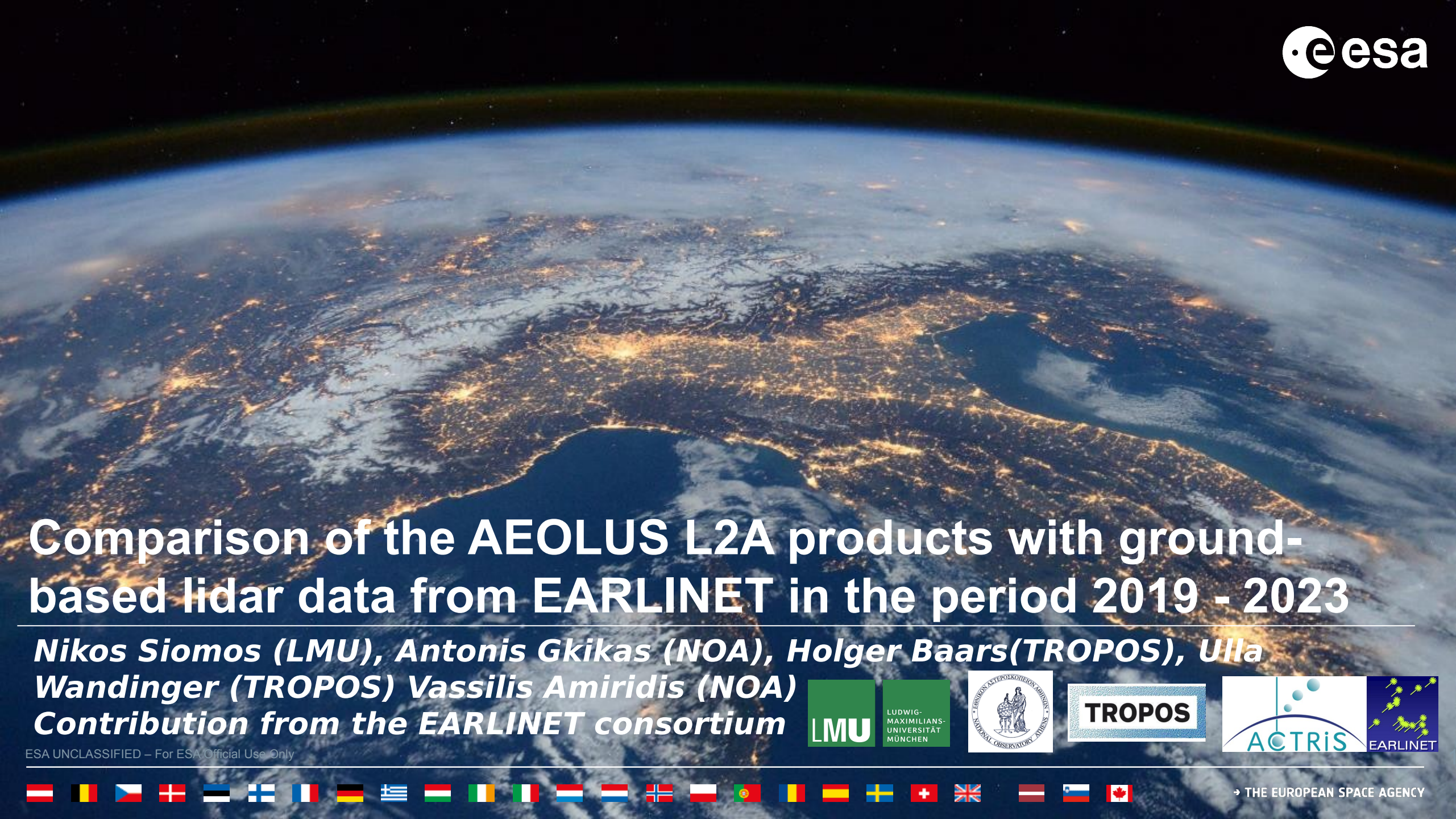
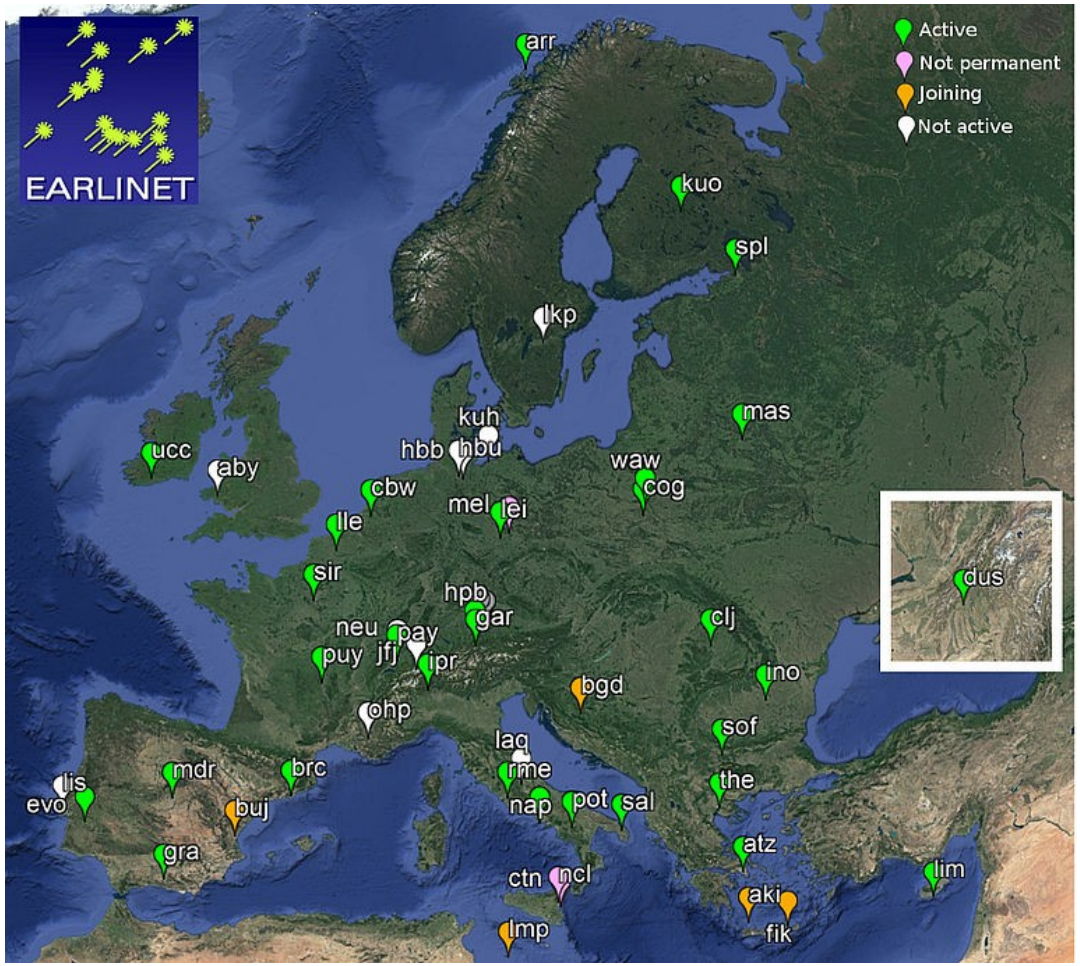


Comparison of the AEOLUS L2A products with ground-based lidar data from EARLINET in the period 2019 - 2023

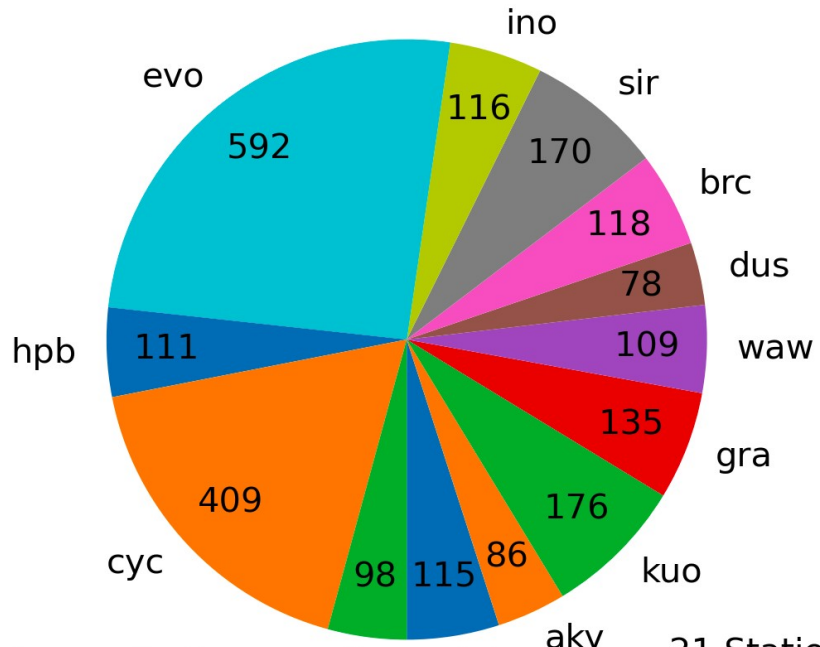
Nikos Siomos (LMU), Antonis Gkikas (NOA), Holger Baars(TROPOS), Ulla Wandinger (TROPOS) Vassilis Amiridis (NOA)
Contribution from the EARLINET consortium

EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**



Overpasses Collected: **06/2019 - 05/2023**



atz pot puy ipr arr lle the pay clj

21 Stations
2313 Overpasses

EALRINET Dataset:

- EARLINET DB files --> nominal dataset
- SCC DB files --> experimental dataset

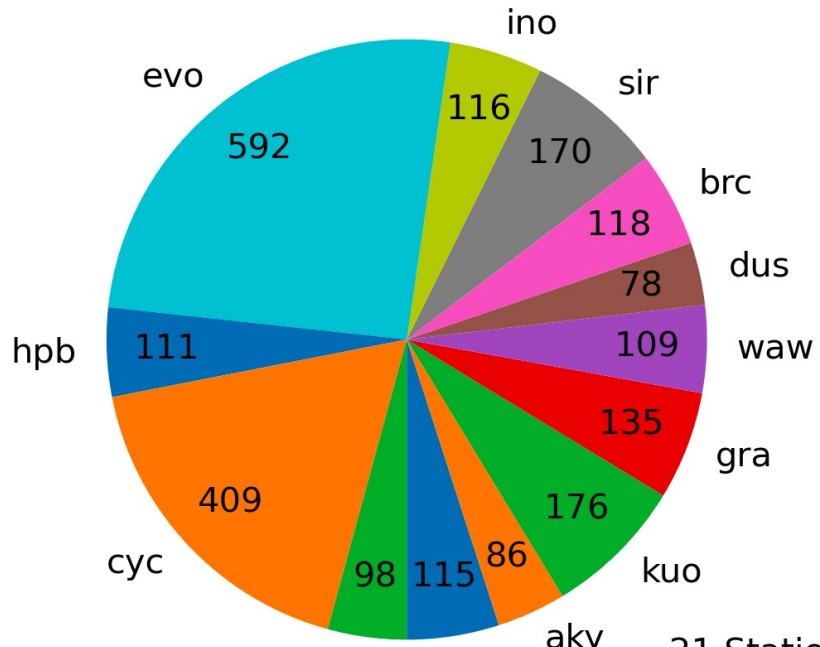
AEOLUS Dataset:

- B11 – B16 L2A files

EARLINET Cal/Val

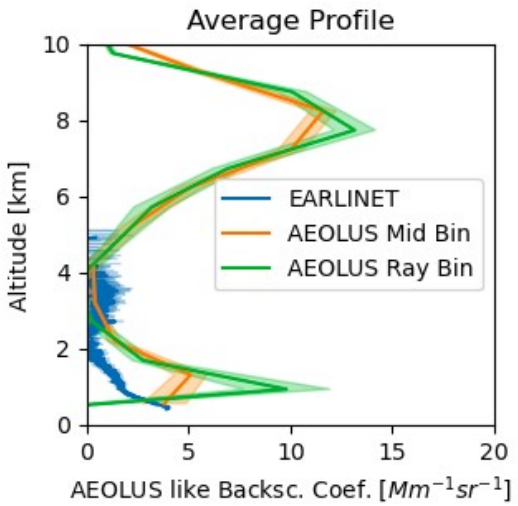
Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

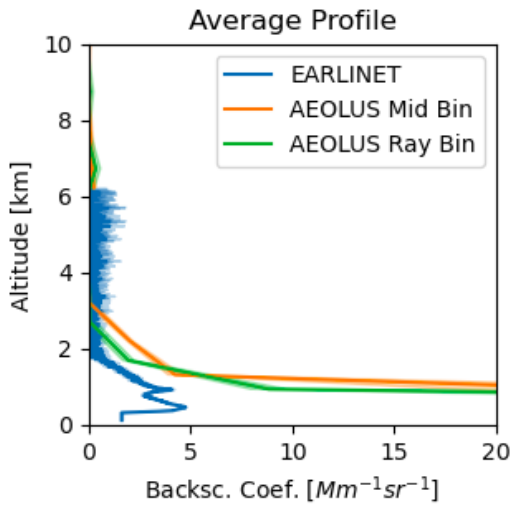
Overpasses Collected: **06/2019 - 05/2023**



Basic Cloud Screening on AEOLUS profiles

- Using the profile optical depth → less than 1.5
- Using bin-to-bin backscatter difference → less than 15 Mm^{-1} sr^{-1}





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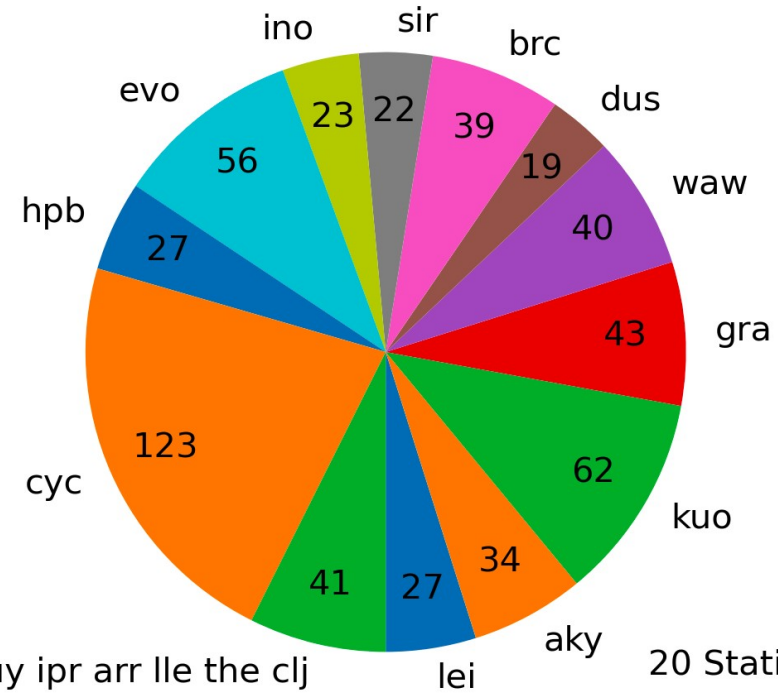
- B11 – B16 L2A files

EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

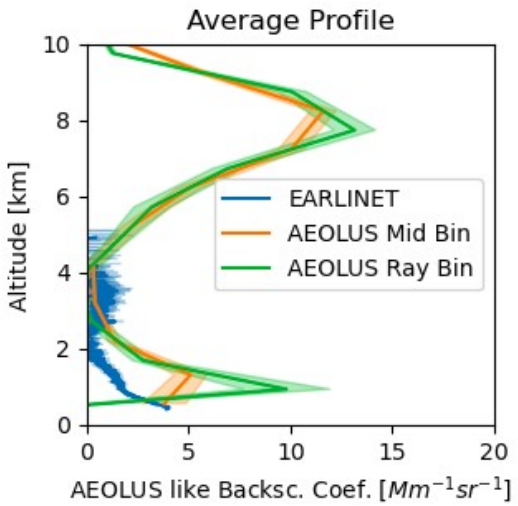
Overpasses Collected: **06/2019 - 05/2023**

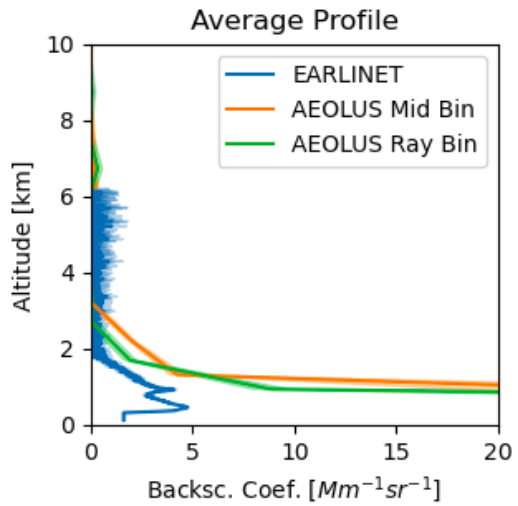


20 Stations
556 Overpasses

Basic Cloud Screening on AEOLUS profiles:

- Using the profile optical depth → less than 1.5
- Using bin-to-bin backscatter difference → less than 15 Mm^{-1} sr^{-1}





EALRINET Dataset:

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AEOLUS Dataset:

- B11 – B16 L2A files

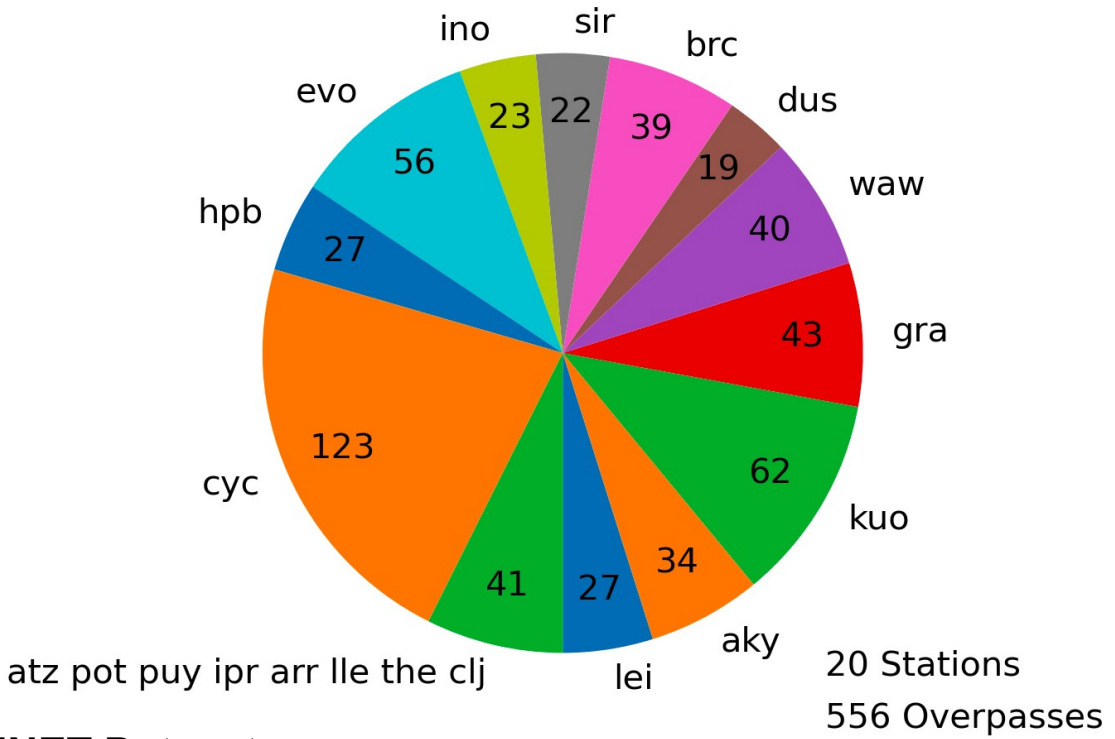
EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

QA Screening of SCC DB problematic profiles:

- The SCC dataset is **experimental** (not public)
- Not all measurements are quality assured
- **Manual screening is required**

Overpasses Collected: **06/2019 - 05/2023**



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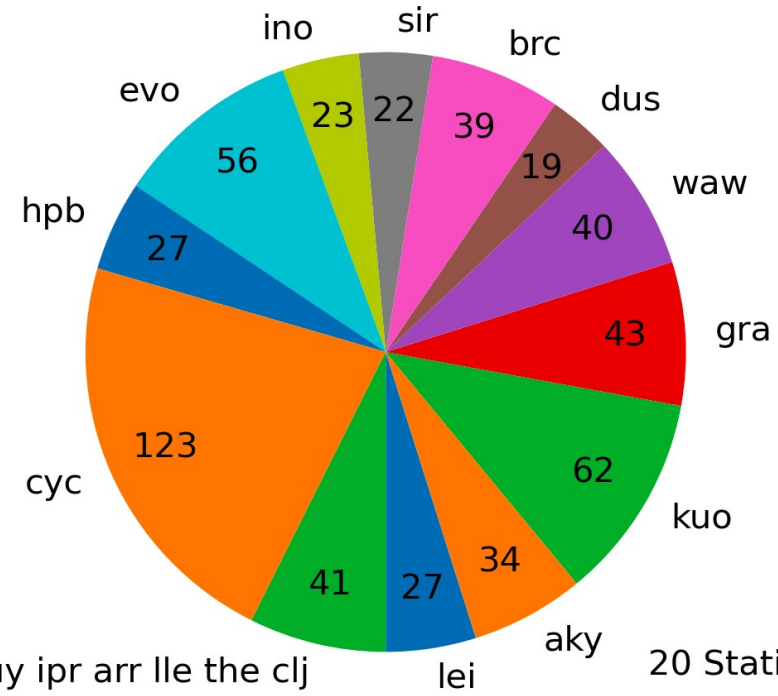
- B11 – B16 L2A files

EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

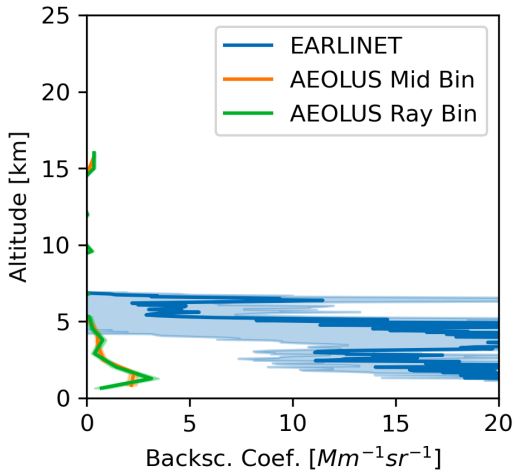
Overpasses Collected: **06/2019 - 05/2023**

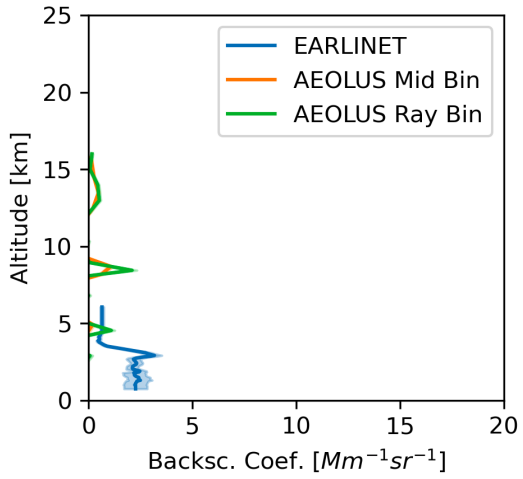


20 Stations
556 Overpasses

QA Screening of SCC DB problematic profiles:

- Laser alignment issues
- Reference height issues





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AEOLUS Dataset:

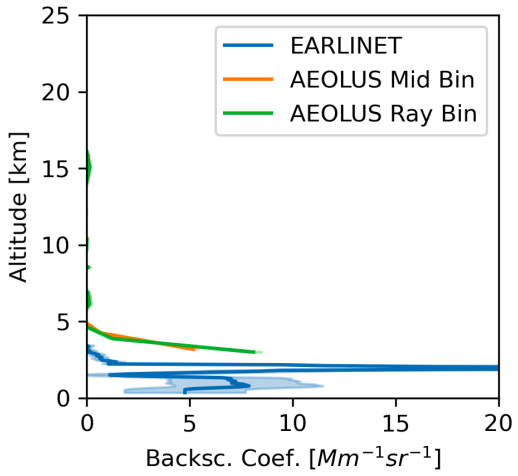
- B11 – B16 L2A files

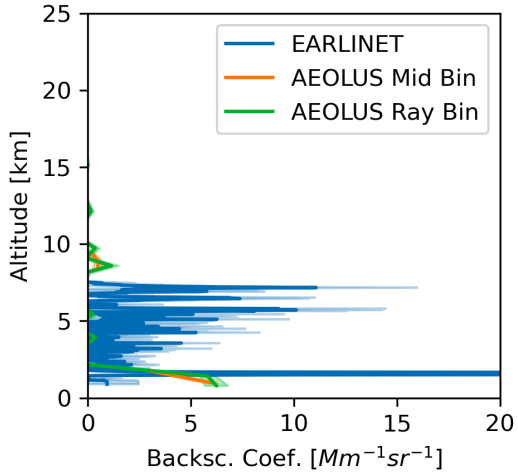
EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

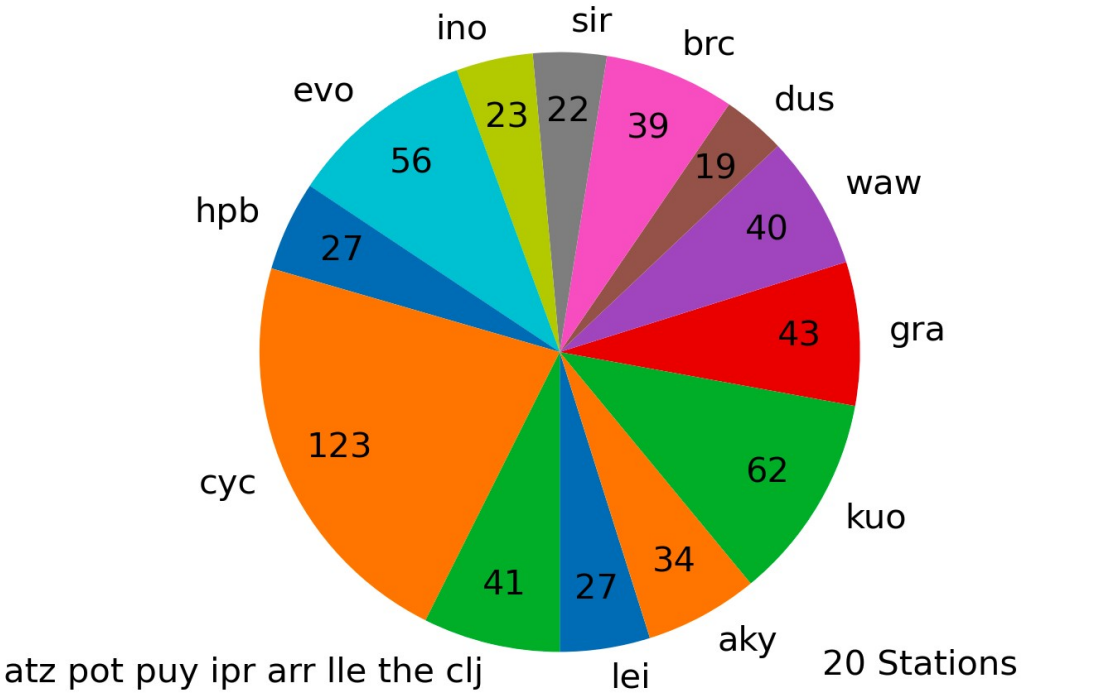
QA Screening of SCC DB problematic profiles:

- Spike/leftover cloud issues
- High noise issues





Overpasses Collected: **06/2019 - 05/2023**



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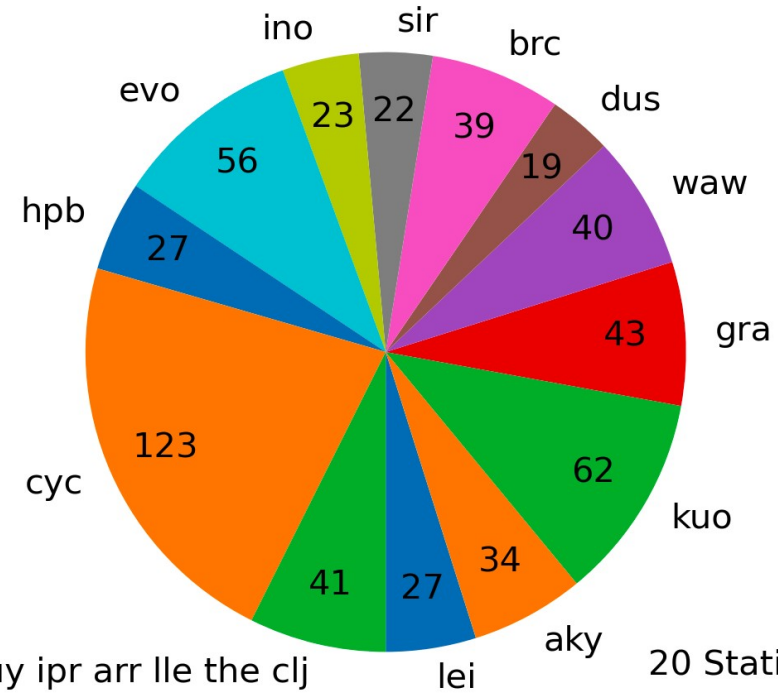
EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

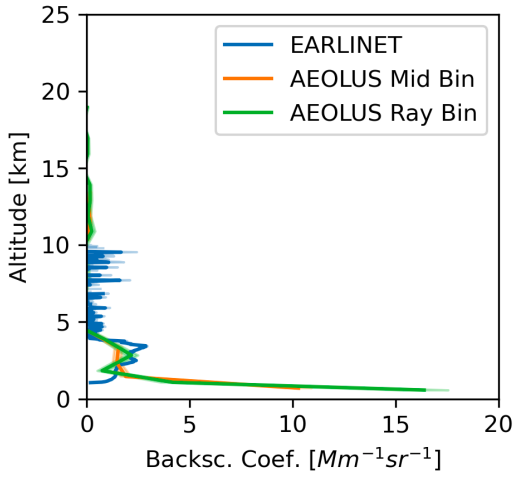
Overpasses Collected: **06/2019 - 05/2023**

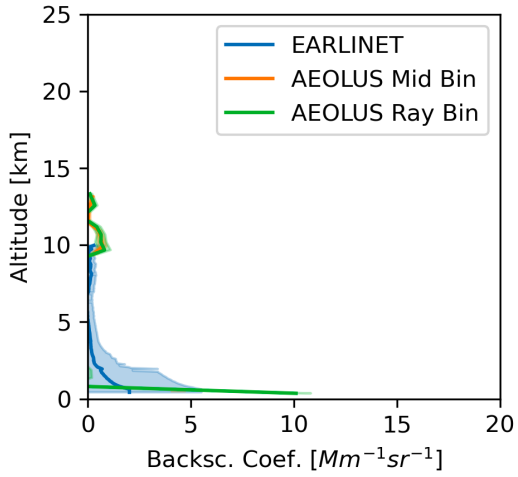


20 Stations
556 Overpasses

QA Screening of SCC DB problematic profiles:

- Overlap region issues
- High uncertainty issues





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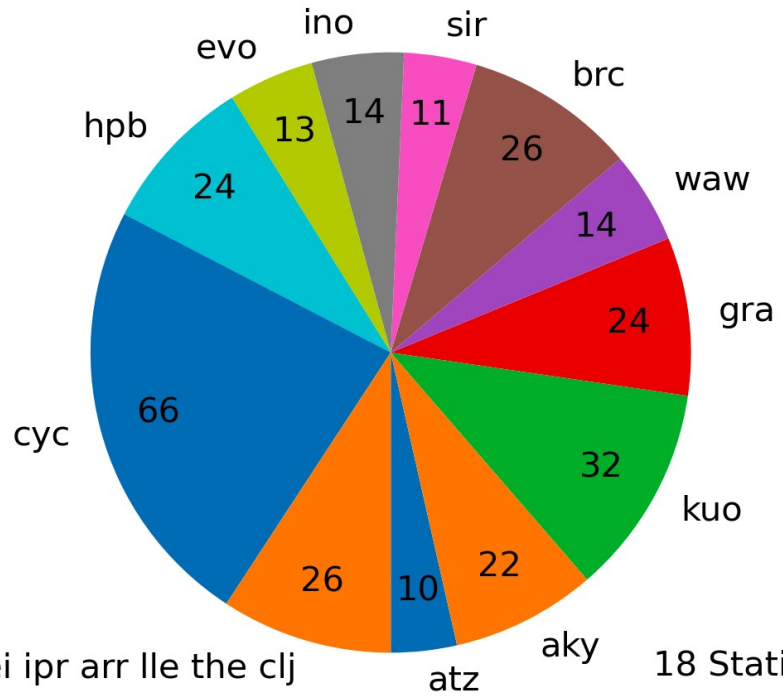
AEOLUS Dataset:

- B11 – B16 L2A files

EARLINET Cal/Val

Main target: Evaluate the performance of the **AEOLUS satellite L2A product**

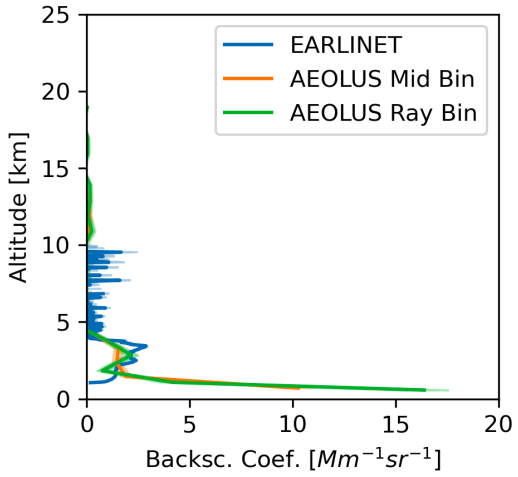
Overpasses Collected: **06/2019 - 05/2023**

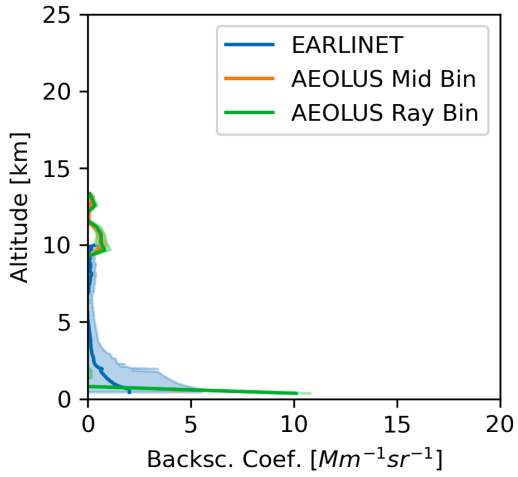


18 Stations
282 Overpasses

QA Screening of SCC DB problematic profiles:

- Overlap region issues
- High uncertainty issues





EALRINET Dataset:

- EARLINET DB files --> nominal dataset
- SCC DB files --> experimental dataset

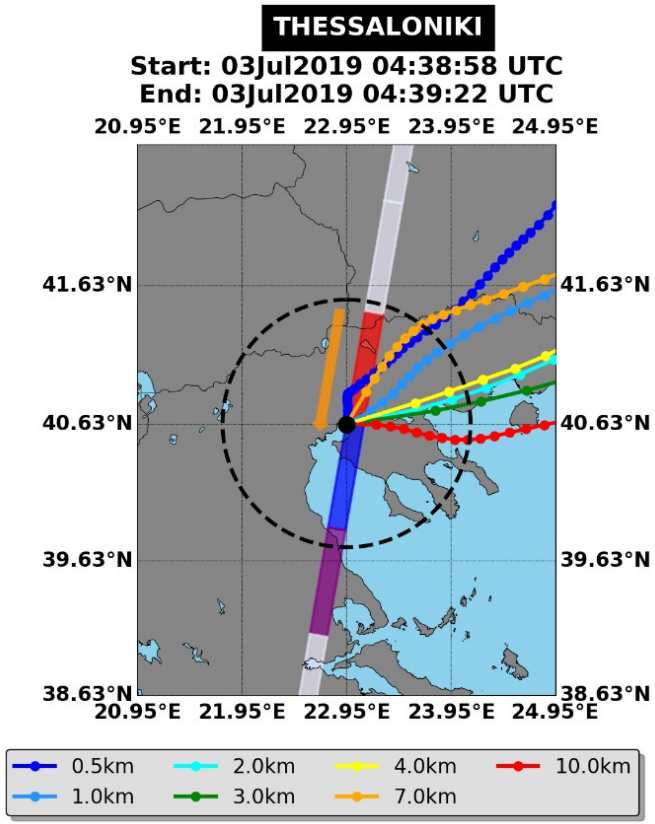
AEOLUS Dataset:

- B11 – B16 L2A files

Overpass Definition

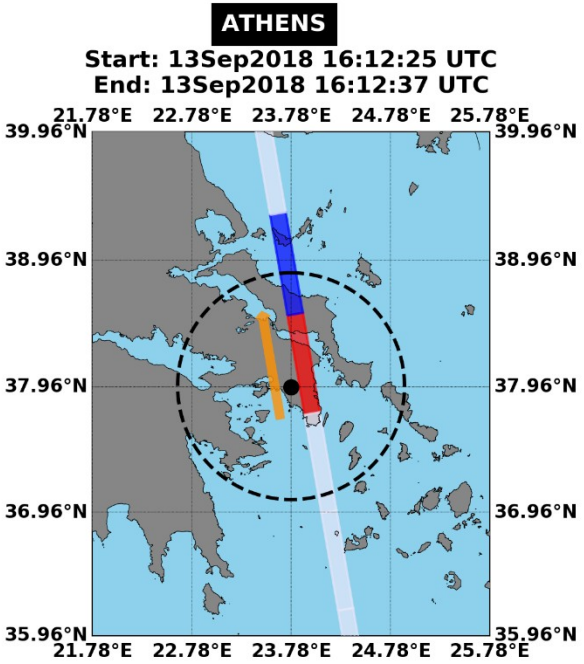
Collocation Criteria

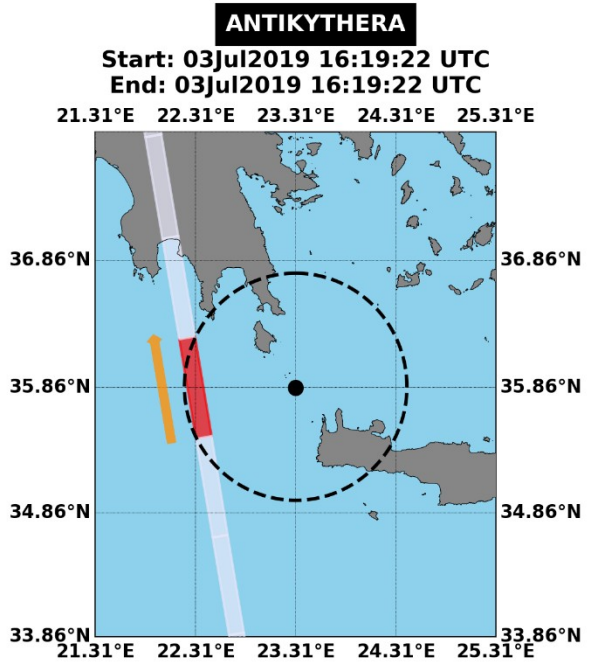
- Spatial collocation → **120km**
- Temporal collocation → **±1.5 hours**



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





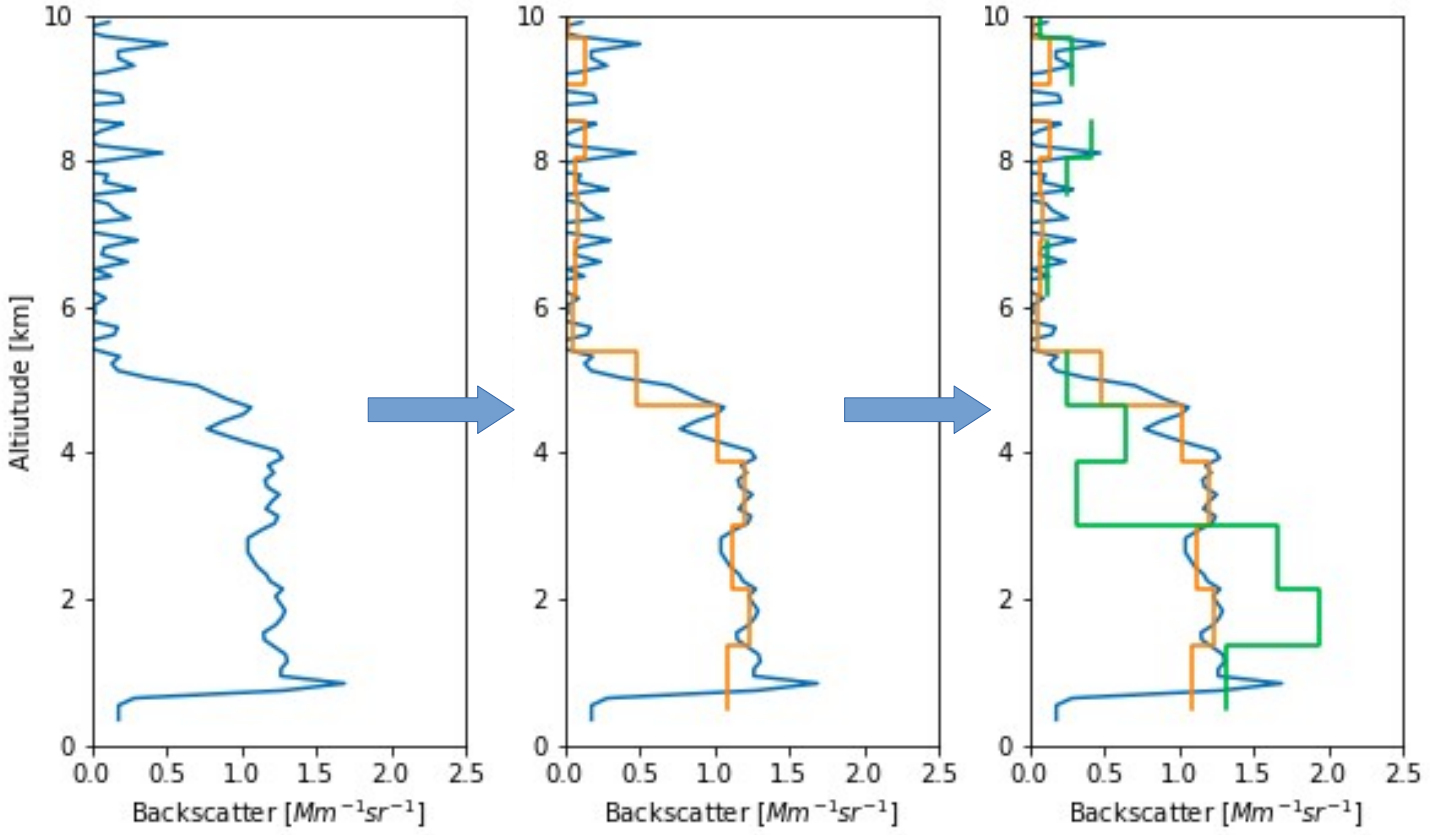
Comparison methodology

<u>Aerosol products for the validation:</u>

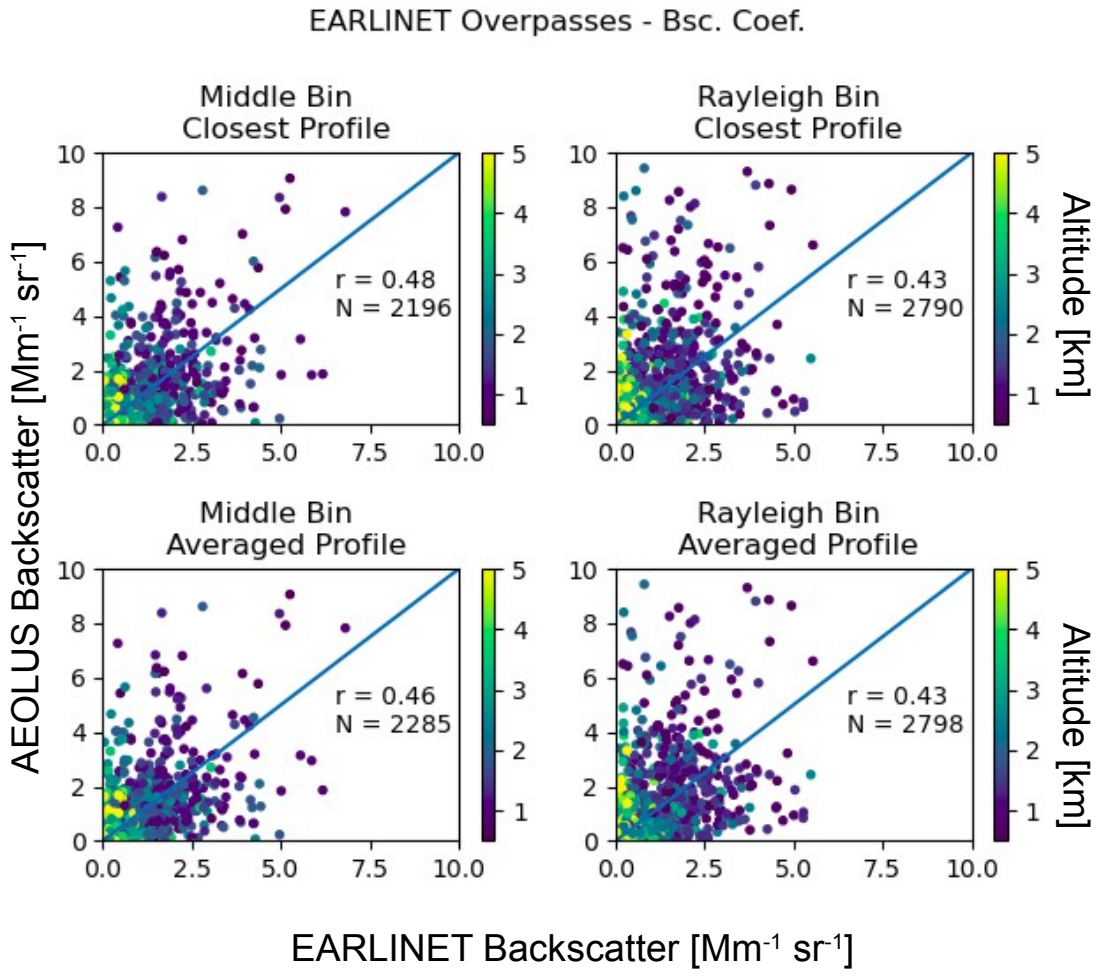
- EARLINET (355 only products)
  - Total backscatter (larger dataset)
  - Circular co-polar (converted) backscatter
  - Nighttime Raman Extinction
- AEOLUS
  - Circular co-polar backscatter
  - Extinction

<u>Conversion to AEOLUS bins:</u>

- Variable height scale
- **Overpass wise** conversion
- Bins with central height **below 0.5km and above 10.5km are excluded**

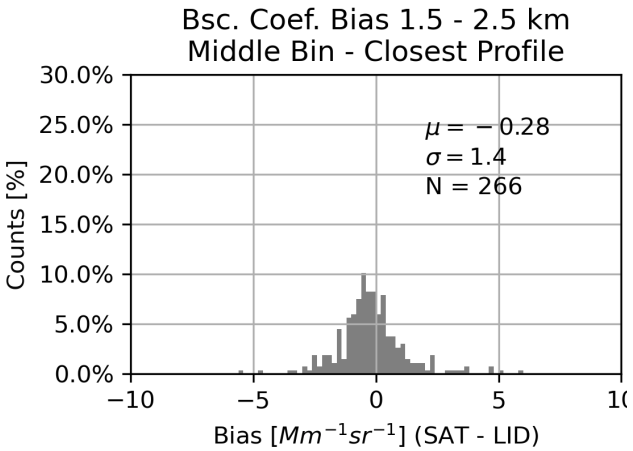


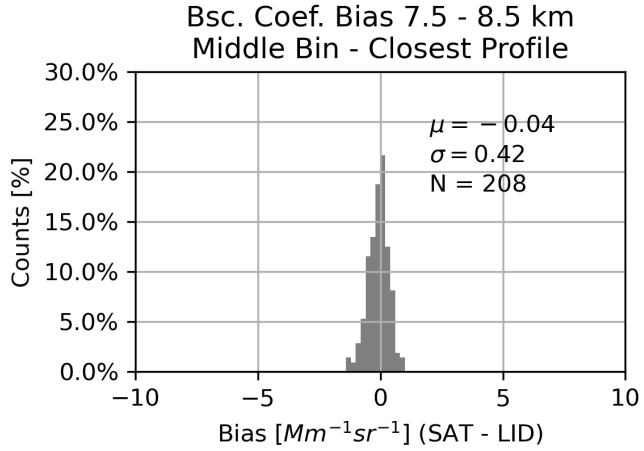
How to compare?



Correlation-wise:

- Decent correlation
- "Average" and "Closest Profile" very similar
  → use "Closest Profile"
- **Too high variability to actually reveal patterns**
  → divide in classes and use histograms

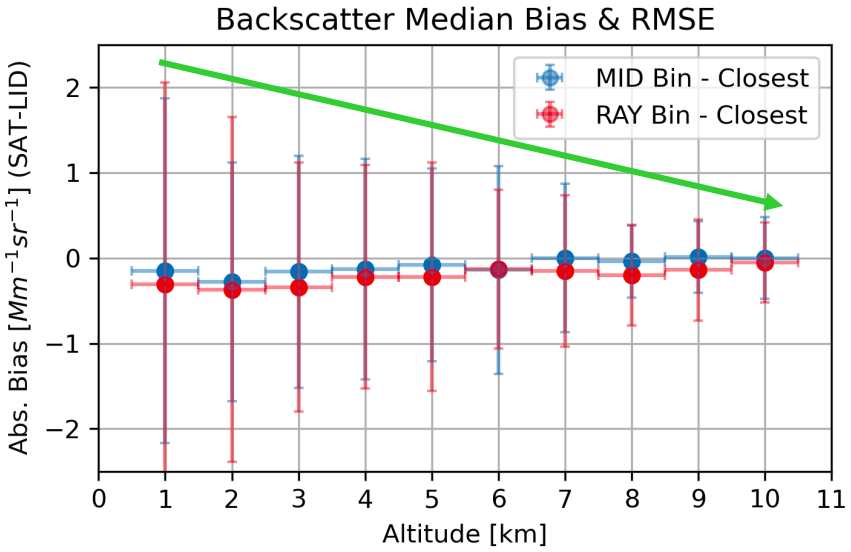




μ: Median Bias --> the systematic error

σ: RSME --> the random error (noise + spatiotemporal variability)

Systematic and Random error of the AEOLUS Backscatter Product



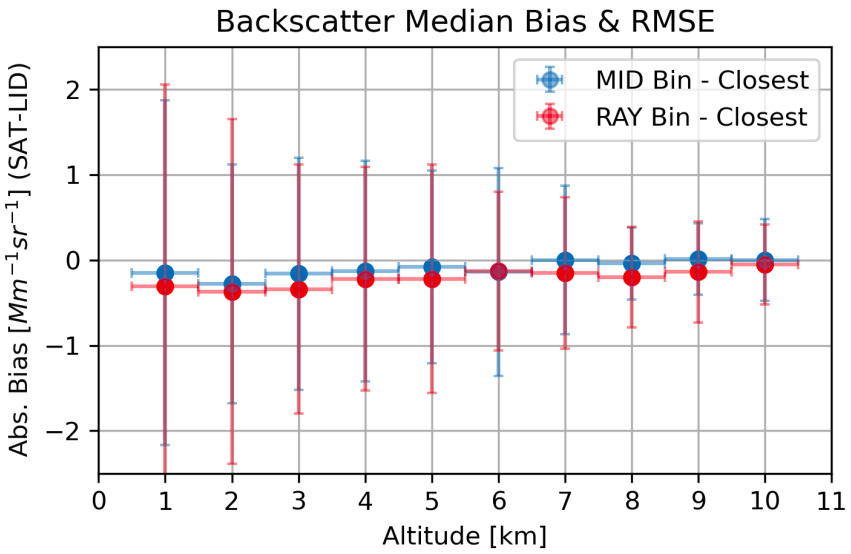
About the plots:

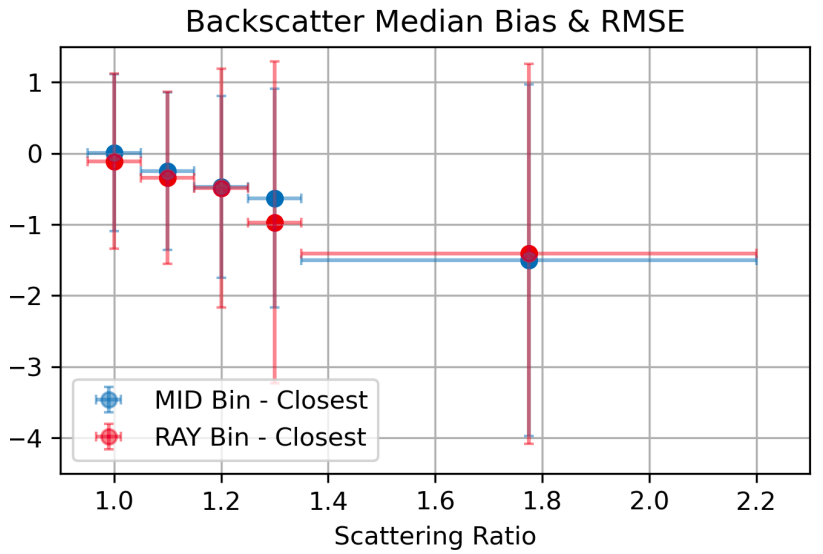
- Each point represent a class (e.g. height class)
- More than **50 bins** averaged per class
- **Points**: Median bias (AEOLUS systematic error)
- **X Error-bars**: Class range
- **Y Error-bars**: RMSE (AEOLUS random error --> noise + variability)

Findings (**height** classes):

- Slightly higher biases for **RAY bin**
- The **random error** decreases with height from ~2.0 to 0.5 Mm^{-1} sr^{-1} (MID Bin)
- The abs. **systematic error** is also decreasing with height from ~0.3 to 0.01 Mm^{-1} sr^{-1} (MID bin)
- The Abs. Bias is generally small (< 0.3 Mm^{-1} sr^{-1})

Systematic and Random error of the AEOLUS Backscatter Product

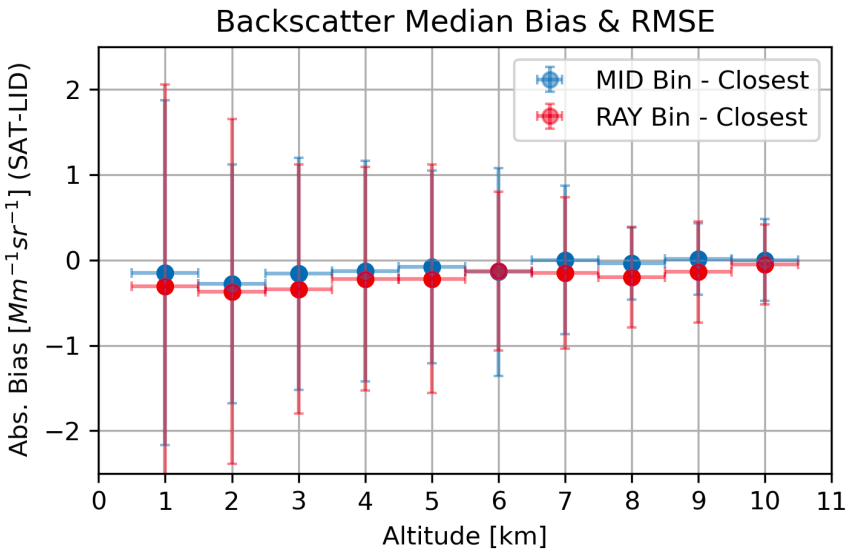


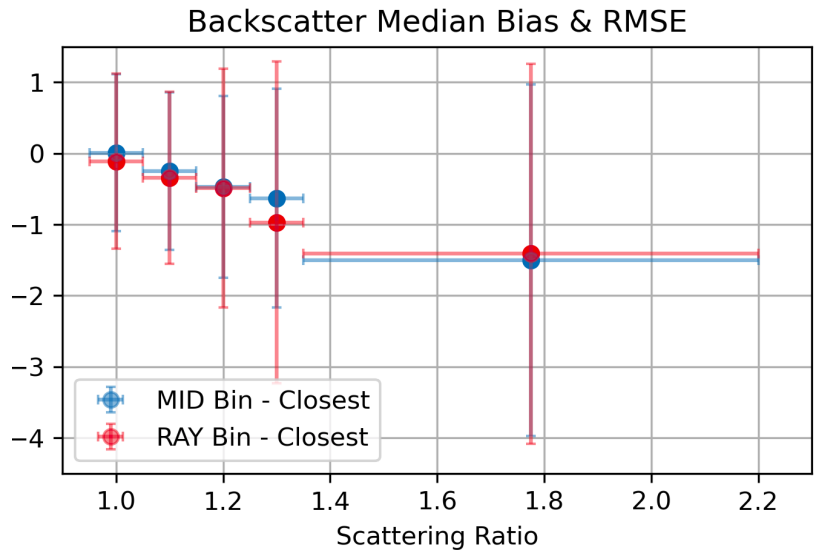


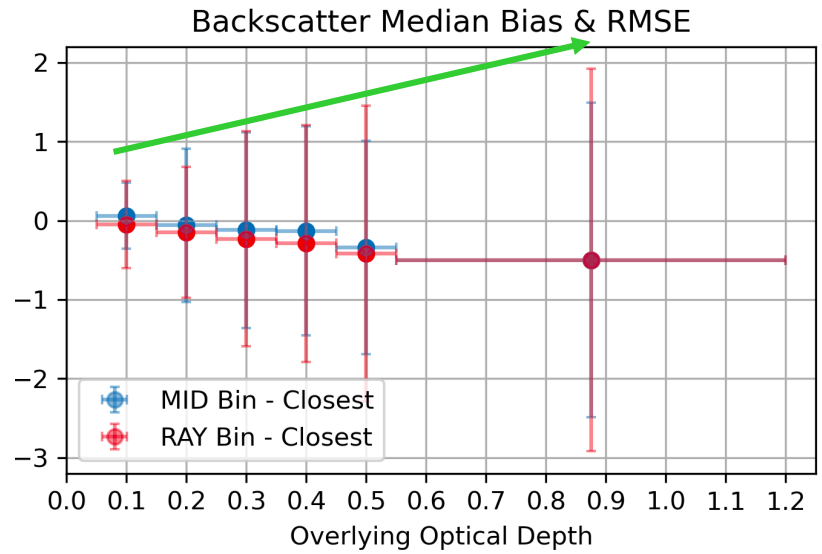
Findings (**scattering ratio SR** classes):

- Slightly higher biases for **RAY bin**
- The **random error** increases with SR from ~1 to 2.5 Mm^{-1} sr^{-1} (MID bin)
- Pattern visible for the **systematic error**, decreasing with SR from ~1.5 to 0.01 Mm^{-1} sr^{-1} (MID bin)

Systematic and Random error of the AEOLUS Backscatter Product





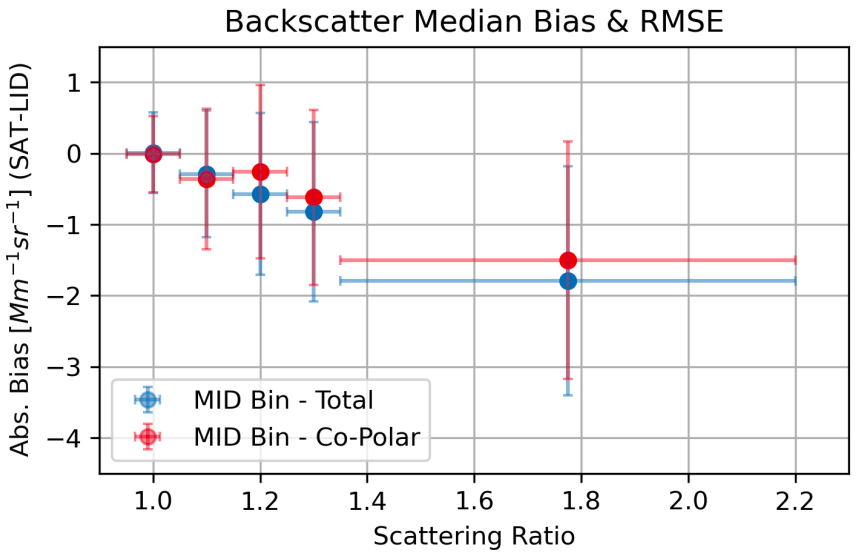


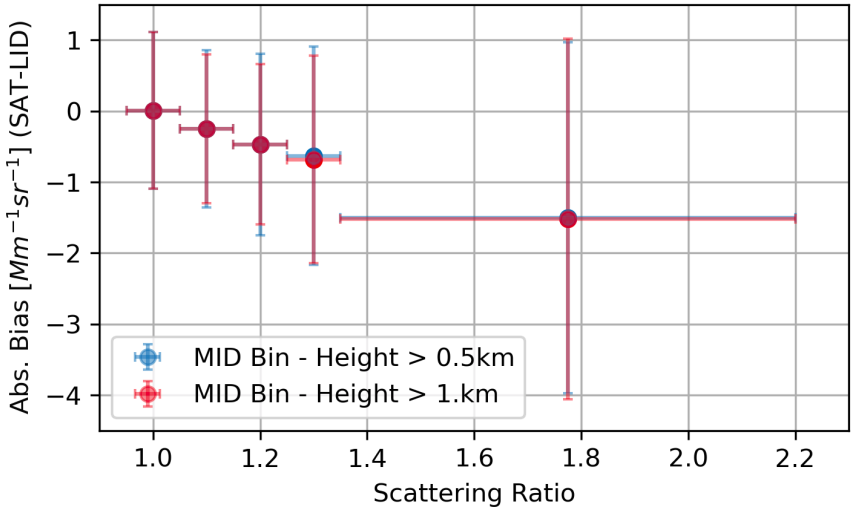
Vertical OOD used!
Slant OOD at 37.5° off zenith is ~ 25% larger

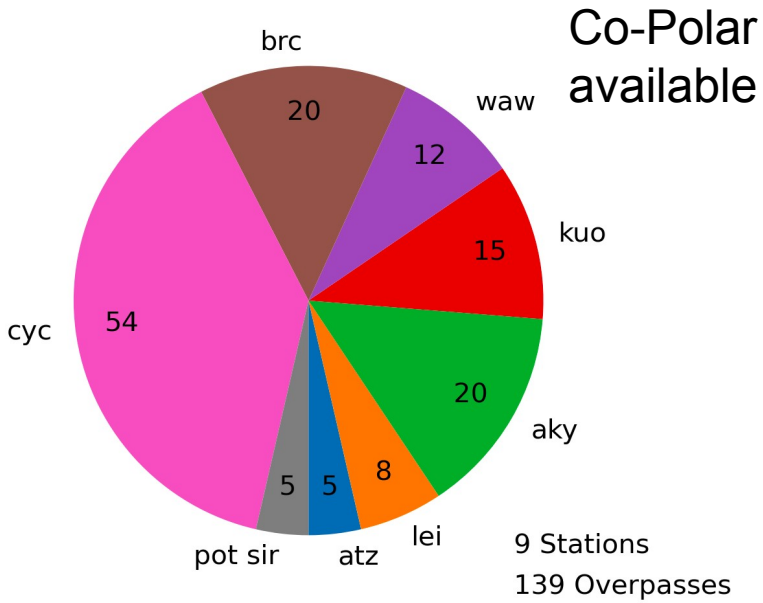
Findings (**overlying optical depth OOD** classes):

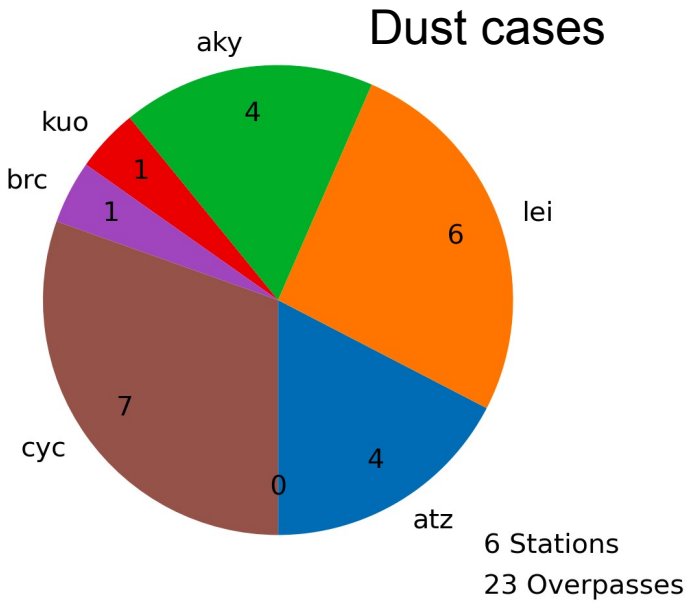
- Slightly higher biases for **RAY bin**
- The **random error** increases with SR from ~0.4 to 2 Mm^{-1} sr^{-1} (MID bin)
- Pattern visible for the **systematic error**, decreasing with SR from ~0.5 to 0.05 Mm^{-1} sr^{-1} (MID bin)
- Where does the pattern come from?

Co-Polar Backscatter









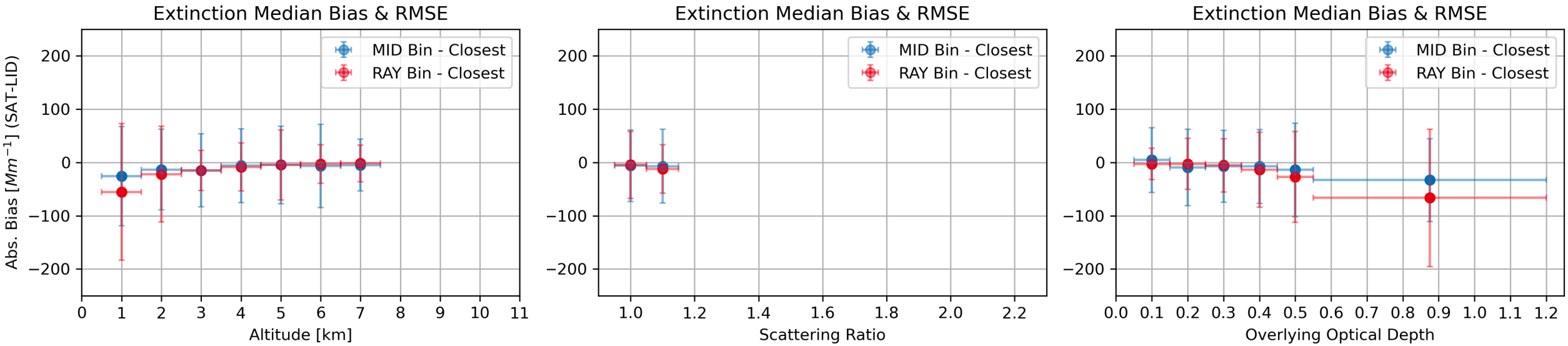
- 16.5% of the overpasses are “dust”

  (Part. Lin. Depol. Ratio > 0.1 for layers thicker than 500m)
- The co-polar bias is reduced but not enough

  → The pattern is still there
- Using EARLINET bins with central height > 1.5km

  → Almost no change

Systematic and Random error of the AEOLUS Extinction Product



Findings:

- Lower data availability (night-time only Raman)
- Higher **RAY bin** biases below 1.5km (high OOD) – smaller above 5.5km (low OOD)
- **Random error** generally ranging between ~60 to 70 Mm^{-1} (MID bin)
- Similar pattern for the **systematic errors**, decreasing with OOD from ~35 to 5 Mm^{-1} (MID bin)
- What do these AEOLUS products have in common? → cloud mask, binning, calibration?

- Automated ground-based lidar measurements and QA assusrance critical for Cal/Val studies
- Cloud screening removes **~75% of overpasses**
- Better general performance for the **MID bin** products
- **Backscatter** systematic and random error < 1.5 Mm^{-1} sr^{-1} and < 2.5 Mm^{-1} sr^{-1} respectively increasing with SR and OOD
- **Extinction** systematic and random error < 75 Mm^{-1} and < 150 Mm^{-1} sr^{-1} behaves similarly to backscatter
- Publication in preparation

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Thank you for your attention !