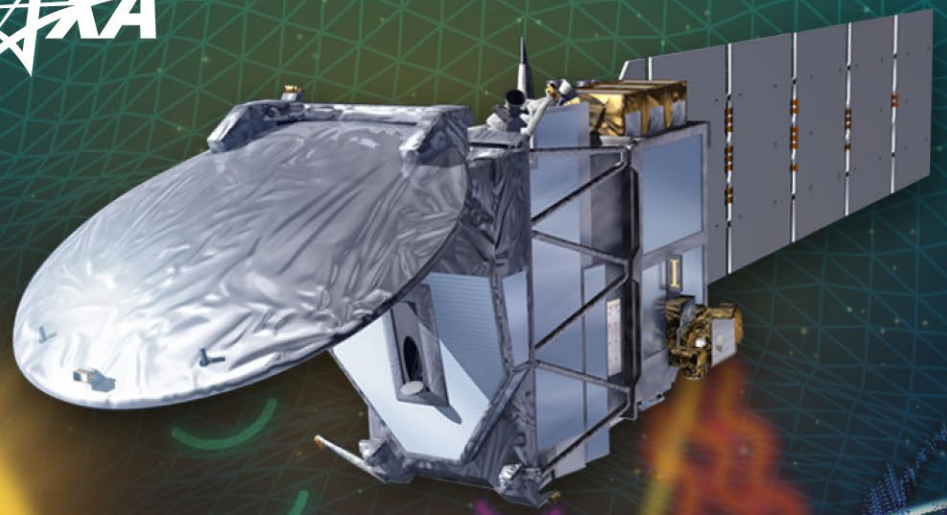

ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

DEMO-3: L1 CPR transformation operator

from suborbital observations to synthetic EarthCARE CPR

Lukas Pfitzenmaier[1], Nils Risse[1], **Pavlos Kollias**[1,2], **Bernat Puigdomènech**[7], Imke Schirmacher[1]

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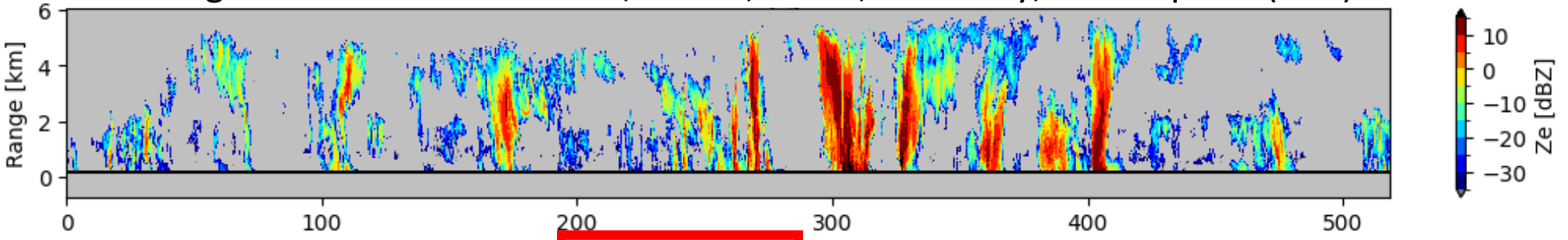
5) Finish Meteorological Institute, Finland 6) Earth Observation Ground Segment Department, ESA / ESTEC,
7) McGill University, Montreal, Canada

Motivation: CPR Forward Simulator tool

Motivation:

- Create data base for CPR Cal/Val
- Use of existing long term data sets
- User-friendly and quick processing (python)

INPUT: ground-based radar data, JOYCE, Jülich, Germany, 2021 April 6 (24h)



INPUT: Ground based data:

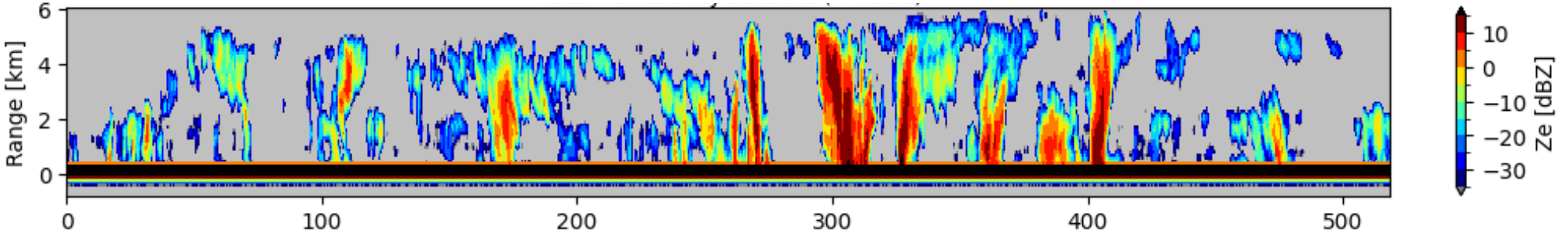
- Date comparability: ACTRIS, GEOMS, airplane
- flexible satellite configuration: EarthCARE or Cloudsat

Simulator/ Python tool

Output: EarthCARE synthetic CPR data:

- Validation of L1 with ground
- Creating data for L2 development
- Creation of long term data sets for statistical comparisons

OUTPUT: EarthCARE synthetic CPR data for, JOYCE, Jülich, Germany, 2021 April 6



Make use of cloud radar network data sets:

- Coverage of different cloud and climate regimes
- Long term data stets – many stations with 10 years or longer
- Instrumental synergy with ceilometer and microwave radiometer
  - Run cloud target classification algorithm – ACTRIS Cloudnet algorithm
  - Validation of CPR retrievals
- Make use of airplane data sets
  - More direct comparison to Satellite Radars
- Data: www.cloudnet.fmi.fi

What is the CPR Forward Simulator doing?

Mimic the sensor characteristics:

- Introduce a surface echo (52 dBZ)
- Mimic EarthCARE CPR characteristics: resampling, weighting, integration of data

Flexibility in the applied satellite characteristics

- CloudSat and EarthCARE are implemented – changes are easy to do
- Specifications can also be defined and changed
  - PRF
  - Integration along track,
  - Range resolution

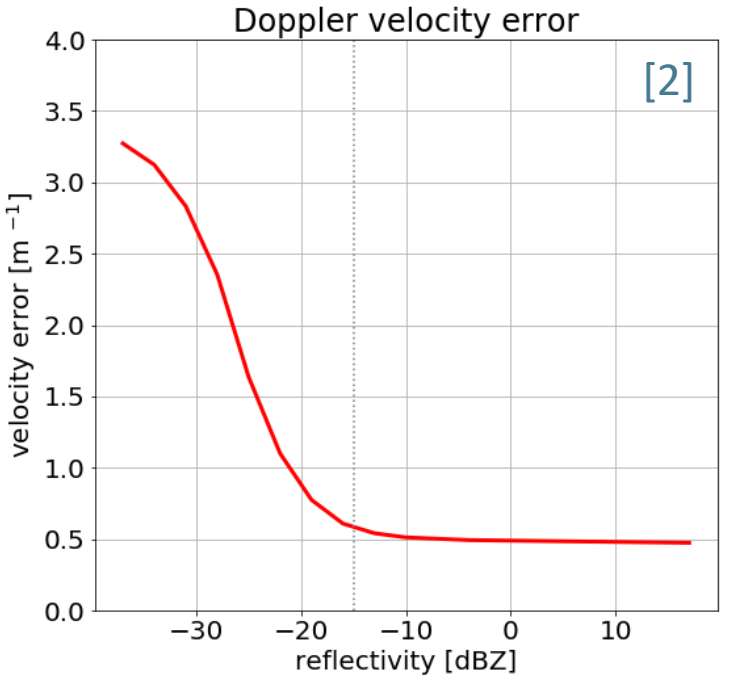
Simulate Satellite and CPR noise for Ze- and Vm [2,3,4]

- Doppler velocity error due to
  - ➢ Satellite motion
  - ➢ non-uniform beam filling,
  - ➢ antenna pointing
  - ➢ SNR
  - ➢ Doppler velocity folding – v_{Nq}+/- 5.7 ms-1
- Reflectivity error

Python Code – Conversion 35 GHz to 94 GHz included [5]

References:

[1] Lamer, et al.,2020
[2] Kollias, et al., 2014
[3] Kollias, et al., 2022.
[4] Delanoë, & Hogan, 2010
[5] Kollias, et al., 2019



Example: CPR Forward Simulator tool

JOYCE, Jülich 6th April 2021

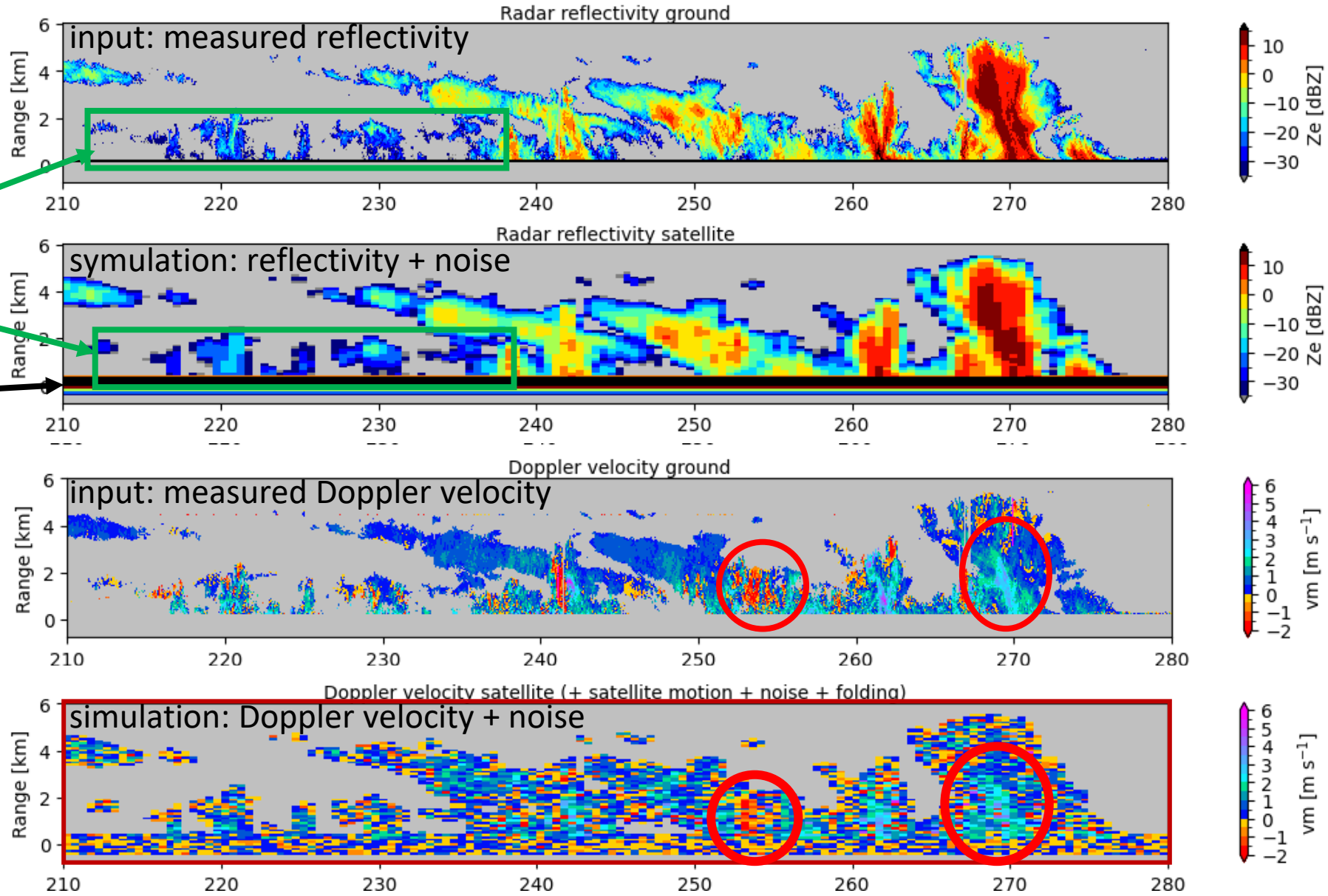
Cloud boundaries are smoothed

Loosing low level cloud structures

ground echo

Doppler velocity is noisy because of

- Sat motion,
- low SNR
- non-uniform-beam filling



Conclusion - CPR Forward Simulator tool

First attempts for 94 GHz Microwave Radar/Radiometer for Arctic Clouds flown on Polar 5 for CloudSat (Schirmacher et al., 2023, AMT)

Extend the tool to be applicable to forward simulated radar observations from...

- RASTA, ARM,...

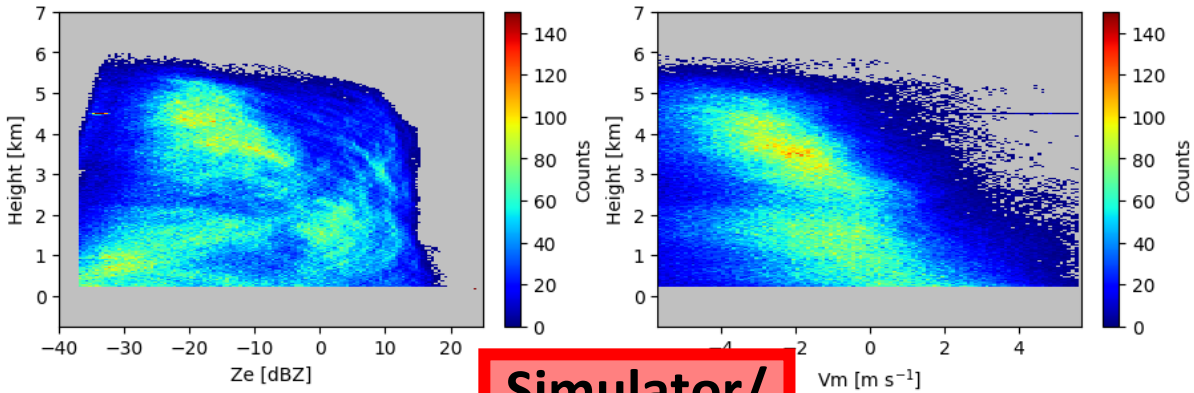
So we will have, a flexible forward simulation tool for airborne and ground based data sets for EarthCARE

TO DO: documentation/publication

Plan: Radar forward simulations from NWP model input using PAMTRA (Mech et al, 2020)

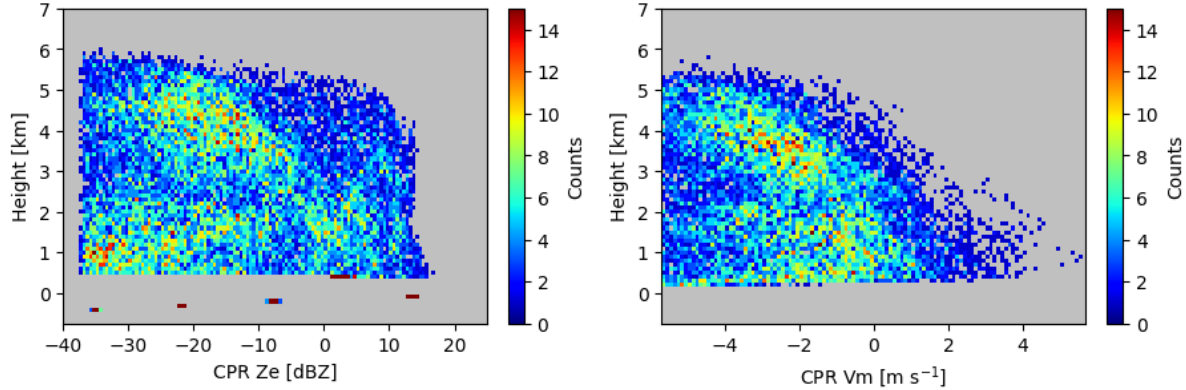
Demonstration / questions / chat?
Meet me at the DEMO-3!

INPUT: ground-based radar data



Simulator/ Python tool

OUTPUT: EarthCARE synthetic CPR data



For any Demonstration, questions, discussion

Meet me at the DEMO-3!

CPR L1 simulation tool

from ground based radar to synthetic EarthCARE CPR

orbital-radar.py

Lukas Pfitzenmaier[1], Nils Risse[1], Pavlos Kollias[1,2], Bernat Puigdomènech Treserras [3]

[1)] University of Cologne, Germany [2)] Stony Brook University, NY, USA [3)] McGill University, Montreal, Canada

Motivation:

- Create data base for CPR Cal/Val
- Usage of existing long time data sets
- Easy usage -> python code (github)

INPUT: Ground based data:

- Date comparability: ACTRIS, GEOMS, airplane radar (MIRAC-A, BASTA)
- Input data can act as 'ground truth' for synthetic CPR data
- flexible satellite configuration
  - CloudSat
  - EarthCARE

CPR simulation tool – orbital-radar.py

1) Data re-gridding and axis conversion

- Time to along-track conversion: use constant v_{hor}
- Re-gridding: common range grid for input data
- Introduce a surface echo (52 dBZ)

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

- Convolution along track for each bin
- Along track integration: EarthCARE
  - ➡ flexible along track integration

3) Data Convolution along range [1]

- Convolution of data according to satellite range
  - ➡ flexible range sampling

Best CPR estimates - synthetic CPR without noise

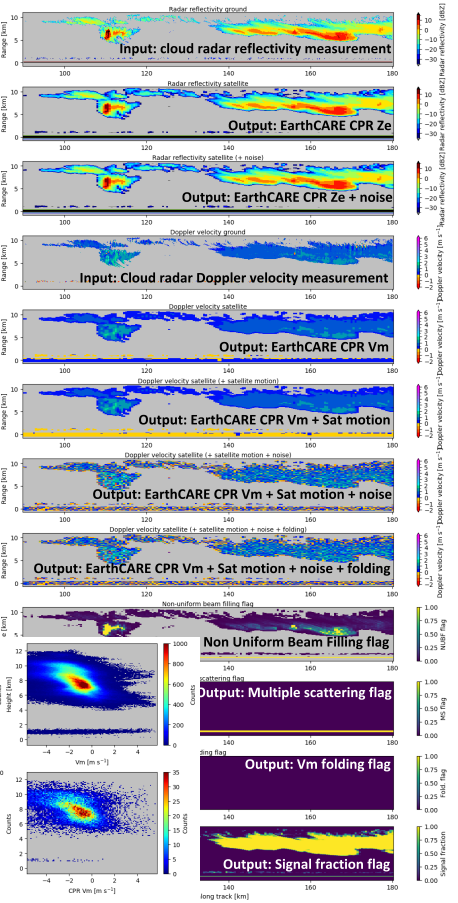
4) NEW: Noise field simulation of CPR Ze and Vm [2,3,4]

- Doppler velocity error:
  - Non-Uniform Beam filling
  - Antenna pointing
  - SNR dependent velocity error
  - Doppler velocity folding
- Reflectivity error

Python Code includes 35 GHz to 94 conversion [5]

Output: EarthCARE syn

- Validation of L1 with grou
- Creation of test data for
- Creation of long term dat comparison



References:

[1] Kamar, et al., 2020
[2] Kollias, et al., 2014
[3] Kollias, et al., 2022
[4] Delanoë, & Hogan, 2010
[5] Kollias, et al., 2019

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