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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Hydro-Climatic Modelling of an Ungauged Basin in Kumasi, Ghana" *by* Marian Amoakowaah Osei et al.

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The authors would like to thank our anonymous reviewer for his constructive comments.

1) The paper uses a single GCM. The uncertainty of this choice might be significantly large. What are the results for different GCMs? Do they go in the same direction? This must be tested.

RESPONSE: The study used projection data from the Canadian Regional Climate Model of the Fourth Generation (CanRCM4), which is a regional climate model and not a GCM.

2) The analysis is carried out for a very small basin (70 kmq). The spatial scale of GCM is much larger. It introduces further uncertainties that should be considered and

discussed. For instance, the use of Regional Climate Models might be needed. As before, it must be investigated and assessed

RESPONSE: As stated in earlier, the Canadian Regional Climate Model (CanRCM4) was used and this is clearly stated on page 7 line 8, with the data being bias corrected before use. The spatial resolution is quite coarse and hence, the manuscript is being updated with a new projection at 0.22 lat/lon (approximately 25 km) and three different ensembles for the various RCPs to observe the future discharge trends.

3) Discharge observations from a neighbouring basin are used for SWAT model calibration and validation. However, no details are given on the used dataset, and how it is used as a proxy of discharge observations for the investigated basin. It should be clarified and clearly specified.

RESPONSE: The study used monthly streamflow data from the nearest catchment, the Offin Basin and spanned a period of 2001 to 2010. This information is seen in table 1. However, it has again been updated in the text. Please note that, the data was not subjected to any rigorous statistical tests before use, however, we applied the spatial proximity global arithmetic mean method (page 6 line 8-9) as used in Oudin et al. (2008) and the results obtained with the raw data for calibration purposes were good for the Owabi catchment.

4) Overall, several details are missing in the explanation of the methodology. For instance, two different land use scenarios are considered but no information is given on the criteria used for the selection of such scenarios. Similarly, for the selection of a single GCM. A single hydrological model. A single downscaling approach (not explained properly). All these aspects must be clarified.

RESPONSE: The following has been updated in the manuscript accordingly:

(i) Criteria for landuse scenario: Although the catchment is prone to anthropogenic invasion, there have been strict forestry rules that safe-guards the forest from human

occupation. These rules are unlikely to be relaxed for the benefit of the residents since the catchment is prided as an international and only inland ramsar site in Ghana. Forest guards are observed to patrol the forest at least twice a day, with severe penalties awarded on any defaulters. It is therefore likely, that current settlement areas can either remain the same, or grasslands and croplands would be urbanised to support growing population. These assumptions formed the criteria for developing the two landuse scenarios.

(ii) As previously stated, the Canadian Regional Model of the fourth generation (CanRCM4) was used.

(iii) The SWAT model was chosen for its thorough modelling of hydrology of catchment as observed in most hydrological manuscript. On the other hand, this study was undertaken through the Building Stronger Universities Phase 2 (BSU II) project, where panelists selected the SWAT model to be most convenient for assessing the Owabi catchment hydrology.

(iii) The CmHyd software has about seven bias correction options available for precipitation and temperature. This included; distribution mapping of precipitation and temperature, linear scaling, delta-change correction, precipitation local intensity scaling, power transformation of precipitation. All these options were used to correct for biases in the historic rainfall and temperature datasets which included the observed data and that of the RCM for different RCP scenarios. After correction, the best bias correction option was the distribution mapping and hence was chosen for the hydrological climate change analysis. This option has also been found to be the most reliable per Teutschbein and Seibert (2012).

(5) SWAT model is calibrated with discharge observations only (and not for the same basin). In the paper it is speculated what are the different contribution of precipitation and evapotranspiration on surface and subsurface runoff. By using only discharge data for model calibration, it is not possible to give information on the different components

of the hydrological cycle. Different SWAT parameterizations might provide the same performances in terms of discharge simulation while providing very different shares in the hydrological components. The overall discussion should be removed and totally revised.

RESPONSE: It is certain that the calibrated model was based on discharge only. With the exception of precipitation (which is unlikely to undergo calibration), records for the other components of the water balance are non-existent at the catchment and hence cannot be calibrated. The discharge calibrated model therefore served as a first check to assess the degree to which the water balance reflected that of the catchment area. A second check was done using the SWAT Check tool to analyse any errors with the monthly averaged values of the water balance components. This also proved successful, as no errors were identified, taking into account the soil and landuse categories within the catchment.

References: Oudin, L., Andréassian, V., Perrin, C., Michel, C., and Le Moine, N.: Spatial proximity, physical similarity, regression and ungaged catchments: A comparison of regionalization approaches based on 913 French catchments, Water Resources Research, 44, 2008.

Teutschbein, C. and Seibert, J.: Bias correction of regional climate model simulations for hydrological climate-change impact studies: Review and evaluation of different methods, Journal of Hydrology, 456, 12–29, 2012.

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