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Using variable relationships between reflectivity and snowfall rate obtained from coincident MRR and disdrometer measurements to estimate snowfall at Mario Zucchelli Antarctic Station

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Quantitative estimation of snowfall using radar is a challenging task that is usually accomplished using relationships between the equivalent radar reflectivity factor (Ze) and the liquid-equivalent snowfall rate (SR), typically expressed as power-law ($Ze = a \times SR^b$) whose parameters are obtained from long-term measurements. Unfortunately, the changeability of microphysical and scattering characteristics of snowflakes makes them highly variable. The proposed method takes advantage of the estimation of the snowflake microphysical characteristics and develops six Ze-SR relationships depending on particle habit. A classification of particles is obtained by comparing co-located Micro Rain Radar and Parsivel disdrometer observations coupled with a DDA backscattering model in terms of radar reflectivity and is used to select the appropriate Ze-SR relationship.
The method was tested using ground-based instruments installed at the Italian Antarctic Station Mario Zucchelli, in the framework of the projects APP (Antarctic Precipitation Properties), MALOX (MAss LOst in wind fluX), and IAMCO (Italian Antarctic Meteo-Climatological Observatory), funded by the Italian National Antarctic Program (PNRA).
The Micro Rain Radar was set at the highest vertical resolution (35 m) so that the first trusted range gate was at only 105-m height, close enough to the ground level to be compared with disdrometer particle size distributions. We analyzed data from 52 precipitation days of the 2018–2019 and 2019–2020 summers for a total of 23,566 snowfall minutes.
Disdrometer data were corrected from the influence of wind by assigning a reliability weight to each Parsivel bin based on simultaneous disdrometer, MRR, and wind measurements. This method preserves more precipitation data than the more widely used censoring methods that eliminate data collected when wind speed exceeds a given threshold: since strong winds are often associated with significant snow events, censoring methods tend to discard inportant precipitation measurements.
The consistency of disdrometer and radar measurements is tested for six snow categories (aggregate, dendrite aggregate, plate aggregate, pristine, dendrite pristine, plate pristine) in terms

of radar reflectivity matched in a 10-min time frame. The related Ze-SR relationship of the selected snow category is used to calculate the cumulated snowfall amount.

The comparisons of Ze from disdrometer and MRR at the 105-m height show good agreement, even for nonwind-corrected disdrometere data, although agreement significantly improves if wind-correction is applied.

Of the precipitation minutes, we classified 75% of them as aggregate, with a significant percentage of dendrites. Only 5,830 out of 23,566 falling particles showed pristine characteristics. We estimated 84.6 mm w.e. of accumulated snowfall for the 52 events. Such estimates were compared with measurements from a weighing pluviometer available for 32 out of the 52 considered days. Estimation using variable Ze-SR relationships results in a better agreement with the pluviometer (64 mm w.e. vs. 66.5 mm w.e.) with respect to estimates from fixed Ze-SR relationships found in the literature.

Results show that combining MRR and disdrometer is undoubtedly valuable for snowfall estimations. In fact, the significant uncertainties in snowfall radar estimates related to the variability of snow microphysical features can be mitigated by using variable Ze-SR relationships.