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Interactive comment on "Automatic detection of avalanches using a combined array classification and localization" *by* Matthias Heck et al.

Anonymous Referee #1

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The authors present a method to automatically and in real-time classify avalanches in a region in Switzerland. They use an exemplary seismic waveform of an avalanche and use it to detect more avalanche events. However, this approach, just based on 1 array led to more than 50% of false detection of earthquakes and airplanes. They used a second array and removed signals that were simultaneously recorded at both arrays in order to reduce the number of false detection. However, even more false classifications were detect, when the authors computed back azimuths and removed the ones that scattered too much.

General comments: To me it seems that the approach they suggest is very difficult, despite they claim a near real-time detection of avalanches. So maybe it would be a better idea to e.g. choose windows with a high enough signal to noise ratio and then

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[Discussion paper]

perform the array processing in it rather than trying to find events with a master event, and the need for a second array and the array method? The authors discuss limitations of their method in the discussion. However, I feel that in this section the discussed literature is mainly their own papers i.e. first authors "Heck" and "Hammer". In addition I counted 11! references to the paper Heck et al. 2018B which is not published yet and it is therefore not possible to check the content, figures etc. of it. Could the authors provide the manuscript, as this manuscript seems crucial for the paper here?

Below are my detailed comment: p2, 5: what does "rather poor" mean? Can you quantify it or specify? Is this their conclusion or your interpretation? p2, 30: I think it is unclear what these arrays are. e.g. the one to locate avalanches and the one at 14 km distance and then your are talking about one in Dischma Valley and one at Wannengrat array. Are these the same arrays or different ones? Maybe the names or location of arrays should be introduced earlier and a link to figure 1 should be added? p2, 32: is this the winter season 2016/17? p3, 10: two ")" too much p3, 15: ")" too much p3, 15: where were these cameras and weather stations located? p4, 2: In this sentence you describe that the cameras helped to identify avalanches in the winter of 2016/17. But then you cite a publication from 2011? Clearly this publication does not describe the winter 2016/17? Maybe rephrase. p4, 6: Is the amplitude in noise that stable in time, that it ok to use a fixed threshold like you do or did you change it in time? p4, 6: given a sampling rate of 500 Hz your time window is only 2 seconds long when selected. This sounds pretty short to me when looking for avalanches. p5, 4 "Using these properties, a widespread background model can be learned from the general properties" I think this sentence sounds odd. Are you trying to built a model from information you derive from the general properties? p5, 4-7: I cannot follow how your method works in detail. Maybe the text should be rewritten with more reference to figure 3? p5, 14: are assuming that two events are separated by at least 24 hours? And if two events have a closer spacing in time they cannot be picked/ located? p5, 15: you state that the t_{class} window is 1 h long, but on p4, 6-8 you state that the chosen event is only 122 s long. Is there an error somewhere? p5, 25: What is a instantaneous

frequency? P5, 27: maybe you should explain cepstral coefficients? p5, 30: what do you mean with "the first half-octave band has [. . .] a total number of 6 bands"? p6, 6: what if the event model is very unlike the avalanche signal you try to detect? P6, 10: "Each classified event having a duration shorter than 12 s was dismissed" replace with "Each classified event shorter than 12 s in duration was dismissed" p7, 6: I am a bit surprised that you state that your second array at 14 km distance does not record the avalanche any more. After all you mentioned this array in the introduction that could detect avalanches up to a distance of 30 km (p2, 10). p7, 8: "12 km away" replace with "at 12 km distance" p7, 10: rephrase the heading as I find it pretty unspecific p7, 12: what MUSIC code did you use? Where is it available? p7, 27: does this approach not exclude avalanches along other potentially longer or more curved paths? p7, 33: what is the "used array"? p7, 34: "through further analysis" instead of "by further analysis"? p8, 2: "to speed up the calculation time": you "reduce the calculation time" or "speed up the calculation" p8, 2: so if I understand this correctly for a 2 minute long window it takes 6 minutes to process? So in order to do this in real time you need to skip time windows e.g. of "noise" p8, 15: figure 4a p8, 16: figure 4b p9, figure 4: maybe remove the legend in figure 4b as the information is already there as label of the y axis. Could you limit the yaxis at 110 or so in order to make the low numbers of avalanches in February more visible? p9, 2: On p7, 30 you state that you minimum event length is 20s whereas here you state it is 12 s. p9, 6: What do you mean with "classes with 5 and 6 votes" what votes? p9, 10: It that a good thing or a bad thing that you detect avalanches that are not listed in figure 4? E.g. does this mean that there are avalanches missing in figure 4 that should have been listed or are there completely different avalanches recorded in different areas and the only common thing is the huge amount of snow in that time period? p10, figure 5: move the sentence "the red area..." up to the description of subfigure a p10, figure 6: what do you mean with vote in the legend? What is a vote in the context of avalanches? p11, 2: two ")" too much p11, 21: I keep wondering why you detect the avalanched only up to 4 km distance and not 30 km distance as mentioned in the introduction. p11, 31: "except for detections at the

beginning of April" consider replacing it with: "except for detections at the beginning of April and no detections at the beginning of February" Any ideas as of why these avalanches in February could not be detected? p12, figure 7: Does the gray area in figure 7 have the same meaning as the red area in figure 5? If yes I suggest to use the same color. p12, figure 7: I am surprised about the low frequency content of the airplane and the lack of overtones. How did you classify this as an airplane? p13, figure 8: What is the unit of the normalised time and how is it calculated? Do the events have the same length or did you just stretch/ squeeze them to fit in between 0 and 1? p13, 6: one ")" too much p13, 8: one ")" too much p13, 11: Do you know what these 37 other avalanche like events might be? Maybe these are just avalanches along an unexpected path or longer paths? p13, 16: It sounds to me a bit like you remove events until you end up with back azimuths or locations you would like to get. p14, figure 9: How do you know that these are airplanes? p15, discussion: I find the discussion a bit repetitive with respect to the rest of the manuscript. Many points seem to have been made already in the rest of the text. Also my impression is that they barely refer to work of others in the discussion i.e. papers that are not lead by "Heck" or "Hammer". p15, figure 10: change to that the legend is not overlapping the bar any more p16, figure 11: "for avalanche event" replace with "for an avalanche event" Figure 11a: I don't understand to what part of the figure you refer to with "solid part". Beneath what threshold? Figure 11b: is this really the derivative of the angle (y axis label) or derivative of the back-azimuth path (caption)? To me this figure seems to show the "angle" or "back azimuth" during, before and after the avalanche event with very stable back azimuths during the event and larger scatter afterwards. p17, figure 12: so there are 100 visually observed avalanches in Davos but you could detect only 20? Were you too far away or was this recorded but not classified as event? Move the legend so that it does not overlap with the bars p17, 1: "closer" replace with "closer to"? p17, 8-10: First you say that you could confirm no avalanche visually, but in the next sentence you state that "another 12" events were identified. Were they identified in a different way i.e. not visually or is there an error in the sentence? P18, figure 13:

How do you know to what distance the duration of the event corresponds to? p18, 4: number of votes: in my opinion it would be better to replace "vote" with something like "detections on sensors" or similar. p18, 12: the overall feature behavior from distance airplanes... "was" not "were" p19, 9: remove "really". Based on the 5 events that were possible to locate, it is apparently possible to detect some avalanches on both arrays. p19, 9: I am not sure I fully agree. It is not possible to record an avalanche at 14 km distance if it couples to the ground sufficiently or is large enough? p19, 10: "since distance" replace with "since the distance" p19, 10: I am not sure where installing two arrays at 2-3 km distance would help. They would then pick up the same avalanches, and hence "events recorded at both arrays" are then not a valid criteria any more to find falsely classified earthquakes or airplanes... p19, 11: "improving" replace with "improve" p19, 22-24: Can you not locate airplanes and earthquakes with the array because the frequency content is different? So if the MUSIC method is perfectly suitable of detecting avalanches, why should one go through the hassle of finding a exemplary event, the need of having two arrays and then removing a lot of false detections? Rather than using the output from the array method to detect evetns? p19, 26: typo in "theses" p19, 30: typo "form" p19, 32: "avalanches were released" instead of "avalanches released"? p20, 5: Why is it that costly? Can the processing be sped up? p20, 14: "be still needed" replace with "still be needed" p21, references. There are 11! referrals in the text to a not published paper (Heck et al. 2018b). Can the authors provide the manuscript in order to cross-check e.g. the content?

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