

The Cryosphere Discuss., referee comment RC1  
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## Comment on tc-2021-313

Anonymous Referee #1

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Referee comment on "Impact of measured and simulated tundra snowpack properties on heat transfer" by Victoria R. Dutch et al., The Cryosphere Discuss.,  
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Review of "Impact of measured and simulated tundra snowpack properties on heat transfer", submitted to The Cryosphere, November 2021.

The paper deals on modeling the heat transfer through the snow pack in order to obtain the variability of the soil temperature through two different snow seasons in the Canadian Arctic. The work is well presented and the topic is dealing with critical issue related to snow thermal conductivity. There is no doubt it fits into the scope of TC.

General comments:

Thermal conductivity of snow is critical and still very challenging to access. Field measurements have been proven to be satisfactory to a certain level but the inclusion of theoretical equation (or assumption) into models is not yet actual. While most of the main parameters have been discussed and tested, and appropriate literature cited, in order to explain the differences between measured and modeled snow KT, the hardness of the snow pack has never been mentioned in the work, neither its permeability. For sure hardness is kind of included if we think of the measurement using micropen, but as demonstrated in the work, such measurements had to be tuned to the Arctic snow pack as originally validated for Alpine snow packs. Vapour kinetics transfer are necessary to form depth hoar, but the original structure of the snow on ground will also affects such transfers.

The depth proportion of each different layer is indicated on fig 2 but not discussed, as for example to presence of indurated depth hoar in 2019 and not in 2018. Both seasons had some warming events, which seems to not have affected the soil temperature, but what about the snow pack and the formation of internal, even small, ice layers? Are there any relation between the wind (speed threshold during storms?), the amount of rain/positive degree days and the errors in term of soil temperature? It is also surprising that no wind

data are presented in the climatology...

Snow depth has been shown in the work to be the dominant factor for applying the correcting factor, but if one think of snow being deposited as a single homogeneous layer, then only the physical snow parameters are of interest. The amount of snow layer and their internal properties would be then the controlling factor, for example an very hard and dense snow layer or thick ice layer with a low permeability likely to enhance the formation of depth hoar. Such phenomena are likely to be more present in the future as it is expected more extremes events in the Arctic. I do not think it is necessary to change a lot of the work done and am sure all the data are available in the runs done.

A discussion around that topic is to me of interest in order to pave the future work into such topics and go further into the effects of snow heat properties on the soil's ones, as it is unlikely in the coming years we would be able to develop, and run, a full model with a proper physical scheme for snow thermal conductivity, without considering the validation. It is then today only by using such work presented in this paper that we could be able to better understand the soil-snow-atmosphere feedback in the Arctic.

Minor comments:

Line 117: am not sure a value of 2 for k is what was intended to write

Figures 8 and 9 appear before 5, 6, and 7

Figure 3, November appears before March from left to right