Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-244-RC1, 2018

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Increased incidence, duration and intensity of groundwater drought associated with anthropogenic warming" *by* John P. Bloomfield et al.

Anonymous Referee #1

Received and published: 26 July 2018

The manuscript by Bloomfield et al. "Increased incidence, duration and intensity of groundwater drought associated with anthropogenic warming" submitted to Hydrolog. Earth Syst. Sci. Discuss presents and analyses two long-time series (1981-2015) dataset of piezometric head collected in a chalk aquifer in UK. The analysis takes advantage from the absence of major groundwater abstractions in the two study areas. This allows for assuming that the observed changes of the phreatic levels are due to climate variations. The manuscript is within the scope of the Journal and it is certainly of interest for the Readers of HESSD. It is well written, in both presenting the research framework and previous literature and showing and discussing results. However, I have some concerns that in my opinion should be addressed before a possible publication

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on HESS. 1. I found figure 4 (the core business of the work) very interesting. As pointed out by the Authors, SPI<0 appears to be a broad prerequisite for groundwater drought. Moreover, I agree that increasing groundwater drought is associated with increasing temperature. However, there are some anomalies shown in figure 4, which in my opinion should be furtherly investigated. There is an interesting difference between the second and the third period for the CH dataset: the majority of the most intense groundwater episodes during the second period (SGI < -2) occur for negative or close to zero STI, whereas in the third period positive temperature anomalies seem to play a fundamental role, as almost all of the drought episodes (both for SGI < -2 and -2 < SGI < -1.5) are associated to STI > 0 and SPI < 0. This difference is strange and should be somehow explained: why the aquifer differently reacts to meteorological forcing? 2. Addressing the previous point, please consider also the following: the Authors "postulate that increased evapotranspiration associated with anthropogenic warming is a major contributing factor to the observed increasing occurrence of individual months of groundwater drought as well increasing the frequency, duration and intensity of episodes of groundwater drought" (page 15, line 404), despite the phreatic surface is approximately 40 m and 15 m below the topographic surface at CH and DH, respectively. According to the Authors, the fundamental role played by the transpiration is favoured by the significant thickness of the capillary fringe. This could be a possible explanation. However, at DH (where the water table is much higher than at CH, potentially making the aquifer more sensitive to temperature changes), the increase in temperature occurs over the entire period. I would have expected to find also in the second period an increase of the groundwater drought episodes with respect to the first period. In my opinion, an explanation to this anomaly should be given. 3. One more thing on the capillary fringe. Please, quantify its thickness for both sites. 4. It is not clear to me the reason for using standardized indexes in the analyses. As Authors know very well, standardized indexes are related to frequency (pdf) analysis. Therefore, doubling one index (i.e. from -1 to -2) does not mean doubling the intensity of the anomaly. Temperature and precipitation data come from gridded dataset and, considering the

limited surface of the study areas, only one pixel has been considered. Therefore, why not use directly observed data of precipitation and temperature? 5. Page 8, line 241. “The optimal averaging/accumulation period was found to be 6 and 7 months for CH and DH respectively”. If I have understood correctly, Pearson correlation coefficients shown in figure S4 between SGI and SPI have been computed for a range of SPI accumulation periods considering the current month (i.e. SPIn of March, for n= 1,. . .12 is put in relation with SGI computed in March). This means that the percolation time from ground surface to saturated zone is neglected, not considering possible delay time of the impact of precipitation anomaly on groundwater level anomaly. Please, justify this choice. 6. Figure 6: I would have standardized the cumulative frequency distribution. In this analysis, I’m interested in a possible shift of the duration probability distribution. Probably they are very similar for the two analysed periods.

Minor remarks 7. Please, change the order of the subplots in figures 2 and 3 putting SPI first, then STI and finally SGI (groundwater drought is a consequence of climate anomalies) 8. Figure 5. As in this case SGI refers to the mean over a given drought episode and not to the monthly SGI, please use another notation.

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