Snowfall over Antarctica: First evaluation of Cloudsat snowfall rates by ground-based remote sensing (Micro Rain Radar)

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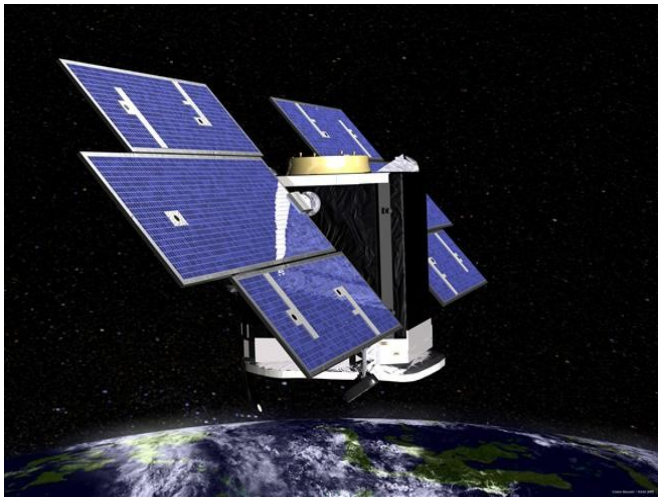
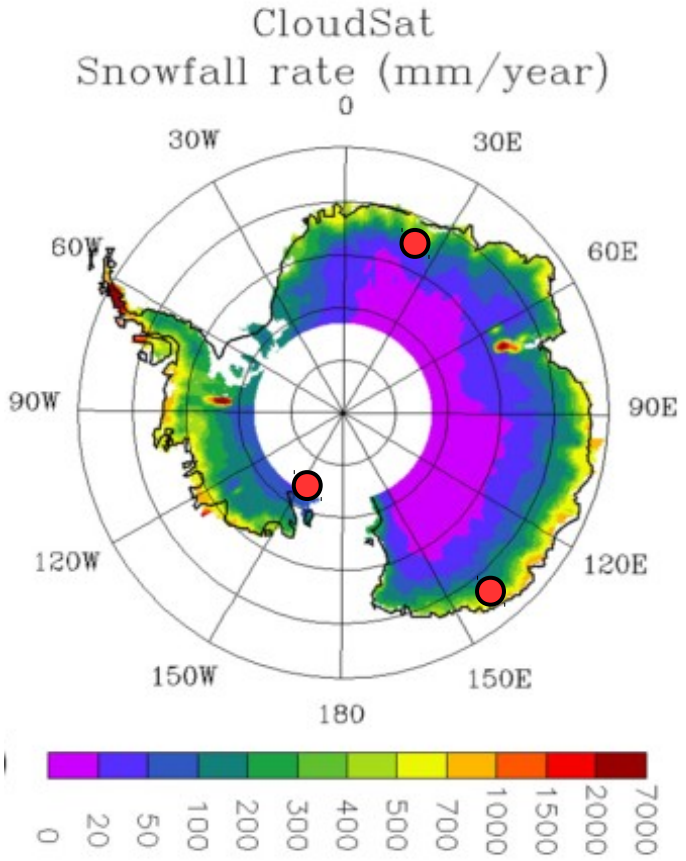
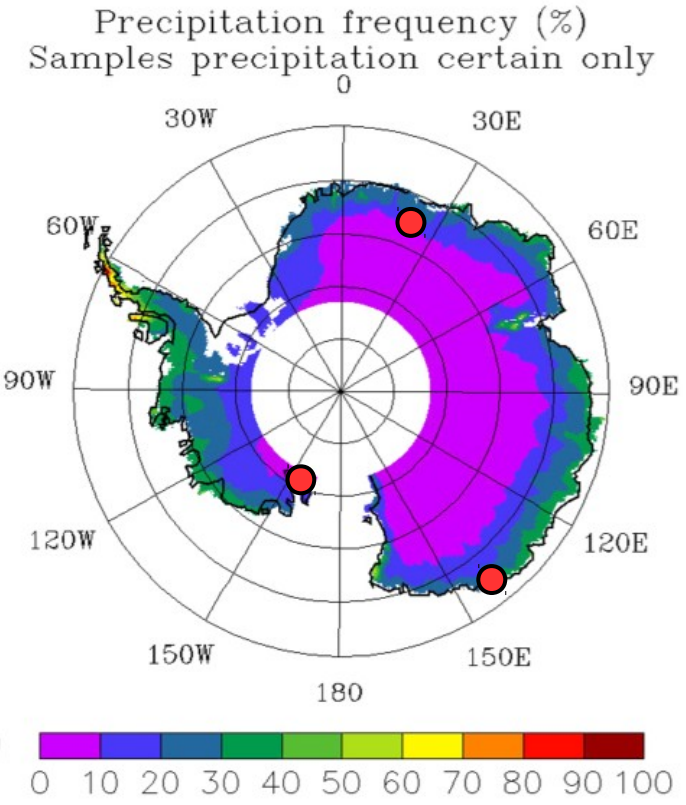


Introduction

- Direct snowfall observations over Antarctica are limited
  - Cloudsat: mainly used to get statistics on snowfall rates over Antarctica (Palerme et al., 2015)
    - Not evaluated over Antarctica up to now
  - Two permanent Micro Rain Radars:
    - Princess Elisabeth (PE)
    - Dumont D'Urville (DDU)
  - Parsival / PWD
    - One year campaign at McMurdo

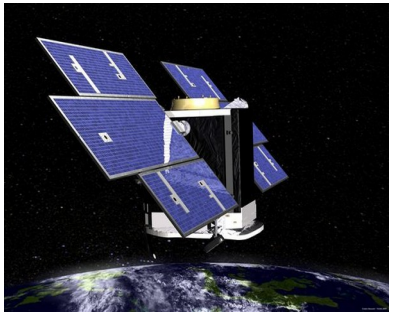
Cloudsat





Palerme et al., 2015

Cloudsat

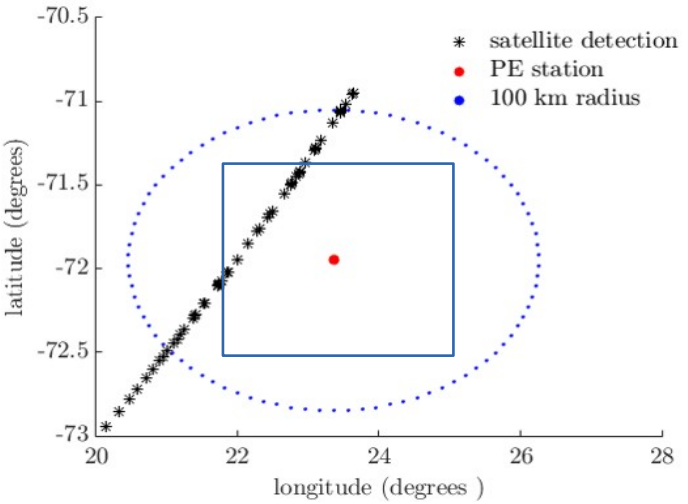


- Operational since 2006
- Since 2010 only austral summer measurements
- Overpass frequency = 5 days
  - Level 2 data product (Granules)
- 94 GHz radar
- Blind zone of 1.5 km (Maahn et al., 2014)
- Snowfall rates are derived by analyzing snow particle properties for each profile (Wood et al., 2013)

MRR

- Operational since 2010 / 2015
- Mostly austral summer measurements
- Measures every 10 sec
- 24 GHz radar
  - Up to -15 dBz (=0.0031 mm w.e./h)
- Blind zone of 300m
- Snowfall rates are calculated based on relations specifically obtained for both locations (Souverijns et al., 2017; Grazioli et al., 2017)

Methodology



- Find overpasses Cloudsat and the stations
  - All overpasses within 1° latitude and 3° longitude of the MRR
    - Average of all profiles within the box
    - Closest profile
  - Compare snowfall rates of the lowest bins of both MRR and Cloudsat
    - For the MRR we take the average precipitation within 5 hours since the overpass to account for displacement of precipitation systems

Overpasses Cloudsat and MRR (average)

- The same snowfall rate threshold is used by both instruments
- PE (dry ~ Sahara)
  - 381 overpasses between 2010-2016 of which in 203 cases both instruments were active

	Cloudsat Prec	Cloudsat No
MRR Prec	15% (31)	5% (9)
MRR No	11% (22)	69% (141)

Events missed by Cloudsat

Small-scale local events that not passed the station

- DDU (wet ~ London)
  - 19 overpasses at which both instruments were active

	Cloudsat Prec	Cloudsat No
MRR Prec	26% (5)	11% (2)
MRR No	16% (3)	47% (9)

Overpasses Cloudsat and MRR (closest overpass)

- The same snowfall rate threshold is used by both instruments
- PE (dry ~ Sahara)
  - 381 overpasses between 2010-2016 of which in 203 cases both instruments were active

	Cloudsat Prec	Cloudsat No
MRR Prec	14% (28)	6% (11)
MRR No	10% (20)	70% (143)

Events missed by Cloudsat

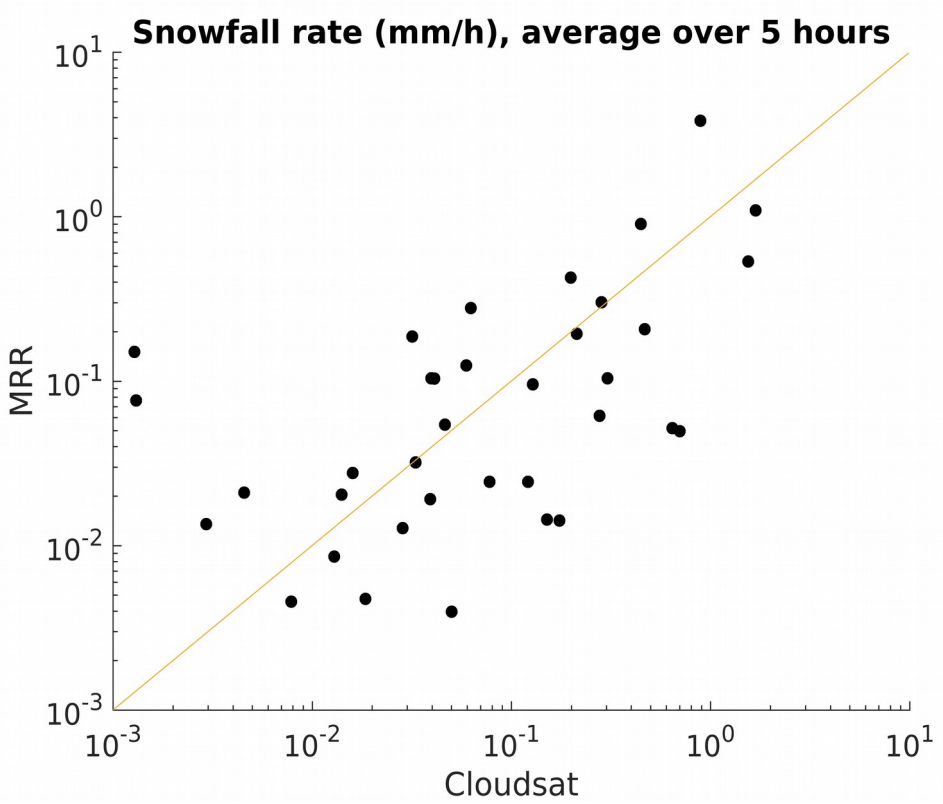
Small-scale local events that not passed the station

- DDU (wet ~ London)
  - 19 overpasses at which both instruments were active

	Cloudsat Prec	Cloudsat No
MRR Prec	28% (5)	11% (2)
MRR No	6% (1)	55% (10)

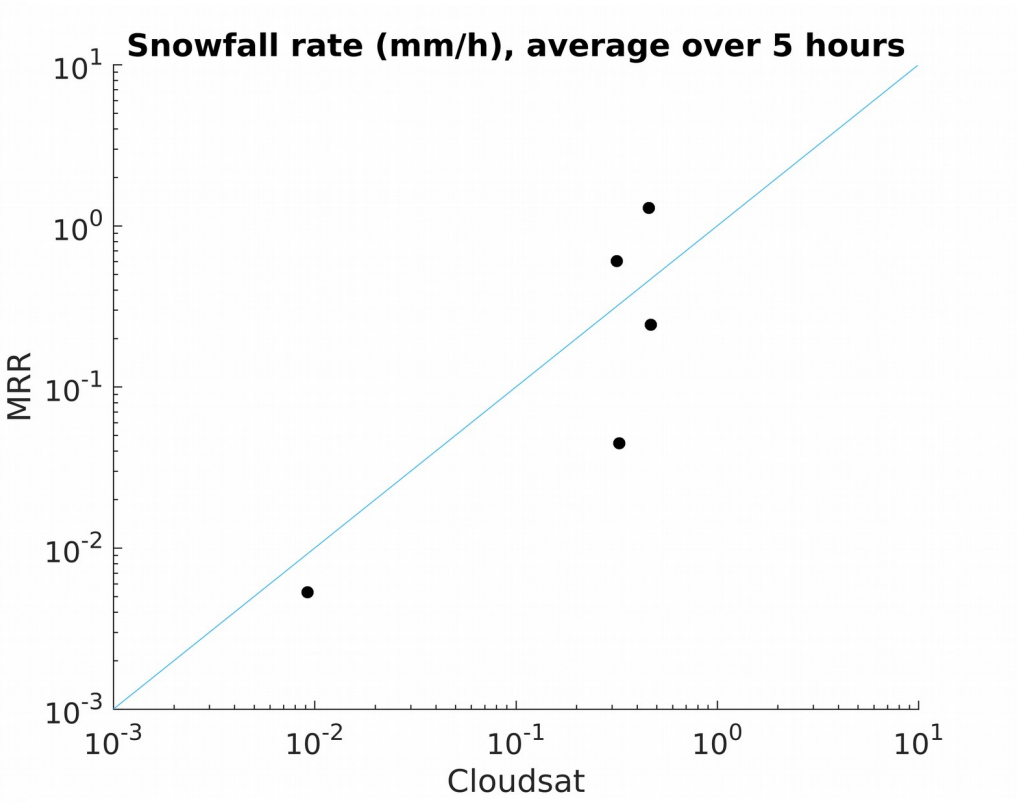
Snowfall rate (average)

PE



MRR = 9.1 mm w.e.
Cloudsat = 8.9 mm w.e.

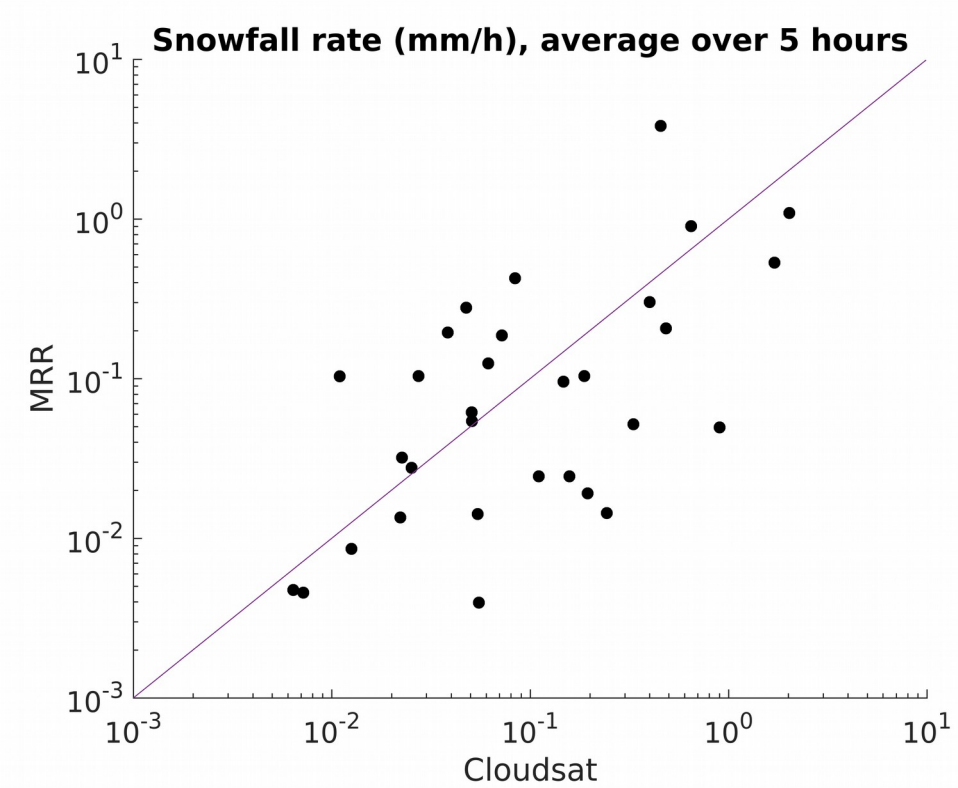
DDU



MRR = 2.2 mm w.e.
Cloudsat = 1.6 mm w.e.

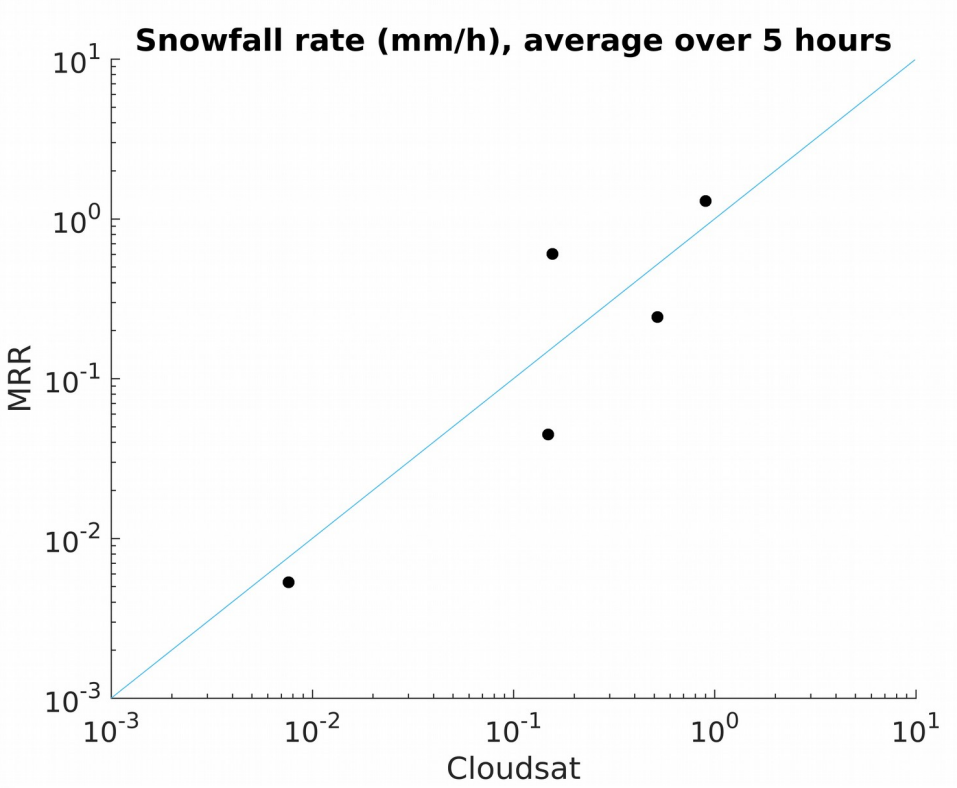
Snowfall rate (closest overpass)

PE



MRR = 8.9 mm w.e.
Cloudsat = 8.6 mm w.e.

DDU



MRR = 2.2 mm w.e.
Cloudsat = 1.7 mm w.e.

Cloudsat sees it all?
No need for MRR?

- Compare time periods in which both MRR and Cloudsat were measuring for a long time instead of individual events!
- In total:
  - 20 months of concurrent data for PE
  - More than 3 months for DDU
  - Mostly summer data!
- Goal: Calculate statistics on this

Princess Elisabeth

- Total amount of precipitation
  - MRR: 466 mm w.e.
  - Cloudsat: 328 mm w.e. (average)
  - Cloudsat: 242 mm w.e. (closest overpass)
  - Local peaks and lows in precipitation?
- Frequency of snowfall (using the same detection limit)
  - MRR: 14 %
  - Cloudsat: 28 % (average)
  - Cloudsat: 22 % (closest overpass)

Dumont D'Urville

- Total amount of precipitation
  - MRR: 119 mm w.e.
  - Cloudsat: 110 mm w.e. (average)
  - Cloudsat: 114 mm w.e. (closest overpass)
- Frequency of snowfall (using the same detection limit)
  - MRR: 24 %
  - Cloudsat: 41 % (average)
  - Cloudsat: 35 % (closest overpass)

Summary

- Overall, a good correspondence between Cloudsat and MRR snowfall rates
  - An underestimation of total accumulation at the inland station
  - The amount of small-scale snowfall events detected by MRR that are missed by Cloudsat is small (~ Palerme et al., 2015)
- Cloudsat generally overestimates snowfall frequency
  - A lot of small-scale snowfall events are detected by Cloudsat, which may not be present at a specific location

- Future work
  - Doing a similar analysis for McMurdo instruments
  - Include snowfall rate distributions
  - Adding uncertainties in both MRR and Cloudsat

References

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