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Comment on nhess-2022-44

Anonymous Referee #1

Referee comment on "What weather variables are important for wet and slab avalanches under a changing climate in a low-altitude mountain range in Czechia?" by Markéta Součková et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-44-RC1, 2022

Review of manuscript “What weather variables are important for wet and slab avalanches under a changing climate in low altitude mountain range in Czechia?” by M. SouÄ□ková, R. Juras, K. Dytrt, VojtÄ□ch M., J. R. Blöcher, and M. Hanel

General comments

Dear Editor, dear Author,

The submitted paper deals with a very interesting topic, namely the change of wet and slab avalanche activity since 1979 with its snow and weather drivers. Indeed, one of the remaining challenges regarding snow avalanche activity is to assess how avalanche activity characteristics will change in the future, notably in terms of avalanche types (e.g., wet/slab avalanches). Moreover, current literature pays little attention to low to medium high mountain ranges, especially in terms of avalanches. It is therefore a major interest of the study to deal with this subject in such a “forgotten” space. This article shows in particular, over the study period, an increase of wet avalanches in spring but also in the middle of winter (February), consistent with the literature in other areas. The authors then analyse main drivers of this wet/slab avalanche activity using state of the art statistical techniques (classification trees and random forests with suitable tools to balance the data sets of avalanche – non avalanche days). Eventually, they discuss their findings with regards mainly to the literature regarding known drivers of avalanche activity, performance of their classifiers and some data and model limitations. Formally, the paper is rather well written, in good English, even if it is lengthy at some places.

This all makes the article a potentially interesting contribution to the state of the art. However, there are several points which should be addressed in a reworked version of the paper before it can be published in NHESS, notably the main point regarding the

discrepancy between the approach retained and the investigated question.

Main point: while introducing their study, the authors introduce rather well (see below) the context of climate change impact on snow avalanche activity. By contrast, thy put little effort in analysing past changes in their avalanche activity using standard techniques (trend analyses, tests, etc.). In addition, their analyses of avalanche drivers makes an underlying assumption of time independence (e.g. the days/years could be shuffled without changing the results). As a consequence, there seem to be a real discrepancy between the scope of the study and the approach chosen, notably with regards to the assumptions made and the potential outcomes of the findings in terms of avalanche forecasting. I would suggest:

- Improve the analysis of the avalanche records through the analysis of time series, to highlight potential significant changes
- To find a way to analyse changes in the drivers over time, e.g. by splitting the time period in two and see if there are significant changes in avalanche activity drivers all over the study period.

This would allow making the link between the climate change context, the avalanche activity series and the forecasting issue. Eventually, the discussion section should carefully discuss to which extent the climate change, avalanche drivers and avalanche forecasting issues fit together.

Alternatively, the climate change issue could be completely omitted, to focus on the classification/forecasting question. This would keep the methods/results as they are but would make the paper less original and interesting as well.

Other general points

- Presentation of climate change impacts on snow avalanche and discussion of main findings with regards to this context should be improved, with reference to relevant literature. Specifically, the distinction of trends with elevation should be clarified (see e.g. Giacona et al 2021). At high elevation, the increase in extreme snowfall should be mentioned (Le Roux et al., 2021). And it should be then properly stated /discussed to which extent what the author observe in their data is consistent with what we know, and what is really new (notably changes in drivers, if this happens). This would indeed benefit from new time series analysis and analyses of drivers over sub-periods. As it is, sect. 4.2 which should include these aspects according to its title, is both lengthy and inaccurate (a large part of the section is about drivers without reference to changes).
- References must be harmonized in the main text. Chronological order is usually preferred. In addition, some important references regarding climate change impact on snow avalanches (Peitzsch et al., 2021) and snow extremes (Le Roux et al., 2021) as

well as on changes in avalanche risk as function of different drivers (e.g. Zgheib et al., 2020) are missing. By contrast, references which do not fully belong to the topic (e.g. Strapazzon et al., 2021) should not be cited so often.

- I miss a detailed presentation of studied avalanche paths and related snow and weather drivers. This could be provided as an appendix .
- Discussion emphasizes some limitation of the data but appear as insufficient on this point. To which extent the analyzed avalanche time series reflect physical reality? Can highlighted trends be fully trusted or do they include some biases related to observation? This is a difficult point but it is of outmost importance and should better be discussed. Annual plots with trends etc. would support this discussion.
- Please avoid the term "long-term avalanche activity" as the study covers 40 years only. Some studies now consider much longer avalanche records (e.g., Giacona et al. 2017; 2021). Similarly, a discussion regarding the size of the data set analyzed with regards to competing studies (e.g. in Europe and north America) would be worthily.
- As it is, the study appear a bit too much as a case study. Can the authors elaborate a bit more regarding the implication of their findings both at the local scale (future of avalanche activity in their area, implications for risk and forecasting), and more broadly (what does the study indicate /confirm that could be of broad interest regarding avalanche activity drivers, its ongoing changes and potential future evolution?)

Specific comments

Abstract: It is rather long and too much detailed. It should be rewritten to highlight more the methodology (which is very diffuse in the presentation) and the main findings, notably w.r.t. the trend/forecasting issue (main point). Some words should be clarified or avoided (decadal, RF).

Introduction: overall it could be both shortened and sharpened with regards to the scope of the study and relevant literature (see before).

64: Please, precise what do you mean by "moderate and high elevation".

70-71: Please, add a reference which points out this evolution in low altitude mountain range in particular?

74-76: How do you explain that this change mainly occurs in February? Was the month of March already characterized by mixed precipitation earlier in the past?

83-85: Authors specify a difference above and below 1200 a.s.l. Could this influence the results? It is mentioned that above 1200 m a.s.l. snowpack is sensitive to precipitation. However, results highlight that wet avalanches are more influenced by air temperature. How are these findings connected?

90: "Bel ; Peitzsch et al. (2012)": please complete the reference of Bel which does not appear in the "references section".

105-107: Please consider reformulating the assumptions and scope of the work (se before).

128-132 : Is a link made between the presence of streams and avalanche activity? Does their presence influence the liquid water in snow? Which kind of geomorphology and land cover factors favor a natural environment for avalanche occurrence? What method is used to determine release areas and which criteria are used? What is the average of the avalanche paths slope? What is the length of the avalanche path (mean, minimum, maximum)? Avalanche paths are mostly facing south and south-east, what about the others? Could you provide a table indicating the number of paths per orientation? Do prevailing wind and topography favor avalanche?

129 : Repetition of "mainly".

133-137: Does land cover influence avalanche activity (especially the presence of trees) in the study area? And what about land cover changes and their impact on the results? Please discuss this somewhere in the paper with reference to relevant literature (e.g. Mainieri et al., 2020).

137: Does this mean that trees or shrubs cover always a part of the release areas?

138-143: What is the impact of prevailing winds on avalanche activity / on south and south-east avalanche paths and the other oriented slopes? How does this combine with topography?

145-147: Has a systematic inventory been made in all of the 60 avalanche paths since 1961? Weather conditions do not always allow to know the exact date of occurrence, how did you proceed when this was the case? How are human observation and web camera records articulated? When date back the camera records? Does it set up on sites where there was human observation before?

153: Liquid water in snow in release areas is apparently not known for all avalanches. Are these wet avalanches distributed over the entire period (which temporal distribution)? Does this data concern all the avalanche paths or preferentially or even only some of them?

155-156: "as the most frequent and dangerous avalanche type for skiers on the Krkonoše Mountains" and more widely in the Alps.

161-163: If I well understand, avalanche size classification is relative both to the path and the avalanches recorded during the study period. Why did the authors make this choice? The length of the study period is not long enough to identify the largest avalanches that can occur in the avalanche paths. Aren't the classification and the results distorted? Why not considering that size 5 corresponds to the whole release area determined according to the topography of the path?

172: Is a 3-day moving average a common choice?

182: Does the study focus on 1961-2021 period or 1979-2020? At this stage it is not clear.

255, Fig. 2: How are recorded avalanches distributed over time? Could this contribute to explain the observed increases? Can the evolution observed (less 3-4-5 sizes) between 2001-2011 and 2011-2021 be explained by land cover changes?

l. 256: What does "again" mean?

257: Size 5 appears during 1981-1991. How do you explain this appearance (not discussed in "discussion section"?

260: reference to Fig 10 is inaccurate (figures should be called one after the other).

Could you replace 1961-1991 by 1961-1981?

263-267: the decadal variability is high. Observed evolution could be part of the natural variability of avalanche activity. An annual distribution with a moving average could maybe allow emphasizing an evolution.

266-267: Is there an explanation to the augmentation of slab avalanches in April (not discussed in "section discussion")?

Sect. 3.5 Please specify which threshold you used to discriminate avalanche and non navalanche days on the ROC curve.

267: Please, move fig. 3 here.

383-384: Is there an explanation for the decrease of wind speed?

397, fig. 10: Please could you remind the elevation of the automated weather station? What is the reason of the data gap? Could it influences the trends highlighted? If yes, this information could be added in "discussion section".

Fig 10. How do you explain the absence of decreasing trends in "snow depth" and "new snow depth? How does this relate to the trends in avalanche activity And are there some covariates that could support the trend in wet snow avalanches?

403-405: Please, could you explain the link between treeline and slab density and storm slab avalanche?

443-445: When the specific date of the avalanche triggering is unknown, how did you proceed?

481: How can you be sure that the recorded avalanches are naturally released? And how can you determine the presence/absence of liquid snow in release areas?

482: Please add a reference "the most dangerous type of…"

References:

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