Reviewer 1

We warmly thank the reviewer for the comments and positive feedback. Please find below our point-by-point replies to the comments.

ESSD review criteria:

Is the article itself appropriate to support the publication of a data set? - Yes. The experimental procedure is clearly described and scientifically sound. A suggestion would be to plot time traces of the snow microstructure evolution (density, SSA, mean curvature, etc.) instead of or in addition to the 3D visualizations. This could serve as a 'preview' for further analysis and already yield some interesting results.

The present paper is a data paper that provides little or no data analysis, in agreement with the guidelines of the ESSD journal. However, we agree with the reviewer concerning the interest in investigating the temporal evolution of the snow microstructure geometrical properties. This raises results and comments that are out of the scope of the present paper. Data analysis will be presented in a separate paper, which is in preparation.

Is the data set significant – unique, useful, and complete? - Yes. The data set fits well within a history of time and spatially resolved microCT investigations of snow metamorphism and the resolution and detail will be useful for further investigations into these phenomena.

Is the data set itself of high quality? - Yes. The data set quality is adequate for the described effects of snow metamorphism. A few issues are discussed in the detailed comments below.

Is the data set publication, as submitted, of high quality? - Yes. A few remaining issues are discussed below.

Detailed comments:

Table 1: I think that the density for the snow sample 'DF' is incorrect. Looking at Fig. 4, 'DF' seems much less dense than, e.g., 'RGl'. Also, I would expect DF snow to have a density closer to 100 kg/m3. I processed the sample data 'DF_light_grad_10_3_seg.zarr' and found a density of approx. 80 kg/m3 and a specific surface area of approx. 58 m2/kg (as correctly reported in Table 1). The other samples are characterised correctly. Regarding the previous comment, it would be good to provide a script (along with the data set) that reproduces the numbers (density and SSA) in Table 1.

Yes, this was a mistake (typo, not a bug in the calculation code). Indeed, the correct density range for the DF samples is 84 - 91 kg/m3. We have corrected the values in the revised version of the manuscript. Regarding the computation of density and SSA on the 3D images, we used standard methods that are described in the references provided in the paper. As done by the reviewer, the values can be easily retrieved with this information.

'RG_dense_grad_100_3' is missing from the dataset.

Thank you for this comment. The missing file is now on the server sDrive (https://sdrive.cnrs.fr/s/HHJt56dj63sNTYg). Please note that the data are now also accessible on PANGAEA using the temporary key: https://www.pangaea.de/tok/49074e0ffa886fcd8fc18e21e45991ea867ce45e

l 122: correct to 'Schneebeli'

Corrected

l 143: Do you mean 'insulating' cap?
(https://dictionary.cambridge.org/dictionary/english/insulate)

Yes, we corrected the wording in the revised version.

l 257: What do you mean by '... and shorten its duration.'?

We meant that applying equi-temperature condition by setting the Peltier probes at the mean temperature for 5 to 10 minutes fastens the thermalization of the snow sample (which has just been moved out of the storage fridge at -85°C), compared to just letting the snow sample in the cold room and waiting for a "natural" thermalization. We agree that the formulation is not clear and was modified in the revised version to read "*To start an experiment, the snow sample was taken from the freezer and immediately placed in CellCold for temperature control. The temperatures imposed by the cell on the top and bottom of the sample were, for the first 5 to 10 minutes, an isothermal condition that corresponds to the mean temperature of the experiment. In doing so, we force the thermalization of the snow sample.*"

l 312: Gb (English) instead of Go (French).

Corrected

l 337: Why do you resort to using a grain size estimate, instead of using quantifiable parameters from your experiments (SSA, some sort of averaged grain size, or similar)?

As mentioned above, a physical description of grain size and shape is out of the scope of this paper. Here, we provided a qualitative description of the grain size and shape, as seen on the 3D images. We, however, agree that the sentence mentioned by the reviewer (l 337) is confusing and was removed.

Fig4/5: 'mm' (millimeter) on the colorbar should not be italic.

Corrected

Fig6-8: Add the colorbars for convenience.

Corrected

https://www.youtube.com/watch?v=wCCmKa7rk6o -- timestamp: 72h to 76h -- particles seem to be appearing. Can you comment on this? I did not go through all videos in detail, just noticed this by chance. Maybe recheck, if this is some sort of error.

We understand the reviewer's concern. However, we did not notice any error in the data set and its processing. We can only hypothesize that the occurring metamorphism led to grains' rearrangement, which resulted, for this time series, in a "sudden" movement of a grain from one time step to another. The same process happens for the DF sample in equi-temperature evolution (https://www.youtube.com/watch?v=tMXvGgdIP8E –timestamp: 108h to 112h). In addition, as videos only show a thin vertical section of the whole sample, of thickness 0.85 mm, a sudden grain movement results in a grain, or some part of it, suddenly appearing/disappearing out of sight, giving this strange behavior.

Reviewer 2

General comment:

The paper is very well organized, well written, does not leave open questions and is perfectly suited for the scope of the journal. Therefore, I suggest publication after considering minor revisions.

We warmly thank the reviewer for the comments and positive feedback. Please find below our point-by-point replies to the comments.

Detailed comments:

L14-16: Maybe be more specific for what these measurements are useful than just "interface growth velocity" and "various physical properties". Missing here something like: Basis for developing physical models for different types of dry snow metamorphism, including SSA evolution, densification, shape (dendricity & sphericity), structural anisotropy, polydisperity evolution.

We agree with the reviewer and included a sentence about the usability of our data for snow modeling of dry snow metamorphism.

L122: Schneebeli

Corrected

L135: Why aluminium side walls? Plastic not better? Plastic has lower thermal conductivity, lower x-ray absorption.

L140: Isn't a high thermal conductivity along the side walls of the cylinder unfavourable?

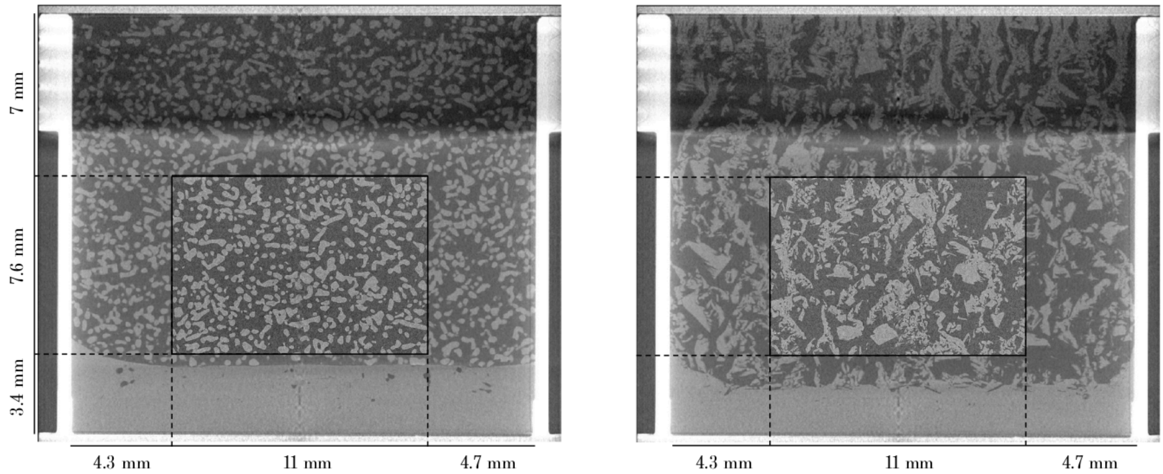
We choose aluminum side walls for mechanical reasons: the sample is screwed to the cell at its top and bottom, so the material needs to allow for that. Besides, a high thermal conductivity is necessary to ensure an efficient conduction of the heat from the Peltiers to the top and bottom of the snow samples. As our sample holders have been produced by precision machining a single aluminium piece for each holder, it was technically impossible to produce sample holders with top and bottom parts made of aluminium and with side walls made of plastic.

L205: DF … DH, as you mention these her for the first time, you maybe better write the full names and put abbreviations in brackets.

Thank you, it is now corrected.

L230: Regarding ice layer at the bottom: I think this needs a bit more discussions about how this may or may not affect TG metamorphism. Basically, what you simulate is a certain snow stratigraphy with an ice layer below your snow layer. -> I see, in Fig. 3 it looks very homogeneous the microstructure at the interface ice-snow, but I guess in Fig. 3 it is the initial sample before metamorphism. You should mention it in the figure caption what snow type it is, and if before or after the experiment. Could not find this information. In Fig. 3 I would rather prefer seeing both, a sample before (left, as is) and after (right, instead of the enlargement which does not provide any more information). This will show if the ice-snow transition affects metamorphism locally or not. Anyway, the cropped parts Fig. 4-5-6 always looks good (i.e. homogeneous over height) I think.

During the experiment, for high temperature gradients, the bottom ice layer tended to decrease in thickness, whereas ice deposition occurred at the top against the aluminum cap. These effects are very localized and concern, at most, the upper and lower 3 mm part of the sample. We agree with the reviewer that this information was missing, so we included it in the revised version. Also, we have now provided an additional figure, in the appendix of the revised version of the manuscript, to illustrate the evolution of the top and bottom boundaries of the snow sample during the experiments (see figure below).
Finally, we agree with the reviewer concerning the description of Figure 3 and modified it accordingly.



L243: Above you give absolute temperatures in Kelvin, e.g. 270 K. Should be consistent throughout the paper. I would prefer everything in °C as more typical for Water / Ice / Snow.

We changed all the degrees Kelvin into degrees Celsius.

L245-246: Why not all combinations? Due to time constraints or because you were not expecting to see any more differences for the other combinations?

Unfortunately, we could not cover all the combinations due to time constraints. Because of that, we had to select our experiments. The effect of mean temperature was investigated only for one type of snow sample in TGM and in ETM. We also decided to perform more TGM experiments than ETM experiments, because there is more ETM data available in the literature, and because the snow evolution shows less variability.

L312: GB instead of Go

Corrected

Fig. 4 – FC: Crystals do not look really faceted to me. Also, with densities in Table 1 seems to be something wrong when compared to the structures in Fig. 4.

We agree that there is a mistake in the density values of Table 1 (typo). We corrected the density range for the DF samples, which now reads 84 - 91 kg/m3. Concerning the faceting of the FC sample, it can be seen in Figure 4; although we agree that it is not straightforward. For example, we can notice characteristic 120° angles and the presence of flat surfaces. The facetting process can be more easily seen in the video of the experiment (https://www.youtube.com/watch?v=45r77SFZihc).

L352: I would give the images in all Figures sub labels (a, b, c, …) and then reference individual figures more often: E.g. here: Compare Fig. 4e with Fig 5e instead of referring to the video. Generally, this would help readability if you directly and more often refer to the right sub-image in the text.

Thank you for this advice! We have implemented it.

L363-365: This is a nice result, however, the perception that "doubling the time is similar to doubling the gradient" should be referenced if somewhere published, maybe Pinzer et al? Or is it just a widely accepted assumption? I don't know.

We agree that this statement is confusing, as it is not well described in the literature. We corrected this comment, so the paragraph now reads: "*Videos available in section 6 also show, especially for the DF sample, that the grain evolution at a temperature gradient of 100 K m−1 is not similar to the grain evolution at a temperature gradient of 40 K m−1. This highlights that there are discrepancies of shape within depth hoar depending on the temperature gradient magnitude, as shown in e.g. Akitaya, 1974*."

L365-370: Maybe you want to provide some physical explanation here, i.e. pore scale vapor pressure gradients depend on the absolute temperature due to exponentially increasing saturation vapor pressure at higher temperatures? Furthermore, not just the pore space is smaller, also the depth hoar crystals are smaller, no? And maybe estimating a total re-crystallization turnover rate would be interesting, i.e. how long it takes until a crystal is totally sublimated and recrystallized into a new crystal. From the videos, it seems that at 100K/m-1 and -3°C, the crystals recrystallized like 3-4 times during the entire experiment, whereas just once at -17°C.

We included more explanations about the effect of temperature on the metamorphism, as well as references to previous studies on that topic. The paragraph now reads: "*The effect of the temperature on snow metamorphism can also be observed. For the same intensity of temperature gradient, the temperatures at which the gradient occurs significantly impact the final snow microstructure: the lower the temperature, the slower the metamorphism and the recrystallization rate of the ice grains, as shown by previous studies (e.g. Kamata et al., 1999; Kaempfer and Schneebeli, 2007; Pinzer et al., 2012. The effect of the temperature is explained by the fact that the saturation vapor pressure in air increases exponentially with temperature. Hence, a given temperature gradient in snow induces a larger saturation vapor pressure gradient in warmer conditions compared to colder ones, and thus a higher metamorphism rate.*". In the present paper, we did not investigate the recrystallization rate of snow during the experiments, as this work would require substantial additional image analysis, including interface tracking, which is not in the scope of this data paper.

Fig. 6: Could be interesting, if you could cut in this figure (and Fig. 5) each image in half, and make the left half the initial microstructure and the right half the final, then you have a nice side by side comparison. Otherwise it is difficult to judge the changes from the beginning to the end. And you still can keep the arrangement as it is in Fig. 6 to compare the effects of absolute temperature and temperature gradient.

In the present version of the paper, the initial and final stages of the snow microstructures during TGM are shown in distinct figures (Fig 4 and Fig 6, respectively). We tried alternative presentations, where both initial and final snow microstructures are shown in the same figure, as suggested by the reviewer. However, by doing so, the size of each individual image is too small, and it is difficult to appreciate the details of the snow microstructure, such as grain shape. Because of that, we prefer to keep the original version of the figures.