

The Cryosphere Discuss., author comment AC3  
<https://doi.org/10.5194/tc-2021-124-AC3>, 2021  
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## Reply on CC1

Anton Jitnikovitch et al.

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Author comment on "Snow water equivalent measurement in the Arctic based on cosmic ray neutron attenuation" by Anton Jitnikovitch et al., The Cryosphere Discuss.,  
<https://doi.org/10.5194/tc-2021-124-AC3>, 2021

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### Community:

Very interesting paper.

**Author reply:** Thank you for this review.

But, it is a rather technical article on the evaluation of a CRNS sensor, in that sense it is generally not the type of article from The Cryosphere?

**Author reply:** I respectfully disagree. The Cryosphere notes that the primary journal subject areas include all aspects of frozen water and ground on Earth and focuses on seasonal snow cover as well as in-situ studies of the aforementioned. Which is among the focus of this works. Note that there are similar papers with a technical focus published on TC. Refer to Howat et al (2018) <https://tc.copernicus.org/articles/12/2099/2018/> and Sigouin and Si (2016) <https://tc.copernicus.org/articles/10/1181/2016/tc-10-1181-2016.html>

Unfortunately, one regrets the comparison of the SnowFox with the CRS-1000 which was also installed at TVC, I think?

**Author reply:** Thank you. CRS-1000 are also installed at TVC, however, for this works, we elected to focus on solely the SnowFox CRNS model due to its limited testing in an Arctic landscape.

The weak point of this sensor raised about the need for soil water calibration is clearly highlighted. The authors could refer to the sensor comparison paper:

Royer A., A. Roy, S. Jutras and A. Langlois (2021). Review article: Performance assessment of electromagnetic wave-based field sensors for SWE monitoring. The Cryosphere Discuss. [preprint], <https://doi.org/10.5194/tc-2021-163>, in review, 2021.

**Author reply:** Thank you. We will review and consider this citation.

Have you tested the intercalibration between the 5 sensors?

**Author reply:** We did not test intercalibration in this works due to the proximity of each sensor to one another. However, this is an interesting topic to explore in future research. Thank you.

We would have liked to see a figure showing these spatial variations for some dates, in relation to the height of the shrubs for example. Is the sensor on the edge really representative of the tundra (it seems close to the shrubs, as seen in Fig. 3)? An analysis of the evolution of snow heights and densities along the transect would have been very interesting.

**Author reply:** Thank you. I will clarify the wording to state that the first and last CRNS are along the tundra-shrub boundary – in these areas, the shrubbery is only onsetting and the onset shrubbery height is significantly lower than within the shrub patch itself. We have considerably sized metadata of the evolution of snow depth and density along the transect throughout the two winter seasons, and although we did not identify a strong relationship between either parameter, we acknowledge this is an interesting topic to consider in future research.

### **Specific comments (L = line in the pdf version on line)**

L49-50 The statement “ Measurements of snow depth are typically not representative of the surrounding natural terrain as they are limited to point observations using ruler measurements or acoustic distance systems ” is also valid for SWE.

**Author reply:** Thank you. This is among the reasons we decided to focus the study on an Arctic snowdrift. Although deep drifts are small in area, they often contain a large portion of the total landscape SWE (Gray et al., 1974; Marsh and Woo, 1981; Gray et al. 1989; Marsh and Pomeroy, 1996; Sturm et al., 2001).

L87 “the SF measuring point SWE along a transect.” specify: with several instruments. As written it is not clear.

**Author reply:** Thank you. We will clarify this in the following submission.

L 175 The map in Fig. 1 does not seem to me to be very useful or necessary?

**Author reply:** There is value in immediately identifying the general location of the project sites – particularly for readers that are not knowledgeable on Canadian geography. Note that The Cryosphere is a publication on behalf of the European Geosciences Union.

L210 “standard measurement error » for snow core: see also the discussion in Royer et al. 2021 TCD.

**Author reply:** Thank you. We will review the discussion in Royer et al. 2021.

L245 Result section: Accuracy statistics should also be given relative to the SWE average, which is very low at the Ontario site (between 0 and 40 mm), and quite low at the TVC site (0-400 mm).

**Author reply:** Thank you. We will review and consider adjusting accordingly in the following submission.

Unfortunately, the distribution of the measurement points at TVC results in a regression (SWE vs. Counts) being defined almost by two points: a “0” point and a mean ~350 mm SWE point.

**Author reply:** Thank you. We will adjust this section for the following submission – including using a Theil-Sen Regression.

And why no scatterplot between SWE CRNS and SWE snow core?

**Author reply:** We prepared and considered including this figure in the original submission. We will revisit and reconsider for the following submission. Thank you.

L421 Conclusion: Finally, what is the recommended sampling frequency?

**Author reply:** This is dependent on several factors. Some factors include power capabilities, application purpose and scope, prominence of the snow feature being monitored, length of observation/study, the weather conditions during the monitoring period, and the geographic location. As such, the sampling frequency should be considered on a case-by-case basis. It is important to note that a higher sampling frequency will result in higher data resolution, but will come at the cost of increased noise.

Would it not be advisable to shield the sensor to avoid the important problem of contamination of the SWE signal by soil moisture?

**Author reply:** More research needs to be done to extensively compare the results of a grounded-in-situ CRNS, which is buried, to those which are placed on the soil surface. This is among the purposes of this work. Kodama et al. (1979) suggested either approach is feasible – we also believe both approaches have value and, in this work, have focused on the latter.