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Interactive comment on "Drought propagation and construction of a comprehensive drought index based on the SWAT-$K_{C'}$: A case study for the Jinta River basin in Northwestern China" *by* Zheng Liang et al.

Zheng Liang et al.

xin447422907@163.com

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Thank you for the reviewers' comments concerning our manuscript entitled "Drought propagation and construction of a comprehensive drought index based on the SWAT-KC': A case study for the Jinta River basin in Northwestern China". Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. We have studied comments carefully and have made correction which we hope meet with approval. The responds to the reviewer's comments are as following:

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Major Comments:

Comment 1: Grammar and language. In several places, the grammar and language hinder understanding of the meaning of statements (please see minor comments). This manuscript could be enhanced by carefully proofreading the context. Response: Thanks for the reviewer's suggestion. We reviewed this article based on the language revisions proposed by the reviewer in Minor comments to improve the overall level of the article. The specific modification content is shown in the response to Minor Comments.

Comment 2: Structure. There are three main sections in the results. Are there any connections between them? For example, does the analysis of paragraph time in 3.2.1 help the evaluation or explanation of 3.2.2? In the current form, it seems 3.2.1 and 3.2.2 are independent. This is also reflected in the title "propagation" and "construction". What is the connection? Response: Thanks to the reviewers for your helpful comments. Both drought propagation and the construction of comprehensive drought index are based on the data output by the SWAT hydrological model. Drought propagation is based on the propagation time from meteorological drought to agricultural and hydrological drought, which describes the response relationship between different types of drought. The construction of comprehensive drought index is to combine different types of drought indexes, and include the lag time from meteorological drought to agricultural drought and hydrological drought. It can reflect the drought state when only one or two kinds of drought occur, and can be used to characterize all the characteristics of drought. And those sentences were added in the end of 3.2.1.

Comment 3: Novelty and evaluation. The novelty of the study seems to be the new drought index. A critical question following this is the evaluation of the index. How do we know that this proposed index is reliable? There is some comparison with the individual indicators. Apart from this, could you find some other evidence? For example, what about the public records or reports of historical drought events or losses in the study area? Response: Thanks to the reviewers for helpful comments. According to

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the opinions of reviewer, we added information about MAHDI's ability to capture the historical drought events in 3.2.2. We plotted the changes of MAHDI for month scale in No.6 sub-basin, and compared them with the drought months in the study area introduced in "China Meteorological Disaster Dictionary ïĆ§ Gansu Volume" and "Water Resources Bulletin of Gansu Province". We found that MAHDI can capture the historical drought events with records. (1) Line 289, "SSI, SDI, SPEI and applicability analysis of MAHDI" were corrected as "Applicability analysis of MAHDI". (2) Line 290-299, we added "Using the empirical Kendall function to combine the univariate drought indexes, a comprehensive drought index MAHDI that can simultaneously characterize meteorological, agricultural, and hydrological drought was obtained. The monthly change of MAHDI series in the No. 6 sub-watershed from 1986 to 2012 was plotted, as shown in Fig. 5. It can be seen from the figure that 1991, 1999/07∼2000/05, 1994/11∼1995/01, 2009 and 2010/07 were the drought months. According to the " China Meteorological Disaster Dictionary Gansu Volume ", the area was hot and less rainy in 1991, continuous drought occurred in summer and autumn; in 1994-1995, the region suffered from continuous drought in winter and spring; in 1999, the region suffered from severe drought autumn and winter, which were consistent with the drought events described by MAHDI. According to the "Water Resources Bulletin of Gansu Province in 2009", the area had slightly less annual precipitation and higher temperatures. MAHDI also captured the drought in this year. Above all, MAHDI can be used to detect the occurrence and development of drought.". (3) Lines 300-301, the Figure 5 was added.

Figure 5: Monthly-scale MAHDI sequence at the No.6 sub-basin

Minor Comments:

Comment 1: Line 31: please add related references on this. Response: Thank you very much for your valuable comment. Line 31, "(Zhang et al,. 2018)" were added. And "(Zhang et al,. 2018)" were added in line 33. In References, "Zhang, X., Wang, Y., Xiao, W., Yang, R., Wang, Y., and Zhu L.: Responses of net primary productivity of natural vegetation to climate change in the Shi-yang River basin, Chinese Journal of

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Ecology, 37, 3110-3118, http://doi.org/10.13292/j.10000-4890.201810.033, 2018. (in Chinese)" were added in line 505-507.

Comment 2: Lines 48-49: This statement can be more concise. Please also check the grammar. Response: Thank you very much for your valuable comment. Line 48-49, the statements of "Drought index is an important role in representing, measuring, and comparing the degree of drought for monitoring, evaluating, and studying the development of drought (drought analysis)." were corrected as "Drought index is an important indicator to characterize and measure the degree of drought, and it can be used to monitor, evaluate and study the development of drought."

Comment 3: Lines 61-64: hard to understand. Please rewrite and make it clear. Response: Thank you very much for your valuable comment. Line 61-64, the statements of "The shortcomings of a univariate drought index gradually emerged with the advancement of drought index research. As drought characteristics are usually interrelated, it is difficult for traditional drought studies that are based on univariate frequency analysis to reflect the complex and extensive characteristics of drought affecting social life. Therefore, it is necessary to develop a comprehensive drought index that integrates multiple variables related to drought." were corrected as "With the deepening of drought research, the insufficiency of univariate drought index has gradually emerged. Because drought characteristics are usually interrelated, traditional drought research based on univariate frequency analysis can hardly reflect the multi-dimensional effects of drought on society. Therefore, it is necessary to develop a comprehensive drought index that takes into account multiple variables related to drought."

Comment 4: Line 68: "ensuring the independence of variables" what do you mean? Response: Thank you very much for your valuable comment. Line 68, ", not only ensuring the independence of variables but also considering" were corrected as "and consider".

Comment 5: Lines 70-71: Please check the grammar. Response: Thank you very

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much for your valuable comment. Line 69, ". It is used to develop comprehensive drought indexes" were deleted. ", for example" were corrected as ". For example".

Comment 6: Lines 82-84: This seems to be redundant, as similar statements have been shown in lines 33-34. Response: Thank you very much for your valuable comment. "mid-latitudes of Eurasia and is sensitive to global climate change" were corrected as "climate-sensitive area".

Comment 7: Lines 86-87: "limitation . . . outweigh the advantages" hard to understand. Please justify this or just remove it. Response: Thank you very much for your valuable comment. "However, the limitations of copula function in the construction of a multidimensional drought index outweigh the advantages of the copula." were deleted.

Comment 8: Lines 251-253: "propagation time of agricultural drought to meteorological drought"? How so? (also in lines 264, 275, 279) Do you mean from meteorological drought to agricultural drought? These statements need revisions to make it clear. Response: Thank you very much for your valuable comment. We checked all similar related descriptions and revised them one by one according to the comments of the reviewers. (1) Line 250, "propagation time of agricultural drought to meteorological drought" were corrected as "propagation time from meteorological drought to agricultural drought". (2) Line 259, "propagation time of agricultural drought responding to meteorological drought" were corrected as "propagation time from meteorological drought to agricultural drought". (3) Lines 274-275, "lag time from agricultural drought to meteorological drought" were corrected as "propagation time from meteorological drought to agricultural drought". (4) Line 278, "lag time of agricultural drought to meteorological drought" were corrected as "propagation time from meteorological drought to agricultural drought". (5) Line 279, "lag time of hydrological drought to meteorological drought" were corrected as "lag time from meteorological drought to hydrological drought".

Comment 9: Line 267-268: Could you please elaborate how the "infiltration of soil

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water . . .” could induce the “long lag time”? Response: Thank you very much for your valuable comment. Compared with spring and summer, the evaporation rate of soil water in autumn and winter was slower than that in spring and summer, which prolonged the time when the soil water content reduced to the that of threshold for agricultural drought. This made the agricultural drought lag behind the meteorological drought for a long time. And this reason was added in line 266-268.

Comment 10: Lines 299-301: The statement about “warming and humidification” leading to “increased rainfall and temperature” needs careful justification. Do you have references to support this? Response: Thank you very much for your valuable comment. “The reason for SPEI to exhibit the lowest degree of drought might be due to the warming and humidification of the Shiyang River Basin, which increased rainfall and temperature.” were corrected as “SPEI reflected the lowest degree of meteorological drought, which was similar to that described by Thornthwaite aridity index (AI) constructed by Zhang et al. (2017) using rainfall and potential evapotranspiration.”.

Comment 11: Lines 308-309: “lack of empirical . . . with extreme values”? This limitation of the proposed index could be discussed in the conclusion or somewhere else. Response: Thank you very much for your valuable comment. “This might be due to the lack of empirical Kendall function’s ability to deal with extreme values.” were deleted in 308-309. And “This may be due to the fact that the empirical Kendall function uses nonparametric method to connect three-dimensional sequences, weakening the influence of extremum in the sequence.” were added in Conclusion in lines 389-391.

Special thanks to you for your good comments.

Please also note the supplement to this comment:
https://nhess.copernicus.org/preprints/nhess-2020-237/nhess-2020-237-AC2-supplement.pdf

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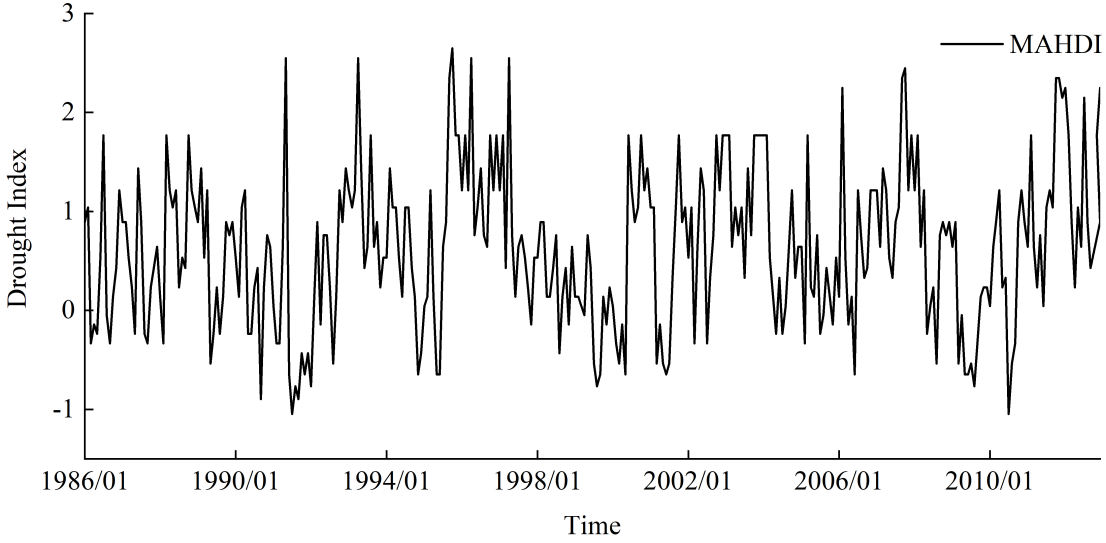

Fig. 1. Figure 5: Monthly-scale MAHDI sequence at the No.6 sub-basin

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