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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Asymmetric impact of groundwater use on groundwater droughts" *by* Doris E. Wendt et al.

Anonymous Referee #1

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This study uses a framework that consists of two approaches, and conducted a case study in UK to investigate the impact of groundwater use on groundwater droughts. Generally, the manuscript is well organized with clear logic, before I recommend it for publication, major improvements are still needed, particularly for the method they used for recognizing the presence or absence of human-influence on groundwater. Please find my specific comments below:

1.Lines 171-172: 'In this study, the presence or absence of human-influence on groundwater was determined in relation to the lowest SPIQ-SGI correlation of each near-natural reference cluster'. I think it is questionable to determine the presence or absence of human influence depending on the correlation analysis. For example, for a certain site, SGI is best correlated to SPI at short time scales. Due to human inter-

ference, the drought duration indicated SGI may become longer, leading to SGI best correlated with SPI at longer time scales. The increased time scale of SGI does not necessarily corresponds to reduced correlation of SPIQ-SGI, and the correlation may also increase. Moreover, considering the significant spatial heterogeneity of groundwater (e.g., groundwater of the monitoring sites may show different patterns from reference sites), it would be better to recognize human influences by analyzing the temporal variation of groundwater for the same site (e.g., compare the statistics of groundwater among different decades). The uncertainty derived from the method for recognizing the presence or absence of human-influence on groundwater needs to be discussed.

2.Section 3.2.4 Lines 185-196. The authors use the statistic variable 'Z' of the Mann-Kendall test to judge whether the groundwater of the monitoring sites involves human influences. I think the statistic variable 'Z' can indicate the significance level (e.g., when $|Z|>2.56$, it suggests a significant trend), however, it seems arbitrary to conclude that the detected trend becomes more significant with increased value of $|Z|$. Fortunately the authors mentioned that both PET and precipitation present no significant trend, while groundwater level presents significant trend. This inconsistent pattern between PET /precipitation and groundwater level may imply the existence of human influence. I suggest the authors use additional methods (e.g., linear regression) to confirm the existence of human influence.

3.The time series of SGI for reference wells in Figure 1 (Section 4.1) show significant spatial heterogeneity, and their time scales vary from one site to another. For example, C2 #5 presents long time scales, while C4#9 presents short time scales. This may lead to the higher correlation between SPIQ-SGI for C2 #5 than C4#9 (see comment 1). I think the way of using correlation to judge the human influence is worth thinking.

4.Lines 254-264 and 315-318: The authors mentioned that 'The first pattern, apparent in Lincolnshire, Chilterns, and Shropshire, shows an increase in short drought events often found before a major drought event or during hot summers, which is probably related to an increase in water use'. However, from Fig.2 it shows that 'minor droughts

before major drought events' are not limited to influenced sites, similar phenomena are also observed in uninfluenced sites. Other factors such as the drought identification method, and the spatial heterogeneity of groundwater may also generate such minor droughts. It seems arbitrary to attribute such events to the increased water use and there is much uncertainty on the results.

5.Lines 322-323, The authors mentioned 'We see the effect of this local increase in water use in our data in the temporarily lowered groundwater levels, resulting in additional drought events'. Could you provide additional information on the evolution process of water use and droughts, e.g., show the time series of both water use data and groundwater levels in one figure.

6.Lines 115-118ïijŽThe authors failed to illustrate how they calculate SGI clearly. For example, which probability distribution was employed to fit the groundwater series. Whether the impact of data seasonality was considered when calculating SGI? More details on the computation of SGI should be added.

7.Lines 120-121: '208 sites have been included in the analysis, 39 are reference sites and 170 monitoring sites. ' Here '208 sites' should be '209 sites (170+39=209)'.

8.Lines 130-131: How do you fill the missing sequences, using the time series of adjacent sites? Details on the linear interpolation method should be supplemented. Besides, sites with missing data more than 6 months would be removed directly?

9.The current form of Fig. 2 makes it difficult to judge the impact of human influences. The authors could add the time series of SGI for the monitoring sites so that readers can easily find human influenced periods.

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