requirements or lack of information on human interactions, such as dam operations and irrigation practices at local scale (Chawanda et al., 2020). But these adaptations are essential for impact model assessment as demonstrated by Krysanova et al. (2018). To address this challenge the Hydrological Mass Balance Calibration (HMBC) (Chawanda et al., 2020) was developed. HMBC tunes the model to make sure the major hydrological processes such as Evapotranspiration and Surface Runoff better represent observations in the long term. Thus, aiming for a more accurate Hydrological Mass balance, all done with less computational requirements.

For these reasons, our study used HMBC and we did not expect very high NSE values because we did not calibrate routing parameters in the SWAT+ model setup (such as Channel Mannings Coefficient and Channel Hydraulic Conductivity, among others). Calibrating for specific river flows would require more runs estimated in the thousands (and may be in the tens of thousands considering many gauging stations considered). For such a large-scale model, this would be impractical, hence, HMBC.

However, by looking at the river flows we could see how the improvements in the model's representation of internal processes improved river runoff simulation even though we did not calibrate for it. We have clarified this in section 4.1 as follows:

> *The model was calibrated using HMBC following Chawanda et al. (2020). This methodology aims to match long term averages of major components of the hydrological cycle. However, even though HMBC does not calibrate against river flows, looking at the changes in performance of river flows may reflect any improvements (if any) in the representation of internal processes.*

Figure 2: I couldn't see figures 1a and 1b, Could you please provide and level it in the figure. And the same is in Figure 3 as well.

Thanks for catching that. This has been done.

In the results section authors have repeatedly used the latitude grids to spatially elaborate their results. That is good but it could have been better if at least one map of Africa could show the latitude and longitude values so that we can easily understand where it would be they are referring to.

This feedback has been incorporated. Figure 1 now includes coordinates.

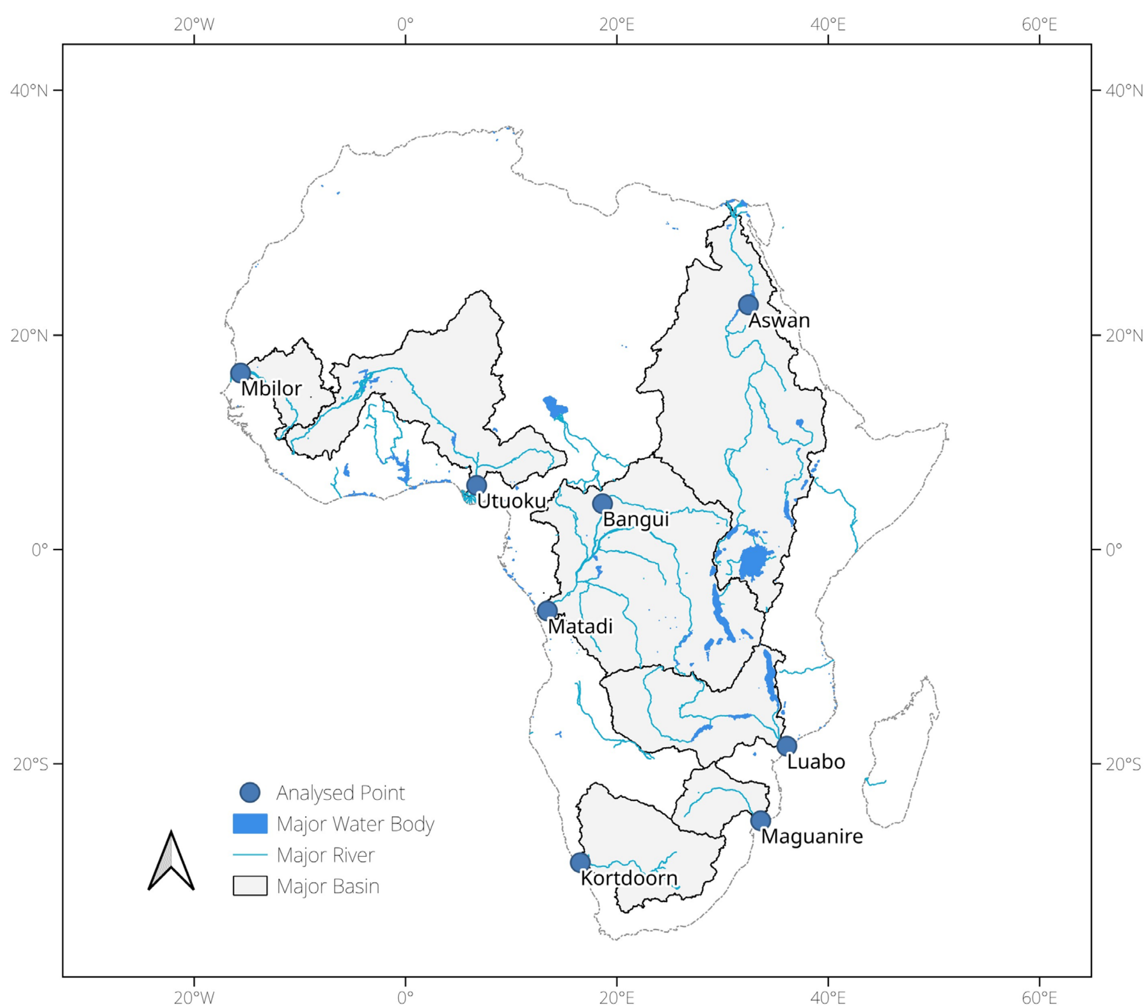

Figure 1: Major river basins in Africa

In section 3.1.2, it could be good if the authors explain how they evaluate the model performance in quantifying the ET performance across the river basins.

We thank the reviewer for this comment. We realise this element was indeed missing. We have adapted the manuscript in Section 3.1.2 to reflect that the comparisons between WaPOR and SWAT+ ET was based on spatially averaged annual ET per major basin:

> *Further ET checks were done by comparing simulated and WaPOR spatially averaged annual ET values for each major basin. The model captured the low ET values expected in the Sahara, Namib and Kalahari Deserts (Figure 5 a and b). However, the SWAT+ model overestimated ET in the Congo Basin by 58 mm year^{-1} and underestimated annual ET in the lower Nile River by 42 mm year^{-1}. The high observed ET values (locally up to 500 mm year^{-1}) in the lower Nile, which the model underestimates, are expected due to irrigation activity and multiple cropping sessions in the area.*

References

Boucher, O., Servonnat, J., Albright, A. L., Aumont, O., Balkanski, Y., Bastrikov, V., Bekki, S., Bonnet, R., Bony, S., Bopp, L., Braconnot, P., Brockmann, P., Cadule, P., Caubel, A., Cheruy, F., Codron, F., Cozic, A., Cugnet, D., D'Andrea, F., … Vuichard, N. (2020). Presentation and Evaluation of the IPSL-CM6A-LR Climate Model. *Journal of Advances in Modeling Earth Systems*, *12*(7). https://doi.org/10.1029/2019MS002010

Chawanda, C. J., Arnold, J., Thiery, W., & van Griensven, A. (2020). Mass balance calibration and reservoir representations for large-scale hydrological impact studies using SWAT+. *Climatic Change*, *163*(3), 1307–1327. https://doi.org/10.1007/s10584-020-02924-x

Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S., & Collins, W. (2013). Evaluation of climate models. *Climate Change 2013 the Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, *9781107057*, 741–866.

Krysanova, V., Donnelly, C., Gelfan, A., Gerten, D., Arheimer, B., Hattermann, F., & Kundzewicz, Z. W. (2018). How the performance of hydrological models relates to credibility of projections under climate change. *Hydrological Sciences Journal*, *63*(5), 696–720. https://doi.org/10.1080/02626667.2018.1446214

Mortier, A., Gliß, J., Schulz, M., Aas, W., Andrews, E., Bian, H., Chin, M., Ginoux, P., Hand, J., Holben, B., Zhang, H., Kipling, Z., Kirkevåg, A., Laj, P., Lurton, T., Myhre, G., Neubauer, D., Olivié, D., von Salzen, K., … Tilmes, S. (2020). Evaluation of climate model aerosol trends with ground-based observations over the last 2~decades -- an AeroCom and CMIP6 analysis. *Atmospheric Chemistry and Physics*, *20*(21), 13355–13378. https://doi.org/10.5194/acp-20-13355-2020

Thiery, W., Lange, S., Rogelj, J., Schleussner, C.-F., Gudmundsson, L., Seneviratne, S. I., Andrijevic, M., Frieler, K., Emanuel, K., Geiger, T., Bresch, D. N., Zhao, F., Willner, S. N., Büchner, M., Volkholz, J., Bauer, N., Chang, J., Ciais, P., Dury, M., … Wada, Y. (2021). Intergenerational inequities in exposure to climate extremes. *Science*, *374*(6564), 158–160. https://doi.org/10.1126/science.abi7339