

Dear editor,

We sincerely appreciate your time and effort in reviewing our manuscript. Below, we respond to each point first to you and then to the two reviewers and outline the corresponding revisions we suggest (colour-coding: blue editor/reviewer comment, black answer statement).

Public justification:

Dear Gwendolyn and co-authors,

First of all, I sincerely apologise for the long delay in providing this decision. The process was slowed down by two contrasting reviews, which required an in-depth analysis from my side, and some personal circumstances which have complicated my availability to put in the necessary effort. Thank you for your patience and understanding.

Your manuscript received two very different recommendations: Reviewer 2 suggested acceptance, while Reviewer 1 recommended rejection, outlining several major concerns. Given this contrast, I wanted to take an in-depth look at the paper myself. I have provided detailed comments in the attached annotated PDF.

Overall, I agree with the potential of your work identified by Reviewer 2, but I also share the concerns raised by Reviewer 1. In its present form, I do not believe it meets the standards of The Cryosphere. Significant revisions are required before the paper can be published. The comments of reviewer 1 touch upon the clarity and narrative of the paper, and properly addressing the raised comments will be essential to bring the manuscript to TC level. Below I summarise my main points:

E1. Paper structure and flow

The manuscript lacks a clear and logical structure. Data and methods are mixed together, making it difficult to identify the conceptual novelty and the steps taken. I strongly recommend reorganising into distinct sections:

2.0 Study Area

3.0 Data (including preprocessing), with separate subsections for in-situ AWS data (3.1), ancillary data (e.g., DTM) (3.2), Sentinel-1 data (source products, orbits, Copernicus products) (3.3), and avalanche validation data (3.4)

4 Methods, including:

4.1 Snowmodel forcing and creation of output model data

4.2 LRW processing, with a clear distinction between different processing strategies (4-track, 2-track, temporal filtering)

4.x Description of the analysis steps performed to assess LRW performance (comparison with standard S1 product, comparison with in-situ/modelled data, sensitivity analysis, validation, etc.)

5. Results: Focus on quantitative comparisons of different products versus in-situ and modelled outputs

6 . Discussion: Structured into subsections. Currently, the discussion mixes methods and results; these should be moved to the appropriate sections.

Thanks, we revised the manuscript according to your input. However, we kept SNOWPACK in the data section, because we did not create modelling ourselves, but only received the results gained from the model. We rephrased in the manuscript to make this clearer.

E2. Core narrative and logic

The paper's premise is that LRW composites improve performance compared to standard Sentinel-1 products. However, this is not demonstrated in the methodology or results. If you want to claim LRW is better, you need to show this quantitatively throughout the paper, for example by comparing different LRW approaches (4-track vs 2-track, rolling median vs none) against a standard S1 benchmark. At present, there is only one illustration in the discussion, which is not sufficient for validation.

Thanks, since the product has now become accessible, we implemented this comparison.

E3. Validation and use of reference data

The validation concept needs major improvement. Currently:

- There is no clear distinction between measured and modelled data from SNOWPACK. Readers must know which variables are observed and which are simulated. It is also crucial that the model outputs themselves are validated; using unvalidated model outputs as reference introduces large uncertainties.

Thanks, we made the distinction clearer and added an overview table in the main text.

- The comparison with avalanche data (DAvalMap) is very limited despite being a key motivation for the study. This should be expanded and quantified.

Thanks, we have expanded our research into this direction and quantified by identifying transitions on snow avalanche records associated to wet snow ratio values retrieved with our method.

- Correlation analysis with SNOWPACK outputs is presented, but correlation alone does not constitute validation. More robust metrics (e.g., prediction accuracy, overlap, error statistics) are needed.

We revised the manuscript to make the purpose and limitations of the correlation analysis explicit and by avoiding term "validation" and instead treat it as a sensitivity check to make sure which variables we are measuring.

- Claims about validation with in-situ measurements (in discussion/conclusion) are misleading; the paper does not show this.

Thanks we revised the manuscript according to the statement above.

E4 Results and interpretation

Results rely heavily on visual interpretation without quantitative evidence. Statements such as "good agreement" or "substantial improvement" are subjective and need numerical backing.

- Comparison with standard Sentinel-1 products is missing.

Thanks, done.

- Quantitative comparison with avalanche data is missing.

Thanks, done.

- Unsupported claims in the discussion and conclusion should be removed or substantiated.

Thanks, we revised the manuscript accordingly.

Summary of key components

- Clear methodological description of LRW and its advantages over standard approaches

Thanks, done.

- Systematic comparison of different processing options (4-track vs 2-track, rolling median vs none)

Thanks, we have taken out the 2-track LRW processing, since it introduces ambiguity while not being required for the storyline anymore and hence also the rolling mean.

- Quantitative validation against both SNOWPACK and avalanche observations

Thanks, this is now implemented.

- Stronger link between the stated motivation (avalanche forecasting) and the results presented

Thanks, we have revised accordingly.

Data availability compliance

It is critical to address Reviewer 1's comment on data availability. The manuscript is still not compliant with The Cryosphere's Open Data Policy. Please ensure that all datasets (including DAvalMap and SNOWPACK outputs used in the analysis) are archived in a recognised public repository with proper DOIs and metadata. This is a necessary for FAIR science.

Thanks, revised accordingly to fully comply with The Cryosphere's Open Data Policy. All datasets and scripts required are available and referenced to in the corresponding section.

I believe the topic is relevant and the dataset is valuable, but the manuscript needs substantial restructuring and additional analysis to meet TC standards. Please carefully address the comments of Reviewer 1 and my additional comments in the attached PDF when preparing your revision.

We thank the editor for his time and effort to help us in improving our manuscript.

I look forward to receiving:

- A thoroughly revised manuscript addressing the points above
- A detailed response to all comments
- A tracked-changes version for transparency

Thank you again for your patience and effort. Sorry again for the delay! I hope these comments help you strengthen the paper.

Kind regards,
Stef Lhermitte

Reviewer 1:

We sincerely appreciate the time and effort reviewer 1 has invested in reviewing our manuscript.

Suggestions for revision or reasons for rejection

Thank you for the detailed and thorough responses, as well as the easy to follow document with track changes.

Major Comments

1. Portions of the manuscript remain difficult to follow and lacking in specific results (e.g., time lag between S1 wet snow and modeled LWC). I highlight additional examples below. I encourage a very careful and rigorous review of the text to improve readability, flow, and specificity of the results. One opportunity to improve readability would be to include additional sub-headings in the methods (for example, 2.1 could be the Sentinel-1 SAR data and processing (with sub-headings for key steps)) and discussion, and using these sub-headings to re-organize key ideas (particularly in the discussion). Thanks, we revised the manuscript accordingly.

2. The DAvalMap inventory is a prominent part of the analysis/results, yet the details on inventory are sparse and vague to someone not familiar with the dataset. I suggest providing a more detailed description of the methods, as well as how wet snow avalanches are classified in the methods. This would facilitate a more thorough discussion of uncertainties later in the paper (for example, around ln 338-339). Additionally, the distinct size threshold difference between years is a major inconsistency and deserves further discussion. Assuming the inventory provides size estimates, can the 2019-2020 dataset be filtered to approximate the other years?

Thanks, we revised the manuscript accordingly. We decided not to filter the dataset based on size threshold, since also the small avalanches recorded help us understand the conditions at release state.

3. Data Availability: As noted by both reviewers during the first review, the manuscript is not compliant with the TC data policy. The response to reviewers suggests that this has been addressed, but the revised manuscript is still not compliant (e.g., the DAvalMap library and SNOWPACK data for WFJ station can be requested from SLF). This needs to be addressed appropriately.

We now have the permission to publish also the other used datasets and can therefore comply with the TC data policy. All required scripts and codes are available and referenced.

Minor Comments

5 – state years for the study

Done, thanks.

8 – state statistical relationship

Thanks, added.

8-9 – clarify sentence phrasing

Thanks, done.

11 – quantify the increase in wet snow avalanche releases

Thanks, we revise and added a histogram analysis.

12 – is a new paragraph needed here?

We got rid of the indent, thanks.

14 – satellite based methods are unlikely to provide sub-daily observations (outside of geostationary satellites) in the near future; I suggest revising the concluding sentence as this seems like an unreasonable expectation given current and near future satellite assets/configurations

We agree that open-source satellite data will not soon become available at sub-daily temporal resolution. We rephrased accordingly.

16 – I suggest revising wording; the difficulty in predicting is not directly related to their destructive potential, making the use of however confusing in the sentence

Thanks, we revised.

22 – clarify meaning of “spatial models” in this context

Thanks, we clarified.

38 – clarify meaning of “representation style”

We we revised and hope it’s more clear now.

42 – should this be e.g., as to provide examples of the drawbacks?

We would leave it to be *id est*, since e.g. *exempli gratia* would hint at an existence of more drawbacks than the ones we can name here.

46-47 – this sentence “We combine...” is better suited for the methods

Thanks, we adjusted.

55 – check “;” use

Thanks, we revised to: “such as Li et al. (2025) and Karbou et al. (2021).”

60 – I suggest revising this sentence to clarify that the described limitation is the result of using an optical mission to evaluate/validate a radar based mission

Thanks, in the revised manuscript the sentence was removed since it wasn’t within the storyline.

65-66 – I suggest providing the mean and standard deviation of winter/spring temperatures, as these values would provide more context for the reader than the winter/summer min/max temperatures.

Thanks, done.

70 – state the years that S1 SAR data was used in the study

Thanks, done.

79 – assuming that this is prior to S1B outage, but please clarify

We specified now the time range as stated (see above) and the date of outage is provided, so it is now cleared up in the manuscript.

85 – the significance of the 424 LRW composites would be enhanced if the study period was previously stated

Thanks.

103 – provide a formal reference for this DEM

Thanks, done.

113-115 – provide brief description for how SNOWPACK is used in this overview sentence

Thanks, implemented.

129 – provide formal reference for the SNOWPACK version

Thanks, done.

140 – use en dash rather than hyphen; check for consistency throughout

Thanks. Adjusted and revised manuscript accordingly.

164 – should swiss avalanche forecasting service be capitalized?

Thank, done.

185 – reference appropriate figure and describe magnitude/timing of backscatter drop with more detail

Thanks, done.

188 – clarify meaning of “the results diverged....”

Thanks, done.

191 – clarify what is meant by off-season?

Thanks, we revised to make it clearer.

194 – provide more detail regarding what aspects of the results were similar between the stations
Figure 2 - LWC (panel C) appears to increase 1-2 months prior to the Sentinel-1 wet snow detection (purplish hue) in the time-series. What explains this discrepancy?

Thanks we revised and expanded slightly, also in the discussion part.

Figure 2 – consider moving portions of the legend to the appropriate subplot; it took me a minute to figure out where the different LRW lines were being plotted in this figure.

Thanks, done.

Figure 2 – consider not using red and green in the same plot, as this is the most common form of color vision deficiency

We agree with the reviewer, which is why we used different symbols as well. So, also readers with colour-deficiency can perform all required image interpretations.

197 – check formatting/consistency for how the appendix figures are being referenced

Thanks, done.

199 – include specific results regarding LWC and snow height decrease

Thanks, added and moved at end of paragraph.

201 – quantify “about a week” more specifically; please see previous comment on Fig 2: the temporal offset between LWC and Sentinel-1 wet snow detection appears to be closer to 1-2 months rather than 1 week. Please clarify.

Thanks, we added time in days.

208 – I’m confused by the reference to SNOWPACK’s potential albedo – please define potential albedo. What is the physical basis for a positive correlation between LWC and albedo?

Thanks, this was actually Parametrised snow albedp. However, we took the statement out of the revised manuscript since it is not a reoccurring correlation.

211 – check “:” formatting

Thanks, done.

Figure 3 caption – check date formatting throughout the manuscript as multiple formats are used; for example the x-label is yyyy-mm-dd but the caption is mm.yyyy.

Thanks, adjusted.

Figure 5 - use same units for georeferencing as figure 1 (m vs km)

Thanks, we decided the figure is not really aligned with the new storyline.

Figure 5- I assume the purplish hue are pixels that have been detected with wet snow; please clarify with a legend and/or caption

Thanks, we decided the figure is not really aligned with the new storyline and took it out.

Figure 5 – it is difficult evaluate whether the wet snow avalanches (x) directly correspond with wet snow in this figure; are there additional ways of showing this comparison? Panel C appears to have the greatest % coverage of wet snow, but the second least number of reported avalanches, while panel b has a large number of avalanches but modest amounts of wet snow. I suggest describing these spatial patterns in the results/discussion. **after searching the pdf, the only reference I see to Fig. 5 is in the Fig. 3 caption, further highlighting the need to present these results if including this figure**

Thanks, we agree it is not ideal and instead provide a map view in comparison to the Copernicus dataset which is while extra much more valuable to the storyline (Appendix 10).

233 – this is an opportunity to improve the specificity of the results; how much earlier were the S/E slopes determined to be wet?

Thanks, we performed an aspect dependent threshold analysis (Appendix 7) to try and quantify the aspect dependency a bit more. We refrained in the revised manuscript to add a specific temporal value as requested, since this analysis would require the introduction of even more concepts and definitions.

244 – check italics of in-situ throughout

Thanks, done.

283-285 – The clear benefit of using an “all season” median is not apparent to me, at least not in terms of processing costs (i.e., taking a single reference image vs computing a season long median value?) and update-ability. Please clarify.

For single reference image it is not the processing costs but the randomness. Even if this is the standard approach, no standard way of selecting or assembling the dry-no snow reference image could be established up to now. We try to circumvent this randomness by using the all seasons median. We make the discussion more clear.

295 – how close was this infrastructure?

Using satellite imagery we measured 27m to railway and 16m to the closest house. We added more detail in the discussion.

319-320 – Specify the time lag in the results; was it consistent between the years?

We revised accordingly.

Figure 6 – I suggest increasing the font size modestly, at least for the variable names and colorbar labels to improve readability.

Thanks, will be implemented.

Figure A2 – the shadings in the legend do not seem to match the shadings in the figures. Add subplot labels to plots and caption; same with A3 and A4.

Thanks, done.

Table A1 – consider date format consistency with other parts of the manuscript

Thanks, we revised for consistency.

References

D. Small, "SAR backscatter multitemporal compositing via local resolution weighting," *2012 IEEE International Geoscience and Remote Sensing Symposium*, Munich, Germany, 2012, pp. 4521-4524, doi: 10.1109/IGARSS.2012.6350465.

Hannula H-R, Pulliainen J. (2019). Spectral reflectance behavior of different boreal snow types. *Journal of Glaciology*, 65(254), 926–939. <https://doi.org/10.1017/jog.2019.68>

Reviewer 2

We highly appreciate the time and effort reviewer 2 has invested in reviewing our manuscript and the positive feedback we received. We hope the reviewer will find the revised version still matching his expectations and that they can agree on the revisions having improved the manuscript.