Reply to Reviewer 1

The Reviewer's comments are in black, and our response is embedded in the text, in blue italics. Line numbers refer to those of the version in track changes mode.

General comments: The paper analyzes measurements of thermal conductivity of snow and soil in the Arctic, specifically at Bylot Island, Canada. Measurements occurred through 3 field seasons, and values compared to other studies, and to modeled values from the French snow model Crocus. Results are very interesting since it is suggested that a bi-modal distribution can be used to characterize the soil thermal conductivity. Simulated values from Crocus are contrary to measurements, the authors explain this by the absence of upward vapor flux from temperature gradient in the model.

Overall, the analysis and measurements are thorough and are quite relevant for the improvement of snow modeling in the Arctic, which remains poor. This paper provides insights on improvements needed for a better assessment of climate variability in the Arctic. I recommend this paper for publication in The Cryosphere, after minor revisions detailed below.

Thank you for these positive comments.

Specific comments:

Section 2.1: The authors describe the vertical locations of NPs and thermistors. One was moved following observations of depth hoar height. Furthermore, the chosen height for the other NPs and thermistors seem to be motivated by stratigraphy, which makes sense. However, such detail is not mention. It would be nice if the authors explain the reasoning behind the 2-12-22cm heights for NPs, and the 2-7-17-37 for thermistors? Also, why are thermistors at different height than NPs? They seem aligned with the initial positions of the NPs (7-17-27), why were they not lowered to match the NPs?

NPs were initially placed arbitrarily before we had a chance to observe the snow. Subsequently, thermistors were not moved to allow heat flux calculations. This is now mentioned lines 84 and 87.

I will leave to the discretion of the author to include a map of Bylot to Figure-1.

We have now added a map.

Line 142: I would clarify why depth hoar are more conductive in the vertical direction (i.e. owing to the higher thermal conductivity of ice relative to air, and an elongated grain). . . And why is it more conductive horizontally in wind slab?

This is detailed at length in the references given (Calonne et al., 2011; Riche and Schneebeli, 2013), and we feel that repeating this here would unnecessarily lengthen the paper.

Section 2.3: Although the modeling is described in details elsewhere, I would put a little more details here, otherwise the section can be removed and stated elsewhere since it is only 2-3 sentences long. The authors could simply add the data that was missing, the reasoning using ERA, and how Crocus computed thermal conductivity. The conclusions are significant with regards to Crocus, and more context need to be provided here for the reader's understanding.

We have added a brief sentence regarding ERA and mention how thermal conductivity is calculated in Crocus, using a simple correlation with density (lines 179-181).

Figure-2 has very poor resolution and consequently very hard to read.

We have improved Figure 2.

Section 3.1: I assume SSA are from DUFISSS? This should be mentioned in the paper .

Yes, this was already mentioned in the methods section (now line 165)

Figure-6: dates are in French

Not just Figure 6. This has been corrected throughout.

Section 4.3.: A figure on Crocus output, visualized profile with marks on the melt event would greatly help the understanding of this section. The authors could display Crocus thermal conductivity and snow temperature (or temperature gradient). The problem of density profiles and simulated grains would be more obvious.

Do we really need an extra Figure while other Reviewers request condensation? One of the main points is really that Crocus predicts melting in the early season and does not predict the transformation of the melt-freeze crust into depth hoar, and this is well detailed. Note that if the editors request so, we will add a Figure showing the evolution of snow stratigraphy over the season, as predicted by Crocus, and the reader can compare that to Figure 2. The danger is that since spatial variations are important, over-interpretations of the differences may be made.