Investigating the impact of spaceborne radar blind zone on surface snowfall statistics in polar regions

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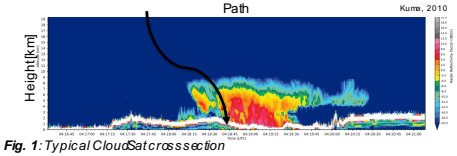
1. Motivation

CloudSat

- is the only source of global snowfall estimates derived from radar reflectivity (Ze at 94 GHz, 3.2 mm) profiles.
- cannot observe snowfall closer than 1200 m to the ground ("blind zone").



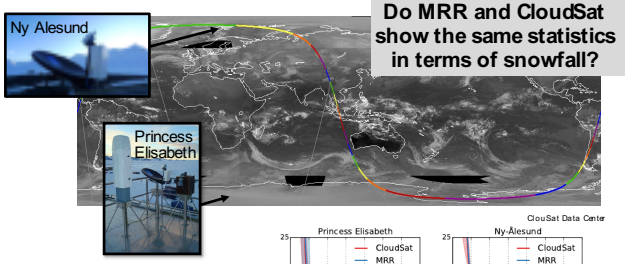
What are the implications for global snowfall statistics?

***Fig. 1**: Typical CloudSat cross section*

2. Data set

- Temporally continuous radar reflectivity profiles measured by ground-based **Micro Rain Radar** (MRR) at 24 GHz (12.4 mm)
- Sites in both hemispheres: Princess Elisabeth (PE) station in East-Antarctica and Ny-Ålesund (NÅ), Svalbard. 1 year of data is analyzed.
- MRR Blind-zone: PE 400m, NÅ 240m

Do MRR and CloudSat show the same statistics in terms of snowfall?



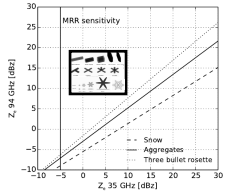
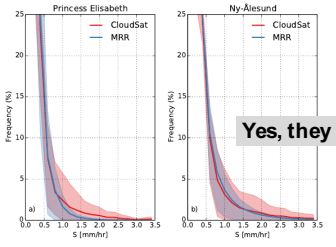


***Fig. 2**: Conversion of reflectivity Ze from 35 GHz to 94 GHz for snow (dashed), aggregates (solid), and three bullet rosettes (dotted) derived from the Ze-S relations of Kulie and Bennartz [2009].*



Yes, they do

***Fig. 3**: Frequency distribution of snowfall rates S for CloudSat (red) and MRR (blue) data at 1200 m agl for the (a) Princess Elisabeth and (b) Ny-Ålesund stations, where snowfall rate was determined by the range of Ze-S relationships in Kulie and Bennartz [2009]. The line/polygon represents the mean range of S for these Ze-S relationships.*

3. Impact on reflectivity (Ze)

- 2D histograms (Fig.4 left) show only little change of Ze with height.
- Detrended Quantile-Quantile plots (Fig 4, right) reveal that the distribution of Ze is shifted by up to 2.5 dB toward smaller values if measured at 1200 m.
- Reduction of blind zone by 50% leads to a reduction of the offset by more than a factor of 2 for PE, and in NÅ the remaining shift is negligible.

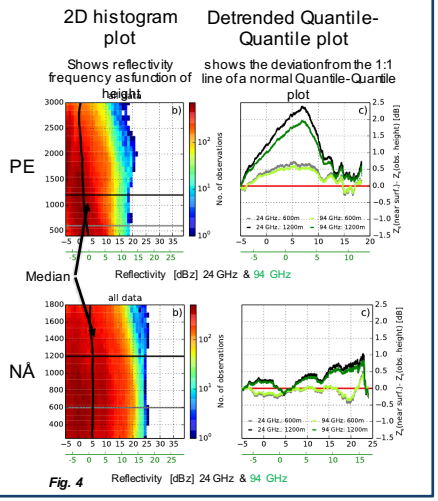
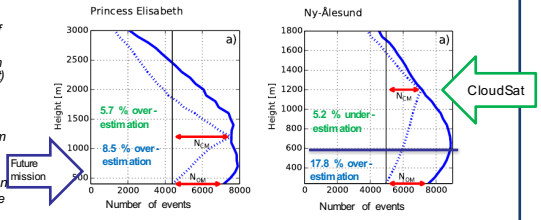


Fig. 4

4. Impact on number of events (N)

- At 1200 m, the total number of events is underestimated by 5% to 6% (Fig 5).
- When investigating the total number of events, the better agreement due to a reduction of the blind zone cannot be seen:
  ➡ change from underestimation to overestimation of 9% to 18%
- This change is more strongly pronounced at NÅ.
- The reason are most likely competing processes: virga and shallow precipitation.

***Fig. 5**: Total number of observations N with Ze of MRR observations at Princess Elisabeth station (left) and Ny-Ålesund (right) larger than −5 dBz (solid blue line) are compared with profiles, which also contain snowfall at 1200 m agl (dashed blue line) for the complete data set. Commission and omission errors (NCM and NOM) are marked with red arrows.*



5. Impact on precipitation (S)

- Change in both *N* and *Ze* contributes to the estimation of precipitation amount (Fig 6).
- For NÅ, the belly shape of *N* can be also seen in the total precipitation amount:

  underestimation at *1200 m*, overestimation at *600 m*
- For PE, such a belly shape is less clear, but still present.
- This shows that virga and shallow precipitation effects are probably partly overlapping at NÅ and PE.

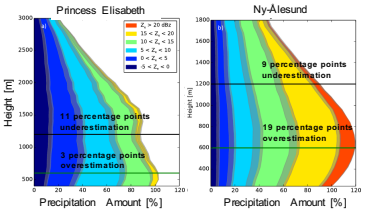


***Fig. 6**: Contribution of various reflectivity intervals to the total precipitation amount in dependence on height for (a) Princess Elisabeth and (b) Ny-Ålesund. For the colored areas, the Ze-S relation by Kulie and Bennartz [2009] for snow is used. Uncertainty of the borders between the different intervals due to the Ze-S relations is estimated by the gray, shaded area, which is estimated by applying also Ze-S relations for three bullet rosettes and aggregates by Kulie and Bennartz [2009]. The figures are normalized by total surface precipitation. CloudSat's blind zone of 1200 m agl and a reduced blind zone of 600 m agl are denoted by black and green lines, respectively.*

6. Conclusions

- Blind-Zone has an impact on reflectivity, number of events and total precipitation.
  ➡ effects differ in both hemispheres
- A lower blind-zone improves observation of reflectivity, but does not improve number of events and total precipitation.
  ➡ Overlapping of different processes
  ➡ Consider in future satellite missions
- More data needed to investigate spatial representativeness.

References:

Maahn M., C. Burgard, S. Crewell, I. V. Gorodetskaya, S. Kneifel, S. Lhermitte, K. Van Tricht, N. P. M. van Lipzig, 2014: How does the spaceborne radar blind zone affect derived surface snowfall statistics in polar regions? *J. Geophys. Res.- Atmospheres*, 119, 13604–13620, doi:10.1002/2014JD022079.

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