Responds to the reviewer #3

Dear reviewer,

Special thanks to you for constructive comments concerning our manuscript entitled *Research on the evolution of snow crystal necks and effect on hardness during snowpack metamorphism (ID: water-2754056)*. Your comments are all valuable and very helpful for revising and improving our manuscript. All modified parts are marked in red font in the new version. Please see the resubmitted manuscript. Here are the responses for your comments and suggestions.

(1)

In some sections of the paper, especially the introduction, there are so many not related sentences after each other. It is suggested to go through the introduction.

Response:

We have improved the logical coherence between sentences, rewritten the introduction, and eliminated a few unnecessary sentences. (see lines 28-32, 39-41, 47-49, 53-60, 68-70, 80-82 of the revised manuscript)

(2)

English should be improved significantly. For example, on page 2 line 51 to 56 is a big sentence. Please avoid using sentences bigger than 3 lines maximum.

Response:

We revised the sentence to: Its deformation characteristics are determined by the stresses that are transferred between the grains and the movement of the grains under natural conditions. The snow's continuous densification over time causes the snow hardness value to continuously increase over a certain period of time, with a tendency to increase with the snow depth[14]. Like other physical characteristics, snow hardness is largely influenced by the microscopic connections between snow crystals.

AJE (https://www.aje.cn/) have been consulted and other sections of the document have been reviewed.

(3)

What does "side limit" on page 2 line 50 mean? Please elaborate.

Response:

"Side limit" refers to the limitation of lateral displacement of snow by using restraint components in experiments We have changed the wording of this description and replaced it with "lateral confined". Explanation has been added in lines 53-55 of the revised manuscript. The penetration test can be divided into two categories. One is to immediately penetrate the snow in situ, at which point the snow body can be thought of as endlessly vast, meaning that the surrounds are unrestricted. Another type is the lateral confined test, where the wooden box used in this test provides side restraint.

(4)

Line 64: "Gubler et al.[17] investigated chain snow crystals, and the growth pattern of snow crystal shapes and neck bonds was improved by counting the line lengths of the grain bonds,..."

What do you mean by "the growth pattern of snow crystal shapes and neck bonds was improved"? Please modify the text or elaborate more.

Response:

Revised accordingly. The sentence is revised to: Gubler et al.[17] studied chain shaped snow crystals and used ice chains to describe the load-bearing capacity of snow by calculating the length of grain bonds. Improved the model for analyzing snow intensity using snow crystal shape and neck bond growth.

(5)

How the borders between the neck and the main snow grains were defined and their surface area was obtained?

Response:

As described in Figure 4 in the text, the snow neck and snow crystal boundary rely on manual identification of the four inflection points where curvature changes. The straight line formed by the two inflection points on the same snow crystal is the boundary between the snow neck and the snow crystal. The measurement of its surface area relies on the built-in scale after being photographed under a microscope. During calibration, the pixels occupied by the scale bar are marked as the corresponding actual length, and then the actual length and area of the selected area can be determined. This has been supplemented by lines 188-190 in the manuscript.

The specific methods are described in the manuscript. The method of selecting the neck area relies on manual identification and extraction. First, the area where two ice crystals are connected is found, and the four inflection points where the edge profile of the ice crystal changes from convex to concave are identified, i.e., the four points where the curvature of the edge profile of snow crystals with positive and negative signs changes (e.g., the four yellow dots in Figure 4b). Afterwards, the two inflection points between different ice crystals were connected by smooth curves along the outer contour of the ice crystals (e.g., two red curves in Figure 4b), and the two inflection points of the same ice crystal were connected by straight lines (e.g., two blue straight lines in Figure 4b). The closed area formed by the two curves and two straight lines is the neck area needed for this test, and finally, the area, perimeter, and equivalent diameter of the box selected are calculated using image processing software.

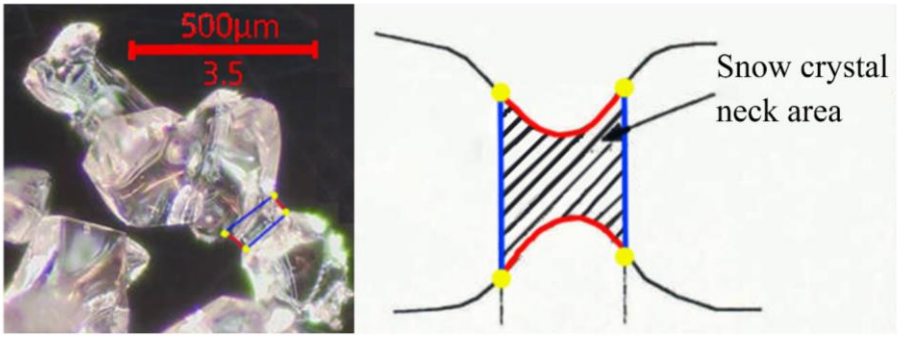


Figure 4. (a) Actual measurement of the neck area (magnification effect at 3.5 magnification) (b) Schematic diagram of the neck area.

(6)

In Figure 5 f in the snow body, there are some sections with a temperature of 4 °C. To the best of reviewer's knowledge wet snow temperatuer should be close to 0 °C. Why does the high-temperature section exist on the snow body?

Response:

Firstly, the snow in Figure 5f did not reach 4 °C and did not exceed 1 °C at its highest point. This can be attributed to the large upper limit of the temperature scale on the color overlay chart during drawing, which can easily lead to visual misjudgment. We replace another image to avoid any confusion and is shown in Figure 5f. Secondly, considering that snow is a porous three-phase composite material. When the temperature rises sharply (exceeding 3 °C), the water vapor and air in the snow become warm. This part is in contact with the temperature sensor, causing the snow temperature to display above zero.

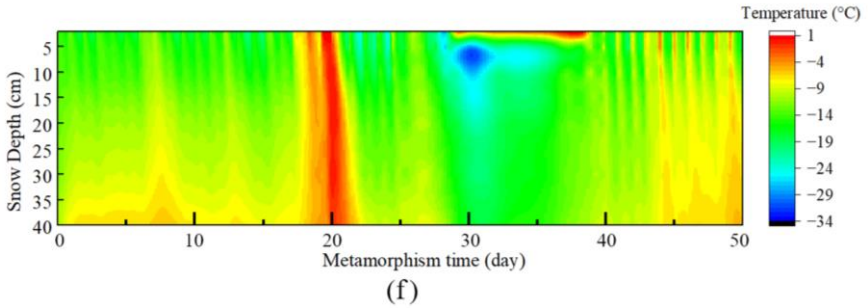


Figure 5. Changes in physical quantities over time during the experiment (f) snow profile temperature of solar radiation group samples.

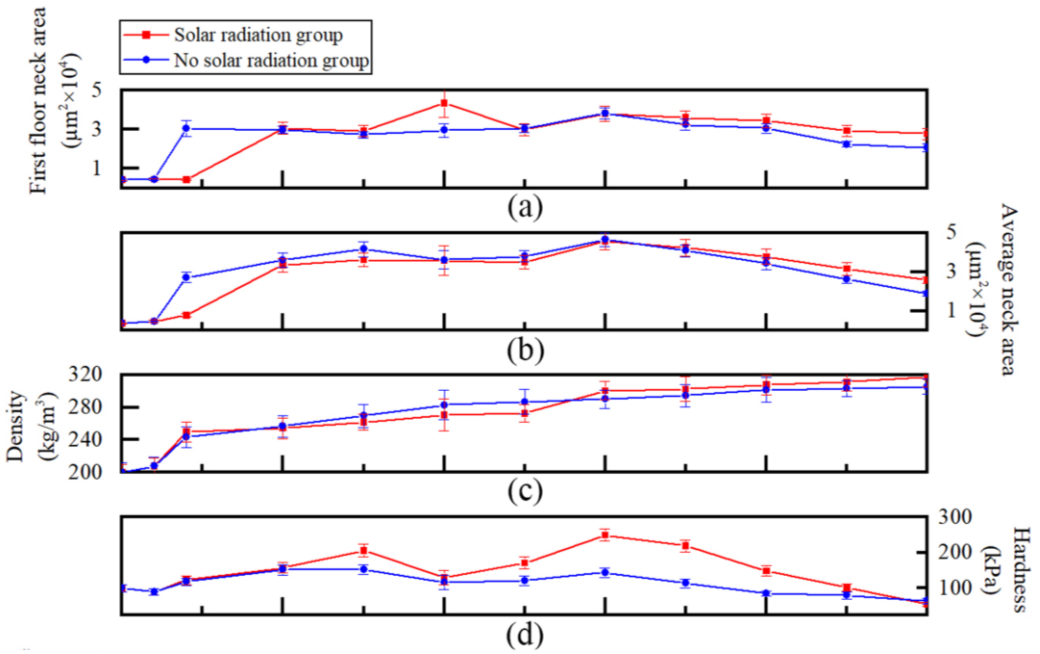
(8)

Most of the plots lack error bars. How many times each experiment was conducted to make sure the results are repeatable?

Response:

We have added error bars and redrawn Figures 5a-d.

The error bar records the error situation during repeated experiments. For the penetration test of snow hardness metamorphism, limited by the number of wooden boxes and the long deterioration time, three wooden boxes are used for hardness testing each time. A single wooden box can undergo three to four different penetrations, and its hardness value is the average of the final results, with relatively small dispersion. When measuring the neck size of snow crystals, the selected snow crystals come from multiple locations on the sidewalls of the snow layer. For snow layers at the same depth, select three to five locations parallel to the profile to extract snow crystals. Sprinkle them separately on the acrylic board and select clear positions to take photos, which can extract about ten images at a time. After summarizing the snow crystal photos of the same layer, 40–60 neck areas can be selected by framing. Except for a few days when the temperature surged, the error in the neck area remained within a small range.


Solar radiation group
No solar radiation group
First floor neck area (μm²×10⁴)
5
3
1
(a)
Average neck area (μm²×10⁴)
5
3
1
(b)
Density (kg/m³)
320
280
240
200
(c)
Hardness (kPa)
300
200
100
(d)