

Interactive comment on “Characterizing the spatiotemporal variability of groundwater levels of alluvial aquifers in different settings using drought indices” by J. C. Haas and S. Brink

Anonymous Referee #1

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General remarks:

1. According to the first sentence of the abstract, the paper aims at “improving the understanding how aquifers in different alluvial settings respond to extreme events in a changing environment”. This is a highly relevant and interesting topic. The authors performed a comprehensive correlation analysis of time series of SPI, SGI and SRSI for numerous sites in three different subregions in the Mur catchment. In fact a thorough correlation analysis can be a powerful first step. This study, however, is limited to the description of the correlation matrices and speculation about the reasons of the identified correlation patterns rather than providing a sound test of hypotheses or clearly identifying single processes (see below). The authors often emphasize that observed

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similarities might reflect the interplay of various effects. That has been known for long. However, rather than speculating about different effects there is urgent need for disentangling these different effects. Unfortunately, this paper falls short of the mark in this regard.

2. Time series of the SPI were used to assess the role of climatic drivers for groundwater level and river stage dynamics. I would assume that snow melt would play a major role for river discharge and groundwater dynamics in this alpine catchment which is not accounted for, especially for the upstream parts (cf. p. 21, l. 7-8 and p. 24, l. 12-13). Correspondingly, the observed long-term increase of correlation between SPI and SGI or SRSI (Fig. 4) could indicate a long-term tendency of decreasing snow cover. In addition, unlike the SPEI (Vicente-Serrano et al. 2010, Journal of Climatology), SPI does not account for evapotranspiration which is assumed to play an increasing role with regard to drought risk due to climate change.

3. P. 2, l. 6-7: It is stated that “the river is generally found to be a dominant factor, frequently affecting not only the wells closest to the river, but also more distant parts of the alluvial aquifer.” Correlation or coincidence does not necessarily imply a causal relationship. In addition, the term “dominant” implies that river stage dynamics would explain a large fraction of the variance in a statistical sense. But that has actually not been quantified in the study. Approaches like that followed by Longuevergne et al. (2007, Water Resources Research) are much more powerful in this regard and would in fact allow to disentangle different effects in a quantitative way.

4. Comparing the correlation matrices for different groups of measurement sites, for the flood year and the drought year, or for different 12-year periods, etc., the stated differences should be tested for significance. The same holds to stated causal relationships, where possible.

Details:

5. P. 4, l. 25: I guess you mean “facies”, not “faces”.

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6. P. 5, l. 20-21: Shouldn't elevation rather decrease from North to South, that is, along the river flow direction?
7. P. 8, l. 16-19: You mean lag times of maximum correlation?
8. P. 8, l. 21-23: The "mirror symmetry" needs not to be mentioned explicitly because it is an inherent feature of correlation matrices.
9. P. 9, caption of figure 2: I suggest to change the first sentence to "Correlation matrices for the three subregions (left panel) and time series of standardized groundwater head, SPI and SRSI (right panel)". The second sentence of the figure caption can be deleted. The labels of the colour scales in the figure are much too small.
10. P. 10, caption of table 2: What do you mean by "precipitation averaging periods"?
11. P. 17, l. 14-20: The authors argue that poor correlation between SPI and SRSI is due to the fact that river stage reflects more patterns of rainfall in upstream parts of the catchment rather than local precipitation. They do not provide any evidence for that. I would assume that snow melt plays a major role in parts of the alpine catchment that is not accounted for by the SPI. In addition, the low-pass filtering of the temporal pattern of rainfall is the strongest in the uppermost soil layer and has a major effect even on the probability distribution of the resulting groundwater and river stage data, thus presumably resulting in poor correlation between SPI and SGI or SRSI.
12. Fig. 5-7: I guess that the respective indices have been determined for each site separately and have then been averaged rather than first averaging the measured values and then determining the index values, is that right? However, even then different periods covered by time series of single sites might introduce some spurious trends. Have you checked for that?
13. P. 23, l. 4-5: What do you mean by "visual similarity"? What aspect of the time series are you talking about?

Linguistic details: Often some rather sloppy and imprecise formulations are used which

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is not only annoying but sometimes even confusing or misleading.

14. The plural form of "correlation", "river level", "time" etc. is not adequate. Instead, the terms "correlation coefficients", "time series of river stage", "time periods" etc. should be used. Using the term "rivers" rather than "river gages" (e.g., p. 12, l. 18-19) is not only misleading but false, because it is partly the same river throughout. Correspondingly (p. 12, l. 23-24), not the wells are different but the time series of groundwater head at different sites, and wells cannot be correlated to each other (p. 11, l. 11). It is not the "matrix visualization" that is different but the matrices themselves that are dissimilar (p. 12, l. 21-22).

15. P. 3, l. 9-10: What do you mean by a "starting data set"?

16. P. 17, l. 35: Please replace "depth" by "thickness".

17. P. 18, l. 8-10: Please replace "decrease" by "lower correlation coefficients". The term "decrease" describes a more or less monotonic change over time which is not adequate when you compare two distinct time periods without considering the transition period in between.

18. P. 22, l. 10: Please replace "culprit" by "reason".

19. P. 24, l. 22-24: What is a "negative event"? Do you mean "periods with negative index values"?

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