Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-166-AC2, 2018

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "The influence of diurnal snowmelt and transpiration on hilllslope throughflow and stream response" *by* Brett Woelber et al.

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Received and published: 24 June 2018

Comments from Reviewer #2

This is a very good manuscript that presents and analyzes a dataset of snowmelt, groundwater levels and stream stage measurements. The authors present analyses of stage a level variations, focusing on amplitude, phase shifts and so on. In general, there a few shortcomings in the manuscript. The material is presented coherently, the figures are of very good quality, and the discussion is supported by a clearly presented conceptual model.

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The more frequent comments I have pertain to the organization of the text, as sometimes the authors mix result presentation with discussion. Also, grammar should be checked, as there are a few instances of mixed-up singular/plural noun and verb usage. Please see the attached annotated manuscript for specific comments.

Overall, I recommend accepting with minor reviews.

Please also note the supplement to this comment: https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-166/hess-2018-166-RC2-supplement.pdf

Response to Reviewer #2

We thank reviewer #2 for their time in reviewing the manuscript. We appreciate their positive assessment of the work and the general and specific comments that improve the organization of the manuscript and its readability. To facilitate the review process and to clearly identify the actions taken to address the reviewer comments, we reproduce below, line by line and in bold letters, the specific annotations the reviewer left on the pdf version of the original manuscript, along with the corrections/changes made (in italics).

Page 2, line 28: Please verify citations format. All citations have been verified to comply with the journal style.

Page 2, line 34: A word is missing here. Fixed.

Page 4, line 21: Did the stream cross section remain stable (unchanged) during the season? In many alpine sites, sediment transport in spring can be significant and alter the discharge/stage relationship? We did not use a stage-discharge curve for this study, we only analyzed the variations in streamflow stage. Nevertheless, the channel cross section remained stable during the study period, during which peak flows were moderate. The creek is incised to the stable underlying bedrock and during our visits to download the dataloggers we did not notice changes in the banks or any significant accumulation of sediment. In the revised manuscript (page 4, line 18 of supplemental

review materials) we indicate that the channel cross-section around the measurement point remained stable during the study period.

Page 5, line 6: Is it appropriate to talk about a “regional” aquifer in this geographical setting? We mean the aquifer in the consolidated rock, which is of a larger extent than the perched saturated layer in the soil-bedrock interface. In the revised manuscript we have changed “regional aquifer” by “mountain-block aquifer”.

Page 5, line 9: Later in the manuscript you introduce a discussion on hydraulic properties of unsaturated/saturated soils and how they change in time. I think this discussion should be introduced much earlier, probably here. We believe you are referring to the discussion on the possible emerging beat interference in the diurnal pressure signals. Following this suggestion, we have moved the conceptual figure and the associated explanatory discussion to this section (see changes to section 3.3. in supplemental review materials).

Page 5, line 11: Something is not quite right in the definition of terms: when working out the variables in eq. 1, it comes to dq_h = q_in - q_out. Thus, the inline equation in line 11 is mathematically wrong. The inline equation defining qhqin-qouthad incorrect s in the qin qout and has been corrected. Also, storage (S) is in dimensions of [L] (volume per unit area), such that SydSdhis dimensionless specific yield or drainable porosity. In the revised manuscript we specify units to make this clear (page 5, lines 23-26 of supplemental review materials).

Page 7, line 15: This is true except for well 4, which shows a more sensitive behavior than well 3. It’d be great to discuss why well 4 might be more sensitive overall. Soil at well 4 is significantly deeper than at any of the other wells and is less susceptible to saturation. This additional storage permits this well to record diurnal snowmelt events when other wells are saturated and register constant pressure head. Although the final recession in late June seem to start a little earlier than at well 3, situated immediately uphill, the recession follows the expected downhill progression from wells

1 to 5 in which draining rates are lower and saturation last a little longer as upslope accumulated length and water subsidies increase. However, well 4 also seems to lose pressure faster during periods of no snowmelt indicating higher draining capacity. The reasons for this are hard to determine because the exact subsurface water flow paths are unknown. The most likely explanation is that at the location of well 4, bedrock permeability is higher and the soil loses water to the bedrock aquifer at a faster rate. A second possibility is that horizontal conductivity is higher and downhill drainage is faster. A sentence discussing this is added in the revised manuscript (page 8, lines 1-4 of supplemental review materials).

Page 8, lines 2-5: This belongs in the discussion section. This sentence has been moved to the last paragraph of discussion section 5.1.

Page 8, lines 19-20: This sentence should come after the cited references... or maybe delete altogether as it is redundant with what comes afterwards. The sentence was redundant and is eliminated in the revised manuscript.

Page 8, lines 27-28: I believe this figure and the entire conceptual explanation should be presented before showing your actual measurements. We have revised the manuscript to introduce this figure and a conceptual explanation in section 3.3, which describes the conceptualization of the hillslope model.

Page 9, lines 6-10: This should go in discussion This paragraph was unnecessary and is removed in the revised version of the manuscript.

Page 9, line 23: In the soil? In the stream? Both in the soil and in the stream. We clarify this in page 10, lines 10-11 of supplemental review materials. This approximation is justified by the relatively small variations in stage induced by diurnal fluctuations.

Page 11, line 31: Check citation formatting. All citations have been verified to comply with the journal style.

Page 12, lines 10-12: Earlier you provided a convincing conceptual approach of su-

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perimposed signals. In your results, you measure these signals individually (snowmelt, stream, and et)... please state more clearly why it is difficult to disentangle this interaction, even though seemingly all intervening variables are measured directly. Even though we observe clear diel cycles of radiation and transpiration, and we observe clear cycles in the hillslope storage, we could only infer indirectly the joint effect of both signals. We weren't able to directly observe or attribute the contributions of the individual input signals (snowmelt and ETP) to pressure fluctuations. It is clear, however, that the snowmelt cycle dominates the resulting signals. As soon as the soil water drains out, the diurnal cycles in the stream disappear, which complicates attribution. A further complication is that the strength of both signals are very different. While a good snowmelt day can input into the soil amounts of water in the order of tens of mm (30-90 mm per day), transpiration takes out of the soil water amounts in the order of a few millimeters (2-4 millimeters per day). In the supplemental review materials (page 12, lines 28-34) we clarify why we say that disentanglement and attribution is complex:

"[...] we did not find more direct indications of the balance of individual contributions such as recognizable changes in the symmetry or the emergence of multimodality in water level diurnal cycles. A reason for this is that the strength of snowmelt and transpiration signals are different. Water inputs into the soil from snowmelt in a typical day are of the order of tens of mm (30-90 mm per day), however transpiration uptakes out of the soil water amounts in the order of a few millimeters (2-4 mm per day). With an extensive snow pack on the ground, snowmelt fluxes dominate diurnal hillslope storage fluctuations. This, and the varying interaction between the signals due to the shift in their timings, make it difficult to directly observe or determine the individual contributions of diurnal water inputs and uptakes on the observed hillslope response."

page 12, line 29: Check grammar. Grammar corrected, thanks.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-166/hess-2018-166-AC2-

supplement.pdf

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