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Discussions
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Interactive comment on "Field-scale water balance closure in seasonally frozen conditions" *by* X. Pan et al.

Anonymous Referee #1

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In this manuscript the authors describe a study that confirms care must be taken when using residuals of the water budget to estimate hydrological fluxes. This is a particular problem in cold regions where measurement accuracy is typically lower. Furthermore, the results as presented suggest such residuals would be associated with high levels of uncertainty, because the residuals contain all the error associated with the estimates of the other fluxes. This is perhaps not a novel finding on its own. Could I suggest that the manuscript would be much improved if the authors, particularly in the discussion and the summary, focused on the implications of this uncertainty (as is noted in the abstract), or make recommendations of when certain observations could be more or less important to reducing the uncertainty in the residuals? This type of discussion would elevate the paper.

Furthermore, there are three major issues that should be addressed as the manuscript

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proceeds.

First, there needs to be better analysis of the available data, rather than making assumptions of hydrological behaviour. For example, the effect of antecedent soil moisture on infiltration and runoff.

Second, the authors' conclusions on the influence of antecedent conditions need better justification and discussion. Explore alternative theories (e.g., the rate of snowmelt), and the subtleties of differences in soil moisture. The differences in antecedent moisture were not substantially different between the two study years.

Third, the summary is poor, and needs to be written to provide more impact for the reader. Perhaps this can be addressed as the authors expand the discussion of uncertainty in water budget residuals.

Minor comments:

ABSTRACT

Line 8: It is not impossible to measure water budget terms independently in the field. It is difficult, and maybe uncommon. Perhaps rephrase the sentence to say ". . .... yet in practice it is uncommon to measure every . . .."

Line 17: The snow pack does not infiltrate. Rephrase ". . . melt from the snow pack mostly . . .."

INTRODUCTION

Page 4 Line 22: I'm not sure you need this sentence on salts as it is tangential to the water budget problem that is the focus of the paper.

Page 5 Line 4: Exactly because of the issues discussed in this paper, I have always shied away from the term "water balance", and preferred to use the term "water budget". The authors might consider using the latter term when appropriate in this manuscript.

Page 5 Line 11: Drainage fluxes while measured at a point in space, and not point measurements, but integrated over an area. They are not measured at a point scale, and this sentence needs to be corrected.

Page 6 Line 10: The figures in the paper are not presented in order. The first figure presented should be numbered one, not five. Furthermore, maybe the content in these couple of sentences should be presented in the results section.

Equation 1: The field scale vertical water budget should also include melt (M).

Page 6 Line 16: Perhaps G should be ". . .. net drifting snow over the field domain . . .." That might be more accurate.

Page 7 Line 12: I disagree that a +2°C temperature is a killing frost. Maybe -2°C; is this what the authors meant?

Page 8 Line 9: Streamflow is typically a rate (m3/s), but here the total volume is presented. That would be yield. This sentence should read " Mean annual yield in the Brightwater . . .. . ."

Page 13 Line 14: Again, check the order in which figures are presented.

Page 13 Line 20: Please provide the data that supports this statement that there were similar surface temperatures. Furthermore, it is wrong that wetter soils freeze faster or deeper. Wetter soils are warmer soils because of the energy required to freeze the water content. An alternative hypothesis that the authors do not consider to explain the different soil temperatures was the growth of snowpack development relative to the air temperatures.

Page 14 Line 10: Another flux is vapour migration from the snowpack to the soil. This is what creates depth hoar in the snowpack. Quinton was one of the first to document this.

Page 15 Line 3: It is effective drainage area not contributing area; stay consistent to

the language you used earlier in the paper.

Page 15 Line 8: Showing increases in soil moisture as negative is not intuitive. Perhaps this should be changed.

Page 15 Line 23: I disagree that the soil moisture conditions were strikingly different. They were both near 0.2. This is not enough to explain the different responses.

Page 16 Line 3: These are saturated at this level? What is the porosity?

Page 17 Line 3: if the error is due to unaccounted for soil drainage, why did it not happen in both years? Please discuss.

Page 18 Line 13: As noted in the major comments, the authors need to expand the discussion to include the implications for hydrologists. Also, a good reference to include in this would be Barr et al. (2012).

Barr et al., 2012. Energy balance closure at the BERMS flux towers in relation to the water balance of the White Gull Creek watershed 1999–2009. Agricultural and Forest Meteorology 153: 3-13.

Page 19 Line 7: This should read ". . .. because we did not measure the fluxes. . .. "

Figure 2: Could the authors please provide an explanation for the strange soil temperatures in 2014. Also, related to the discussion the authors have a 'post snowmelt' period, it was hard to judge exactly where on these figures that was, so perhaps another vertical line would help.

Figure 6: If the authors had a Geonor precipitation gauge, why not present daily precipitation rather than 10 day intervals?

Figure 7: There was no change in soil moisture post thaw in 2013? And shouldn't net precipitation be negative – see Table 1.

Figure 8: Why are there 4 lines, but only 3 in the legend?

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