

***Interactive comment on “Shallow soil moisture – ground thaw interactions and controls – Part 2: Influences of water and energy fluxes” by X. J. Guan et al.***

**Anonymous Referee #1**

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This work presents an investigation to the water and energy budgets for three subarctic sites in Canada. The goal is to answer the question: What are the dominant hydrological and energy controls on the interaction between shallow soil moisture and frost table depth in soil filled areas located in the subarctic (Canadian) Shield? The connection between shallow soil moisture and frost table depth is made in a companion paper. This work is well-written and warrants a stand-alone manuscript, but need some major revision before it can be accepted for publication. Most important, the authors need to provide more clarity to their estimates. This should be done in terms of addressing uncertainties and clearly stating assumptions (and potential limitations). In the following, several general comments are made that should be considered during revisions.

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Minor/editorial comments follow at the end.

A much better presentation of the Peclet number as it is being interpreted in this study is needed. There is a lack of background in what is presented. This is needed to help the reader appreciate the differences between the current interpretation of a Peclet number and interpretations made in other disciplines and other hydrological studies. Also, the authors need to better outline the inherent assumptions made when they consider a Peclet number here. Is it fair to say that, for example, total conductive energy is the same as (or similar to) a diffusivity term? What about advective fluxes and their difference/similarity with convection? A better overall review of the concepts and assumptions is needed. If not, the reader is left pondering if the ratio defined in Eq. 15 is truly a Peclet number or if there might be a better dimensionless number for heat transfers.

In general, the water and energy budgets are well presented. I wonder, though, about the uncertainties associated with these estimates. There must be (as noted by the authors) some variability across these three study sites. Yet many of the estimates made (in terms of both heat and water budgets) assume uniform values across the area of each site. Is it strange to assume uniformity across the sites when applying the Peclet estimates? Could the authors comment some on that and/or address the uncertainty explicitly in their estimates? That would help strengthen the analysis as it would allow for the differences estimated between the sites to be made independent of any uncertainty associated with the estimates (regardless if uncertainties come from measured values or assumed parameters). Another way of thinking about this is ‘How large would the error bars be on the different terms in the water budget reported in Figure 4?’ Are the uncertainties associated with each estimate on the same order of magnitude as the estimates themselves? If not, can we be sure that these order of magnitude estimates are within the right order of magnitude?

Also, somewhat connected to the above, I miss a validation of the water budget. When reading the manuscript, it appears that the authors will do this since they present a

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method to estimate change in storage from the water budget and have data available to estimate storage changes from observations of shallow water (i.e., Eq. 12). Figure 4 shows the calculated value (I assume) from Eq. 1 (i.e., the water budget). How well does this value compare to the observation estimated values? At P73, L8 there is mention of a missing flux term used for correction of the water budget. What is this value? How much temporal variability does it have? It would help add validity to the reported water budget if this value is given. For example, is this value the same order of magnitude as the overall influx of water to the wetland site? Adding this information would make the methods and uncertainties more transparent to the reader.

Minor/editorial comments P71L14: 'are needed to be understood'?

P76L11: Does the s subscript in  $ls$  mean surface? Before it meant snow (Eq. 2). In general, I begin to find the different subscripts confusing. This could be made clearer and/or an appendix listing clear definitions of all terms/parameters could be provided.

P76L15: What is a C pipe? Not clear to me.

P77L5: Hydraulic conductivities range across 4 orders of magnitude here. How does this uncertainty influence your estimates? How do all the uncertainties in the values in Table 1 influence your estimates? See above comments.

P87L16: I assume that 'wetland' here should be 'valley'?

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