Point by Point Responses on:

Impacts of climate change under CMIP5 RCP scenarios on the streamflow in the Dinder River and ecosystem habitats in Dinder National Park, Sudan

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Response to comments from Anonymous Referee #1

General comments: In general, the manuscript is technically sound and the story is described in understandable way. This is an important step forward in the search of future impacts of climate change on the streamflow in Dinder River Basin (DRB), and its relative expected impacts on the Dinder National Park (DNP) ecosystem habitats in the Sudan. Although the results are unexpected, and not entirely easy to interpret, I think the paper should be accepted for publication. This manuscript is good in all respects. The contribution is important, the exposition is clear, and the references are balanced. However, I have some comments on this manuscript, reacting its good works, and strongly recommend acceptance.

Response:

Firstly, we would like to express our thanks to K. Hassaballah for his great effort and enthusiasm regard reviewing the undertaken research. His insightful comments, suggestions and advices would significantly participate in improving the quality of the manuscript.

1. On page 10162; line 5: the authors presented the annual average of the river to be 1.9 x 106 m3 during the previous 40 years. According to the book on "the hydrology of the Nile" by J. V. Sutcliffe and Y. P. Parks (1999), the annual average flow of the Dinder River is 3.086 x 106 m3 during (1907-1960), decreased to 2.797 x 106 m3 during (1907-1997). It seems to be a general decreasing trend in the annual river flow. Moreover, Tavakoli and De Smedt, (2011) and Setegn et al., (2011), stated that arid and semi-arid areas are particularly more vulnerable to changes and expected to suffer from water shortage due to precipitation reduction. In contrast, the author's results showed an increasing patterns in the annual future streamflow. Accordingly, I would like to ask the authors to react on this, and give explanation on why the streamflow results from this study are in contrast with the previously mentioned studies.

Also how certain are the authors about their results taking into account the uncertainties represented in future emissions scenarios, GCMs projections, downscaling approaches and hydrological model parameterization.

Response:

This is a very important comment and we agree with the reviewer that the annual average flow of Dinder River (DR) is 2.2 x 106 m3 during the last 40 years. In addition, we agree with reviewer it seems to be a general decreasing trend in the annual river flow. The average flow of DR is observed to be decrease from 3.2 BCM to 2.5 BCM during 1907-1951 and 1907-1997, respectively. In spite of this, the highest flow decline and more influential on DNP ecosystem habitats, was during two drought periods. Therefore, comparing streamflow in the future periods with that average simulated of the drought periods could produce more reliable results rather than comparing with period including extreme flood years. This because we aimed to infer how is likely that projected change tend to restore back the normal situation as such before the drought periods. It is therefore, useful for the assessment of the potential effect of adaptation measures to cope with future changes. For these reasons, the baseline period used by this paper for comparing the future periods is the simulated drought period from 1977 to 1988 which has a relatively low average flow rates though we have considered the flooding of 1988. This interprets why the streamflow reveals increasing trend in the future periods.

The aforementioned statements will be added to related parts in the manuscript core.

Although the uncertainty is inevitable in the assessing of impact of climate change on hydrology and water resources, there are many recommendations to adjust the associated uncertainty within reasonable and realistic range. In this context, Prudhomme et al. (2003) and Minville et al. (2008) recommended the use of multiple models and scenarios to reduce the involved uncertainty. To this end, in the present work, we used MPI-ESM-LR (dry model) and CCSM4 (wet model) and two scenarios (RCP4.5 and RCP8.5). Furthermore, the downscaling approach is considered as an important source of uncertainty, it therefore suggested that more than one downscaling methods should be used in the study related to impact of climate change (Stoll et al., 2011;Chen et al., 2012). As response, two downscaling approaches are used in this paper. Moreover, we used (SWAT) which is considered as one of the most appealing tool to adequately simulate the future runoff, particularly with good values of the Nash–Sutcliffe coefficient of efficiency (NSE) and the coefficient of determination (R^2) obtained in the calibration and validation periods. The NSE and R^2 results given in Table (2) confirm that SWAT model efficiently capture the hydrology process in the study catchment.

2. On page 10162; lines 9, 10 and 11: the authors state that the land use of the study area has changed over time due to over increasing population density and agricultural practices without giving any evidence.

Response:

El Moghraby and Abdu (1985), stated that over the past decades there was a remarkable population growth due to the successive migration and immigration to the Dinder area. Consequently, the related human activities such as farmland expansion for both traditional and mechanized rain-fed agriculture have been dramatically increased.

This statement will be added to related part in the manuscript core.

3. On page 10162; line 14: the authors wrote “The sandy river bed is left with only a few pools (Mayas)”. By definition, Mayas are not pools inside the river bed, but they are oxbow lakes and wetlands that are naturally formed along the river floodplain.

Response:

We agreed and the correction has been made by deleted (Mayas). The corrected sentence “The sandy river bed is left with only a few pools”

4. On page 10174; lines 12, 13 and 14: the authors state that the Dinder streamflow declined by 47 during (1972-1977).To me this is too much when taking into account that the year 1975 is the wettest year in the records. According to the Ministry of Water Resources and Electricity (MoWRE) data the mean annual streamflow decline in this period by about 7%. In contrast the authors state that “the streamflow decline by 20% during (1978-1987)” which is expected to be more than the decline during (1972-1977) when taking into account that the year 1984 is the driest year in the records. Also according to MoWRE data the mean annual streamflow decline in this period by about 40%.

Response:

Thanks, this is a very insightful comment. We agreed with the reviewer that the mean annual streamflow decline in the first drought period (1972-1977). Accordingly, after correction, the mean annual streamflow decrease for the period found to be about 9.8%. Meanwhile, in the second drought period (1978-1987), the streamflow is observed to decrease about 42.25% compared to the baseline period 1961-1971. It is worth noting that, the period 1961-1971was used as a reference period to assess the impact of the climate change on streamflow during the drought periods.

The corrected sentences "*The rainfall over DRB during the first drought period (1963 and 1965) and (1969 to 1972) declined about 23 and 11 %, respectively, which led to decline the runoff about 9.8 % during (1972 to 1977). The second wave of drought started in 1978 to 1987 that decreased the rainfall about 14.8 %, led to decrease the runoff about 42.25 %, compared to the baseline period 1961-1971*."

5. On page 10183; Table 1 content information only on the resolutions of the two climate models. I suggest to remove this table and combined this information with the descriptions of the two models in section 2.4.

Response:

CMIP5 requests the use of a separate table listing the models and institutions that provided model output, as a citation style in any publication. Therefore, we used table 1 in order follow their recommendation. {Please refer to: http://cmip-pcmdi.llnl.gov/cmip5/citation.html}

Technical corrections:

6. On page 10161; line 12: I suggest to change "(2) investigation of the potential impact" to "investigate the potential impact" to be consistent with (1) "assess the climate change".

Response:

Thanks, agreed, the change is made.

7. On page 10161; line 20: Typing error "their affect" must be corrected to "their effect".

Response:

Thanks, agreed, the changes have been made.

8. On page 10161; line 24: the sentence seems to be not correct, I think the authors are talking about the Dinder River (DR) as a water stream, not about the Dinder River basin (DRB). So the correct sentence will be "the Dinder River (DR) is the largest tributary of the Blue Nile......etc.

Response:

You are right, the change has been made.

9. On page 10162; line 1: the authors state that the entire basin elevation ranges from 2646m at an Ethiopian plateau to 515m. While the digital elevation map in Figure 1 showed that the elevation varied from 2646m to 407m.

Response:

Thanks, agreed, the change has been made in the manuscript core. The corrected elevation varied from 2646 m to 407 m.

10. On page 10163; line 3: the authors stated that the DNP elevation variation ranges from 2646m at an Ethiopian Plateau to about 515m. The 2646m is the highest elevation in the entire basin not in the DNP. Also it is important to note that the whole DNP is located inside Sudan and not extended to the Ethiopian plateau.

Response:

Thanks, agreed, the changes have been made. The 800 m is the highest elevation in the park. Also, the sentence (the whole DNP is located inside Sudan) has been added to the manuscript core.

11. On page 10163; line 13: typing error “Al-gwisi” should be corrected to Al-Gwisi (name of the hydrological station).

Response:

Corrected - thank you.

12. On page 10188; what is the physical meaning of the minus sign (-) in Table 6?

Response:

The physical meaning of the minus sign (-) indicates a decrease in the river discharge.

13. On page 10189; Figure1: there is a typographical error in the caption. The topographic map of the basin is based on the 90m digital elevation model not 90 km.

Response:

You are right, corrected.

14. On page 10190; Figure 2: there is a typographical error in the caption. The word gauges should be changed to gauge, because there is only one gauge at Al Gewisi station. Also the sentence “SIM indicates to simulated flow” should be corrected to “SIM indicates the simulated flow”.

Response:

You are of course right, corrected to gauge. Also SIM indicates to simulated flow corrected to“*SIM indicates the simulated flow*”.

References

Chen, H., Xu, C.-Y., and Guo, S.: Comparison and evaluation of multiple GCMs, statistical downscaling and hydrological models in the study of climate change impacts on runoff, Journal of hydrology, 434, 36-45, 2012.

El Moghraby, A., and Abdu, A.: The Dinder National Park, study area. Final report, Environmental management in the Sudan. Institute of Environmental Studies, University of Khartoum Reports, 45, 1985.

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