

Interactive comment on “Analysis of groundwater drought using a variant of the Standardised Precipitation Index” by J. P. Bloomfield and B. P. Marchant

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General:

The paper deals with a new groundwater drought index, i.e. the Standardized Groundwater Level Index (SGI). The derivation of SGI is inspired by the approach used for the well-known and widely-used Standardised Precipitation Index (SPI). Effects of seasonality were accounted for by determining SGI for each calendar month from monthly groundwater level observations prior to generating a continuous SGI time series for an observation well (at site analysis). The proposed SGI methodology uses a non-

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parametric normal scores transformation of groundwater data rather than a parametric distribution as done for SPI. The SGI was tested with data from 14 groundwater observation wells, which represent different consolidated aquifer types in the UK. Time series of SGI were compared with SPI, which shows that maximum cross-correlation is reached when different SPI accumulation periods were used for the selected sites and that in some cases a lag correlation yields better results. Negative SGI values reasonably agree with major droughts in the UK that are reported in the literature. Duration of severe groundwater droughts derived from SGI time series show a close link with the auto-correlation structure. Evidence is given that hydrogeology (aquifer type, depth of water table, transmissivity, storativity) controls to some extent the SGI time series and their auto-correlation structure.

I believe that development of groundwater drought indices is crucial for proper monitoring and management of the resource (e.g. domestic water supply, irrigation), but also for groundwater storage/discharge dependent functions (e.g. inflow to riparian areas/wetlands, capillary rise lowlands). The world of drought indices is dominated by meteorological (in particular SPI) and soil water (PDSI, SMA) indices, whereas there is a clear need for hydrological drought indices to assess impacts, and provide guidance to water resources management and water-related policies. So far development of hydrological drought indices is biased to river flow/runoff (e.g. RDI, low flow characteristics, threshold approaches), whereas science have paid little attention to groundwater indices. This paper contributes to filling this gap and advances our knowledge. The paper deals with relevant scientific questions within the scope of HESS. The work discovered the weaknesses of the SPI methodology to quantify groundwater drought and developed, tested and illustrated a methodology to obtain a new groundwater drought index (SGI). The authors made a first step to link the auto-correlation structure of SGI to hydrogeological control through investigating explanatory variables, like unsaturated zone thickness, aquifer transmissivity.

I found the paper to be well-written and presented. It is understandable and well-

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documented with tables and graphs. The paper is potentially a very relevant contribution to HESS. However, it needs some additional elaboration (see major items below and minor items in the supplementary material).

Major items

1. The study shows too much respect for the Standardised Precipitation Index (SPI). This happens more. It seems that the drought community, when introducing a new index, it always has to “validate” it against the SPI. This paper demonstrates that a straightforward link between a soil water index or hydrological drought index (in this study a groundwater index) and SPI, which is readily transferrable to other regions (this is essential), does not exist. The paper demonstrates through a lag-correlation that a site-specific SPI accumulation period (varying from 6 to 28 (!) months) and in some places a lag (1-2 months) was required to obtain maximum cross-correlation coefficients of 0.7-0.9. The heat maps (Fig. 8) excellently display the lack of such a straightforward relationship. Why searching for maximum cross-correlations and forget about combinations accumulation period – lag that have a low cross-correlation. We need a breakthrough on this in drought research and associated operational water management; the SPI is a good meteorological drought indicator (with some reported weaknesses), but it is not appropriate because of being too site-specific to identify droughts with SPI in other hydrological domains (soil, groundwater, surface water). I suggest to change the focus of the paper from searching a link between SGI and SPI (e.g. Sect. 4.2, Introduction, Discussion, Conclusions), to demonstrating that the SPI does not work (in this case to characterize groundwater drought). Hence, we need other indices than SPI. I believe you still can use all the material (tables and graphs). You only need to rephrase the text at some places to accommodate the revised focus. I also recommend to revise the title to reflect the other focus. The revised title might be: “Analysis of groundwater drought using a new index” or “Analysis of groundwater drought building upon the Standardised Precipitation Index’ approach”. Your paper earns more credits than just suggesting that you propose a revised SPI applicable to

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identify groundwater drought.

2. Reconsider the structure of the sections on Results and Discussion. In the manuscript new analysis are reported in the Discussion. The whole link between SGI, i.e. the auto-correlation range, m_{max} , and hydrogeological control is described in the Discussion. The results on the link could be described in Section 4 and the discussion in Section 5. This would reduce the length of Sect 5.

3. Elaborate in the Discussion the pros and cons of the newly proposed SGI versus existing groundwater indices, such as the Standardized Water Level Index (SWI) (Bhuiyan et al., 2006), spring flow as a proxy for groundwater storage (Fiorillo and Guadagno, 2010; 2012), base flow (Fendeková and Fendek, 2012), threshold approaches (Peters et al., 2003; Wanders et al., 2010).

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/10/C3963/2013/hessd-10-C3963-2013-supplement.pdf>

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