Review of: On the energy budget of a low-Arctic snowpack

For "The Cryosphere"

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Overall this paper should be published. There are earlier papers looking at snow energy balances in the subarctic/low arctic (I refer to Anthony Price' early work in the Schefferville area when he was a PhD student at McGill). In the Lackner et al paper there are notable discrepancies between the real world and the model. Though I thought the discussion was quite good it might be an idea to add a few words directed at the model and why it doesn't seem to model Qh well. There is acknowledgment of this but I wondered if the authors, after their experience with this data set have suggestions to better the model? I have made a few comments below some out of curiousity and others more specific. In tundra environments herbs and shrubs in the snowpack can play a role in the energy balance at I assume they can…especially in the late winter when the sun is becoming more intense and in the early spring as they absorb radiation (I understand coniferous plants can photosynthesize under the snow surface).

Overall I would accept the paper with some minor modifications.

Page 3: line 50: they measured ground heat flux under the glacier? Is that right?

Line 53: small point: would be slightly clearer to say that 50% of the winter precip is **lost** to sublimation

Line 59: though in the subarctic, the earlier study by Price (PhD at McGill) was a detailed energy budget of a snowpack. (Water Res. Res Vol12:4: 686-694

Page 7: line 145 or so: as the density of the snowpack changes the amt of air space changes…would this not have an impact on calculating the heat capacity of the snowpack?

Page 8: Line 179: 12 m or 1.2m? earlier you state that you have thermocouples at 4 and 14 cm…so not sure what you are doing here…assume this is a typo

Line 180: did you measure field capacity in the lab

Line 194: a small question (though it probably makes little difference) do you adjust specific heat wrt temp – I assume you are but would it make much difference? Thinking here too about air in the snowpack

Figure 2: Probably quite explainable…however there are places here where your snowpack

drops significantly over what appear short periods of time…wind? (coupled with compression) -for example 2018-19 late Jan there is a snowfall (i assume) and on or about 7 FEb there is a sudden drop of snowpack height from about 55cm to 40cm (or so)/ as well in 2019-20 late Feb snowpack is about 75cm or so and by mid March around 60cm…significant wind at this time..assume it is wind scour

p10. Line 255: I assume that this pattern of precip is tied somewhat into the proximity of Hudson's Bay….does the drop in precip in December tie into ice covering a large part of the bay?

Figure 3: net radiation in 2018-19 in early January show a slightly positive balance out of curiousity what is happening here; similarly 2019-20 in early March; in both cases longwave in and out is balanced …significant cloud cover? Thinking that in years ahead with more of Hudson bay staying open longer there may be increased cloud cover…might be interesting to speculate how this may play a role in the energy budget of these low Arctic snowpacks?

Figure 6: you are inferring a linear relationship here…is there any point? are these relationships significant? What might be interesting is to look at (for example) in (b) at Ts-Ta 1°C to about 2.3°C the range of Qh is very large, though focused primarily between ~+50 and -45 W/m2…for more or less similar Ts-Ta values you get a very large range of Qh: is there anything of interest here: similarly for (d) between ~.15VPD and .18 VPD a very large Qe range

P 14 line 280: are these relationships statistically significant? Though when looking at these relationships the important thing is the visual message that the model in Qh and Qe under/overestimates for a reasonable range of the W/m2 range

P15 Line 301-302

You refer here to residual snowpack heat flux. In our experience in subarctic and low arctic snowpacks there can be a notable concentration of coniferous shrubs that absorb energy and appear to be photosynthesizing (we were not measuring this but colleagues mention this goes on). Is the snowpack in any way impacted by energy absorption by shrubs in the snowpack at all? Seems it might…of course depending on the characterisitics and density of the shrubs. I see no mention here of shrubby veg…so assume this isn't the case here?

P 15 line 294: would the sensors be in any way impacting the energy balance? as they are close to the surface of the snowpack/ what about blowing snow along the surface…impact the ability of the sensors in any way?

Figure 7. so with Qh you have wide scatter in the model. might be interesting to look at some observed values of Qh and investigate the very large range of modelled responses…to isolate what other variables might be playing a role in producing a large range/

for example at ~+10W/m2 (observed) you have a range of modelled responses between ~ -5 and +35 ….in the upper range of the modelled responses versus the lower range were there any standout differences in other variables (wind speed?)

Figure 7 and Figure 8
I see why you have included Fig 8 but there are some interesting differences between these figures which leads to a couple of questions. 1. In Fig 8 where you are confident you have good control on all measureable variables there is very good agreement between the modelled and observed Qe. However in Fig 7 there is consistent underestimation (I think I am reading this correctly). So what did you learn (and what could we learn) from this discrepancy with respect to the model and where the issues are?
2.With respect to Fig 7 if it wasn't for a number of values >25 W/m2 or below -5 W/m2 the relationship could well be close to vertical as I would guess 90+% of the values fall within the large lump. In Fig 8 the model again overestimates under very good controlled conditions. Any idea why the model seems to overestimate sensible heat? Any physical explanation?

P17. Line: 315: I assume crossing out the Qa term simply means that while you identify it is important it is not included here…the arrow to the zero?

P17 Line 326: so you have more energy coming in than can be accounted for in heat loss from the system/ possibilities? (a bit of guess work here)underestimating energy used to raise the temperature of the ice in the snowpack to melting point? Early in the melt as melting water infiltrates the frozen ground (is it?) the runoff refreezes complicating the issue? Some issue with calculating heat loss from the snowpack re: turbulent fluxes…..and going out on a limb here but are there periods when you may have laminar flow and underestimating heat loss// later I see that isn't an issue…but thought I would leave this comment in

P17 line330: the phrase: "*slightly* less"… are you being generous using this term especially for Qh? re: fig 7

P17 L333: issue re: observations of instrument location an issue…
P 19: line spelling of *recommend*
P20 Line 397: again, if herbs and shrubs are present are they playing a role here?
P21 line 436: spelling of word: *consisted*