Interactive comment on "Shallow soil moisture - ground thaw interactions and controls - Part 2: Influences of water and energy fluxes" by X.J. Guan, C. Spence and C.J. Westbrook

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Response to Referee #1 Comments (in bold font)

We thank Referee #1 for the comments posted on 17 February 2010. We acknowledge the Referee's helpful suggestions for improving this paper. These suggestions will be considered in the final version of the paper.

Response to specific comments:

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.

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.

- **While the variables used to calculate each of the Qg terms in Equation 13 do not explicitly match those in Equation 14, Equation 15 stays true to the underlying concept by calculating heat transfer ratios. Since each of the Qg values in Equation 14 is calculated differently from those in Equation 13, that prompted us to call our equation the modified version – but still true to the original concept of finding the relative influence of one heat transfer against another. More information relating to the Peclet number has been added.**

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 strength the analysis as it would allow for the differences estimated between the sites to be made independent of any uncertainty associate 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?

- **Additional information on the assumptions and limitations in the water budget and Peclet estimates have been added and stated more explicitly in the paper. With the issue of variability and uniformity across space, through logistics of data availability, we and many other studies of water budget have to make some assumptions of uniformity across space in the water and energy budgets and some of these are carried through to the Peclet number – to make this more clear, this uncertainty is stated in the text more explicitly now.**

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 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.

- **The plan was to use the storage values from the two approaches to determine an estimated uncertainty. However, as P73L8 noted, various missing fluxes needed to be filled in (cannot be measured/estimated for various reasons, e.g. surface outflow from wetland site during earlier part of season because of extensive sheetflow). Using the observed storage change twice in the water balance would have created a circular calculation. P73L8 actually meant the water budget was used to approximate the missing flux term rather than the inverse. The actual missing fluxes from P73L8 are listed now. Overall, more accuracy/error values, assumption and limitation notes have been added to the paper.**

P71L14: 'are needed to be understood'?

- **Fixed**

P76L11: Does the s subscript in Is 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.

- **The subscript in I_s is for surface rather than snow. An appendix will be included with the final paper to make the symbols and abbreviations clearer.**

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

- **Extra deep pipe. Fixed in text now to better clarify.**

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.

- **Sensitivity analysis was carried out for K in the subsurface flow calculation and found to have negligible influences due to an overall low subsurface discharge. From Table 1, hydraulic conductivity and specific yield were used in Equation 6 and Equation 12, respectively. Relating to previous comments, accuracy for both subsurface flow and observed storage change have been included in the paper.**

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

- **Thanks for pointing that out. Corrected.**