

Review of the manuscript ‘egosphere-2023-2007’:

Mapping and characteristics of avalanches on mountain glaciers with Sentinel-1

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Comments to the authors

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.

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The article currently relies - particularly in the introduction but also throughout the whole article - on many outdated references and lacks recent studies, notably in the context of avalanche detection using satellite data.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.

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.
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 analysed and if daily images were taken 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.
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.
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.
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.

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.

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

References

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