Reviewer 2

In this article, the authors apply methods to manually and semi-automatically map avalanche deposits across the Mt. Blanc, Everest, and Hispar regions in Sentinel-1 Synthetic Aperture Radar (SAR) imagery over a five-year period. By applying their technique, they mapped 16,302 avalanche deposits across multiple glaciers, enabling the quantification of their activity and spatio-temporal variability, thus offering vital insights into mass redistribution processes affecting glacier mass balance. The approach shows enhanced performance for images taken in winter mornings, and it indicates that avalanche deposits are mostly situated at lower elevations within glacier catchments.

I found this article to be interesting and written in polished, articulate English. The topic appears to hold significant relevance for the avalanche/glacier research community and promises to be a valuable reference for future work. The article offers a comprehensive account of the of the significant work accomplished by the authors. However, I recommend some major and minor improvements in the methods, results, and discussion sections, which I will detail and justify in the following text. Consequently, I advise a major revision of this article prior to its publication. Additional specific recommendations and corrections are outlined in the attached PDF.

We would like to thank Reviewer 2 for their thorough review and their very relevant and constructive comments.

Major Comments

1. **References and literature review:** The article currently relies - particularly in the introduction but also throughout the whole article - on many outdated references and lacks recent studies, notably in the context of avalanche detection using satellite data. For instance, a recent paper by Thu Trang Lê et al. (2023) demonstrates deep semantic fusion of Sentinel-1 and Sentinel-2 for snow monitoring in mountainous regions, which is highly relevant to this research. The inclusion of more current references, such as this study, is essential to validate and contextualize the findings. Some further examples to incorporate could be Sartori & Darbiri (2023) for the comparison of the methods, Guiot et al. (2023) for avalanche data from the French Alps, Liu et al. (2021) as example of avalanche detection in Asia. I highly recommend to add some more recent references.

   Thanks for these suggestions. We will make sure to add them in the text, specifically at the following locations:

   - Refer to Guiot et al. (2023) and Sartori and Darbiri (2023) in the introduction
   - Refer to Liu et al. (2021) and Lê et al. (2023) in the discussion relative to the use of machine learning approaches for the automated mapping of avalanches in Sentinel-1 images.
2. **Data validation with ground truth records:** The comparison between detected avalanches and actual recorded events in the three studied regions has not been sufficiently addressed. While acknowledging the limited availability of data in some areas, the integration of ground truth avalanche records, where possible, could substantially improve the credibility and reliability of the findings. Possible references

could be Guiot et al. (2023), Acharya et al. (2023) and respective regional avalanche warning services. Please consider adding a comparison or at least a thorough investigation of available ground truth avalanche records in relation to the detected avalanches.

This is a very good point, thanks for bringing it up. Data on avalanches is particularly scarce in remote glacierized regions, which is one of the reasons we decided to go for this automated mapping with Sentinel-1 images. For example, the French historical avalanche maps (CLPA: Carte des limites probables des avalanches, map of probable avalanche limits in English) do not cover the glaciers of the Mt Blanc massif due to a lack of data. We also note that while the work by Acharya et al. (2023) is tremendous and brings a nice perspective on avalanche hazard in HMA, it is biased by populated regions where avalanches were visually witnessed or caused damages. We have checked their dataset and they did not identify any avalanches in the Hispar region and only identified two avalanches in the Everest region, dating from 1997 and 1980. We therefore consider that this comparison is not really relevant to evaluate our outlines.

We did make the comparison with avalanche warning services, as shown in the Supplementary Information, figures S21-S23 for the Mt Blanc massif (shown below), although we forgot to mention it in the main text. There was indeed a good correspondence between this avalanche warning and the detected avalanche activity, at least in the winter months. We will explicitly mention this comparison in the discussion section:

'There is also a good correspondence between the avalanche activity and the predicted avalanche danger level in the winter months (Fig. S21-23). The number and size of avalanches decreases and their minimum elevation increases in spring with rising temperatures and their dependence on precipitation and correspondence with the avalanche danger level is less strong (Fig. 11, S19-23), highlighting the transition from dry to wet avalanches (Baggi and Schweizer, 2009).'

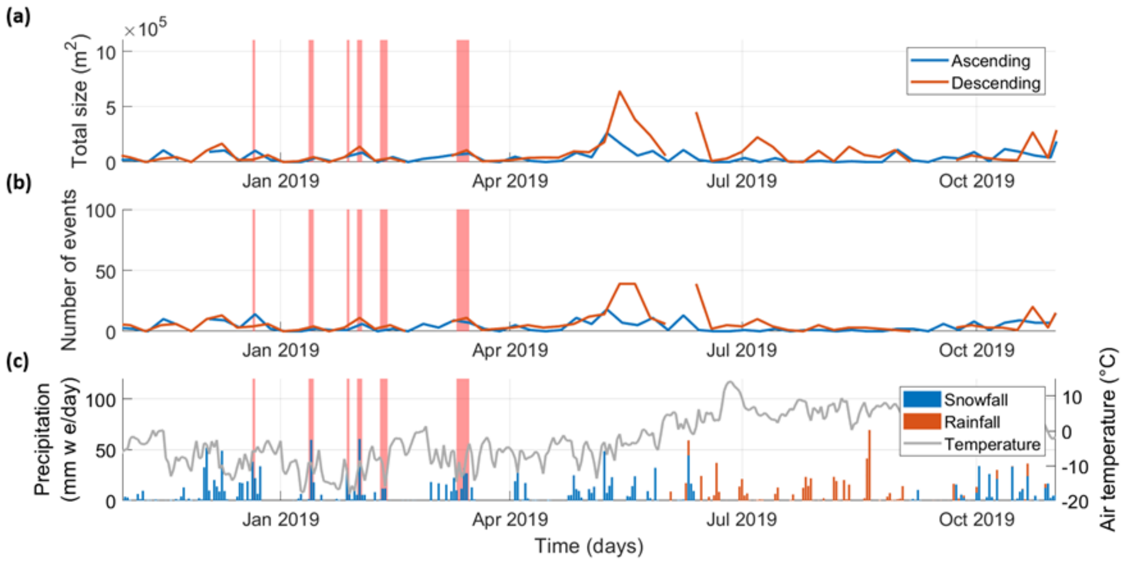

Figure S21: One year (11/2018-10/2019) of avalanche time series over the Mt Blanc massif in the ascending and descending orbits. (a) Total area and (b) number of avalanches as a function of time across all elevations. (c) Total daily precipitation and mean daily air temperature at 3000 m a.s.l over the Mt Blanc massif according to the SAFRAN reanalysis product (Vernay et al., 2022). The red shaded areas indicate days with a predicted avalanche danger level higher than or equal to 3 (Source: Météo-France).

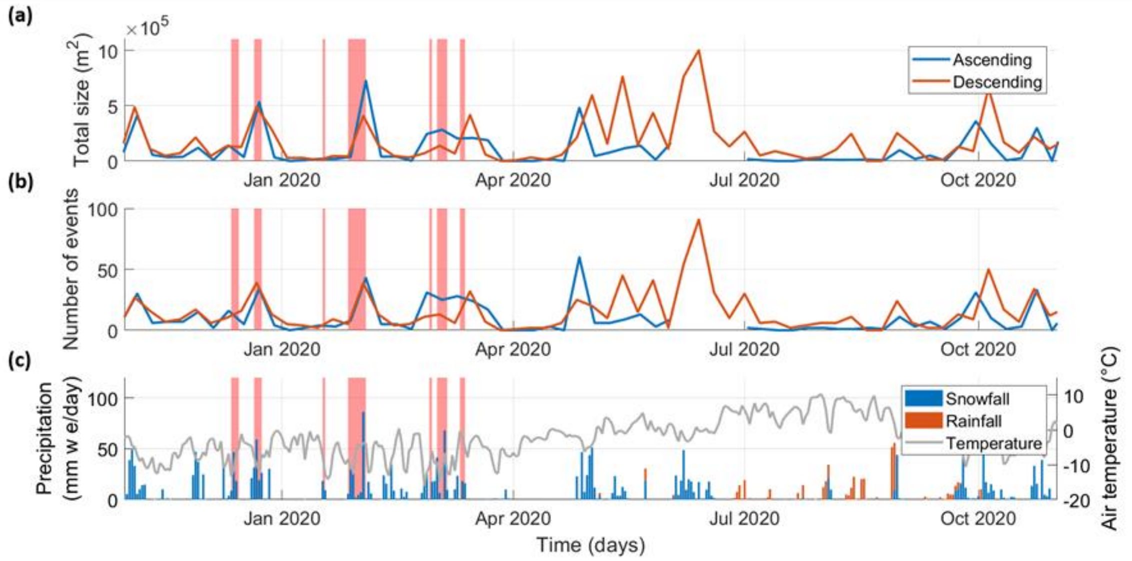

Figure S22: One year (11/2019-10/2020) of avalanche time series over the Mt Blanc massif in the ascending and descending orbits. (a) Total area and (b) number of avalanches as a function of time across all elevations. (c) Total daily precipitation and mean daily air temperature at 3000 m a.s.l over the Mt Blanc massif according to the SAFRAN reanalysis product (Vernay et al., 2022). The red shaded areas indicate days with a predicted avalanche danger level higher than or equal to 3 (Source: Météo-France).

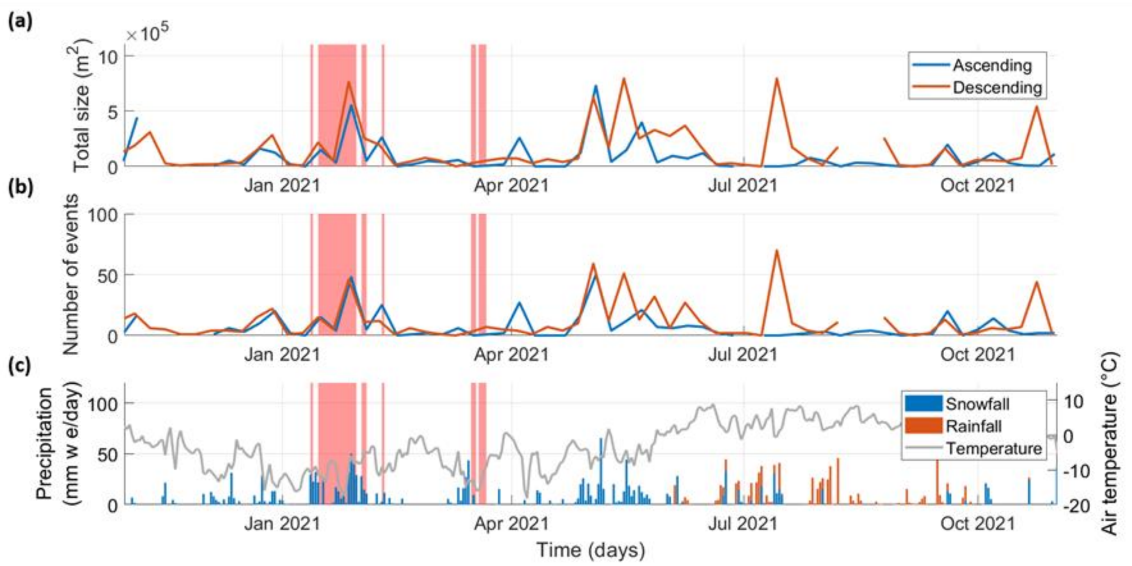

Figure S23: One year (11/2020-10/2021) of avalanche time series over the Mt Blanc massif in the ascending and descending orbits. (a) Total area and (b) number of avalanches as a function of time across all elevations. (c) Total daily precipitation and mean daily air *temperature at 3000 m a.s.l over the Mt Blanc massif according to the SAFRAN reanalysis product (Vernay et al., 2022). The red shaded areas indicate days with a predicted avalanche danger level higher than or equal to 3 (Source: Météo-France).*

3. **Clarity in methods section:** The Methods section requires further detail and a more coherent structure to improve readability and comprehension. Presently, the steps lack information, making it challenging to follow the methodology applied. For example, it is unclear which images were used for comparison to detect avalanches. Sentinel-1 provides daily images but with different geometry (track number). However, the geometric configuration recurs every 6 or 12 days, depending on the specific region. Clarification is needed on whether only two consecutive images or a series was analysised and if daily images were taking into account. Providing, e.g., the track number would give clarity. Related to this context it should be clarified if avalanches were observed beyond 6 (or 12) days in the Sentinel-1 images.

   We apologise for the lack of clarity in the methods section. Relative orbits (what you refer to as track numbers) are indicated in Table 1 of the data section. We always used the same track numbers to keep the same geometric configuration, thus the revisit times of 6 and 12 days obtained for the different regions (Table 1). This will be highlighted in the Data section:

   'We used the same orbits for each survey domain to guarantee that the incidence angles remained the same throughout the study periods.'

   In paragraph 3.1 it is specified at two occasions that the images are at 6 day intervals for the Mt Blanc and 12 days for the HMA regions.

   We will specify it again in 3.4:

   'After calibration and validation of the mapping approach, we applied it to a five-year time series of Sentinel-1 images over the three survey domains (Table 1), using 6-day intervals for the Mt Blanc region and 12-day intervals for the Everest and Hispar regions. '

4. **Performance metrics - Dice Coefficient/F1 Score:** The reported F1 score (Dice coefficient) of 0.47 for manual detection appears to be very low in comparison to the automatic detection. In general, automatic detection still lacks the manual detection behind. In addition, the F1 scores of the automatic detection are lower than F1 scores in the literature. Both points should be explained in detail in the discussion.

   The F1-score of 0.47 corresponds to 2 things:

   - the comparison of the aggregated Sentinel-1 manual outlines for the period 01/11/2019-09/08/2020 and the end-of-season Pléiades manual outlines from 09/08/2020. While we find this comparison interesting, it is not a central part of the analysis, and can be misleading, as indicated by reviewer 1. We will therefore remove panel a of Fig. 5 from the main text and move it to the SI. Similarly, in the text we will shift this comparison after the description of the scene-by-scene comparison.

- the average score of the ascending orbits. We note that the score of the descending orbits is much higher (average score of 0.62), as detailed in Section 4.1.2. These lower scores for afternoon scenes are discussed in Section 5.1 of the Discussion. While 0.47 is relatively low, 0.62 is quite a high score relative to the F1-scores obtained in other studies. We will make this comparison more explicit in the Discussion:

  'The performance metrics obtained from our automated mapping approach compared to the manual detections in the Sentinel-1 outlines, have a wide range of values (F1-score between 0.29 and 0.78) depending on the season and acquisition time. These results are similar to that of other studies following similar threshold-based approaches (Leinss et al., 2020; Eckerstorfer et al., 2019; Karas et al., 2022; Wesselink et al., 2017).'

Following these variable scores, and particularly the low ones for the ascending scenes, we manually updated our dataset to analyse the characteristics and spatio-temporal variability of avalanches. We will insist on this aspect at the start of the Results section:

'Here, we first compare our manually derived outlines with high-resolution Pléiades images and evaluate the results and transferability of the automated mapping approach (Section 4.1). We then use the manually updated set of outlines to obtain the characteristics of avalanche deposits (Section 4.2) and their spatio-temporal variability (Section 4.3) for all three survey domains. '

5. **Explanation of results:** The explanation of results in section 4.2 lacks clarity. Further elaboration is required to adequately convey the findings. Please refer to specific comments in the PDF.

   There are no specific comments in 4.2 in the PDF and overall very few comments in the results sections. Following the specific comments in the results, we will specify wherever necessary that only the Sentinel-1 outlines were used for the analysis, the Pléiades only being used as a qualitative check. We will thoroughly check the results sections and update the text where more clarity is needed. Specifically we will:

   - Add a sentence at the start of the results to describe the overall organisation of this section:

     'Here, we first compare our manually derived outlines with high-resolution Pléiades images and evaluate the results and transferability of the automated mapping approach (Section 4.1). We then use the manually updated set of outlines to obtain the characteristics of avalanche deposits (Section 4.2) and their spatio-temporal variability (Section 4.3) for all three survey domains.'

   - Remove from 4.2 any explanations that belong to the methods
   - Remove from 4.3 any interpretations that belong to the discussion

6. **Discussion:** The discussion does not address several critical issues, including the impact of radar shadow, the differences between SAR and optical data (Sentinel-1 and Pleiades images), and the low F1 scores, as mentioned before. Moreover, the comparison with actual avalanche records, although little in number, is missing and should also be added. Additionally, it is important to discuss the effects of radar shadow and layover, especially in regions located in HMA that are significantly impacted by these phenomena. A quantification of the area not taken into account due to radar shadow and layover in relation to the total investigated area should be added.

   As mentioned in our answers to the previous general comments:

   - We have added a comparison of the avalanche activity and the avalanche danger level in the Mt Blanc massif. No such comparison is possible for the Everest and Hispar regions.
   - The F1-scores that we obtained are low for the afternoon scenes, but are in-line (or even higher) than the scores obtained by other studies. We will outline this comparison in the discussion section:

     'The performance metrics obtained from our automated mapping approach compared to the manual detections in the Sentinel-1 outlines, have a wide range of values (F1-score between 0.29 and 0.78) depending on the season and acquisition time. These results are similar to that of other studies following similar threshold-based approaches (Leinss et al., 2020; Eckerstorfer et al., 2019; Karas et al., 2022; Wesselink et al., 2017). The performance of such approaches is generally very good in dry snow conditions, with high precision (>0.7) and low false positive rates (<0.4), which correspond to F1-scores above 0.6-0.7 (Leinss et al., 2020; Eckerstorfer et al., 2019). '

   Regarding the other points raised:

   - The comparison of the Pléiades and Sentinel-1 is already discussed in detail in section 5.1 of the Discussion. We will therefore keep it as is:

     'Our comparison of the Sentinel-1 with the Pléiades avalanche outlines indicate that avalanches detected with Sentinel-1 are of relatively large size (>4000 m^2 deposits) with high surface roughness, which limits the detectability to avalanches with high enough snow temperatures to form granular deposits (Steinkogler et al., 2015), or which are formed from cohesive wind slabs (Fig. 5d) or that entrain rock or ice debris, for instance from serac falls (Fig. 5c). Therefore, cold, low density snow progressively redistributed down steep rock faces or snow gullies (Sommer et al., 2015) is likely to be missed by this method, which likely also explains the upper elevation limits to avalanche detections, especially during the cold season (Fig. 11-13). Similarly, the detection of the avalanche events requires the previous deposits to have regained lower backscatter values for the signal to be visible, meaning that the surface of the deposit needs to have been smoothed by additional precipitation or melt for the next events to be visible at

this location. We have observed this smoothing to require several weeks and even months before avalanches can be detected at the location of old deposits, while avalanche events are still occurring in the meantime (Fig. S9d). The avalanche activity that is detected is therefore a lower bound value of the actual avalanche activity, and the aggregation of all Sentinel-1 deposits is still an underestimation of all the glacierized areas affected by gravitational snow redistribution (Fig. 5a). Nevertheless, this semi-automated approach is promising to explore the temporal and spatial variability of avalanches in remote areas, especially in glacierized regions of HMA, where close to no data exists on the occurrence of such events (Ballesteros-Cánovas et al., 2018; Caiserman et al., 2022; Acharya et al., 2023; Singh et al., 2022).'

- Radar shadows and layover were removed from the surveyed areas (Section 3.1). We will however insist in the discussion that as a result only 57 to 72% of the surveyed areas were actually covered (as indicated by the numbers in Fig. 1):

  'We used Sentinel-1 images to detect avalanche events, which enabled us to obtain a massif-wide distributed dataset, at least for the zones unaffected by shadow and layover (57-72% of our survey domains characterized by steep topographies), therefore less spatially biased than ground-based inventories in populated valleys (Eckert et al., 2010; Schweizer et al., 2020).'

Minor Comments

1. **Figures:** Please add latitude/longitude to all figures showing details of Sentinel-1 images. Especially Fig. 1 needs a map context with an overview map showing the location of the respective insets a,b, and c. In addition, the boundaries of the used Sentinel-1 and Pleiades scenes should be added to Fig. 1a,b,and c. Country borders would be also useful addition.

   We will add latitude & longitude to all the different panels of Fig. 1, 5 (for the Pléiades panels) and 9. We will also add a context map to figure 1 (following the recommendations from reviewer 1, this context map will replace panels d and e). These regions are a small subset of Sentinel-1 scenes, and the boundaries of the Sentinel-1 tiles will not be visible in this small subset. We will also add the Pléiades boundaries to the figure. We usually refrain from indicating country borders in scientific figures, particularly for such regions which all have disputed borders.

2. **Consistency in abbreviations:** Once introduced, abbreviations should be consistently used throughout the document to ensure clarity and reduce redundancy. The parameters of the threshold calibration have not been introduced at all.

   We will consistently use the abbreviations SAR and RGI throughout the text.

   The parameters of the threshold calibration were introduced in section 3.2 and Figure 2. We will indicate this more clearly by directly referring to TS and TV for the saturation and value threshold, and by directly referring to the 2nd filtering step in Figure 2 when introducing TO.

3. **Clarification on Dice coefficient/F1 score:** I recommend using the term 'F1 score' instead of Dice coefficient due to its definition in the article. Please refer to the article of Chicco et al. (2020) for a short summary of its history.

   Agreed. We will change this in the main text, SI, and figures.

4. **Detection coverage by different sensors:** It should be noted, e.g., in the results and/or discussion, that Pleiades imagery captures the entire avalanche area, whereas SAR images may only capture part of it. Understanding this difference is critical for evaluating the outcomes of manual detection accurately.

   Thanks for pointing this out. While it is possible to map the avalanche path and rupture zone with Pléiades, it is important to note that, as mentioned in section 3.5 of the methods and section 4.1.1 of the results, we only mapped the avalanche deposits in these images. We will explicitly mention this term in the discussion as well:

   'Our comparison of the Sentinel-1 with the Pléiades avalanche deposit outlines indicate that… '

5. **Pearsons's correlation coefficient**: should be introduced in the methods section with formula and reference.

   This statistical coefficient is widely used throughout all scientific fields (en.wikipedia.org/wiki/Pearson_correlation_coefficient). We will add a reference to the original 1895 article where it was first described:

Pearson, K. (1895). Note on Regression and Inheritance in the Case of Two Parents. *Proceedings of the Royal Society of London Series I*, *58*, 240–242.

Line-by-line comments

Title: change to 'Mapping and characterization of mountain glacier avalanches using Sentinel-1 satellite imagery'

Will be changed as suggested.

L14: 'They' -> The avalanches

Will be to 'Avalanches'.

L21-22: 'at the surface of' -> 'on'

Will be changed as suggested.

L33: I suggest to change to: Additionally, the mass balance of a glacier is traditionally expected to increase with elevation, as higher altitudes typically have colder temperatures leading to less melting and more snow accumulation (Reference).

Agreed, we will add it as suggested:

‘Mountain glaciers usually gain mass via solid precipitation falling in their accumulation area that is then advected downstream with ice flow. The mass balance of a glacier is traditionally expected to increase with elevation, as higher altitudes typically have colder temperatures leading to less melting and more snow accumulation (Benn and Lehmkuhl, 2000)’

L46: Here I would restructure the sentence - if you are talking about avalanches- because there are observations as you state in the paragraph below. Now it sounds like there are no records of avalanches.

We will remove this sentence as it is repeated in the next paragraph.

L46: ‘these events’: Do you mean 'avalanches'? Please substitute if so.

Will be changed as suggested.

L59-61: Maybe the Enquête Permanente sur les Avalanches (EPA) or somethoing similar is worth mentioning here. as additional reference for avalanches in general in the Mont Blanc region

Agreed, we will add a reference to the work by Eckert et al. (2013)

L64: Some -> For example, some

Will be changed as suggested.

L72: I would add here Hafner et al. (2022)

Will be added as suggested.

L75: Sentinel-1 images are provided daily and not on demand

By near real-time we mean that avalanches can be extracted almost immediately once the images are released. We will keep it here.

L79: add Bianchi et al. (2021)

Will be added as suggested.

L84: ‘high repeat frequency’ -> in middle Europe it would be an image every 3 days in the same geometry. SO i would remove this part.

In our opinion this still falls within the definition of ‘high repeat frequency’. Will keep it as is and mention that these are 6-12 days repeat cycles.

Maybe change to: Sentinel1 satellites are independent of light, free of charge and.. .. or sth similar

We will add ‘free of charge’

L86-88: Avalanches located in areas affected by radar shadow, layover etc are also difficult to detect. Especially in regions with high mountains and steep topography this can affect the detection results and should be mentioned, here as well as taken into account in the analysis/discussion.

We will mention it as suggested: *'or will not work in areas affected by radar shadow or layover'*

L86-88: here i would rather refer to Eckerstorfer et al. (2022) showing the descrepancy of the detection of wet-snow avalanches in SAR images

We will add the reference

L94: remove 'full'

Will be modified as suggested

L104: 'This' - PLease specify: e.g.: The steep topography/Slopes >30% etc.

Will be modified as suggested

Fig. 1: PLease add lat and lon values to (a)-(c) or a bigger map to show the location of the 3 areas as insets. It would be nice to see the overall extent of the SAR scenes int the image.

Please refer to response to general comment

L121: 'were applied the avalanche mapping' -> 'the avalanche mapping was applied'

Will be modified as suggested

L147-148: Do you mean that you took the average between the VV and VH images? In some studies VV and VH were treated separately for the different information they hold. For different application one of the two used to be more useful and avalanches can be more visible in one of the two. Did you try to detect avalanches in VV and VH separately?

This is a good point and was also pointed out by reviewer 1. We reproduce our answer to reviewer 1 below:

> We averaged the VV and VH polarizations in order to reduce the radar speckle, as has been done in previous studies (e.g. Leinss et al., 2020). However, you are correct in the sense that VV and VH have a difference in backscatter and therefore should in theory be treated separately. We had conducted some initial tests to check if it really made a difference for the automated mapping of avalanches, but results were inconclusive. Some studies have indicated that VH polarization is more suited for avalanche detection (Hafner et al., 2021), but this difference is likely most important for low incidence angles (e.g. Fig. 7 of Tompkin and Leinss, 2021), which were regions that were in part masked out when applying our shadow/layover and brightness masks (Section 3.1). When calibrating our method separately to the VV and VH RGB images for the Mt Blanc massif for the period 2019-2020, we find generally lower values than those obtained with the averaged polarizations (Table R1). This indicates that our approach is better suited to the combined VV and VH

polarizations. We will now mention this interesting point in the discussion section and add Table R1 as Table S7 to the SI:

'Future method developments could also benefit from separating the VV and VH polarizations, particularly for regions of the SAR images with low incidence angles (Tompkin and Leinss, 2021). While in our case we obtained better results by averaging the two (Table S7), other machine learning-based approaches would likely benefit from the additional information provided by the two polarizations (Liu et al., 2022).'

Table R1: F1-scores obtained for the calibration of our method to VV and VH RGB triplets for the period 2019-2020 over the Mt. Blanc massif.

Polarisation	***Path***	***Season***	***F1-score calibration***
VV	*Descending*	*November-April*	*0.29*
		May-October	*0.40*
	Ascending	*November-April*	*0.47*
		May-October	*0.31*
VH	*Descending*	*November-April*	*0.17*
		May-October	*0.18*
	Ascending	*November-April*	*0.14*
		May-October	*0.30*
(VV+VH)/2	*Descending*	*November-April*	*0.56*
		May-October	*0.56*
	Ascending	*November-April*	*0.54*
		May-October	*0.49*

L154-156: Please assess the amount of area that is removed from the total area. and mention it here.

We will add it as suggested:

‘As a result, 35%, 28% and 43% of the considered area was masked out for the Everest, Mt Blanc and Hispar regions, resulting in a total area available for mapping of 492, 140 and 762 km^2, respectively (Fig. 1).’

L161: Can you cite the F1 score or similar measure of he results of Karas here.

We will add it as suggested: *‘this approach is well suited to identify avalanche deposits in RGB images, with a true positive rate between 0.36 and 0.58 (Karas et al., 2022)’*

L171-172: Here it is not clear what you did. You filtered the images at 2 different time steps and then differentiated the D image how exactly with the high-pass filtered images?

It is in general easier to understand to talk about activity and reference images instead of D and D-i

We apologize for the confusion, the filter was not a high pass filter but a low pass filter (smoothing). These low-pass filtered images at D and D-i correspond to Sm D and Sm D-i in the figure. We will specify it here:

‘Second, we directly differentiated the image at D with low pass filtered images at D and D-i (Sm D and Sm D-i)’

We however argue that the notations D and D-i, introduced in the previous subsection, are well understandable and we will keep them as such.

L174-175: being -> was

Will be modified as suggested

Fig. 2: What does Sm indicate? Please mention in the caption.

Will be added to the caption: *‘Sm indicates the smoothed images after application of the 45 pixel low-pass filter.’*

L177: ‘images’ -> VV and VH

Will be modified as suggested

L178: PLease explain the meaning of D and D-i

These were introduced in 3.1. We will add the meaning in the caption as well.

L188: (TS… TD3): Please specify he range of these values and why you chose these values.. PLease indicate what the abbreviations mean, T_S.. saturation threshold etc.

These thresholds were first introduced in 3.2 and we will indicate there the meaning of the abbreviations.

We will indicate a bit lower in the text the range of values and how they were obtained:

'using the following ranges of value obtained from trial-and-error tests: [0.20; 0.65], [0.20; 0.65], [0.01; 0.16], [0.05; 0.11], [0.01; 0.09] and [0.31; 0.43].'

L190: change to F1-score

Will be modified as suggested

L190: remove 'the'

Disagree. Will keep original.

L191: F1 score (also change in equation). Change throughout the text.

Will be changed throughout the text.

L191: PLease add Sørensen T. A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. K Dan Vidensk Sels. 1948; 5(4):1–34.

Will be added as suggested

L195: true positives -> TP-

Will be modified as suggested

L196: false positives -> FP false negatives -> FN

Will be modified as suggested

L202-203: Could you please clarify in figure (e) which parts are TN, TP, FP, FN f.e. with different colors. Increasing the figure (e) would also help.

We will update the figure as suggested

L204: can you state here maybe how many pairs there were in the end?

We will specify this here: *'(~28 pairs for the Mt Blanc, ~14 for the Hispar and Everest regions for ascending and for descending scenes).'*

L210: 'Monte Carlo approach': Could you please add some information here, e.g., a reference, more specific details.

We will remove this sentence to prevent any confusion.

L210: Which parameter set are you referring to in FIgure 2? PLease specify.

All of them. We will specify 'all parameter values'

L213: What do the Sm boxes indicate in Figure 2? this should be mentioned in this paragraph as well.

We will define this in the caption and section 3.2

L215-216: Why did you not consider T_v? It has higher

We are not sure what you mean here. In any case the same plots for Tv are available in the SI. All thresholds were used in the method, we just thought we'd highlight the fact that Ts is the most sensitive here. However, we agree that this might be confusing and will therefore move Figure 4 to the SI.

L215: As a result of the threshold calibration, then saturation threshold T_s was the only ....

We believe the current version is clearer

L224-232: This part should rather be in the Data section or in 3.1

In our opinion, this is rather a methodological point and fits well here, after having focused on the automated mapping with Sentinel-1.

L242: What about the Hispar region?

No such high-resolution optical images were available for this region. We will mention it in the text:

'*For the Hispar region also, no such high-resolution (<5m) optical images were available for the study period'*

L250: Why nor 35 degrees? you use it as threshold.

30° is the value used by the two papers we refer to here and is a classic threshold value used for avalanche risk assessment (e.g. https://www.data-avalanche.org/cristal). For consistency we will keep this value.

L254: I'd rather change the section title to: Evaluation results of the manual mapping approach and 4.1 instead to: Sentinel-1 avalanche mapping or similar.

We agree that these titles could be a bit more explicit, we will make the following changes:

- '4.1 Sentinel-1 avalanche mapping' instead of 'avalanche mapping'
- '4.1.1 Comparison of Sentinel-1 and Pléiades manual detections' instead of 'Sentinel-1 avalanche mapping potential.'

L261: season without 's'

Disagree. Will keep it as is.

L261: remove (dates)

Agreed, will be removed as suggested.

L263: Do you mean 5?

All the figure numbers will be updated and carefully checked

L282: +/-: please improve this symbol: (-29 \pm 36)%

We are not using latex. This will be updated in the final typesetting stages before publication.

L286-287: These were the outlines obtained from the Sentinel-1 or the Pleiades images? Please specify!

Good point. We will specify here that these are the Sentinel-1 outlines.

L298: Was this checked with the precipitation time series or how can you link it to to snow wetness changes?

If yes, please mention it, otherwise, there can be other reasons for this false positive!

Furthermore, inferences of the results should be made in the discussion and not in the results section.

This comes from the observation of wide-spread snow backscatter changes, as shown in figure S9a. We will specify this:

'can in some cases be linked to widespread snow backscatter increases likely due to wetness changes, especially during the May-October season (Fig. S9a)'

We consider this to be an observation result, rather than an interpretation, and will leave it here.

L311: 'number of manually': where the Pleiades detection taken into account? Please indicate this here or earlier in the text.

This section and the following ones only refer to Sentinel-1 images. We will specify it here and will mention it also at the start of the results:

'Here, we first compare our manually derived outlines with high-resolution Pléiades images and evaluate the results and transferability of the automated mapping approach (Section 4.1). We then use the manually updated set of outlines to obtain the characteristics of avalanche deposits (Section 4.2) and their spatio-temporal variability (Section 4.3) for all three survey domains. '

L313: 'Pearson's correlation coefficient': This coefficient should be introduced in the Methods section with forrmula and reference!

Please refer to response to general comments

L325: 'generally above 0.5': here it would be better to judge the results if average values plus/minus stdev are reported.

Agreed. Will change as suggested.

L326: also here average values plus/minus stdev

Agreed. Will change as suggested.

Fig. 9: The color choice is not convenient. Ascending and descending are both in the red spectrum. E.g. red and blue spectra would be better distinguishable.

We will change one of the plots to blue as suggested

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