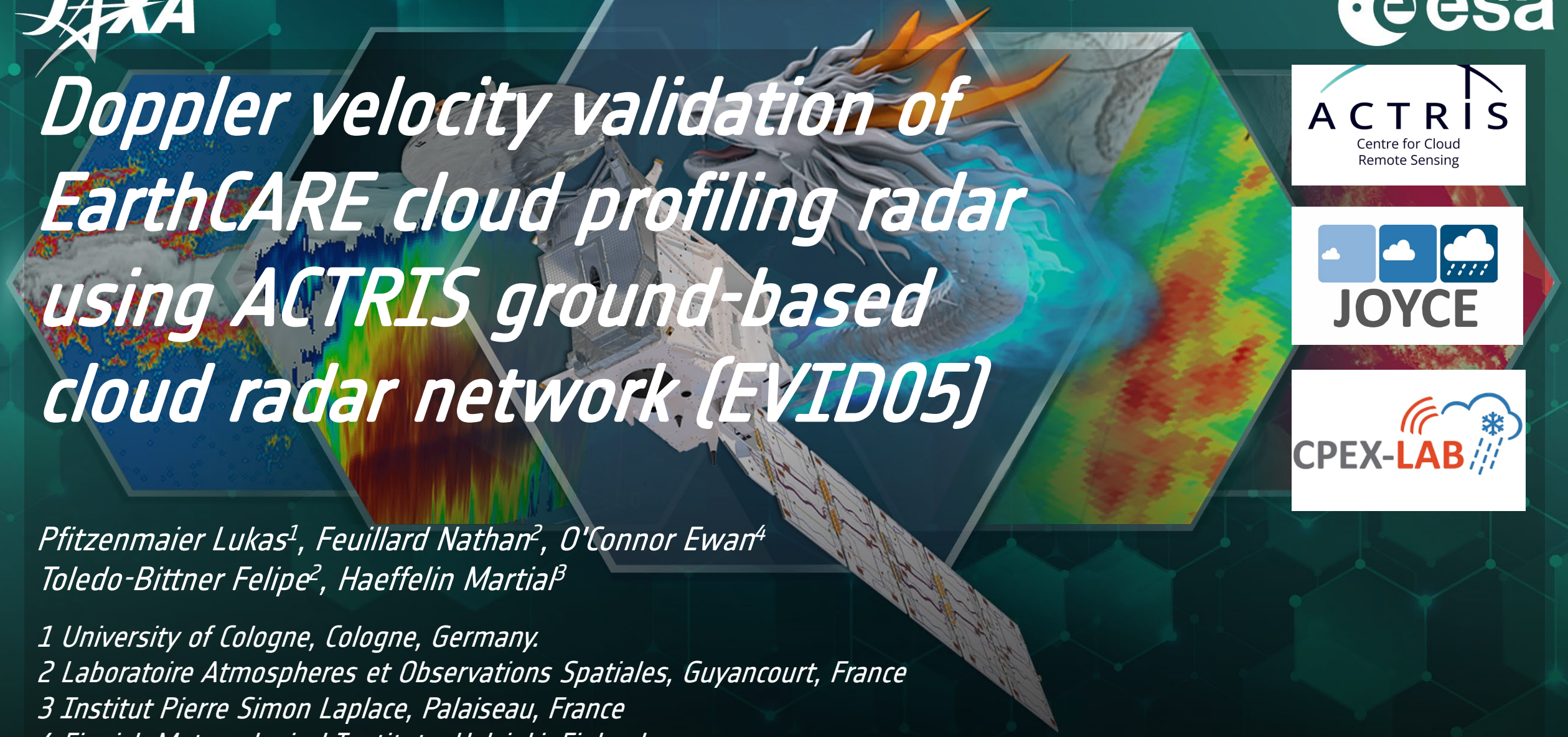


Doppler velocity validation of EarthCARE cloud profiling radar using ACTRIS ground-based cloud radar network (EVID05)

Pfitzenmaier Lukas[1], Feuillard Nathan[2], O'Connor Ewan[4]
Toledo-Bittner Felipe[2], Haeffelin Martial[3]

1 University of Cologne, Cologne, Germany.
2 Laboratoire Atmospheres et Observations Spatiales, Guyancourt, France
3 Institut Pierre Simon Laplace, Palaiseau, France
4 Finnish Meteorological Institute, Helsinki, Finland

2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

Results: Doppler velocity Val 1st workshop

Site	Vm bias/ RMSE (BA)	Vm bias (BB)	
Ny Ålesund	0.65 / 0.67 ms^{-1}	no ground data	BA overpasses (91)
Hyytiälä	0.40 / 0.42 ms^{-1}	0.25 ms^{-1}	mirroring ground echo BA overpasses (34)
Lindenberg	0.59/ 0.61 ms^{-1}	0.43 ms^{-1}	BA overpasses (20)
Cabauw	0.65 / 0.70 ms^{-1}	0.33 ms^{-1}	BA overpasses (19)
Jülich	0.29 / 0.86 ms^{-1}	Not enough data	BA overpasses (29)
Palaiseau	0.53 / 0.72 ms^{-1}	0.47 ms^{-1}	
Munich			No analyzed
Galati	0.49 / 0.52 ms^{-1}	0.34 ms^{-1}	BA overpasses (20)
Bucharest	0.71 / 0.77 ms^{-1}	0.46 ms^{-1}	BA overpasses (16)
Potenza			No analyzed
Granada	0.44 / 0.53 ms^{-1}	not enough data	BA overpasses (23)
Mindelo			No analyzed
Neumayer	0.18 / 0.32 ms^{-1}	0.42 ms^{-1}	BA overpasses (41)

North

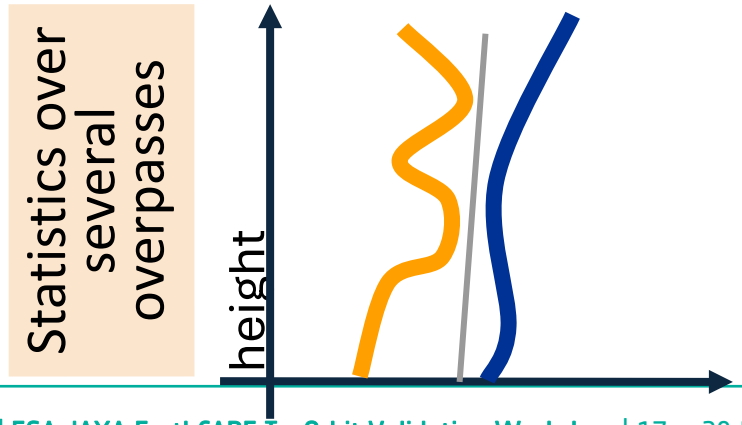
Number of overpasses

- Work in progress
- Used L1 data:
  - NUBF not corrected
  - Doppler velocity unfolded
- Expect improvements using L2 CPR data
- Tendency of the L1 data is:
  - Overestimation of ground-based Doppler velocity
  - Outliers are not dramatic
  - Mean range: 0.50 ms^{-1}
  - Other Doppler velocity validation results to compare are missing.

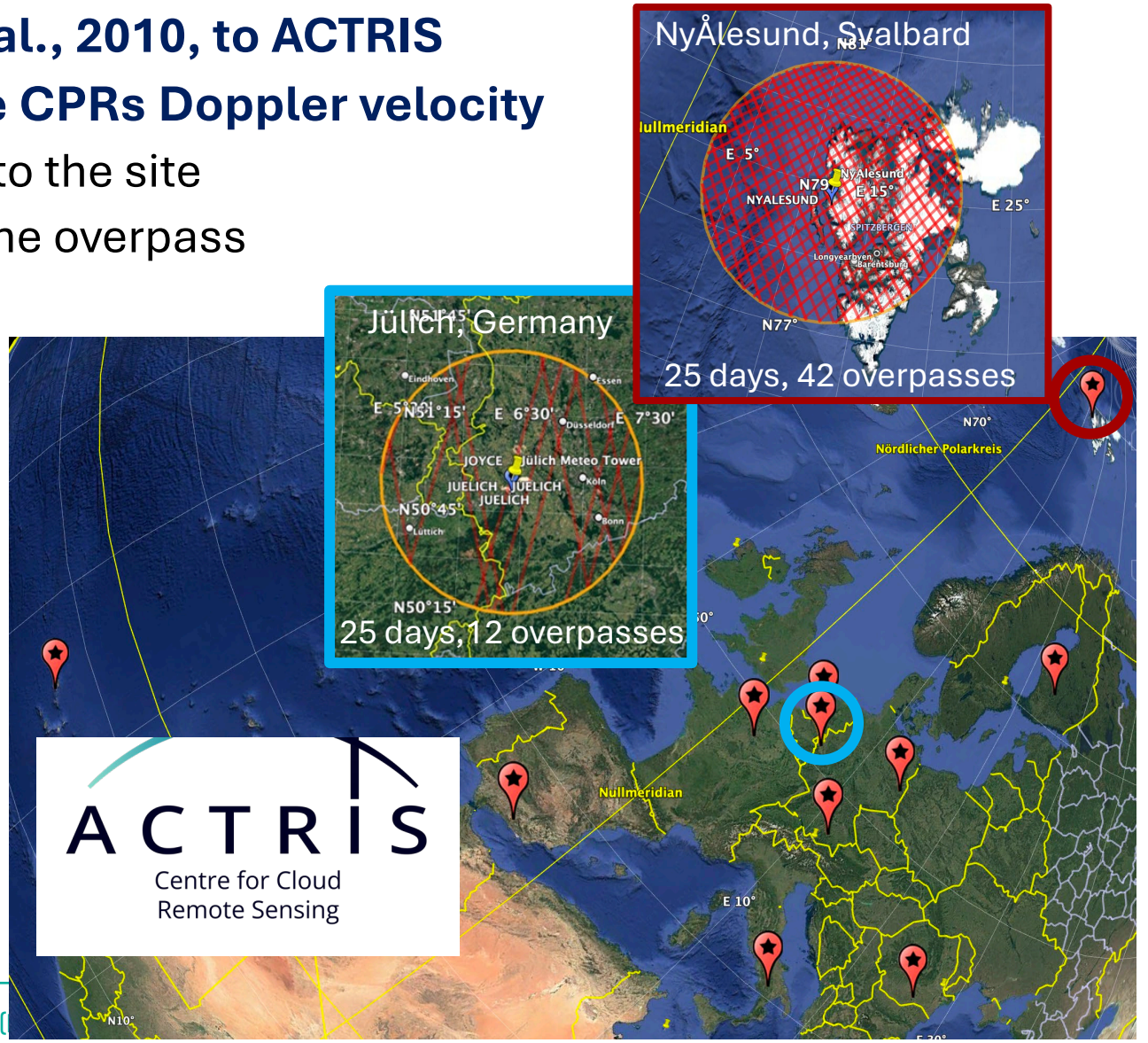
Doppler velocity Cal/Val – Method: statistical comparison

Adapt the statistical comparison of Protat et al., 2010, to ACTRIS ground-based cloud radar network to validate CPRs Doppler velocity

- **CPR:** sample **all overpasses ± 100km** distance to the site
- **GROUND: zenith observations ± 1.5 h** around the overpass
- compare values only where
  - **Ze_{CPR}/Ze_{GROUND} > -15 dBZ**
  - **3.5km and higher from the ground**
- use CPR **baseline BA and BB data**
- **CPR L2 is planned for the future**

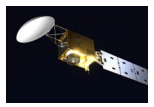


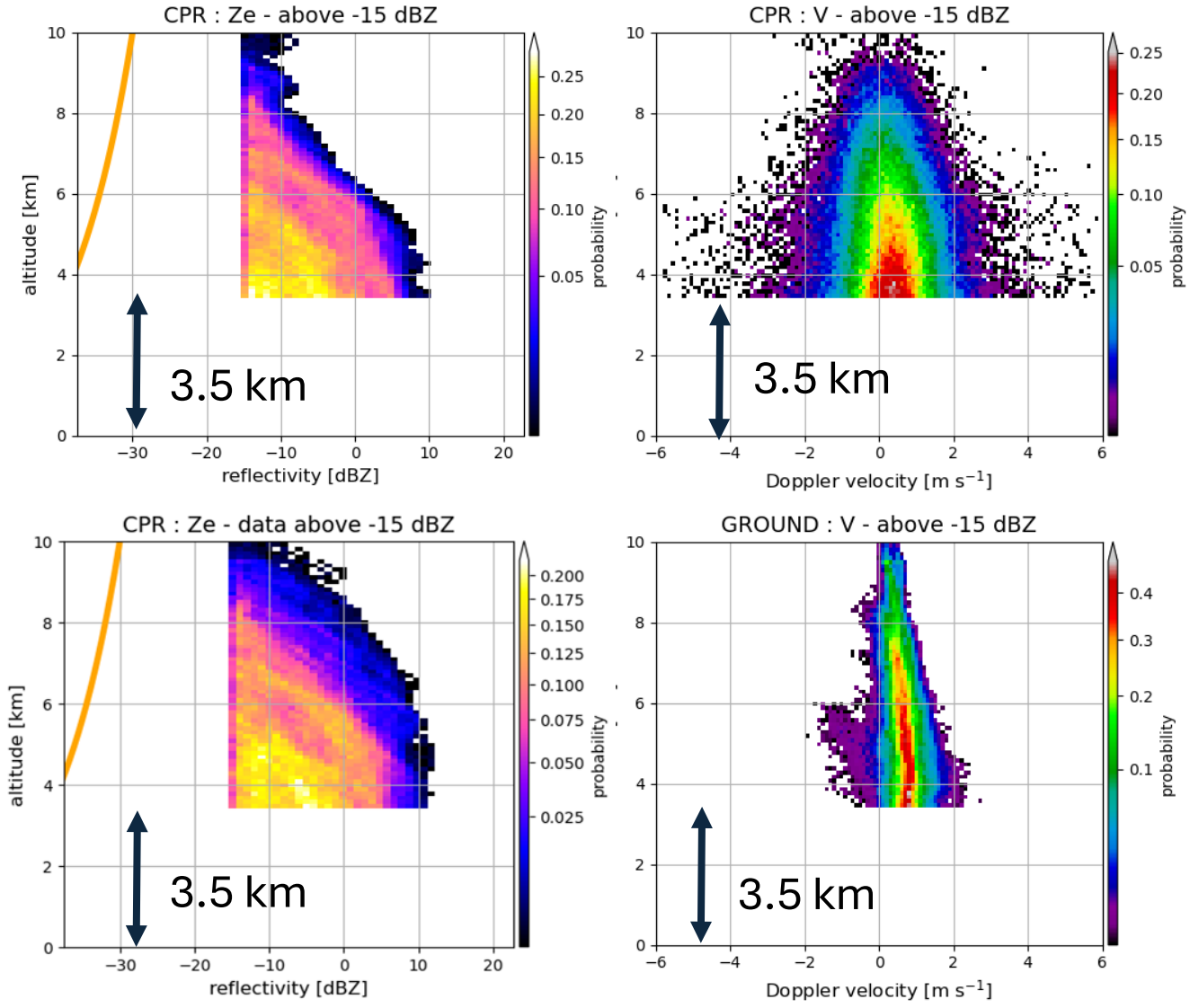
Mean of GROUND and CPR data set > estimate the mean bias



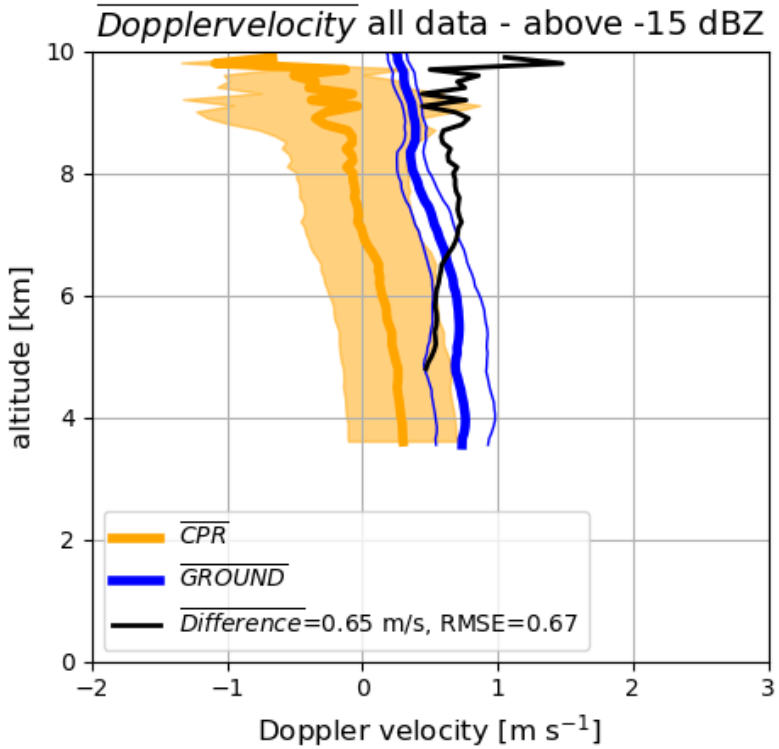
Example Doppler velocity val – NyÅlesund – BL BA

All overpass from baseline BA, NyÅlesund ~ 60 overpasses





- Applying ground - based radar SNR to filter CPR
- Better Doppler velocity data
  - Vm only above -15 dBZ
  - Site - dependent height clipping
- Mean profiles of overpass vs ground



Results: Doppler velocity Val 1st workshop

Site	Vm bias (BA)	Vm bias (BB)	Vm bias (CA, 2025)	Vm bias (CA, all)
Ny Ålesund	0.65 ms^{-1}	ms^{-1}	0.14 ms^{-1}	0.17 ms^{-1}
Hyytiälä	0.40 ms^{-1}	0.25 ms^{-1}	0.16 ms^{-1}	0.26 ms^{-1}
Lindenberg	0.59 ms^{-1}	0.43 ms^{-1}	0.06 ms^{-1}	- 0.21 ms^{-1}
Cabauw	0.65 ms^{-1}	0.33 ms^{-1}	0.48 ms^{-1}	0.42 ms^{-1}
Jülich	0.29 ms^{-1}	No enough data	0. 27 ms^{-1}	0.26 ms^{-1}
Palaiseau	0.53 ms^{-1}	0.47 ms^{-1}	- 0.05 ms^{-1}	0.28 ms^{-1}
Munich			0.19 ms^{-1}	0.44 ms^{-1}
Galati	0.49 ms^{-1}	0.34 ms^{-1}	-0.24 ms^{-1}	-0.09 ms^{-1}
Bucharest	0.71 ms^{-1}	0.46 ms^{-1}	0.08 ms^{-1}	0.08 ms^{-1}
Potenza			0.16 ms^{-1}	0.32 ms^{-1}
Granada	0.44 ms^{-1}	ms^{-1}	- 0.34 ms^{-1}	0.01 ms^{-1}
Mindelo	No enough data	No enough data	No enough data	No enough data
Neumayer	0.18 ms^{-1}	0.42 ms^{-1}	0.39 ms^{-1}	- 0.31 ms^{-1}

North

Number of overpasses

- Work in progress
- Used L1 data:
  - NUBF not corrected
  - Doppler velocity unfolded
- Tendency of the L1 data is:
  - Overestimation of ground-based Doppler velocity
  - Longer temporal averaging reduces bias

→ Variation of the Doppler in time?

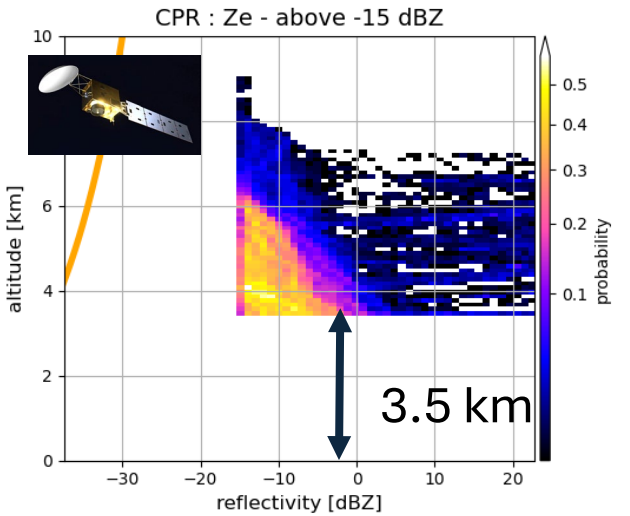
- Other Doppler velocity validation results to compare are missing.

north hemisphere
issues in CPR L1 data
Hyytiälä example next slide
Mindelo example next slide
Neumayer example next slide

Issues CPR L1 and limitation of the current method:

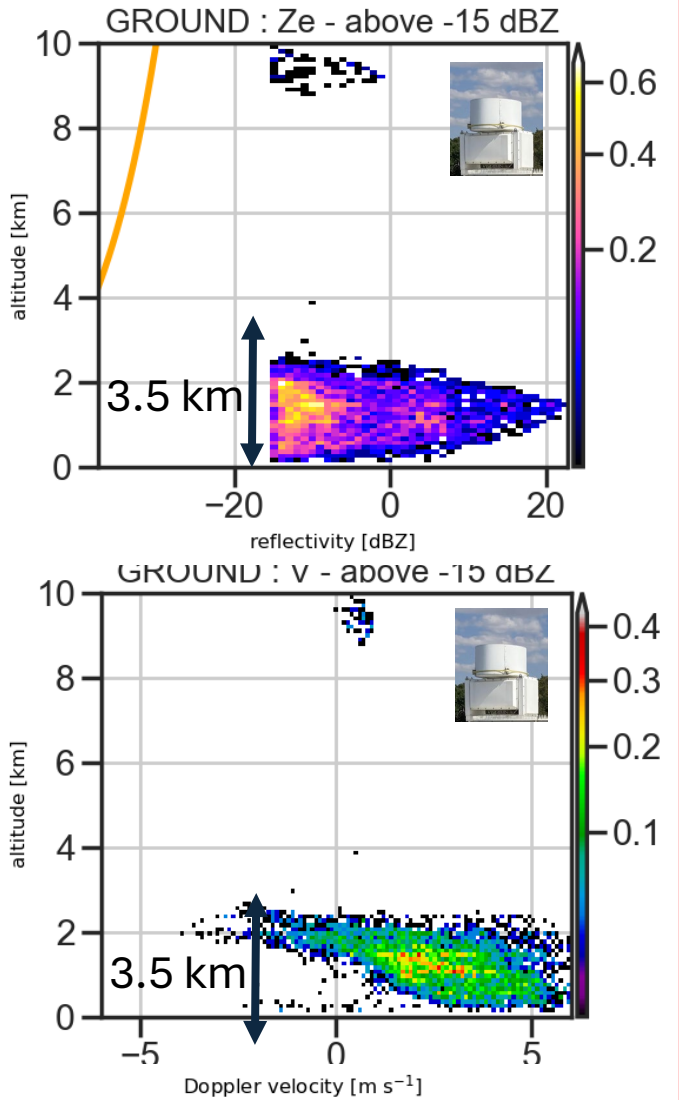
artifacts over antarctica

Nenmayer, BL BA



Data are near ground → filtering
Data are below -15 dBZ → cirrus removed

Mindelo, CA 07-2024 – 02-2025



Some artifacts in the L1 data → disturb the statistics?

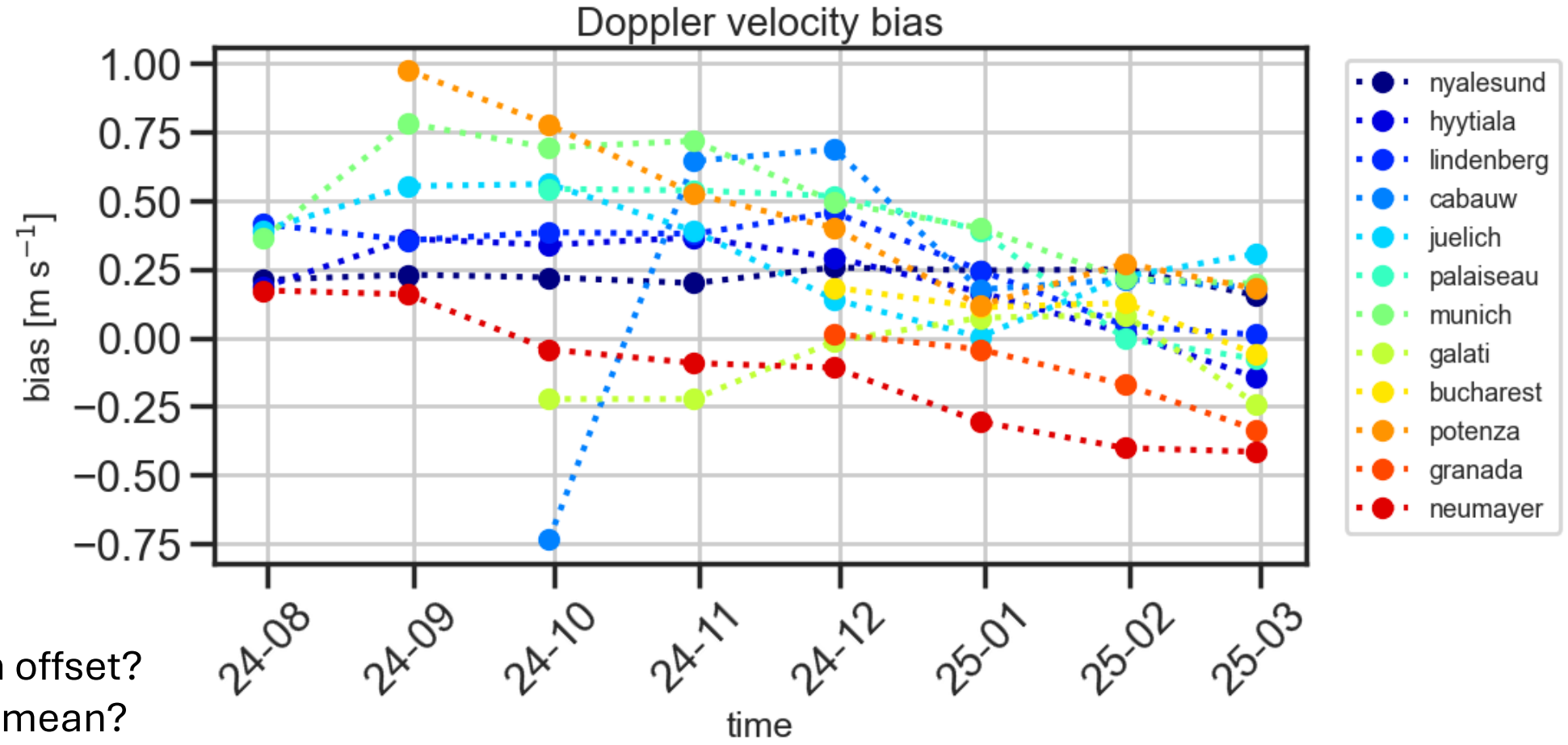
Not enough data to compare

Example: 3 Month moving average for Doppler val.

Make use of the reprocessed BL CA L1 data set

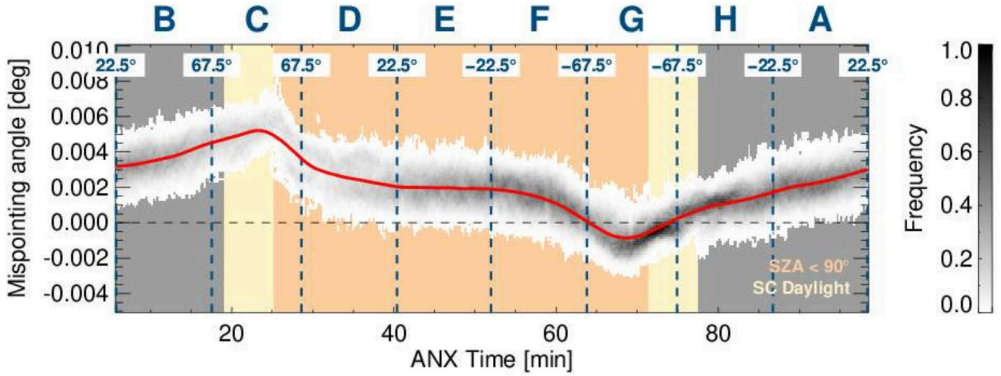
- Calculate Vm bias as 3 - month running mean
- Analyse the ACTRIS sites
- Analysing trends in the temporal evolution of the Vm bias

→ A trend towards negative values



- How stable is the Vm offset?
- What does the trend mean?
- Connection to the antenna pointing of the CPR?

Results: Doppler velocity 3 Month average



Satellite line-of-sight velocity contamination

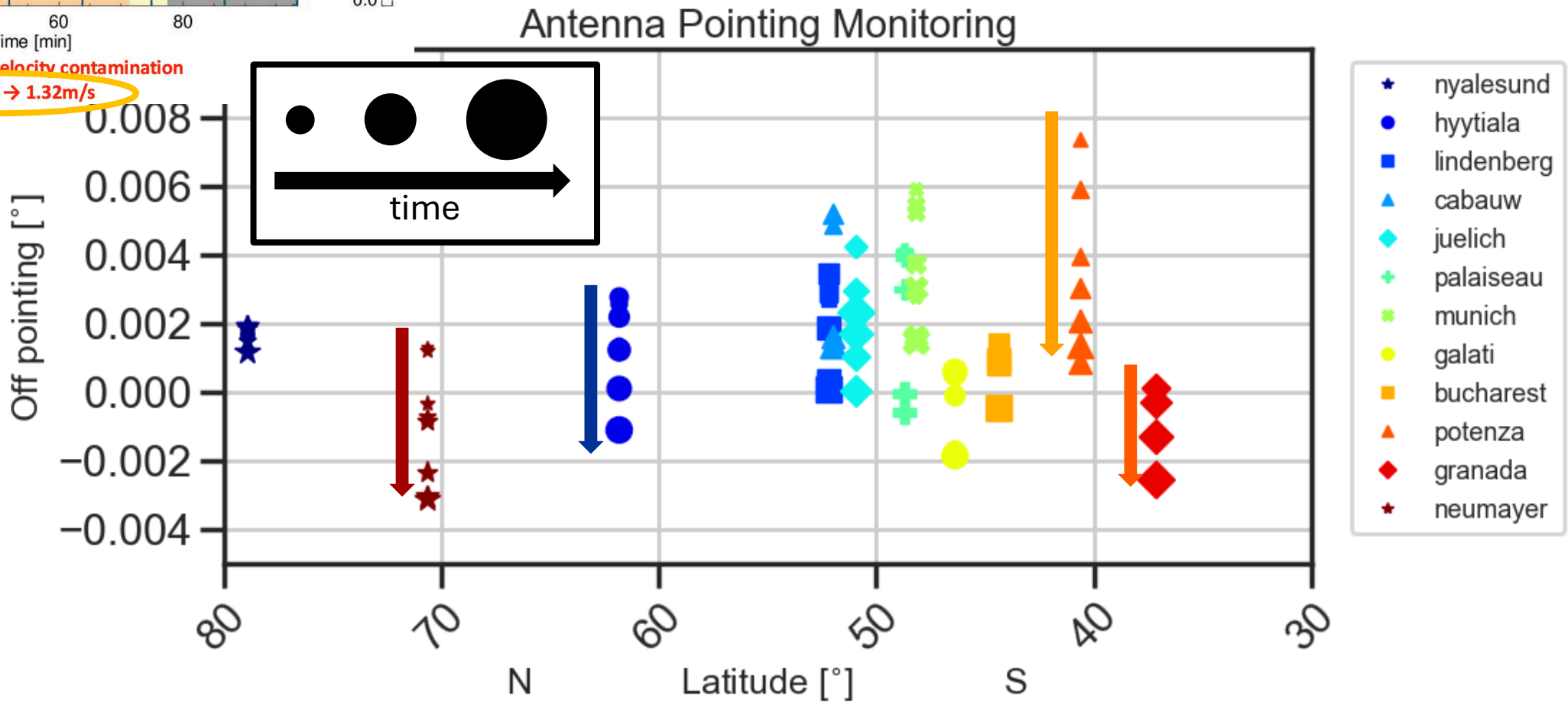
0.01º(7.6km/s) → 1.32m/s

- How stable is the Vm offset?
- What does the trend mean?
- **Connection to the antenna pointing of the CPR?**

Calculate antenna pointing using

→The trend in the antenna pointing is visible at some sites

!!! Hyytiälä has lots of artifacts in CPR L1 data



Results: Doppler velocity Val 1st workshop

North

Number of overpasses

a	Vm bias (BA)	Vm bias (BB)	Vm bias (CA, 2025)	Vm bias (CA, all)
Ny Ålesund	0.65 ms^{-1}	ms^{-1}	0.14 ms^{-1}	0.17 ms^{-1}
Hyytiälä	0.40 ms^{-1}	0.25 ms^{-1}	0.16 ms^{-1}	0.26 ms^{-1}
Lindenberg	0.59 ms^{-1}	0.43 ms^{-1}	0.06 ms^{-1}	- 0.21 ms^{-1}
Cabauw	0.65 ms^{-1}	0.33 ms^{-1}	0.48 ms^{-1}	0.42 ms^{-1}
Jülich	0.29 ms^{-1}	No enough data	0. 27 ms^{-1}	0.26 ms^{-1}
Palaiseau	0.53 ms^{-1}	0.47 ms^{-1}	- 0.05 ms^{-1}	0.28 ms^{-1}
Munich			0.19 ms^{-1}	0.44 ms^{-1}
Galati	0.49 ms^{-1}	0.34 ms^{-1}	- 0.24 ms^{-1}	- 0.09 ms^{-1}
Bucharest	0.71 ms^{-1}	0.46 ms^{-1}	0.08 ms^{-1}	0.08 ms^{-1}
Potenza			0.16 ms^{-1}	0.32 ms^{-1}
Granada	0.44 ms^{-1}	ms^{-1}	- 0.34 ms^{-1}	0.01 ms^{-1}
Mindelo	No enough data for method used → adjust current approach for such sites			
Neumayer	0.18 ms^{-1}	0.42 ms^{-1}	0.39 ms^{-1}	- 0.31 ms^{-1}

Work in progress! Next steps:

- Validate L2a CPR data against ground-based radar data
- Compare our method with other Doppler velocity validation results
- Monitor the ground-based radar pointing

Questions:

- What can we lead from temporal variation of the Doppler velocity offsets in L1?
- Monitoring of the CPR antenna pointing?

More CPR discussion ? → Poster #13

north hemisphere
issues in CPR L1 data → slide 6
Hyytiälä example → slide 6
Mindelo example → slide 6
Neumayer example → slide 6


JAXA
esa