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Hydrology and Earth System Sciences Discussions

Interactive comment on "Assessment of climate change impact on hydrological extremes in two source regions of the Nile River Basin" *by* M. T. Taye et al.

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The authors wish to thank the reviewer for the constructive comments that will surely help in improving the manuscript.

General comments

Response – We acknowledge the reviewer's general comments which we found to be constructive. The comment regarding the comparison of hydrological models and two catchments is valid. We were not overly clear on these differences in the discussion and results section. This comment will be addressed as explained hereafter. The

unclear sentences will be revised and the focus of the paper will be revisited.

Specific comments

Comment 1: Include the area of the catchments.

o Response – The area of catchments will be included.

Comment 2: The 'materials and methods' section needs to describe in more detail the relevant aspects of the models and any other model (e.g. exponential equations) used in the study. For example the equations given in the 'results and discussion' section could have been presented in the methods section. Describe how ETo was estimated using maximum and minimum temperature. Is there any particular reason you chose 0.1mm to define a wet day and not, say 1.0mm or 0.05mm?

o Response – The authors agree that more descriptions and extra equations are required to improve the readability of the paper in the materials and methods section. For instance, the ETo calculation will be better explained in the methods section as indicated in responses to reviewer 1 and the response to the short comment from Axel Thomas.

o – The choice of a wet day threshold of 0.1mm is based on previous studies. We are aware that this wet-day threshold is arbitrary based on the climate and objectives of the study (often in the range of 0.1mm to 1mm). We selected 0.1mm as a threshold because it is a standard wet-day threshold in many studies (making it easier for comparison of the results).

Comment 3: GCMs - the core of the paper seems to be about climate change and the downscaled projections yet there are no statistics, graphs or any numbers to show their performance and how well they reproduced the observed climate, given that this was the basis for their selection. Why were A1B and B1 SRES scenarios chosen? A brief note on this is necessary. Different baseline periods are mentioned throughout the paper, there is need for consistency. A table showing mean values of rainfall,

temperature, ETo and flow for the baseline and the two scenarios may help the reader understand the context better.

o Response – The results on the performance of GCMs will be incorporated in the revised paper. Our previous intention was to publish them in a separate paper. However, we are now of the view that for a better context, both GCM and hydrological model results should be merged.

o – The reason why A1B and B1 were selected is because the global warming for the 2050s indicates that A1B and B1 are the high and low scenarios respectively. This will be clarified in the revised text.

o – The reviewer wonders why different baseline periods are mentioned throughout the paper. Having consistent baseline periods would indeed be more appropriate. However, this was not possible due to the differences in the data availability in the two catchments. The authors now realise an inter-comparison of the future catchment impacts would be somewhat unrealistic. Differences in baseline periods would also explain the differences in the future impacts. Nevertheless, the future impacts in the two catchments are interesting for assessing the relative differences in impacts of the two catchments for the same future time horizon. The suggestion to add a table showing the mean values for rainfall, temperature, and ETo will be taken.

Comment 4: Two hydrological models were used in the study. However, the differences in their performances that could be attributed to differences in their model structure and/or parameters are not discussed, and how these impact on the uncertainty in the flow predictions. Also, the results presented, especially in the graphs, do not indicate which model they are from. The authors mention in their introduction that the impact of using different hydrological models is not widely investigated and this gives the reader the impression that the authors will address the issue.

o Response – The differences in the model structure will be addressed as explained in the response to reviewer 1 (see comment 3) and reviewer 3 (see comment on materials

and methods). The graphs presented are results from the VHM approach. After, it was established that the VHM hydrological model performed better than the NAM model for the extremes, the subsequent sections only considered the VHM model. The authors agree that the paper gave an impression that the hydrological modelling differences would be examined more closely. In this regard, more explanations will be included. It is not straightforward to pinpoint the reasons for the differences in the extremes' performance. The calibration process and model structure may explain the differences. Compared to the NAM model, the VHM model calibration process is more elaborate with an extra step that enables the modeller to evaluate the different sub-flows. On the other hand, the NAM model structure may be underestimating the saturation state of the catchment leading to increased infiltration. The updated paper will aim to clarify on this.

Comment 5: Model validation was mentioned in the 'methods' section. In addition to calibration results in Table 1, validation results on model performance need to be given. Time series graphs of observed and simulated flow would also be appropriate. Figure 2 may not be necessary. Also mention how WBD was calculated.

o Response – Model validation results will be included in table 1 and time series graphs will be included to make it clearer.

o –Figure 2 will be removed and replaced with a more appropriate figure.

o –WBD is calculated as the percentage difference between the modelled and the measured total flow. WBD = (modelled total flow - measured total flow)/ measured total flow

Comment 6: There may be little basis for comparing the two catchments because; i) they use different baseline periods, ii) different GCM runs, iii) great difference in the number of rainfall stations between the catchments (38- Nyando and 5-Tana). Given that the authors have attributed poor rainfall simulation to inability of GCMs to capture topography and the complex climate system, the sparse data (5 stations) for Tana in

itself may have been inadequate to drive the hydrological model, and to generate future representative rainfall scenarios. The authors could comment on whether they believe that sparse rainfall data in Tana catchment could have biased their results

o Response – The reviewer states that there is little basis to compare the catchments due to different baseline periods, different GCM runs, differences in rainfall stations. We agree that these differences make it less meaningful to directly compare the catchments. However, there is still value in some of the future change characteristics in terms of the directions of change such as whether the future extremes get higher or lower, frequent or less frequent, and wetter or drier in both catchments for the same time horizon. The data constraints preclude a solid basis for comparison but this problem is hard to overcome in the data scarce regions. We will make this point clear in the updated paper.

o – The sparse data in the Tana catchment does indeed contribute to less representative rainfall scenarios for the region. More stations would improve on this. Nevertheless, the GCM performance is still poor. It was established that the areal reduction factors did not change the conclusion of the poor quality of the GCMs. The Authors wish to clarify that the stations were not used to derive areal rainfall before comparing with the GCMs (given the scarcity of the rainfall stations). Instead, areal reduction factors were applied to the station closest to the GCM grid point; the stations with the longest record were used.

Comment 7: Include in the 'references' section all references cited in the text (e.g. Anderson et al 2006)

o Response –The reference for Andersson, et al. (2006) will be included.

Comment 8: The conclusions need to be more precise and not repeat the results already presented. Some of the conclusions given are not supported by the results presented in the paper.

o Response –The comment on the conclusions is valid. The conclusion will be improved as suggested.

References

Andersson, L. Wilk, J., Todd, M., Hughes, D., Earle, A., Kniveton, D., Layberry, R., Savenije, H.: Impact of climate change and development scenarios on flow patterns in the Okavango River, Journal of Hydrology 331 (1-2): 43-57, 2006.

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