ILRC 32 – 32nd International Laser Radar Conference
Hiroshima, Japan, 5-10 July 2026

Ground-Based Sunphotometer and Lidar Assessment of EarthCARE Aerosol Products from MSI and ATLID

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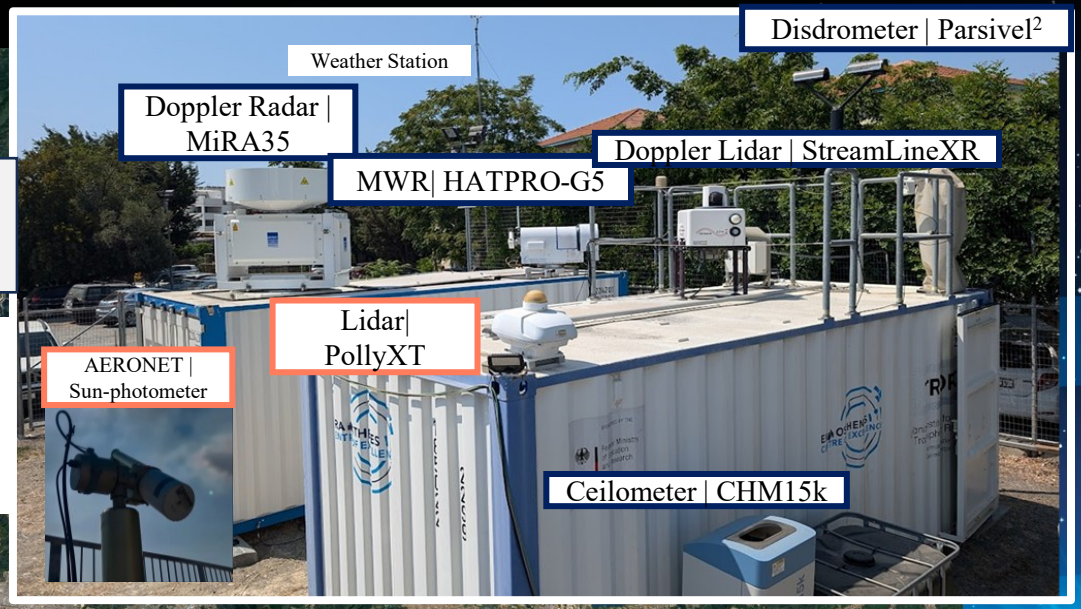
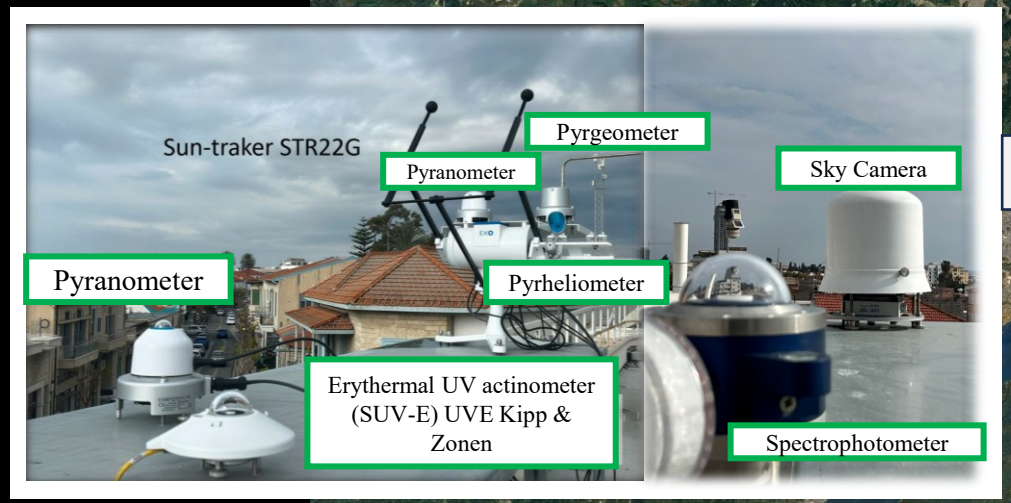
Cyprus Atmospheric Remote Sensing Observatory

~H. Panahifar et al., 2025, G. Charalampous, et al. 2025

Cloud Remote Sensing Observational Platform

Aerosol Remote Sensing Observational Platform





Solar Radiation Monitoring Station

P:125 - Cloud Microphysical Properties Derivation through Multi-Sensor Synergy: Joint Lidar-Radar Retrievals, *Konstantinos Chrysostomou*

P:143 - Long-Range Smoke Transport from North America: Optical Characterization of Smoke Layers over the Eastern Mediterranean by Means of PollyXT lidar, *Maria Poutli*

P:192 - Assessing the Impact of Volume Depolarization Ratio on GRASP Aerosol Retrievals: A Comparative Study Using PollyXT Raman Lidar and Sun-photometer Data in Limassol, Cyprus, *Athina Savva*

Session 3

Introduction and motivation

- **The assessment of spaceborne aerosol retrieval products is essential for advancing atmospheric research, improving air-quality monitoring, and enhancing climate-model applications.**
- **The recently launched EarthCARE satellite (2024) provides a new generation of aerosol products with recent baselines under validation.**

MSI

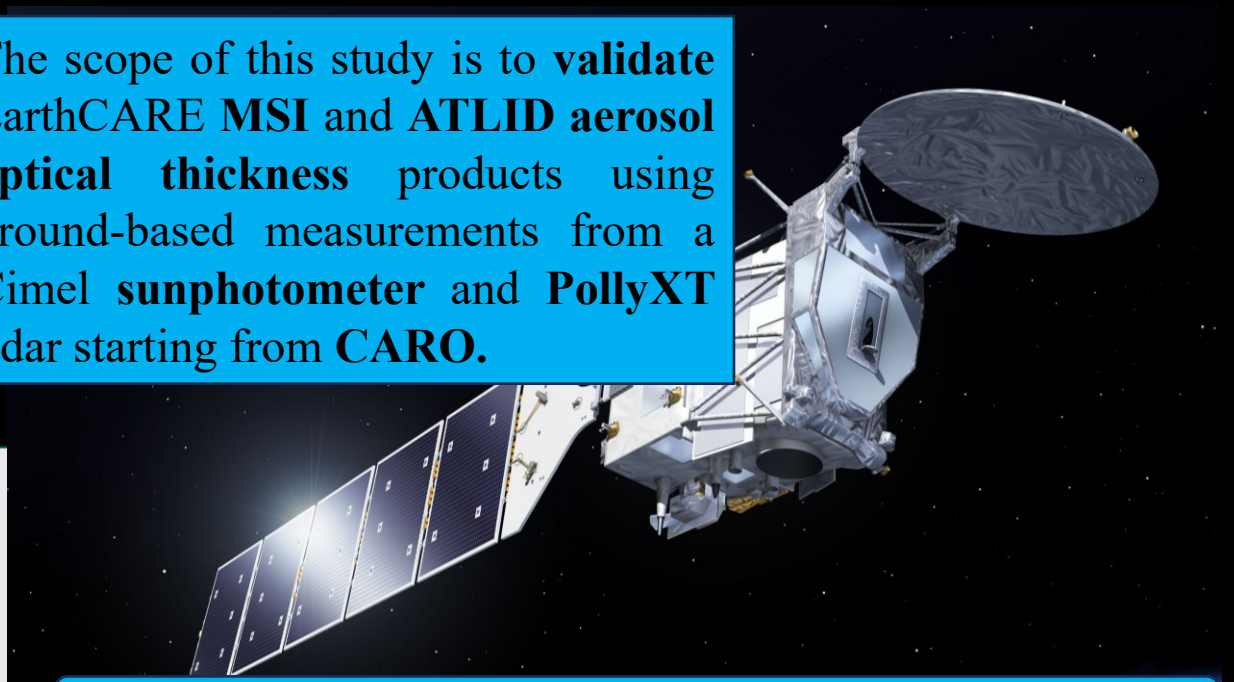
Aerosol Optical Thickness Retrieval (M-AOT)
Level 2A • Baseline BA
Validation Requirements
Diverse land and ocean scenes ~ **Coastal region** coverage

~Product handbooks

ATLID

Extinction, Backscatter & Depolarization Retrieval (A-EBD) Level 2A • Baseline BA
Validation Requirements
Airborne lidar campaign measurements ~ **Ground-based lidar network observations**

The scope of this study is to **validate** EarthCARE **MSI** and **ATLID aerosol optical thickness** products using ground-based measurements from a Cimel **sunphotometer** and **PollyXT** lidar starting from **CARO.**

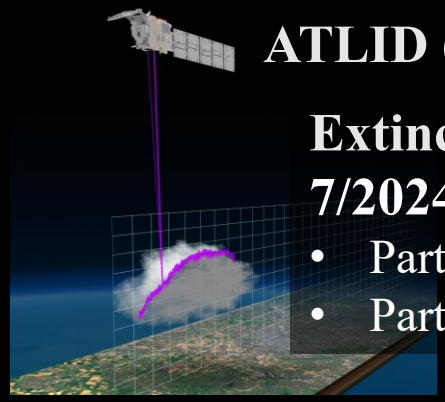


EarthCARE satellite mission launched in May of 2024

Data sources – ATLID and MSI

EarthCARE (Earth Cloud, Aerosol, and Radiation Explorer) satellite mission

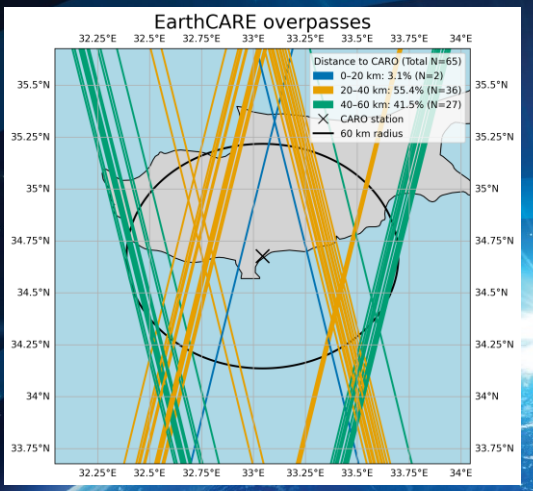
The analysis includes satellite overpasses within 60 km of the station since July 2024

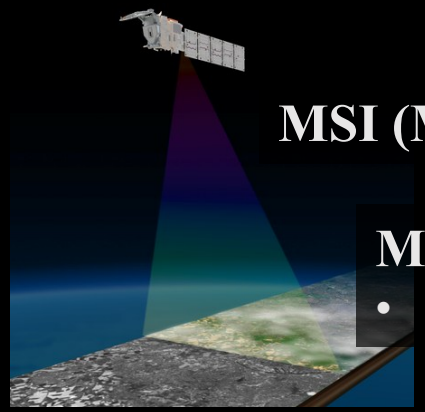


ATLID (ATmospheric LIDar)

Extinction Backscatter and Depolarization (Baseline BA, data from 7/2024 to 9/2025):

- Particle Extinction Coefficient at 355 nm
- Particle Extinction Coefficient at 355 nm low resolution (41 horizontal JSG pixels)





MSI (Multi-Spectral Imager)

MSI – Aerosol Optical Thickness (Baseline BA, data from 7/2024 to 9/2025):

- Aerosol Optical Thickness at 670 nm, 150 km swath, 500 m spatial resolution, daytime observations

Data sources – Ground Truth

CARO data

PollyXT (Raman Polarization Lidar)

- Part of PollyNET, a global network of remote-controlled multiwavelength polarization Raman lidars (Polly) for automated and continuous observations of clouds and aerosols.
- PollyXT provides measurements at 3 wavelengths: 355 nm, 532 nm and 1064 nm (2α+3β+2δ).

Products used: Extinction in 355 & 532 nm

Sunphotometer (AERONET CE318)

- Part of AERONET, a global network delivering standardized, quality-assured aerosol data for research and satellite validation.

Products used (level 1.5): AOD_675nm, AOD_340nm, 440-675_Angstrom_Exponent,340-440_Angstrom_Exponent

Methodology

DATA SOURCES

-Main dataset: 01/07/2024 – 30/09/2025 (PollyXT subset: from 29/09/2024)

MSI	ATLID	AERONET	PollyXT
(670 nm, Baseline BA) daytime only	(355 nm, Baseline BA) daytime & nighttime	(340 & 675 nm) daytime only	(355 & 532 nm) daytime & nighttime

PREPROCESSING & HARMONIZATION

- Ångström exponent (AERONET) used for wavelength conversion of ground-based measurements

$$AOT(\lambda) = AOT(\lambda_0) \times \left(\frac{\lambda}{\lambda_0}\right)^{-a}$$

α: Ångström exponent

Methodology

DATA PROCESSING OPTIMIZATION

MSI
< 60 km

Spatial averaging, radius from station:
- 50 km, 60 km , 100 km

ATLID
CP low resolution

- **C**losest **P**oint

Spatial averaging from CP:
- ± 25 km
- ± 50 km

AERONET
±30 min

Temporal averaging:
- ±30 minutes
- ±1 hour
- ±2 hours

PollyXT
±30 min

Temporal averaging:
- ±30 minutes
- ±1 hour

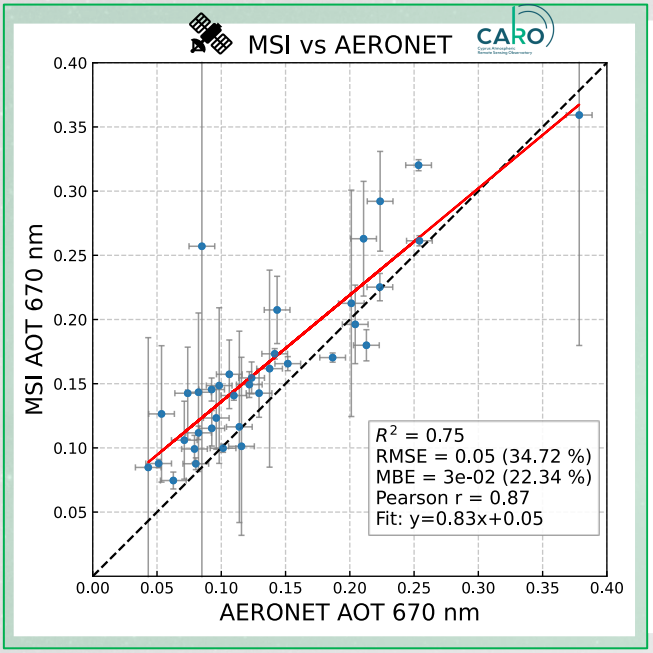
LIDARs
- Extinction integration -> AOT up to 10 & 12 km
- **BEST**: 10 km

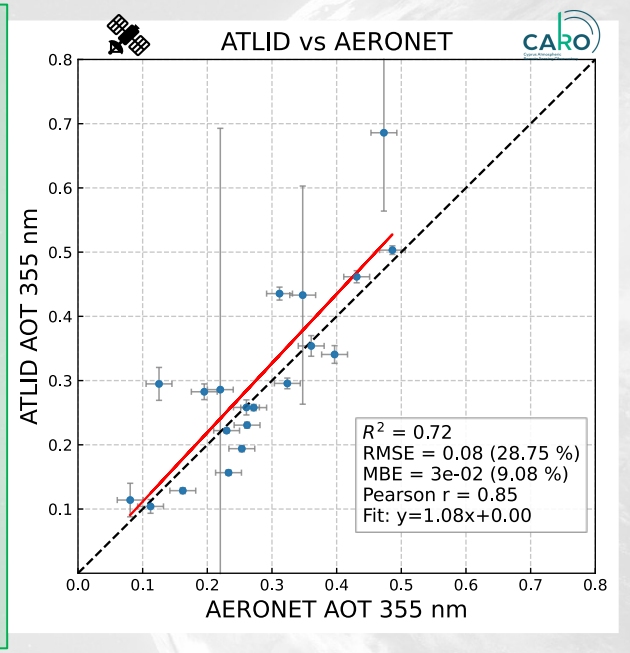
SATELLITE DATA VALIDATION

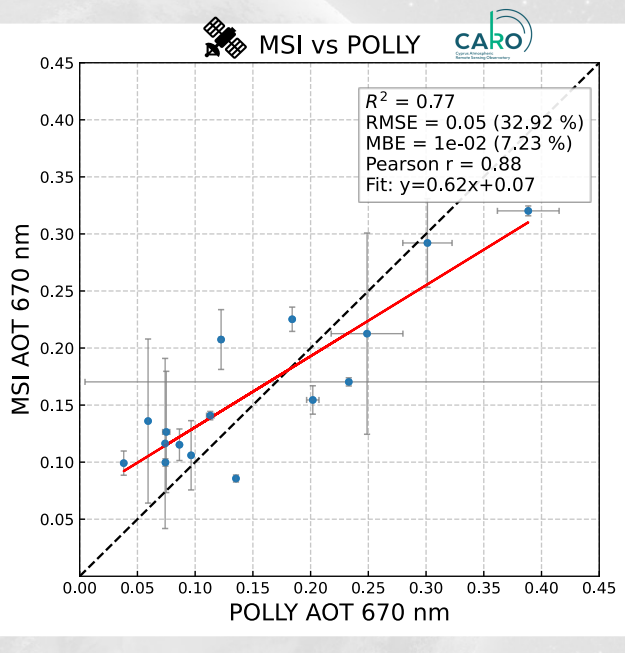
- MSI vs AERONET
- ATLID vs AERONET
- MSI vs PollyXT
- ATLID vs PollyXT

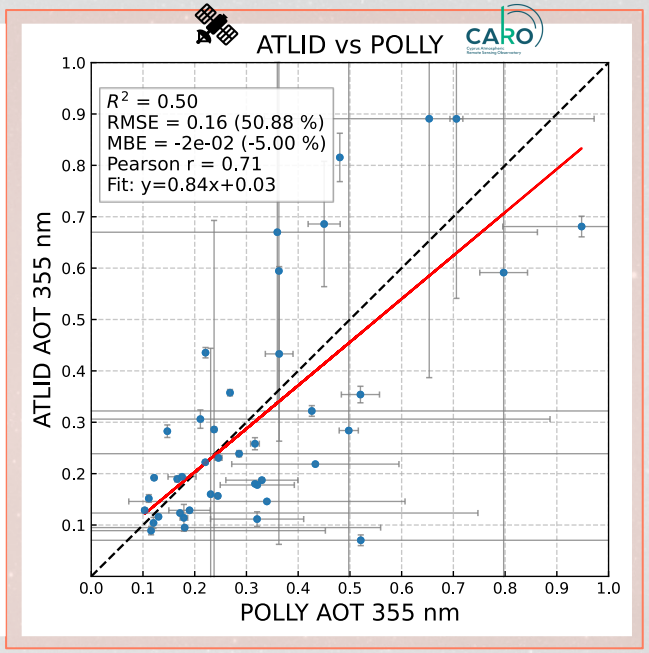
Satellite and ground-based observations are compared using linear regression on scatter plots. **Statistical metrics:** R^2, RMSE, MBE, Pearson correlation (r)

Results - Limassol, Cyprus



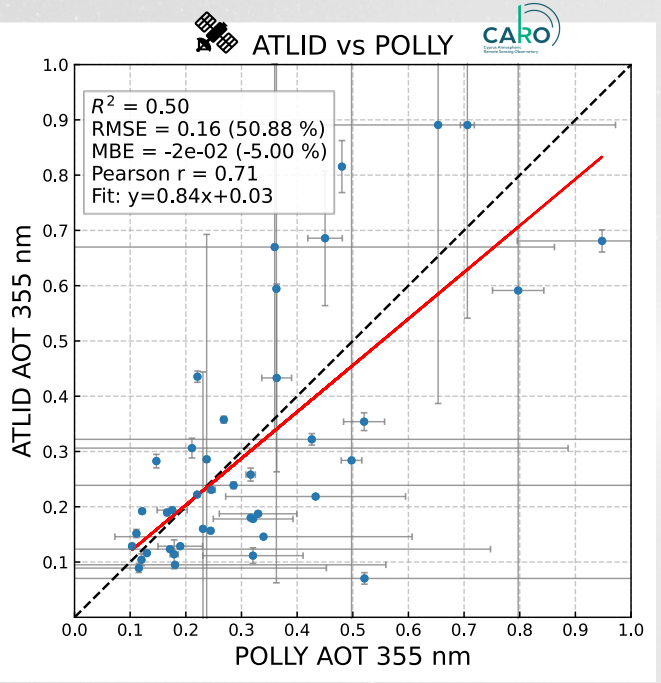


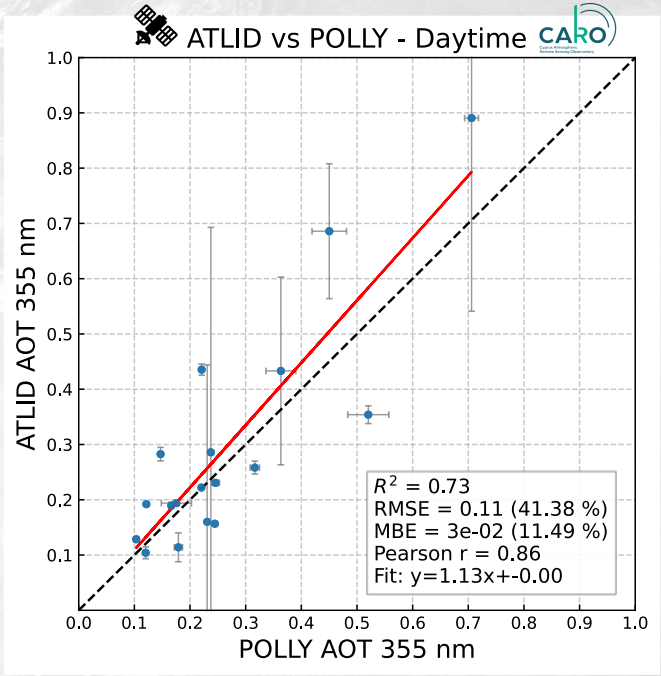


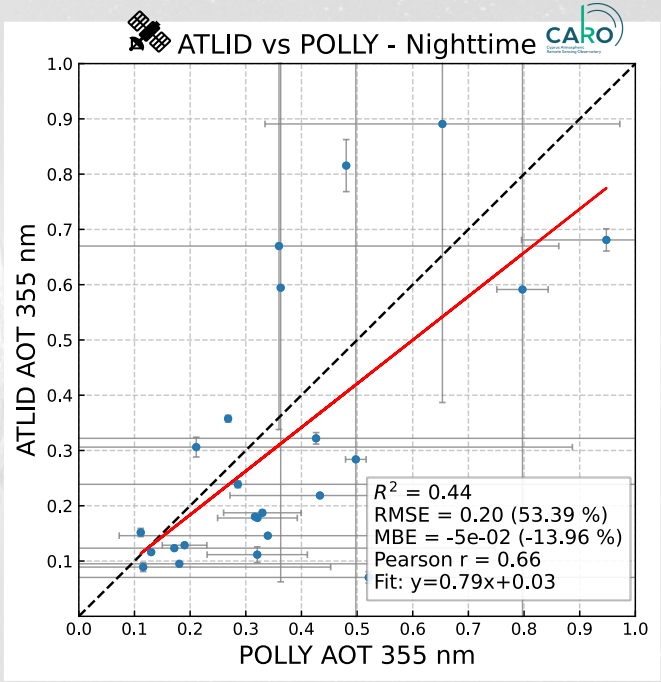


- Quality status of the spaceborne: MSI: 0 (99.88%), 1 (0.1 %), 2 (0.02%) ATLID: 0 (93.8%), 2 (5.4 %), 3 (0.8%)
- The best results are achieved using optimized spatial and temporal averaging - MSI: 60 km, ATLID: closest overpass point (low resolution) with integration up to 10 km, AERONET/PollyXT: ±30 min and PollyXT with integration up to 10 km.
- MSI–AERONET shows the strongest agreement, though with a slight AOT overestimation by MSI.
- ATLID-POLLY comparison is the weaker due to the extra nighttime observations and handling of lidar ratio during daytime observations.

Results - Limassol, Cyprus – ATLID vs Polly^{XT}



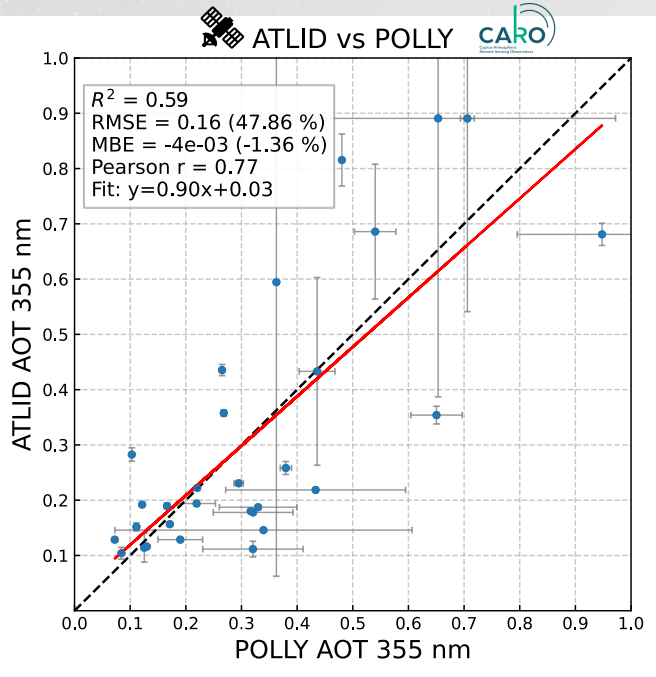


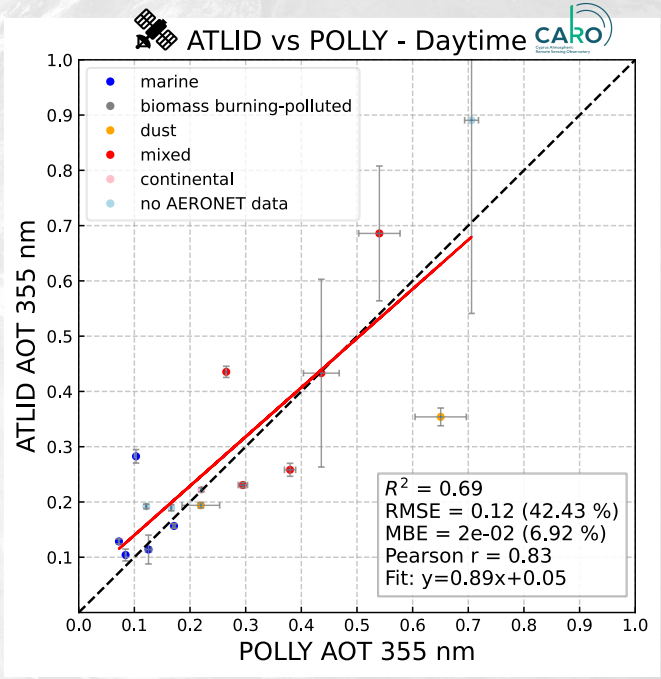


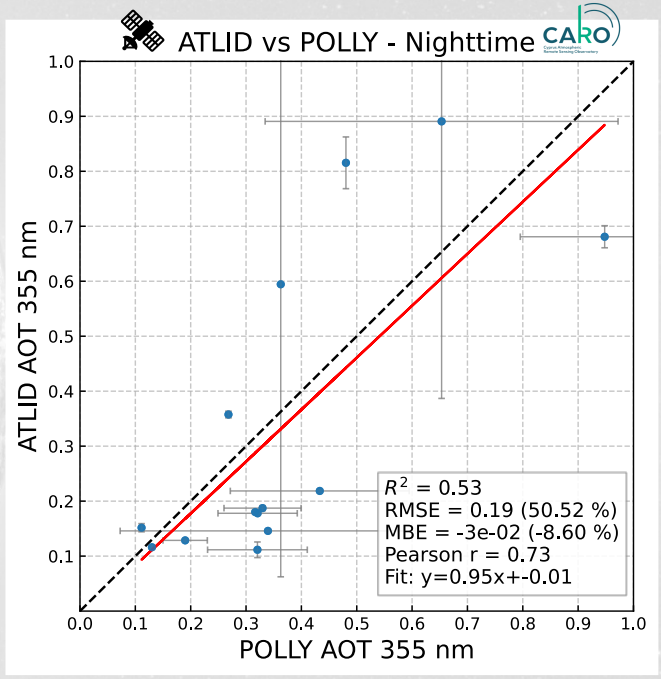
- During nighttime, the extinction is measured from Polly^{XT} Raman observations.
- During daytime, the extinction (α) is initially calculated with lidar ratio (S) equal to 40 and backscatter measurements (β).

$\alpha = S \cdot \beta$

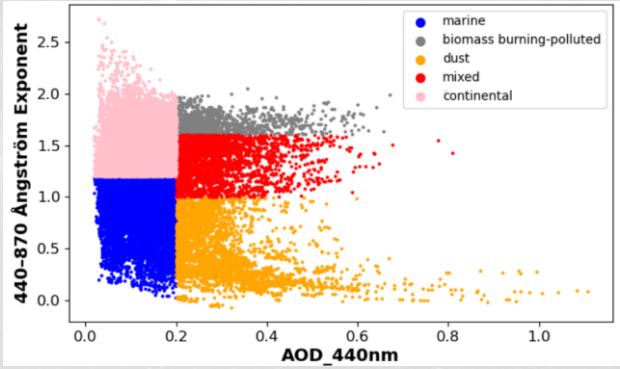
Results - Limassol, Cyprus – ATLID vs Polly^{XT}

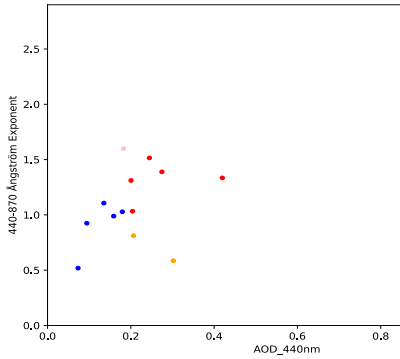






- Remove observations with errors > AOT values.
- Classify the daytime observations by AERONET-Dubovik's climatology, applied in Cyprus [G. Charalampous et al., 2026], and change their lidar ratios accordingly [A. Floutsi et al., 2023]





Expanding methodology to Eastern Mediterranean

GODDARD SPACE FLIGHT CENTER

AERONET

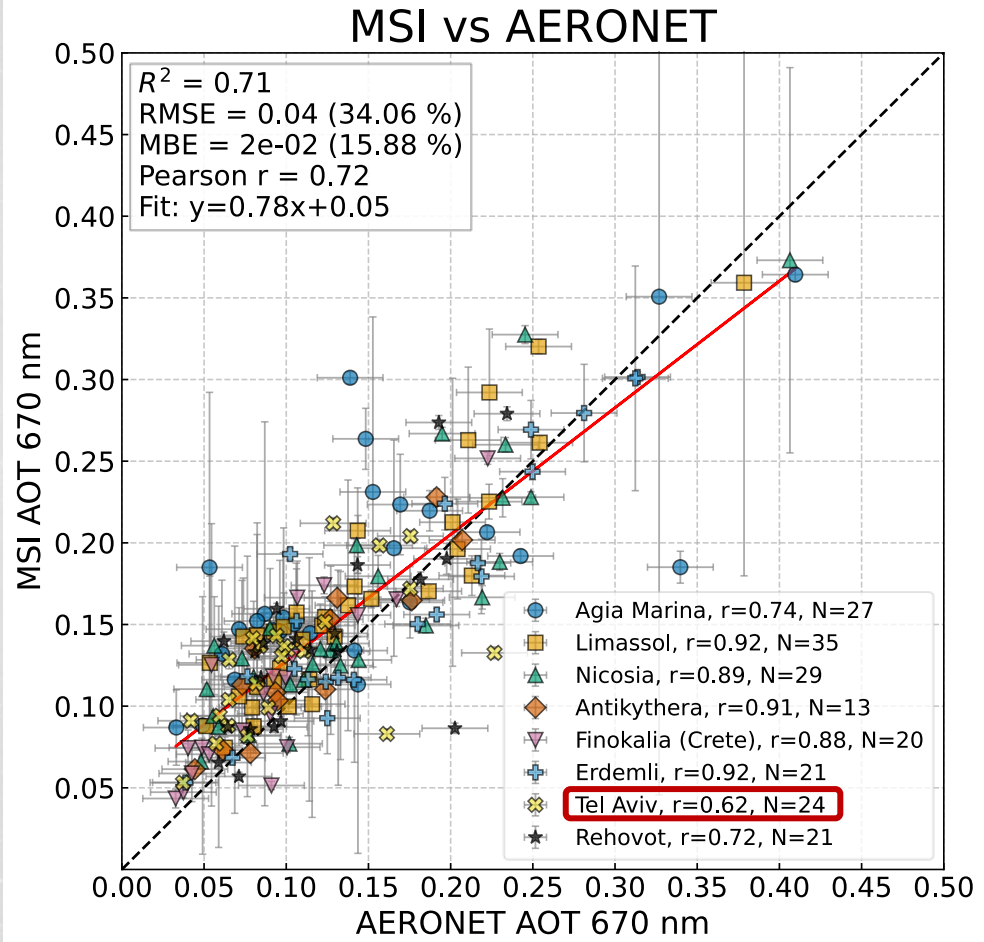
AEROSOL OPTICAL DEPTH

AERONET (AErosol RObotic NETwork) is a global network of ground-based aerosol monitoring stations established by NASA and PHOTONS and expanded through international collaboration. It has provided a continuous, publicly available database of aerosol optical, microphysical, and radiative properties, supporting research, **satellite validation**, and data integration. The network ensures standardized instruments, calibration, processing, and data distribution. It delivers global measurements of **AOT**, inversion products, and precipitable water, with Version 3 AOD data available at three quality levels: Level 1.0 (unscreened), **Level 1.5 (cloud-screened)**, and Level 2.0 (quality-assured).

➢ ATLID_EBD-2A and MSI_AOT_2A validation with AERONET

Expanding methodology to Eastern Mediterranean

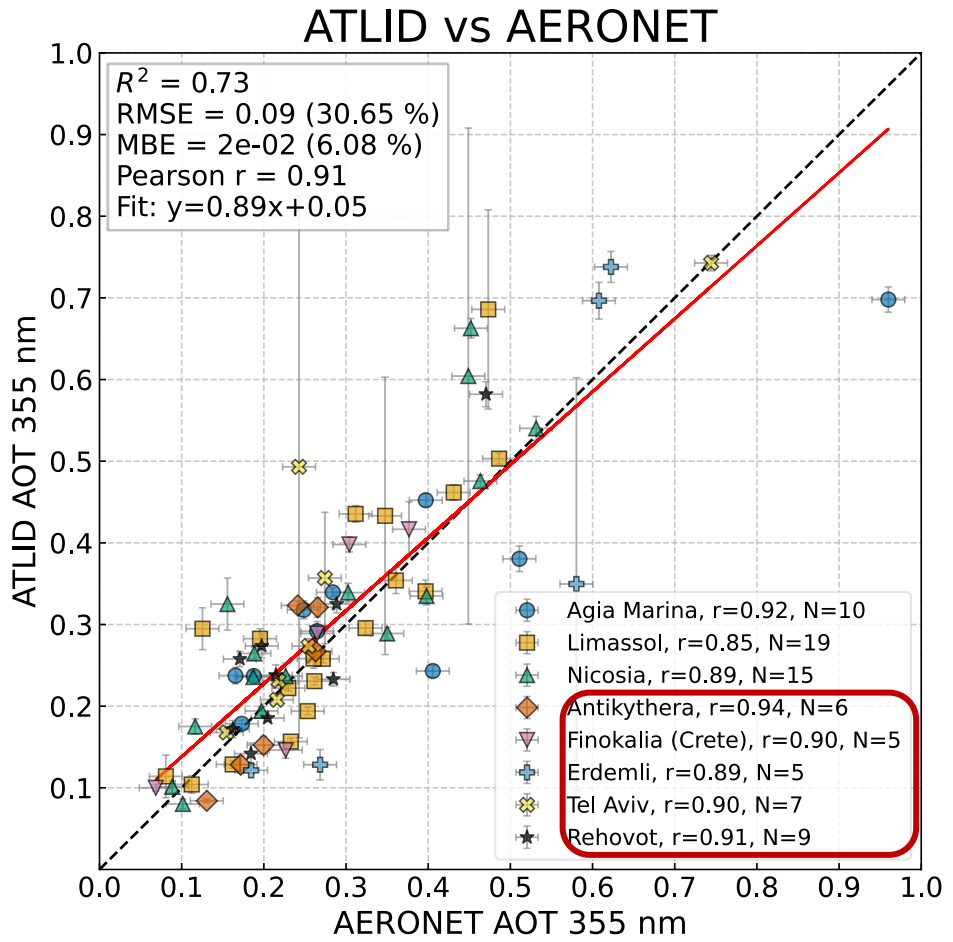
MSI vs AERONET



Reminder:

MSI: averaging data in 60 km radius
ATLID: closest overpass point within 60 km
AERONET: averaging ±30 min

ATLID vs AERONET



MSI-AERONET: Good agreement, with MSI generally overestimating AOT values.

ATLID-AERONET: Good agreement but generally only a few data from ATLID within a radius of 60 km from the stations.

Conclusion and Future work

The strong validation of MSI_AOT and ATLID_EBD aerosol retrievals against ground-based aerosol data demonstrates their readiness to contribute to EarthCARE's core objectives (in agreement with EC Workshop 2026 conclusions).

These validated products are well suited for future use in model evaluation, climate-monitoring services, and operational applications such as air-quality and hazard monitoring.

Future work:

- Implement method for latest baselines.
- Extend method to other AERONET stations and lidar stations (ACTRIS) in the Mediterranean region.
- Include Sentinel-3 mission's retrievals in the comparisons.

Thank you!

Questions?

Poster Session 3

P:125 - Cloud Microphysical Properties Derivation through Multi-Sensor Synergy: Joint Lidar-Radar Retrievals, *Konstantinos Chrysostomou*

P:143 - Long-Range Smoke Transport from North America: Optical Characterization of Smoke Layers over the Eastern Mediterranean by Means of PollyXT lidar, *Maria Poutli*

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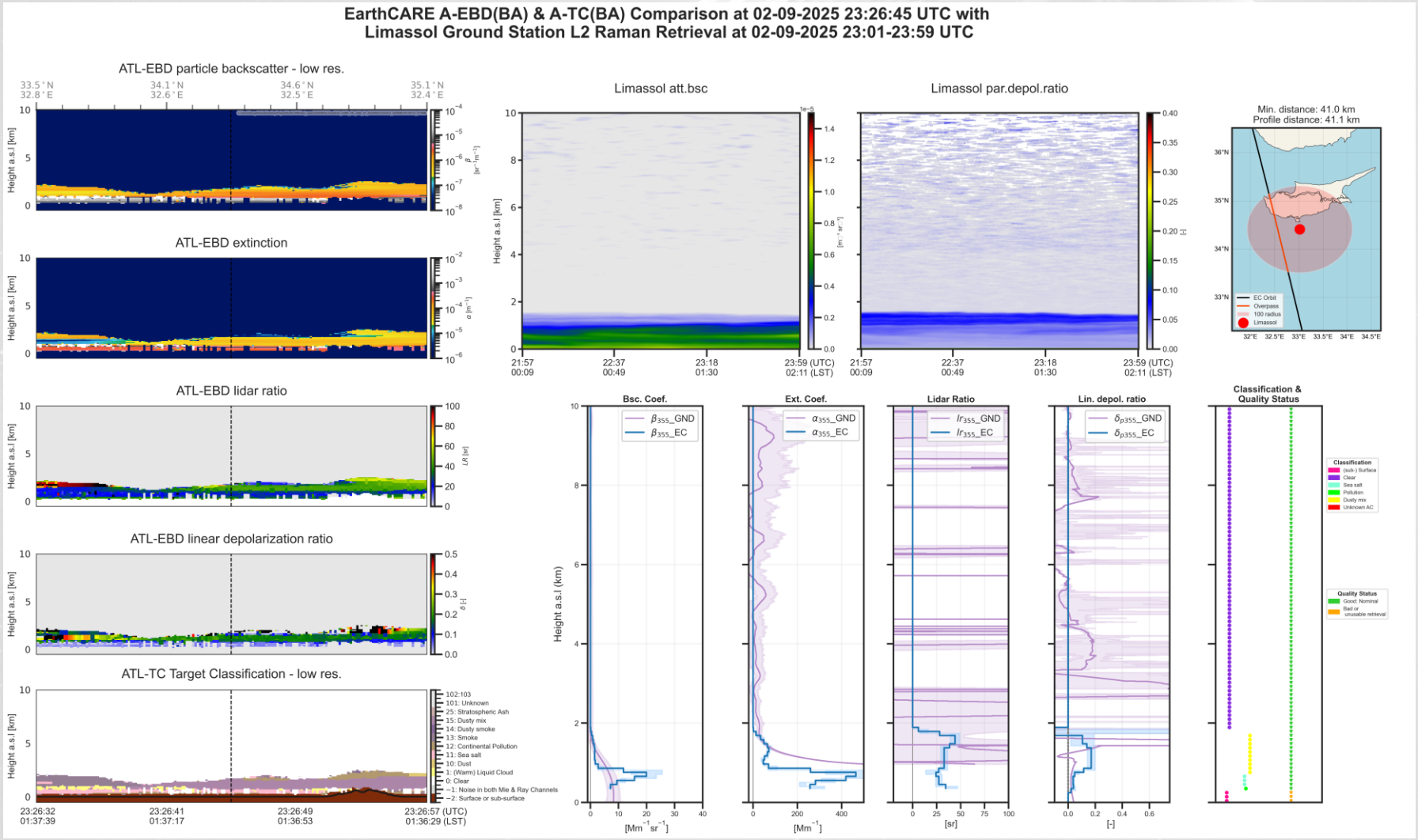
The CARO NF is supported by the EXCELSIOR' project funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 857510 and from the Government of the Republic of Cyprus and the Cyprus University of Technology. The authors acknowledge the ATARRI Horizon Europe Widespread Twinning Project. ATARRI receives funding from the European Union's Horizon Europe Twinning Call (HORIZON-WIDERA-2023-ACCESS-02) under the grant agreement No 101160258. The travel expanses for ILRC32 supported by HARMONIA COST Action CA21119 - International network for harmonization of atmospheric aerosol retrievals from ground-based photometers, supported by COST (European Cooperation in Science and Technology). The work was supported by CORAL EVID39 CAL/VAL project.

Lidar ratios

Class	Lidar ratio
Dust	50
Mixed	48
Biomass burning – pollution	51
Marine	48
Continental	40

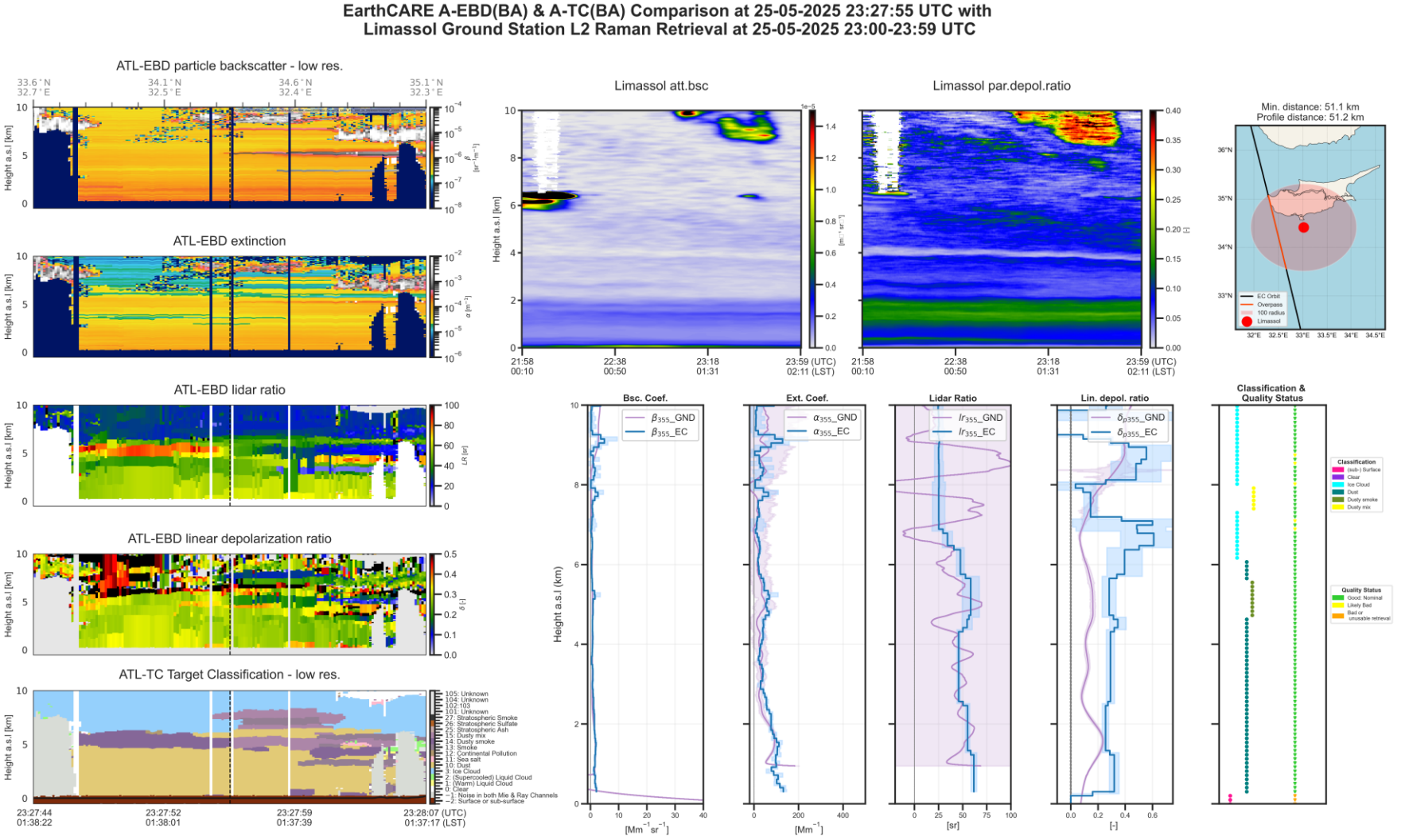
Results - Limassol, Cyprus – ATLID vs Polly^{XT}



ATLID AOT = 0.07

POLLY^{XT} AOT = 0.52

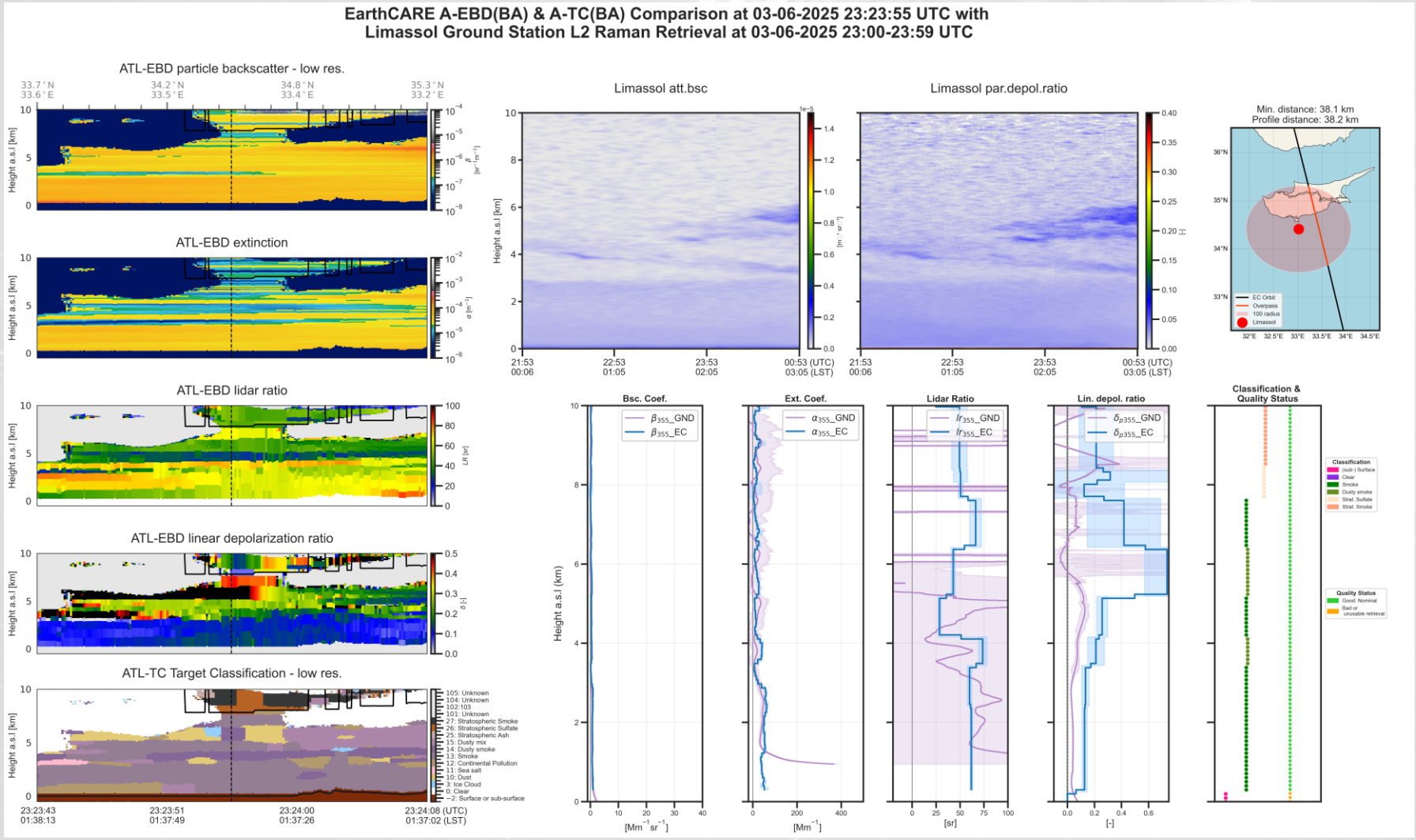
Results - Limassol, Cyprus – ATLID vs Polly^{XT}



ATLID AOT = 0.81

POLLY^{XT} AOT = 0.48

Results - Limassol, Cyprus – ATLID vs Polly^{XT}



ATLID AOT = 0.24

POLLY^{XT} AOT = 0.29