

## General comments

Here, the authors presented a framework for quantifying the change in water scarcity at major river basins of China. Although, the study is interesting the methodology is not new and the manuscript is poorly written. For publishing purpose, the entire manuscript should be presented in a high quality format. The details of methodology is also not clear. In addition, the authors did not provided equal importance for all the objectives mentioned in the study.

Response: We thank you for your recognition of our work, and appreciate the favorable comments and insightful suggestions that have helped improve our paper. The detailed responses are as below.

## Specific comments:

### **Introduction**

The introduction should be improved with proper citations and sentences which shows the importance of the current study.

Response: Thank you for the helpful suggestion. We plan to rewrite the introduction section to focus on the competition of water resources between upstream and downstream.

Page 2 second paragraph is confusing. The sentences should be clear. Please add references for "A recent study has shown that the impact of anthropologic interventions on water scarcity is not always negative".

Response: It is the paragraph that will be rewritten and extended to sum up the studies of water resources changes between upstream and downstream regions systematically. And the reference for the mentioned sentence is as following:

### Reference:

Veldkamp, T.I.E., Wada, Y., Aerts, J.C.J.H., Döll, P., Gosling, S.N., Liu, J., Masaki, Y., Oki, T., Ostberg, S., Pokhrel, Y., Satoh, Y., Kim, H., and Ward, P.J.: Water scarcity hotspots travel downstream due to human interventions in the 20th and 21st century, *Nat. Commun.*, 8, 15697, doi:10.1038/ncomms15697, 2017.

Line 21-22 (page2) is confusing. Please correct the sentence. Line 26 is not clear. Please rewrite the entire paragraph.

Response: This paragraph was talking about the method and why the method was chosen in this study. We will rewrite the paragraph to make it more understandable for readers.

Page 3. The presentation of objects is poor and not clear. Please write with specific reasoning. In addition, the sentence "The answers will provide experiences and lessons for global water resources management" is not matching here.

Response: Thank you for the suggestion. A good presentation of objectives will make the study more logic and easy to follow. We will rewrite the objects in the revised manuscript. And the sentence mentioned above might be deleted or corrected here.

Overall, the introduction is too short and not clearly written. Please provide more information on the importance of water scarcity analysis by using different indices such as, water stress and water shortage. Please try to link the importance of Fu-Budyko in water scarcity analysis in a river basin scale.

Response: Thank you for the specific instructions. The introduction section will be thoroughly rewritten accordingly in the revised manuscript.

### **Materials and methods**

The manuscript needs more explanation on method section.

Response: More explanations will be added into the method section accordingly.

Starting the paragraph with 'because' is not recommended. In table 1 provide the lat/lon for gauge locations. Need more explanation on the section Hydrological data reliability.

Response: The first sentence will be corrected and lat/lon information will be added into Table 1. More information about the extracting and processing observed runoff will be provided to explain the data reliability.

Line 29 - please replace e.g. by such as.

Response: This will be corrected in the revised manuscript.

Page 4. The sentence "The steeper the catchment, the smaller was the parameter" is not clear. Need more explanation on the catchment parameter ( $\theta$ ) used in the study?

Response: During the calibration, we found that the  $\theta$  of upstream is lower than that of downstream for all basins, no matter dry climate or humid climate. Given the fact that more steeper terrains in upstream, we think the topography most likely contributes to the change of  $\theta$ . The observation is consistent with study from Sun et al. (2007), who thought that three factors - infiltration rate, water storage capacity and average slope - had impact on the parameter  $\theta$  of Fu-Budyko framework. More explanation about the change of  $\theta$  will be added here.

Reference:

Sun, F., Yang, D., Liu, Z., and Cong, Z., 2007. Study on coupled water-energy balance in Yellow River basin based on Budyko Hypothesis (in Chinese). *Journal of Hydraulic Engineering*, 38(4), 409-416

The equation 1 shows the Fu-Budyko framework, and it is a function of aridity index. But the authors did not mention it here. But in page 5 authors introduced the AI (aridity index). It will make confusion to the readers. Please rewrite the section accordingly.

Response: Thank you for pointing out the mistake. It will be corrected in the revised manuscript.

Expand the unit mm/a (line 13)

Response: It will be corrected to mm/year.

Hargreaves is not a suitable method for quantifying the potential ET hence it is only based on Tmax and Tmin. Please mention the drawback in the manuscript.

Response: The Hargreaves method was chosen because only temperature and precipitation were available in the gridded meteorological dataset. And the PM-based potential ET from pointed dataset was used to corrected the Hargreaves-based potential ET, which will be greatly improve the accuracy especially in the eastern regions. More details will be added here.

What does the value 17.8 indicates in the equation 2. Be more specific.

Response: The 0.0023, 17.8 and 0.5 in equation 2 are the default parameters of Hargreaves equation. The explanation of the parameters will be added in the revised manuscript.

Then line 23-27 is not clear. Please rewrite.

Response: The paragraph will be rewritten in the revised manuscript.

Page 5. Line 2-3. What is the basis of this classifications? Include references.

Response: The classification of AI is based on the method presented by Arora (2002) with arid, semi-arid, semi-humid, and humid regions ranging from 12~5, 5~2, 2~0.75, and 0.75~0.375. In this manuscript, there was mistakes to label the limits of AI and these will be corrected in the revised manuscript. The references are as follows:  
Arora, V.K., 2002. The use of the aridity index to assess climate change effect on annual runoff. *Journal of Hydrology*, 265(1-4), 164-177.

The trend analysis section is not clear. Need more explanation including the equations used.

Response: We will consider either include the equations or add citations to make the method more understandable.

Line 12-13 is not clear. Rewrite. Line 10-19 please rewrite. Please rewrite the section 'water stress and shortage'.

Response: The statements mentioned above will be written in the revised manuscript to make them easier to follow.

Line 17 Populations or population

Response: Populations will be changed to population.

The definition of WW is confusing. Please explain the Qnat and Qobs more specifically.

Response: Here, the WW refers to local water withdrawal which should subtract the

WW in previous reach to avoid double counting. More explanation about WW, Qnat and Qobs will be added here.

Page 6. Is it population count data or population data?

Response: It is population count data here.

Overall, the methodology section is not clearly written and confusing for the readers. Please improve the section.

Response: We will consider all suggestions above and improve the method section to avoid confusion.

## **Results**

The first sentence is not clear. What does the term sustainability indicates. Why did the authors calculate the correlation between observed and natural runoff? Need a clear explanation for this section.

Response: The suitability refers to the reliability of the model when it is applying in China. The sentence will be reorganized to make it clearer.

At the beginning, we thought the correlation between observed and natural runoff might reflect the human interventions on runoff. Now we will reevaluate the conclusion based on additional analysis. We will use correlation coefficient in calibration period to show the model performance here.

Page 6. The line 15-18 is not written well. Please improve the writing quality.

Response: We will reorganize the paragraph by using numbers to make it less subjective.

Page 7. Line 18 shows that the authors selected only 9 large river basins for analysis. Please explain the reasons.

Response: The rest three basins missed some critical data so can't do the upstream-downstream analysis. For example, the record of hydrological data in Liao's upstream gauge started from 1984, which was too short to conduct the analysis; the hydrological data of Huai's downstream gauge was missing; and there was only hydrological data in tributary gauges for Qiantang basin. A short explanation will be added in the data section.

The explanation for the questions "How did the imbalance in surface water scarcity develop between upstream and downstream regions? and What do we learn from China's water management strategies?" are not sufficient in the manuscript.

Response: The second objective will be further discussed in the discussion section by linking with the local policies and economic development. And the last objective might be deleted because it is a little subjective and overlapped with the second objective.

Explain how the model framework is performing for different regions such as, snow

regions in the manuscript.

Response: Previous studies showed that the Budyko framework performs better in humid regions than in arid regions. Our study proved the result. Further explanations will be added to describe the result.

The discussion on percentage decrease in surface water withdrawal is not clear. Please explain the possible reasons.

Response: As mentioned above, more discussions will be added by linking the economic development and water policies with the result in the revised manuscript.

Page 9. Line 26-29 is not clear. The discussion section is not sufficient and well written.

Response: We consider to rewrite the discussion section to make it focusing on this study and the influence of local water policies and economic development on water scarcity.