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Comment on egusphere-2022-501

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Community comment on "Impact of the sampling procedure on the specific surface area of snow measurements with the IceCube" by Julia Martin and Martin Schneebeli, EGUsphere, https://doi.org/10.5194/egusphere-2022-501-CC1, 2022

First of all, I would like to thank Julia Martin and Martin Schneebeli for this interesting contribution. Measuring SSA can be very delicate. Errors, mostly due to an inadequate sampling procedure, are common. A detailed study on one such error type is therefore very welcome. I also thank both anonymous Reviewers for contributing to the discussion and therefore help improve sampling protocols.

Thousands of SSA measurements were done with DUFISSS and Ice Cube since (Gallet et al., 2009) was written. I have taken many new Ice Cube users to the field for training to realize that the sampling procedure described in that paper and in the Ice Cube sampling manual does not describe in sufficient detail many common potential sources of errors. I often thought of writing a detailed paper but this has unfortunately remained wishful thinking, my apologies.

One error is indeed the production of small particles when cutting the sample surface. As (Martin and Schneebeli, 2022) nicely describe, the magnitude of the error depends essentially on the hardness of the snow, not on the SSA.

The usual sampling procedure is to place the sampler vertically on the snow surface of interest and to sample downward. The 35 mm-thick sample is then placed in the 25 mm-thick sample-holder so that there is 10 mm of snow protruding above the sample holder. This is shaved off with a spatula. If the snow is sufficiently hard not to fall apart, I recommend shaving off the extra 10 mm of snow by placing the snow surface vertically. The particles formed then mostly fall out rather than inside the sample. Then, a soft brush is used to remove most remaining particles. I have done many comparisons of both protocols (1) shaving off horizontally and no brushing, and (2) shaving off vertically with brushing. For hard snows, I found a difference similar to the data of (Martin and Schneebeli, 2022). The largest difference was for about 12 m deep firn in Greenland. Values with vertical shaving off and brushing were around 5 $m^2\ kg^{-1}$ while without these precautions, SSA was almost doubled because of the effort required to cut the sample. I do not want to interfere with the writing options of the Authors, but I suggest (Martin and Schneebeli, 2022), if possible, stress this protocol for hard snows.

Another frequent errors I have seen is measuring soft snow of too low density. Then the optical depth is insufficient as detailed in (Gallet et al., 2009). The 1310 radiation reaches the bottom of the sample holder where it is absorbed. This reduces reflection and inferred

SSA. To overcome this problem, DUFISSS uses the 1550 nm radiation, where ice is more absorbent and the e-folding depth therefore shallower. Ice Cube however does not have the 1550 nm option. The alternative is to compact the snow to about 200 kg m^{-3} to decrease the e-folding depth. Tests showed that for soft snows, compaction does not affect structure and SSA in a detectable manner.

Lastly, it may be useful to mention difficulties in measuring large soft loose depth hoar crystals, as frequently encountered in the Arctic. Such snow samples cannot be shaved off and can be scooped directly onto the sample holder. The critical part is getting a surface at the correct level. If crystals stick out of the surface of the sample holder, reflection is enhanced, while the reverse is observed if the snow crystal level is too low. This can lead to SSA variations exceeding 20%. Great care is required to ensure that the average crystal level is flush with the top of the sample holder.

Coming back to the paper of (Martin and Schneebeli, 2022), it may be worthwhile specifying that reflectance measurements at 950 nm are less sensitive to a layer of fine particles than at 1310 nm because the e-folding depth is about twice as much at 950 than at 1310 nm. At 950 nm, the thin surface layer then contributes less to the signal. However, precision is lower at 950 nm, as detailed in Figure 1 of (Gallet et al., 2009). This was one reason for choosing 1310 nm.

References

Gallet, J.-C., Domine, F., Zender, C. S., and Picard, G.: Measurement of the specific surface area of snow using infrared reflectance in an integrating sphere at 1310 and 1550 nm, The Cryosphere, 3, 167-182, https://doi.org/10.5194/tc-3-167-2009, 2009.

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