General comments:

I enjoyed reading this paper, very interesting, relevant research. I was very surprised to see a 10 m resolution backscatter product with such good performance measures. In my opinion a groundbreaking paper that shows the potential of S-1 SAR snow depth retrieval in mountain areas. Some adjustments are however necessary in my opinion to improve the quality even further.

1. Would it be an idea to validate over an area where LIDAR or photogrammetric data is available? NSIDC has freely available ASO L4 Lidar snow depth maps where you can validate against. Also, Envidat has photogrammetric snow depth data available over the Alps (Yves Buhler will be able to help you further). Since the presented product has a very high resolution it would be very interesting to see how its performance holds in such a context. The validation presented now is based on a very small amount of datapoints.
2. Since the high amount of snow depth data available in the Alps maybe it would be better to select in-situ stations located in a range of incidence angles instead of assuming the snow depth being equal in a 4 km area around your in-situ station to extract your local incidence angles. In this context the photogrammetric and LIDAR datasets could also help. I think this will lead to a scientifically more robust relationship between LIA and the SIsar-index considering the use of 10 m backscatter data and the strong spatial variability of snow.
3. Be careful when mentioning the use of dual-polarimetric data, since it can be easily confused with actual PolSAR data. Dual-pol polarimetric variables are derived from the Single-Look Complex (SLC) data, are then processed into covariance matrices to in the end extract metrics like the DpRVI. In this paper only backscatter, and no phase information, is used. I would emphasize this more throughout the text. It would also be interesting to analyze metrics derived from the SLC observations, however I understand this is out of scope.
4. To strengthen the claims made within this paper I would also analyze the behavior of the VV and VH backscatter with changes in snow depth or changes in incidence angle. This will allow the reader to understand the underlying processes related to a change in SIsar. So, in other words, it would be of interest to add an analysis that investigates the change of the components that make up SIsar-index to see exactly where the change in SIsar is coming from.
5. I would in general mention the resolution of the product more, because sometimes I was confused whether 10 or 50 m was used (see specific comments).
6. I sometimes found it hard to follow the flow of the data and methods section. I would opt for a combination of both to improve flow. My suggestion would be to start with the study area, then go to the description of the SAR data and data processing, then followed by the weather and snowpack measurements and snowpack modelling, then the mathematical modelling to combine them both and then the model validation strategy.

Specific comments:

Line 36 and 37: I would change SAR signal by microwaves.

Line 44: This statement is not true for cross-pol. I would specify co-pol here.

Line 64: I would be careful with this statement because in the mentioned paper only backscatter was analyzed but no true dual-polarimetric indices (those derived from SLC-data).

Line 70: I would cite Feng et al. again here after Alps.

Line 108: What is the reason for working with a buffer zone of 50 m? Your backscatter data is processed at 10 m, is it not better to take the same resolution?

Line 115: independent as in your pixel AWS pixel was not taken into account for the LIA sampling? Since I saw your AWS pixel and LIA area overlap. Also, what is the resolution used for the LIA sampling is it 50 m, or 10 m?

Line 117: idem, why 50 m? Also, how many measurements were taken as validation points?

Line 127: 168 is descending captured in the morning, 15 is ascending captured in the evening . Idem on line 135 descending morning and ascending evening.

Line 133: Mention the source of the downloads.

Line 135: Mention why these dates are used.

Figure 1: I would add the validation area as well.

Line 169: What was the original resolution of your GRD product, is this 10 by 10 m? Why is resampling needed in line 175 or was it a reprojection to another CRS? If resampled, which technique was used?

Line 185: Indicate the resolution, also in section 3.4 indicate whether you also do an upscaling to 50 m. If this is the case it is maybe better to immediately indicate in section 3.2 that you are using a 50 m resolution to avoid confusion.

Line 190: Indicate why you would exclude negative values and why you would make sure the data follow a normal distribution.

Line 205: Explain what the acronym mdl stands for the first time it is used, same for msr.

Line 225: Is this one α value for each orbit and regression area or is this everything combined in one α value?

Line 233-235: This is a very tricky statement to make which I would not necessarily agree with. See general comments 2.

Line 243: Did you exclude values from your validation set? Or is this sentence related to the calibration? If it is related to the calibration, I would leave this sentence out because it is a bit confusing, otherwise there is a mistake here since excluding data from your validation set because they have negative values is not good. It will lead to performance metrics that are unrealistic since you have tuned it to artificially create better results.

Line 266: Would it be an option to set an extra parameter that takes care of the slope? Why does it necessarily have to be 0?

Line 268: I would add the sentences on line 315-316 here to immediately bring clarity on why you only take one variable.

Line 302: errors drop significantly, did you do a statistical analysis?

Line 307: I do not think I understand this well, what does c1 * g_bar explain? You could make it equal to α if c1 would be lower but then you would just have a worse correlation between HSmsr and HSmdl_LIA. I do not see the added value of this sentence.

Line 321: larger snow mass and more grains per unit volume of snow.

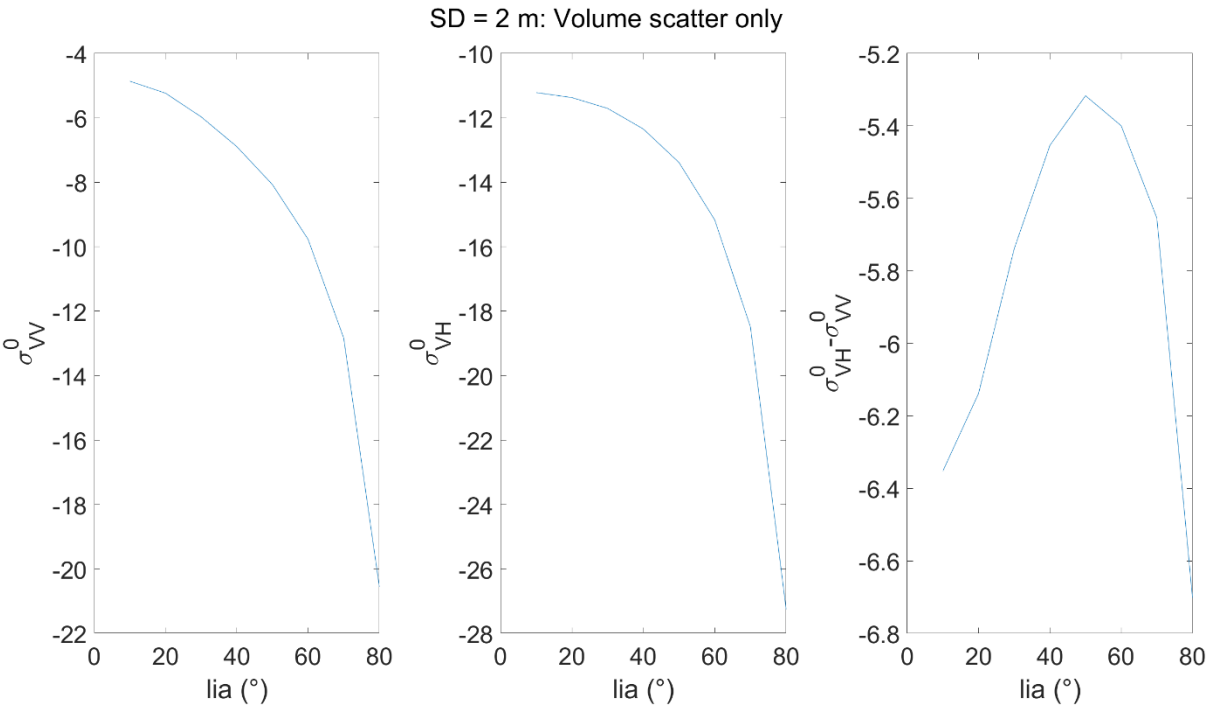
Line 327: Can this be related to signal attenuation? I think I would mention it here.

Line 332: Is this not because your SIsar index is also dependent on soil backscatter processes?

Line 321-335: This is quite speculative since your index depends on both VV and VH but you only describe HH here, what about the change of VH during those periods of GS increase and density increase?

Line 360-362: I agree but I do not think this is relevant here since your SIsar measurement is a measurement over time and this sentence only explains what happens at one point in time. It is the change in VV under a certain LIA that is critical.

Line 366: The statement that VH backscatter increases is not correct. Depolarization will increase but only because VV backscatter will decrease more than VH backscatter if you go to higher local incidence angles. The specular reflection captured by the sensor will decrease leading to a decrease in both VV and VH (but a stronger decrease in VV than VH). See figure below for the effect of LIA on the volume scattering component of a snowpack (simulated using a radiative transfer model DMRT-Bic on a snowpack of 2 and 4 m):



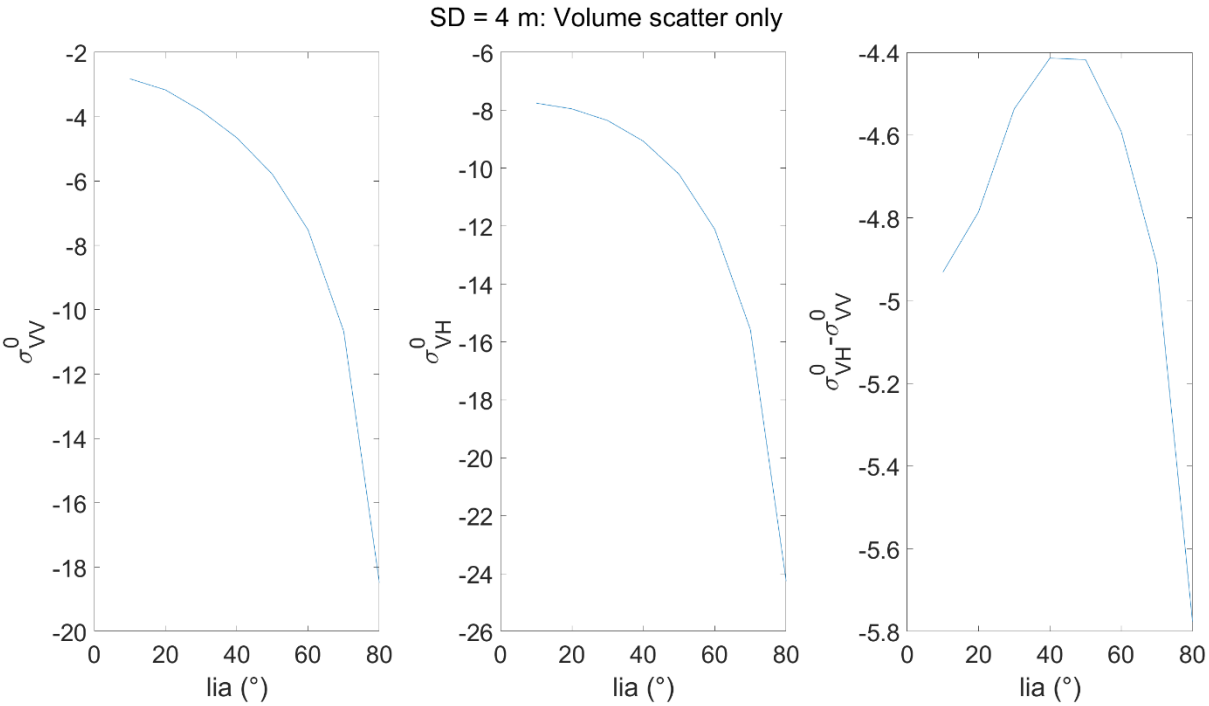


Figure 7: The change in backscatter from one LIA to the other is not well represented here, change the magnitudes of VH and VV accordingly. The depolarization depends on the ratio of the two. (see previous comment and see comment 4 in the general comments section).

Line 376: Is this a valid approach if HS is considered equal over the entire study area where LIAs were extracted? See comment 2 in the general comments section.

Line 414: Is this a hypothesis or did you see this in the data, if you saw it in the data, please include it, very interesting stuff.

Technical corrections:

Line 19: Set snowpack to snow.

Line 23: I would rephrase to snow monitoring is critically important for avalanche forecasting

Line 78: sentence difficult to read, I would rephrase.

Line 123: are available and is right-looking

Line 233: derived instead of deriving

Line 423: high number of pixels