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**MS TITLE: Comprehensive evaluation of hydrological drought and the effects of large reservoir on drought resistance in the Hun River basin, NE China**

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## RESPONCES TO THE REVIEWERS' COMMENTS

We do appreciate all useful comments and suggestions on our manuscript.

The MS was thoroughly revised, against all revision comments from the editors and reviewers. We have taken this opportunity also to read through and tried to perfect the analysis details, discuss the results more comprehensively and pick up any minor grammar, wording or format problem and made corrections accordingly so that it strictly follows the Journal formatting requirements. Detailed corrections and revisions are listed below point by point. And, all the revisions have been addressed in the reply and highlighted in the manuscript with yellow background.

***Reviewer # 4:***

***1. Page 2 Line 3 Hydrological drought refers to the condition when the water level of a river or aquifer is lower than normal. This is not true.***

[Authors' response]: We gratefully appreciate for your comment. We have revised the definition of hydrological drought after referring to relevant references (Page 2 line 6 to 8).

***2. Page 2 line 7 the concept of drought resistance is not explained, it is not clear for me. No references are given. Any way I would think that it is not appropriate to compare the SRI severity for basins with different sizes. Severity should be scaled according to basin size.***

[Authors' response]: We gratefully appreciate for your comment. I quite agree with you that the severity should be scaled according to basin size. In this paper, drought propagation threshold was applied to characterize drought resistance of watershed. We have added the explanation of the drought resistance in the manuscript (Page 21 line 3 to 5).

***3. Page 2 Line 8 Run 8 Run theory, a time series analysis method. Here Yevjevitch 1980 should be cited as first reference.***

[Authors' response]: We gratefully appreciate for your valuable suggestion. As suggested, we have already added this reference in the manuscript (Page 2 line 13 to 15).

***4. Page 3 line 9 Authors need to mention the climate of the 3 studied sub regions DHF, SY, XJWP.***

[Authors' response]: We gratefully appreciate for your valuable suggestion. The climate difference within the basin is weak. As suggested, we have added the description about the climate of the three sub-regions of DHF, SY and XJWP (Page 3 line 21 to 22).

***5. Pqge 3 line 27 what is tison polygon method?***

[Authors' response]: We are very sorry for the mistakes in this manuscript and inconvenience they caused in your reading. We have changed 'tyson polygon' to 'Thiessen polygon' (Page 4 line 16 to 18).

***6. Page 5 line 11 why did authors selected these pdf?***

[Authors' response]: We gratefully appreciate for your comment. The selection of these pdfs was based on references to the relevant literature (Page 6 line 19 to 21). (https://doi.org/10.1016/j.advwatres.2017.07.007; https://doi.org/10.1016/j.jhydrol.2020.124751)

***7. Page 5 Line 21 RMSE and AIC do not seem adequate to measure the adequacy of Copula. Authors should use Kolmogorov Smirnov test or other tests based on Monte Carlo simulations and Cramer Von Mises statistics to check the copula model adequacy ( See for example the paper of Genest et al 2011 https://arxiv.org/pdf/1102.2078.pdf )***

[Authors' response]: We gratefully appreciate for your valuable suggestion. As suggested, we have added Kolmogorov Smirnov (K-S) test and Cramer Von Mises statistics (C-M) to check the copula model adequacy in the manuscript (Page 13 line 6 to 8 and Page 18 line 13 to 14).

***8. Page 5 line 24 how did authors computed F (d,s)?***

[Authors' response]: We gratefully appreciate for your comment. F(d,s) is joint distribution function of drought duration and severity, which was calculated according to Equation 1 (Page 7 line 12).

***9. Page 6 line 10 Did authors compute the Pearson correlation coef between SRI 1 month and SPI k months from k equal 1 to k equal 24?***

[Authors' response]: We gratefully appreciate for your comment. We calculated the Pearson correlation coefficient between monthly SRI and SPI k months from k equal 1 to k equal 24 for each month from 1967 to 2019.

***10. Page 6 Line 13 it is not clear how authors used Bayesian network BN. There is no graphical model. The causal influences among variables are not described. May authors add a graphical model? I understood that authors contribute to identify or fit the conditional probability which is known as parameter learning component in learning BN but the structure learning is missing. A reference to Pearl papers should be included for example https://ftp.cs.ucla.edu/pub/stat_ser/R246.pdf***

[Authors' response]: We gratefully appreciate for your valuable suggestion. As suggested, we have added the graphical model of Bayesian network in the revised manuscript (Page 9 line 2 to 4). It describes the causal relationships among the cumulative precipitation deficit (CPD, mm), drought duration (D), severity (S) and hydrological drought levels (HDL). In this model, the drought duration and severity of each drought event are taken as the target, respectively, and the corresponding CPD is identified as the condition. The conditional probability of hydrological drought under different CPD conditions would be calculated.

The conditional probability distribution in Figure 11 was obtained by fitting the conditional probability and CPD. Then, the CPD corresponding to the confidence level of 0.95 was identified to determine the drought propagation threshold for triggering hydrological drought events.

***11. Page 6 Line 21 Authors do not use the conventional words within BN which are nodes and parents, response variable y here hydrological drought with two components duration and severity and the feature variable x that characterizes y and which is here is rainfall deficit***

[Authors' response]: We gratefully appreciate for your comment. As suggested, we have added in our revised manuscript (Page 8 line 7 to 10).

***12. Page 7 line 21 what do authors mean by seasonal scale SRI? Is it SRI 3 months beginning in January; April etc…or is it SRI3 of 3 ;onth period beginning in January, then in February m then in March etc… ?***

[Authors' response]: We gratefully appreciate for your comment. In this paper, the SRI-3 values in February, May, August and November were applied to describe the variations of hydrological drought in winter, spring, summer and autumn, respectively (Page 10 line 5 to 7).

***13. Page 9 line 1 figure 4 what does mean heat map?***

[Authors' response]: We gratefully appreciate for your comment. Indeed, Figure 4 (present Figure 5) shows temporal variation of hydrological drought at seasonal scales in the HRB from 1967 to 2019. we have modified the title of Figure 5 in our revised manuscript (Page 12 line 1 to 2).

***14. Page 7 to 9 trend analysis should be first presented in methodology section and then in results section***

[Authors' response]: We gratefully appreciate for your valuable suggestion. As suggested, we have added the introduction of trend analysis in the methodology section (Page 5 line 4 to 9).

***15. Page 9 line 3 it is not clear whether the trend analysis is about SRI. It is not clear how are obtained the results of Table 2 . What are the series that are analyzed using M K test?***

[Authors' response]: We gratefully appreciate for your comment. In this paper, the SRI-3 and SRI-12 were applied to analyze the seasonal and annual variation trend of hydrological drought. The trend characteristic *U* values of M-K trend test of SRI-3 and SRI-12 was calculated to explore the temporal evolution characteristics of hydrological drought. Table 2 shows the calculation results of trend characteristic value *U* at seasonal and annual scales (Page 11 line 1 to 13).

***16. Page 9 line 18 why do authors analyze 1 month SRI?***

[Authors' response]: We gratefully appreciate for your comment. For hydrological drought, the change of hydrological regime can be sensitive and accurately captured by single time scale SRI. The multi-timescale SRI applies to describe the mean hydrological regime during the preceding few months. Therefore, three drought factors, namely drought frequency, duration and severity, were identified from the 1-month scale SRI sequence (Page 9 line 7 to 8).

***17. Page 10 line 9 alpha equal 0.01 is problematic. Usually, we use 0.05. Other tests should be used.***

[Authors' response]: We gratefully appreciate for your valuable suggestion. As suggested, K-S test ($\alpha = 0.05$) were applied to select the best-fit marginal distribution in our revised manuscript. Meanwhile, the RMSE test was added to select the best-fit marginal distribution (Page 13 line 3 to 5).

***18. Page 10 line 11 it is not clear whether Table 3 is about precipitation data, this should be indicated in the title***

[Authors' response]: We gratefully appreciate for your valuable suggestion. Table 3 shows the optimal marginal distribution function of drought characteristics (D, S and CPD). As suggested, we have indicated in the title of Table 3 in the revised manuscript (Page 13 line 9).

***19. Page 10 discussion of the number of droughts. How did authors took into account the reservoir impacts on the runoff downstream ? Downstream stations SY and XJWP are affected by the reservoir operation . The comparison of the three hydrological stations does not hold because drought conditions in Downstream stations SY and XJWP are not due to natural variability but to both natural variability and storage decisions. This explains the seasonal characteristics discussed in Page 12 Line 8 and the results in Page 13 Line 7 and 8. However the comparison between DHF and BKQ holds. So in Fig. 7 c and d are not worth for comparison***

[Authors' response]: We gratefully appreciate for your comment. Built in 1958, the reservoir has been in operation for many years, and its water supply plan has not changed much. In this paper, the data are from 1967 to 2019, and the hydrological drought under the operating state of the reservoir was studied.

Fig. 7 (present Fig. 8) shows the drought propagation duration $T_p$ of four sub-basins under current conditions, which varies in different basins. Meanwhile, we have added the discussion in terms of droughts, physical processes, and reservoir operation to further reveal the changes of $T_p$ (Page 16 line 5 to 18 and Page 17 line 1 to 23).

***20. Page 11 in Figure 6 and Table 5 why not representing results of station BKQ station?***

[Authors' response]: We gratefully appreciate for your comment. Indeed, In this paper, the temporal and spatial variation and periodicity of hydrological drought were studied by dividing the basin into three sub-basins. However, However, for the analysis of drought propagation duration, the value of $T_p$ in DHF, SY and XJWP showed great differences, so BKQ was introduced to verify whether this difference is mainly caused by the operation of the reservoir. Thus, the results of BKQ station were not represented in Figure 6 (present Figure 7) and Table 5.

***21. Page 12 line 6 What is Poisson correlation coef?***

[Authors' response]: We are very sorry for the mistakes in this manuscript and inconvenience they caused in your reading. We have changed 'Poisson correlation coefficient' to 'Pearson correlation coefficient ' (Page 15 line 14).

***22. Page 14 Line 1 to 3. I would not agree with authors conclusions, the result of 4 months as propagation time in relation with an interdistance of 40 km is due to the fact that the reservoir exists. Otherwise I guess that the propagation time would be one month or less for such a distance***

[Authors' response]: We gratefully appreciate for your comment. After our further discussion, we decided that it would be imprecise to attribute the differences in results obtained at different sites to reservoir construction. Indeed, it would be more convincing if we get a comparative assessment on the data before and after the construction of the reservoir. However, the data before the construction of DHF reservoir are lacking. Therefore, based on the calculation of drought propagation threshold for triggering different scenarios hydrological droughts, we discussed the drought resistance capacity of the basin and the influence of factors including the operation of Dahuofang reservoir on the drought resistance of the basin in section 4.4 (Page 20 line 1 to 30 and Page 21 line 1 to 10).

***23. Page 14 the complexity of the situation (lines 7 to 17) argues in favor of drawing a Bayesian network BN scheme.***

[Authors' response]: We gratefully appreciate for your comment. We are very sorry for the mistakes in this manuscript and inconvenience they caused in your reading. We have rewrote this section, stating the distribution of $T_p$ in the four sub-basins, summarizing their differences and discussing the reasons for the differences, making it more general and convenience to read (Page 16 line 5 to 18 and Page 17 line 1 to 23).