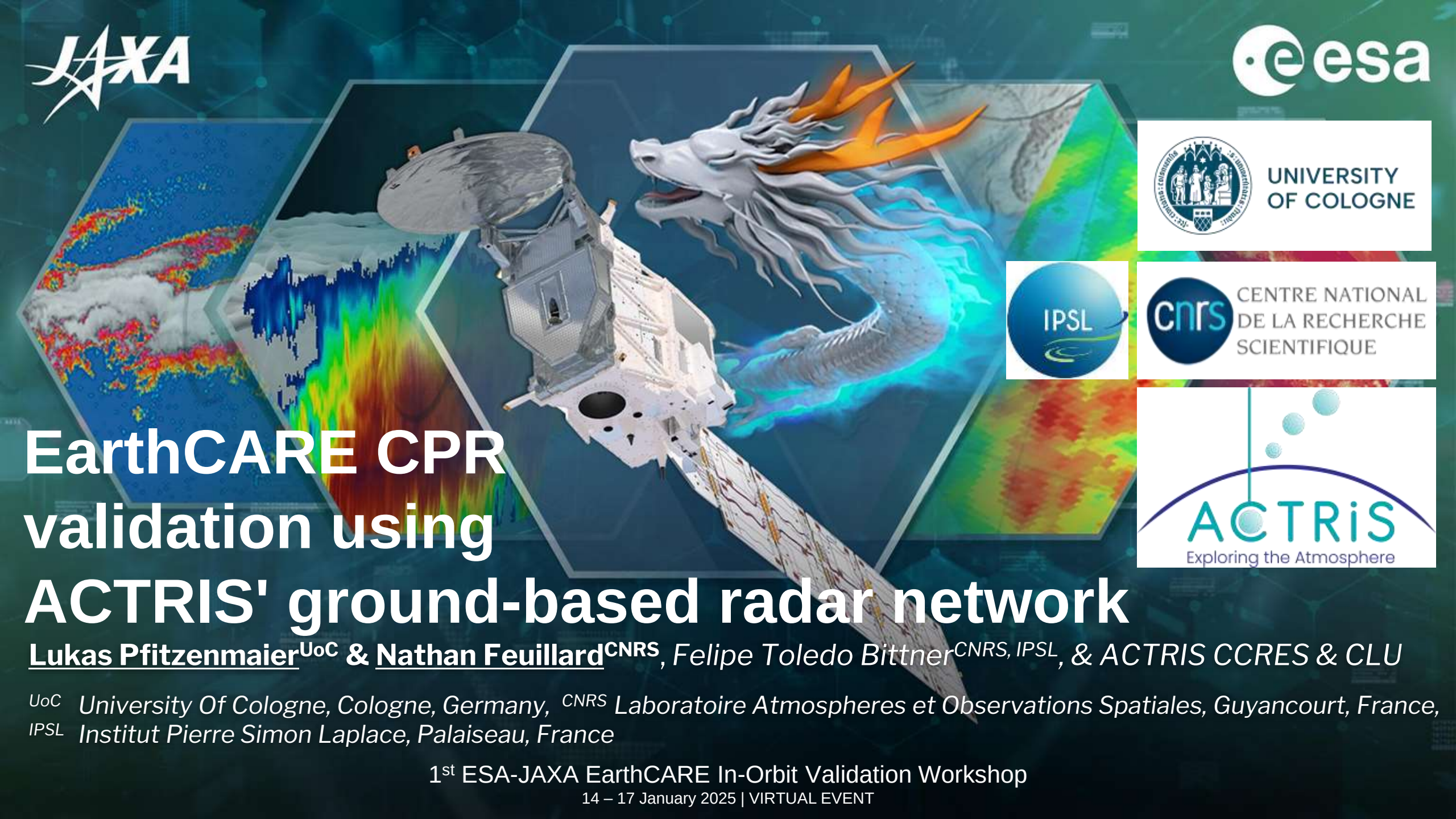

EarthCARE CPR validation using ACTRIS' ground-based radar network

Lukas Pfitzenmaier[UoC] **& Nathan Feuillard**[CNRS], *Felipe Toledo Bittner*[CNRS, IPSL], *& ACTRIS CCRES & CLU*

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[IPSL] *Institut Pierre Simon Laplace, Palaiseau, France*

1st ESA-JAXA EarthCARE In-Orbit Validation Workshop
14 – 17 January 2025 | VIRTUAL EVENT

ACTRIS network of cloud remote sensing sites

Legend

Doppler Cloud Radar

Micro wave radiometer

Ceilometer

Doppler lidar

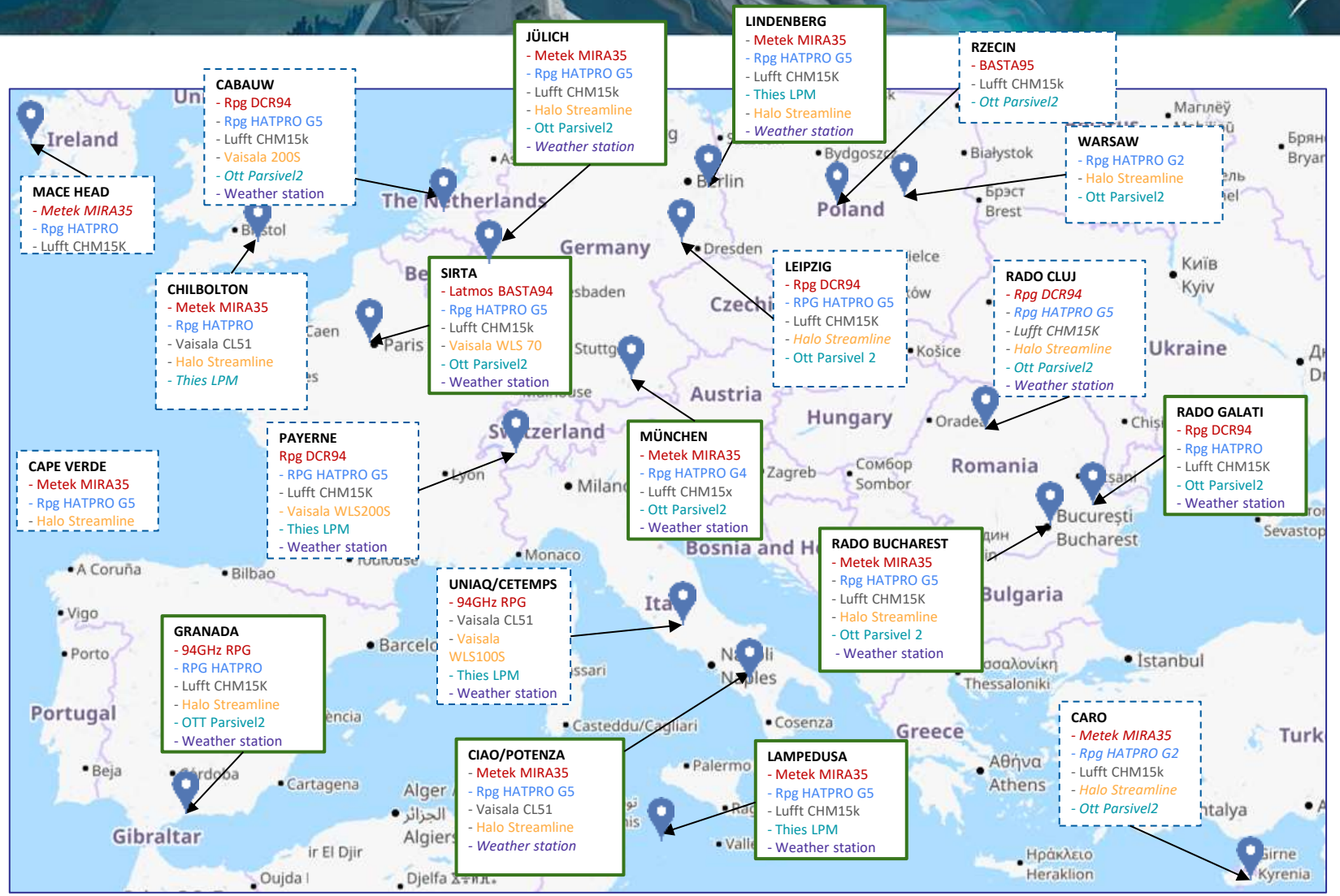
Disdrometers

Weather stations

In Progress/Operational

accepted for labelling step 1A

In progress for labelling step 1a



SWEDEN

NORUNDA
- Rpg DCR94
- Vaisala CL51
- Ott Parsivel2

FINLAND

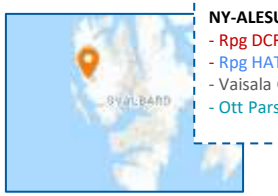
PALLAS
- Rpg DCR94
- Vaisala CL61
- Halo Streamline
- Weather station

HYYTIÄLÄ
- Rpg DCR94
- Rpg HATPRO
- Vaisala CL61
- Halo Streamline
- Ott Parsivel2
- Weather station

LA REUNION

OPAR
- BASTA
- Rpg HATPRO G5
- Campbell
- ?
- Ott Parsivel2
- Weather station

NORWAY



NY-ALESUND
- Rpg DCR94
- Rpg HATPRO G2
- Vaisala CL51
- Ott Parsivel2

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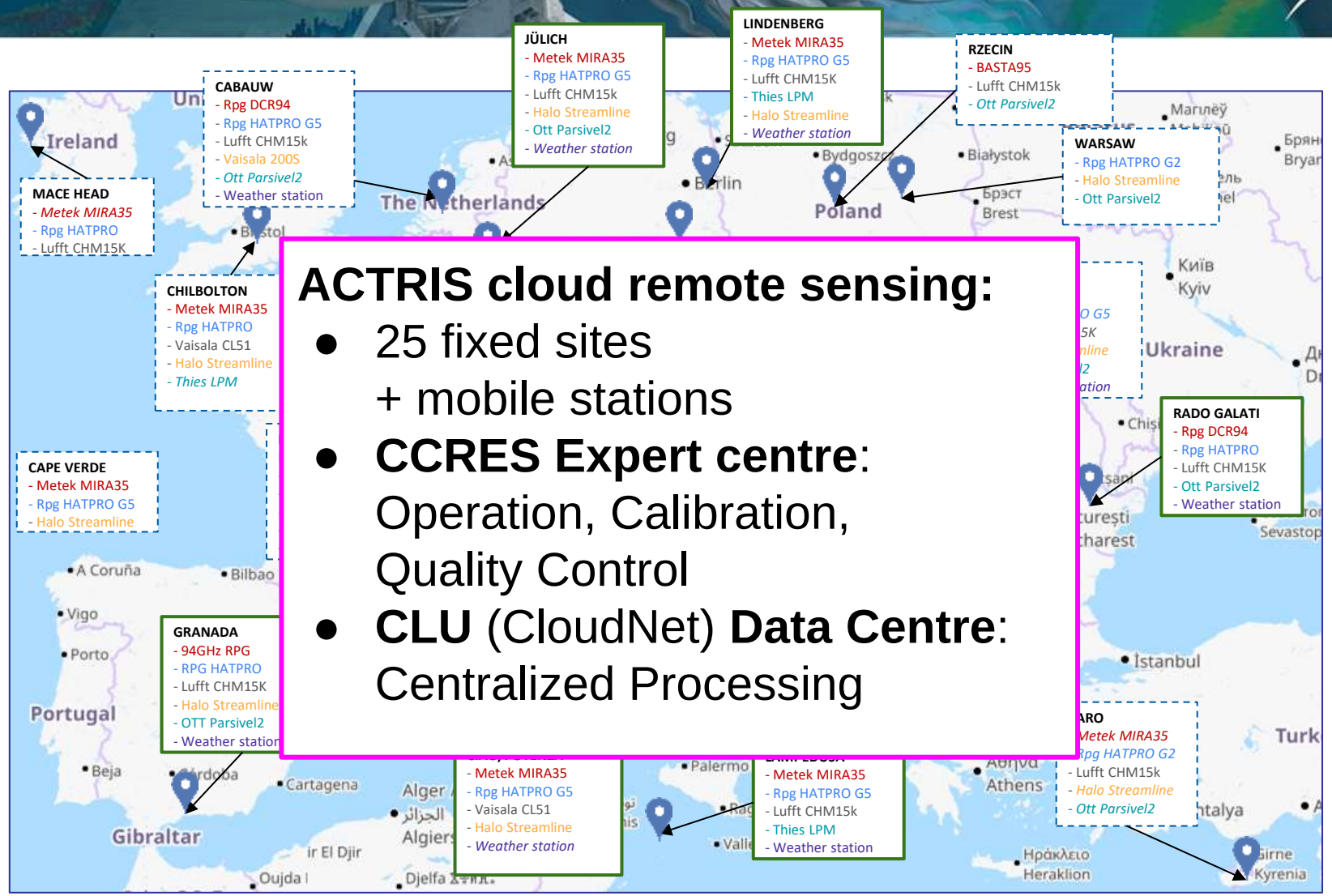

ACTRIS cloud remote sensing:

- 25 fixed sites + mobile stations
- **CCRES Expert centre**: Operation, Calibration, Quality Control
- **CLU** (CloudNet) **Data Centre**: Centralized Processing

SWEDEN

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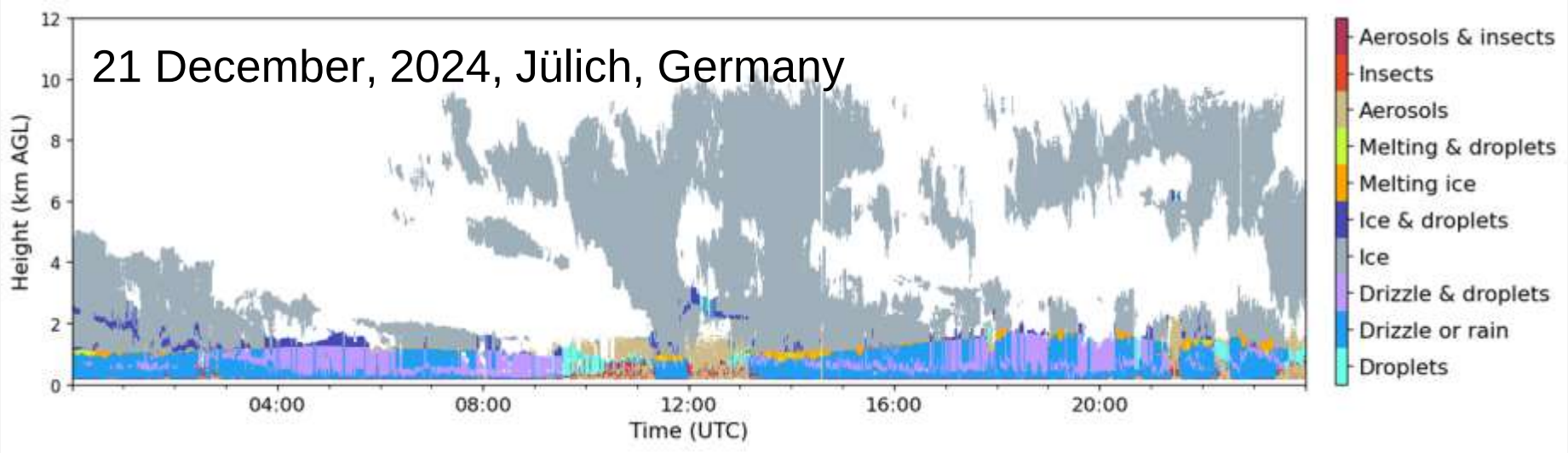
ACTRIS data quality control and products

ACTRIS cloud remote sensing network

- has good geographical coverage
- automated data quality controlled and centrally processed
- cloud radar calibration using reference radar & stability monitoring using disdrometer drop size distributions
- cloud radar + microwave radiometer + backscatter lidar

➔ cloud target classification - “Cal/Val of L2 data ready”



Data are available at: cloudnet.fmi.fi

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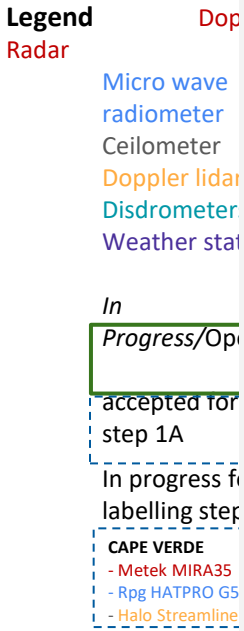
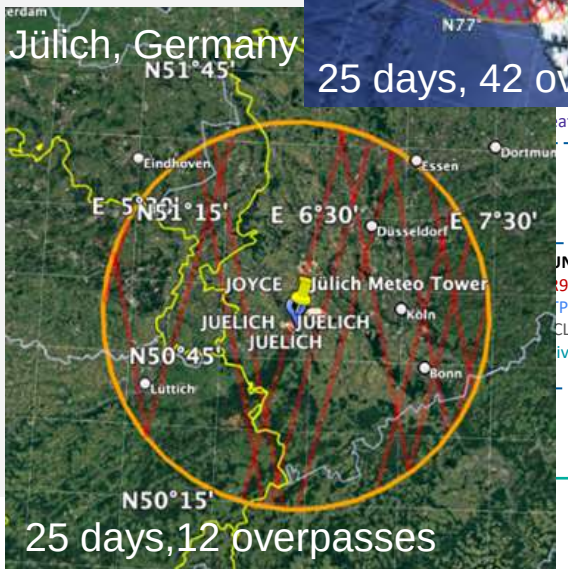


Cal/Val of ACTRIS sites: statistical comparison

- **method:** Protat et al., 2009 **& modified method**
- sample **all overpasses ± 200km** from the site
- **zenith observations ± 1h around the overpass**

\+ good geographical coverage, growing network

\+ homogeneous data sets and products

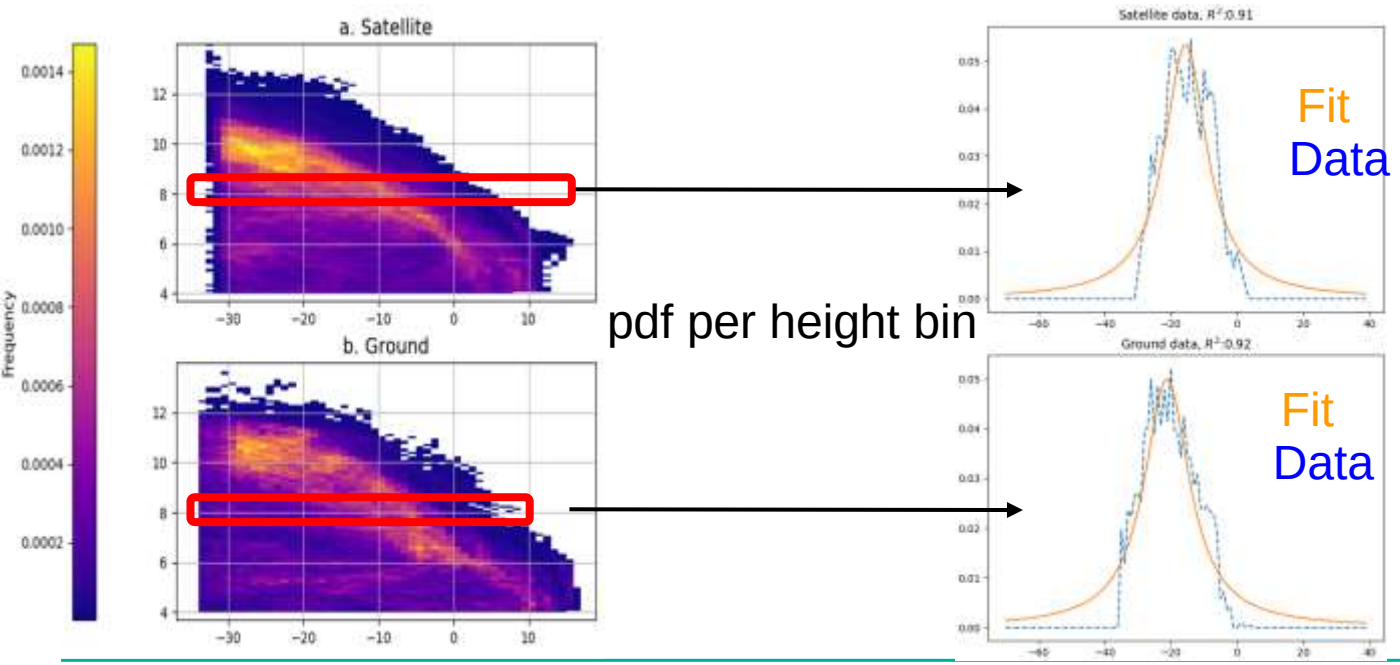


Reflectivity validation

Reflectivity Cal/Val - Method: statistical comparison

Period used for the comparisons: 08-2024/11-2024 ~ 3 months
Data used: BA and BB baselines, L1 data only.
Filter out liquid clouds because of attenuation of the ground radar
- CPR : filter out data below 1 km above the 0°C isotherm → waiting for L2 products
- GROUND : using the classification from CloudNet

Modified statistical method :



Fit with a Lorentzian model to sort data (threshold based)

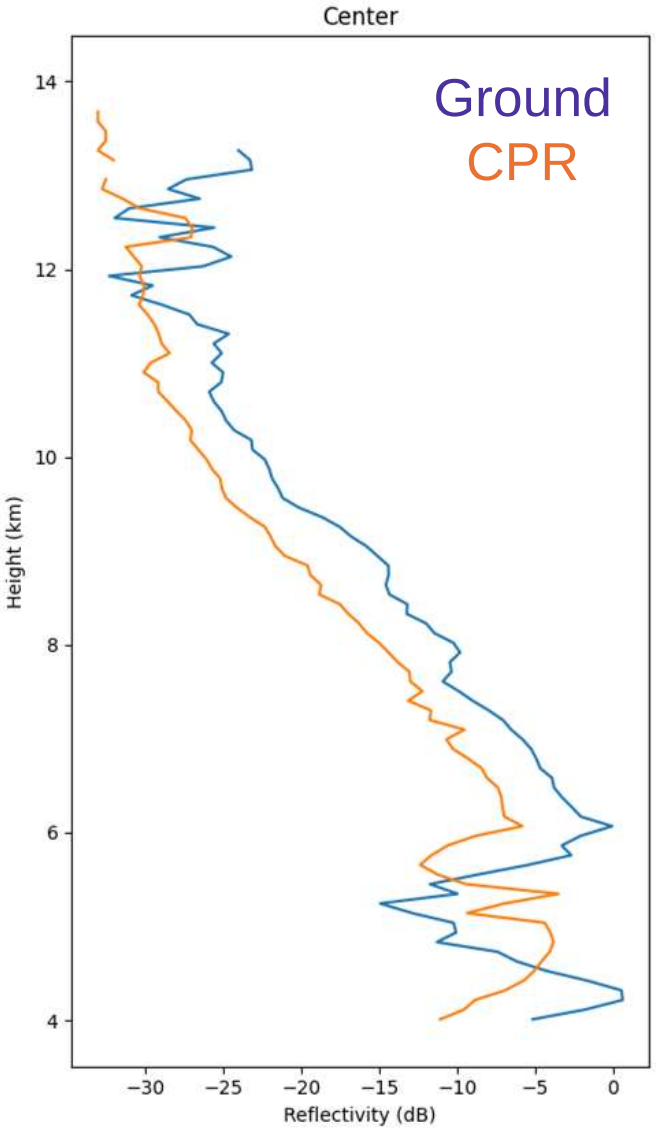
- If fit fulfill certain criteria data used for comparison
- Otherwise height bin filtered out

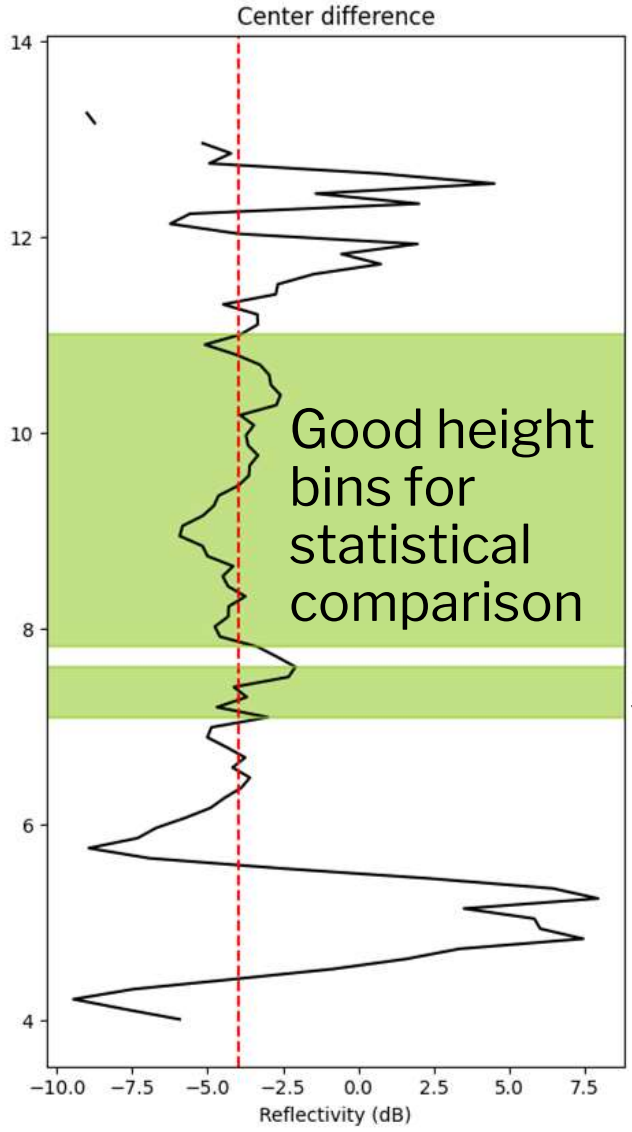
Lorentzian model criteria:

- Amplitude of the distribution
- Maximum of the distribution
- Width of the distribution
- R^2 of the fit

Reflectivity Cal/Val - Method: statistical comparison

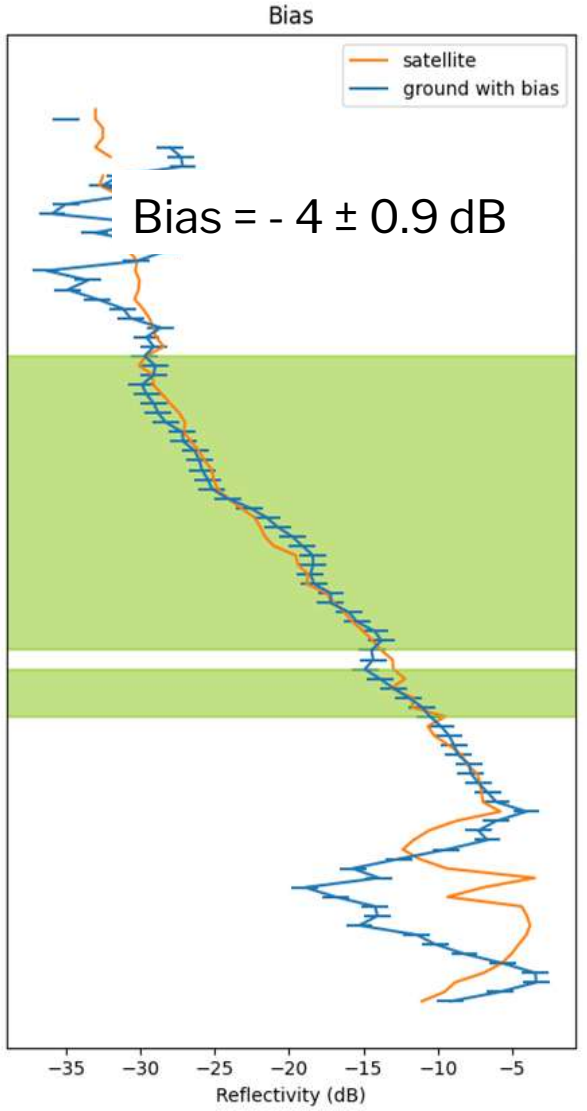
Site: Lindenberg



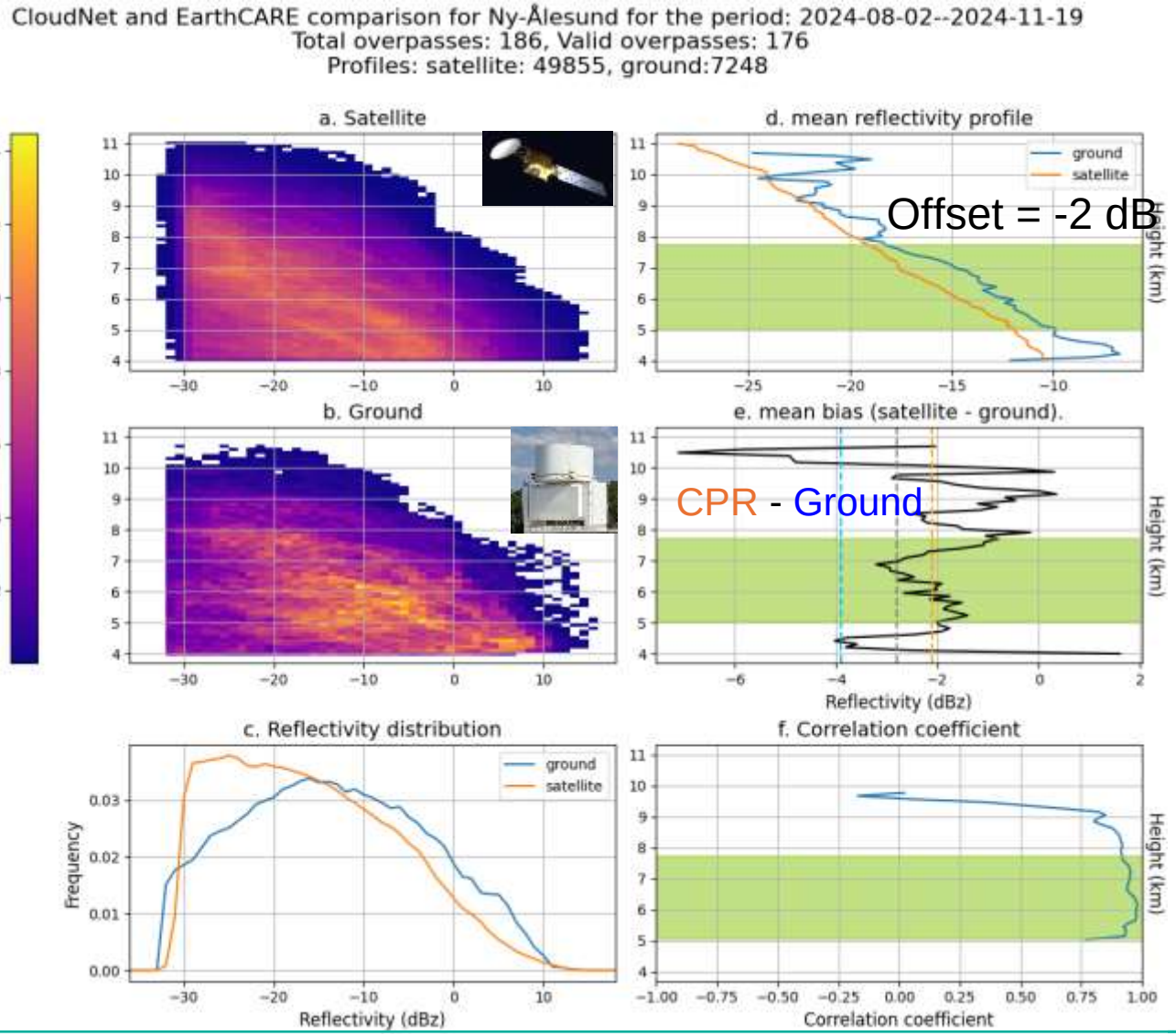


Bias = mean(centers differences)

Uncertainty = std(center differences)



Reflectivity Cal/Val - Result: Ny-Ålesund

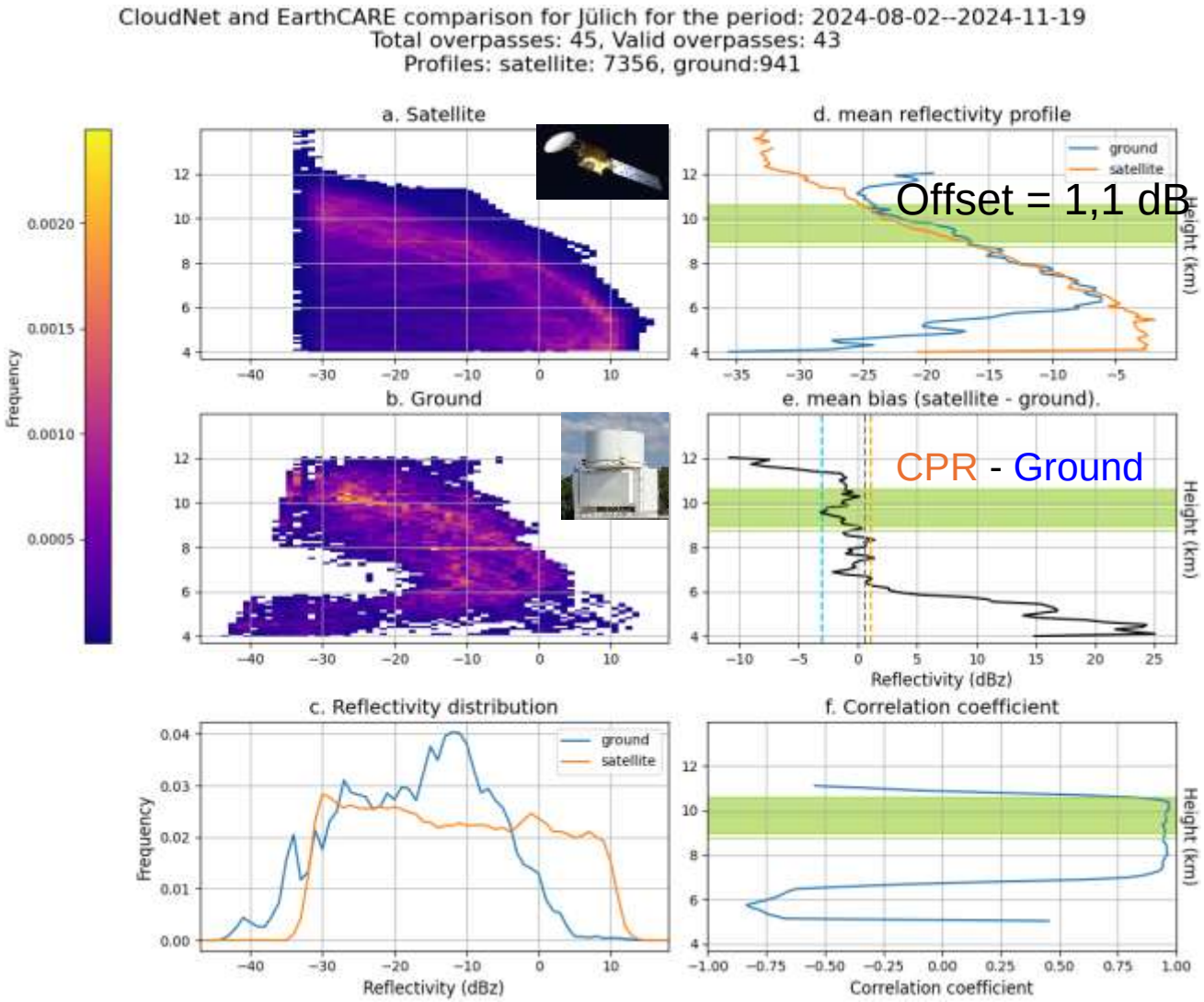


< Ny-Alesund site: most northern site.
(Site with the most overpasses)

In general we observe:

- Mean profiles and reflectivity distributions similarities.
- 3 months is enough data for comparisons for most sites → more data will only improve comparisons.
- The modified statistical method helps in assessing the goddess of the comparisons.

Reflectivity Cal/Val - Comparisons limitation



< Jülich site: mid latitude site.
(Site calibrated by ACTRIS)

Limitations come from:

- Liquid water events not well filtered for the satellite.
- Not enough overpasses.
- Too many rain events.
- No statistical similarities.

Reflectivity Cal/Val – Results overview ACTRIS

North

Number of overpasses

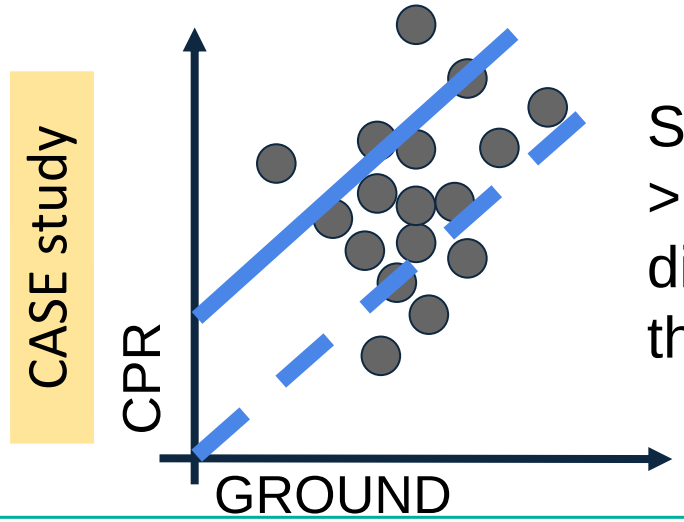
Site	Ze (Protat et al., 2009)	Ze (ACTRIS)	Comments Ze
NyAlesund	**-2**	**-3,9 ± 1,2**	Calibration monitored by ACTRIS
Hyytiälä	**x**	**x**	No ground echo: **mirroring ground echo**
Lindenberg	**0**	**-3 ± 1,2**	To be calibrated by ACTRIS (2025) & monitoring CloudSat to EarthCARE within 4.5 dBZ
Cabauw	**0,25**	**x**	No height bins selected for comparison
Jülich	**1,1**	**-3 ± 2**	Calibrated by ACTRIS (2024) + monitoring
Palaiseau	**1,1**	**-3 ± 1**	Calibrated by ACTRIS (2024) + monitoring CloudSat to EarthCARE within 4 dBZ
Munich	**-0,6**	**-1,6 ± 1,7**	
Galati	**-2,8**	**-4,6 ± 3,3**	Calibration monitored by ACTRIS
Bucharest	**4,7**	**4,3 ± 0,4**	Calibration monitored by ACTRIS
Potenza	**1,7**	**-4 ± 1,8**	Calibration monitored by ACTRIS
Granada	**5,9**	**x**	Calibration monitored by ACTRIS Low number of overpasses
Mindelo	**14,6**	**x**	Low number of overpasses

- Work in progress.
- CloudSat to EarthCARE within expected range for test sites.
- Similar offset for sites calibrated by ACTRIS.
- Few sites with low number of overpasses.
- Expect improvements using L2 CPR data.

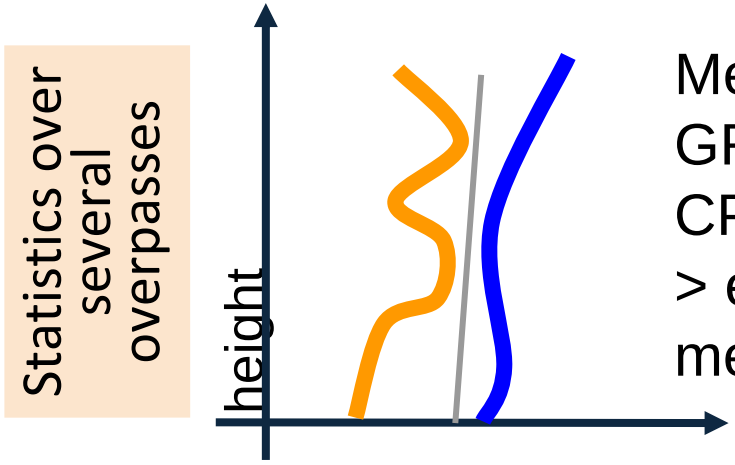
Doppler velocity validation

Doppler velocity Cal/Val – Method: statistical comparison

- **CPR:** sample **all overpasses ± 100km** distance to the site
- **GROUND: zenith observations ± 1h** around the overpass
- compare only where
  - **Ze_{CPR}/Ze_{GROUND} > -15 dBZ**
  - **3.5km and higher from ground**
- use CPR **baseline BA and BB data**
- **CPR L2 is planned in the future**



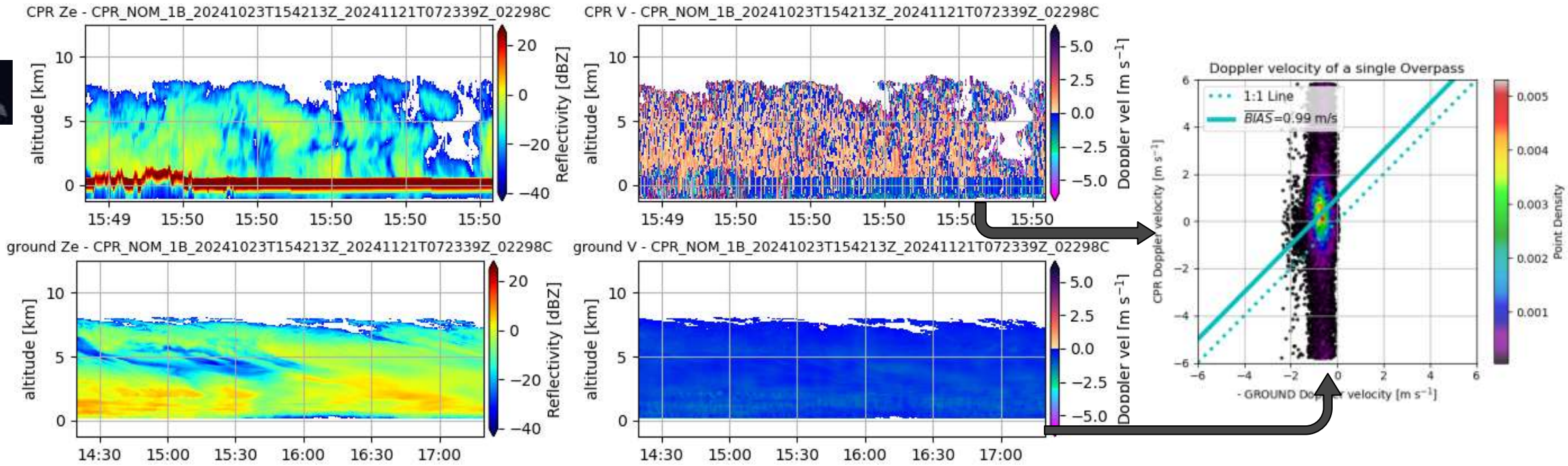
Scatterplot:
> estimate the difference to the 1:1 line



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

Doppler velocity Cal/Val - Single overpass Ny Ålesund

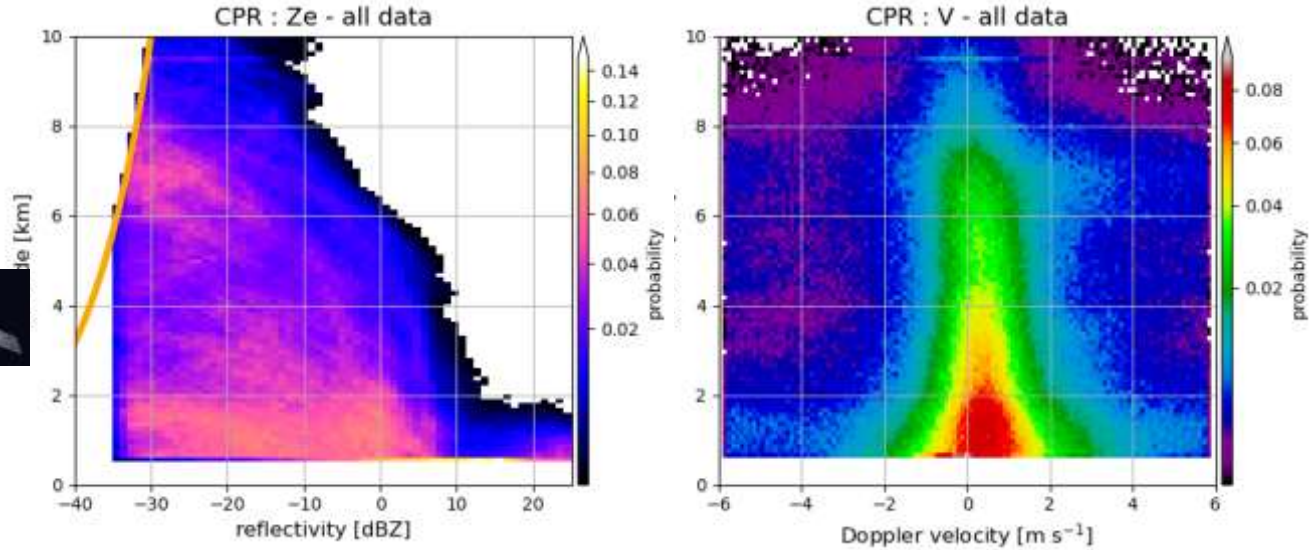
CASE study: Single overpass, 23 Oct 2024 Ny Ålesund, baseline, BA

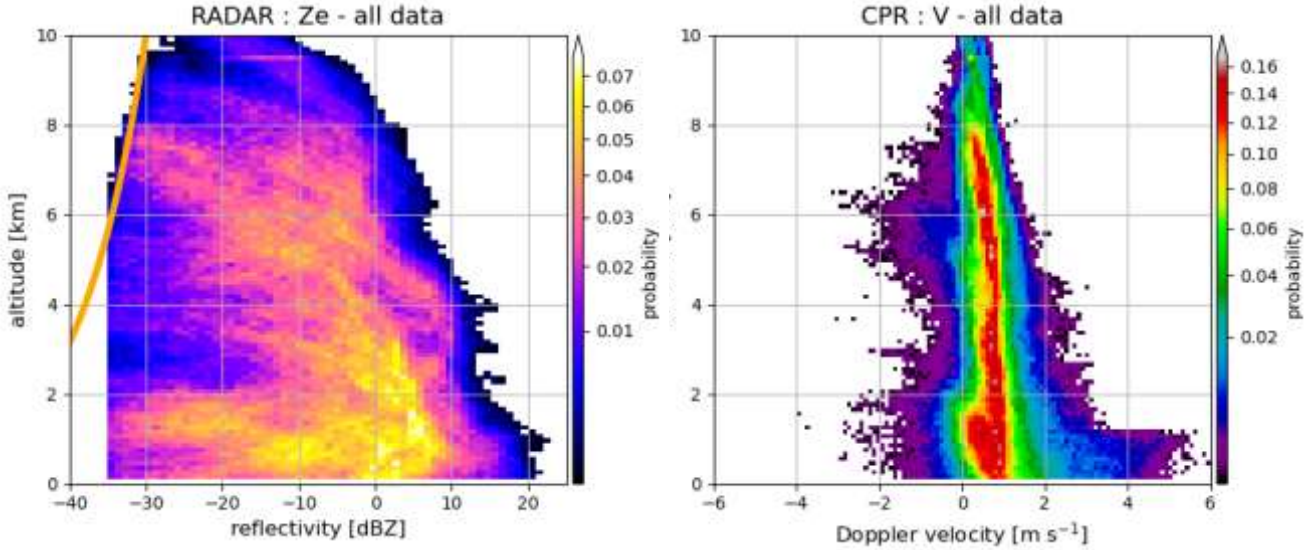


- Some ‘golden’ cases can be used for validation
- CPR antenna problems in the data → different values for different cases
- Data filtering: high vm noise for Ze > -15 dBZ
- → filtering improves results
- → Make statistics over several overpasses for a site

Doppler velocity Cal/Val - Results whole data set

All overpass from baseline BA, NyÅlesund ~ 60 overpasses

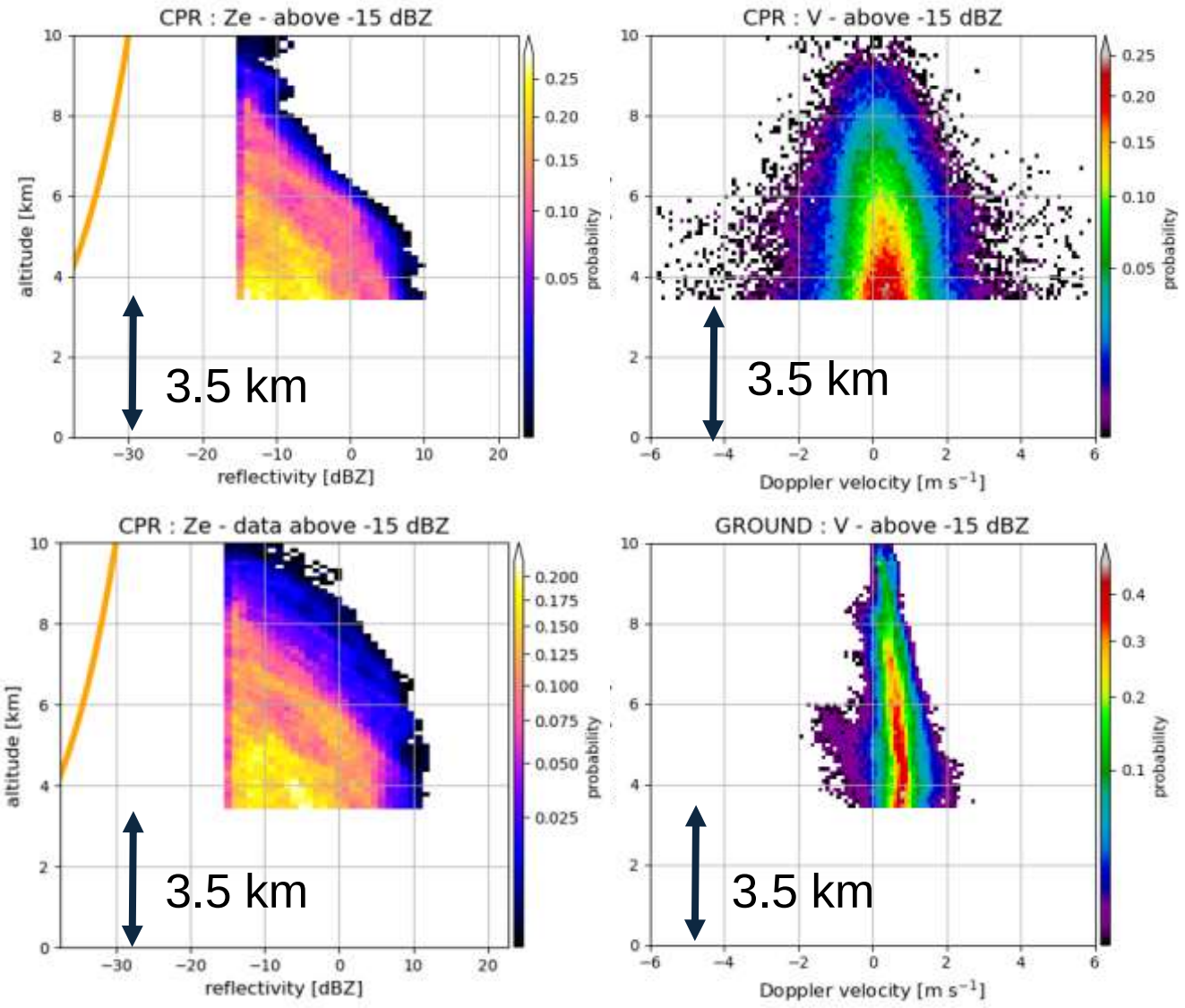




- Applying ground based radar SNR to filtzer CPR

Doppler velocity Cal/Val - Results whole data set

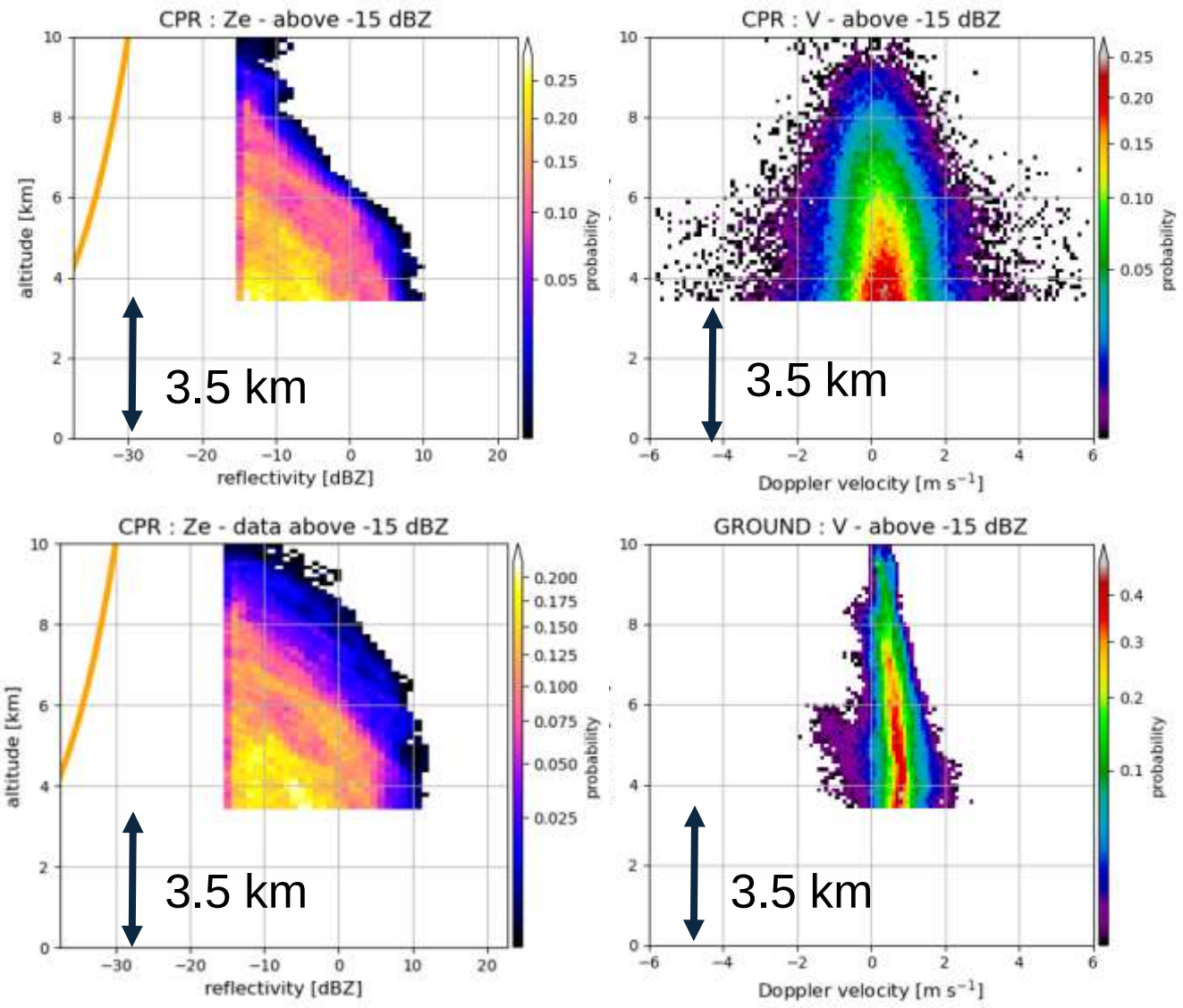
All overpass from baseline BA, NyÅlesund ~ 60 overpasses



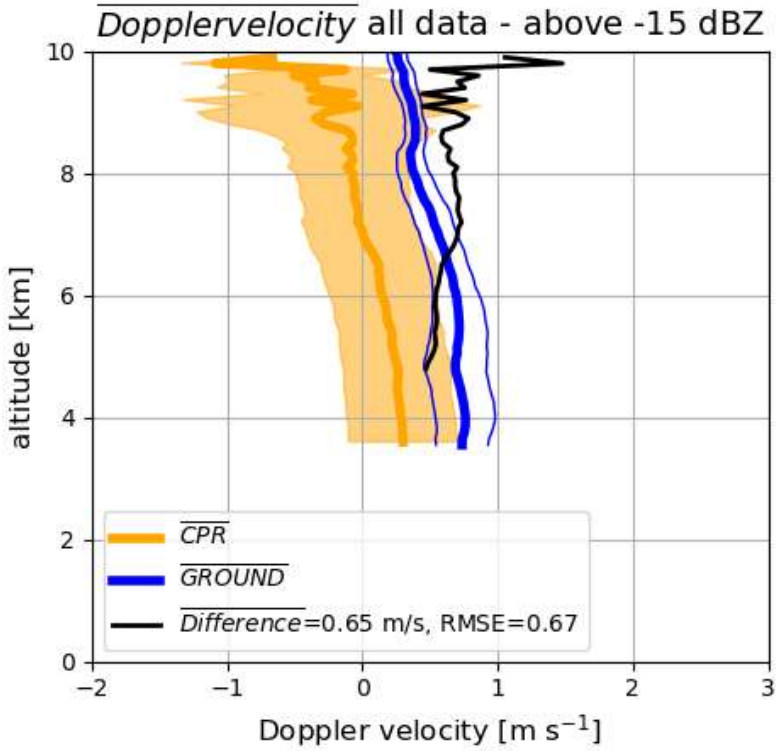
- Applying ground based radar SNR to filtzer CPR
- Better Doppler velocity data
  - Vm only above -15 dBZ
  - Site dependent height clipping
    - Suppress the influence of folding in data set

Doppler velocity Cal/Val - Results whole data set

All overpass from baseline BA, NyÅlesund ~ 60 overpasses



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



Doppler velocity Cal/Val - Results overview ACTRIS

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) BB not enough data
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 is missing

Overview results and conclusion:

Site	Ze (Protat 2009)	Ze (ACTRIS)	Vm (BA)	Vm (BB)	Comments Vm
Ny Ålesund	-2	-3,9 ± 1,2	0.65 ms^{-1}	no ground	Calibration monitored by ACTRIS
Hyytiälä			0.48 ms^{-1}	0.25 ms^{-1}	mirroring ground echo in the data
Lindenberg	0	-3 ± 1,2	0.59 ms^{-1}	0.43 ms^{-1}	To be calibrated by ACTRIS (2025) & monitoring CloudSat to EarthCARE within 4.5 dBZ
Cabauw	0,25		0.65 ms^{-1}	0.33 ms^{-1}	No height bins selected for comparison
Jülich	1,1	-3 ± 2	0.49 ms^{-1}	To low data	Calibrated by ACTRIS (2024) + monitoring
Palaiseau	1,1	-2,3 ± 1,8	0.53 ms^{-1}	0.47 ms^{-1}	Calibrated by ACTRIS (2024) + monitoring CloudSat to EarthCARE within 4 dBZ
Munich	-0,6	-1,6 ± 1,7			
Galati	-2,8	-4,6 ± 3,3	0.56 ms^{-1}	0.34 ms^{-1}	Calibration monitored by ACTRIS
Bucharest	4,7	4,3 ± 0,4	0.78 ms^{-1}	0.46 ms^{-1}	Calibration monitored by ACTRIS
Potenza	1,7	-4 ± 1,8			Calibration monitored by ACTRIS
Granada	5,9		0.75 ms^{-1}	To low data	Calibration monitored by ACTRIS Low number of overpasses
Mindelo	14,6				Low number of overpasses
Neymayer			0.18 ms^{-1}	0.46 ms^{-1}	

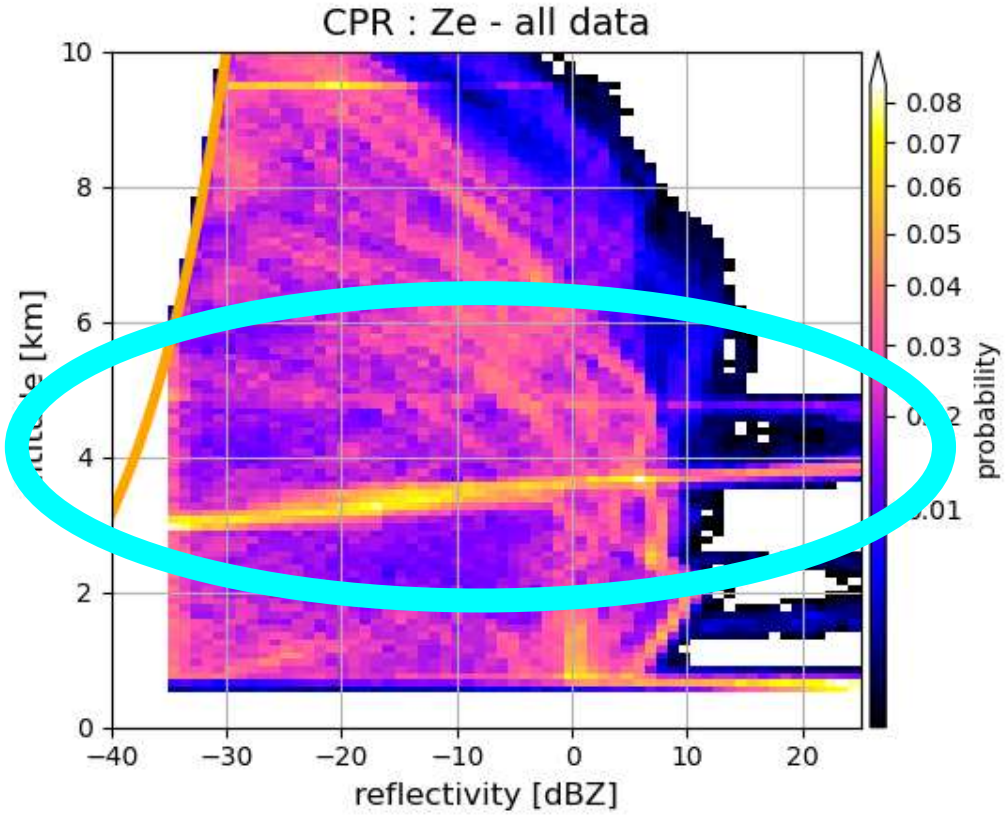
North

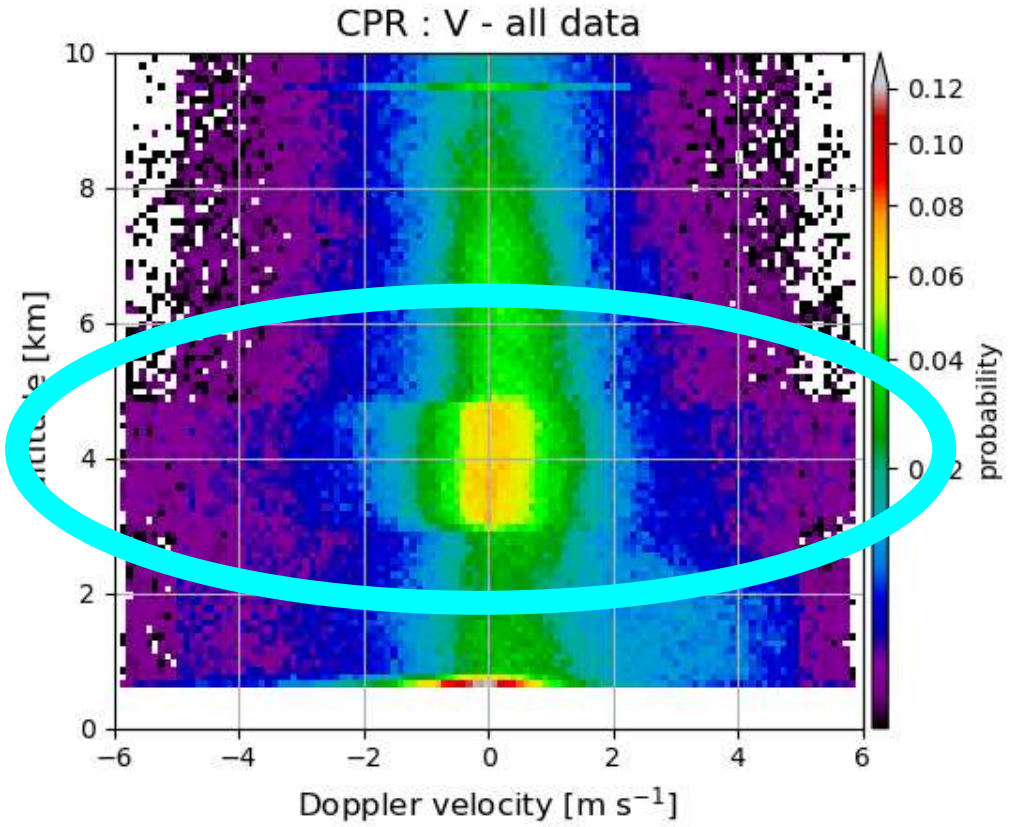
Number of overpasses

1st

- Limitations when low number of overpasses.
- Expect improvement using L2 CPR data.
- Reflectivity comparison CloudSat to EarthCARE within expected range
- More comparison time is needed to consolidate the results.
- Similar approaches for L2 products.
- Doppler velocity comparison ongoing - looks promising
- Implementation at CLU planned - make it operational

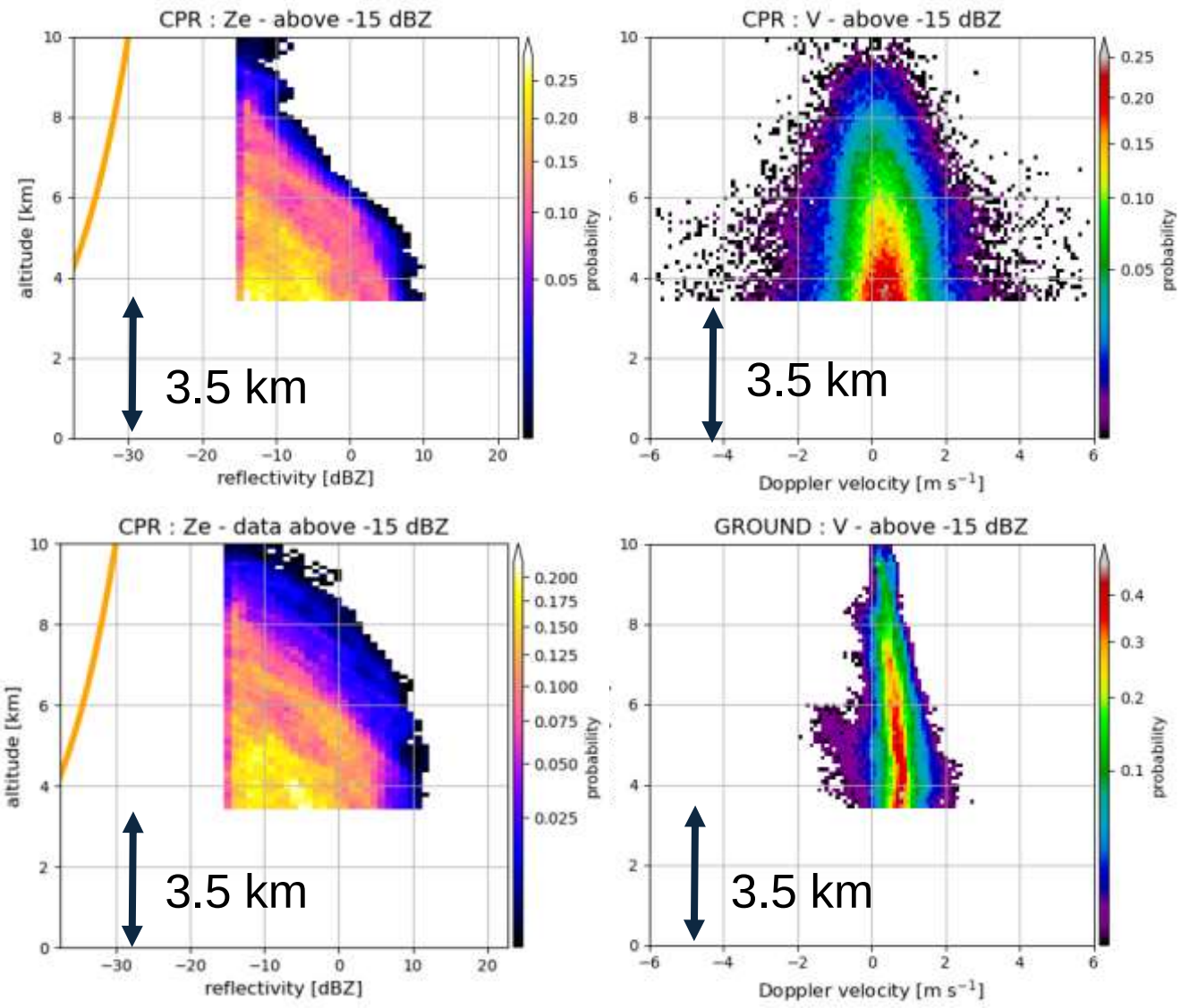
Hyytiälä - ground echo in baseline BA





Doppler velocity Cal/Val - Results whole data set

All overpass from baseline BA, NyÅlesund ~ 60 overpasses



- Applying ground based radar SNR to filtzer CPR
- Better Doppler velocity data
  - Vm only above -15 dBZ
  - Site dependent height clipping
- Scatterplot of data - bias calculation