

Interactive comment on “Spatial and temporal variability of snowfall over Greenland from CloudSat observations” by Ralf Bennartz et al.

Anonymous Referee #1

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General comments :

The paper presents a method for assessing the snowfall rate from CloudSat over the Greenland ice sheet. While a standard CloudSat product (2C-SNOW-PROFILE product) provides snowfall estimations over Greenland, it has been shown that this product is affected by ground clutter contamination over some areas of the Greenland ice sheet. In this study, the authors present an interesting approach for removing ground clutter contamination by using another digital elevation model than the one used in the CloudSat 2C-SNOW-PROFILE product. Moreover, an empirical correction is also performed in order to account for precipitation processes occurring between the height of the observed CloudSat reflectivities and the surface. After correcting the reflectivity profiles from CloudSat, the authors have applied three Z-S relations to assess the snowfall rate

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from CloudSat. Then, the snowfall climatology derived from CloudSat has been compared to ERA Interim reanalysis in the last section of the paper. I think that the method described in this paper is interesting and represents a significant improvement in the assessment of Greenland snowfall. However, I have some comments that should be addressed before publication of the manuscript. Please find these comments below:

“Accumulation” is often used for describing the ice sheet surface mass balance. As snowfall is only one component of the surface mass balance, it would be better to use another word for the snowfall derived from ground-based and spaceborne radars such as “accumulated snowfall” or just “snowfall”.

Section 3.1: A recent paper has pointed out some ground clutter issues over Greenland in the CloudSat 2C-SNOW-PROFILE product:

Palerme, C., Claud, C., Wood, N. B., L'Ecuyer, T., & Genthon, C. (2018). How does ground clutter affect CloudSat snowfall retrievals over ice sheets?. IEEE Geoscience and Remote Sensing Letters. doi:10.1109/LGRS.2018.2875007

Section 3.2: It would be interesting to see a map showing the effect of the ad-hoc correction (equation 1) on the Greenland snowfall rate. What is the spatial variability of the ad-hoc correction in terms of snowfall rate ?

Section 3.4: The authors did not discuss the possible effect of blowing snow on the snow accumulation measured by the stake field. Would it possible that blowing snow significantly affects the snow accumulation measured by the stake field ?

Specific comments :

P3, line 23: I would not say “leading to a slight annual cycle in the number of observations available over Greenland” since the number of CloudSat observations is reduced by about 50 % during the winter.

P5, figure 2, caption: “CloudSat data density over Greenland at 1x2 degrees (left, approximately 100 km x 100 km) and 0.025 x 0.05 degrees (right, approximately 2.5



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km x 2.5 km)."

Please provide the latitude at which "1x2 degrees" is equal to 100 km x 100 km and 0.025 x 0.05 is equal to 2.5 km x 2.5 km.

P13, lines 18-19: I don't understand the following example: "For example, for an observed reflectivity of -30 dBz, the correction is +4 dB leading to a corrected reflectivity of -26 dBz, which still does not produce any significant snowfall".

From equation (1): $\text{dBz corrected} = \text{dBz } 1000\ldots1500 + [(1 - 0.2 * \text{dBz } 1000\ldots1500) > 0]$,

$$\text{For } -30 \text{ dBz: } \text{dBz corrected} = -30 + 1 - 0.2 * (-30)$$

$$\text{dBz corrected} = -23$$

P20, line 7-8: "We correct for topography issues and identify the lowest radar bin above the surface not affected by ground clutter using the IceBridge BedMachine topography as outlined in Section 3.1"

I would not say "and identify the lowest radar bin above the surface not affected by ground clutter" but rather that the 5th bin above the surface deduced from the IceBridge BedMachine topography is used for estimating the surface snowfall rate. There is no test performed on the vertical profiles of reflectivity in order to identify ground clutter contamination.

P22, line 1: How is the mean snowfall rate from CloudSat calculated ? Is it calculated from the monthly averages in order to avoid the sampling issues ? This should be reported in the text.

P30, lines 4-6: "This result might well be specific to ERA-Interim and in the future studies it will be interesting to test different climate models and reanalysis against the CloudSat observations."

Behrangi et al., 2016 have compared Greenland precipitation from CloudSat to several



reanalyses (ERA-Interim, MERRA, and NCEP).

Behrangi, A., Christensen, M., Richardson, M., Lebsack, M., Stephens, G., Huffman, G.J., Bolvin, D., Adler, R.F., Gardner, A., Lambrightsen, B., & Fetzer E. (2016) Status of high-latitude precipitation estimates from observations and reanalyses. *J. Geophys. Res. Atmos.* 121, 4468–4486.

Interactive comment on *Atmos. Chem. Phys. Discuss.*, <https://doi.org/10.5194/acp-2018-1045>, 2019.

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