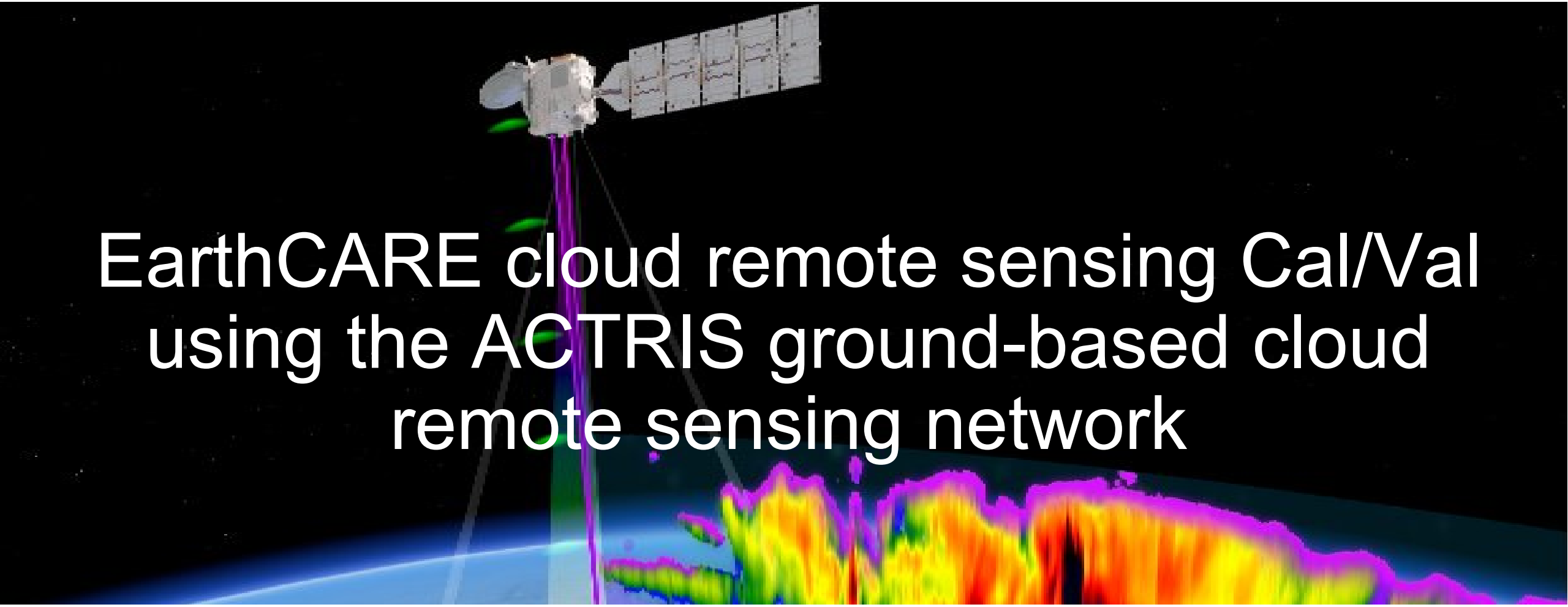


EarthCARE cloud remote sensing Cal/Val using the ACTRIS ground-based cloud remote sensing network

N. Feuillard (LATMOS), Felipe Toledo (OVSQ/LATMOS), Martial Haeffelin (IPSL), Jean-Charles Dupont (IPSL/UVSQ), Julien Delanoë (LATMOS/UVSQ), Christophe Genthon (LMD/CNRS), Lukas Pfitzenmaier (University of Cologne, Germany)

10 juin 2024

CAL/VAL project objectives

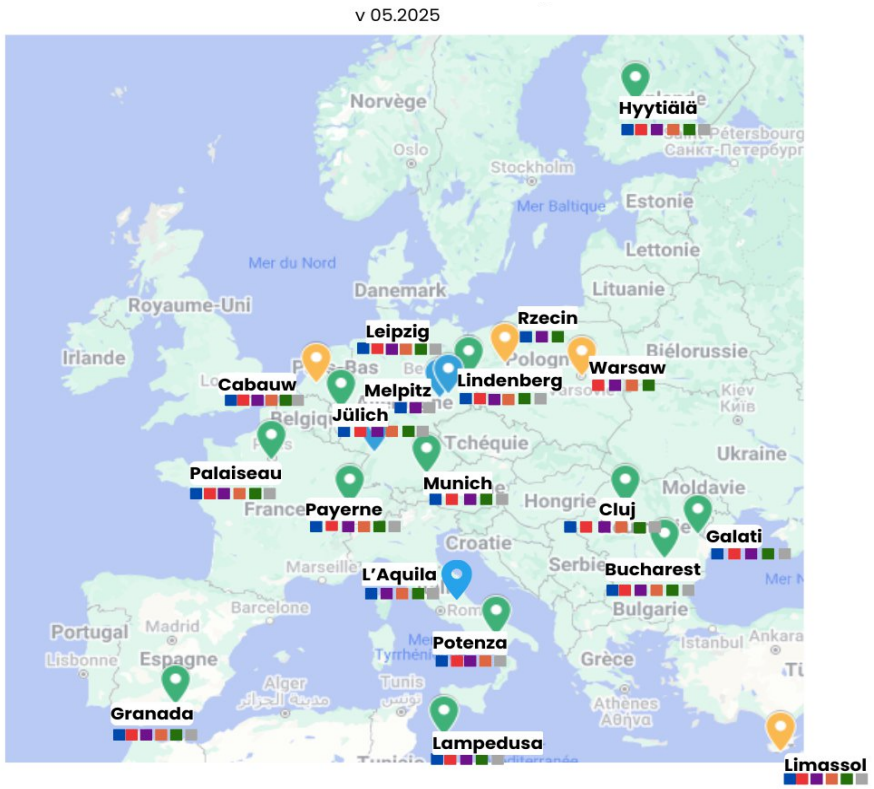
- Validation of EarthCARE's CPR reflectivity and Doppler velocities.

- Statistical approach, comparison with ACTRIS and AWACA cloud radars.

ACTRIS : 25 fixed sites + mobile stations

DCR
MWR
ALC
DL
Disdrometer
Weather station

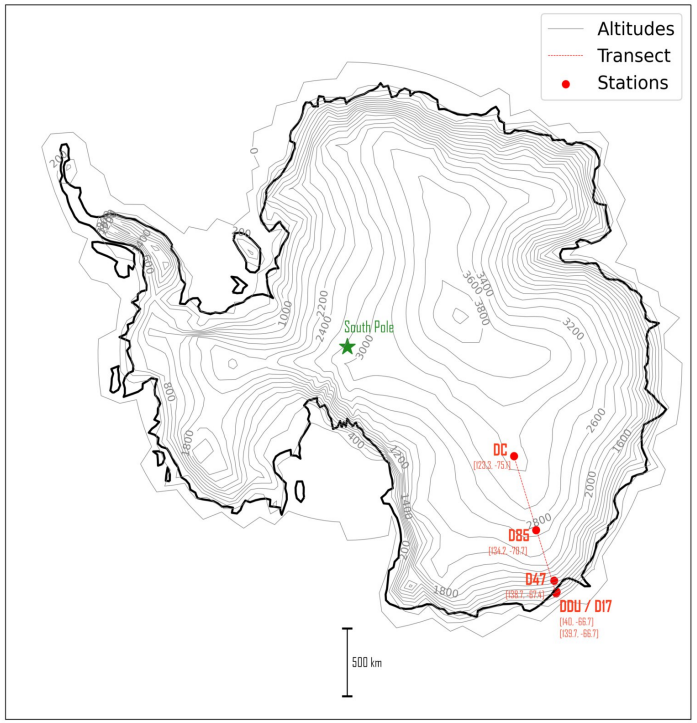
ACTRIS CRS Labelling in progress
ACTRIS CRS Labelling initiated
ACTRIS CRS candidate



Cape Verde

Finland

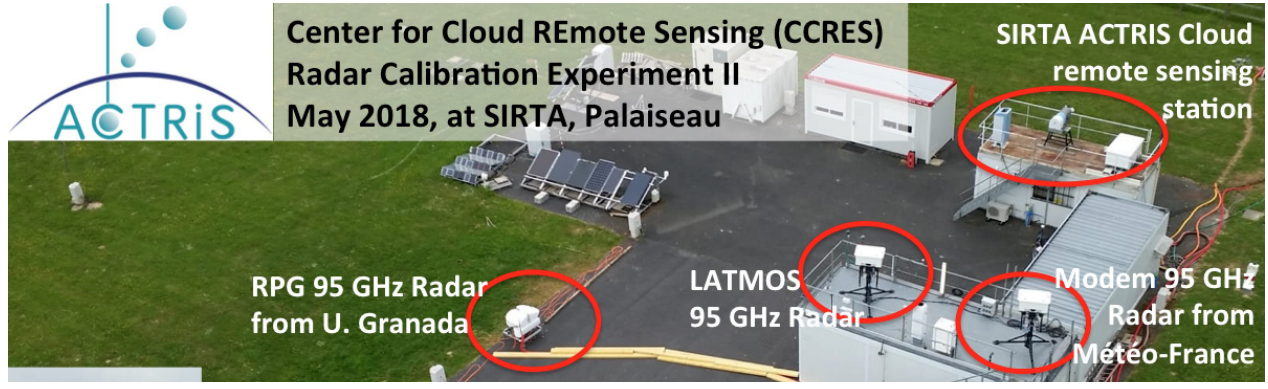
La Réunion

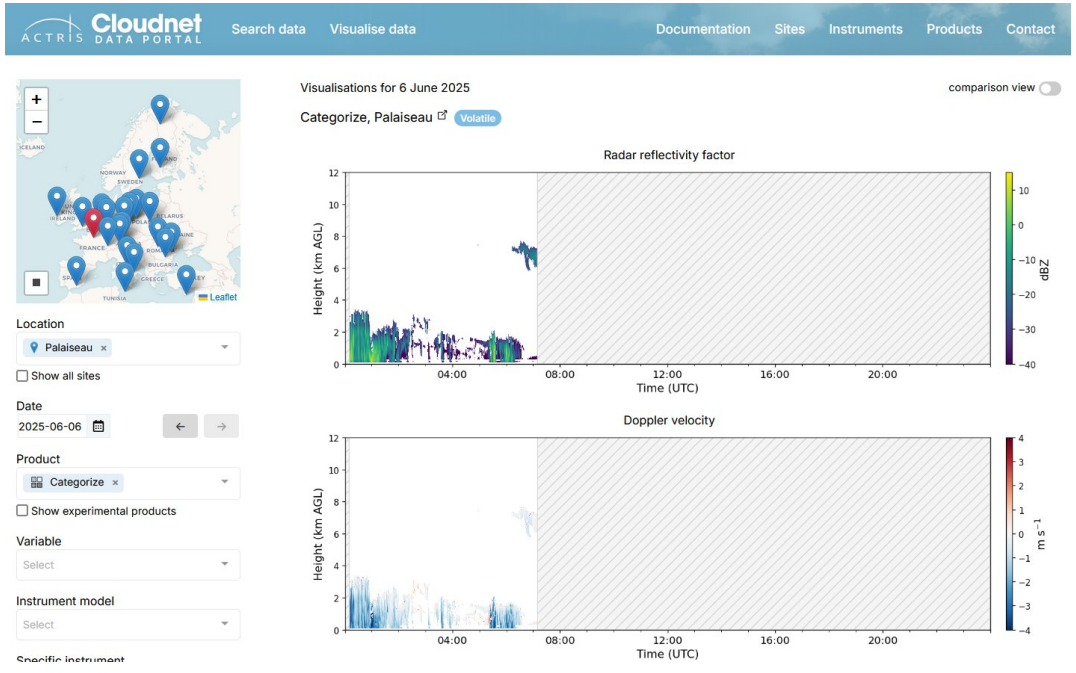


AWACA : 5 fixed sites on a 1000km crossing

Advantages of the ACTRIS network

- ACTRIS Centre for Cloud Remote Sensing (CCRES) :
  - Calibration protocols for ground cloud radars.
  - Multi-instrument sites -> target classification available.
  - Automatic data processing and data quality control.
- Standard Operating Protocols (SOPs) compatible with CalVal.
- Large geographical area, wide variety of cloud types to observe.






Doppler Cloud Radar


Microwave radiometer


Doppler lidar

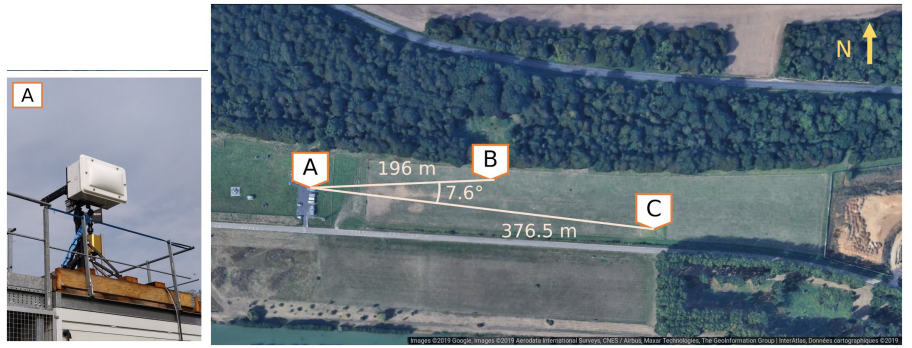

Low power lidar and ceilometer


Disdrometer

ACTRIS network: calibration strategy

- Reference radar calibrated at SIRTA.
  - ➢ Uncertainty: 0.8 dB
- Calibration transfer at the ACTRIS site.
  - ➢ Uncertainty: 0.8 - 1 dB
- Calibration monitoring using a colocated disdrometer.

➢ Make use of the calibrated sites to validate the method implemented.

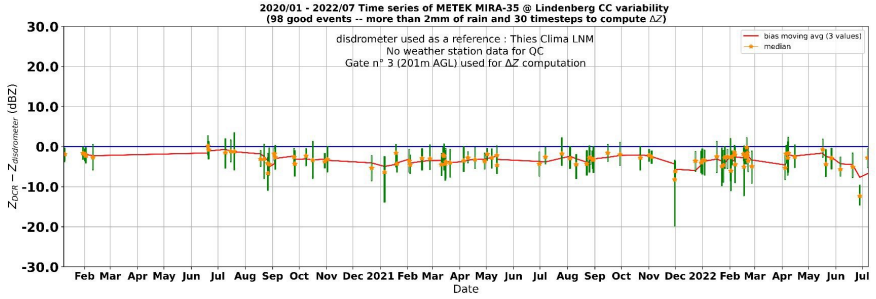


Method :
Toledo, Felipe, et al. "Absolute calibration method for frequency-modulated continuous wave (FMCW) cloud radars based on corner reflectors." Atmospheric Measurement Techniques 13.12 (2020): 6853-6875.

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.



EarthCARE description

Broad Band Radiometer (BBR)

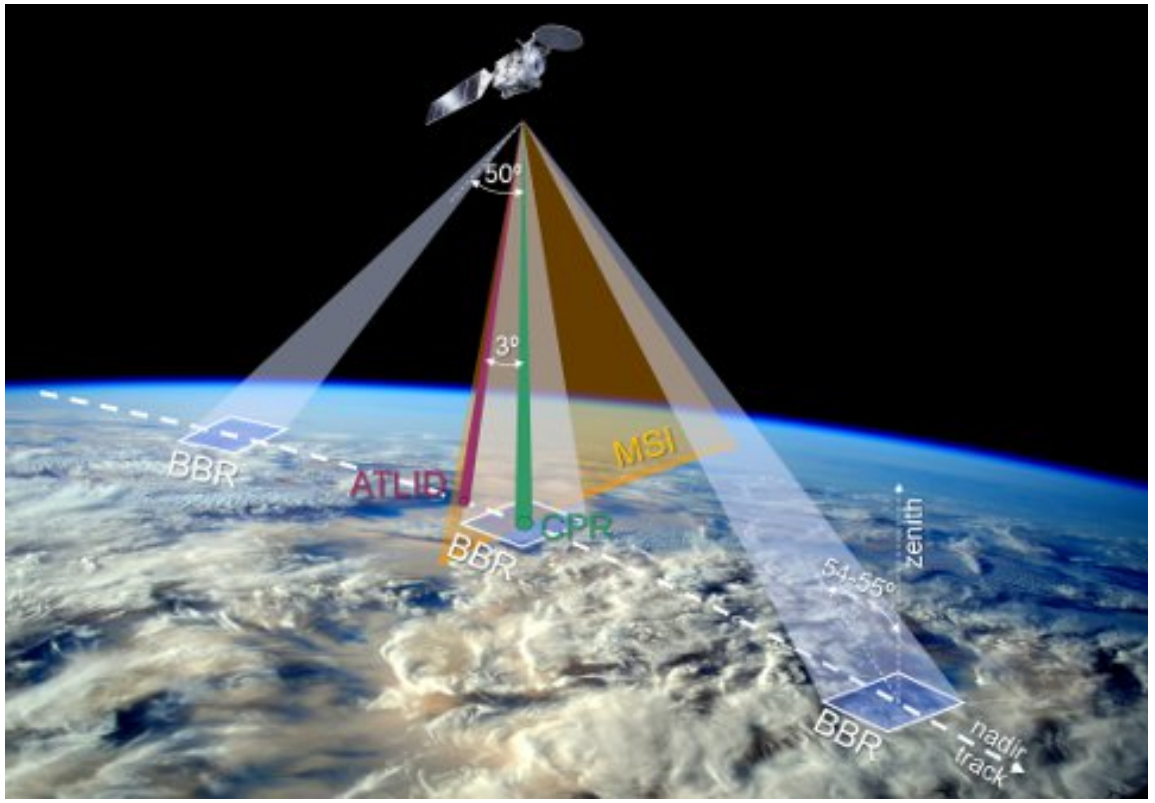
channels: 0.25 - 0.50µm & 0.50 - 4 µm
10 km by 10 km pixels

Multi Spectral Imager (MSI)

channels: 0.670, 0.865, 1.65, 2.21, 8.80, 10.80. 12.00 µm
view: 35 km to the right and 115 to the left

Cloud Profiling Radar (CPR)

94.05 GHz - range resolution 100m - footprint 800m
Sensitivity: ~ -37 dBZ & +/- 5.6 m/s
Doppler uncertainty: <= 0.5 m/s for Ze > -20 dBZ



Atmospheric Lidar (ATLID)

High spectral resolution Lidar (HRSL) - range resolution 103 m
355 nm, Raylight and Mie and depolarisation channel

=> flying ACTRIS site

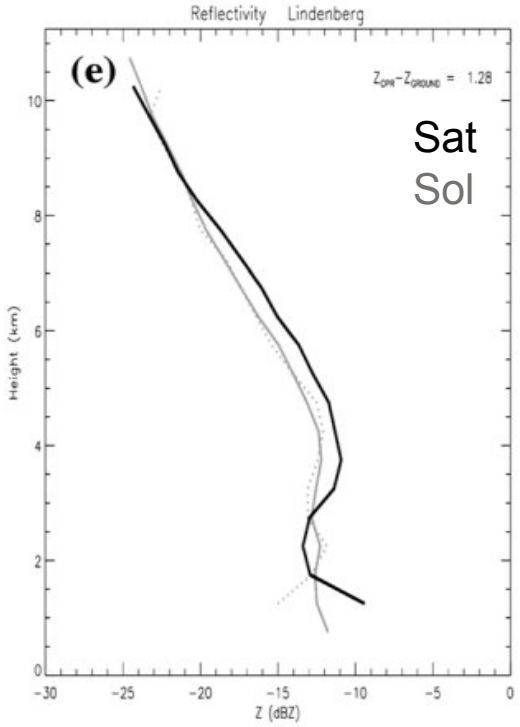
***Wehr et al.**, 2023:*
The EarthCARE Mission – Science and System Overview, *EGUsphere , https://doi.org/10.5194/amt-16-3581-2023, 2023.*

EarthCARE-ACTRIS reflectivity comparisons algorithm

Comparaisons historic

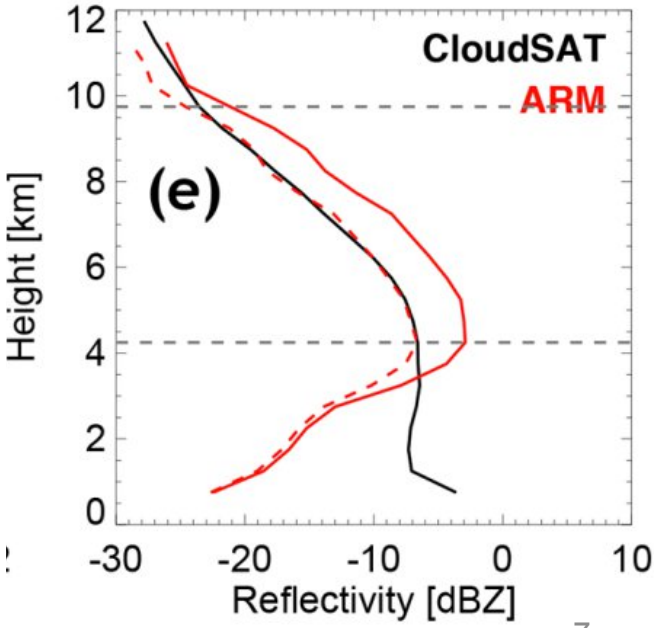
Method inspired from Protat et al (2009):

- Statistical comparisons of ice cloud profiles between ground and satellite radar (CloudSat) on a certain time period (6 months - 1 year).
- Similarities in **mean reflectivity** profiles.
- Evaluation of the bias between the satellite and the ground radars.



< Mean reflectivity profiles for the ground and satellite. 9 month period. Protat et al (2009).

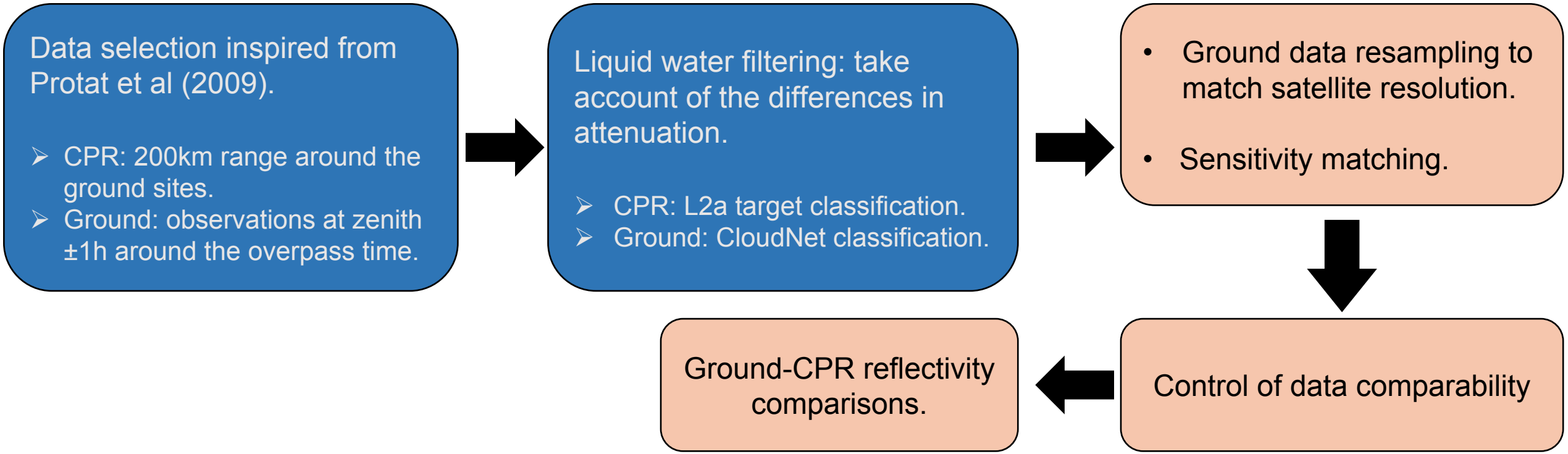
Mean reflectivity profiles for the ground and satellite. 2 years period. Kollias et al (2019). >



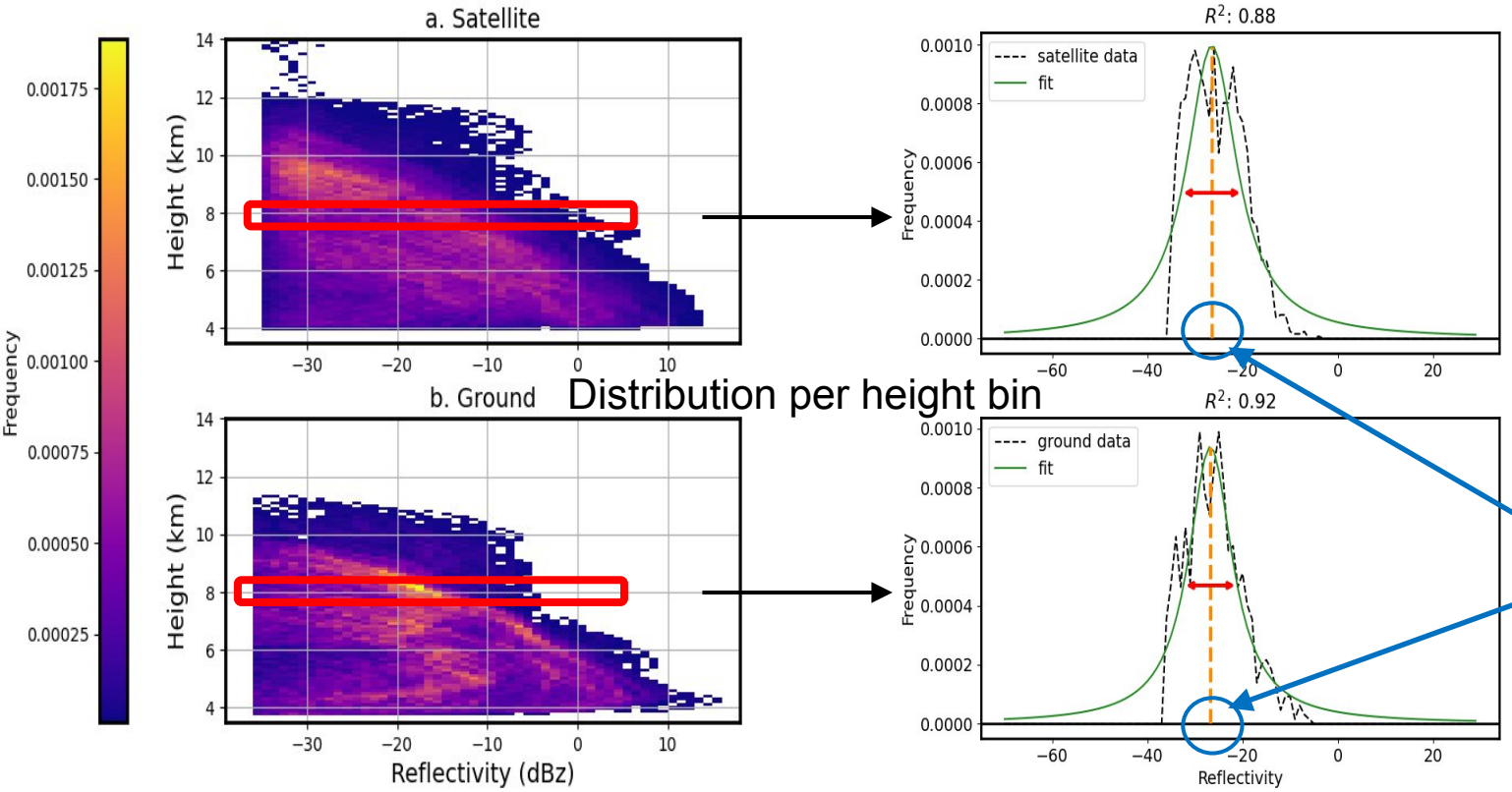
Method description

Data used, time period: 12/24 - 05/25 (~5.5 months).

- CPR: reflectivities and classifications L2a.
- Ground: reflectivities and classifications CloudNet.



Selection of heights for comparison



Lorentzian model criteria:

Fit R^2

Distribution width

Distribution amplitude

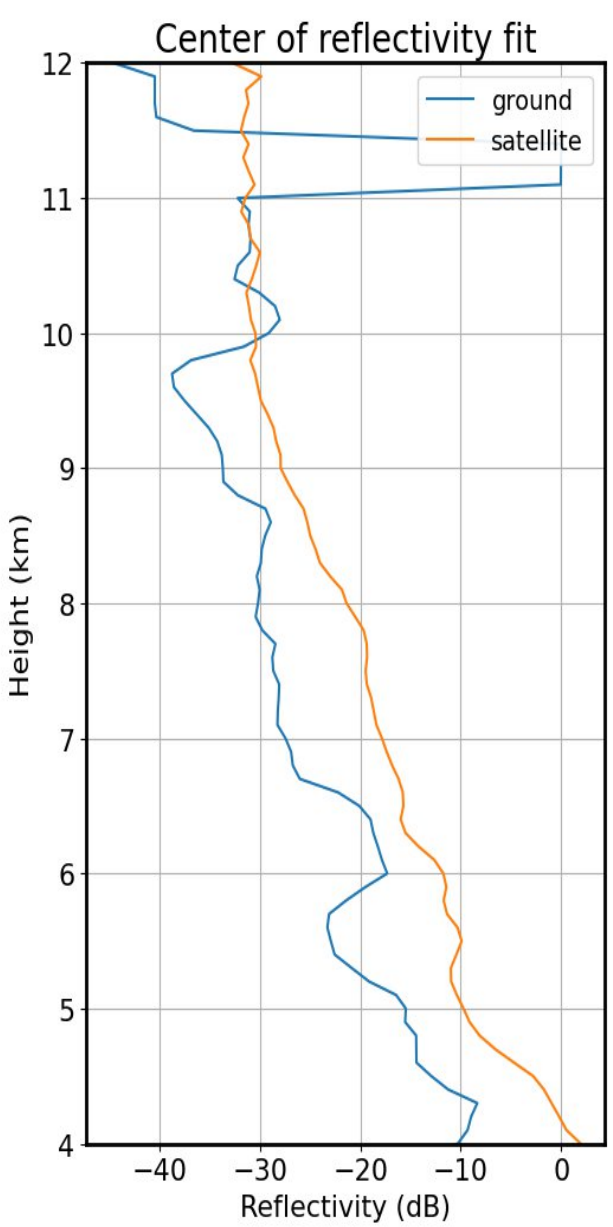
Distribution center

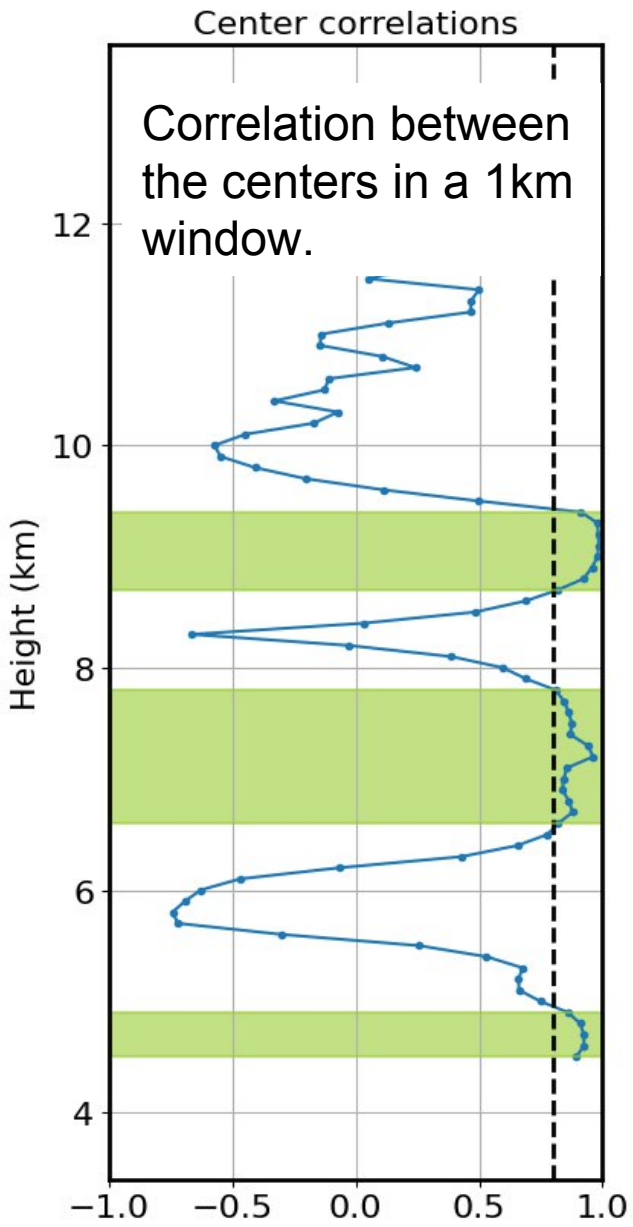
Fit with a Lorentzian model to sort the data (based on thresholds):

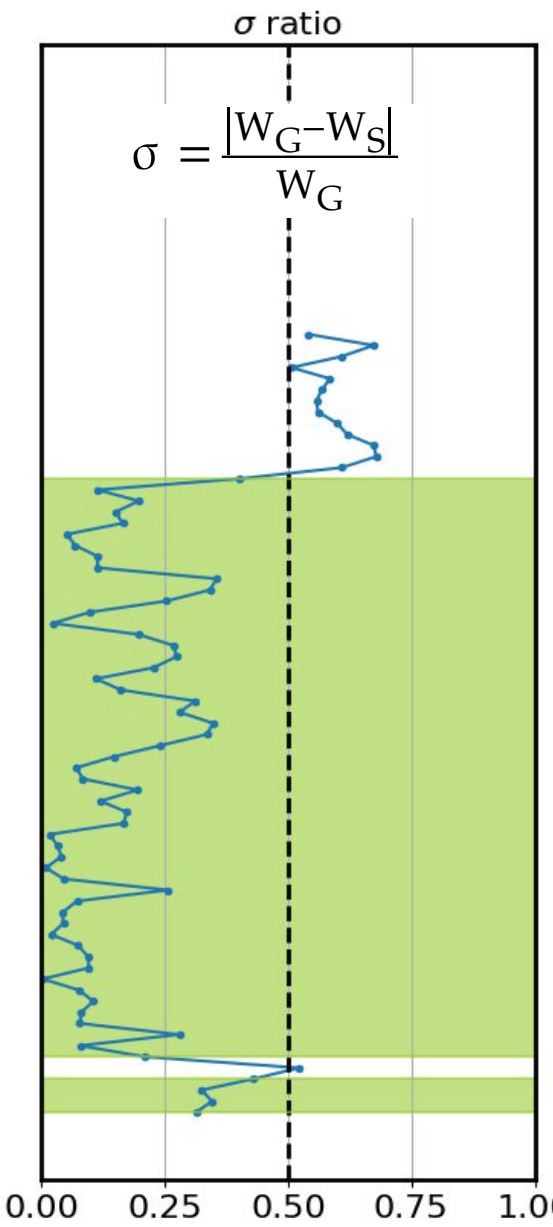
- If the criteria is fullfilled, height bin is selected.
- Otherwise the bin is filtered.

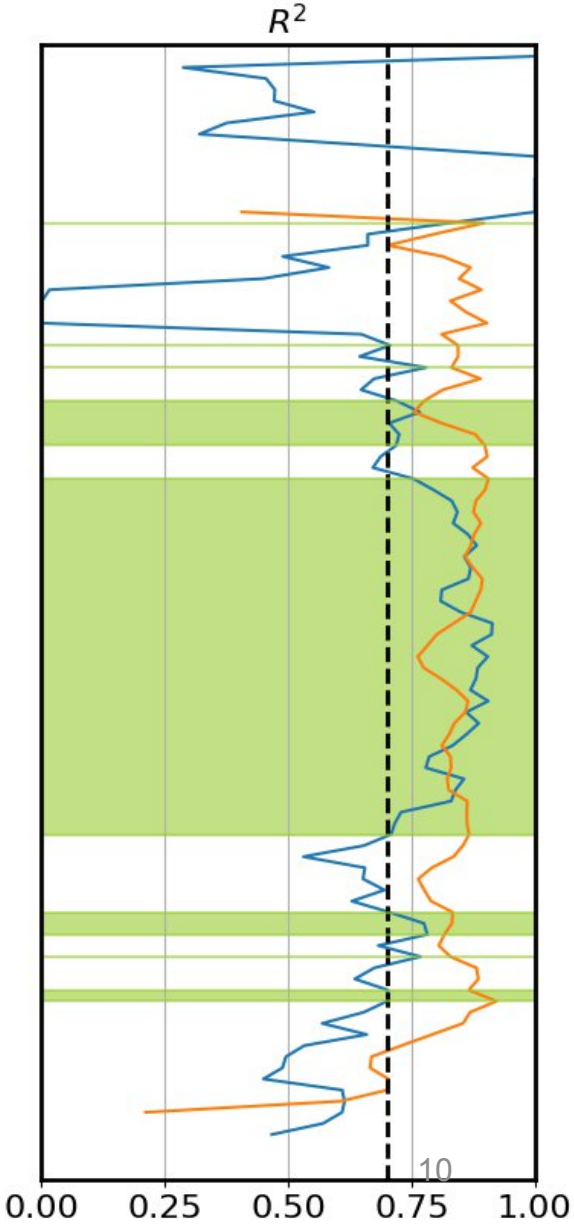
The center of the fit is used as an estimator for the bias.

Satellite-ground bias estimation

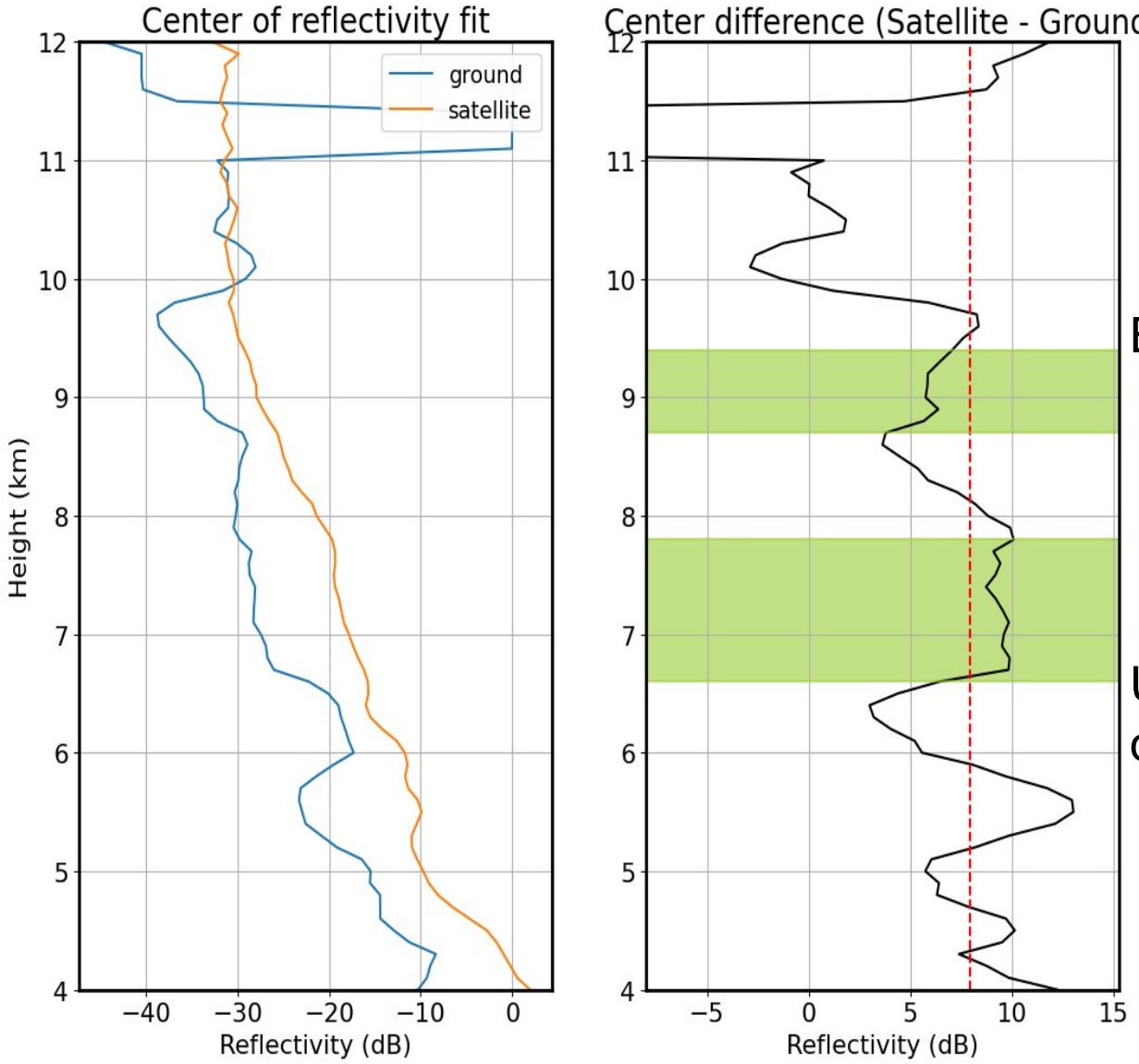






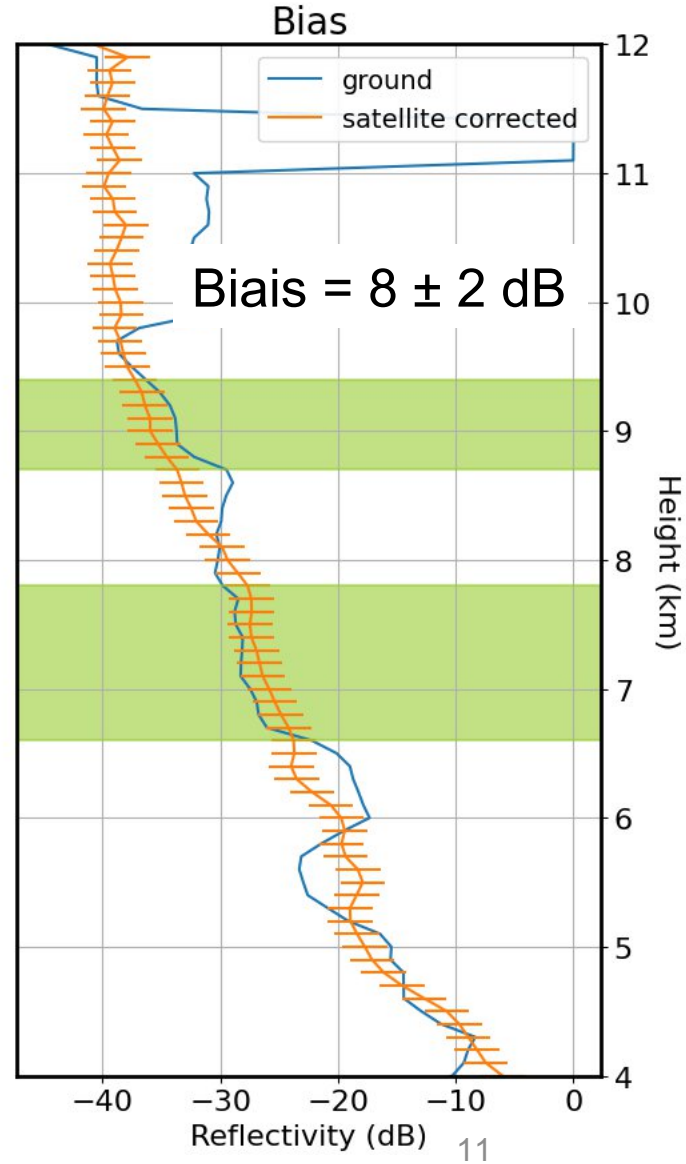


Satellite-ground bias estimation

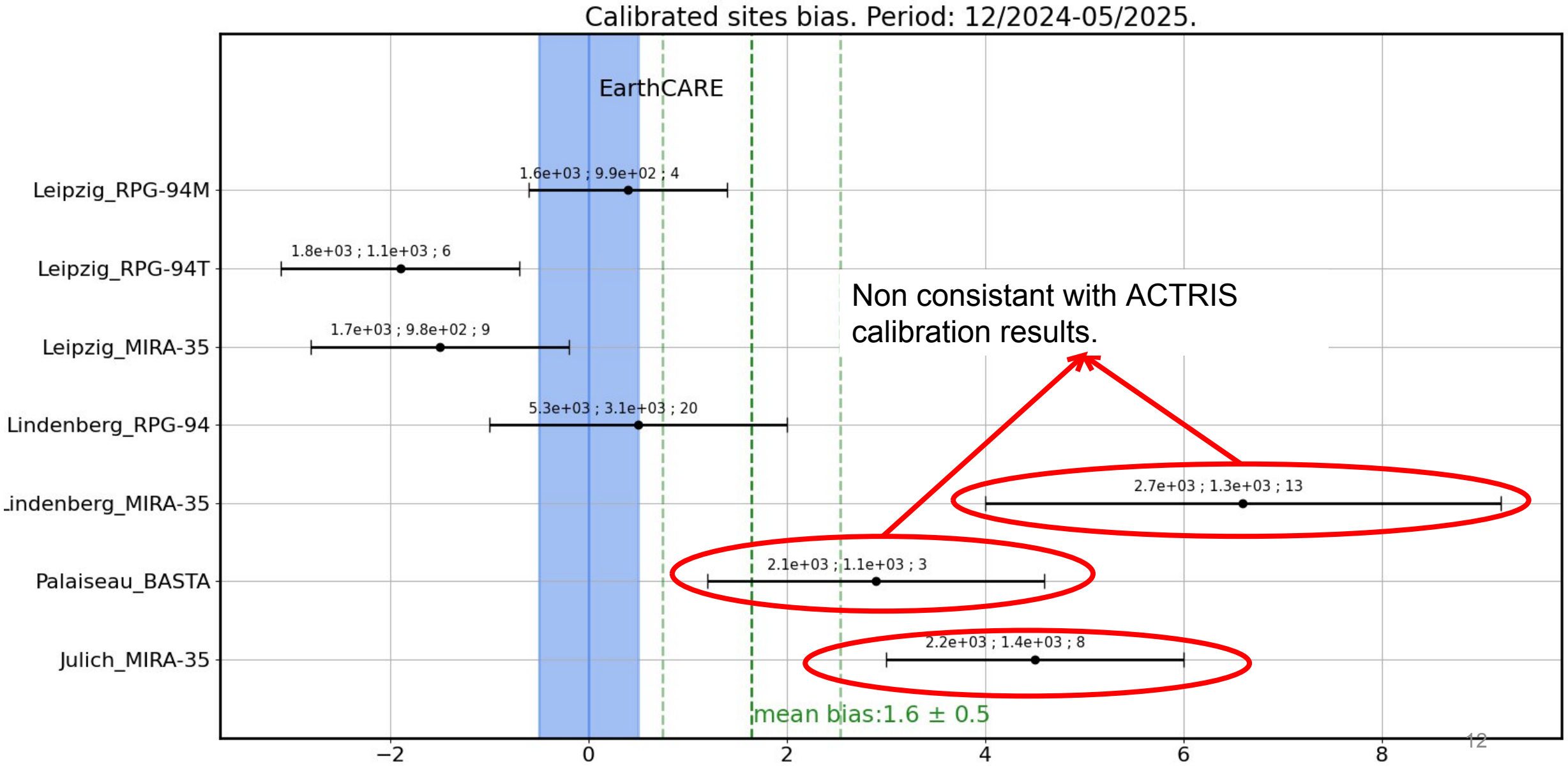


Bias = mean(centers diff)

Uncertainty = std(centers diff)

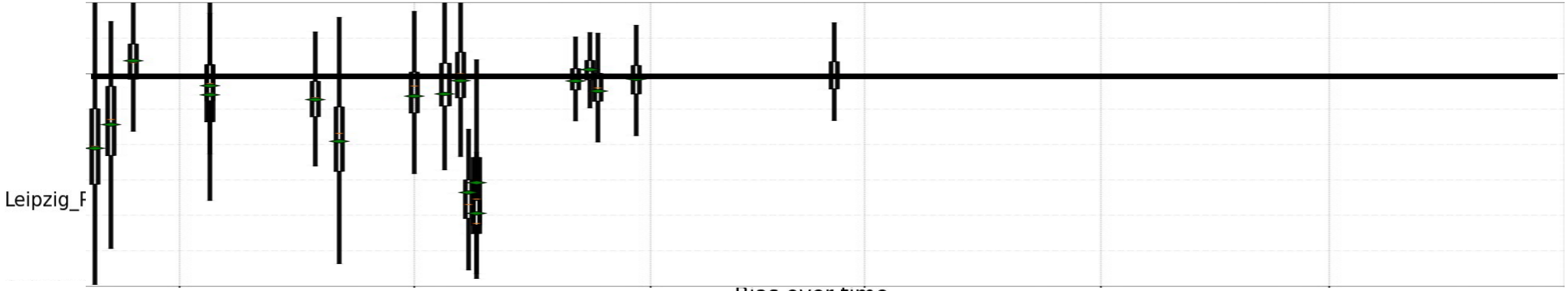


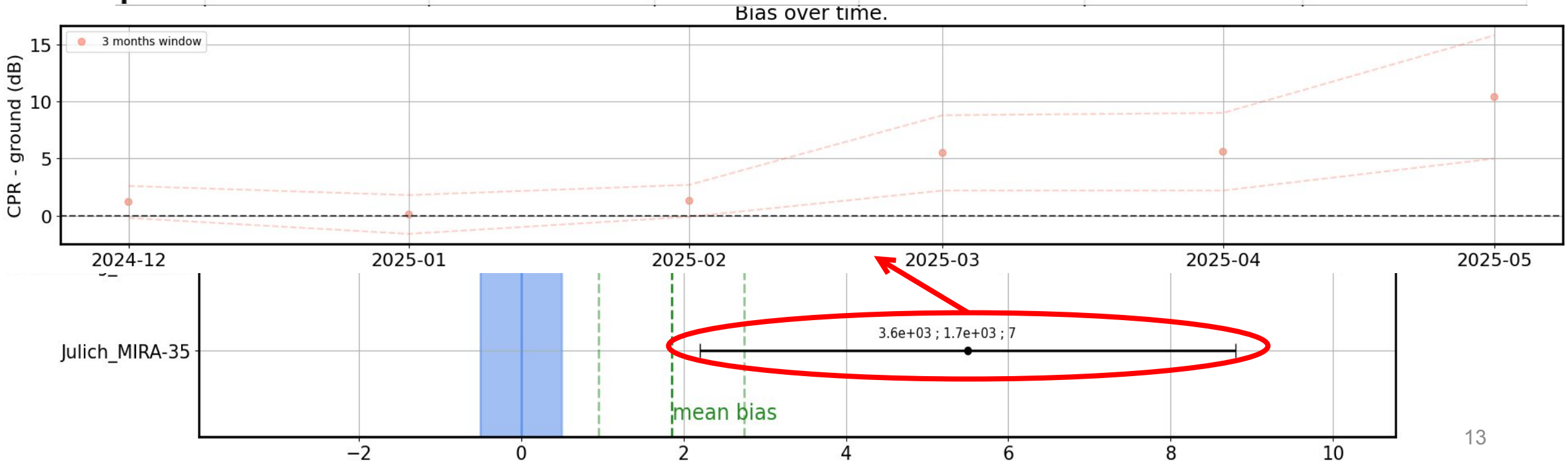
Validation: analyses



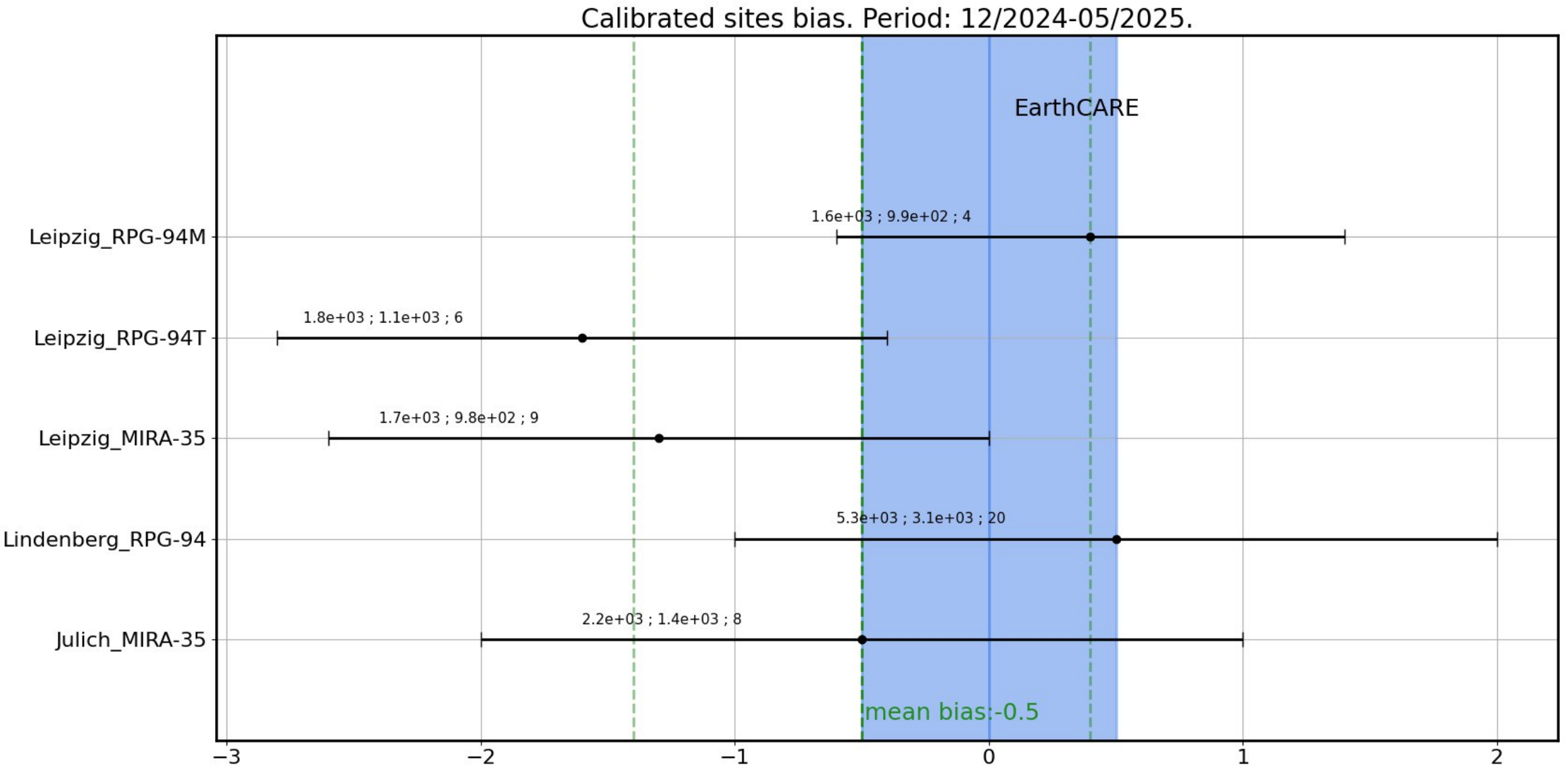
Validation: analyses

Disdrometer calibration monitoring





Preliminary results for validation sites



Conclusion

- Algorithm comparison fully implemented.
  - Compatible with ACTRIS data format.
  - Compatible with EarthCARE (L1, L2) and CloudSat data format.

- Preliminary bias estimated: -0.5 ± 1.5 dB.
  - Within EarthCARE's nominal uncertainty (± 0.5 dB).

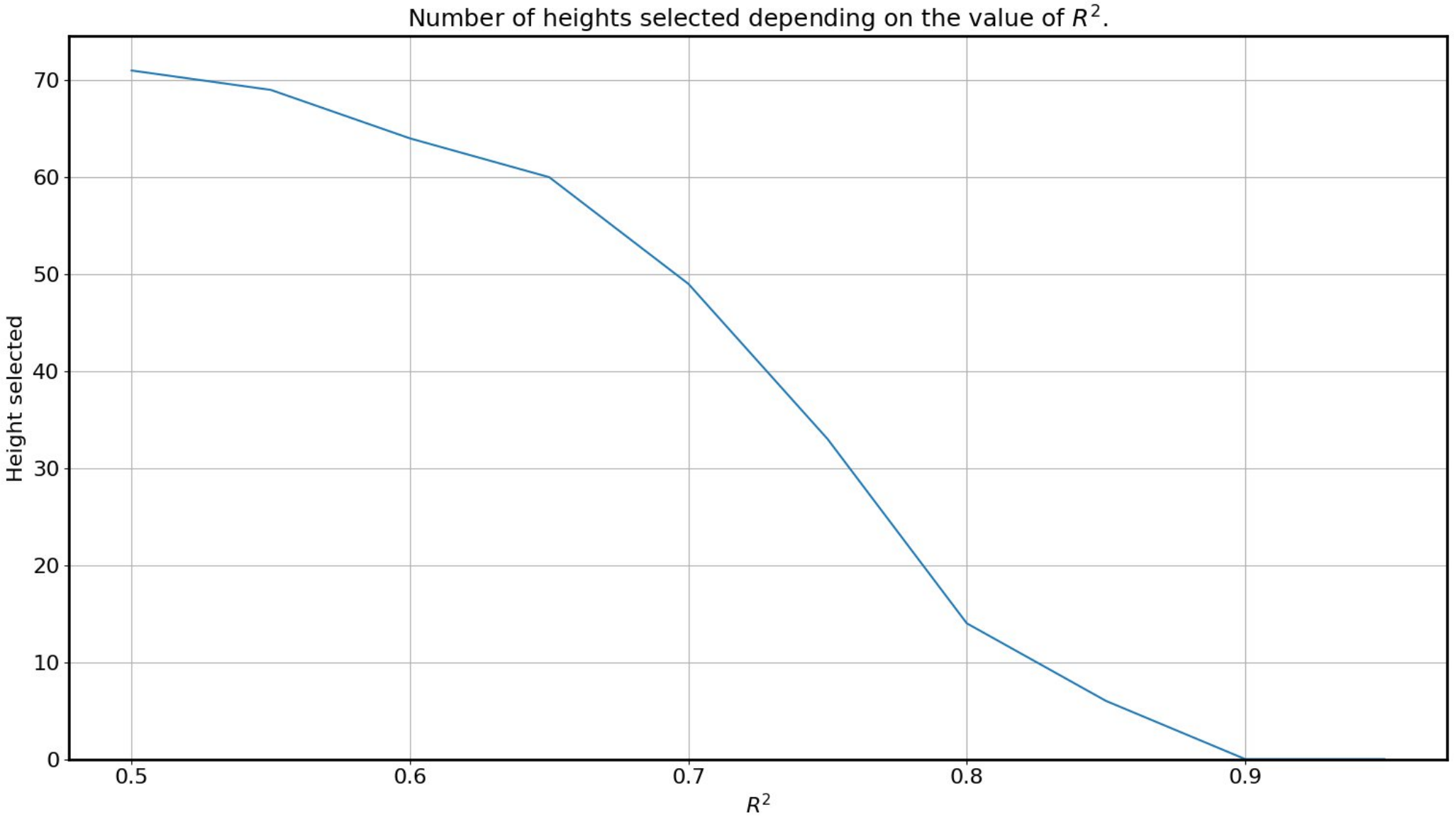
- Validation of reflectivities in an advanced phase, using ground radars calibrated by ACTRIS-CCRES.

Perspectives

- Study of the temporal variability on the results.
- The principles of Doppler velocity comparisons are being studied at the U. of Cologne. Planned implementation in our algorithm.
- Comparisons with AWACA will require efforts to adapt the code and compensate for the lack of classifications.
- Automatic analysis of changes in satellite-ground bias.

ANNEXE

Etude des paramètres: R²



Etude des paramètres: correlations et σ