The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-272-RC1, 2020

The Cryosphere Discussions

Interactive comment on "Mapping avalanches with satellites – evaluation of performance and completeness" *by* Elisabeth D. et al.

Anonymous Referee #1

Received and published: 2 December 2020

General comments:

The authors present a comparative study of the results of avalanche debris detection over 2 periods (20 to 24 January 2018, 13 to 16 January 2019) of high avalanche activity using SPOT-6, Sentinel-2 and Sentinel-1 radar images over an area of 180 km2 around Davos. The authors also use manually mapped avalanche data sets derived from photographs taken from the ground and from helicopters. The studied topic is of high interest for the scientific community since mapping avalanche debris and monitoring the subsequent avalanche activity is a very important issue in mountain regions. The authors therefore present general statistics on the detection of avalanche debris for each of the satellite observations used. They show the significant potential of very high resolution SPOT measurements and Sentinel-1 measurements for moni-

toring avalanche activity and the limitations of using Sentinel-2 for this application.

Overall, the manuscript is well written, the methodology is well described and the objectives of the study are well defined. This paper therefore deserves to be published, but I suggest that the authors make some improvements to the paper according to the comments and questions I list below. Some points would require additional information for the benefit of the readers.

Specific comments:

- Adding a processing scheme of the SAR data processing from Ground Range Detected High Resolution images to local resolution weighting images would be very useful. - It is a very good option to use radiometrically ïňĆattened and terrain-geocoded SAR observations according to the methodology proposed by Small (2011). How the difference in observation time between the pixels of the ascending and descending image is handled ? and what about the differences in observation angle ? Would it be better to merge images in this way or to keep the ascending and descending orbits separated (but still corrected for the radiometric effects of topography) ? And then merge the binary detected avalanche debris pixels ? - For avalanche detection, areas that show an increase in the radar backscatter signal in the difference of the LRW image before and after the avalanche event are targeted. So what is the threshold you used? Did you looked at the signal variation in an observed avalanche corridor to validate the choice of threshold ? - Once the pixel detection is done, I do not really understand how you go from the detected pixel to a detected event ? This is an important step because it is more relevant in my opinion to look at detections in terms of events rather than pixels. - Given the test area, some other SAR images would be suitable from different ascending/descending orbits (A117, D129,) in addition to A15 and D168. - The month of January 2018 was exceptional in terms of avalanche activity and avalanches that were recorded on January 24 (In SPOT) may in fact have occurred earlier in the month. How can this effect be taken into account? Have you filtered the events to retain only the most recent ones? - As you mentioned in the paper, there are

areas that are less well observed using SAR measurements. And this could induce a bias in the detection of debris depending on the orientation of the slope. Have you looked at the results of detections by main orientation? - Similarly, given the difference in observation time between ascending and descending orbits, one would also expect a noticeable difference in detection results between the two orbits, which also argues in favor of separating the morning and evening orbits. - Regarding contingency tables, while the notion of true positive is simple to elaborate, the notion of false negative is more questionable. Because outside the ground truth, it is difficult to say if a satellite detection is "false" (difference in observation time, rain/snowfall after event, ...). - Is it possible to explain the detection difficulties with Sentinel-2? Is it a matter of information content or pre-processing or band selection? - Regarding SAR weaknesses, I think that more effort should be put on methodologies to better isolate avalanche debris signals in images (adaptive thresholding depending on the type of surface, or efficient image analysis methods to detect signal change). These data are rich in information but unfortunately complex to use in the absence of an open and ready-to-use database of pre-processed Sentinel-1 measurements for scientists. - Finally I would like to thank the authors in advance for sharing the data from this work as it was the case following the article by Bühler et al. 2019. I had the pleasure of using this validation data and it was decisive in developing our avalanche debris detection algorithms in France.

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