The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
https://doi.org/10.5194/tc-2021-48-RC1, 2021

Comment on tc-2021-48

Karsten Müller (Referee)

Referee comment on "Synoptic control on snow avalanche activity in central Spitsbergen" by Holt Hancock et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-48-RC1, 2021

Review of "Synoptic control on snow avalanche activity in central Spitsbergen" by Holt Hancock, Jordy Hendrikx, Markus Eckerstorfer, Siiri Wickström

General comments

The authors investigate the correlation of atmospheric circulation patterns and avalanche activity in Nordenskiöld Land, Spitsbergen. They compare manually observed avalanches with the atmospheric circulation patterns based on the ERA-5 reanalysis which have been divided into 11 different types.
Avalanche activity was divided into three classes: non-avalanche days, avalanche days, and avalanche cycles. Findings are in line with the common understanding that events including large precipitation and/or strong winds or rapid warming lead to increased avalanche activity. The link to the synoptic patterns can aid in long-term avalanche forecasting. It will also aid in tracking and understanding the impact of climatic changes on avalanche activity in Spitsbergen.

The presented study is of interest to the scientific community and within the scope of TC. The conclusions support common understanding on the relation between meteorological drivers and avalanche activity but do not provide novel insights. The used time-frame is to short to provide insights on the effect of climate change. However, they present a feasible method to investigate the effect of climate change on avalanche activity once more data is available. The paper is well written and structured. However, several sentences are very long. Shortening and splitting these sentences would improve readability. Figures and tables are of high quality and help to convey the findings and arguments presented. The methods are clearly outlined and the data to reproduce the study is publicly available. However, I argue that the separation between avalanche days and avalanche cycles has pronounced weaknesses. Arguments for why the chosen approach is valid need either be presented more clearly or the methods adjusted.

The separation between avalanche days and avalanche cycles is the main weakness in this study. The AAI is a logarithmic scale that combines the size and number of avalanches. A single large (size-3) avalanche will result in an AAI=1. Which is already twice as high as

the threshold of 0.4 chosen by the authors to define an avalanche cycle.
Why separate between avalanche day and cycle at all. It would be possible to just use the AAI (ideally combined with the actual number of avalanches) directly. You could e.g. use a normalized AAI for each atmospheric pattern: (cumulative AAI for given atmos. type) / (days with given atmos. type) - see also detailed comments below and on Fig.3 and Table 1.
That would indicate which patterns are connected to higher avalanche activity (and/or larger avalanches) and which are not. Introducing the separation between avalanche days and cycles is misleading in my opinion.
You could also "bin" the histogram in Fig.3 and base your classification off them e.g. low, intermediate and high activity.

I miss a discussion on the pros and cons of the AAI. Why did you choose AAI instead of numbers per day? I would argue that the number of avalanche rather than there cumulative size defines an avalanche cycle. Also what effect do lacking observations have on your AAI. On a synoptic scale it would be beneficial to be able to predict cycles involving large avalanches separate from those that involve only small avalanches. What would be required to do so? Please address the above points in your discussion.

I also miss a discussion on the choice of the atmospheric circulation classification. Why was the subjective classification preferred over an objective one. An objective one would be easier to transfer to other regions. What are the benefits of the Niedzwiedz Classification and for what reasons was it preferred here?

Please also provide more details on how the reliance on manual observations of avalanche activity might effect your results and what uncertainties are connected to it.

Details and examples regarding my general comments can be found in the next section.

Detailed comments
Position in the text is referenced by page/line or figure/table number in the following comments.

2/61-66: You mention several options for classification of the circulation patterns. Please provide an explanation/argument for why you chose the one by Niedzwiedz. Advantages and disadvantages (either in the introduction or the discussion). This is also a long sentence that could be split into two.

3/65: ...and snow distribution on *selected* glacial systems...

3/90: Please define avalanche cycle or reference the definition used.

Fig.1: I suggest to use a dashed black line to indicate the border of Nordenskiöld Land. The thick green line is hard to read.

4/100: Please explain or reference "Dramatic recent changes have been superimposed on the region’s baseline climatic variability...".

5/124: remove "purposes"

7/170: Please provide a brief explanation of AAI together with the reference since it is central in your study.

7/178: In my opinion an AAI of 0.4 or 0.5 alone does not necessarily indicate an avalanche cycle. It corresponds to 4 or 5 mid-sized avalanches or (less than) one large avalanche in the Nordenskiöld Land. An AAI of 0.4 due to 40 size-1 avalanches (your typical avalanche size) could be called a cycle, but an AAI of 1 due to one size-3 avalanche (e.g. the single slushflow event) would not be a cycle. You need to emphasize that most of your avalanches are size-1 and manually remove those days that were wrongly classified as cycles due to a single/few large avalanche(s).
Based on Fig.3 you maximum AAI is 5 and generally well below 2.5. I would argue that your manual observations will most likely only provide a fraction of the actual avalanche activity on a given day. Thus, your data does contain little or no avalanche cycles with avalanches larger than size-2. Unless you have an other parameter that you can reliably use to scale your manual avalanche observations. Address this points in your discussion - see also my general comments.

Fig.3: Please show the number of avalanches color-coded by size in addition to the AAI for avalanche days and cycles. Remove "index" in caption.

10/235: What do you mean by "experiencing climatological MSLP conditions"?

14/295: ...highest proportion *of* avalanche days...

Tab.1: This table provides a nice overview of your results. Please add the cumulative AAI normalized by the "total number of winter days" and the cumulative number of avalanches normalized by the "total number of winter days" per type. Is it possible to identify the synoptic type that produces the largest avalanches?

17/314: Please mention Type 4 and 8 in comparison to Type 9 in this section.

18/342: Why do you focus on Type-7 in this section. Please include at least Type 6 as the most common type and Type 10 as a fairly common type with low AAI.

19/386: ...conditions *promote* strong...

21/456: What do you mean by "...linked to other work...help anticipate changing frequencies of avalanche events..."? What is the current frequency? How does it change?

21/459: Why did you choose the Niedzwiedz classification? Why have you not used the objective classification by e.g. Käsmacher and Schneider?

21/457: Replace *modern* by *current*.

22/470: Please provide a reference to why "...modern(replace with *current*) conditions are not representative of conditions even a decade or two prior."

22/480: Another source of uncertainty is that avalanche activity in Nordenskiöld Land, but away from Longyearbyen could often go unnoticed. Have you looked into if certain circulation types are generally correlated to few or no observations in regobs? I could imagine that patterns leading to challenging weather (strong winds, poor visibility or heavy rain) will lead to a reduction in the number of observations especially away from Longyearbyen. The absence of an observation of avalanche activity does not necessarily imply that there was no avalanche. Please address this.

23/500: "...this work demonstrates the *important* role atmospheric..."

23/510: Please link your Conclusions closer to your Results. E.g. mention the circulation types that have significant influence on avalanche activity or its absence in this section - if only in parenthesis.

23/512: "...near Svalbard resulting in positive precipitation..." What do you mean by positive precipitation? Intense/high amounts/...or just any precipitation?

23/512: "...wind speed anomalies..." Can you be more specific? Do you mean anomalies in both direction above and below average or only above average?

23/512-515: Long sentence - split it.

23/517: "the growing body *of* cryospheric,..."

23/517: The entire sentence is vague. Please clarify and put it into context or remove it.