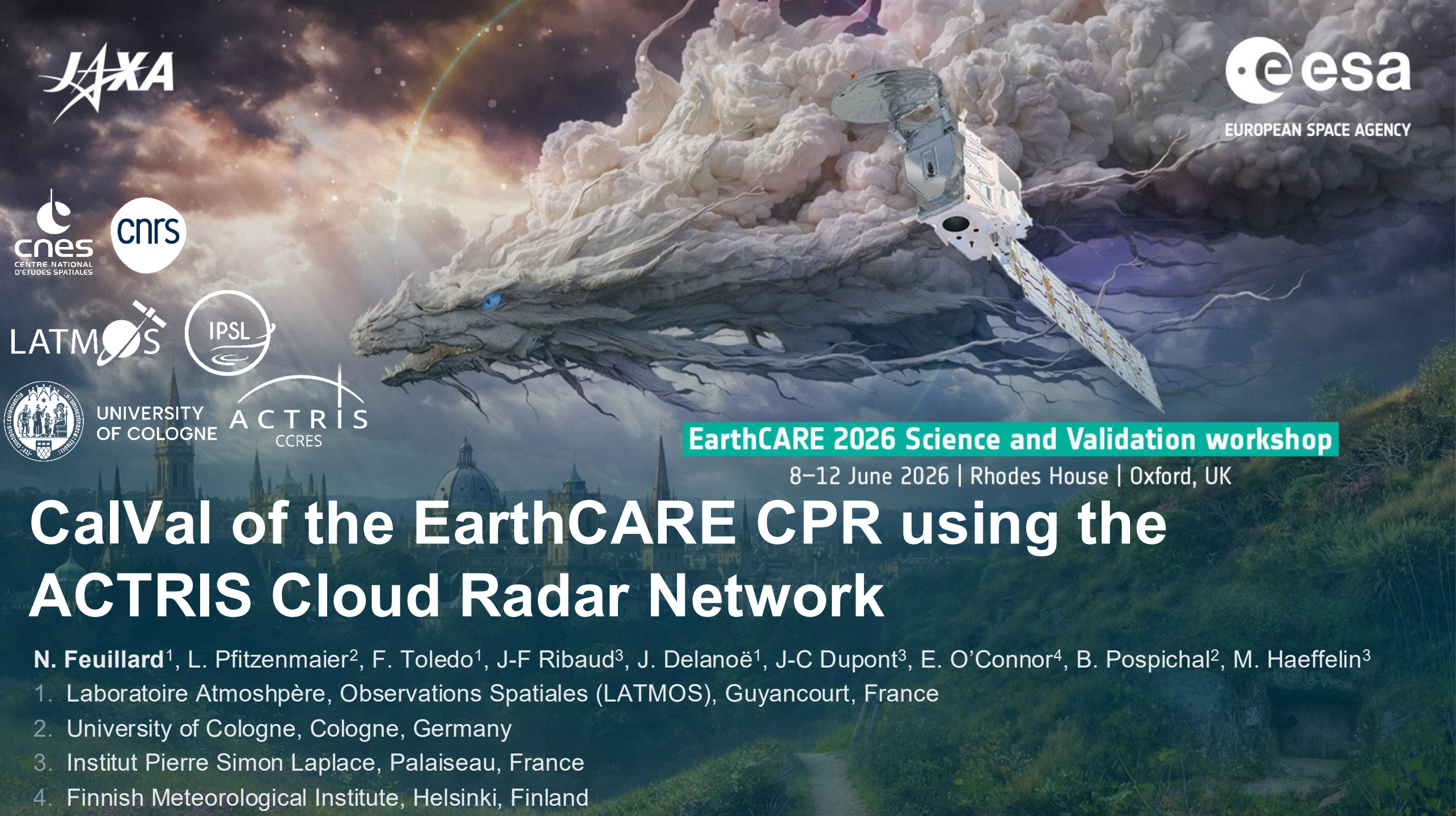


EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK

CalVal of the EarthCARE CPR using the ACTRIS Cloud Radar Network

N. Feuillard[1], L. Pfitzenmaier[2], F. Toledo[1], J-F Ribaud[3], J. Delanoë[1], J-C Dupont[3], E. O'Connor[4], B. Pospichal[2], M. Haeffelin[3]

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

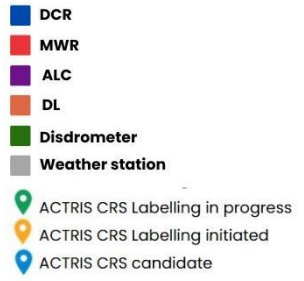
ACTRIS Cloud Radar Network

Advantages of the ACTRIS network:

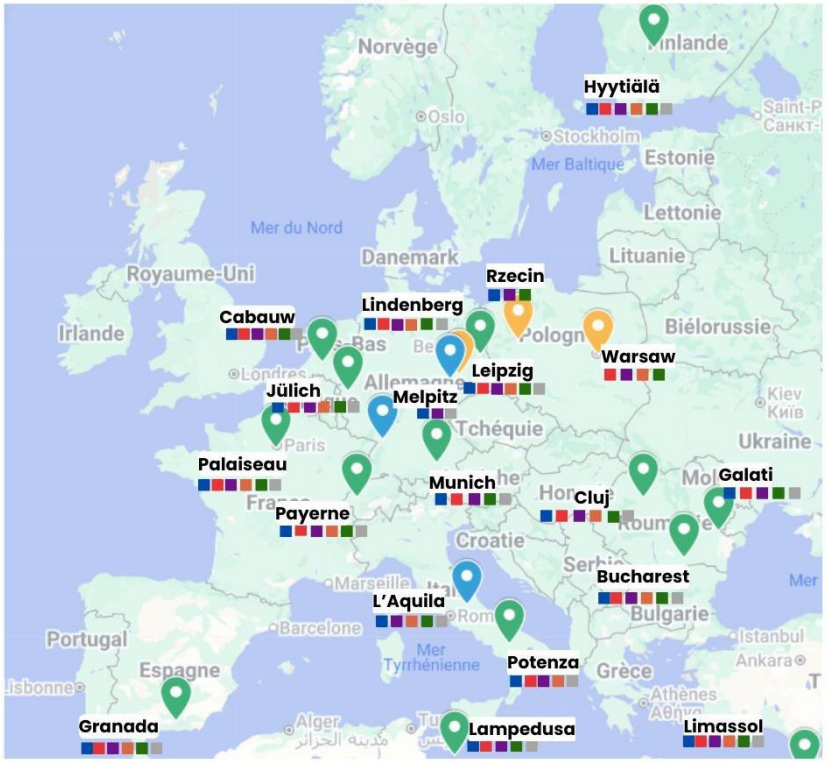
- Large geographical coverage and different types of clouds to observe.
- Multi-instrumented cloud remote sensing sites => hydrometeor classification available.

ACTRIS-CCRES:

- Standard Operating Protocols (SOPs).
- Calibration uniformity (not all sites).
- Automatic data processing and quality control (CLU - CloudNet).



Cape Verde



Finland

La Réunion

The ACTRIS network of cloud remote sensing sites in January 2025.

Data available at: https://cloudnet.fmi.fi/

Reflectivity validation

Reflectivity validation : methodology

Data selection:

- CPR: overpasses in a 200km radius around the ground site (based on Protat et al. 2009).
- Ground: All reflectivity profiles within the comparison period.

Liquid water filtering: to account for differences in attenuation.

- CPR: target classification.
- Ground: CloudNet classification.

- Ground data resampling to match satellite resolution.
- Sensitivity matching.

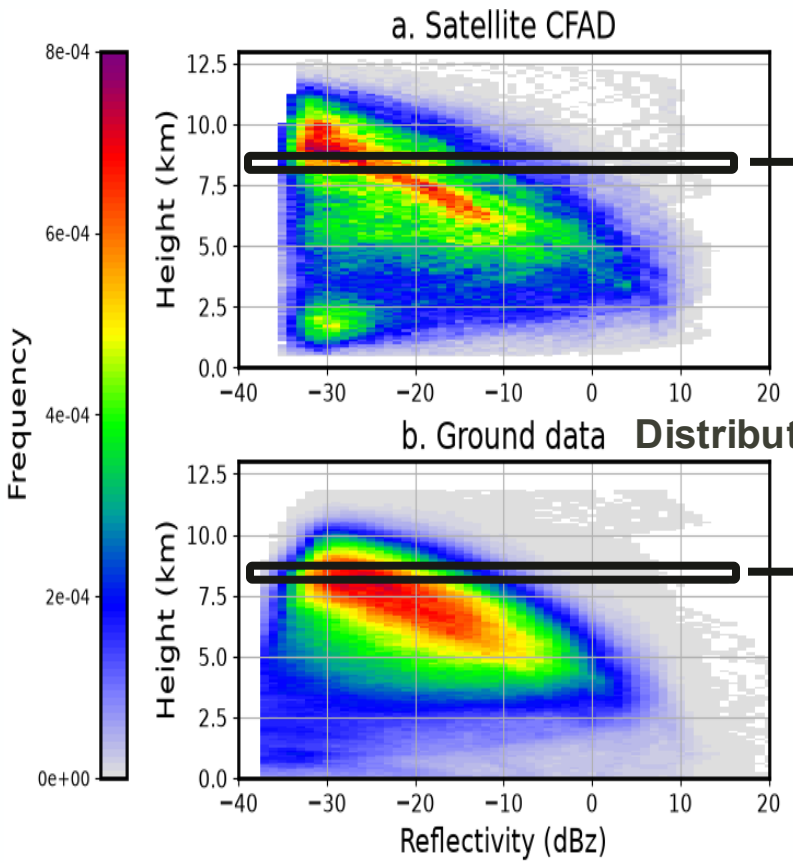
Statistical check to select comparable height bins.

Comparison of ground vs CPR reflectivity profiles.

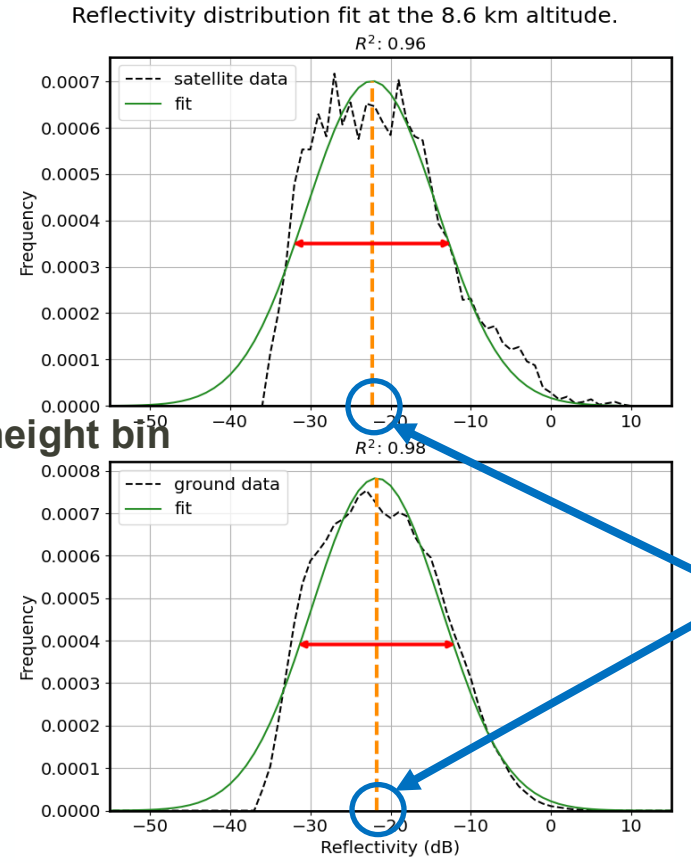
Calibration offset between EarthCARE and the ground radar with uncertainty

For more details see: https://doi.org/10.5194/egusphere-2026-925

Reflectivity validation : methodology



Distribution per height bin



Gaussian model criteria used to compare data similarity:

R^2 of the fit

Width of the distribution

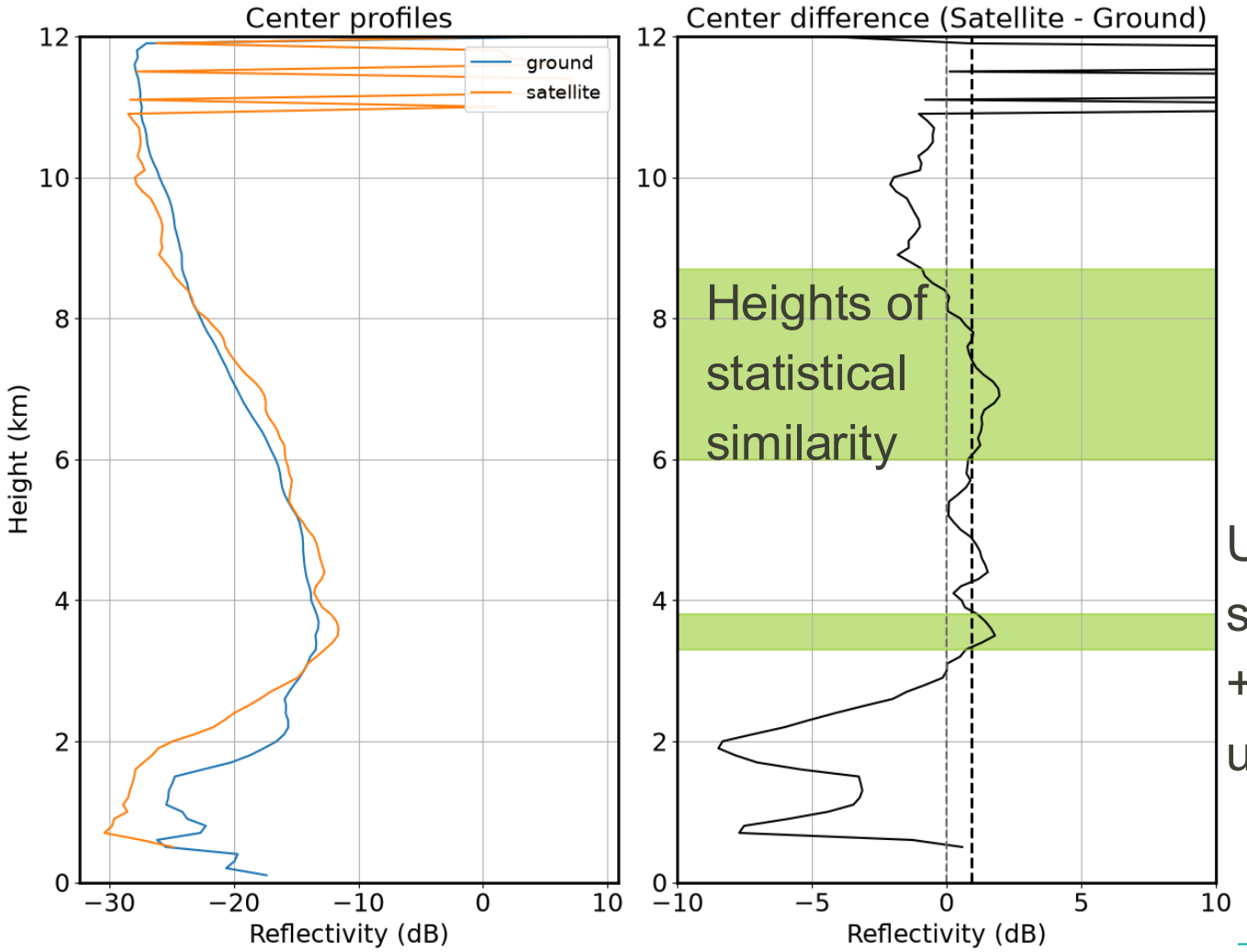
Center of the distribution

Fit with a Gaussian model to sort data (based on thresholds) => Bin selected if criteria fullfilled.

Centers difference is used for the bias estimation.

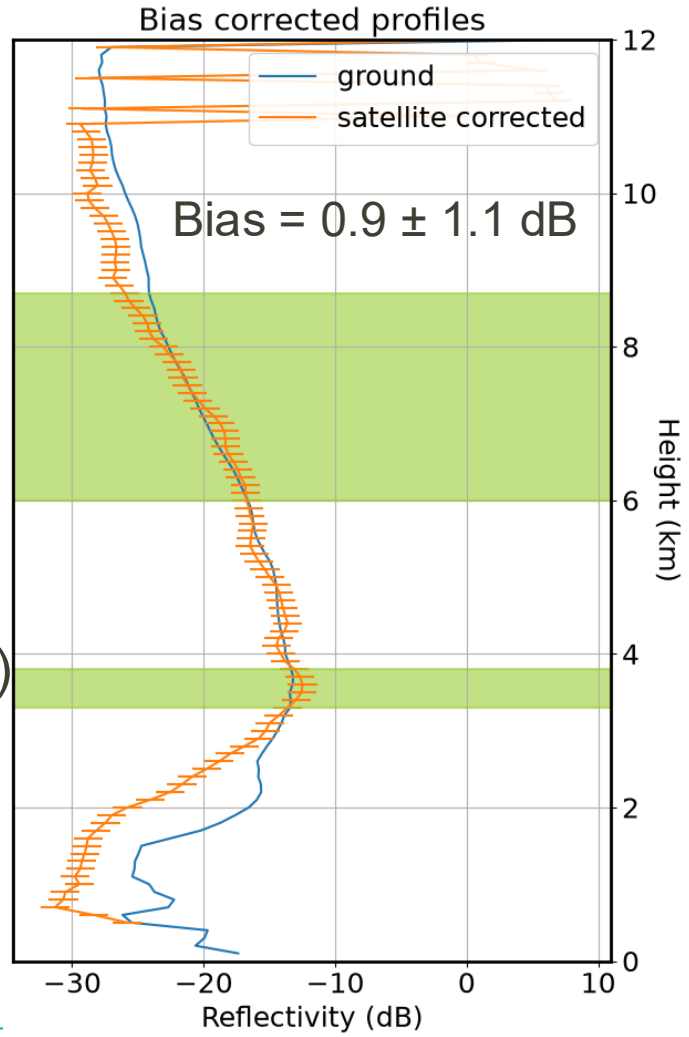
Reflectivity validation : bias estimation

Site of Jülich (MIRA35), time period: 2024/07 - 2026/05. Data from BA and BC baselines.



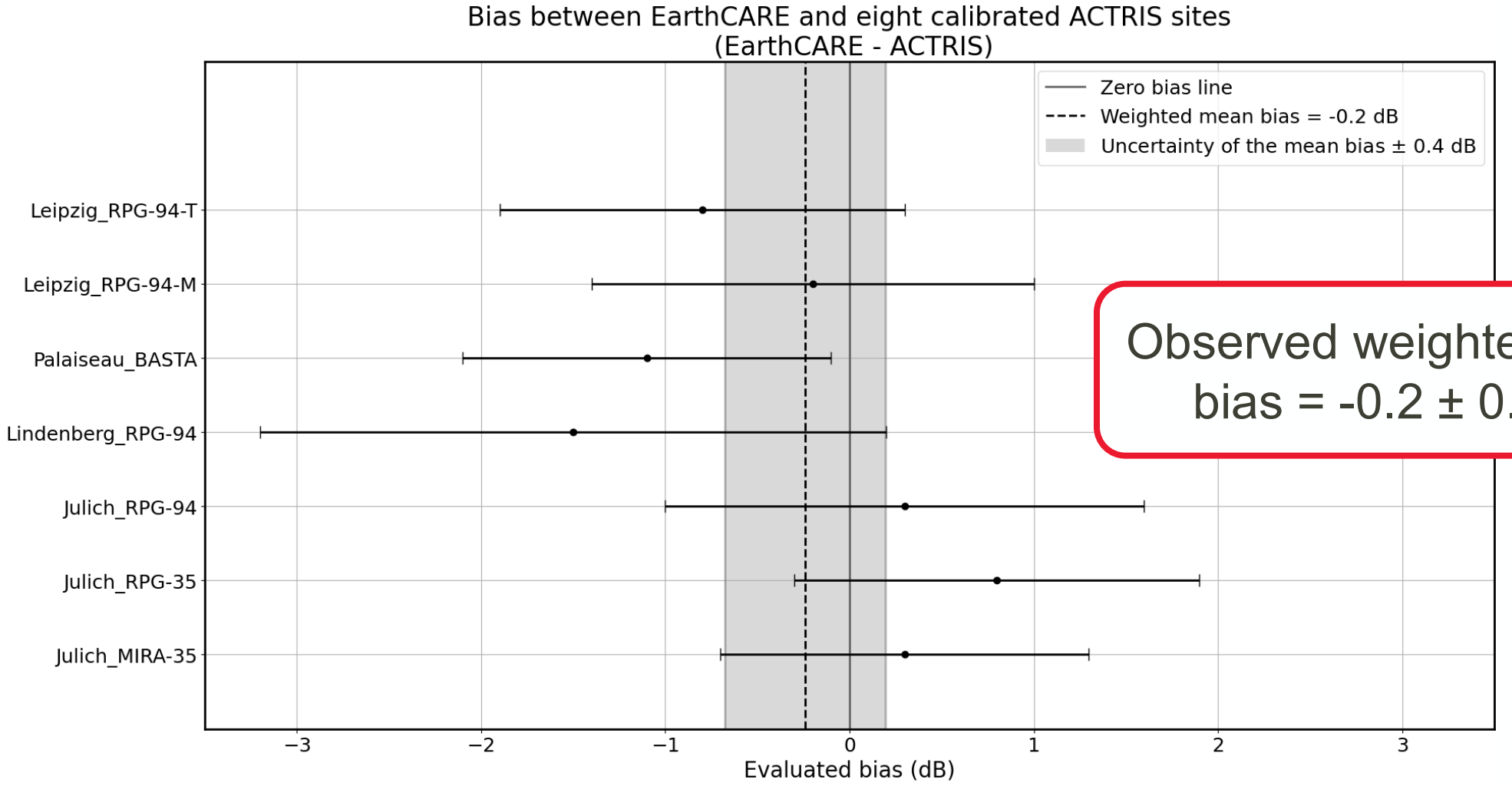
Bias = mean(centers differences)

Uncertainty = std(centers differences) + ground radar calib uncertainty



Reflectivity validation : results for BA baseline

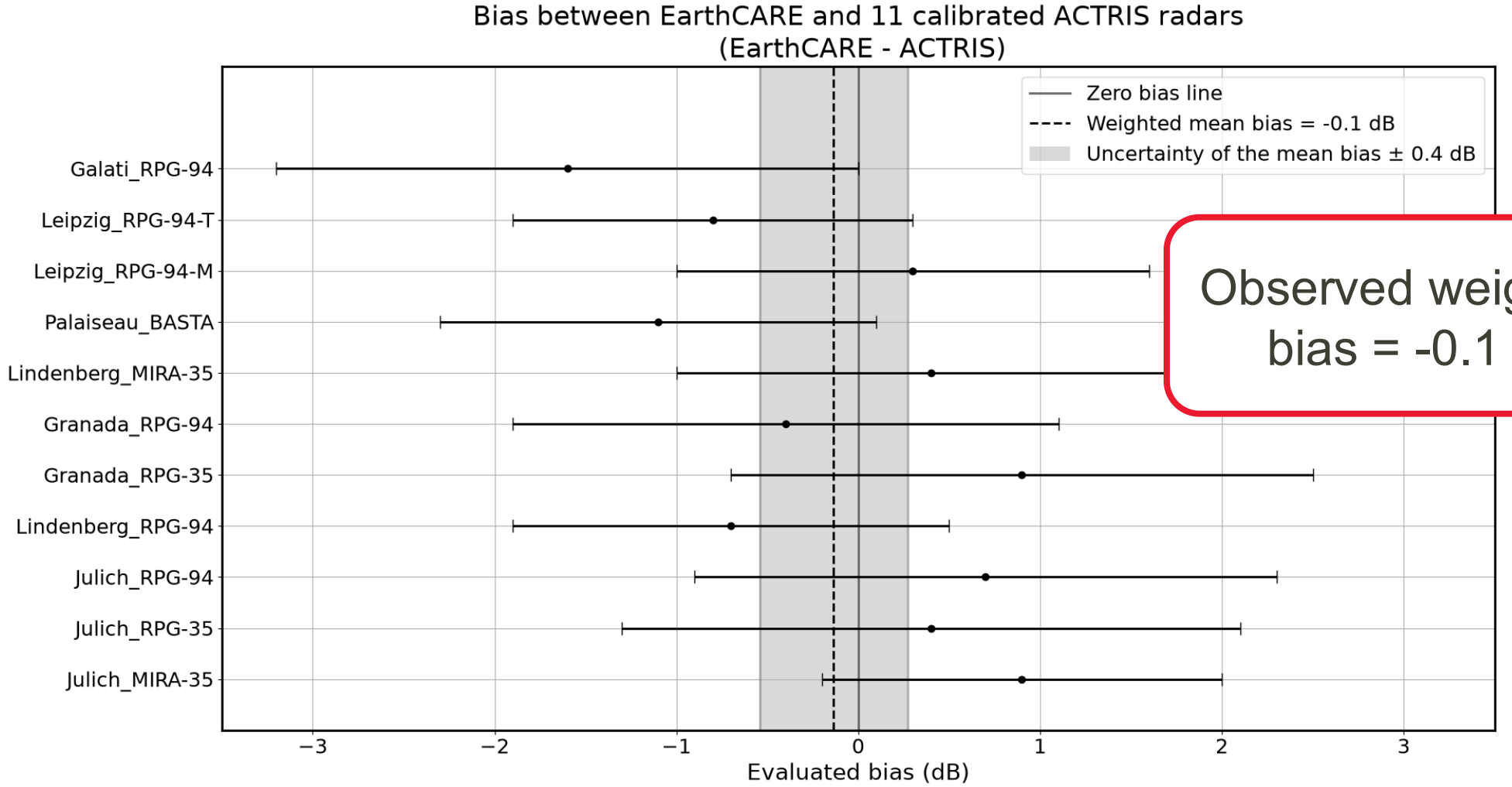
Time period: 2024/07 - 2025/11. Data from **BA baseline**. Results from pre-print.



Observed weighted mean bias = -0.2 ± 0.4 dB

Reflectivity validation : updated results

Time period: 2024/07 - 2026/05. Data **from BA and BC baselines**. 4 additional calibrated radars.



Observed weighted mean bias = -0.1 ± 0.4 dB

Doppler velocity validation

Doppler Velocity validation

Data selection inspired by Protat et al (2009).

- CPR: 100km radius around ground site.
- Ground: ±30 min window around the overpass time.

SNR filtering: remove noisy data.

- CPR and ground: data bellow -21 dB.
- Use of ground calibrated reflectivities.

Statistical filtering:

- Remove outlayer data and height bin with low data count

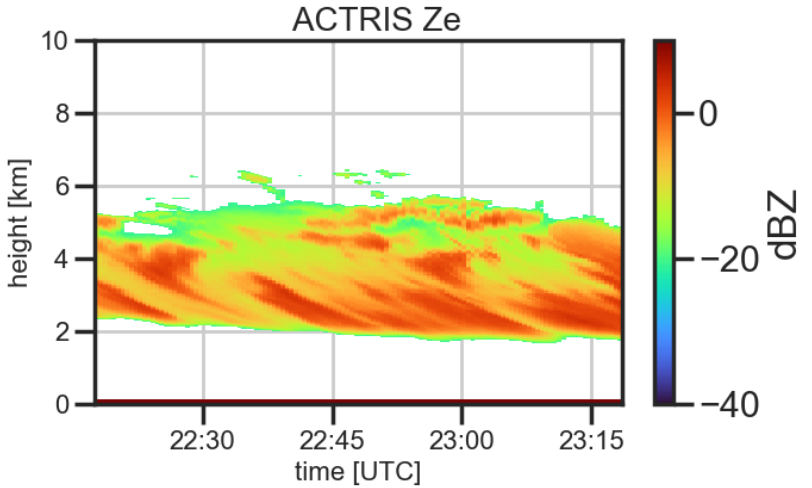
Comparison of ground and CPR Doppler velocities.

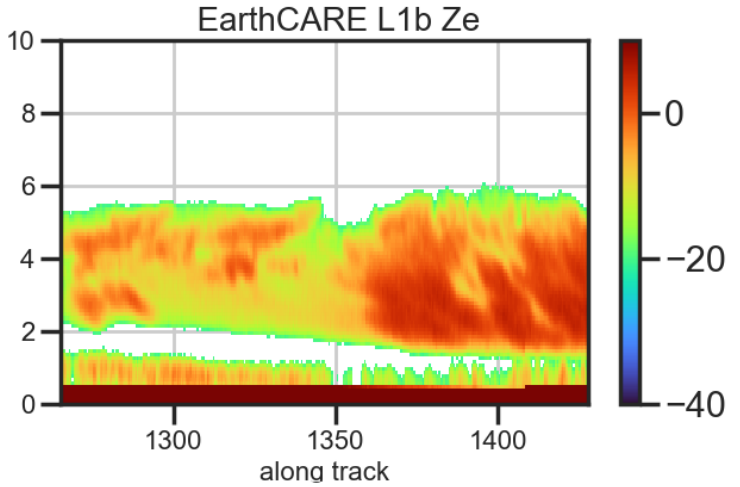
Bias estimator: median($V_{ground} - V_{sat}$)

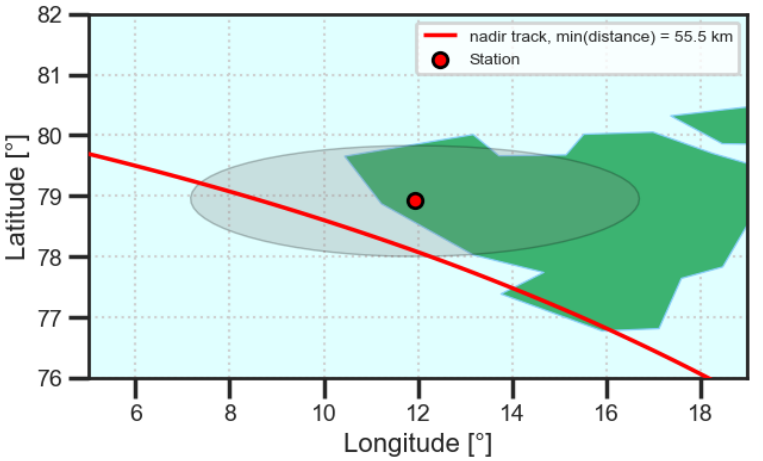
1. Data from ground based radars are forward simulated to improve comparability. (Pfitzenmaier et al. , 2025)
2. Ground based radars are assumed perfectly vertical.

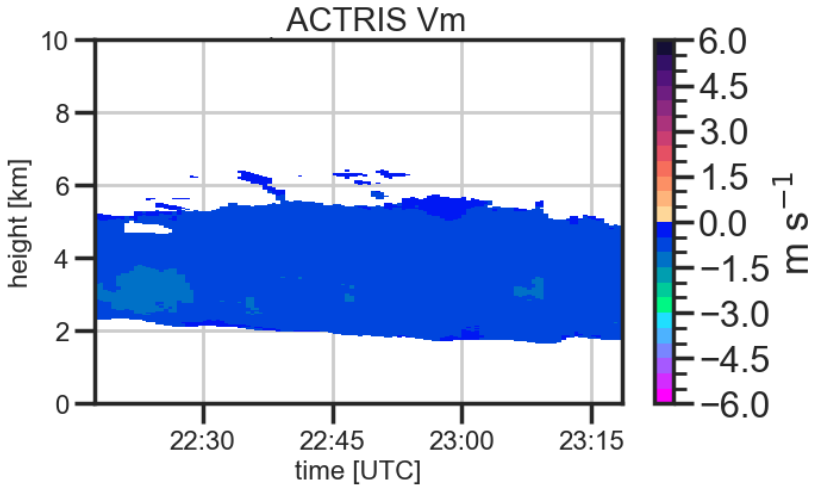
Velocity validation : example of an overpass

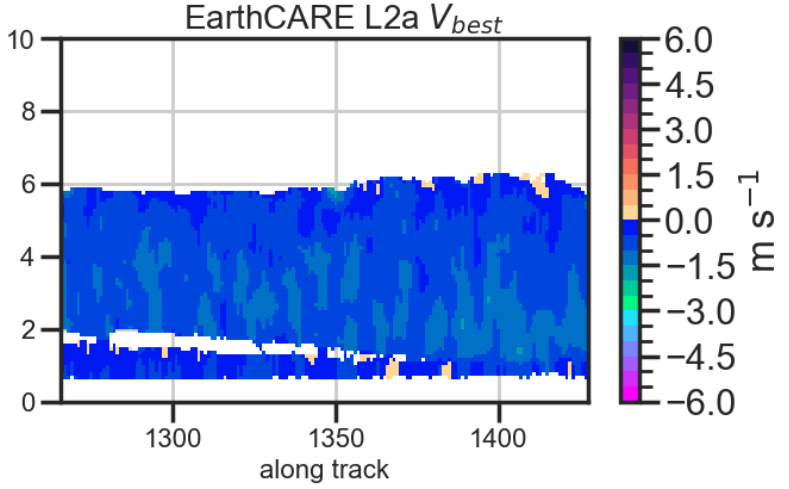
Overpass from the 6th April 2025 (22:47:48 UTC) over Ny-Alesund. Data from BA baseline.

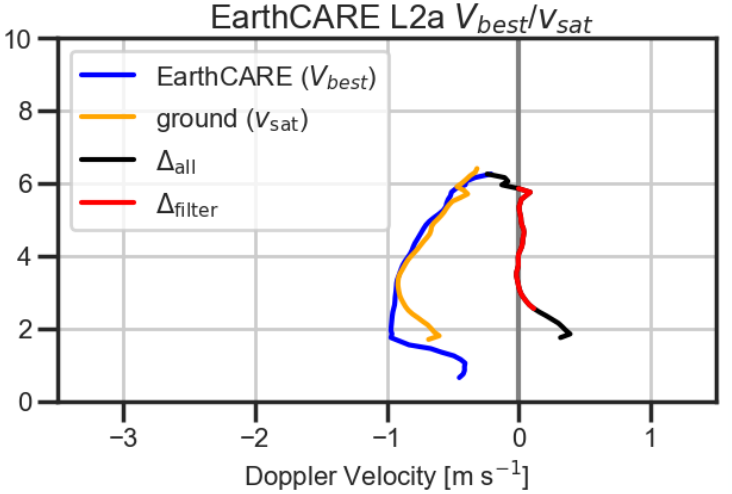






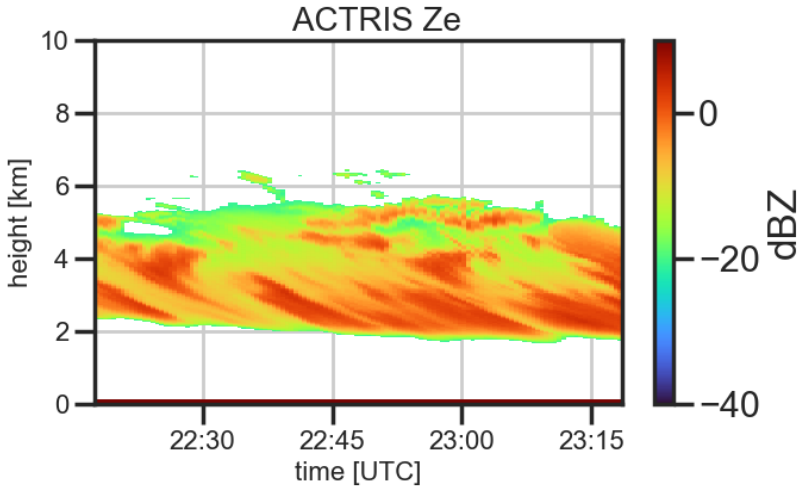


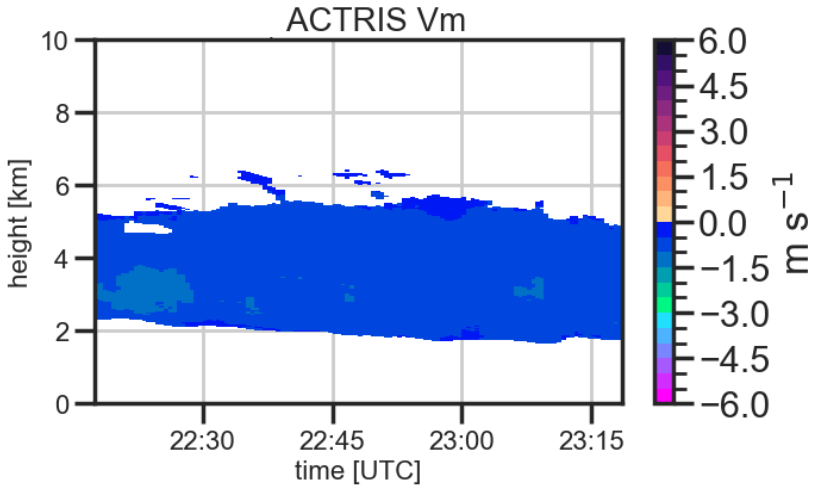


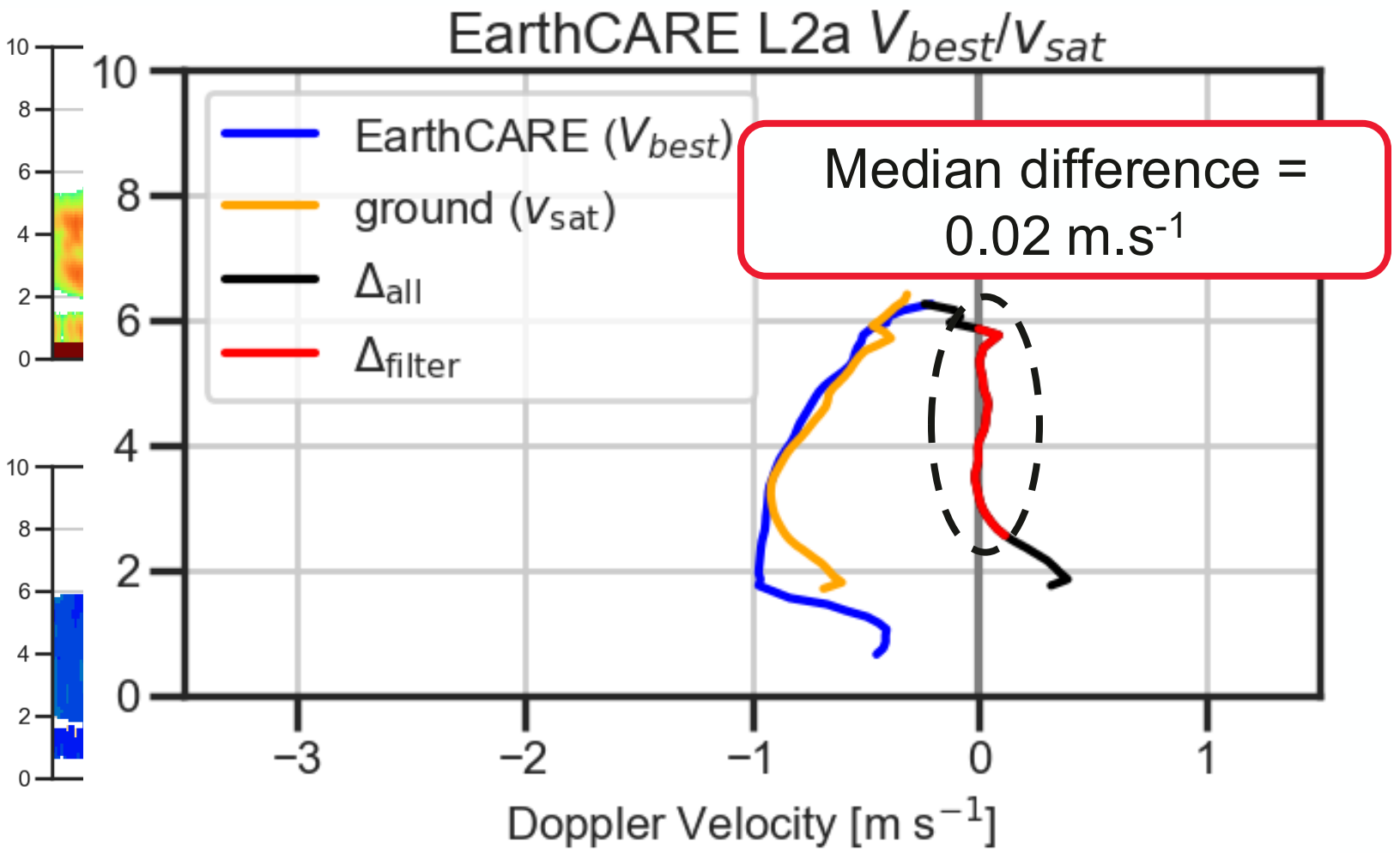


Velocity validation : example of an overpass

Overpass from the 6th April 2025 (22:47:48 UTC) over Ny-Alesund. Data from BA baseline.

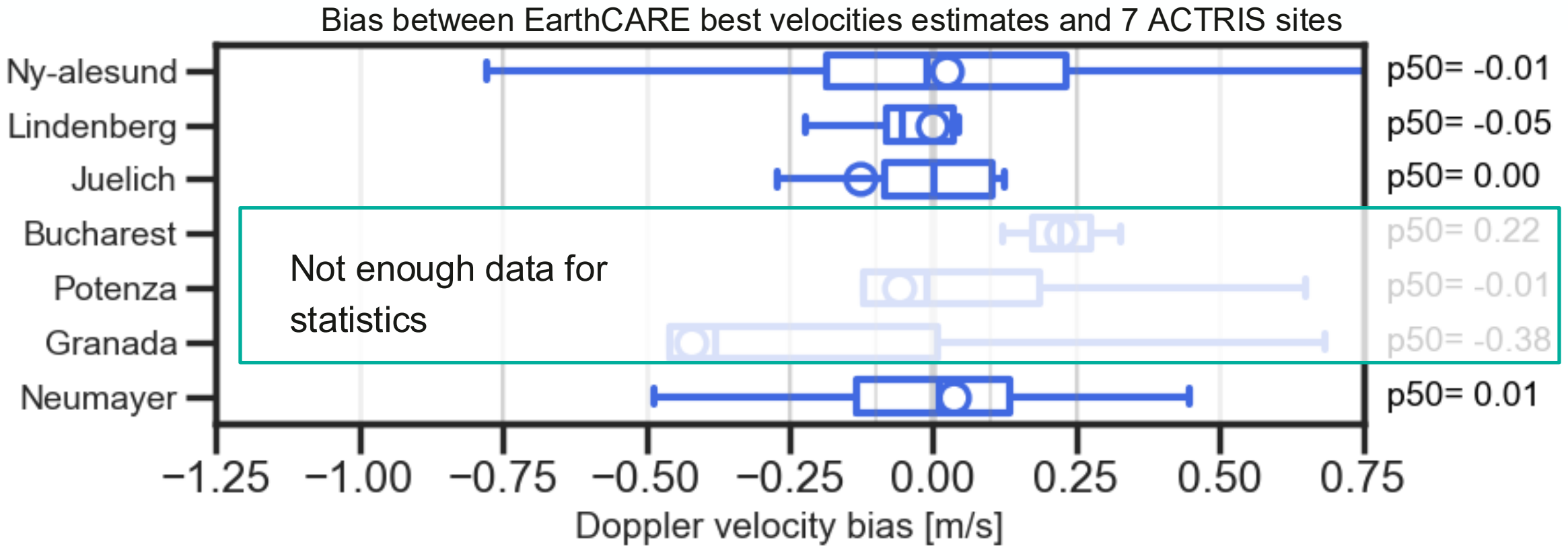






Velocity validation : results

Time period: 2024/07 - 2025/11. Data from **BA baseline**.



Median values of Doppler velocity bias between **0.01 m.s^{-1} and 0.05 m.s^{-1}**

Conclusions

Reflectivity CAL/VAL

- Comparison of satellite overpasses data with ground-based reflectivity climatology.
- Estimated EarthCARE-ACTRIS bias using 11 calibrated radars : **-0.1 ± 0.4 dB**.
- All ground-based radars were calibrated with the same reference and show compatible bias => algorithm validation by closure.
- Calibration changes can be identified and tracked through time series (not shown here).

Doppler velocity CAL/VAL

- Similar cloud scenes must be observed by each instrument to enable a comparison of wind patterns => Comparisons in spatial and temporal proximity from satellite overpasses.
- Successful comparisons show a bias between **0.01 and 0.05 m.s^{-1}**.
- Results using other products (L1, L2 uncorrected) confirm that the main error in the CPR velocity retrievals come from the miss-pointing error (not shown here).

Supplementary slides

ACTRIS cloud radar calibration strategy

Calibrate the reference radar with a corner reflector at ACTRIS-CCRES

0.8 dB calibration uncertainty

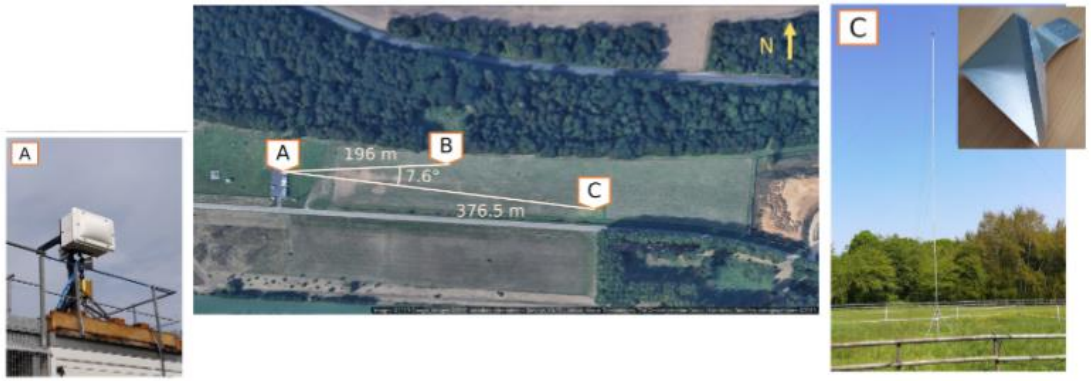
Moving the calibrated radar to another ACTRIS site for calibration transfer

New calibration: 0.8 - 1 dB uncertainty

Re-calibration of the reference radar at ACTRIS-CCRES to validate the campaign results

Continous calibration tracking at the ACTRIS sites using disdrometers

Method :
Toledo, Felipe, et al. "Absolute calibration method for frequency-modulated continuous wave (FMCW) cloud radars based on corner reflectors." Atmospheric Measurement Techniques 13.12 (2020): 6853-6875.

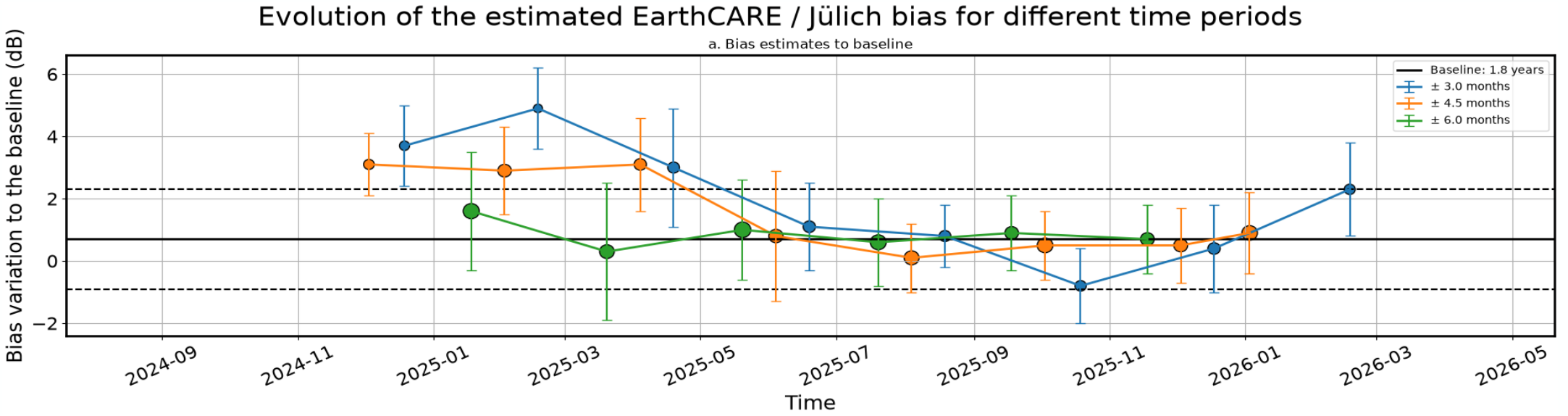


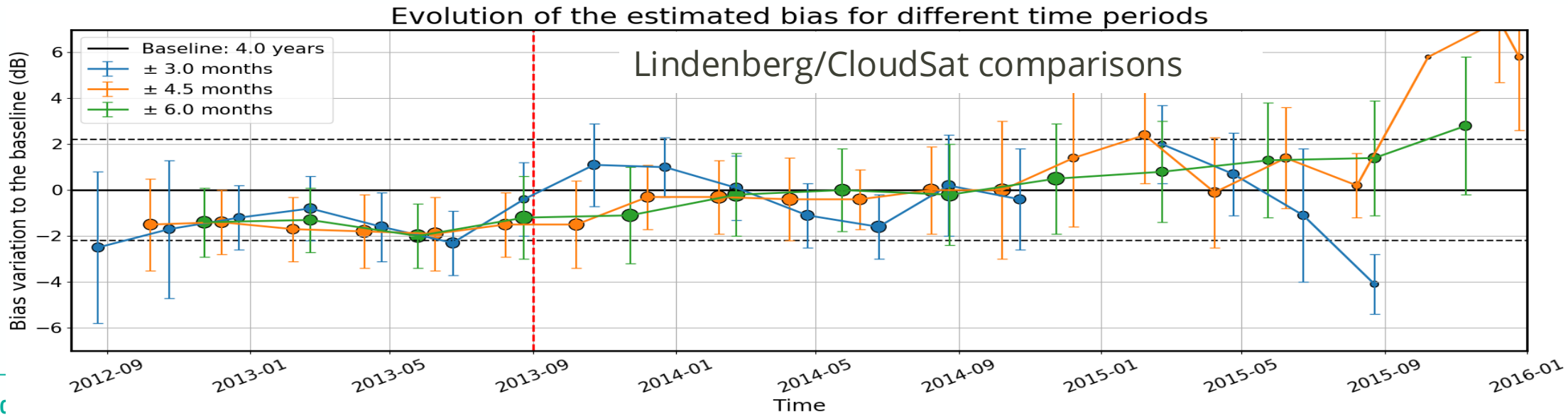
Joyce Obs. Radar
MIRA
Ka Band

Reference Radar
BASTA-Mini CCRES
W Band

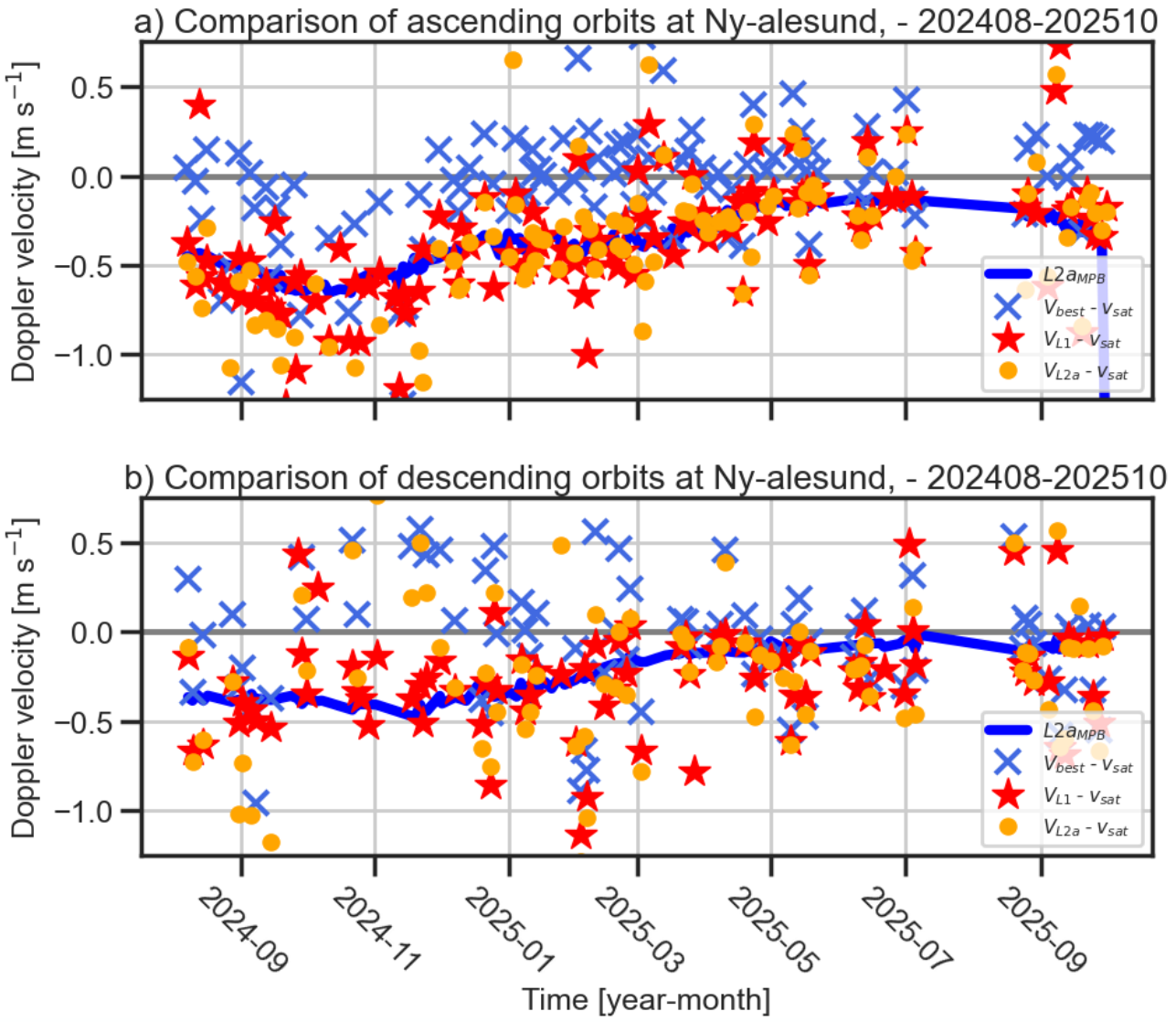
Method :
Jorquera, Susana, et al. "Calibration transfer methodology for cloud radars based on ice cloud observations." Journal of Atmospheric and Oceanic Technology 40.7 (2023): 773-788.

Reflectivity time series





Velocities and miss-pointing error



- Bias between EarthCARE L1b, L2a (uncorrected and best estimate) velocities were evaluated.
- Results confirm that the main error in EarthCARE's velocity retrievals come from small pointing changes of the satellite antenna (Pfitzenmaier et al. in preparation).