

# Response to RC1

We appreciate Dr. Christine Fey for reviewing our work and for her constructive comments to improve this manuscript. We first respond to issues and suggestions provided directly in Dr. Fey's interactive comment and subsequently respond to comments and corrections included in Dr. Fey's supplement to the interactive comment. Reviewer comments are displayed below in bold, author responses are in standard text.

## **Responses to the interactive comment:**

**It would be helpful to add the tiepoints used for registration of the scans to the figures.**

We agree visual tiepoint – and tieobject – display in the figures would enhance this work. Unfortunately, we were unable to use the same tiepoints and tieobjects to register each of the scans. This is primarily due to changing snow cover rendering certain tiepoints and tieobjects unusable as snow free surfaces at different times throughout the two winter seasons. Thus, we drew on a suite of over 50 tieobjects to adequately register all scans included in this work, and we believe including all tiepoints and tieobjects we employed would overly clutter the figures. Additionally, some of the tiepoints were located on buildings not included in the figures' extent.

**To assess the accuracy only one area is used. The registration error can vary significantly between different areas. Because of this, the mean relative error is not representative for the entire scan. Either the authors enhance the accuracy assessment to more stable areas, which might be difficult in the case that there are no other snow free areas. The other option is to explain in the text why only one area was used. However, the research question focuses on changes in the magnitude of meters and in this case the accuracy assessment is not so important for the process understanding of cornices.**

We struggled with this issue ourselves. The concern again, to which Dr. Fey alludes in her review, is the dearth of adequately large snow free areas in the vicinity of the cornices with which to use for accuracy assessments. One option would have been to report accuracies from building walls near the foot of the slope. Accuracy near these buildings is generally very good – and almost always better than near the cornices, as the building roofs and walls served as good surfaces to use in the registration process. Since we agree with Dr. Fey that the accuracy assessment is not so important for the process understanding of cornices, we elected to display accuracy assessment from the only stable, snow free area near the cornices because:

- Accuracy assessments from this location are most representative of scan accuracies near the cornices, and
- Reported accuracies from this location are typically worse than in other locations in the scanning domain (i.e. the relative accuracies assessed from building walls would not be representative of the accuracy near the cornices).

As suggested by Dr. Fey, we have added language in lines 195 – 196 clarifying our decision to use just a single area for accuracy assessments.

**More critical I evaluate the volume estimation of cornices. Here, i) the TLS data uncertainties play a more important role in quantification and ii) it's very challenging to calculate the distance and volume of cornices at scoured areas iii) data gaps are causing significant uncertainties in volume quantification. The problem of data gaps is mentioned and the other points could be enhanced in the discussion. Since the process interpretation in this paper is mainly based on the shape of cornices taken from 2D profiles and distance changes of the snowpack it might be better to study the volume calculation of cornices in detail and publish in another research work.**

All three of the issues raised with our volume estimation of cornices are valid concerns. We have specifically addressed these concerns in lines 464 – 471 of the discussion rather than eliminating these analyses altogether from the paper. We agree another research work specifically studying cornice volume changes is needed, but based on the data we currently have gathered and Reviewer 2's positive responses we have chosen to leave these analyses in this work, acknowledging the uncertainty in our calculations.

### **Responses to the supplement to the comment:**

*Minor grammatical comments and suggestions have been corrected as suggested by the reviewer.*

Revisions from the supplement affecting the content of the manuscript:

**Line 156 – The values given from the RiScan MSA are not the 3D accuracy and does only reflect the distance between the point correspondences used at the ICP. I would neglect this value because it says nothing about the registration quality.**

True, and we did not explain this adequately. Based on these recommendations, however, we will remove both this sentence and the MSA values from Appendix 1.

**Line 158 – You mean the point cloud was thinned by blockthinning? The term “grid” is misleading with raster data.**

We've updated the sentence with more specific and less misleading language. Thank you.

**Line 207 – Headings in chapter 4 can be more meaningful which would help the reader to understand the structure of the paper faster.**

We've updated the headings in chapter 4 to “Seasonal summaries of meteorological conditions and cornice dynamics”, which will hopefully help with readability and clarity.

**Line 635 – A legend would be helpful for faster understanding of the figure.**

We've added a legend for the symbology where appropriate and removed redundant language from the figure caption.

**Lines 663 and 667 – Revise the color scheme of the profile to distinguish between the dates.**  
We've changed the color scheme of the profiles to hopefully enhance readability.

**Lines 683 and 687 – Revise the color scheme of the distance change to allow a better interpretation of the magnitude of change.**

We've adjusted the figure to make interpretation of the changes to the snow surface on the slope below the cornices easier. See the detailed response to RC2 regarding Figures 9 and 12.