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Evaluation of the CloudSat surface snowfall product over Antarctica using ground-based precipitation radars

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Station	MRR	CloudSat	ERA-Interim
Princess Elisabeth	0.99	1.12	0.84
Dumont D'Urville	2.14	1.92	2.26
Mario Zucchelli	1.83	1.78	1.01

Table S1. Daily average snowfall amounts (mm w.e. day^{-1}) for the concurrent periods displayed in Fig. 2 in the main paper. CloudSat snowfall amounts are derived for the grid specified by Palerme et al. (2014).

Text S1. Comparison between CloudSat and MRR snowfall rates obtained at 1200m a.g.l..

Apart from evaluating the CloudSat snowfall climatology and individual events (obtained at 1200m a.g.l.) with MRR measurements at the level closest to the surface (300m a.g.l.), an extra comparison is executed by including MRR measurements at 1200m a.g.l.. The higher level of snowfall rate acquisition of the MRR leads to a decrease in the total snowfall amount of 26 %, 8 % and 25 % for respectively the PE, DDU and MZ station compared to measurements at 300m a.g.l. (compare Fig. S1 and Fig. 6 in the main paper). The total snowfall amount as a function of height is visualised in Fig. S3 and is characterised with a typical shape for all stations. Highest snowfall rates are usually obtained a few hundreds meter above the surface. Towards the surface lower values are observed, induced by katabatic winds that cause sublimation (Grazioli et al., 2017). The decrease towards higher altitudes is governed by the vertical extent of the precipitation systems, which are often present only in the lowest layers of the atmosphere (Maahn et al., 2014). For the PE and MZ station, larger discrepancies between the 300m and 1200m a.g.l. level are obtained. This can be attributed to the fact that for these stations, highest precipitation intensities are mainly located below 700 m a.g.l., indicating that the vertical extent of the precipitation systems is generally low for these stations (Fig. S3). For the DDU station, precipitation systems usually have a larger vertical extent. Therefore, the steady decrease in snowfall rates for higher altitudes only starts from heights over 1000m a.g.l., attributing for the minor differences in snowfall rates between the 300m and 1200m a.g.l. level for this station.

The lower total amount of snowfall rates obtained at 1200m a.g.l. by the MRRs leads, counter-intuitively, to worse performances compared to the snowfall rates obtained by CloudSat at 1200m a.g.l. for both the PE and MZ station (compare Fig. S1 and Fig. 6 in the main paper). When investigating the cumulative distribution of snowfall rates obtained by both instruments, a better agreement is obtained for both stations compared to the initial assessment using MRR measurements at 300m a.g.l. (compare Fig. S2 and Fig. 7 in the main paper). The main reason for the overestimation of CloudSat snowfall rates compared to MRR snowfall rates at 1200m a.g.l. is therefore attributed to the much higher frequency of snowfall events detected in CloudSat (Chen et al., 2016), leading to high commission errors. In the comparison at 300m a.g.l., this overestimation of the frequency of snowfall events was compensated by the higher snowfall rates registered by the MRR (omission errors; Fig. 7 in the main paper), which is not the case at 1200m a.g.l. (Fig. S2). For the DDU station, the frequency of snowfall event detection is approximately equal, explaining the better performance for this station.

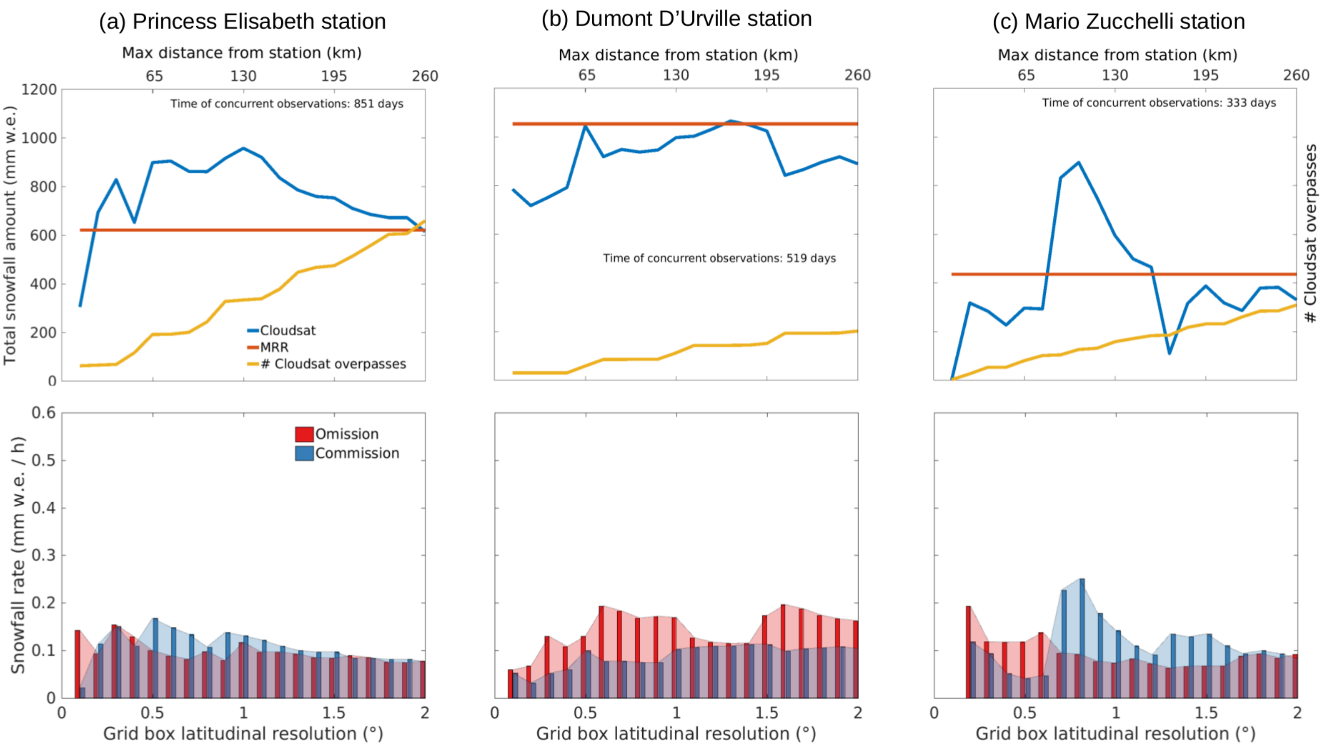

Figure S1. (first row) Overview of the total snowfall amounts for the three stations as observed by CloudSat and the Micro Rain Radars during the periods of collocated measurements both measuring at 1200 m a.g.l. (Fig. 2 in the main paper). (second row) Individual snowfall event error analysis. As Micro Rain Radar snowfall rates obtained at 1200 m a.g.l. are considered truth, omission errors are defined as an underestimation, while commission errors are an overestimation of snowfall rates by CloudSat. The x-axis denotes different spatial resolutions of the CloudSat climatology (grid box longitudinal resolution = 2 * grid box latitudinal resolution).

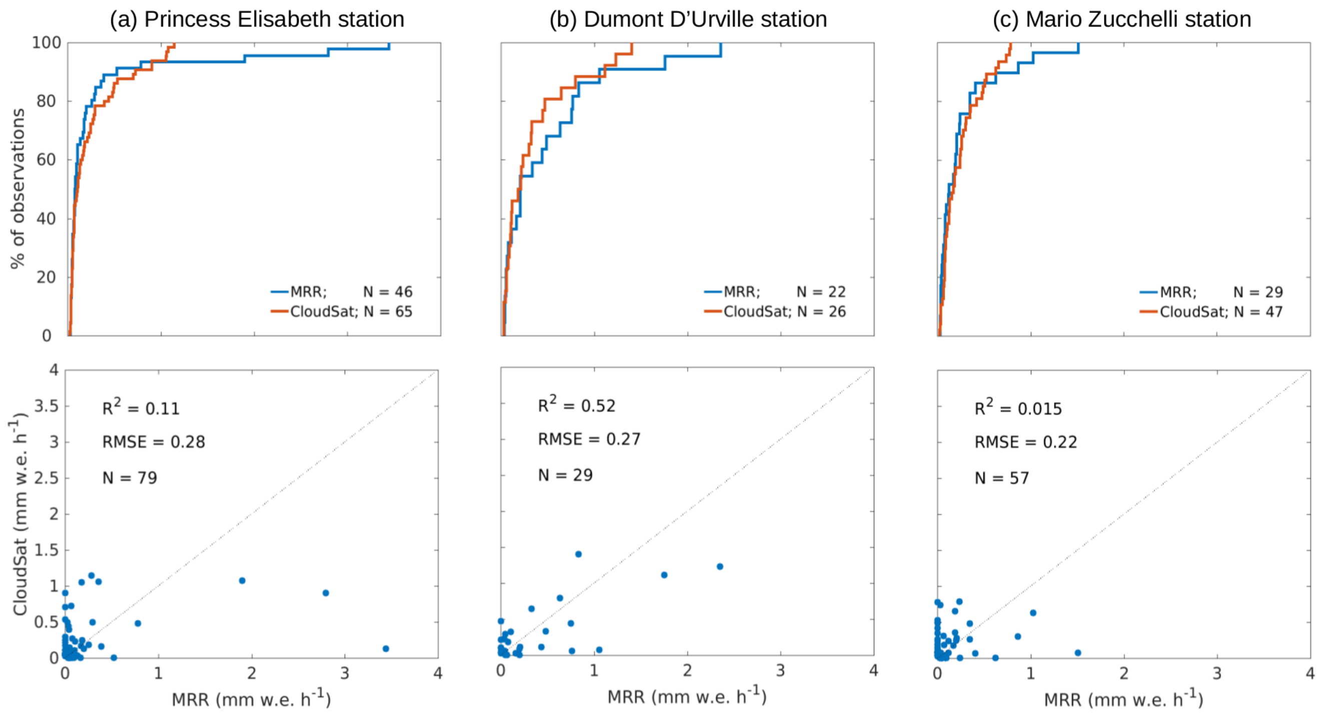

Figure S2. (first row) Empirical cumulative distribution of MRR and CloudSat snowfall events both measuring at 1200 m a.g.l. at a spatial resolution of 1° latitude by 2° longitude. (second row) Direct comparison between MRR and CloudSat individual snowfall events both measuring at 1200 m a.g.l.. R^2 denotes the adjusted coefficient of determination, RMSE is the root mean square error, N indicates the number of observations, while the thin line is the bisector.

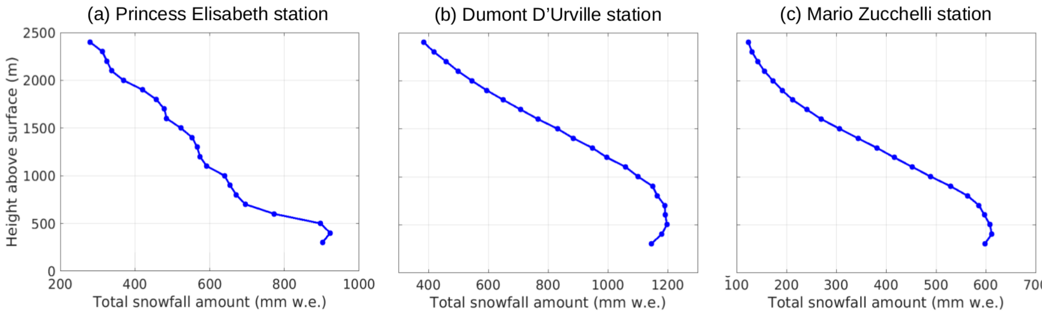

Figure S3. Total snowfall amount as a function of height above ground level as obtained by the MRRs for the periods of concurrent measurements depicted in Fig. 2 of the main paper.

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