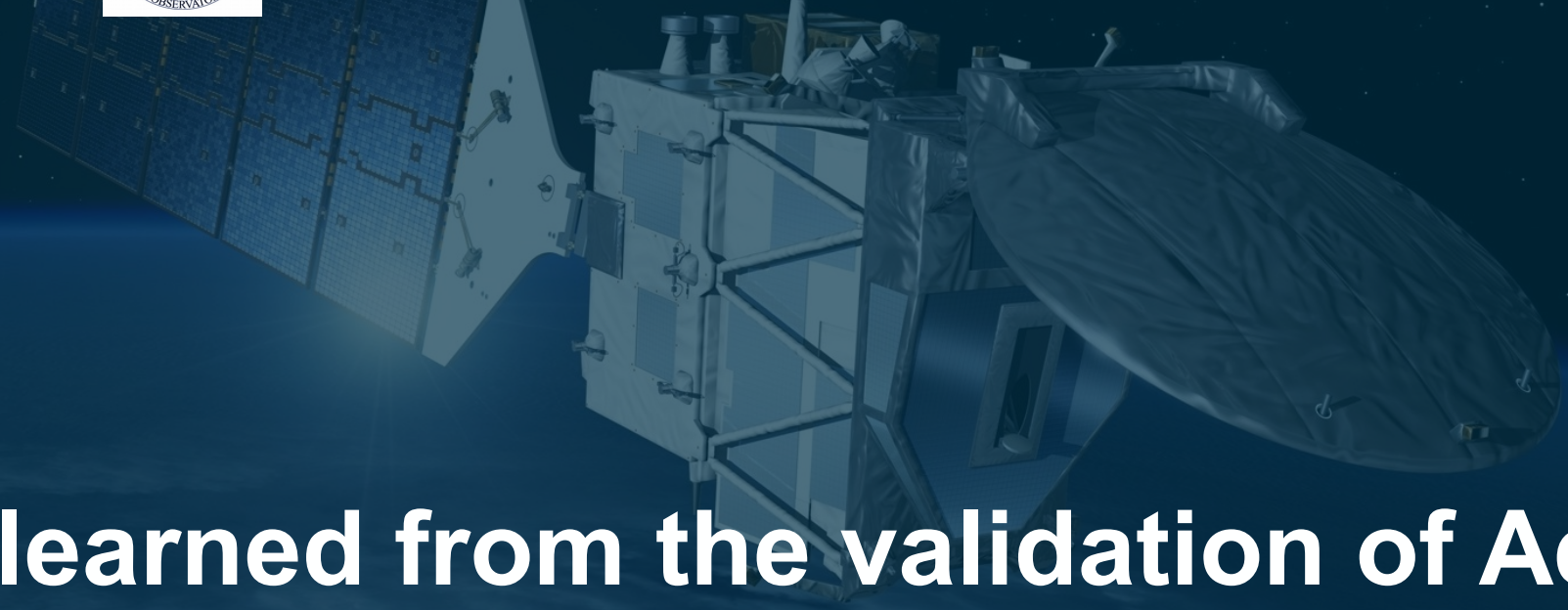

Lessons learned from the validation of Aeolus L2A product with EARLINET

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Holger Baars (TROPOS)

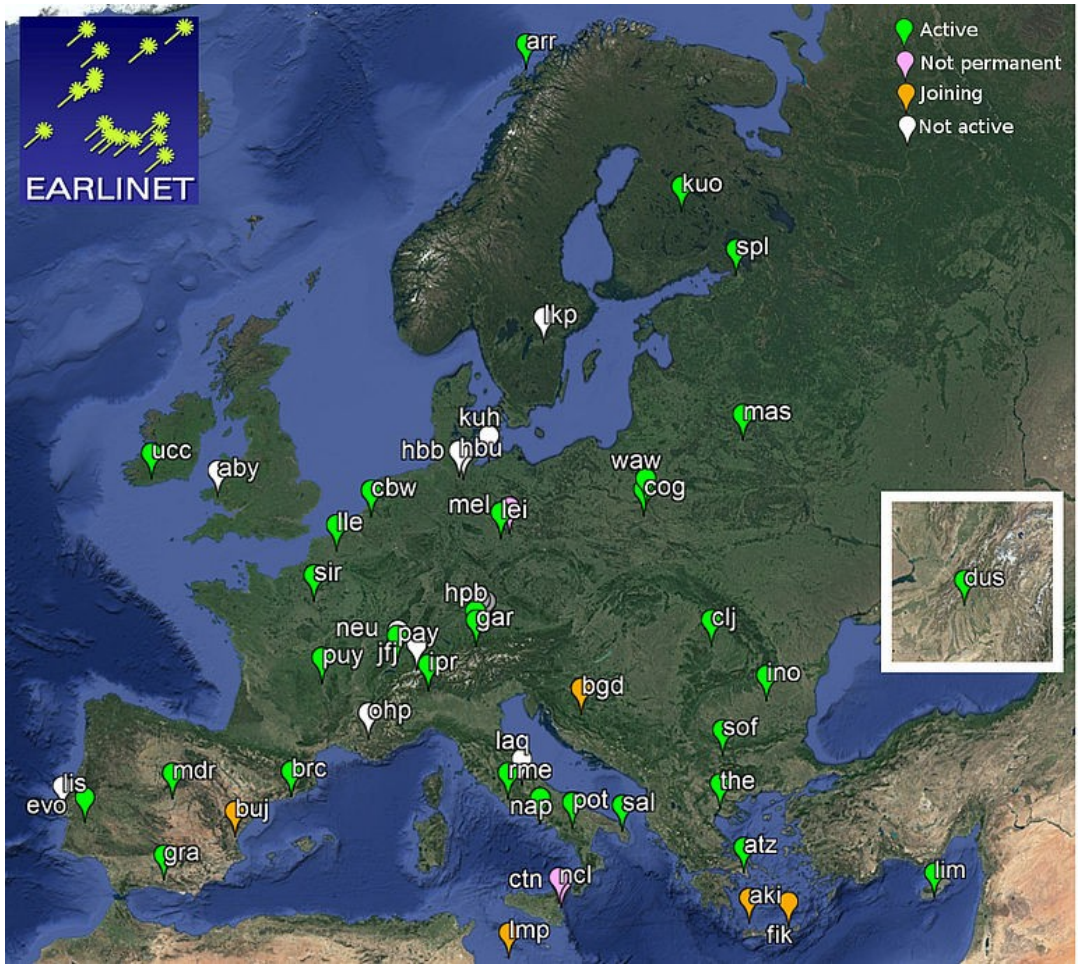
Contribution from the EARLINET consortium

2nd ESA EarthCARE Validation Workshop

25-28 May 2021 (online)

EARLINET Cal/Val

Evaluate the **AEOLUS satellite L2A product** with the retrievals of the ground-based lidar systems of **EARLINET** (European Aerosol Research Lidar Network)



Station	No. of Overpasses
Antikythera	8
Andoya	1
Athens	Under Processing
Barcelona	20
Bucharest	2
Granada	14
Evora	25
Lecce	2
Leipzig	Under Processing
Lille	3
Potenza	6
Thessaloniki	9
Warsaw	1

96 Overpasses

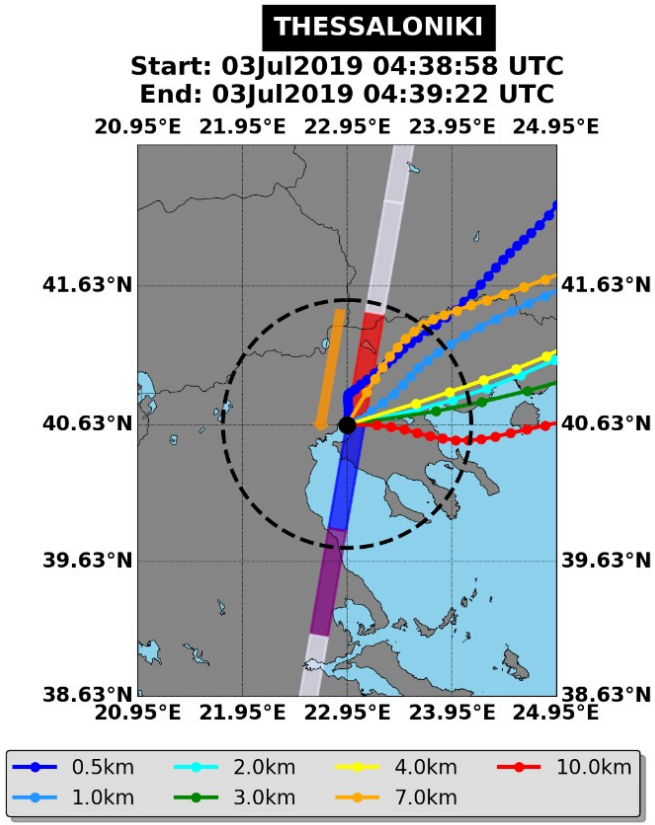
- AEOLUS Baseline 10 files (06/2019 - 10/2020)
- AEOLUS Baseline 11 files (10/2020 – 05/2021)
- Analysis focused on the AEOLUS Backscatter
- Conversion to AEOLUS like co-polar backscatter when possible

- Backscatter profiles from 13 stations were analysed – more will be added soon
- 4 stations included depolarization ratio profiles at 355m – used for conversion to AEOLUS like Backscatter

Methodology

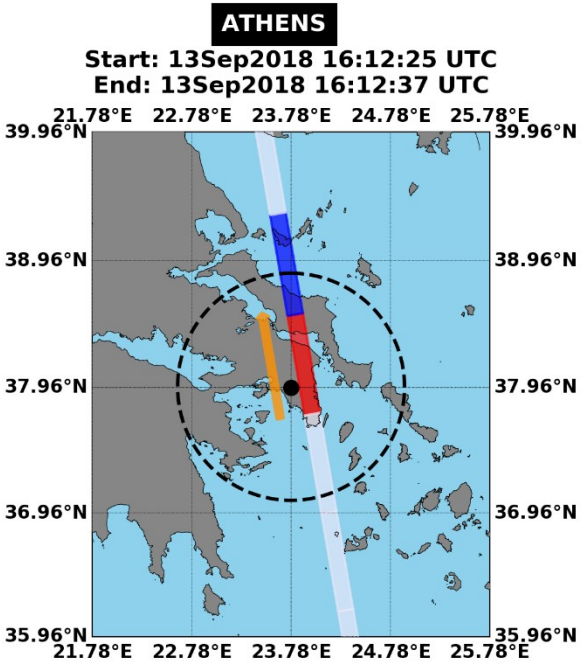
Collocation Criteria

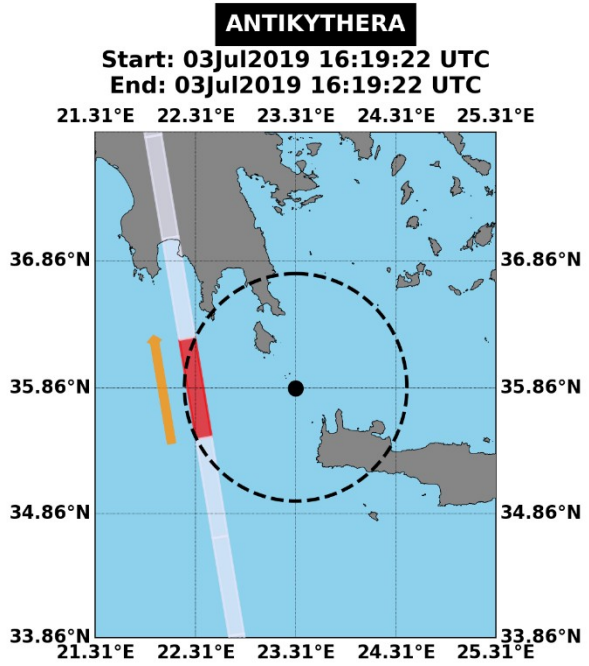
- Spatial collocation → **100km**
- Temporal collocation → **±3 hours**



Handling multiple profiles in a single overpass

- **Closest** overpass: The closest satellite profile in time to the ground-based measurement is selected
- **Average** overpass: The satellite profiles (up to 3 for 100km radius) are averaged

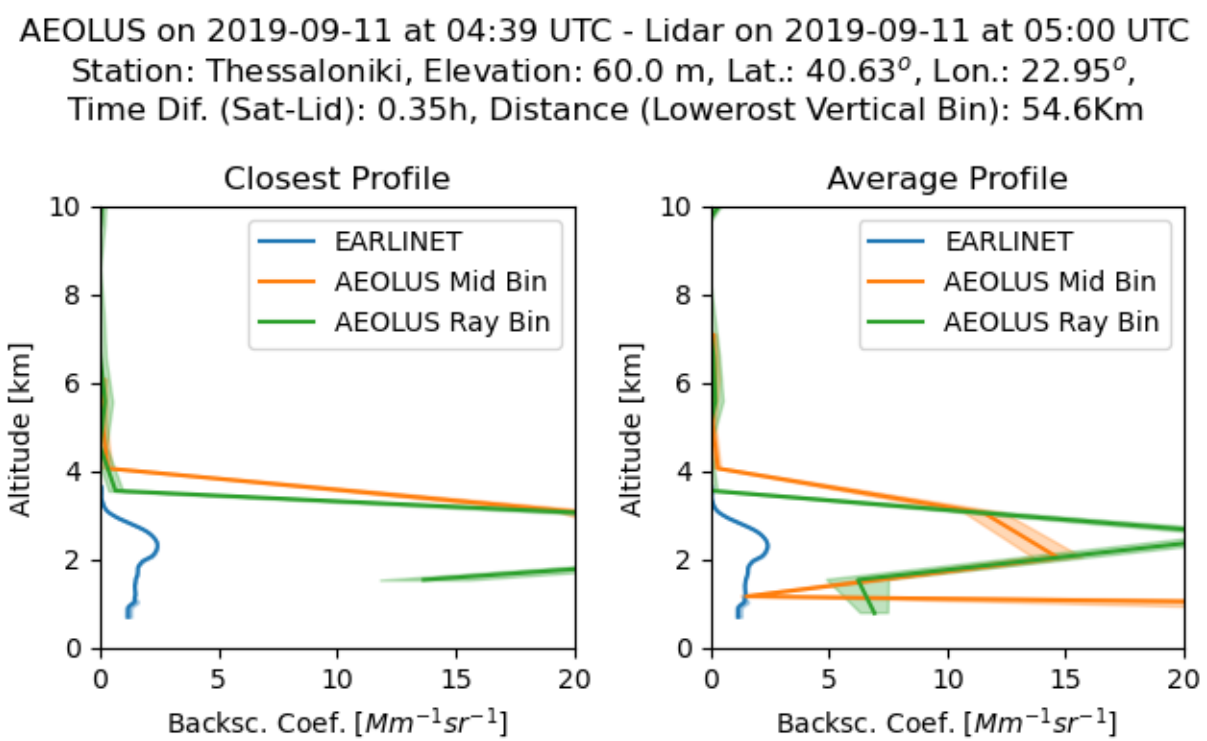


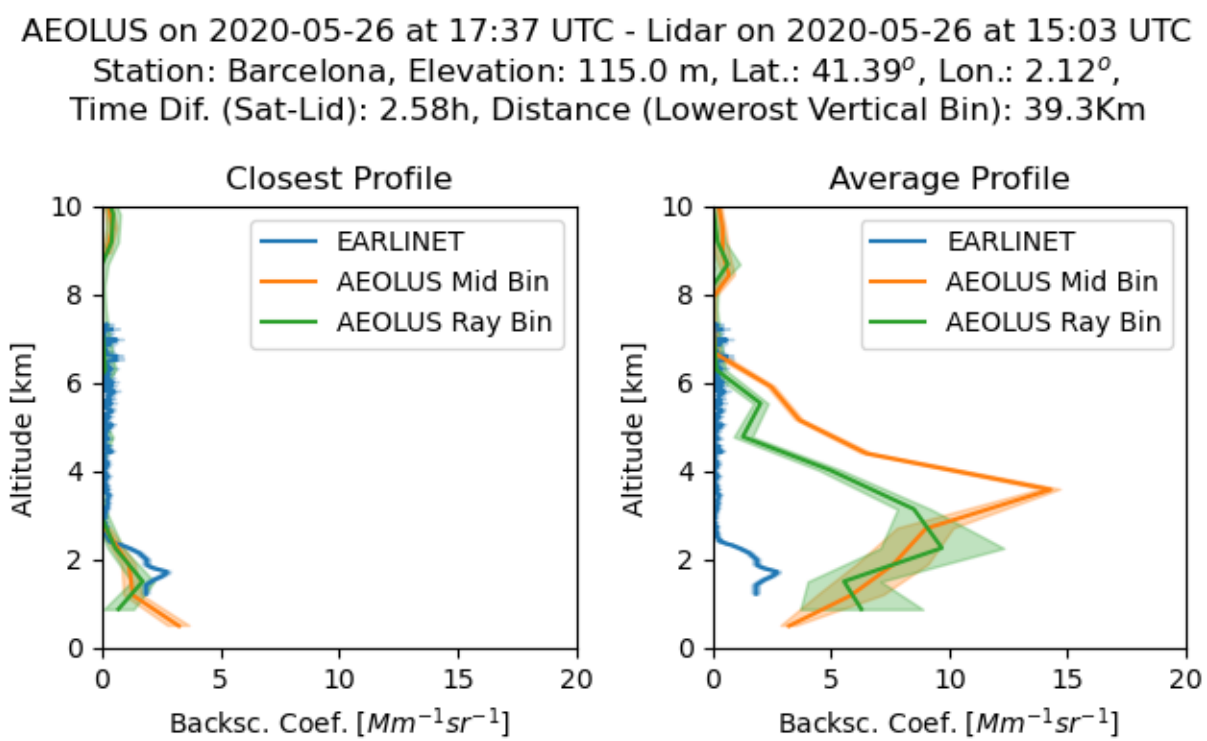


Methodology

Basic Cloud Screening on AEOLUS profiles

- Using the profile optical depth → less than 1.5
- Using bin-to-bin backscatter difference → less than 7.5 Mm^{-1} sr^{-1}





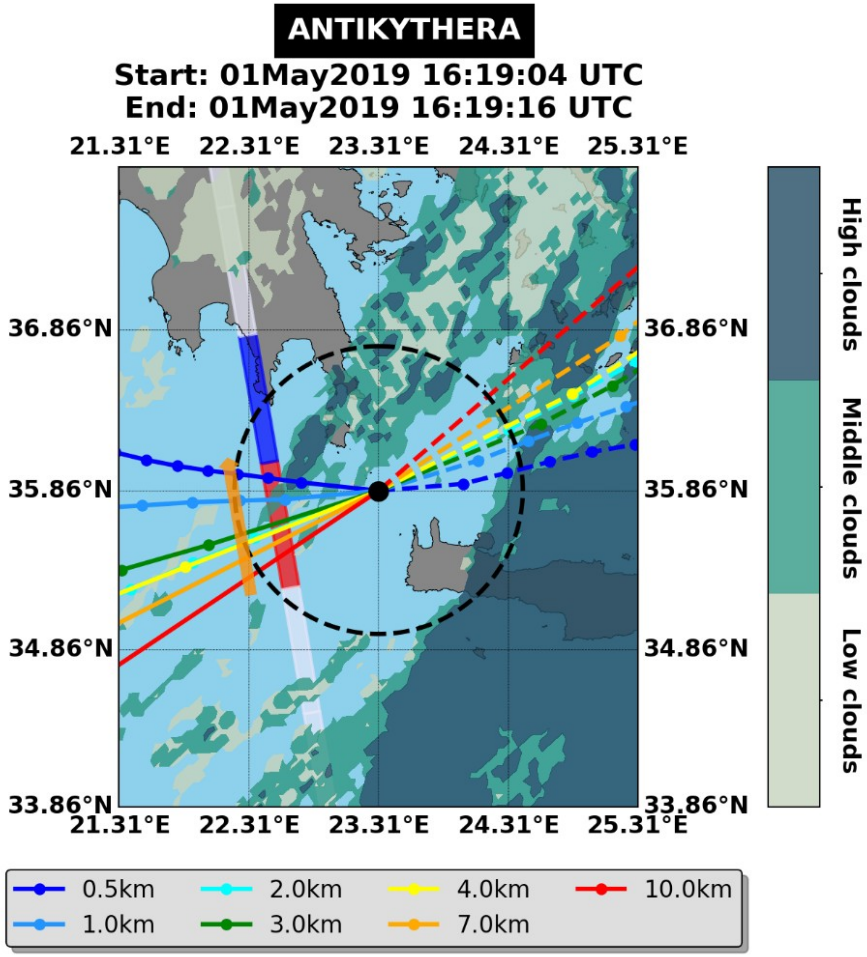
Methodology

Basic Cloud Screening on AEOLUS profiles

- Using the profile optical depth → less than 1.5
- Using bin-to-bin backscatter difference → less than 7.5 Mm^{-1} sr^{-1}

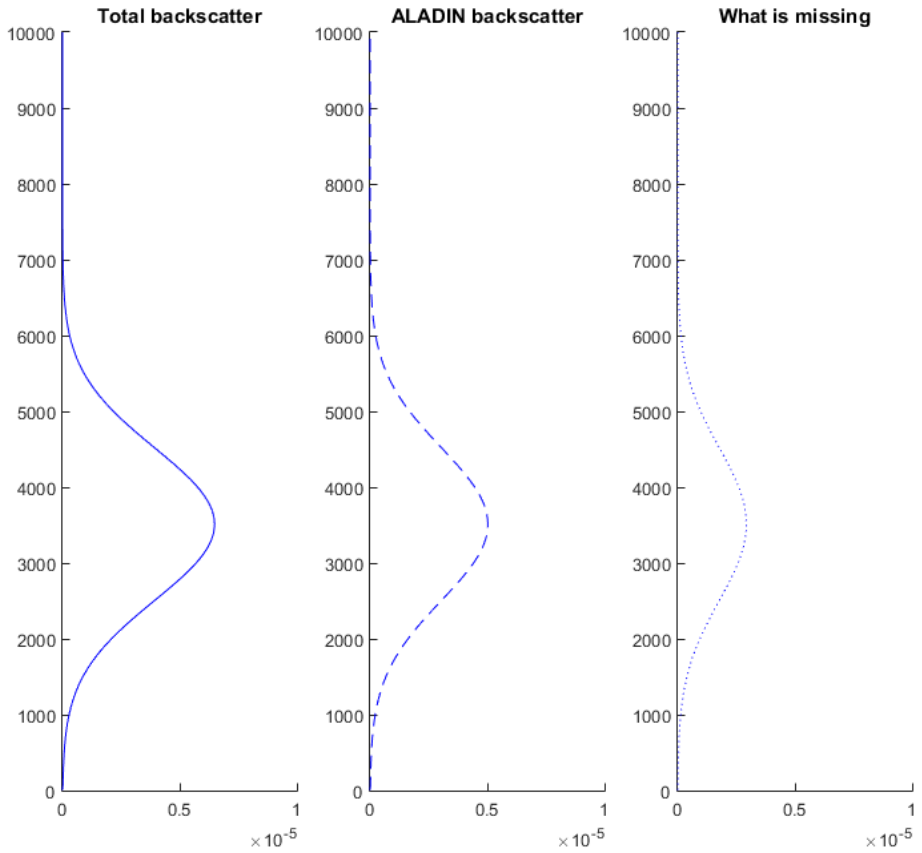
More sophisticated approaches in the future (not implemented here)

- Use satellite cloud data (e.g. MSG) for automated cloud screening



Aeolus-like products: backscatter coefficient

Simulation for a typical dust aerosol layer with a linear particle depolarization ratio ~30%



AEOLUS detects the co-polar component from circularly polarized radiation at 355nm → **underestimation when comparing to the total backscatter**

Some EARLINET stations perform linear particle depolarization measurements

The total backscatter can be converted to AEOLUS like:

- by converting the particle linear to particle circular depolarization ratio first
- Then use the particle circular depolarization ratio to convert the total to co-polar backscatter (AEOLUS like backscatter)

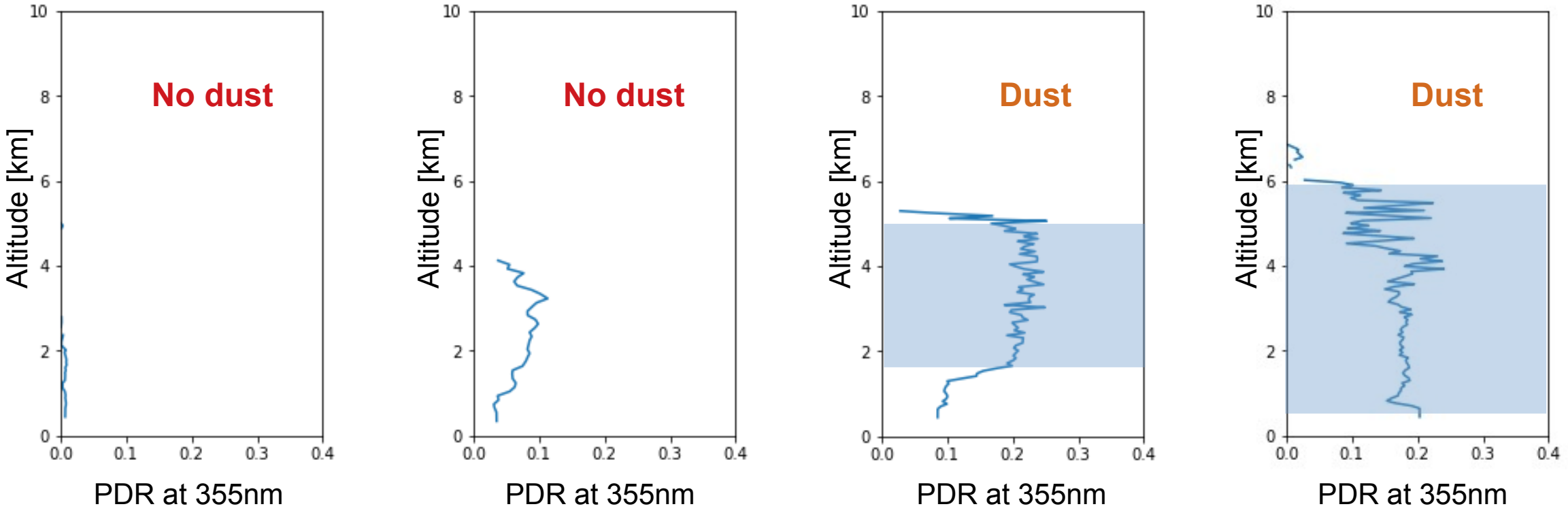
It is important to identify the dust cases!

Dust mask

EARLINET based flags

- Thresholds applied on depolarization profiles (355 or 532nm)
- Particle Dep. Ratio between 0.1 and 0.4 in a vertical region larger than 500m in the profile
- Not all stations have depolarization channels!

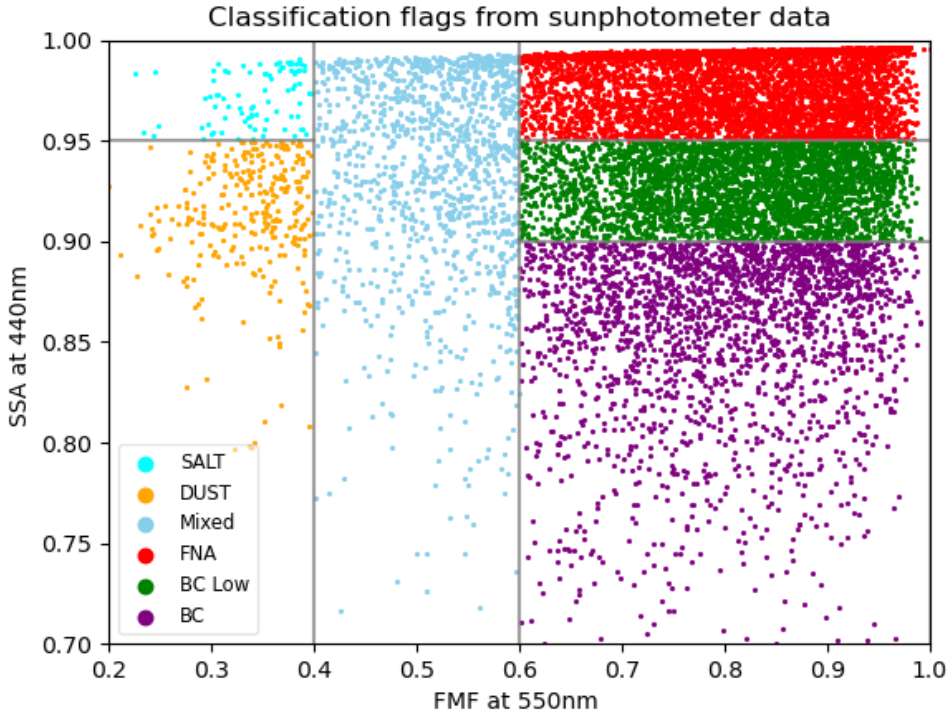
Antikythera Sample Profiles

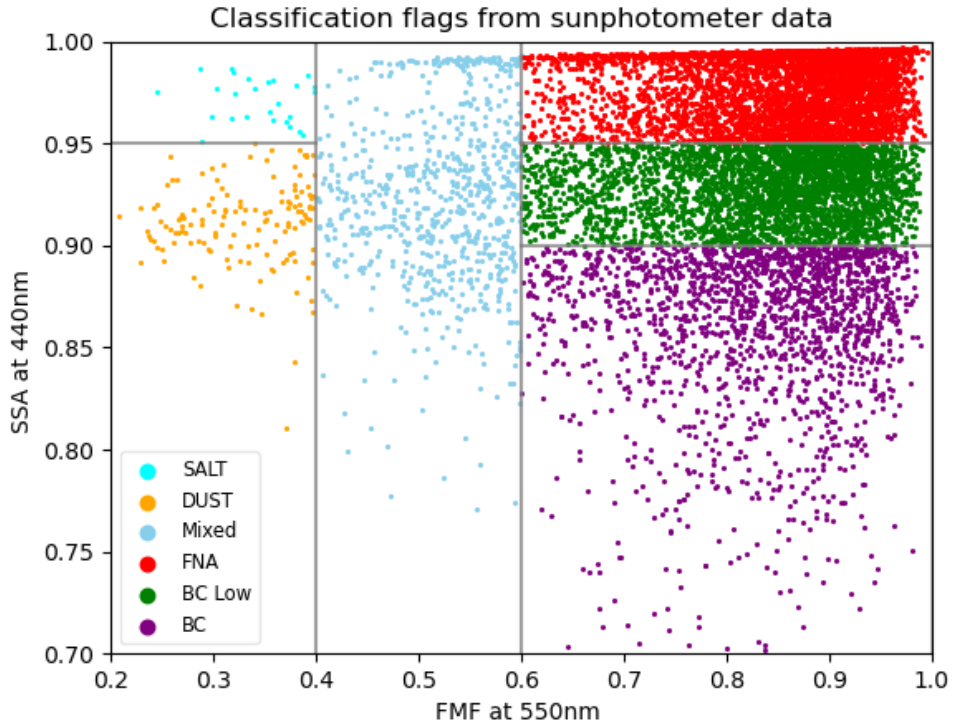


Dust mask

AERONET based flags (Version 3 – Level 1.5 files)

- Using the Fine Mode Fraction 550nm and the Single Scattering Albedo 440nm
- FMF usually available for daytime direct sun measurements

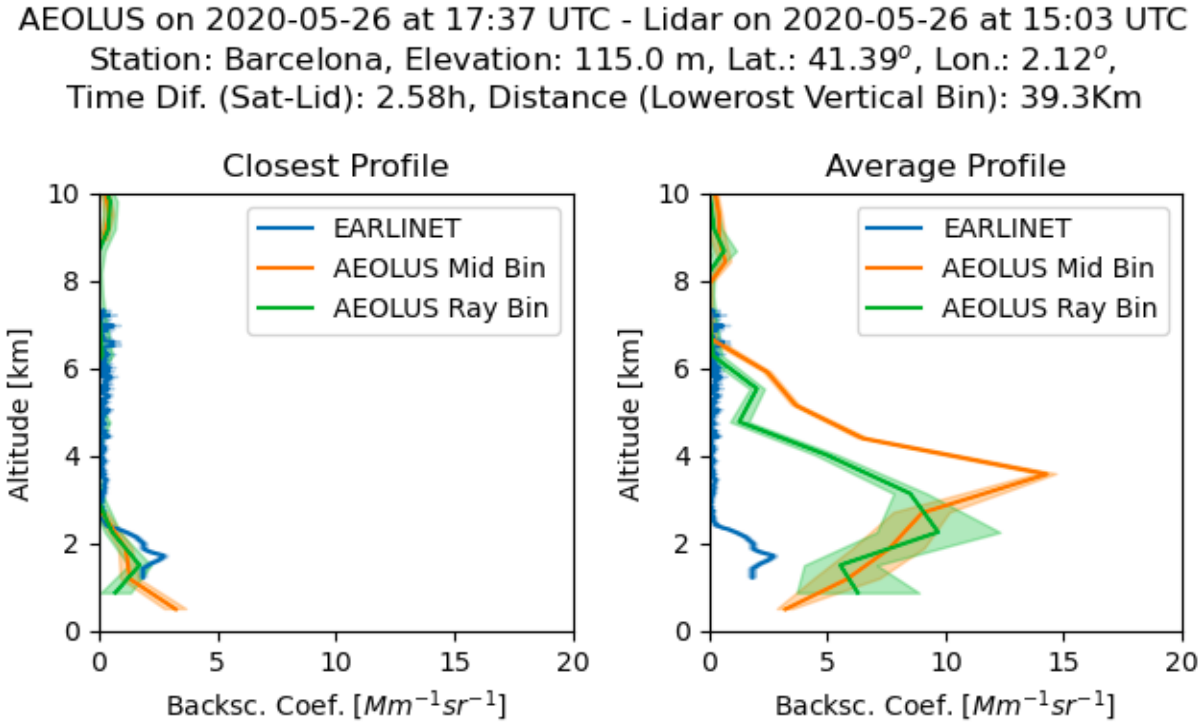




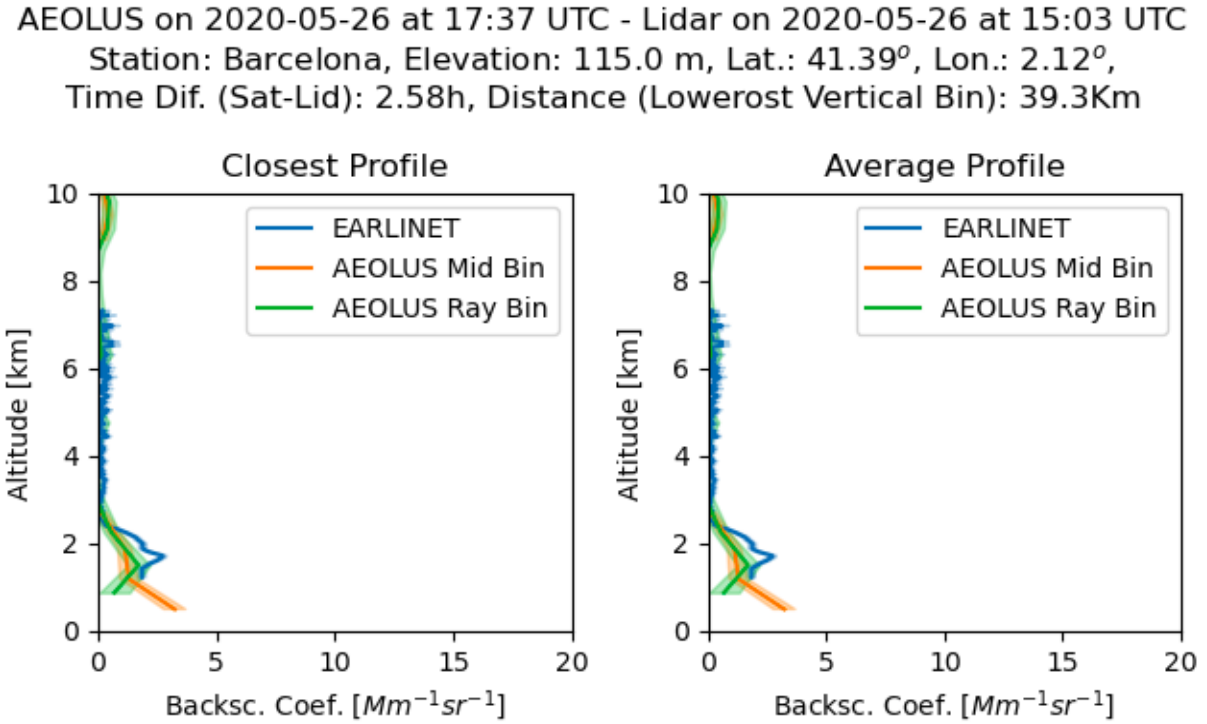
Lee et al. 2010
Siomos et al. 2020

Some examples

Cloud Mask off



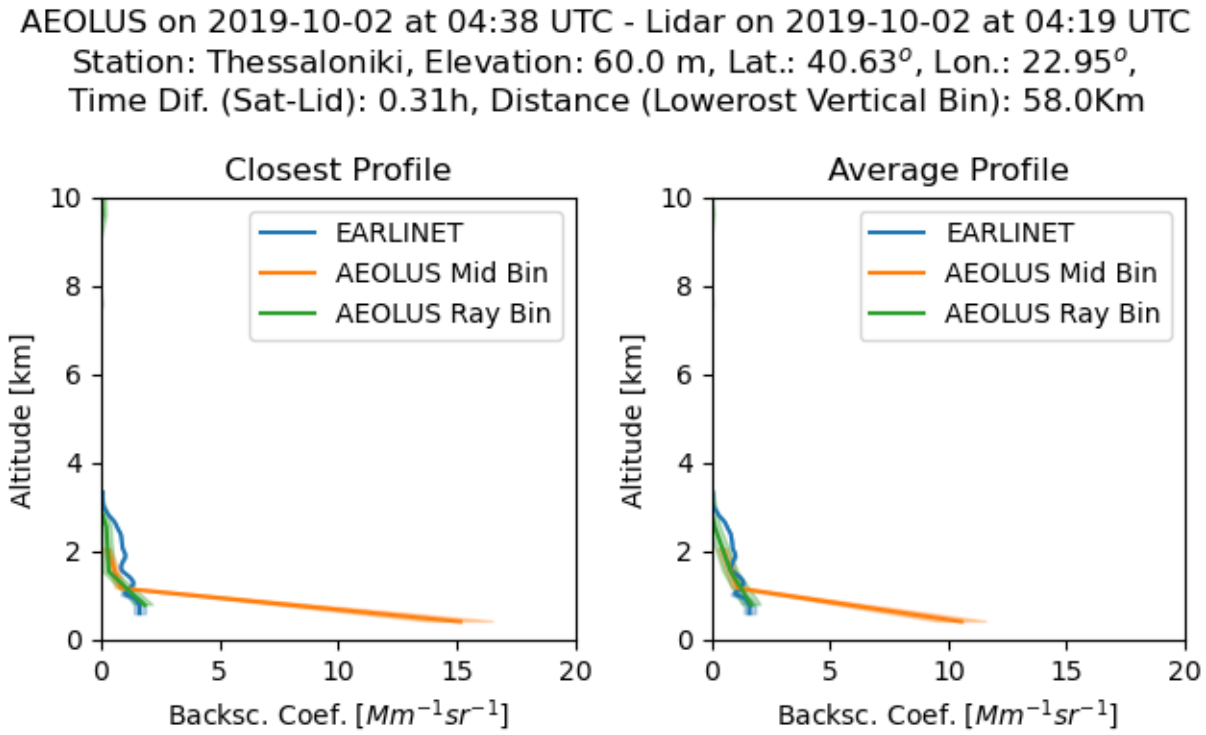
Cloud Mask on



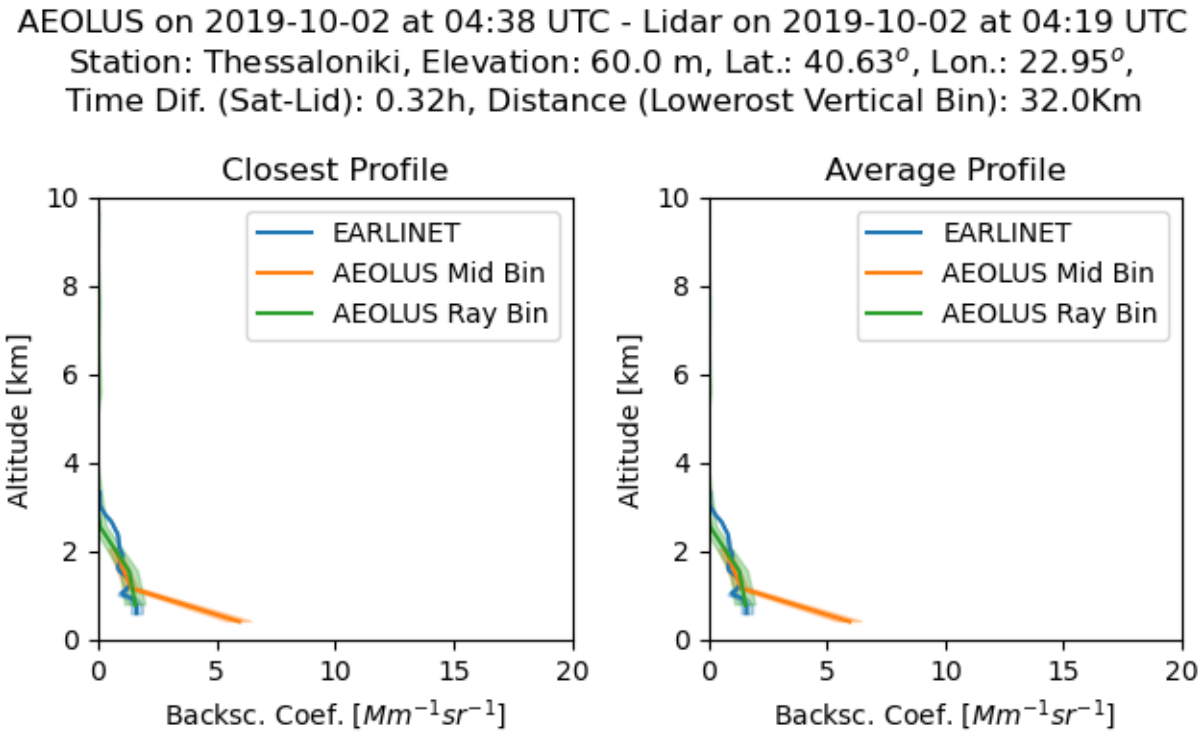
- Here at least 1 satellite profile within the overpass was cloud free.
- Removing the cloudy ones leaves the best to be selected as overpass for the Average profile

Some examples

Cloud Mask off

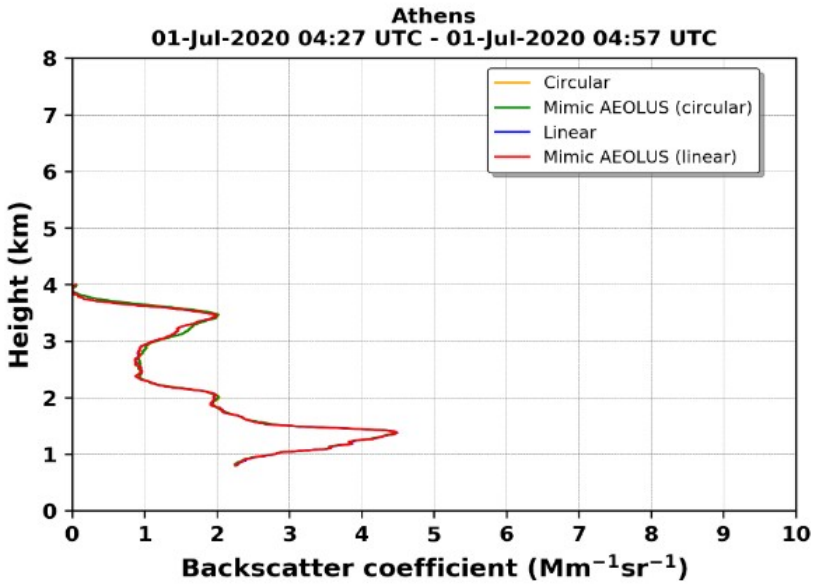


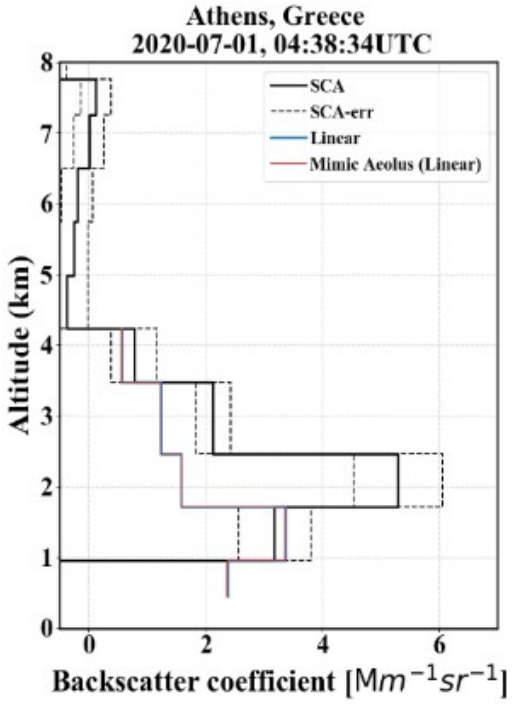
Cloud Mask on



- The ground spike is common. It is not clear if it due to cloud contamination
- The bin-to-bin backscatter threshold leads to better profiles

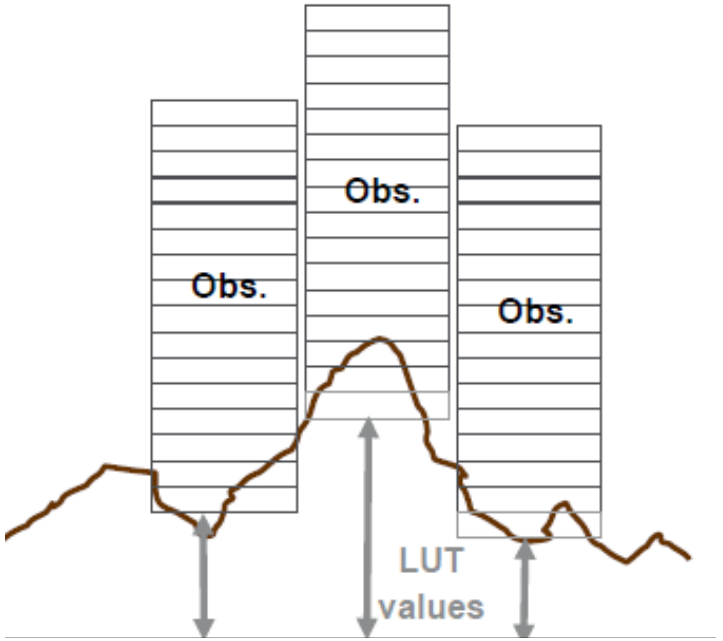
EARLINET vertical profiles to AEOLUS vertical levels





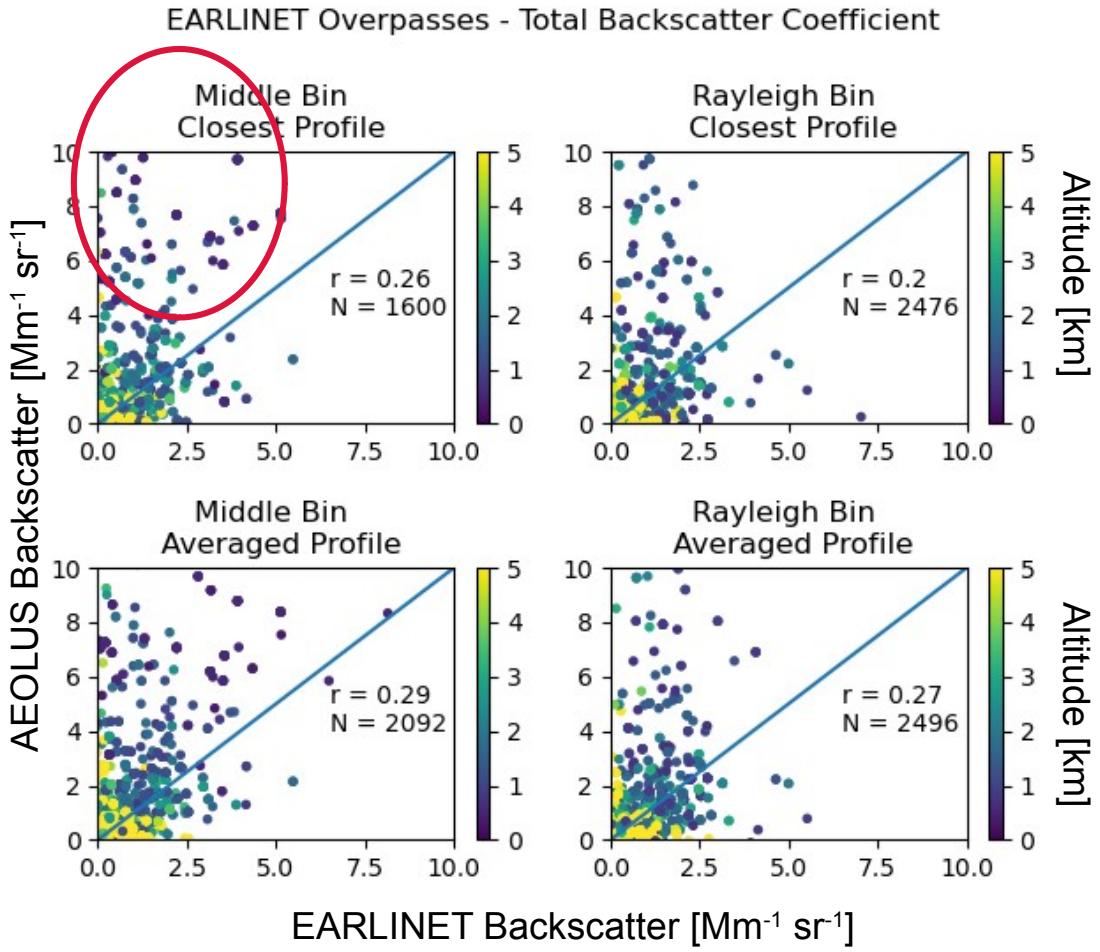
The conversion is performed case wise

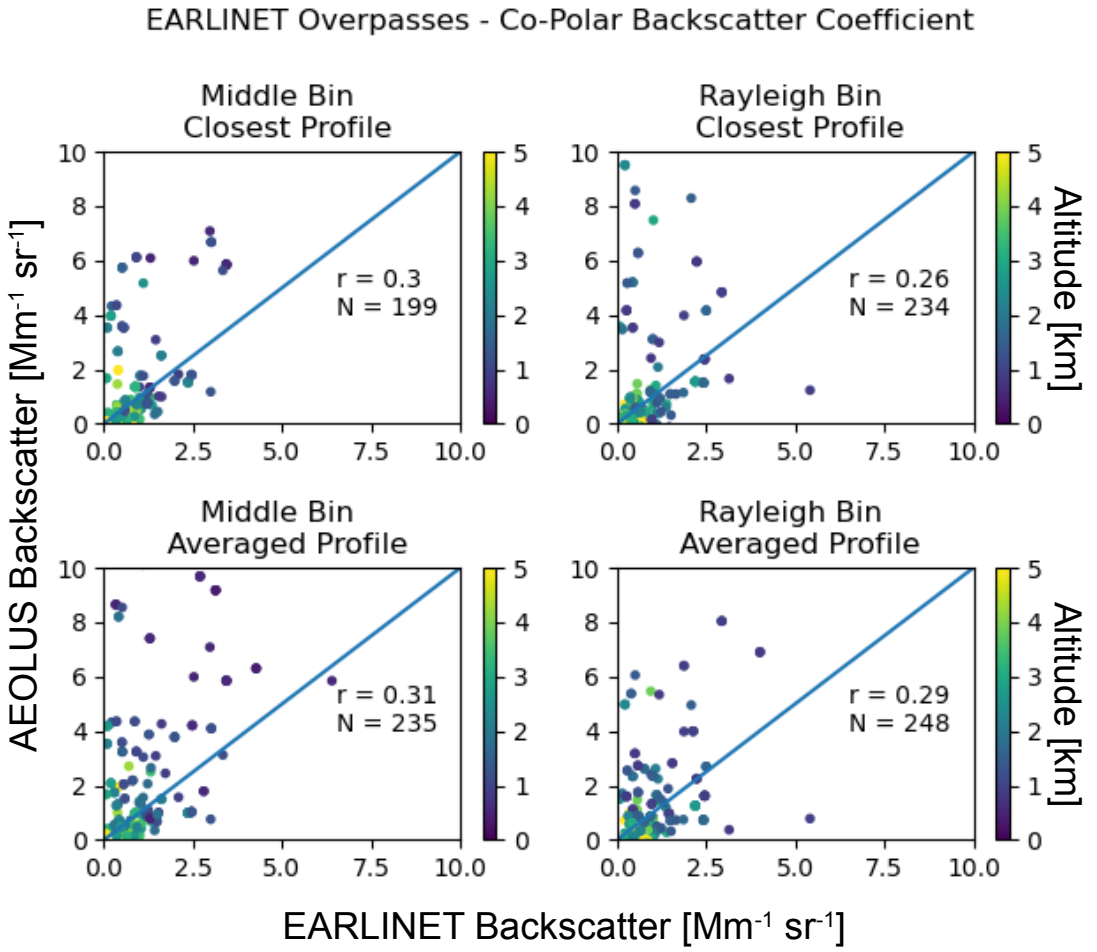
Each overpass corresponds to **slightly different altitude vertical levels** due to orography



- Rescaling of ground profiles to AEOLUS vertical bins
- Modification on the profile shape and optical properties magnitude
- Necessary in order to quantify the differences!

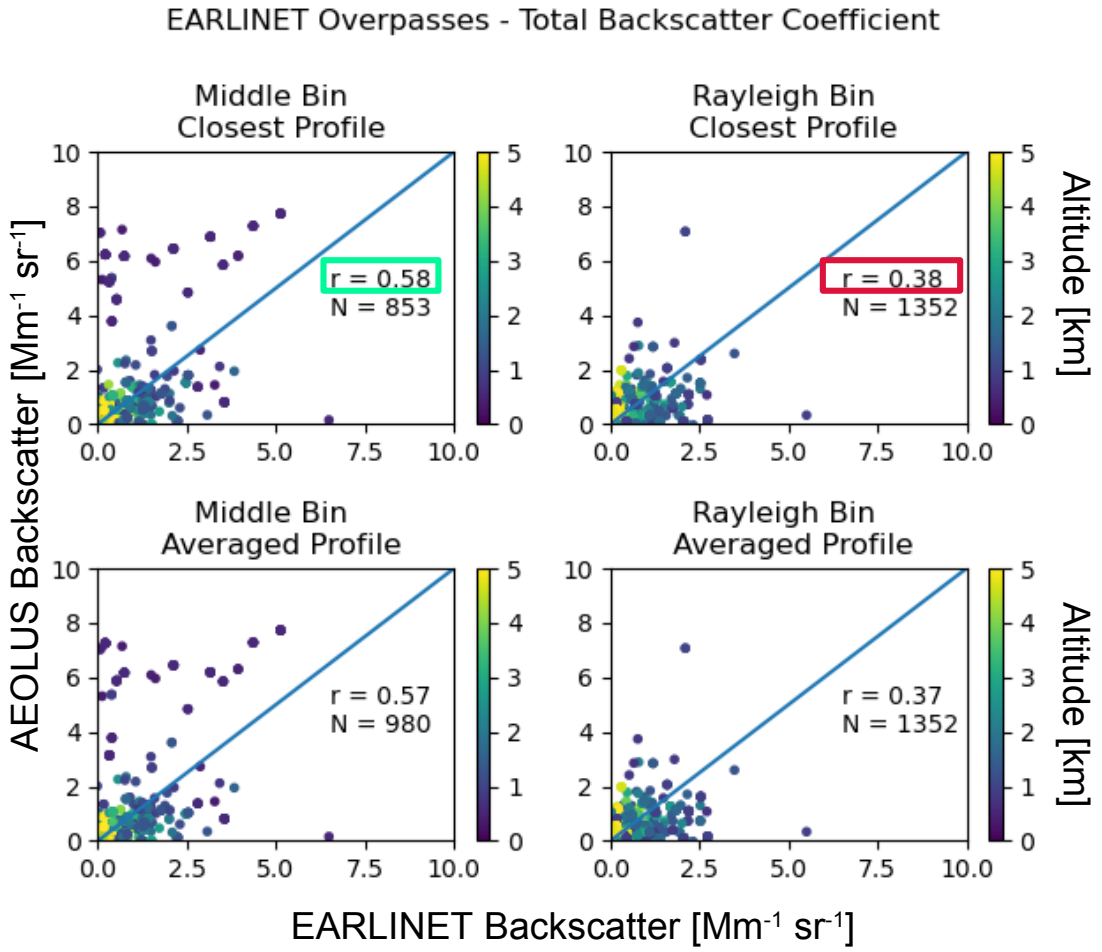
Correlation – cloud mask off

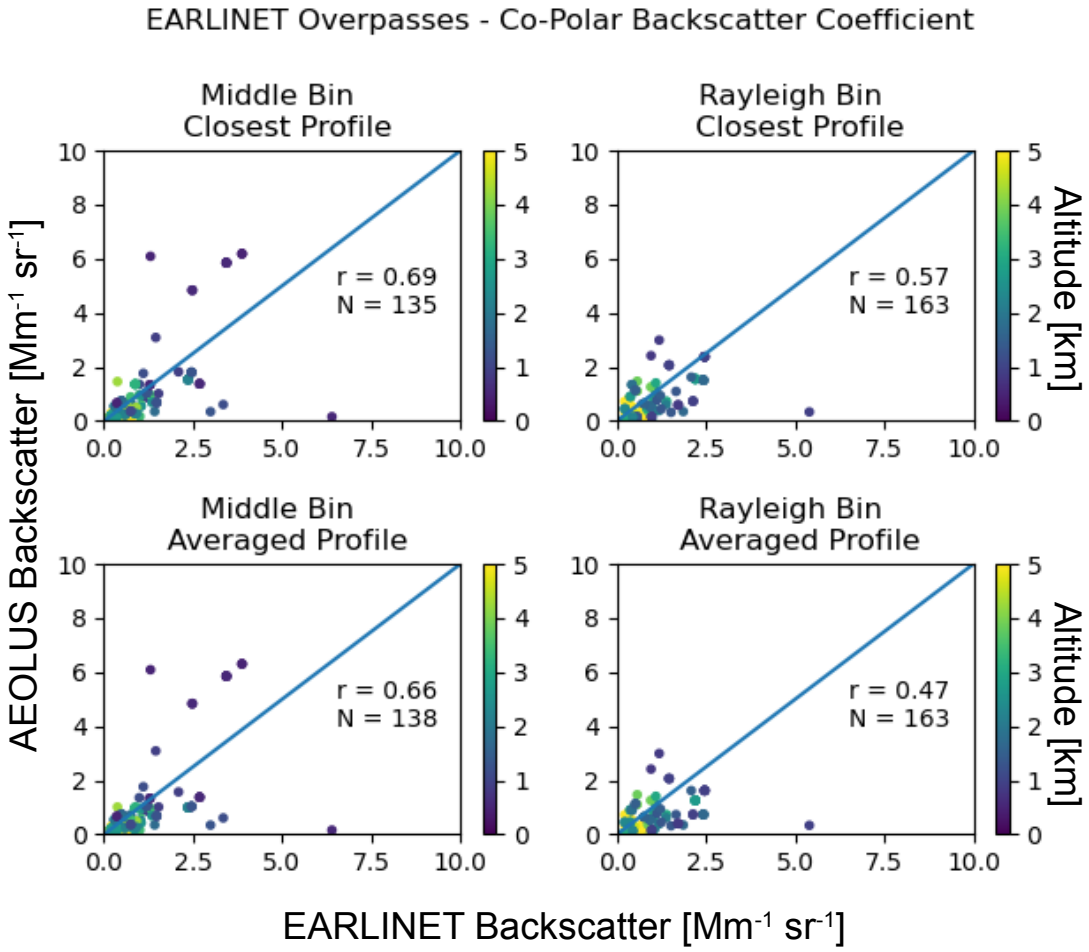




- Larger AEOLUS backscatter values due to clouds --> low correlation

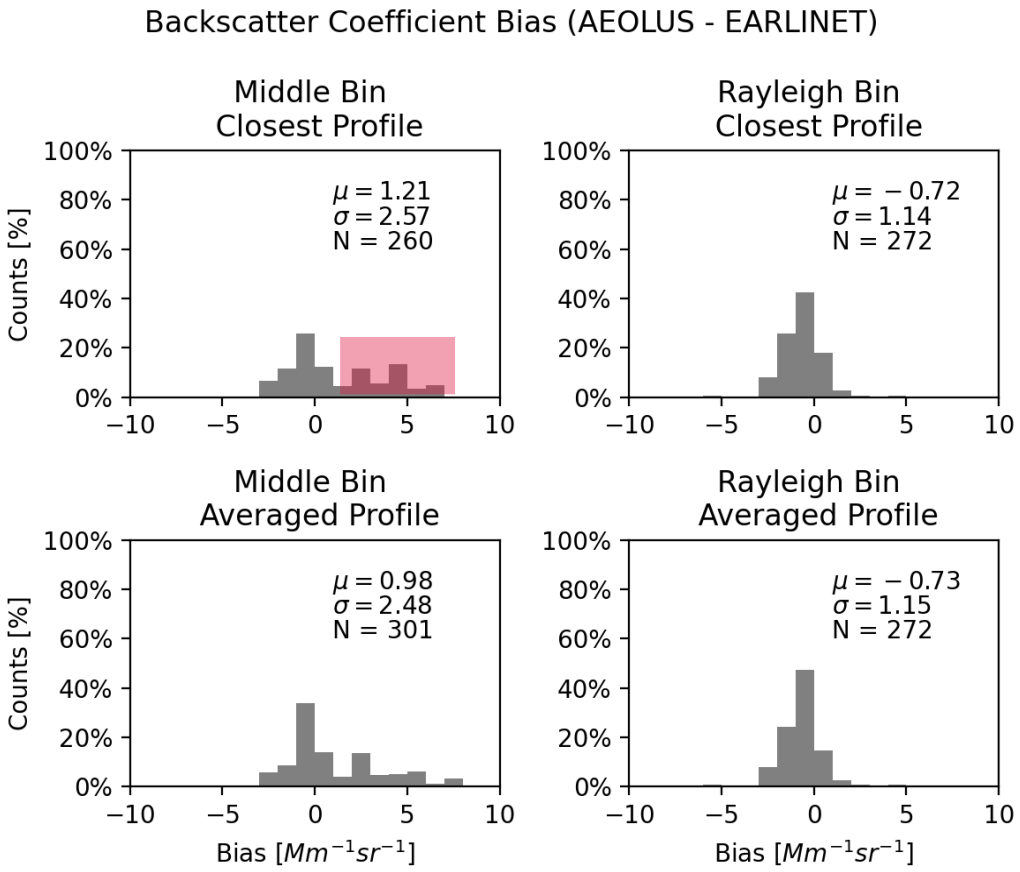
Correlation – cloud mask on

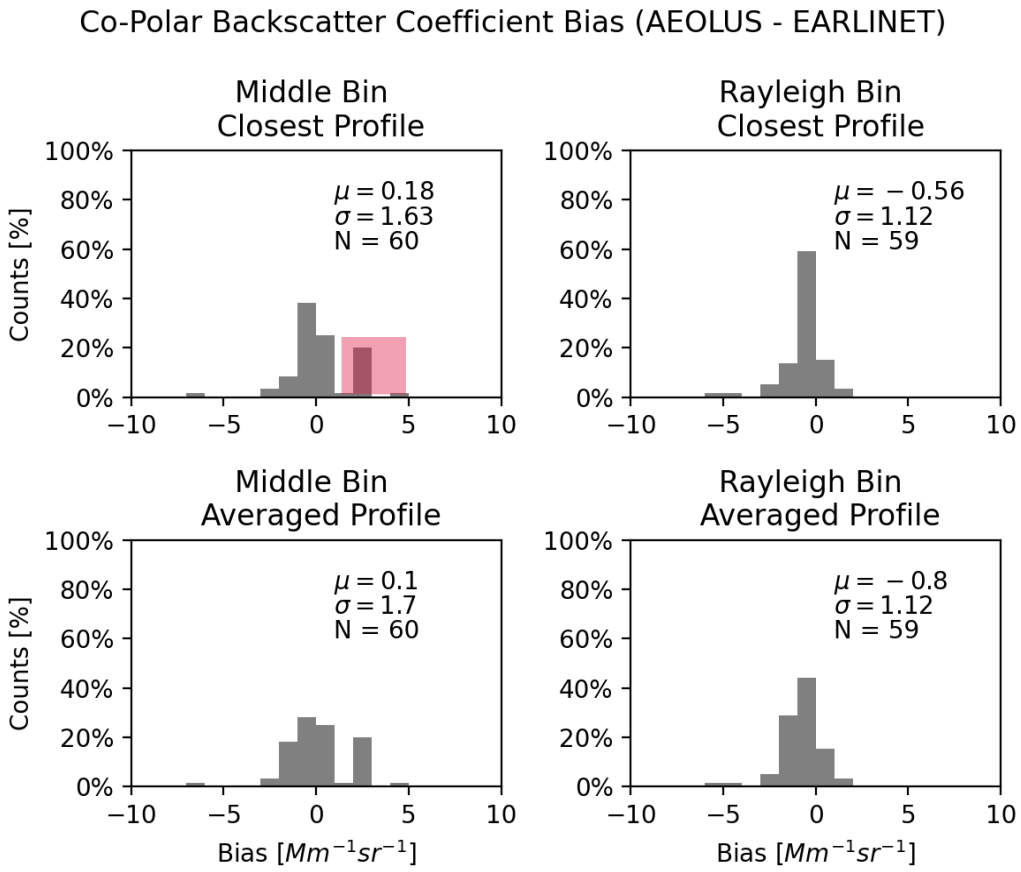




- Most large values are removed and the correlation improves
- Higher correlation values for the Middle Bin algorithm – closest profile better correlated for the co-polar

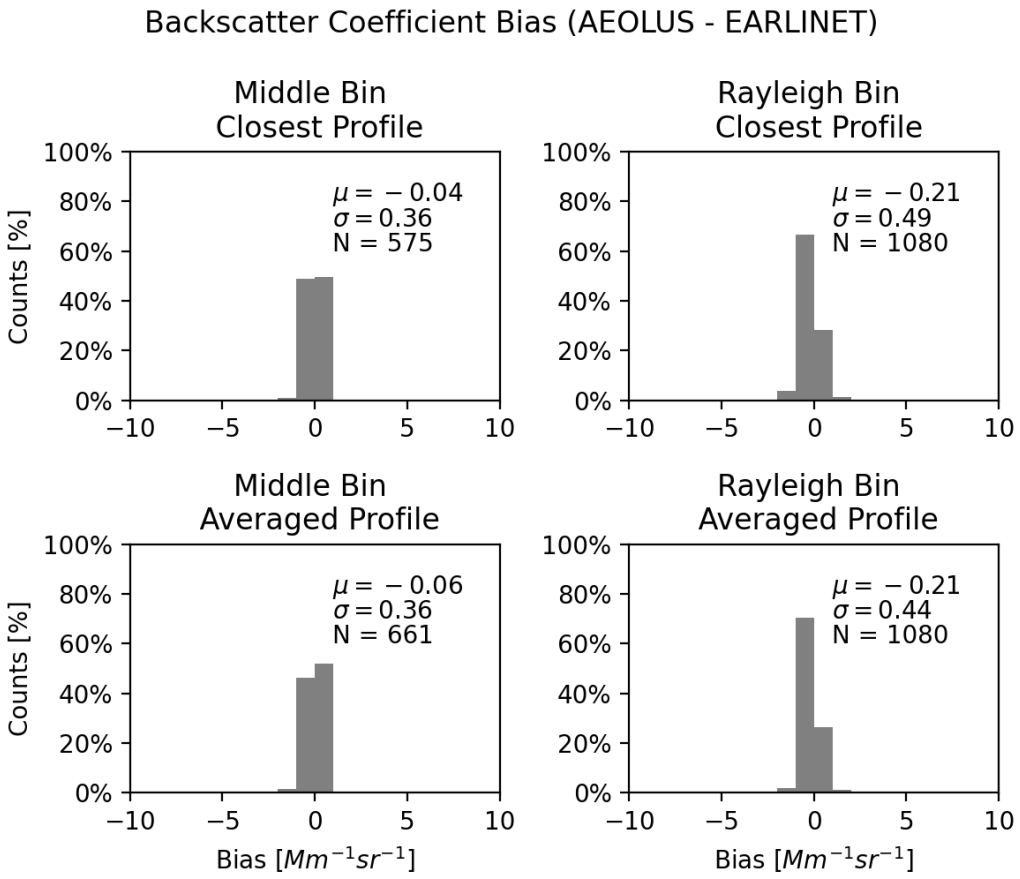
Biases below 2km – cloud mask on

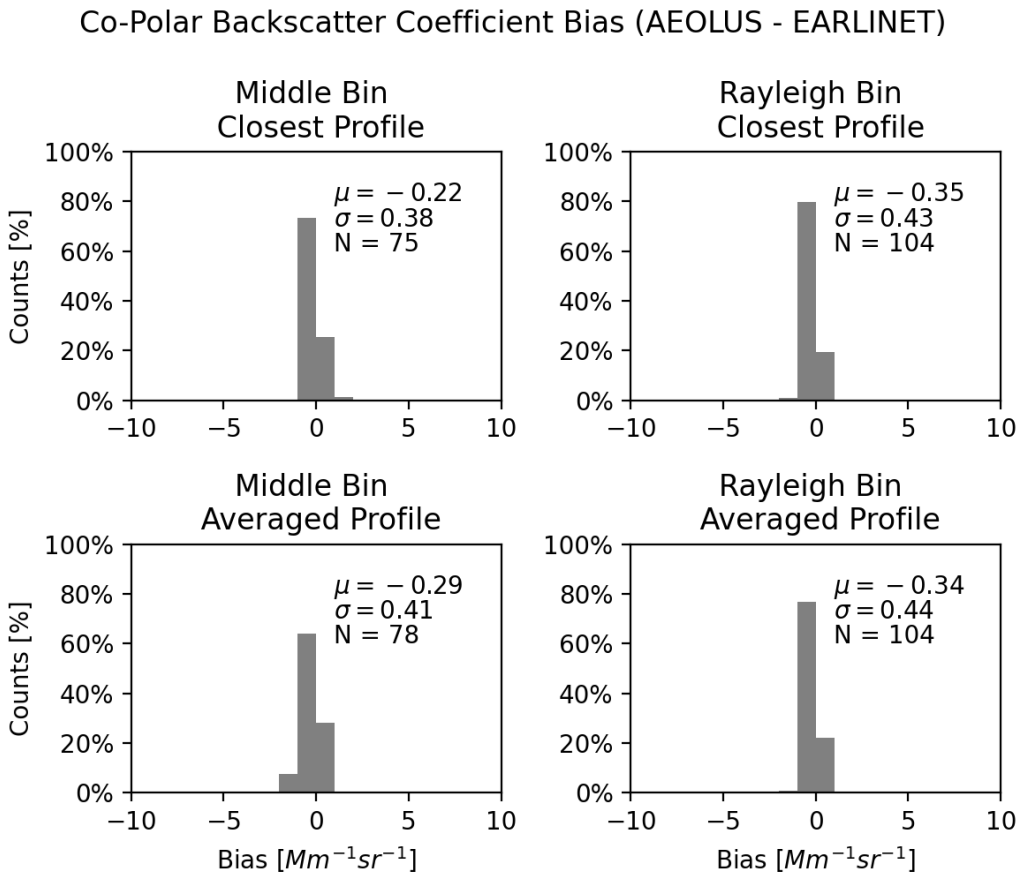




- AEOLUS tendency to overestimate below 2km in the Middle bin algorithm
- Reason --> Ground spike! It mainly occurs to Middle Bin

Biases above 2km – cloud mask on

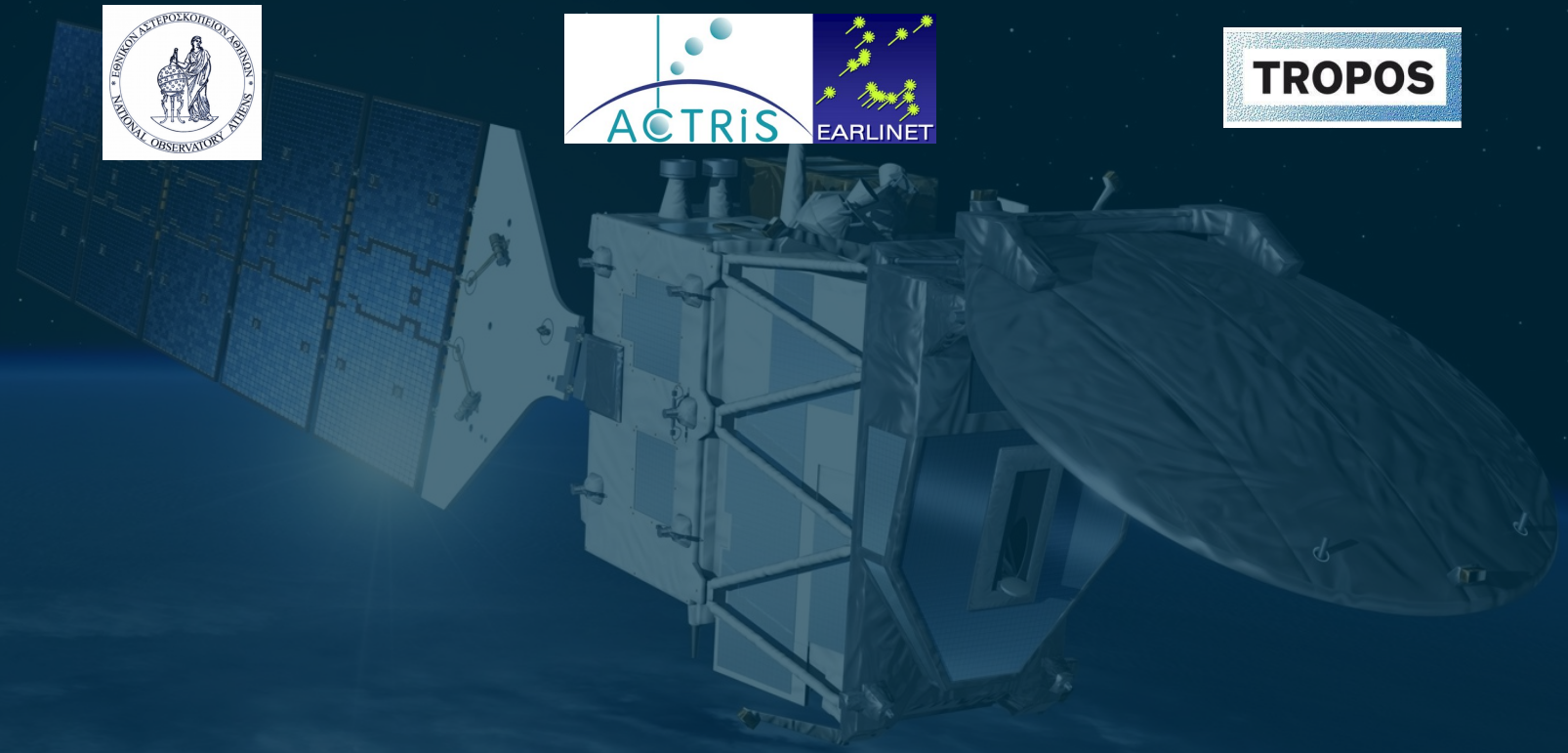




- Better statistics above 2km! Both the mean bias and the spread are reduced
- Using the co-polar backscatter doesn't seem to improve the bias BUT the number of co-polar data is limited
- Applying the dust flags will show if there is a clear negative AEOLUS total backscatter bias

Summary

- A basic **cloud mask** can be achieved from AEOLUS data – awaiting for the Baseline 12 products that include scene homogeneity flagging
- AEOLUS vs EARLINET backscatter **correlation** increase from approx. **0.2 - 0.3** to **0.5 - 0.7** by throwing out the cloud contaminated data
- Better correlation for the **Middle Bin** than the **Rayleigh Bin**
- The **ground spike** issue is more pronounced in the **Middle Bin** algorithm leading to positive biases below 2km
- Better statistics (mean absolute bias and spread) **above 2km**: MAB 1.25 → 0.35 $Mm^{-1}sr^{-1}$ Spread: 2.5 → 0.5 $Mm^{-1}sr^{-1}$
- The dust flags will be applied soon → check if dust cases are associated with more negative total backscatter mean biases



Thank you for your attention!

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