

## **Comments on “Spatial and Temporal Variation of Bulk Snow Properties in North Boreal and Tundra Environments Based on Extensive Field Measurements” by H.-R. Hannula et al., Geosci. Instrum. Method. Data Syst. Discuss.**

### **General comments**

This study presents an extensive dataset of snow depth, density and SWE in Lapland, Finland. Different types of land (open area, forest, ...) are studied. The main goal is to provide ground measurements to support remote sensing snow measurements (comparison of data, parameterization, model validation, etc). Using statistical tools, the authors analyze the spatial variability of the above properties and the “optimal” sampling frequency.

The dataset is remarkable, result from a rigorous measurements protocol, and can be useful for different applications. It represents a considerable work that has to be acknowledged.

The spatial variability study is interesting but the novelty of the results should be presented more explicitly. Discussion about previous studies and results comparison are missing. There are more suitable instruments, such as the snow micro pen (Proksch et al 2015), and methods (e.g. Reuter et al. 2015) to study the snow spatial variability (but probably not available during your 2011/2012 campaign). I think it would be helpful for the reader to better express the motivation of this spatial variability study in the context of the FMI work.

The paper is in overall well written. It can be shortened by being more concise in some paragraphs of the method and results section. The figures are suitable, except Fig 2, which is not described at all in the paper. The number of tables might be reduced by merging some of them together.

### **Specific comments**

Line 30: parametrise → parameterize

Section 2: The organization could be improved for a better clarity.

I suggest

#### **2.1 Study sites**

2.1.1 Sodankyla

2.1.2 Saariselka

2.1.3 Land cover: you can move here lines 142 to 162.

#### **2.2 In situ measurements**

Here in my view, you have to organize better and be more concise about your measurements. For instance, I don't see the reason why lines 117-129 and lines 130-138 are 2 paragraphs?

It would be clearer, if it is possible, to divide into subsection such as:

2.2.1 Snow depth & SWE

2.2.2 Snow density: I will move the density paragraph here

2.2.3 Snow pit measurements

#### **2.3 Analysis of snow spatial variability**

Line 86: which instruments were set up for the airborne acquisition? Which data did you get from these flights? In my view we need this information to understand your motivation to perform ground measurements of density, SWE...

Line 94: Fig.1 left: you should introduce the abbreviation used for the land cover classes before, otherwise we don't understand the color scale.

Line 107, You should not start your paragraph with details about the airborne, but with the general idea of this paragraph, i.e. line 117 "Manual sampling of SD and SWE along flight transects formed the core of the in situ data collection in support of each SnowSAR acquisition."

Line 107 to 113: I wonder if we really need the detailed planning of the airborne acquisitions. I will rather just say that ground measurements were performed during the day of the airborne flights to allow comparison (or the day after, if no strong changes, as mentioned line 114).

Line 124: the description of the tool used for snow depth measurements is missing here. Since you also used the MagnaProbe, you should give a name for this method (latter on, line 199, you define it as conventional method).

Line 127: is there a reference paper on the MagnaProbe? If yes, please cite.

Line 125: the description of the tool used for the SWE measurements is missing.

Line 132: "The main objective..." either this sentence is redundant with line 117, either it should be moved in the beginning of the paragraph.

Line 135: "Additionally, the manual snow measurement...": you have to be more specific, what measurements did you do? Stratigraphy, Ramsonde, temperature profile, etc, with which tools?

Line 163 to 176: I will move this density section above, as suggested in the plan above.

Line 163: Give the equation to retrieve density from depth and SWE, also it is trivial.

Line 171: From your computation of density, is that right that you compute the SWE from depth values in a 10 m radius location? Please clarify in the text. Did you study the error that you do by using 1 density value for all the SWE estimations over a 10 m radius area?

Line 172: "For some data points no density..." either you explained why, either this sentence is not useful since we don't get anything from it.

Line 177-179: should be move in the "snow pit" paragraph.

Line 189: Explanations and references are clearly missing about the autocorrelation method.

Line 199: the information of the snow depth measurements should be moved to the data collection section.

Line 205-214: it might be helpful to give references for all the statistical tests that you are using.

Line 216: delete comma after “investigated”.

Throughout the results section: You should give number instead of only use qualitative words like “low values”, “higher than”. It will give more “dynamic ton” to your writings. I also think that you can be more concise and only mentioned the results that lead to interesting interpretation.

The section could be rename “Results and Interpretation” since you already interprets your results for some of them.

Line 238: it would be nicer to start by an introductive sentence about Figure 3. Explain what is the red line and blue box. Give to the reader a big picture / overview of your SD values, before to go in the details.

Line 240: “generally lower than”, “than” is missing

Line 265: I think you can insert a paragraph break before “Regarding...”

Line 291-293: Give values instead of colors.

Line 300: “Temperature profiles reflect the fact that air temperature was the same at all pits measured on the same day; the differences in the snow surface temperatures can be explained by the differing measurement times.” How can you distinguish the air temperature from the snow surface temperature in Fig 6?

Line 305 to 311: All this paragraph should be move to the method section when you explain the autocorrelation analysis.

Line 323: What is the mean coefficient of variation?

Line 323: I will write “coefficient of variation” instead of using the abbreviation “CV”. A page latter, I would guess that readers would have already forgot this definition.

Line 328 and Table 5: you have to explain the analysis you did in the method section and define all the term “Df”, “t-statistic”, “p”, etc. What does it mean and represent?

Table 5: The term “snow depth” does not appear here and neither in the legend! Please give also the unit.

Line 351: "land cover specific density values": what do you mean? This appellation appears here but was not define before.

Line 390: What do you mean by "true variance"?

Discussion section: In overall, I found very few comparison / discussion of your results with previous studies. In particular, you should point out more clearly what are the new results from your work concerning spatial variability and sampling frequency.

Table 6: The column should be aligned.

Table 3 and 4: Can you merge these two tables together? Ideally 1 or 2 large tables regrouping all the small ones would be even better and make the information easy to find.

Table 3: Please add the unit.

Fig 2: This figure is not commented in the paper, so either there is something interesting about it and you should describe it, either you delete it.

## **REFERENCE**

Proksch, M., Löwe, H., & Schneebeli, M. (2015). Density, specific surface area, and correlation length of snow measured by high - resolution penetrometry. *Journal of Geophysical Research: Earth Surface*, 120(2), 346-362.

Reuter, B., Richter, B., & Schweizer, J. (2015). Snow instability patterns at the scale of a small basin. *Journal of Geophysical Research: Earth Surface*.