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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Less Frequent but More Severe Hydrological Drought Events Emerge at 1.5 and 2 °C Warming Levels over the Wudinghe Watershed in northern China" *by* Yang Jiao and Xing Yuan

Anonymous Referee #2

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In this manuscript, the authors analyze the impact of global warming of 1.5 and 2 degC on hydrological drought in the Wudinghe watershed. This catchment is a semi-arid region in Central China. The authors show that precipitation is slightly increasing in the future leading to a decrease in drought frequency. However, the authors argue that increased variability is leading to more extreme droughts. The manuscript is overall well written and organized, but lacks some important details (for example, validation of the hydrologic model, downscaling of meteorological forcing from monthly to 6-hourly values). The authors use temperature increases based on local temperature instead of

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global ones, which is a mistake. They should substitute it by global temperature (see further arguments below). The calculation of the employed streamflow index leads to the fact that this one is very dry during the baseline period. This seems odd because the baseline should be neither dry nor wet. The authors need to double check these. Given this assessment, this paper is a welcome contribution to HESS that enriches our knowledge about the consequences of global warming. However, the paper requires substantial improvements. During the preparation of their revised manuscript, I recommend the authors to also include a 3 degC global warming threshold. After all, it will be a miracle if mankind will manage to limit global warming to 2 degC. It is much more likely that we will reach 3 degC within the 21st century. Including this threshold would improve the appeal of the paper. Please find my further comments below:

Major Comments

Section 2: Why are their two correction methods for past and future periods? The authors should mention the differences between those. Which downscaling method is used to obtain 6-hourly forcings. Is CLM-GBHM really only driven by precipitation and temperature? I would have expected that radiation, pressure an humidity are also required. The temporal downscaling might be crucial because future projections often include more heavy precipitation events. Is this preserved by the 6-hourly downscaling procedure?

Section 3.1: Sheng et al. 2017 only presented an evaluation of CLM-GBHM for a historical period with observation based forcing. It is unclear if CLM-GBHM will also give a reasonable behavior if forced with GCM output. The authors should present a validation following the strategy of Samaniego et al. 2018 (Figure S5).

Section 3.2: It is not clear which temperature dataset is used for the calculation. According to the abstract starting at l. 22ff an results at l. 225ff, the temperature is referring only to that of the Wudinghe catchment, but this is not valid. Temperature increases are always referring to those periods when global temperature is reaching a

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threshold. Climate change is a global phenomena. We are interested on the effects in the Wudinghe catchment when global temperature increase reaches 1.5 or 2 degC. This also allows to compare the results of this study to that of others.

Section 3.3: As the probability distribution are fitted for the historical values, it is important to mention that this resembles an approach of no adaptation. Using adaptation and no adaptation can have a large impact on estimated drought characteristics (Samaniego et al. 2018).

Section 3.4: It is not clear to me which time series are analysed for the uncertainty contribution. The authors should expand their explanation.

Section 4.2: I do not know why the authors calculate the median year among all models when a threshold is calculated, especcially since this value is depending to a large extent on the RCP considered. It would be more informing to report the range of earliest and latest period when a threshold is crossed. It will happen somewhere around this period.

Section 4.3: L. 259ff. It would be interesting to include drought area. It is very interesting that the drought frequency is 10.2 events per 20 years and the duration is 6.4 months. This implies that there is drought 27that there should be a drought according to the definition. This is also in line with Figure 7, which shows that SSI during the baseline period is less then -0.2, although it should be zero. Taking the values from Figure 6a, the values for 1.5 and 2 degC warming result in droughts that occur 20authors need to double check why the values are so unrealistic for the baseline. This is crucial because the main conclusions are based on these numbers. It seems like the baseline period has been significantly dry within the historical record. The authors should include the standard deviations for the individual characteristics in Figure 6 and show the results for individual GCMs instead of RCPs because the uncertainty is larger for the former.

Section 5: The authors argue that high mean values and higher variability lead to more

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extreme droughts (l. 296ff). I am wondering whether this actually is the case. As the number of events is decreasing from the baseline to the future periods, it could simply be that the modest drought events are not occurring anymore during future periods and only the extreme ones still occur. The authors should check whether the most extreme events during the baseline and future periods show the same characteristics as all events.

L. 300ff.: The uncertainty contribution is not fitting to the analysis because it is based on a continuous time axis. It should be stratified for those periods identified by the time-sampling approach for each GCM/RCP combination. The authors should mention the recent work by Marx et al. (2018) that showed that uncertainty contribution by hydrologic model can be as high as that of the GCM. The former is not included here.

L. 330ff.: I do not think that the different warming rates are an issue because the are effectively removed by the time-sampling approach. Regarding the regions, naturally warming rates are varying in space, but only one region is considered here. Again, local temperature increase have to replaced by global ones.

Figures 3 and 6: There is a contradiction in the use of drought frequency in these two figures. The magnitude of values does not match.

References:

Marx et al.: "Climate change alters low flows in Europe under global warming of 1.5, 2, and 3 degrees C", Hydrology and Earth System Sciences, 22, 1017-1032, doi:10.5194/hess-22-1017-2018, 2018.

Samaniego et al., "Anthropogenic warming exacerbates European soil moisture droughts." Nature Climate change, 2018 pp. 1-9. http://dx.doi.org/10.1038/s41558-018-0138-5

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