

Interactive comment on “Infrasound array criteria for automatic detection and front velocity estimation of snow avalanches: towards a real-time early-warning system” by E. Marchetti et al.

Anonymous Referee #2

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1 General comments

This paper presents results of an experiment investigating the use of infrasound for automatic detection of avalanches and for estimating avalanche velocity. The results are mainly based on data measured in the Grosstal avalanche path, Austria during one winter. The topic is highly relevant for avalanche risk management and fits to the scope of NHESS. However, the paper needs a major revision regarding the content,

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the structure and the language before publication. The experimental setup, the data and the applied method need to be explained clearer in order to attract readers interest, who are not very familiar with this topic. I also think that much more experiments and data are necessary to confirm statements made in the paper.

2 Specific comments

2.1 Abstract

In the first part the authors claim that their method overcomes existing limits of infrasound for detection of avalanches. Since results are based on data of only one winter at one site, authors should be careful. Furthermore, the authors write in the final sentence that their results indicate that infrasound is suited for a robust remote detection of avalanches. I suggest to reformulate the abstract in the sense that this paper is an additional contribution in this field. I recommend to replace the term *avalanche forecasting* by *avalanche detection*.

2.2 Section 1 ‘Introduction’

In the first part of the introduction I would also include recent work on radar e.g. by N. Vriend et al.

2.3 Section 2 ‘The Grosstal avalanche’

The experimental setup and the method is described very roughly, especially for readers who are not fully familiar with radar and infrasound measurements. I recommend to add a sketch of the setup and a brief description of the method including the concept

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of back-azimuth and apparent velocity (see description on p. 2715, eq. 1). It becomes not clear in the beginning of section 2 what your dataset is consisting of. It seems at this point that you have data only from one single avalanche (which is clarified later in the paper). I recommend to briefly describe the whole dataset and which data you used. Why not analyze data of all three events, which is done later in the paper? From Fig. 1 (referred in section 2.2) it becomes not clear which avalanche paths could be measured (detected) by the device.

In section 2.2 you describe results in detail; however, methods for signal processing need to be explained better. In line 6 on p. 2716 you write "... are consistent with the Grosstal avalanche path". I can't see this in Fig. 3 and in the other figures presented up to this point. Line 13 to 19 might fit better in the discussion section than here.

2.4 Section 3 'Avalanche dynamics ...'

Section 3 is difficult to understand without a broader explanation of the method. For example, in line 23 on p. 2716 you mention the term "peak pressure" and in line 19 on p. 2717 "array analysis" which remains unclear.

In the section "Comparison ..." on p. 2718 you provide some basic explanations on how infrasound data have to be analyzed and interpreted. Shouldn't this information be better provided at the beginning (maybe in a method section before section 2; this would also address my comments above)?

I suggest to rewrite the explanation of Fig. 6. I cannot see the good matching of the results as described. In my opinion you cannot draw the conclusion that velocity of an avalanche front can be derived from infrasound data based on the dataset and results presented here. Maybe you can move some sentences from this paragraph to the discussion section and comparing your results with those of other authors instead of simply citing it. Do you have explanations for the pulsing avalanche velocity derived from infrasound (see also Fig. 5)?

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2.5 Section 4 'Automatic avalanche detection'

In the first paragraph you make the firm statement that velocity can be derived from infrasound data. Please consider above comments also in this context. I think you cannot speak of a "robust automatic identification" based on the presented results (p. 2720, line 24).

For this section, I recommend you make clear for which area the results you are presenting are valid. You describe the back-azimuth range (1st paragraph on p. 2721), which seems to me very specific for a site.

On page 2721 and Fig. 7 you show the whole dataset from December 2012 - March 2013 and the filter for the Grosstal events. I suggest to rethink the structure of the paper in the respect that you could also put this evaluation at the beginning and going from there to a specific analysis of the event on the 23rd December event. I also recommend to highlight the three described events in Fig. 7. Why don't you analyze the events on 10, 11 and 28 December in details and compare results with the event on 23rd December? In the last paragraph on p. 2723 you mention 'Hoherzug avalanche'. Please indicate this location (see also comments above on description of investigation site).

2.6 Discussions and conclusions

In this section I miss a critical in-depth discussion of your results with other results presented in cited papers. What is your novel contribution? As mentioned above, I'm very doubtful that your results can be generalized in the way you describe. You also mention this by writing "... a systematic field validation should be still required (I would say: ... is still required). Maybe you can also compare with those of other density (dense) currents, as mentioned on line 27 on p. 2723. Your argumentation in this respect is not very consistent throughout the paper. Sometimes you make firm

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statements, sometimes you're more vague. You can greatly improve the value of your paper if you would present more data and compare them with existing results (as far as available).

3 Technical corrections

- p. 2710, line 23: ... with the forecast models ... > ... with forecast models ...
- p. 2711, line 4: ... measurements of snow avalanches (or of a snow avalanche)
- p. 2711, line 15: Do these observations all refer to Bedard et al.? Otherwise please provide a reference.
- p. 2711, line 21: ... along a single avalanche path ...
- p. 2712, line 23: ... Snow avalanches are typically ...
- p. 2715, line 24: please check the sentence. The last paragraph on p. 2715 is unclear. Please rewrite it.
- p. 2717, line 20: ... multiple sources is recorded ... > ... multiple sources are recorded ...
- p. 2717, line 23: valley bottom
- p. 2718, line 9: ... front velocity of a snow avalanche or ... of snow avalanches
- p. 2719, line 19: one or several Grosstal avalanches ? Therefore, velocity or velocities? (same line)
- p. 2719, line 20-21: Infrasound signal? derived from front velocity ...

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- p. 2720, line 26: I assume you do not mean only Grosstal avalanche with 'Ischgl'? If yes, please specify the investigated area. Add also years, i.e. December 2012 - March 2013 ...
- p. 2722, line 21: is it really 240 - 20 °N?
- p. 2723, line 2: consistent > consistence
- Fig. 1: Other areas which are considered in the paper ('Hoherzug avalanche') should be indicated here.
- Fig. 2: Fig. (b) could be rotated so that it matches Fig. (c); avoid double words, may be you like to replace the second identifies with 'denotes'?
- Fig. 3: Did you record one or several avalanches in 23rd December 2012? (snow avalanches in plural)
- Fig. 6: I cannot detect the grey bars (except the one with 'no radar data').
- Fig. 7: I suggest to indicate the events on 10th, 11th and 23rd December mentioned in the text.
- Fig. 8: Wouldn't it be helpful to integrate derived avalanche velocity in all three graphs (below apparent velocity) ?
- Fig. 9: I would mention from where you got the number of events during the winter season 2012-2013 (Fig. c)

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