The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2021-53-RC2, 2021

Review Comment on tc-2021-53

Anonymous Referee #2

Referee comment on "Experimental and model-based investigation of the links between snow bidirectional reflectance and snow microstructure" by Marie Dumont et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-53-RC2, 2021

The authors presented a new dataset that combines BRF measurements and the X-ray tomography of the snow microstructure for two different snow morphological types. They found that faceted crystals exhibit a more anisotropic reflectance than fragmented particles, and the Malinka et al., (2016) model can generally reproduce the observed BRF using measured SSA. Different factors showed different importance for weak/intermediate and high absorption scenarios. The manuscript is generally well written, but there are still a few places that require further clarifications and explanations. Please see my comments below.

Specific comments:

Section 2: Some descriptions of the measurement uncertainty and accuracy are needed, for example, for measurements of snow SSA and density as well as BRF.

Figure 1: It would be good to also provide microscopic images for the S2 and S3 samples (e.g., FC/DH) that are similar to Fig. 1a.

Equation 3: What does the parameter “alpha” represent?

Equation 4: How many images of a sample were used in the calculation in this study?

Equation 5: It seems a little arbitrary to define x, y, z directions for a sample. How are

these directions determined in this study? For example, did the authors assign the vertical direction of the snowpack layer as the z direction?

Equation 7: Are the quantities (Sint, Vvp, Vint) all derived from the X-ray tomography images?

Section 2.2.3: When computing the two SSA, did the authors used the image-averaged values for all the quantities in Equations 6 and 7?

Section 2.5: The steps shown here use the Cst as another free variable in the fitting procedure. However, (1) the authors did not check if the retrieved Cst is reasonable (since the snow sample are new snow, I assume Cst should be very small). I saw that in Table 2, Cst is about 0.2-1 ppm, which is actually very large for soot content in snow and is typically for dirty snow samples. (2) Following (1), using Cst as a free variable in the fitting may bring uncertainty to SSA retrieval if the model-observation discrepancies that should have been attributed to SSA are attributed to Cst. Thus, using observed Cst or clean snow samples (Cst~0) to constrain the SSA retrieval or check if Cst is in a realistic range would help to improve the SSA retrieval accuracy.

Figure 3: Does the retrieved albedo mean albedo calculated from the retrieved SSA? I did not see the description of albedo retrieval in Section 2.

Figure 9: Would the systematic albedo overestimates at wavelengths < 1300nm also be due to the way of soot-snow mixing treated in the model? Recent studies have reported stronger albedo reduction by soot if soot is internally mixed with snow grains compared with soot-snow external mixing (e.g., He et al., 2018: https://doi.org/10.1002/2017JD027752; Flanner et al., 2012: https://doi.org/10.5194/acp-12-4699-2012). It is not clear how the soot-snow mixing is assumed in the optical modeling in this study based on Equation 11.

Page 23, Lines 13-19: It seems that the authors only described the model-observation differences in Figure 14 here without enough explanations on why the differences occur. It will be helpful if the authors could provide some insights into the causes. Similarly, more explanations of the model biases in Figure 15 will be helpful.

Figure 16: It seems that the uncertainty in ice refractive indices is not sufficient to explain the model-observation differences. Do the authors have any thoughts or speculations on other possible reasons that may contribute to this bias?