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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Characterizing hillslope-stream connectivity with a joint event analysis of stream and groundwater levels" *by* Daniel Beiter et al.

Anonymous Referee #2

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The manuscript by Beiter et al details a study aimed at understanding hillslope-stream connectivity. They collected 5-6 years of paired near-stream groundwater and stream water levels at five locations within an agricultural catchment in western Luxembourg. At each site, shallow groundwater levels were logged at 5 minute intervals at 3 to 4 piezometers located within 15 m of the stream level site. They extracted about 150 individual rainfall-runoff events from the data record using an approach that interrogates the stream water level time series. For each event identified, they also extracted groundwater response metrics from the corresponding piezometers. They compared stream and groundwater responses to quantify temporal changes in hillslope-stream connectivity. They found a threshold-type response in stream water level linked to an-

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tecedent groundwater levels. Low antecedent groundwater levels were associated with variable stream water level responses. In contrast, high antecedent groundwater levels were associated with more consistent stream water level responses. They speculate that the hydrologic processes controlling these patterns were transmissivity feedback at the marls sites and fill and spill at the schist sites.

The topic covered in this manuscript is appropriate for HESS. The study contains an impressive data set and some of the visualizations do a great job of showing these data (e.g., Figure 8 and 9). Overall, the writing is not bad, but some of the grammar is confusing which makes it difficult to understand some of the elements of the paper. Given the amount of data, I'm left feeling a little underwhelmed by the key conclusions. This might reflect the vagueness of the key research questions (page 3, lines 12-15). For example, 'provide information' is a very general statement - try to be more specific about what is learned from this sort of joint analyses. I would encourage the authors to formulate testable hypotheses to help add more structure to the manuscript. This would also help clarify the key findings of this study.

Overall, I agree with reviewer #1's assessment, so I'll try not to repeat things here. I outline one general comment, followed by some more specific comments.

A major strength of this study is looking at the temporal dynamics of hillslope-stream connectivity. In contrast, the study is limited in capturing spatial variability in hillslope-stream connectivity. However, a key question/conclusion of the study concerns whether connectivity can be assessed using a single groundwater piezometer. The authors conclude that 'a single, well chosen, piezometer can already provide substantial information on catchment state...'. How do we know when a location is well chosen? We aren't provided any guidance on this. It is recognized that hillslope-stream connectivity can be spatially variable. How were the locations of the five sites selected? How representative are these locations of subsurface connectivity at other locations within the catchments?

Specific comments:

Abstract: This feels very long for an abstract. With some good editing this could be reduced by half.

P2L6: 'variable in space': Exactly - but this is not well addressed in this study.

P2L9: 'Full connectivity': What is meant here? For the entire catchment or hillslope? Some indication of the spatial scale of interest should be made in this introduction.

Introduction: As reviewer #1 highlights, some of the more recent research on this topic should be discussed here or in the discussion (e.g., Klaus and Jackson 2019 WRR, Gabrielli and McDonnell 2020 HP).

P3L1-3: An example of a run-on sentence that should be avoided.

P3L8: What is meant by a 'rough interpretation'?

Section 2.1: Provide some information about soils and the vegetation cover. Could the sites be given more descriptive names? I realize the 'S' and 'M' represent the dominant geology, but what do 'J', 'V', 'D', and 'K' represent?

Figure 2: Could elevation be added to these plots? Or at least the elevation of the ground surface at the peizometer and the depth of the piezometer relative to the streambed? It might be really helpful to include photographs of the 5 site installations so that the readers can get a better sense of the sites.

Table 1: What are the slope quartiles referring to? The hillslope or catchment?

P6L4: Where is the Roodt station? Any concerns about spatial variability in precipitation inputs? I know it is mentioned that precipitation is assumed to be uniform across the catchments for the runoff ratios; however, it seems like not all stream water level sites respond to precipitation events. This may suggest that the uniform precipitation assumption is not reasonable.

P6L21-22: Looks like this percentage was tested? How sensitive are the results to different values?

Section 2.4: Why not conduct the event detection by using the precipitation record (as is frequently done) instead of the stream level records?

P8L1: Were there times when the piezometers showed a response but not the stream?

P8L15: This would only happen in autumn?

P8L18-22: For the search interval, was this a moving window or fixed interval search?

P10L5-14: Consider re-writing this to improve clarity.

P10L13: What is meant by 'hints'?

P10L26: What is meant by 'a more or less deterministic increase'?

P11L26: For what purpose is this response considered negligible?

Figure 5 (and others): The 'Event type' colour scale is very difficult to interpret for a colour-blind person. Consider using some other way to visualize these data (shapes maybe, although that might be difficult to see as well)?

Figure 7: Perhaps distinguish the Seasons by shape instead of colour.

Figure 8: Very nice graph!

Figure 9: Could the approach used to set those thresholds be discussed a bit more? I realize they were done visually, but there are some sites/piezometers that I would argue don't have a clear threshold (most of S_V, S_J piezo1, most of M_K, etc.).

Section 3.6: Please define 'catchment state' - this seems to appear out of nowhere (unless I missed it earlier).

P17L15: It's not clear to me where the topographic characteristics come from? Is this simply the qualitative discussion in Section 2.1. Are there stream incision data for all

the sites?

Figure 10: Appears that the figure caption for the y axis is incorrect.

P19L1-3: I'm struggling with this logical leap between the results shown in Figure 7 and how they 'indicate that well-placed groundwater observation points can be representative of the given footslope, at least for pre-event conditions'. Given the close proximity of the within-site piezometers, there seems to be a surprising amount of scatter in these plots.

P19L8-10: Or could it be that another portion of the catchment is connected, but not the hillslope with the piezometers?

P21L28-31: How is it known that connectivity 'does not extend far up the slopes' when those observations were not made? The substantial conclusions in this section are based on somewhat subjective placement of a threshold. It could even be argued that no clear threshold exists for some of the sites (see comment regarding Figure 9 above).

P22L1-2: Again, I'm not clear on where the evidence is for this statement.

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