

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-314

Anonymous Referee #1

Referee comment on "Potential of X-band polarimetric synthetic aperture radar co-polar phase difference for arctic snow depth estimation" by Joëlle Voglimacci-Stephanopoli et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-314-RC1>, 2021

This paper presents the first work focussed on examining the use of the wave co-polar phase difference (from TerraSAR-X) to determine snow depth, using detailed field data from the western Canadian Arctic, over a variety of arctic vegetation. This work uses a detailed set of ground data collected at the time of radar acquisitions to explore the relationships and assess the utility over specific classes of vegetation. Results indicate potentially useful findings when the incidence angle was greater than 30 degrees, and the topographic wetness index was high. The manuscript suggests future work to apply these methods to develop snow depth maps – I think this would be especially useful for the reasons the authors present as well as for researchers in many other fields that are affected by snow depth – developing useful, attainable, high-resolution snow maps will be of great interest. This proof-of-concept paper presents the first results towards that goal. Overall, I found this to be a useful study that builds on the growing body of work regarding the use of microwave data in the X band for snow retrievals.

I have no major concerns with this manuscript, though I do note a few sections that could be strengthened through clarification in the writing as noted before publication. These recommendations should be doable within a reasonable amount of time and I do not note any major data re/analysis required to meet these recommendations.

It did take several reads to parse the stats component of the results section – I think it could be explained a bit more clearly. e.g. what exactly is the post-hoc Games-Howell testing for beyond the non-parametric ANOVA? A sentence to explicitly state why you are using them both would be helpful. What does it mean when the ANOVA says there are no differences, but the Games-Howell also reports only some significant differences? (lines 270-273) If you are reporting it to show the overall group stats as a whole, and then breaking them down further using the Games-Howell that would be useful to point out.

How should it be interpreted when results contradict – e.g. the TWI results contradict significance between the 2 tests run. This could all be my misinterpretation of the writing, but in that case, some clarification will make this much clearer.

Section 3.3 snow-SAR correlation – consider revising this wording as you did not do any correlations, you did regressions. Perhaps chose an alternate word like relationship? Or fit, since you did coefficient of determination. Some lines of text also mix correlation with regression (e.g. 325: No significant correlation was found), technicality perhaps, but you didn't test for correlation.

Table 2 raised more questions for me than it answered. It is unclear which in situ dates relate to which acquisition. The text says they are within plus/minus 2 days of the acquisition, but what dates are the actual acquisition from? Observation period covers many days - does each acquisition include data from many days? 24 scenes – how do the snow pits correspond with these? This needs a bit more clarification. It is clear the historical data used for the time series is from Orbit 24, but how many of the 104 scenes are in the 2019 period like the others?

3.2.1 – two snow pit characterization sampling strategies? Unclear what the second is. the revisited pits vs the ones elsewhere in the catchments?

Lines 303-305: Why the variability in the CPD annual mean? Is that an acceptable range of annual variability to group into an overall 2014-19 mean? Or is there any comparison that can be made. Presumably its related to different weather conditions year-to-year? but is there anything you can conclusively say about what is driving that? perhaps I missed that, but it would be interesting to know if the range in annual means can be explained by e.g. snow depth. Perhaps not as 14-15 and 17-18 years highlighted as the min and max are also the years missing from the climate data.

Objective 2 – I don't think you fully met this objective. You do show the temperature and precipitation data with the CPD, but is anything else examined? (see comment below about table 1). Nothing is gone into in depth in this section directly relating the meteorological data to the CPD other than the cyclical pattern between snow and non-snow times. You should consider making more use of the data to explore the meteorological links or revise the wording of objective 2.

A few clarifications and very minor typos that caught my eye as I was reading:

Something that would be useful is a sentence early on clarifying that the winter year you report in some places refers to the previous fall and next years spring (e.g. 2018 means 2017-2018)

Figure 1: define delta rho

Figure 2: text line 148 says east to west transects, figure shows west to east transect?

Figure 4: caption, depth shouldn't be capitalized, also you refer to it as depth hoar fraction elsewhere and ratio here

Figure 5:

"is shows" is shown

"Windows pixels size is 1x1 pixel (5x5m)" – explain?

Any established relationships between the temp/precip at the Herschel Station and somewhere on the north slope Alaska, or Tuktoyaktuk, That you can use to fill the gaps? Or is the weather too unique to the island? Might be worth a sentence clarifying that the nearby stations are not related, or too far to be used. Alternatively, is there a need to exclude the entire winter from the chart when some months are available? (end of 2017 is missing, but early 2018 is available – or is the data flawed?).

Figure 6: snowdepth on the x axis should be 2 words based on how its written elsewhere in the manuscript

Table 1: are you using the ECCC wind and humidity data for anything? Why list just those variables from the tower (and does the datalogger really matter)? If they are used, considering adding a column to the table for what they are used for.

Line 33: snow depth trend[s] (s missing)

Line 44: spatial (says special)

Line 49: (possible elsewhere?) Spaceborne is typically one word

Line 73: just terminology here, consider explaining kinetic metamorphic regime for the more general reader? Presumably, most readers will be snow scientists or related fields and understand this, but a few sentences to clarify would be helpful for those who are not.

Line 83: "...vertical direction after their setting up in the snowpack". While I understand what you mean here, the wording reads a little odd to me. Is 'setting up' in the snowpack common terminology? Consider a more formal explanation here?

Line 87-88: "such as used in this study or below as dry snow can be" – I think this sentence needs a comma, I believe you are referring to shorter wavelengths, but I did have to reread this one a few times.

Line 93: random? vs. randomly

Line 131: you probably need the full citation for ArcticDem here as well as other online data sets mention later

Line 158: snow depth [and] mean density

Line 256: SD decreased significantly? It was tested? Or this is just a word choice here? If I'm missing somewhere here with the stats test, no problem, but otherwise pick something that does not imply a stats test since you have several stats tests also being talked about. Substantially, or greatly, or ...

Line 258: "Along transect #2 (Fig. 4), and snow cover" remove , and