Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-166-AC1, 2018

Hydrology and Earth System Sciences
Open Access
Discussions

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

Brett Woelber et al.

bwoelber@gmail.com

Received and published: 24 June 2018

Comments from Reviewer #1:

Woelber et al. have collected a very nice dataset of diurnal fluctuations in wells, streams and sapflow, and they have a descriptive presentation of their measurements and discussion of related publications in the field. However, I fail to see how this paper advances our scientific understanding of the processes involved. I would recommend that the authors formulate clear hypotheses and focus their work to specifically test these hypotheses. For example, if they want to investigate the snowpack energy balance related to the diurnal timing, they should run an energy balance snow model and

explicitly test this process and then use their data to support or falsify their hypotheses. There is potential in this dataset, but further work is needed before publishing a paper.

Response from Woelber et al.:

We thank Reviewer 1 for their time reading the paper. Our work provides significant observational insight into how diurnal energy cycles drive small-scale pressure variations in a snow-dominated hillslope-stream system and contributes to our understanding of how the snowpack mediates hydrologic behavior at the hillslope and subdaily timescales. Although streamflow variations induced by diurnal snowmelt and transpiration pulses has been studied before, how these processes evolve and combine to generate the observed diurnal hillslope and stream response is still unclear and warrant more research (Graham et al., 2013). We are presenting an observational study, along the lines of many other published studies (e.g. Lundquist and Cayan, 2002, Caine, 1992, Hood and Hayasi, 2015), not a modeling paper. However, to guide the analysis and answer the research questions we used a simple conceptual modeling framework that extends that proposed by Loheide (2008), which has proved very useful to understand small-scale diel hydrologic processes. Although we disagree with the notion that complex models are necessary to test hypotheses and advance science, we agree that running an energy-balance snow model, as suggested by the reviewer, has merit and could yield new insights. That approach is well beyond the scope of our study, however, and would result in a different paper from the one we submitted for review.

To address the suggestion that we more clearly articulate the research questions and hypotheses, as well as the specific insights contributed by the paper, we have revised the paper, especially the introduction and conclusions. The modifications are highlighted in the revised paper attached as supplemental review materials. However, for completeness we reproduce here the specific research questions we address in the paper:

How does the snowpack mediates the interaction between atmospheric inputs and hillslope response in snow-dominated regions? Does night-time snowpack refreezing significantly alter the timing of water pulses into streams? How much and in what form do direct snowmelt and vegetation water uptake pulses contribute to producing the observed diurnal pressure variations in the soil saturated layer? and, How are water pressure variations induced by the diurnal solar cycle transmitted from the hillslope to the stream?

We start our research from the assumption that in our study site, during the melt season, diurnal variations in the snowpack energy state, as well as alterations in flow timings and pathways induced by changes in snowpack depth and density, are larger controls on the amount and timing of diurnal and seasonal water inputs into streams than transpiration or contributions from the mountain block aquifer. This is highlighted in the last paragraph of the Introduction in the revised manuscript. This initial assumption is the implicit working hypothesis that guided the research. The evaluation such assumption led us to quantify the relative contribution of snowmelt pulses to total diurnal pressure variations in the hillslope-stream system and to interpret seasonal variations in the timing of diurnal pressure peaks. The manuscript is also driven by a methodological hypothesis, which is now explicitly stated in the first paragraph of section 3.3 of the revised manuscript (see supplemental review materials). This conceptual model assumes that pressure dynamics in the soil saturated layer are the sum of separable horizontal (hillslope throughflow) and vertical (snowmelt, transpiration) water fluxes. Furthermore, we posit that local daily pressure variations are induced by superimposed cyclic snowmelt and evapotranspiration pulses. Interference in the signals should be observed in the resulting pressure variations as the amplitude and phase of input signals are modified by processes that delay and alter the duration of snowmelt and evapotranspiration, such as nighttime snowpack refreezing, snowpack depth, or changes in soil absorptivity.

Direct answers to the research questions indicated above are that in our study site, soil-water pressure fluctuations are dominated by the snowmelt signal and that the effect

of transpiration is more subtle. We did not observe the change in the shape of diurnal pressure waves reported in other studies when groundwater fluctuations transition from being snowmelt controlled to being evapotranspiration controlled. However, an apparent beat interference pattern in the soil-water pressure signal emerges as indication of the interaction of both input signals. Another relevant results is that cold content accumulated in the snowpack by nighttime radiative losses can delay the production of snowmelt up to 3 hours, especially early in the melt season, which is an important portion of the daytime period. Furthermore, we use our modeling framework to quantify the relative contribution of vertical fluxes to total hillslope throughflow in our study area, which can be up to 20%, and the role of soil absorptivity in damping the propagation of these pressure pulses toward the stream. These and other results directly answering the research questions are more clearly listed in the Conclusions. To increase clarity we have moved the ecological and management implications of these results out of Conclusions.

Finally, we want to point out that the manuscript contains methodological details and field methods that can be useful to guide the experimental design and data analysis of similar studies. We hope that these changes aiming at increasing the specificity of the paper goals address the reviewer concerns about the value of the paper and the specific research questions and hypotheses we investigated.

References:

Caine, N.: Modulation of the diurnal streamflow response by the seasonal snow cover of an alpine basin, J. Hydrol., 137(1–4), 245–260, 1992. Graham CB, Barnard HR, Kavanagh KL, Mcnamara JP. 2013. Catchment scale controls the temporal connection of transpiration and diel fluctuations in streamflow. Hydrological Processes 27 (18): 2541–2556 DOI: 10.1002/hyp.9334 Hood, J. L. and Hayashi, M.: Characterization of snowmelt flux and groundwater storage in an alpine headwater basin, J. Hydrol., 521, 482–497, 2015. Loheide II, S. P.: A method for estimating subdaily evapotranspiration of shallow groundwater using diurnal water table fluctuations, Ecohydrology, 1(1), 59–66, doi:10.1002/eco.7, 2008. Lundquist, J. D. and Cayan, D. R.: Seasonal and Spatial Patterns in Diurnal Cycles in Streamflow in the Western United States, J. Hydrometeorol., 3(5), 591–603, 2002.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-166/hess-2018-166-AC1-supplement.pdf

---

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