Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-618-AC4, 2020

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Assessment of streamflow decrease due to climate vs. human influence in a semiarid area" *by* Hamideh Kazemi et al.

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Received and published: 30 April 2020

Response to the reviewer's comments - hess-2019-618

The authors would like to thank the reviewers for their constructive comments that helped to improve the quality of the manuscript. Our point-by-point responses for the reviewers' valuable comments are listed below.

Reviewer 2: Comment: The manuscript is about using Budyko method and HBV model to investigate mean annual streamflow changes, due to climate variation and human influence, in the important Karkheh River Basin in western Iran. Although this

manuscript is an interesting study but this study doesn't identify any major contributions in terms of process understanding or developing new methods. However as stated in the manuscript, authors claim that their approach combining HBV and Budyko is novel and for the first time used in Iran. However, the knowledge gap/novelty and the importance of this work is still missing throughout the whole manuscript and it needs to be clearly stated.

Answer: Thank you for the detailed review and pinpointing shortcoming of the manuscript. Although, we admit that all the methods including the Budyko, HBV, DBEST, and satellite image processing used in this study are separately developed in previous studies, our manuscript introduces a novel combination of these methods such that a new, more robust framework of separating human vs climate variation effects on streamflow of large river basins in the data-scarce area. As mentioned, this is the first time that Budyko analysis is implemented in an Iranian catchment. The case study is one of the most important catchments in the country and ironically there is the lack of studies investigating separate impacts of human activities and climate variation in the area. In any case, the study offers a new approach for data scarce areas to quantify effects of climate versus anthropogenic influence. This involves a technique to validate the Budyko method with remote sensing analyses. None of the previous studies mentioned by the reviewer has applied satellite remote sensing techniques to quantify land use changes over a long period of time for verification of the Budyko and HBV modelling results. We firmly believe that this is one of the major contributions of this study to the methodological approaches in the field of hydrology. Also, as a novel approach, we used the newly developed DBEST algorithm for detecting breakpoints. DBEST uses a (novel) segmentation algorithm for detecting and characterizing significant breakpoints, and has a general designation making it suitable for different time series data analysis. It has been applied successfully in several other filed of studies and this paper shows its suitability for streamflow change detection as well. Not mentioning that the introduction of the DBEST method here is important because it is new in hydrological studies and specifically relevant in Budyko applications for a more

reasonable, systematic selection of time periods to be compared.

Comment: The method section is too long with elaborated with details. In other hand, the discussion (section is too short and general repeating the same message said earlier rather than putting the results from this study in a broader context of studies in similar regions and worldwide.

Answer: The methodology and introduction sections have been revised and improved. The discussion part was extended by adding more detailed discussion as suggested – page 13-14- line 370 -450, as follow:

[Uncertainty analysis: The HBV modelling results suggested that the proposed parameters provided by Genetic Algorithm (GA) could model the catchments with reasonably well accuracy. However, the model may suffer from some uncertainties due to input observed data or model structure. In order to adequately simulate a hydrological response at the basin level, accurate data such as climate variables (precipitation, ET, etc.) and catchment physical characteristics (topography, land coverage, vegetation, etc.) are vital. In climate variation related studies, in which the study period is on the scale of decades, it is difficult to obtain uniformly distributed and accurate data sets (Kapangaziwiri et al. 2009). In the Karkheh catchment, specifically, part of the uncertainty may arise from observed rainfall, potential evapotranspiration and streamflow data. The weather gauges and stations are not uniformly distributed in the entire catchment. Moreover, elevation and topography of the catchment can introduce bias to the observation time series, which can subsequently affect runoff simulation and modelling (Rientjes et al. 2013). Another sources of uncertainty may arise from non-uniqueness of the model parameters, which means that different combination of parameters may result in the same streamflow prediction (Beven. 2001; Masih et al. 2010). In this study, the non-uniqueness of the model parameters was also investigated. To do so, the 10 best sets of calibration parameters produced by GA were selected for each sub-basin to estimate the impact of human activities and climate variation on streamflow variation. The results appear to be reliable if the streamflow prediction remains consistent,

despite the change in parameters (Masih et al. 2010). Table 9 shows the streamflow simulation is consistent despite the change in parameter sets.]

[Limitations of the study: In order to discriminate the human activities and climate impacts on streamflow, in the hydrological approach, a couple of assumption was made. In this study, like similar studies (Zeng et al., 2014; Zhang et al., 2016; Wu et al., 2017), it was assumed that no human activities were involved in streamflow variation during the pre-change period. In other words, the human activities in pre-change period was considered negligible and the hydrological processes is natural. It was also assumed that climate variation and human activities are two independent variables, however as mentioned by Kim et al (2013) these two are dependent and it is not possible to correctly simulate LULC change without taking climate variation into account. (Kim et al, 2013, Dey and Mishra, 2017). Although the model uncertainty was not significant in this study, but caution must be applied in the interpretation of the findings. For instance, land use classification in the HBV model is rather simple with only three representatives. Catchment characteristic in Budyko method is assumed to be constant. As mentioned earlier, the catchment characteristic parameter is related to soil properties, slope and land use of the catchment, therefore it is subjected to change by changing LULC.]

Comment: In the conclusion, authors claim that “The outcome of this study can be used to assist policymakers and water professionals in proposing a proper water management plan to prevent the further reduction of streamflow and groundwater storage”. How the results of this study would help policy makers to prevent reduction of streamflow and groundwater storage? When the results show that we have a combined effect of both human (increased irrigated area and reduction of forests), and climate (decreasing annual precipitation) on streamflow reduction almost all over the basins.

Answer: Although it might be difficult to manage the impact of climate variation at the local scale, with a better understanding of the human activities’ impact on water quantity, it is possible to introduce better management plans, such as improved agricultural

management methods and urbanization control to limit the inverse impacts. These discussions are added to the revised manuscript.

Comment: Authors need to work properly with all figures for instance order of figures should be improved, authors refer to figure 2 and then figure 9 and then back to figure 3. Figure 11 can be removed from the discussion part and Figure 12 is not necessary.

Answer: Thank you for the suggestion. Your comment has been implemented in the revised version of the manuscript. We fixed the order of the figures in the revised manuscript. We also removed figure 12 and relocated figure 11 to the study area subsection – page 3 – line 90

Comment: This a big assumption in this work that streamflow has not been influenced by human activities before the breakpoint. Please clarify!

Answer: As mentioned by Dey et al. (2017), the applied procedure is a common method, which has been employed numerous studies including Hu, Liu et al. (2012); Sun, Tian et al. (2014); Chang, Zhang et al. (2016). However, your valuable point has now been discussed in the limitation section in the revised manuscript.

Additional References (added to the revised manuscript): Chang, J., H. Zhang, Y. Wang and Y. Zhu (2016). "Assessing the impact of climate variability and human activities on streamflow variation." Hydrology and Earth System Sciences 20(4): 1547-1560.

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on a Budyko hydrological model in China's Loess Plateau. Water Resour. Res., 5, 6500–6519, https://doi.org/10.1002/2014WR01658, 2015.

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Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-618/hess-2019-618-AC4-supplement.pdf

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