Blowing snow detection: a comparison of satellite imagery with ground-based remote sensing observations at Princess Elisabeth Station, East Antarctica

Alexandra Gossart, Niels Souverijns, Irina V. Gorodetskaya, Stef Lhermitte, Jan T.M. Lenaerts, Stephen P. Palm, and Nicole P.M. van Lipzig

1. Introduction

- $SMB = P + ME + SU + SU_{ds} + Er_{ds}$

Webcam image of 22/04/2016 at PE station

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1. Introduction

- How to measure blowing snow?
  - Network of snowdrift instrumentation

    → limited in space and time
  - Blowing snow schemes implemented in models (RACMO, MAR,..)

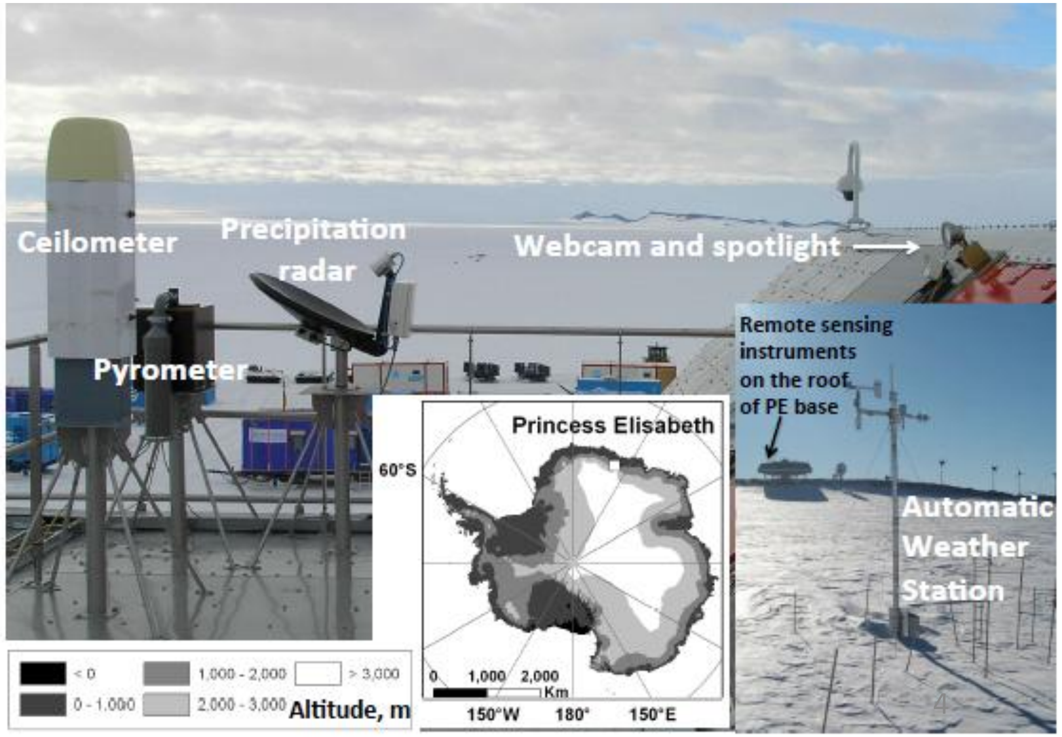
    → ‘only’ models , level of complexity ?
  - Satellite detection

    → limited to overpasses, clear sky conditions and minimum layer height (40m)

2. Remote sensing data

2.1. Ground-based

- Cloud and precipitation observatory (PE station, 2009-ongoing), under Hydrant and Aerocloud projects
- Use of Vaisala ceilometer CL31: attenuated backscatter 910 nm
  - Many station already deployed this instrument



Cloud-precipitation observatory set up on the roof of PE station, Gorodetskaya et al. (2015)

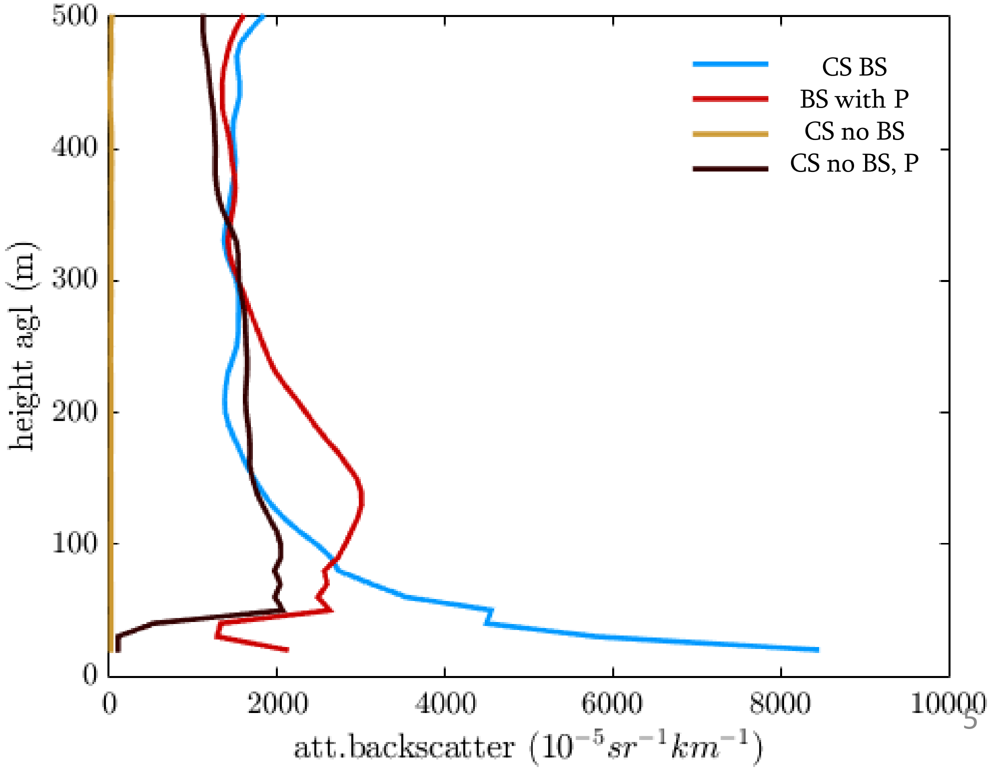
2. Remote sensing data

2.1. Ground-based

- Blowing snow detection algorithm
  - Backscatter threshold → presence of scatterer
  - Decreasing profile → blowing snow

- Validated at Neumayer station

Gossart et al., in prep

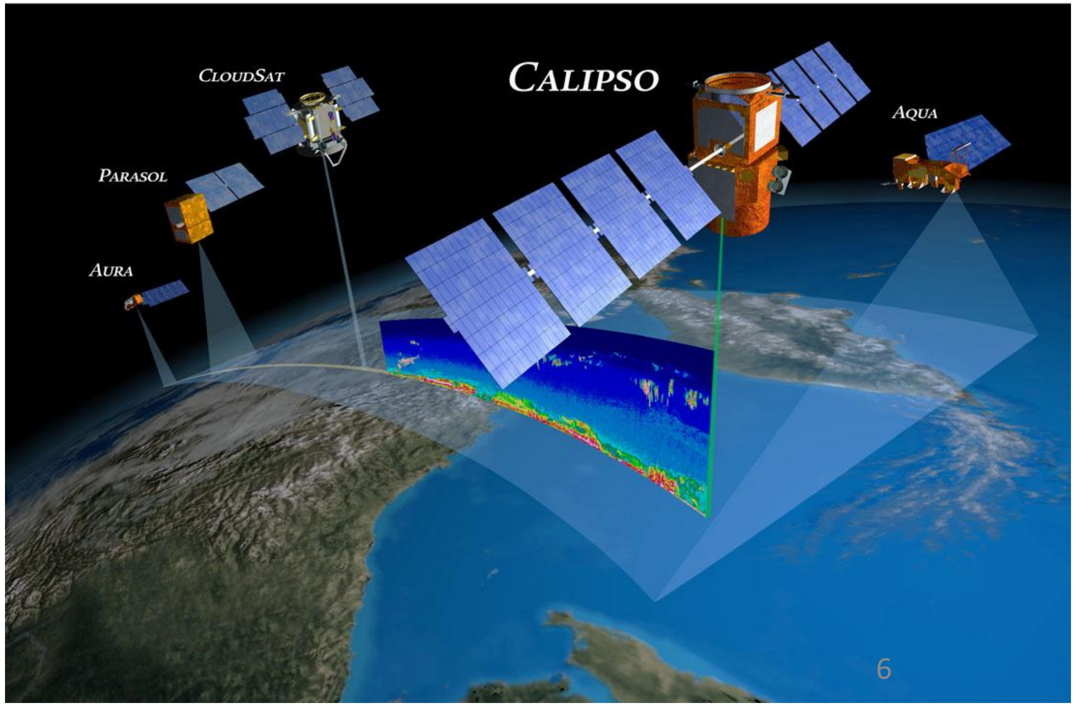


2.2. Space-borne

A-Train: CALIPSO

- 532 nm attenuated backscatter cross section
- Goddart Earth Observing System 5
  - 1 by 1 km DEM
  - 10 m wind speed

Palm et al., 2011



A-train , source: Nasa

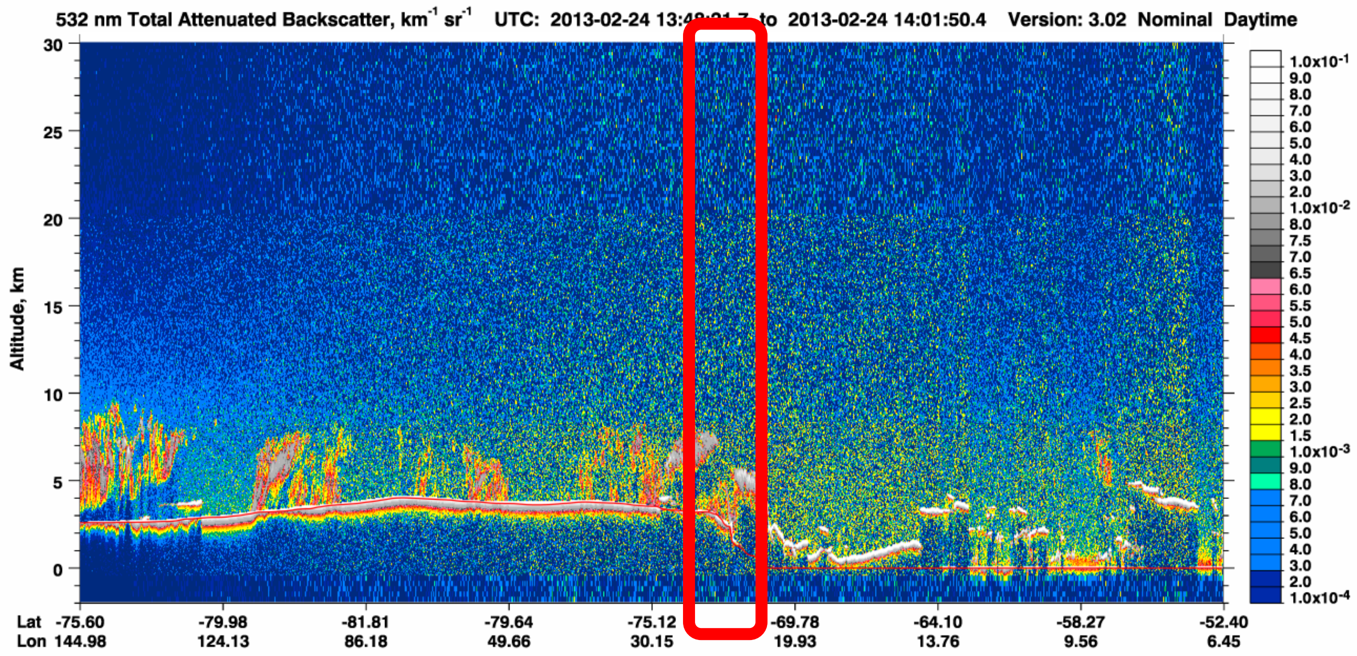
2. Remote sensing data

2.2. Space-borne

Detection algorithm (Palm et al., 2011):

- Ground bin detection
- Backscatter threshold
- Decreasing profile
- Min. wind speed of 4 m/s

- Limited to daylight,
  clear sky conditions and
  minimum thickness of 30-40m



Calipso 532 nm Total attenuated backscatter profile
https://www-calipso.larc.nasa.gov/

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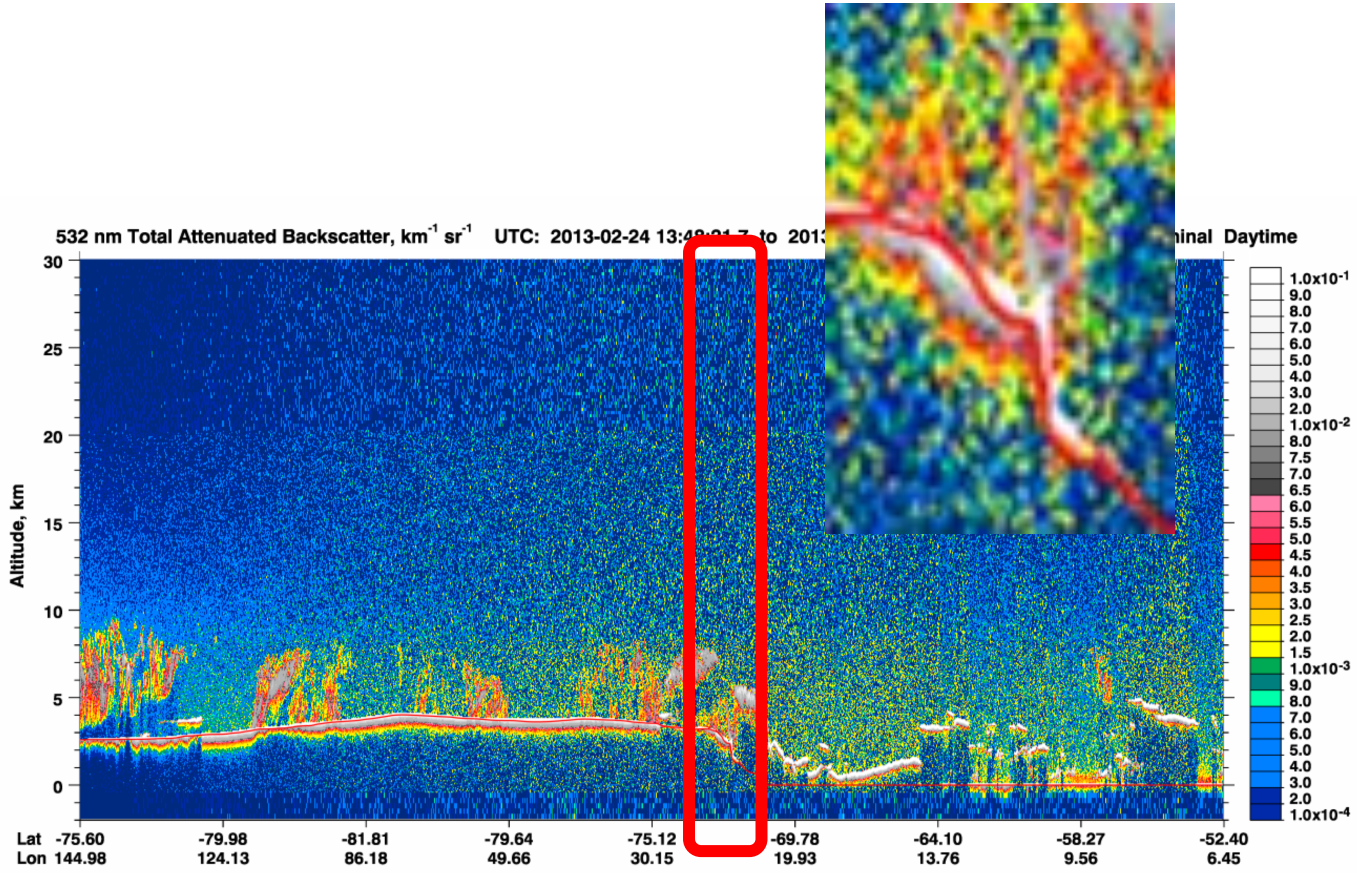

Calipso 532 nm Total attenuated backscatter profile
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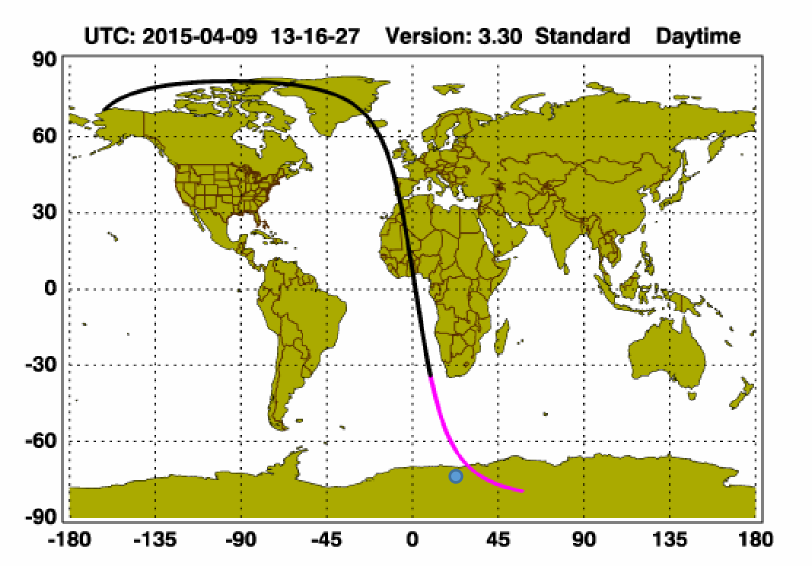
3. Case studies

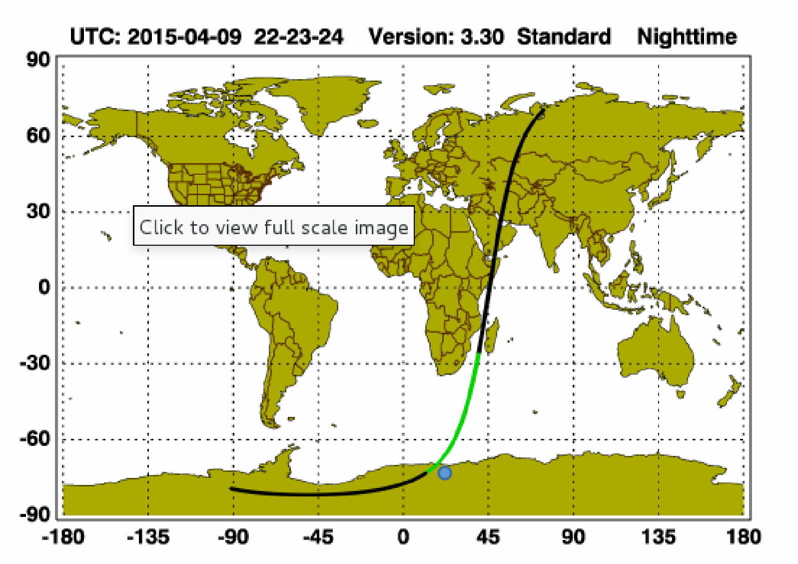
Compare the ceilometer algorithm detection to the satellite records of blowing snow

Period : Antarctic summers

Overpasses at PE station :

- Around 13h30 (left)
- Around 22h00 (right)



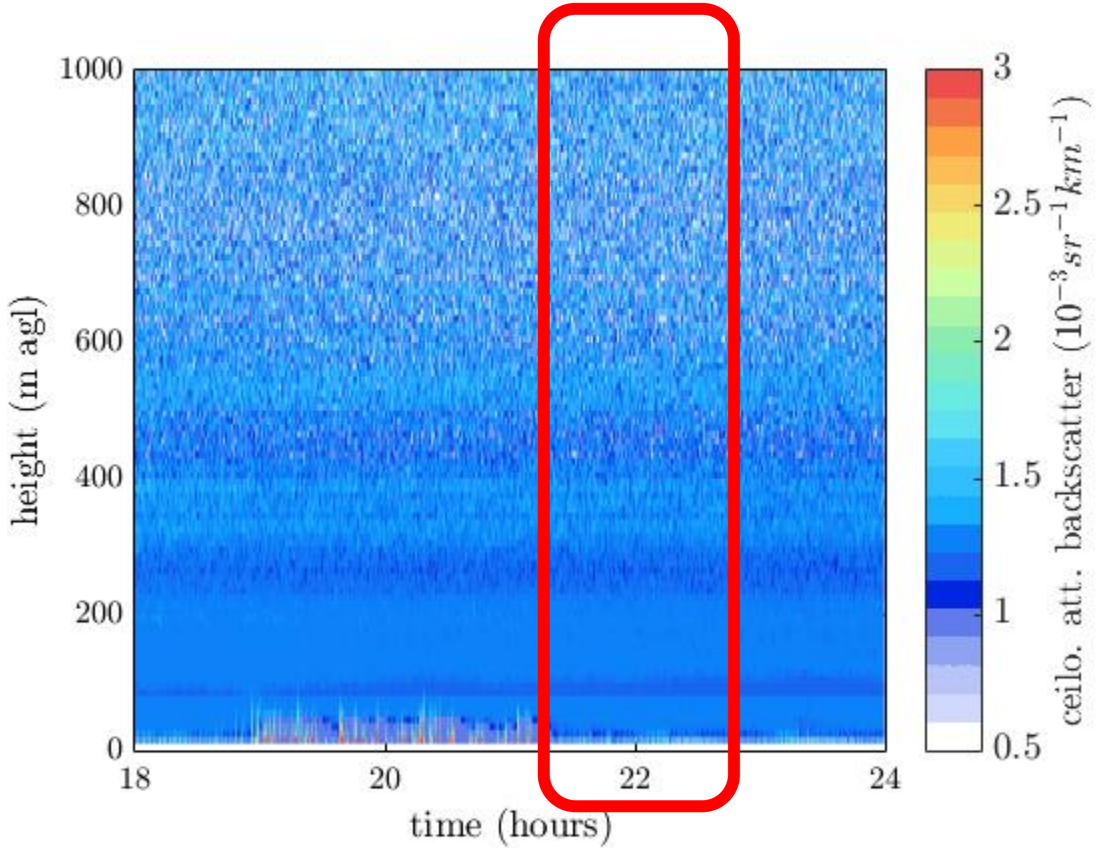


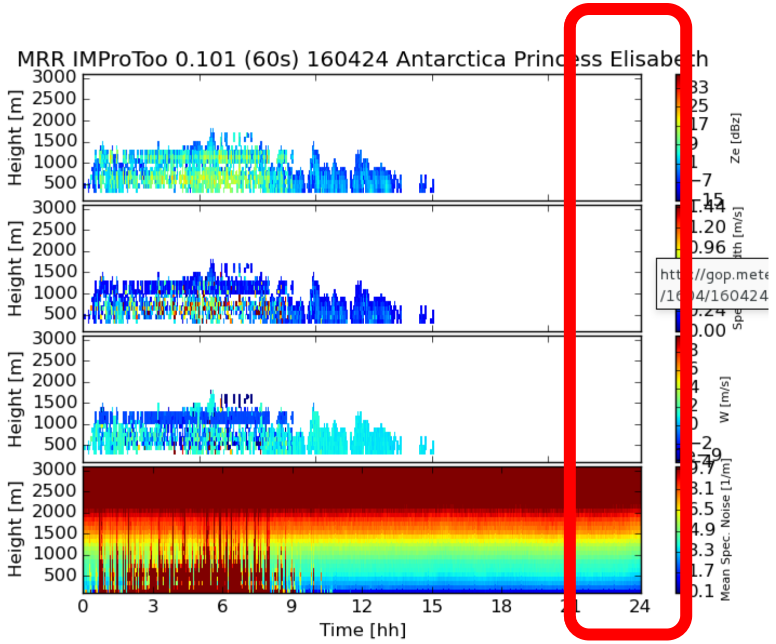
Overpasses : https://www-calipso.larc.nasa.gov/

3. Case studies

3.1. Blowing snow detected by both methods

24 April 2016 around 22h00, no precipitation





Ceilometer attenuated backscatter profile with blowing snow signal (left) and MRR reflectivity (right)

3. Case studies

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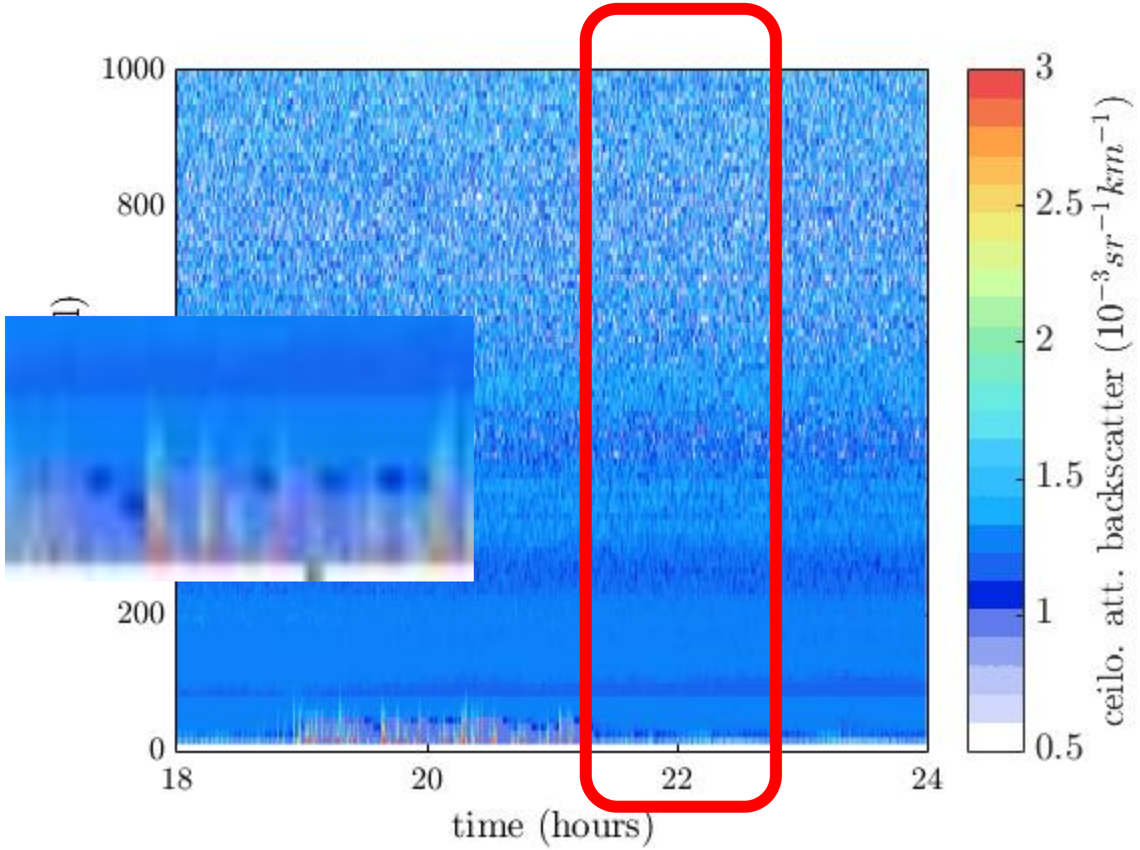

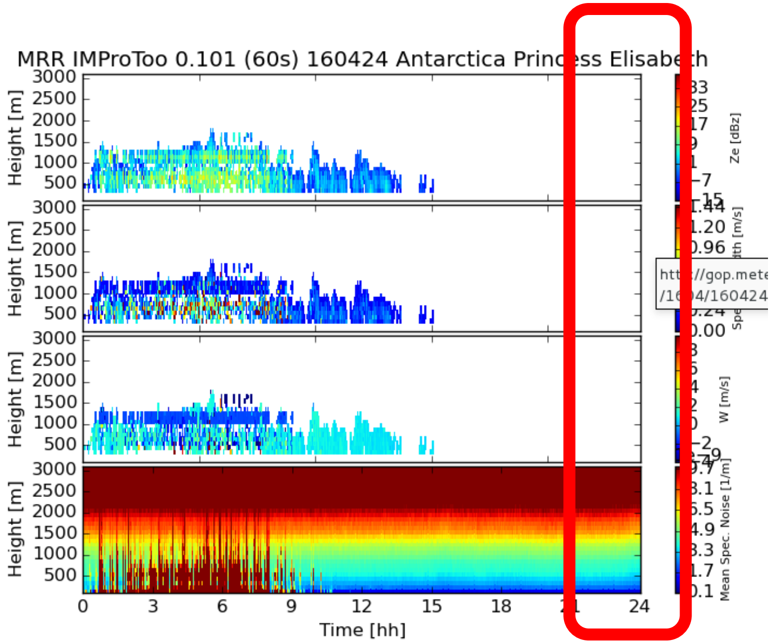

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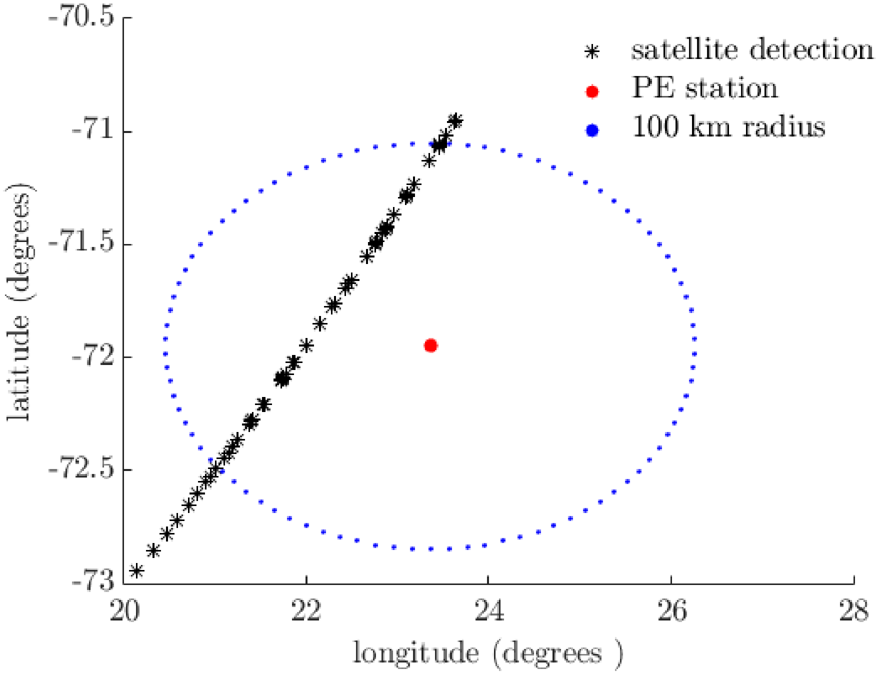
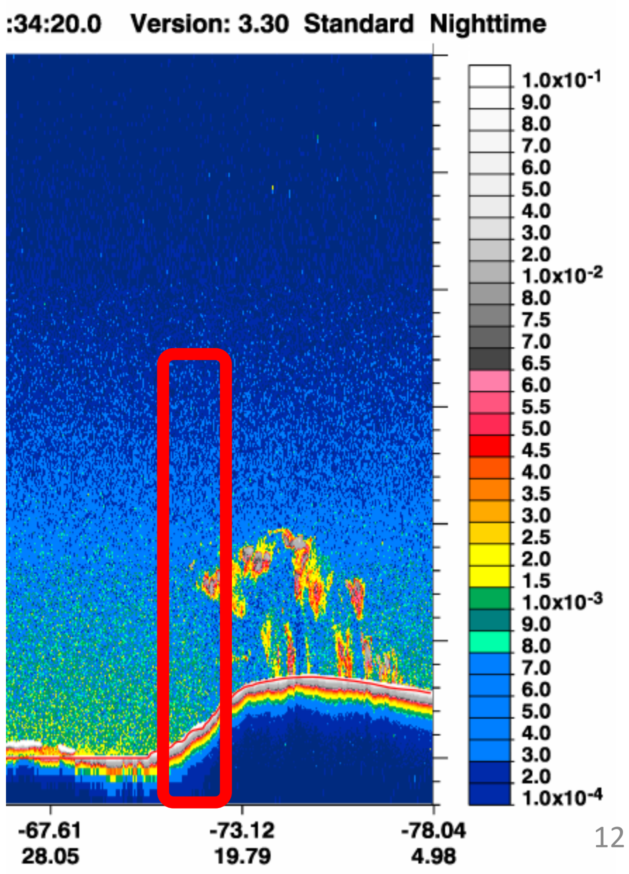


Satellite track compared to PE station location (left)
532 nm Total attenuated backscatter profile from Calipso (right)



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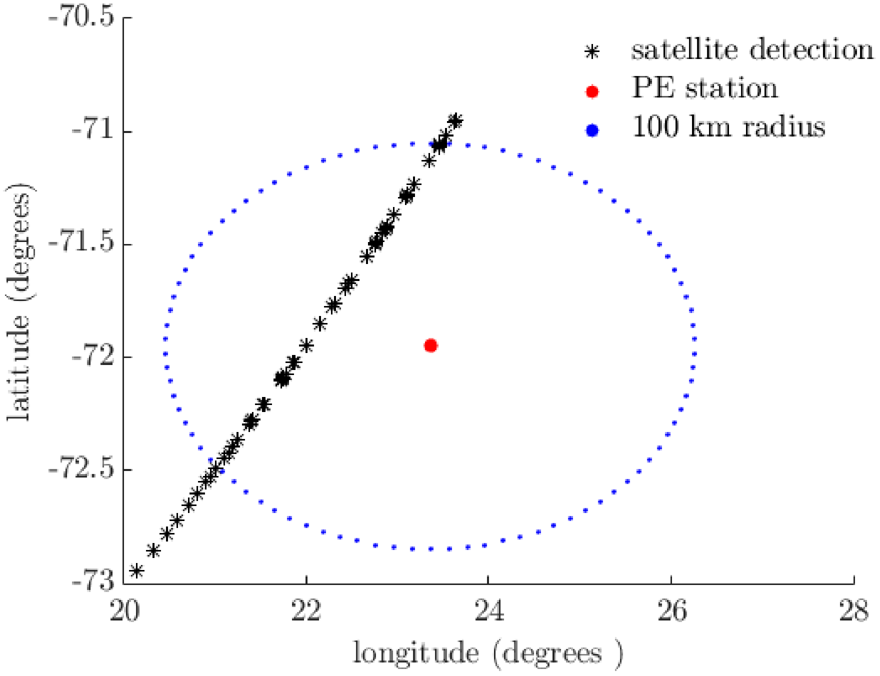

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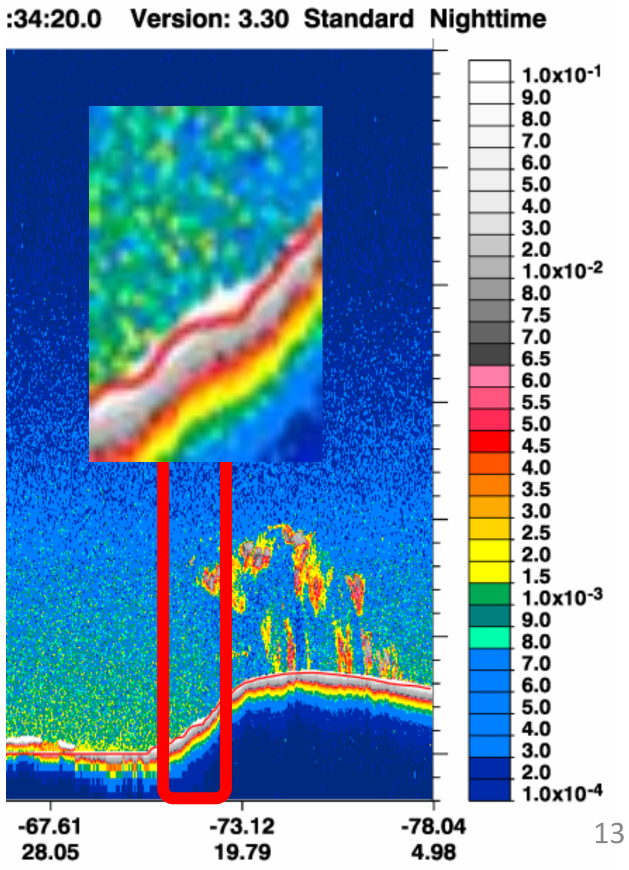
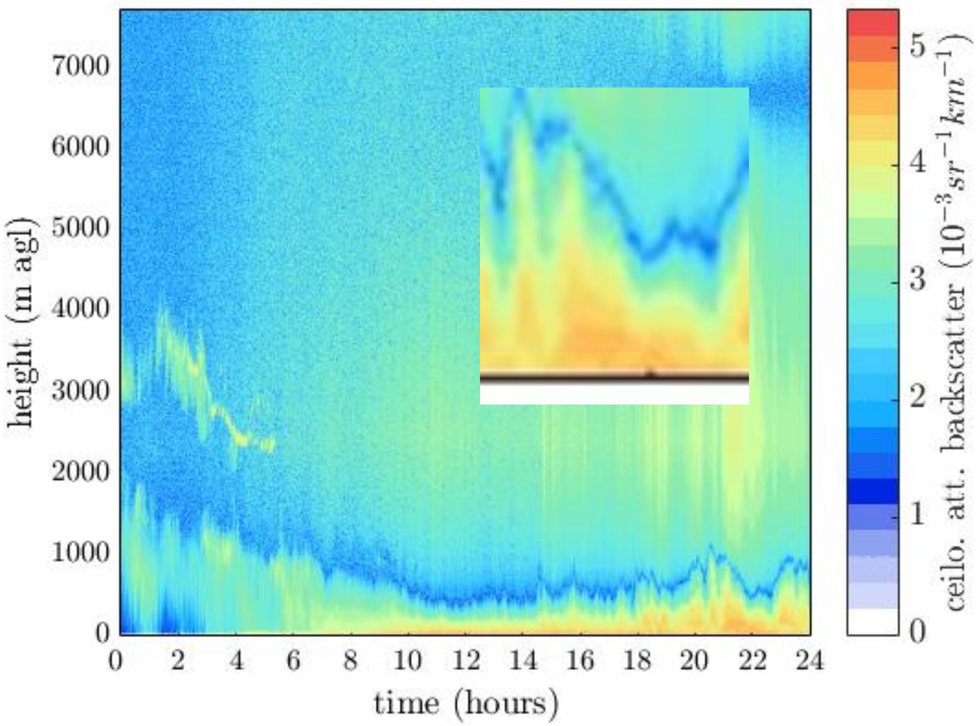
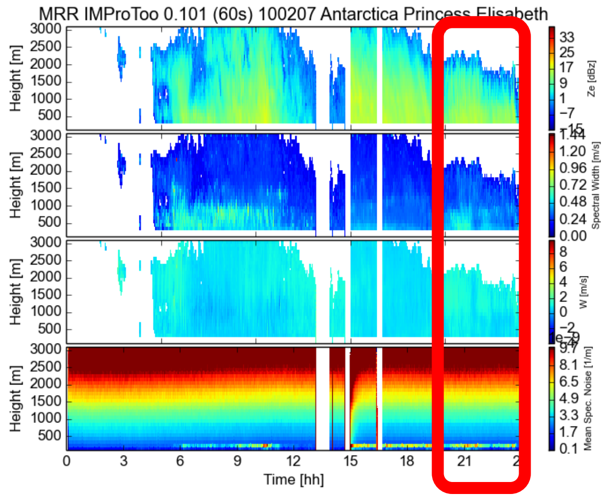


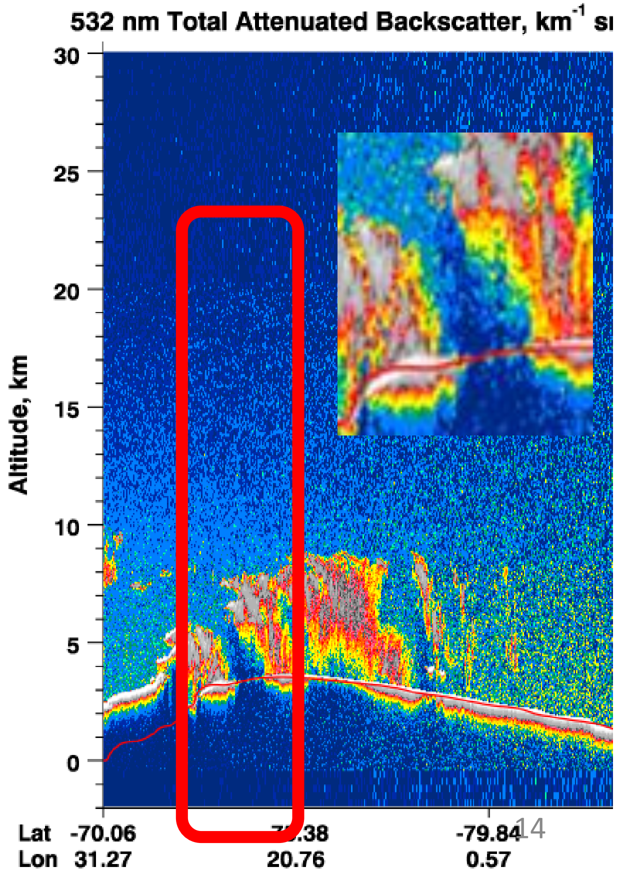
3. Case studies

3.2. Blowing snow detected by ceilometer only

7 Feb 2010 around 22h00 : perfect overpass but no blowing snow record from the satellite: **precipitation** impedes the detection



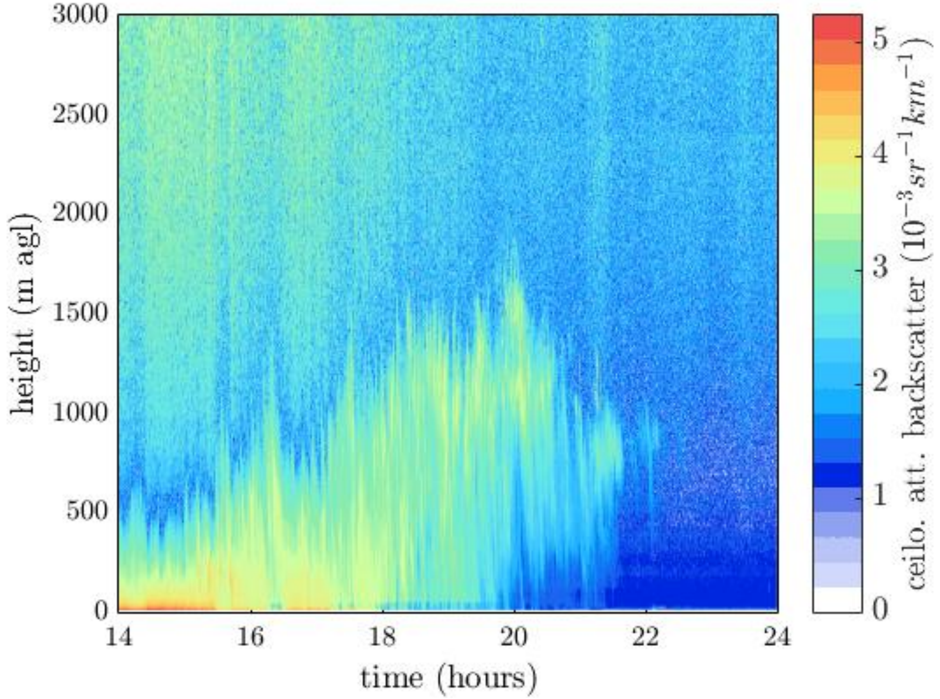




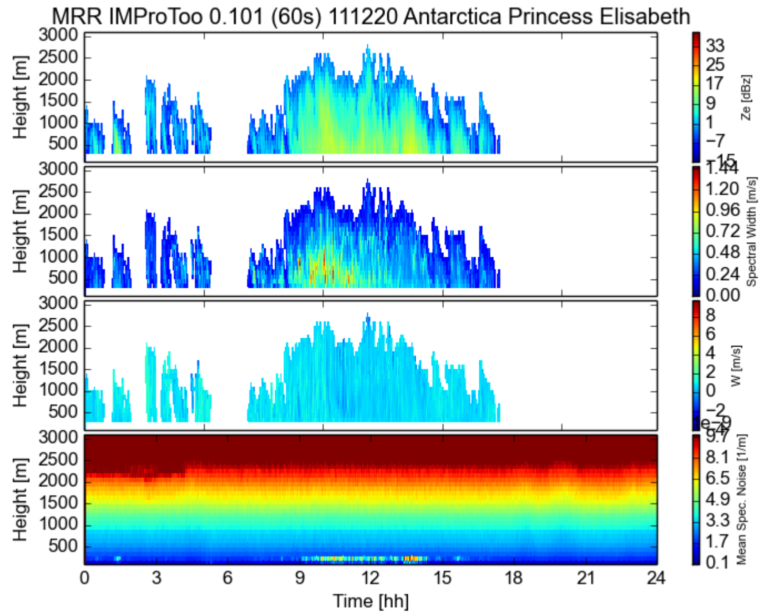
3. Case studies

3.3. Blowing snow detected by ceilometer only

20 Dec 2011 around 21h00 : long blowing snow event, no precipitation



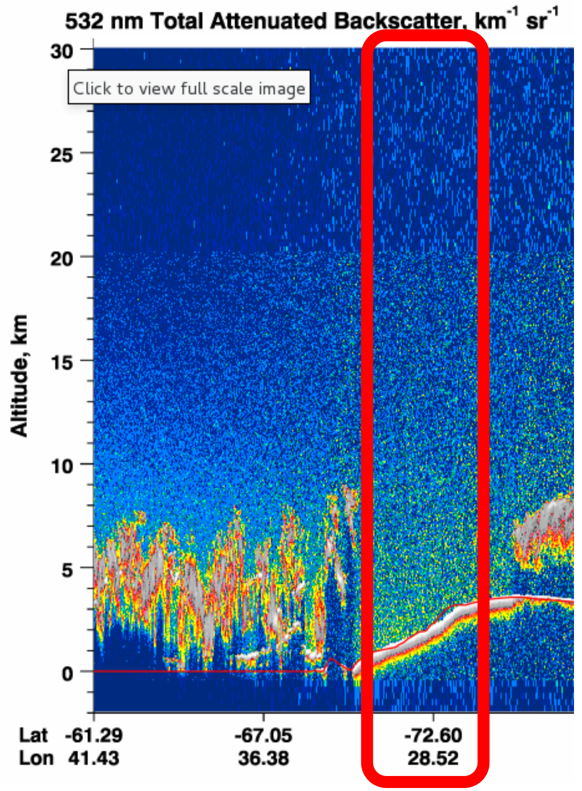
Ceilometer attenuated backscatter (left)
and MRR reflectivity (right)



3. Case studies

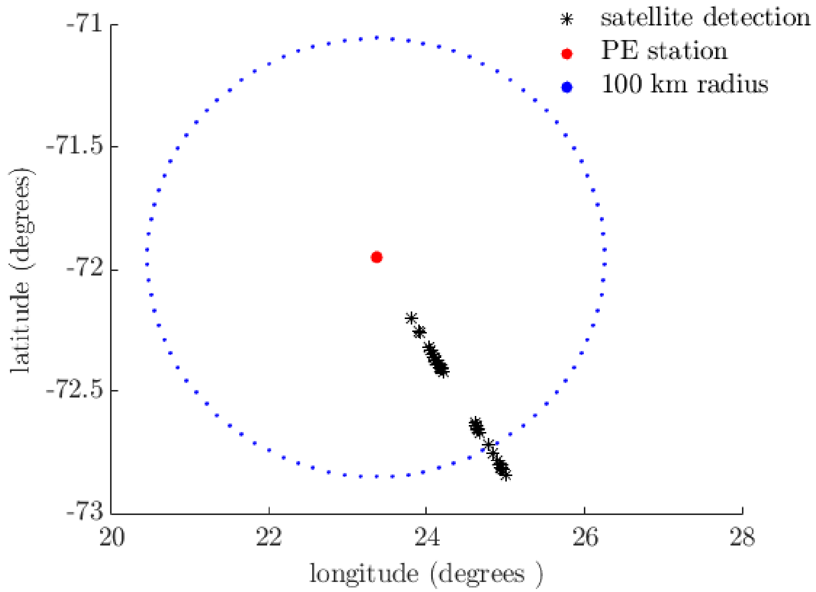
3.3. Blowing snow detected by ceilometer only

20 Dec 2011 around 21h00 : perfect overpass, blowing snow event, no precipitation



Even though there are clear sky conditions on the profile, no blowing snow is detected

Wind speed conditions are around 3 m/s at 2m height



4. Conclusions and outlook

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- The ceilometer algorithm is able to detect blowing snow during precipitating events (represents a large fraction of blowing snow), in the dark and has no minimum thickness limitation
- There is no minimum wind speed criterion on the ceilometer algorithm, which detects less heavy events
  - A substantial fraction of blowing snow events occur after precipitation at low wind speed
- PE is a very specific location, a 100 km radius might not be representative

→ Limited to few overpasses

Future work:

- More extensive dataset
- Work with confidence levels

5. References

- Gorodetskaya, I.V., Kneifel, S., Maahn, S., Van Tricht, K., Thiery, W., Schween; J.H., Mangold, A., Crewell, S., and van Lipzig, N.P.M (2015) Cloud and precipitation properties from ground-based remote sensing instruments in East Antarctica, The Cryosphere, 9, 285-304, doi:10.5194/tc-9-285-2015
- Palm, S.P., Yang, Y., Spinhirne, J.D., Marshack, A. (2011) Satellite remote sensing of blowing snow properties, Journal of Geophysical Research, 116, D16123, doi:10,1029/2011JD015828
- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), NASA portal