A L1 transformational operator for the objective evaluation of the EarthCARE Cloud Profiling Radar data products using suborbital observations

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1. Motivation

Identified **need for pre-launch evaluation of Satellite Cloud Profiling Radar** (CPR) measurements and products to assess their performance. **Ground based radar networks** (FRM4Radar, ACTRIS) have a **good global coverage** and have large data sets, and offer perfect conditions for CPR Cal/Val activities. However one has to transform the ground based data sets to satellite view [1,2,3] to make best use of the data

Research questions:

- How is the CPR's **performance for low clouds**?
- **Can the Doppler capability be used** to capture cloud processes?

Task: Transform ground based radar data into satellite view!

- Assess of CPRs Doppler capabilities
- Identify challenging regions of the CPRs → e.g. low level clouds
- Generate a large data sets for evaluation (statistical and objective)

2. Simulator Algorithm

Input: Ground based w-band radar data (reflectivity and Doppler velocity)

1) Data re-gridding and axis conversion

- Along-track: use constant v_{hor} = 6 ms^{-1} to convert time → along track
- Re-gridding: conman range grid (multiple chirp tables)
- Introduce a surface echo (52 dBZ)

2) Data convolution along track and integration along track [1,2]

- Convolution along track for each bin → flexible along track integration
- Along track integration: EarthCare → 500 m along track steps
- Add Doppler velocity error due to satellite motion

3) Data Convolution along range [1]

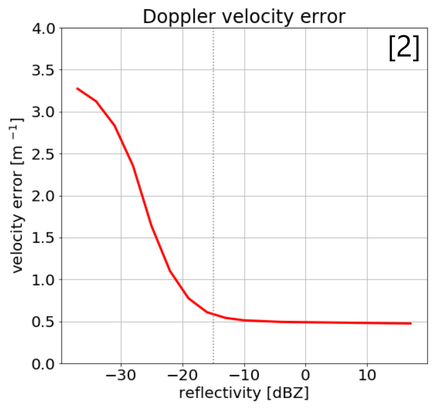
- Convolution of data according to Satellite range resolution (sat pulse length)

➢ **Best radar measurements from space**

4) Add error to the forward simulated Ze- and Vm data [2,3,4]

Doppler velocity error: non-uniform beam filling, antenna pointing

- Doppler velocity error up to +/- 3 ms^{-1}
- Folding to the Doppler velocity – Nyquist velocity +/- 5.7 ms^{-1}



➢ **Forward simulated data set for statistical comparison and retrieval evaluation**

4. Outlook

Apply the forward simulator to larger data set

- Improve the cloud mask for low clouds
- Develop or improve Cal/Val products for EarthCare measurements
- Pre-launch statistics for CPR challenging cloud types

Further applications possible for:

- airplane data sets to satellite view
- Integrate such a simulator into ACTRIS as a standard product

Compare simulation statistics to EarthCare data when it is flying.

References:

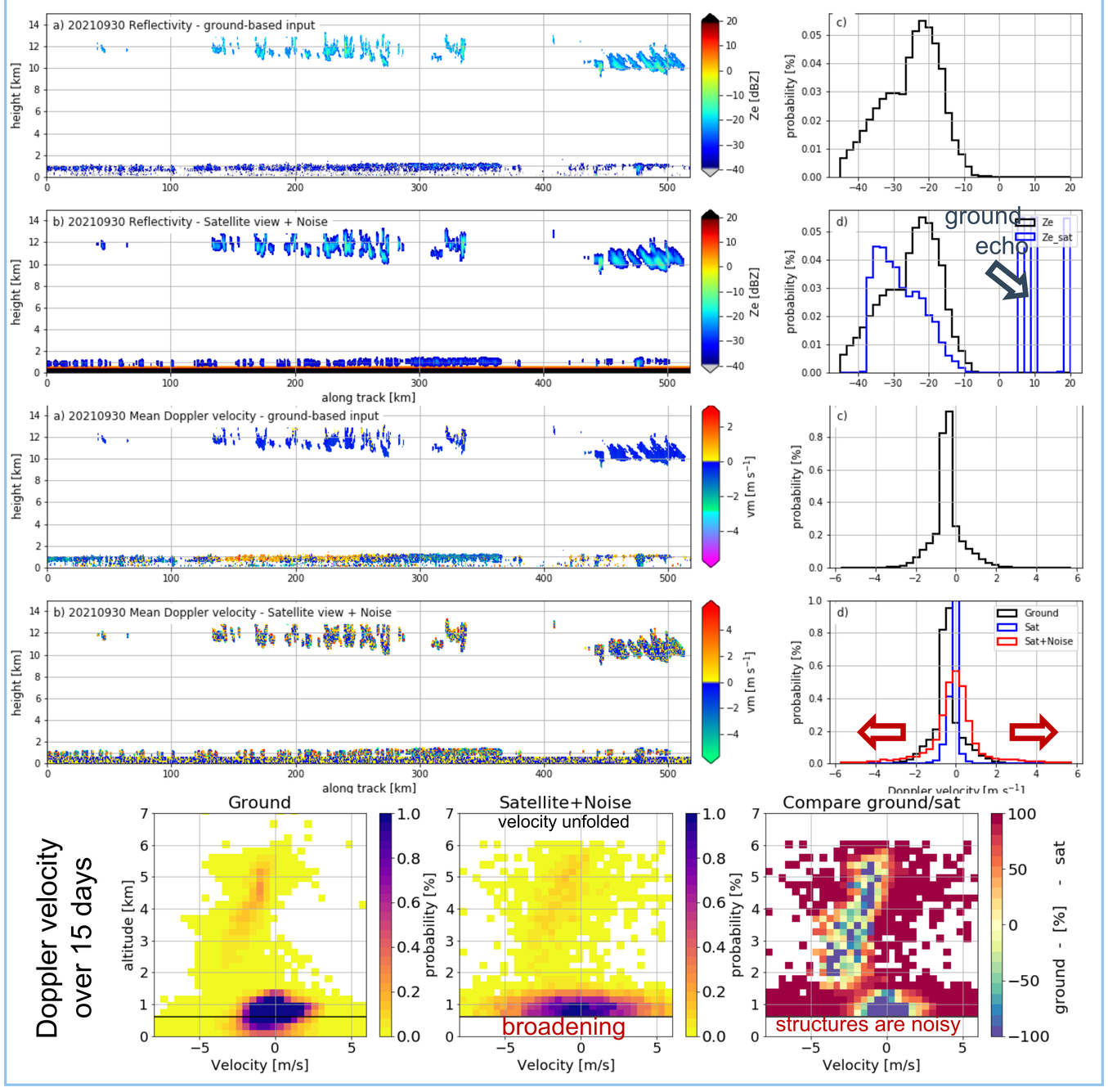
[1] Lamer, K., Kollias, P., Battaglia, A., and Preval, S.: Mind the gap – Part 1: Accurately locating warm marine boundary layer clouds and precipitation using spaceborne radars, Atmos. Meas. Tech., 13, 2363–2379, https://doi.org/10.5194/amt-13-2363-2020, 2020

[2] Kollias, P., S. Tanelli, A. Battaglia, and A. Tatarevic (2014), Evaluation of EarthCARE Cloud Profiling Radar Doppler velocity measurements in particle sedimentation regimes, J. Atmos. Oceanic Technol., 31(2), 366–386, doi:10.1175/JTECH-D-11-00202.1.

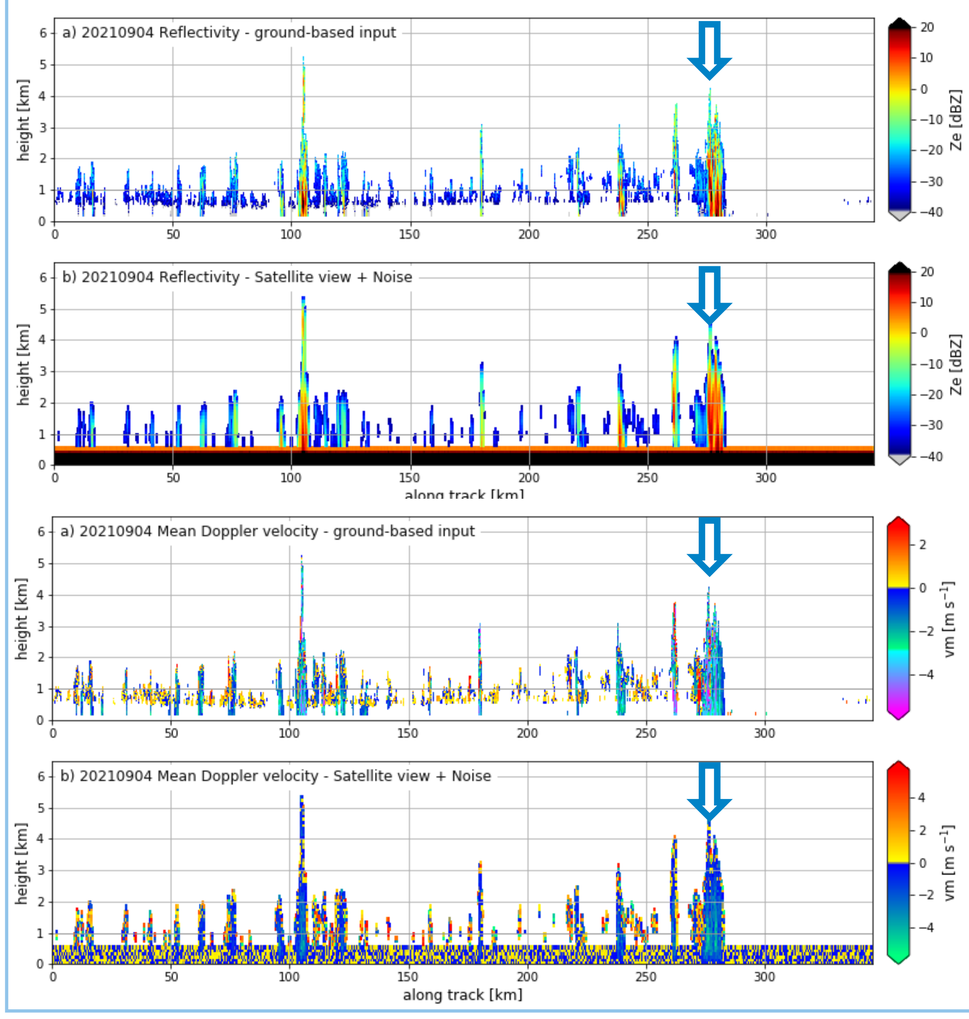
[3] Kollias, Pavlos, Battaglia, A., Lamer, K., Treserras, B. P., and Braun, S. A. Mind-the-gap - Part III: Doppler velocity measurements from space. United States: N. p., 2022. Web. doi:10.3389/frsen.2022.860284.

[4] Delanoë, J. and Hogan, R. J., 2010, Combined CloudSat-CALIPSO-MODIS retrievals of the properties of ice clouds, JGR, vol. 115, D00H29, doi:10.1029/2009JD012346, 2010

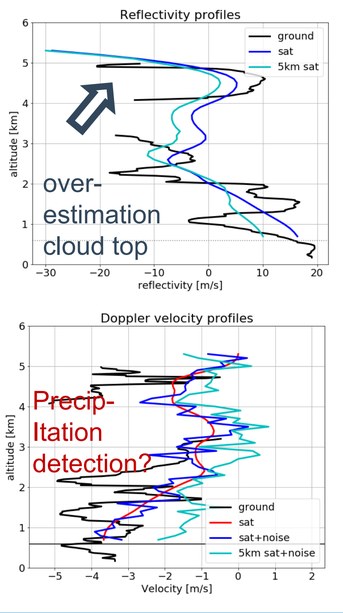
3.1. Case study: Mindelo, Cape Verdes



3.2 Case Study: Barbados Cloud Observatory, Barbados



Convection and precipitation identification is challenging: Features aren't standing out in the statistics and difficult to identify in profiles



5. Take home messages

Identification of tropical low clouds for the EarthCare CPR is challenging due to:

- blind zone below 600m
- overestimation of cloud tops
- only for large motions can be detected with sufficient SNR (Ze > -15 dBZ)
- Averaging along track to decrease noise in the Doppler velocity data