

Reply to Interactive comment on "Field-scale water balance closure in seasonally frozen conditions" by X. Pan et al., Anonymous Referee #2

We would like to thank the reviewer, Jim Buttle, for taking the time to review our manuscript and for providing constructive feedback.

A number of markups on the PDF of the manuscript were provided by the reviewer, most of which are straightforward corrections which will be adopted in a revised manuscript without further comment here. Non-trivial corrections are addressed below under “Reply to minor comments”.

By our reading, the reviewer has three major comments that we need to address:

1. Refocus the paper to emphasize the novel contributions

The reviewer correctly notes that the processes that we describe in our paper are not novel process descriptions/explanations. The contributions of this paper are: i) that we explicitly look at these processes and the water balance on an integrated scale, namely the field scale, root zone, by considering field-integrated observations; ii) that we seek to test existing hypotheses against our dataset at this scale (and essentially find that we corroborate these hypotheses); and iii) we seek to clearly show the limitations of using water balance residuals terms as either field based estimates of fluxes, or as a means of validating models (a point which is perhaps not novel in general, but is routinely violated in practice, including in the academic literature). On the latter point, we show that it is useful, in the Canadian prairies, to consider three separate time periods, (snow accumulation, melt and summer), with some periods raising less difficulties for water balance residuals than others. The single greatest problem in terms of quantifying the water balance, is partitioning of melt between runoff and infiltration, and we feel it is valuable to point this out. We do agree that these contributions are not as clearly described as they could be, and we will endeavor to improve our Abstract and Summary and Conclusions sections.

2. Present a complete error analysis of the various water balance components, and define what is meant by closure

In terms of closure, we do have a definition on page 3, line 4: “In the current paper, we define the problem of water balance closure as that of independently quantifying each term in the water balance equation, such that the changes in storage within a specified domain and over some time interval are adequately balanced by the net fluxes into/out of that domain over the same time interval.” In our analysis we try to be clear about terms that are measured, and terms that are not, and we refer to the latter as closure estimates. We will try to include a more comprehensive error analysis on our observations, by estimating error bounds for observations of precipitation (due to under-catch), evapotranspiration (due to energy balance closure), SWE (due to spatial variability) and soil moisture (due to spatial variability – this is already included).

3. *Present our simplifying assumptions more clearly, perhaps as testable hypotheses.*

We think our point wasn't really to make simplifying assumptions, but to rather explain where observations are unable to capture a particular process, and highlight this as a problem – the biggest of these being the partitioning of melt into runoff and infiltration. The problem then is not coming up with testable hypotheses, it is coming up with ways to test existing hypotheses. We hope this will be clearer in a revised manuscript.

Reply to minor comments

p. 11, line 19: The length of the piezometer screens was 33 cm. The piezometers were 5.5 m long and the water table was no deeper than around 4 m below ground. In this situation, we expect the water table elevation and the potentiometric surface at the mid-point of the screened section to nearly coincide. We will further clarify in a revised manuscript.

p. 13, line 21: We agree that the surface temperature data is important (also Review 1 raised this) and we will include this data in a new figure, or as a subplot in an existing figure.

Section 3.3 contained various awkward phrasing that we will improve.

Table 1 labelling will be improved for clarity, and the associated discussion in the text will clarify the rationale for the columns labelled “closure estimates [mm]”.

Figure 3 and Figure 9 have a caption title that starts “Non-closure of the vertical field-scale water balance...” and perhaps this phrasing leads to confusion. We will delete “Non-closure of” from the start of these captions. The broader point about what we mean by this was discussed above.

Figure 8 – a concern regarding the legend that was also raised by Reviewer 1 and will be resolved in revision of the paper.