Author response to comments from referee #1 on tc-2021-53

Referee comments are in black. Author responses are in blue and proposed changes in the manuscript are highlighted in **bold blue**.

Comments from referee#1

This study presents a new observational dataset and the corresponding model simulation to examine snow microphysics and its impacts on snow radiative properties. Such work is desirable and especially crucial for remote sensing retrievals and data assimilation over the snow-covered regions and is also critical for global climate modelings constrained by reanalysis data. The experiment is properly designed and the discussion is well presented. The reviewer only has some minor questions regarding the sample treatment.

The authors thank the referee for the encouraging feedback. All comments have been accounted for and detailed responses are provided below.

Section 2.1:
"S3 is taken from the same temperature gradient experiment as S2 except that it was turned upside-down so that the grain orientation is changed by 180." Why did you flip sample S3?

Under temperature gradient, the facet formation is oriented toward the warmer side of the snow layer. e.g., when the temperature gradient is pointing downward as it is generally the case in nature, the facets tend to form on the downward surfaces while the upward surfaces stay more rounded (see for example figures 5 and 8 in Calonne et al., 2014a). As a consequence, by flipping S3, the faceted surfaces are oriented upward instead of downward in S2. This flip was thus done to investigate the effect of facet orientation on BRF, the other properties (SSA, density) being relatively close for S2 and S3.

To provide more details about this specific goal, we modified p4 line 1 as follows: "… is changed by 180°. **Under temperature gradient, the facet formation is oriented toward the warmer side of the snow layer. For instance, when the temperature gradient is pointing downward as usually the case in nature, the facets tend to form on the downward surfaces while the upward surfaces stay more rounded (see e.g. Figs. 5 and 8 in Calonne et al., 2014a). As a consequence, by flipping S3, the faceted surfaces are oriented upward instead of downward in S2. This was done to investigate the effect of facet orientation on BRF.** "

Section 2.1.1
"a 7 cm thick snow layer was collected on a 60x60 cm2 styrodur plate after a snowfall close to the lab and stored for 3 weeks in isothermal conditions at -20 C (Fig. 1A)." Why did the authors store the snow for 3 weeks before measurements? Would snow morphology alter during the storage time?

The snow was stored under isothermal conditions since our goal was to obtain a DF/RG sample, i.e., a relatively recent snow sample, but which was sufficiently metamorphosed to exhibit only smooth and rounded shapes. Due to the limited availability of the instrument used for the optical scan, we also had to control the snow evolution to reach the target morphology at the time of experiment. We first started at -20°C for which the changes are relatively slow (see e.g. Kaempfer and Schneebeli, 2007). Closer to the optical experiment, we checked the microstructure and imposed isothermal conditions at -10°C, to get the wanted DF/RG morphology.

Page 4 line 11 was thus modified as follows: "…after a snowfall close to the lab and stored for 3 weeks in isothermal conditions at -20 C. **It then stayed 3 days at -10°C to reach the DF/RG state (Fig. 1A). The objective of this imposed isothermal metamorphism was to obtain a relatively recent snow sample, but with smooth and rounded shape, and that can be resolved at the pixel size we could access with the tomograph (between ~ 6 and 12 µm)**. "

Kaempfer, T. U., and Schneebeli, M. (2007), Observation of isothermal metamorphism of new snow and interpretation as a sintering process, J. Geophys. Res., 112, D24101, doi:10.1029/2007JD009047.

Additional modifications:

Line 30 p 3: "S1 **corresponds to** decomposing and fragmented particles/rounded grains (DF/RG) according to the classification of Fierz et al. (2009)."
Line 1 p 13: "Figure 5 shows that S2 and S3 are denser and coarser—i.e. consist of larger grains—than S1 (**decomposing and fragmented particles/rounded grains**)."

"A vertical temperature gradient of 19.4 Cm−1 was applied inside the box with a mean temperature of -4 C". Could the authors provide more information on why pick this temperature gradient and -4 degree C? Was this tested in a previous experiment? If so, please provide some references here.

The objective of this experiment was to produce large faceted crystals, with relatively simple structures, exhibiting a clear asymmetry between their upper (rounded) and their downer (faceted) sides. Having performed experiments that previously led to this kind of results (Flin and Brzoska, 2008 and Calonne et al 2014a), we used them as guidelines to reach our purposes.

Page 4 line 15 was thus modified as follows: "…of -4°C. **Such conditions produce simple structures of large and regular faceted crystals in a reasonable amount of time (Flin and Brzoska, 2008 and Calonne et al 2014a)."**

REF: Flin, F., & Brzoska, J. (2008). The temperature-gradient metamorphism of snow: Vapour diffusion model and application to tomographic images. *Annals of Glaciology, 49*, 17-21. doi:10.3189/172756408787814834