



INTRODUCTION

The assessment of spaceborne aerosol property retrievals is crucial for advancing atmospheric research, air-quality monitoring, and climate model-related applications. EarthCARE, launched in May 2024 by ESA and JAXA, combines active and passive sensors (ATLID, CPR, MSI, BBR) to improve global estimates of aerosols, clouds, and radiation (Wehr et al., 2023). The ERATOSTHENES Centre of Excellence (ECoE), through the EXCELSIOR project, has established key research infrastructures in Limassol, Cyprus, including the Cyprus Atmospheric Remote Sensing Observatory (CARO), the ACTRIS National Facility. Through the ATARRI project, ECeE aims to maximize the use of these facilities to enhance atmospheric research, Earth observation, and modelling capabilities. The scope of this study is to validate EarthCARE MSI and ATLID aerosol products using ground-based measurements from a Cimel sunphotometer and PollyXT lidar at CARO. The analysis focuses on satellite overpasses within 60 km of the station between July 2024 and September 2025.

DATA

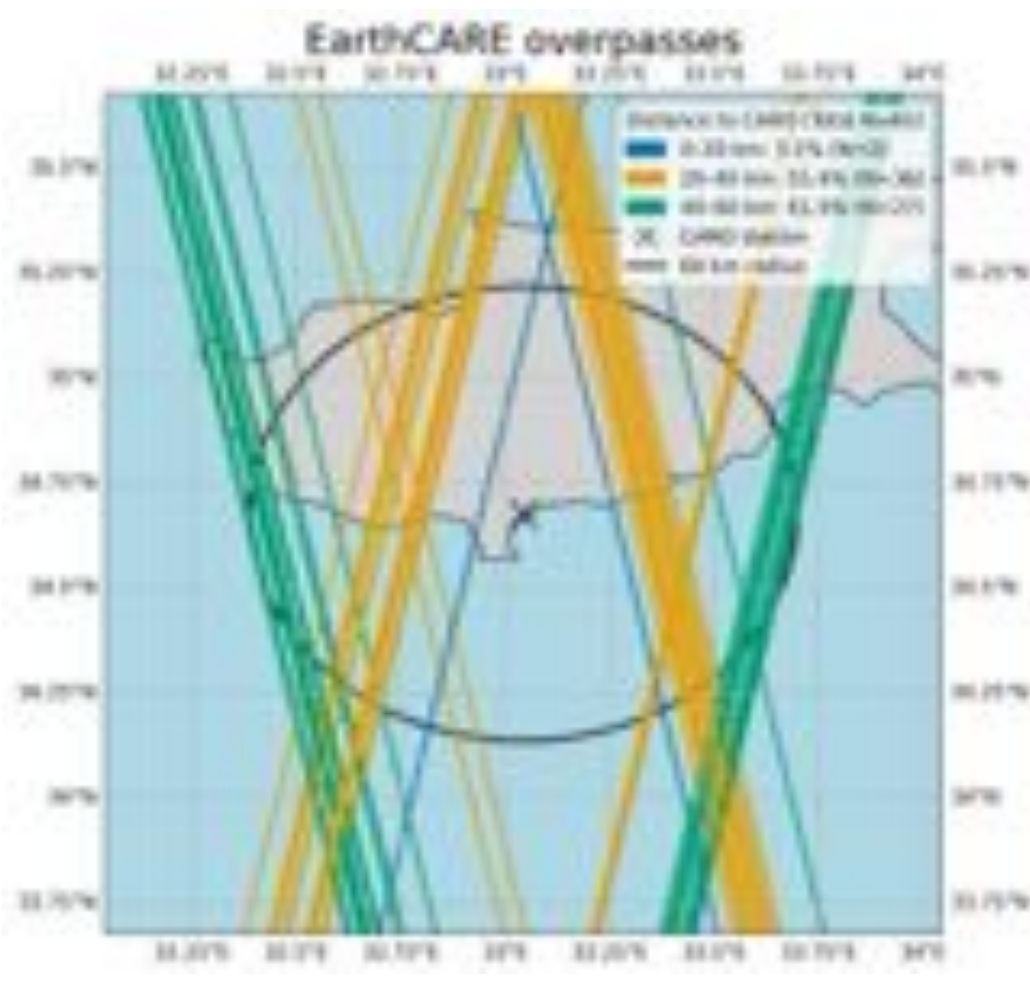
EarthCARE overpasses within 60 km of the station, Baseline BA

ATLID (ATMOSPHERIC LIDAR)

A high-spectral-resolution lidar designed to retrieve vertical profiles of optically thin clouds and aerosols. The instrument provides vertically resolved atmospheric backscatter measurements in three channels, enabling detailed characterization of aerosol and cloud properties.

Products used in this study:

ATL_EBD_2A: Extinction, backscatter, depolarization
ATL_TC_2A: Target classification



MSI (Multi-Spectral Imager)

A nadir-pointing push-broom imager with a 150 km swath. It provides daytime observations at 500 m spatial resolution using two cameras: a visible-near-infrared-shortwave infrared (VNS) camera with four solar channels, and a thermal infrared (TIR) camera with three channels.

Product used in this study:

MSI_AOT_2A: Aerosol Optical Thickness

CARO ACTRIS National Facility of the Cyprus Atmospheric Remote-sensing Observatory (CARO) located in Limassol (Panahifar et al., 2025)

PollyXT (Raman Polarization Lidar)

- Multiwavelength, dual-FOV Raman lidar operating continuously in Limassol since 2020.
- Measures vertically resolved aerosol and cloud properties at 355, 532, and 1064 nm.
- Part of PollyNET, a global network of automated lidars for continuous aerosol profiling.

Products used: Extinction at 355 & 532 nm

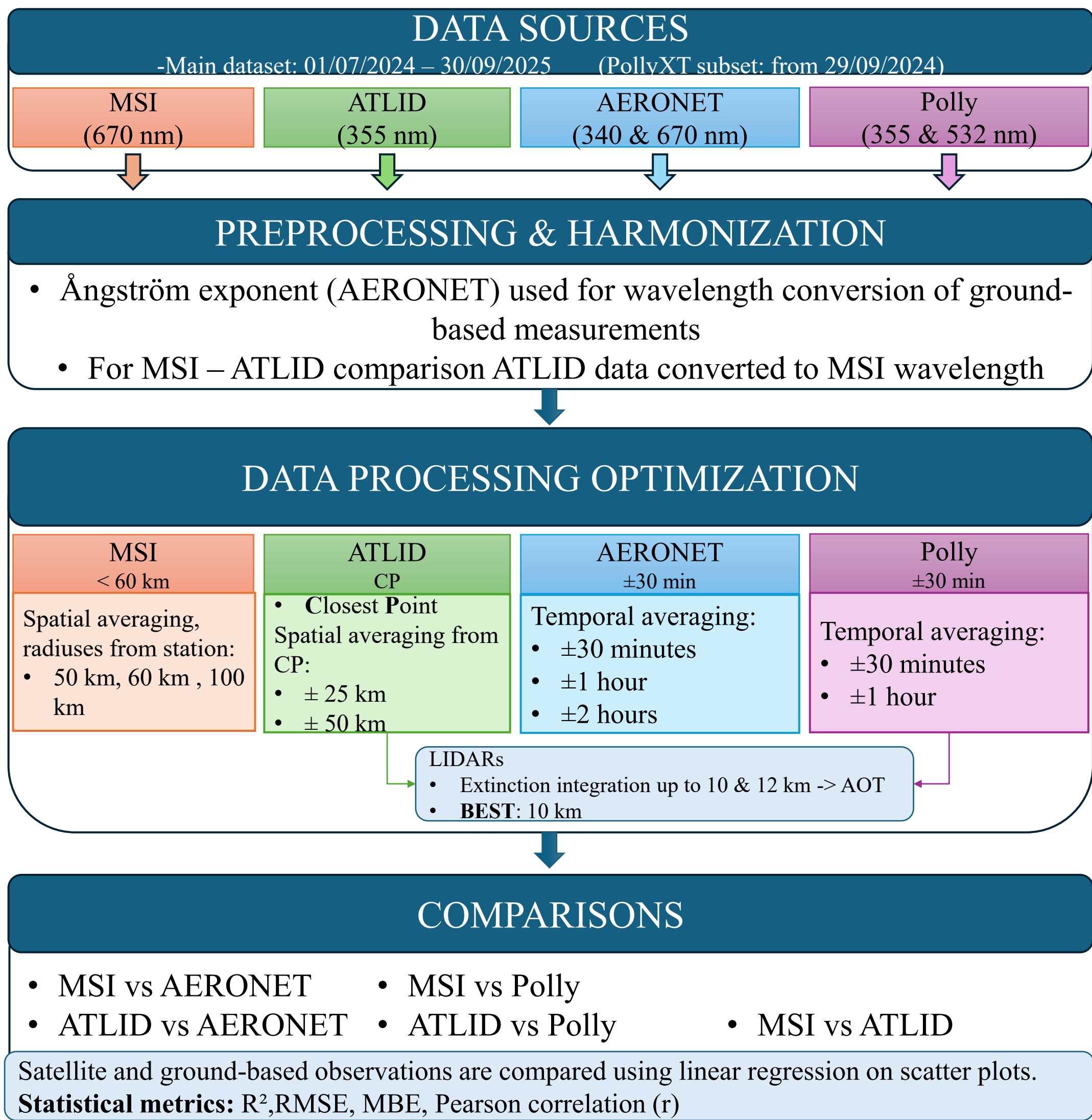
Sunphotometer (AERONET CE318)

- Ground-based sun photometer operating in Limassol since 2010, providing daytime aerosol observations, including aerosol optical depth (AOD).
- 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

Aerosol Optical Thickness retrievals



Extinction, Backscatter, Lidar ratio, Depolarization, Target Classification (cases study)

Dust cases studies:

- 5th of March 2025
- 8th of April 2025

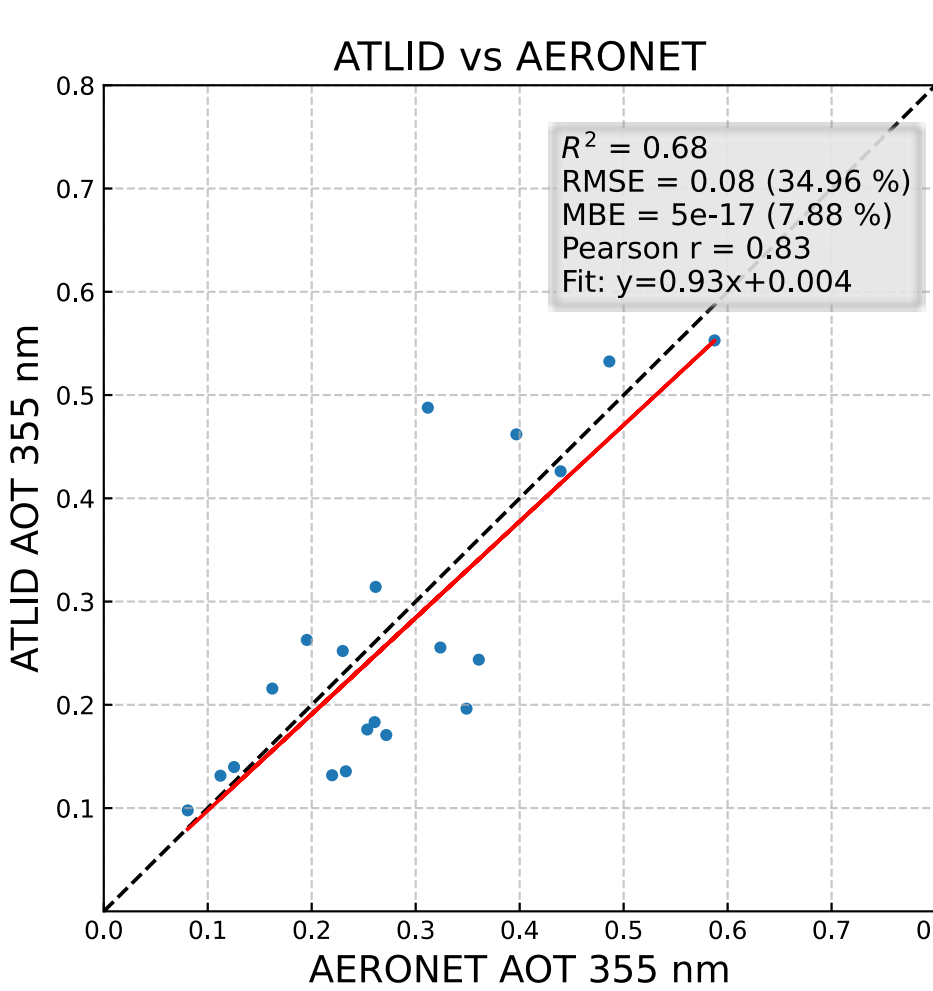
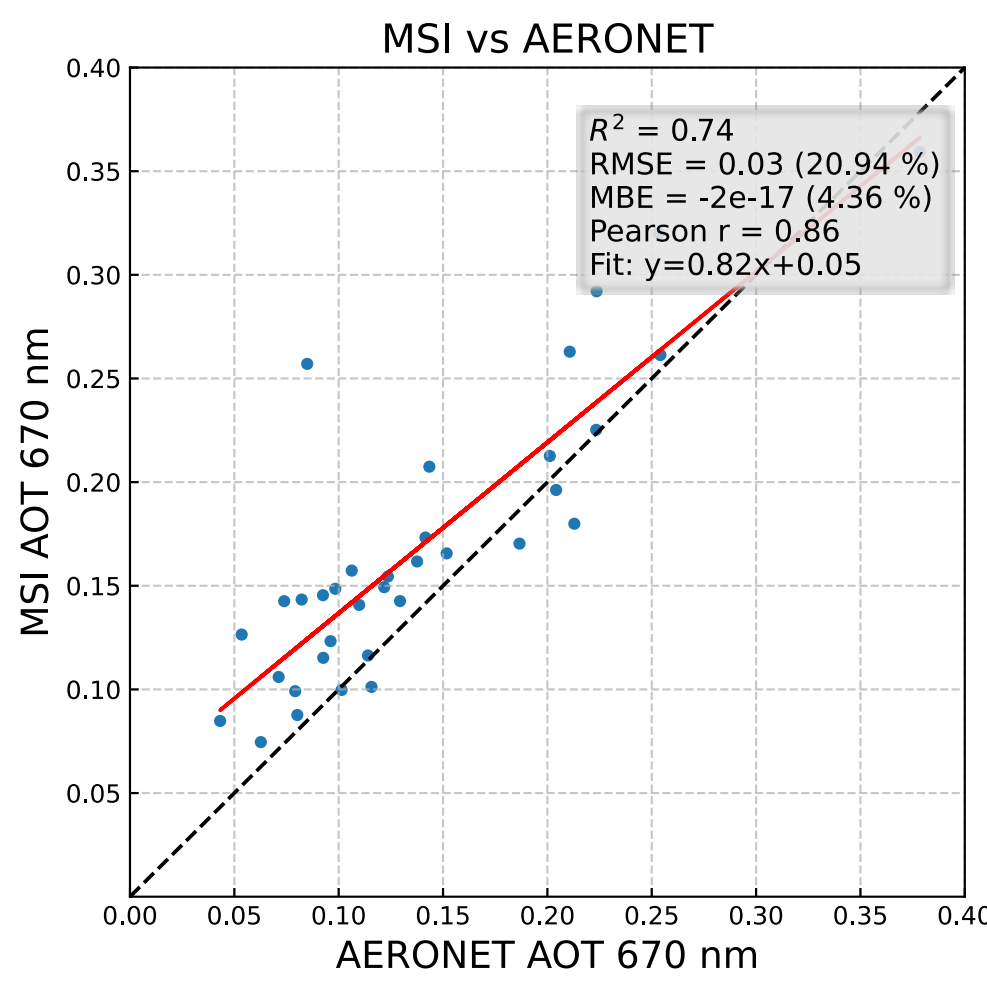
ATLID

± 25 km from CP

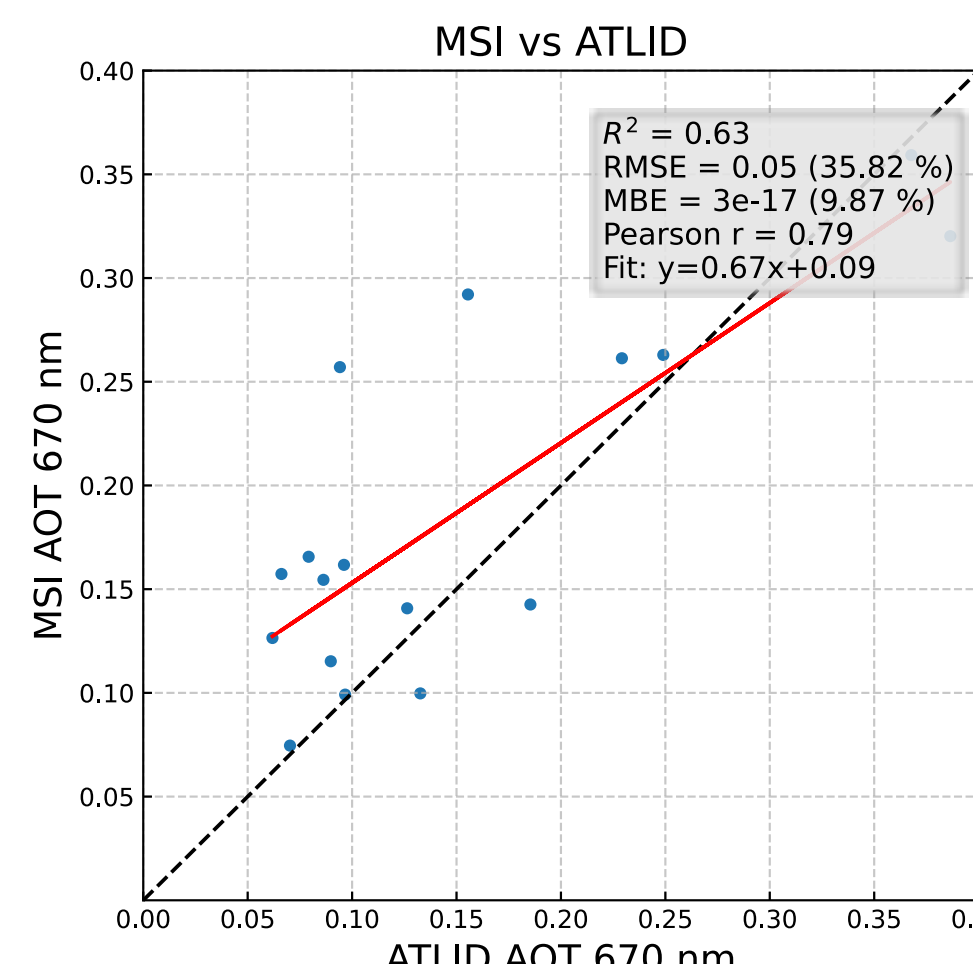
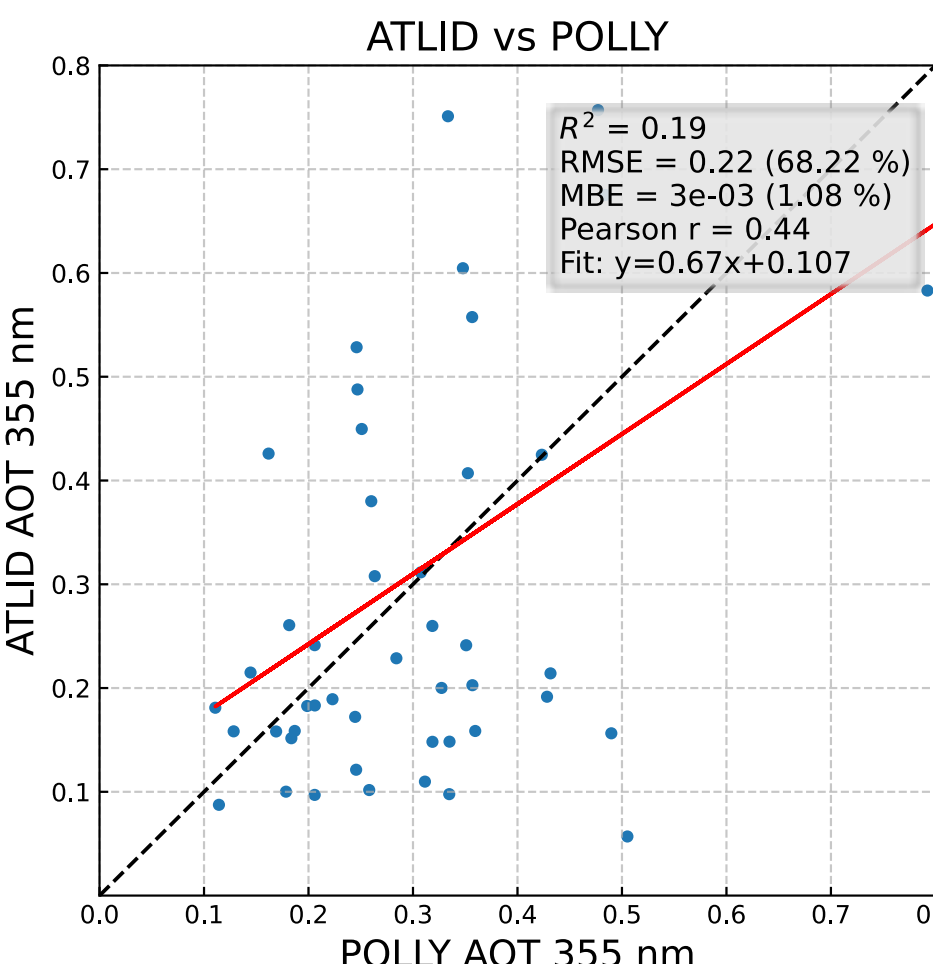
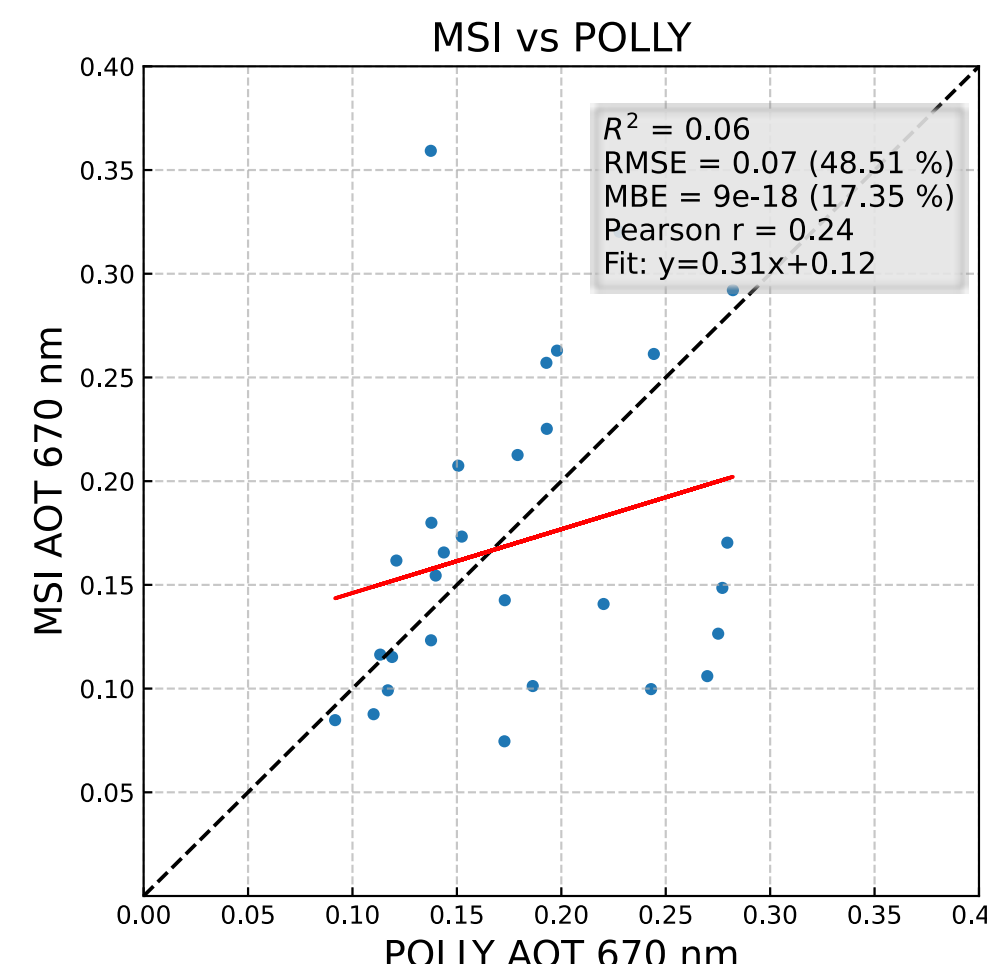
Polly

±30 min

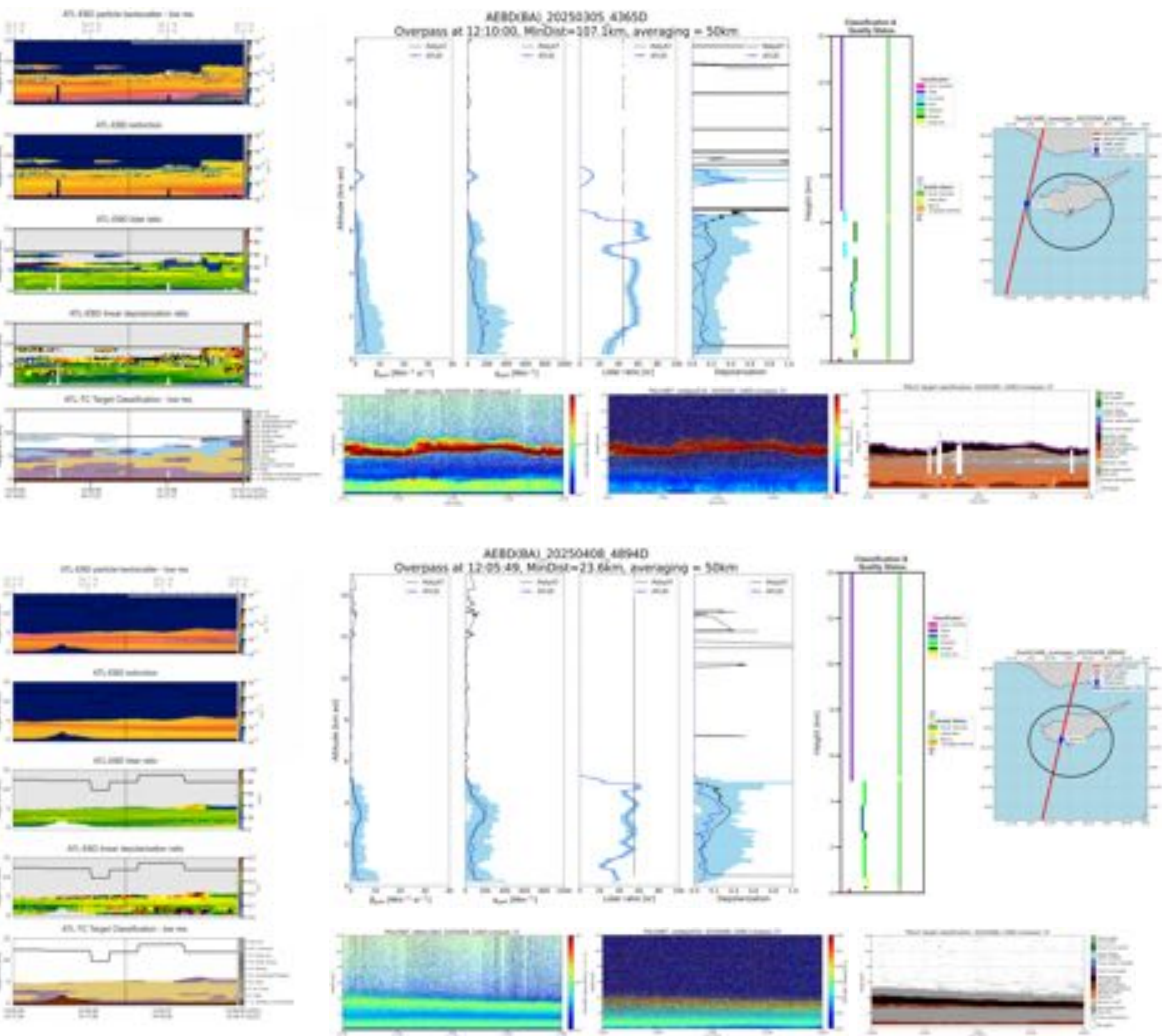
RESULTS



- The best results are achieved using optimized spatial and temporal averaging - MSI: 60 km, ATLID: closest overpass point with integration up to 10 km, AERONET/PollyXT: ±30 min.
- MSI–AERONET shows the strongest correlation, though with a slight AOT overestimation by MSI.



Comparisons with PollyXT show weaker agreement, with larger deviations due to differences in sampling, resolution, and instrument sensitivity. MSI and ATLID data often do not match, highlighting the need for improved validation tools and enhanced assessment of quality flags for the synergistic products.



3 March and 8 April 2025: Strong agreement between the instruments was observed for aerosol variables, with both cases consistently classified as **dust**.

CONCLUSION

Validation of EarthCARE AOT over Limassol shows **good agreement with AERONET** confirming the strong performance of satellite aerosol retrievals. Case studies indicate very good agreement in aerosol vertical structure, highlighting EarthCARE's capability to capture diverse aerosol conditions. The CARO National Facility provides essential long-term reference data for satellite validation in the Eastern Mediterranean. Future work will include expanded datasets with additional satellite overpasses and the extension of the methodology to additional AERONET stations.

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