Answer to David Walter

Thank you for your detailed comments.

Kleine et al. describe a seismic data set of snow avalanches. The novelty is that the data were acquired with distributed acoustic sensing (DAS) using a pre-installed communication fiber running along an avalanche-prone road. In this regard, the presented work is highly relevant, because existing fiber optic infrastructure provides an unrivalled density and coverage of sensors for the detection of and possibly warning against avalanches and other hazardous mass movements. The manuscript is written clearly and the data are of good quality and benchmarked against independent acoustic records. On the other hand, the study makes use of only a small part of the available information: 1. It is not clear how many other avalanches were recorded that are included in the Vasom Regobs catalogue. 2. The signal analysis could be done in more depth. 3. Additional ground observations such as avalanche sizes and locations identified on the webcam or infrasound data could be taken into account for the analysis (based on the manuscript, these data sources exist). For a typical NHESS paper I would expect the authors to take at least one of the above steps beyond the current analysis state. For this reason, I recommend that this paper be rejected in its current form. On the other hand, expanding the paper along one or several of the suggested lines should be straightforward requiring mostly a deeper dive into what the authors have at hand and already partially done. From my point of view, it is not necessary to apply advanced data processing, location algorithms and signal classification, although this should also not be difficult to do. Alternatively, the authors may consider submitting the manuscript as a brief communication. For this, some consolidation of text and figures as well as the addition of more specific information would suffice.

Fabian Walter.

SPECIFIC COMMENTS

In its current state, the manuscript seems to be mainly a first glance at the data. To expand it towards a full-size paper it requires an exhaustive investigation in one of the above-mentioned directions. Here are some suggestions for further data analysis and discussion:

1. Spatial coherence: Are individual phases visible over longer distances? I would expect this if collisions with the cones are indeed seismogenic. How do the signals look like before and after crossing the cable? Are similar moveouts as for the explosion signal also seen in the natural signals? Assuming Rayleigh waves (often dominating high-frequency mass movement signals), different parts of the cable should show a different sensitivity to the approaching avalanche. The closest cable sections should be least sensitive assuming a perpendicular approach unto a straight cable section (Kennett et al., 2024 in GJI). Can this be observed? Are there relevant low-frequency signals that can be attributed to the avalanches' weight? Can the signals be used to differentiate between avalanche paths (see specific comment below)?

   Thank you for this comment. Spatial coherence is indeed expected and should be exploited due to the high spatial resolution in DAS data. However, investigation of several spatial signal processing approaches like semblance-weighted stacks, spatial cross-correlation and FK-filters have not provided significant improvement for the classification of wavetypes. The geometry of the cable towards the protective cones does not allow to investigate changes in the wavefield before and after the avalanche hits the cones. That

would indeed be of high interest to investigate and plans to extend the cable up along the hillside already exist but could not be yet realized due to practical issues.

2. Discussion: The first discussion paragraph suggests that the authors sorted their avalanches by size. How was this size information obtained? Currently, the reader cannot verify which avalanche records correspond to which size of events. A systematic comparison between size, signal strength, central frequency or other waveform characteristics would be interesting.

   We only have a small number of verified avalanche events to work with and only have limited information about those. That is why a systematic comparison is not possible for this dataset. The size information that was included here stems from the webpage www.regobs.no entries.

   Webcam footage (provided externally) is one image per hour, and it only covers the road and part of the cones, not the whole mountain face (and it is not always visible due to snow/ice covering the lens). The webcam images were used to check the presence of avalanche events within the previous hour (through the presence of avalanche cones) as well as to get information about road traffic to be used for signal comparison. We do not have direct access to infrasound recordings and are only able to get that information from Regobs (time, duration and likely location of the event). The test site lies in a remote mountain area, hence manual entries from observers are also sparse.

I was not able to picture the avalanche/road/cable setting. I strongly suggest that the authors include one or more valley cross-sections, even if this is only showing a schematic not to scale. This would answer questions on how an avalanche reaches the road, the cable, the topographic step next to the parking lot or other sites.

We simplified the maps and now only show the eastern mountain face.

MISCELLANEOUS COMMENTS

Avalanche events --> avalanches

Fixed.

Lines 21-22: Delete sentence starting with “Hence, …” (trivial content)

Fixed.

Line 28: delete “reliable”, since more is needed for a reliable tool than just independence of meteorological conditions

Fixed.

Line 31: specify characteristics; which “same test site”?

We added the information, it is the Vallée de la Sionne avalanche test site.

Lines 32-33: approaching which geophone? The reader needs more information, like avalanche size, source-station distance, …

We will add this information.

Line 37: localizing --> locating

Corrected.

Lines 46-47: delete paragraph break

Corrected.

Line 68: rewrite “beginning and end”

Corrected.

Lines 72-73: Indicate infrasound system on Figure 1 or 2.

Done.

Lines 75ff: The described avalanche slopes should be labeled (or color-coded) on Figure 1.

Map was simplified, now only the eastern facing slope is shown.

Line 84: steepness --> slope

Corrected.

Lines 91-92: remove “below in the”

Corrected.

Line 92: remove “during data handling”

Corrected.

Section 3.1: Did you also record earthquakes?

We recorded at least one regional earthquake, which was seen over the whole stretch of the cable. We though did not further analyze the event.

Line 98: Check Varsom Regobs, there are two entries in the bibliography.

One entry is for the website as such, the other one for a specific event.

Line 99: Explain the infrasound measurements. Is this from antenna data?

We do not have direct access to infrasound measurements, we only access the automatic detections on Varsom RegObs.

Line 101ff: Paragraph is too long. Some numbers are spelled out, others are not. When describing channel sections and geographic directions, it would help to label channel distances in one of the plots, or at least refer to the color code in one of the figures.

Good point, we will split the paragraph and refer to the color codes.

Line 112: I would drop a hint here about the source of the four signals (even though they are discussed in more detail later).

This will be added.

Lines 124-125: The modeling and the “similar behavior” have to be explained. Especially the modeling requires details.

We computed first arrival travel times using a simple shortest path method—assuming constant velocity and neglecting topography. We will add more details to clarify this calculation.

Line 128-129: Where does the information on the avalanche location come from? Why is this not shown somewhere?

The information is taken from Varsom RegObs, we will rephrase this sentence.

Lines 134-135: The broadband character can have different reasons and influences. I would include more discussion here or leave out this reason.

This was also mentioned in the first comment. We wanted to establish a link to the collision of the snow mass with the cones, resulting in a broadband signal. Since the sentence was ambiguous in the manuscript, we will make this point clear.

Lines 137-138: I cannot verify the 16 s and the 20-100 Hz range. The figure seems to suggest a different burst signal in b) and a different frequency range.

This sentence refers to the traffic signals, and the one at 16 s is visible on every frequency band. We will break this into a new paragraph to improve readability.

Line 139: Avoid 1-sentence paragraphs. Also, what does "strong" refer to? A high signal-to-noise ratio?

The most energy is found in this frequency range, and while large events are visible in all frequency ranges, smaller ones can only be identified in this band.

Lines 150ff and 160ff: I could not confirm most of the exact time information.

Thanks for pointing that out – we got the text for the figures mixed up. This will be corrected.

Line 165: Can the different duration be related to different flow velocities?

No, as we do not have additional information about the velocities.

Lines 182ff: It would help to see more quantitative information from the Surinach studies (avalanche sizes, source-station distances, sensor types, …).

We will add those in the revised manuscript.

Lines 192: The DAS signals should provide further hints with respect to the different avalanche paths. This is the kind of additional analysis that I strongly suggest (see general comments above), even if this is done on a qualitative level.

As mentioned, we do not have much meta data about the avalanches.

Lines 207ff: I strongly suggest discussing Kang et al., 2024, in GRL, here.

Thank you for the reference, we will look into this.

Line 210: No year for reference.

Fixed.

Lines 204-205: Is it really this simple to distinguish car traffic? What about cars leaving from the parking lot or moving across it?

This is an important point. Distinguishing car traffic is not straightforward, especially in complex scenarios like vehicles leaving the parking lot or moving across it. However, most of the traffic signals during the 3 seasons are visible as inclined lines on the DAS sections.

Line 212: “Sobel operator” needs a reference.

Will be added.

Conclusion is a summary. I suggest deleting it and calling the Discussion section “Discussion and Outlook”.

Thanks for the suggestion, we will adjust this accordingly.

FIGURES AND TABLE

Captions should not include paragraph breaks.

Good point, this was fixed.

Table 1: The meaning of the gauge length is not explained. Either include it or remove the information from the table.

We would argue that gauge length is a well-known term in the DAS community and does not need further description.

Figure 1 caption: I suggest rewriting “discriminability”.

The whole Figure was changed and simplified.

Figure 2: I suggest labeling the cones, also in the inset; What is Saetreskarsfjellet? Is this mentioned/defined in the text somewhere? Caption: correct typo(s); “start of” ◊ “entrance of”.

We added an explanation (Saetreskarsfjellet is the mountain where the avalanche prone slope is located).

Figure 3: Panel b: It seems that the avalanche is visible on practically all channels. I suggest pointing this out or even amplifying the signal to make this more obvious. Panel d: I suggest decreasing the extent of the y-axis so that the explosion moveout can be seen here.

The signal that is visible on all channels in panel b is due to noise (this is a problem we encountered often in the 2024 dataset).

Figure 4: I suggest labeling the columns (rather than defining them in the caption) in their top panels (using titles or text boxes).

This will be adjusted accordingly in the revised manuscript.

Figure 5: Here and perhaps in other figures, I suggest increasing the font sizes of some of the text. The precursory signal in b) (circled in white dashed) is not visible.

Thanks for the suggestions, we will improve readability.

Figure 6: The caption seems to be equivalent to Figure 5, so I suggest replacing it by a respective sentence.

This was adjusted accordingly.

Figure 3 and elsewhere: the colors of the waveforms are difficult to discern, I am not sure the color scale serves its purpose.

Attachements:

Revised Map

Road and infrasound were added, tunnel and gallery sections are displayed as dashed lines. The fiber section used for this study is displayed in magenta. For the overview map, context was added.