Assessment of Aerosol–Cloud Interaction Parameter Retrieval Using Ground-Based Observations and EarthCARE Measurements: A Dust–Cloud Case Study over CARO–Limassol

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CARO Observatory and Instrumentation

- **Cyprus Atmospheric Remote Sensing Observatory (CARO)** is a National Facility of the **ERATOSTHENES Centre of Excellence (ECoE)** located at Limassol, Cyprus (34.67° N, 33.04°E). The CARO actively contributes to EarthCARE validation within the **CORAL project** (EVID-39, site: **CARO_Limassol**).
- CARO operates as a **multi-instrument atmospheric observatory** (Table 1 and Fig 2).

Table 1: Instruments running continuously at CARO_Limassol for monitoring aerosols, clouds, and radiative properties

Active Remote-sensing (1-4 Fig. 2): PollyXT Dual-FOV, Cloud Doppler Radar 35GHz, Wind Doppler lidar, CHM15k ceilometer
Passive remote-sensing (5-8 Fig.2): MWR HATPRO RPG, AERONET photometers, Disdrometer Parsivel
Radiation station: Sun-traker STR22G, Pyrgeometer, Erythemal UV irradiance measurement, All sky camera, Pyrgeometer

- Benefiting from its unique geographical position, CARO is influenced by diverse air masses and aerosol types (Fig. 1), making it a strategic reference site for remote-sensing activities in the Eastern Mediterranean and the wider **MENA region**.

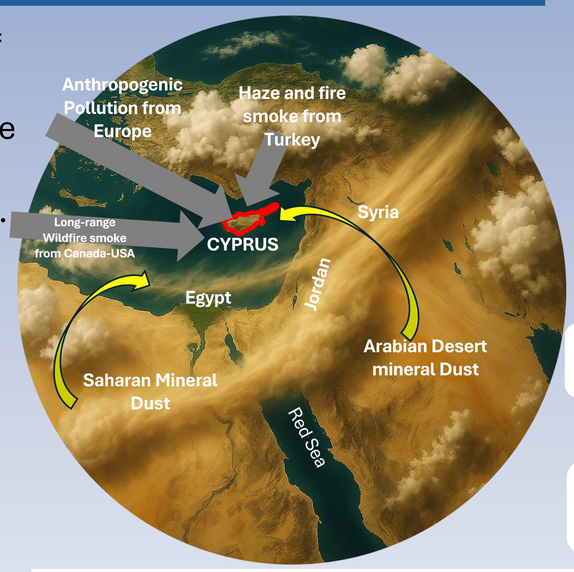


Fig 1- Unique location of CARO-Limassol station

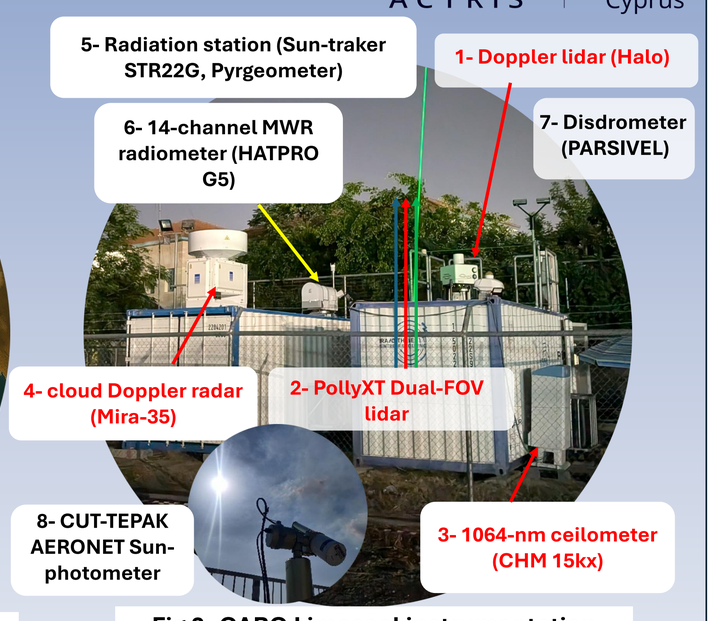


Fig 2- CARO Limassol instrumentation

Scientific Objective, Datasets and Methodology

- The primary objective of this study is to assess the consistency of aerosol–cloud interaction (ACI) parameters derived from EarthCARE ATLID observations with those retrieved from ground-based lidar measurements during a dust–cloud interaction event.
- **Ground-based** observations were obtained from the 355 nm channel of the PollyXT lidar (Level 01, SCC-processed, 1-h averages) and include backscatter coefficient, extinction coefficient, particle linear depolarization ratio, and lidar ratio.
- **EarthCare** dataset used in this study include **L1 (AUX_MET_1D)**, **L2A (ATL_EBD_2A, ATL_TC__2A, ATL_ICE_2A), L2B (ACM_CAP_2B, ACM_COM_2B)**.
- ATLID observations were extracted from **±N pixels** around the satellite overpass point closest to the CARO–Limassol station using high-, medium-, and low-resolution dataset.
- The vertical grids of **AUX_MET_1D** (~137 altitude levels) and **ATL_EBD_2A** (~242 altitude levels) were harmonized onto a common altitude grid using **piecewise cubic Hermite interpolating polynomial (PCHIP)** interpolation.

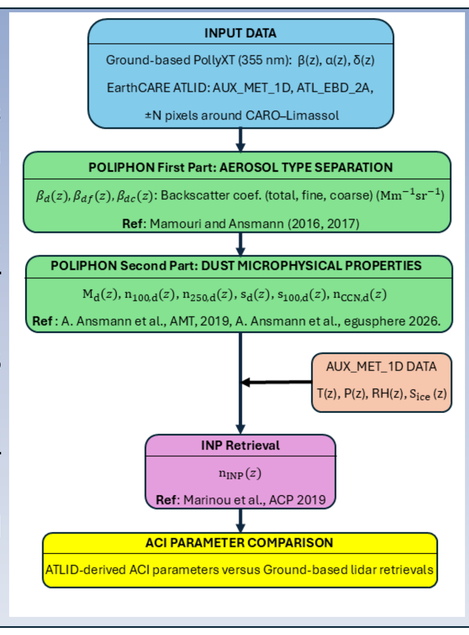
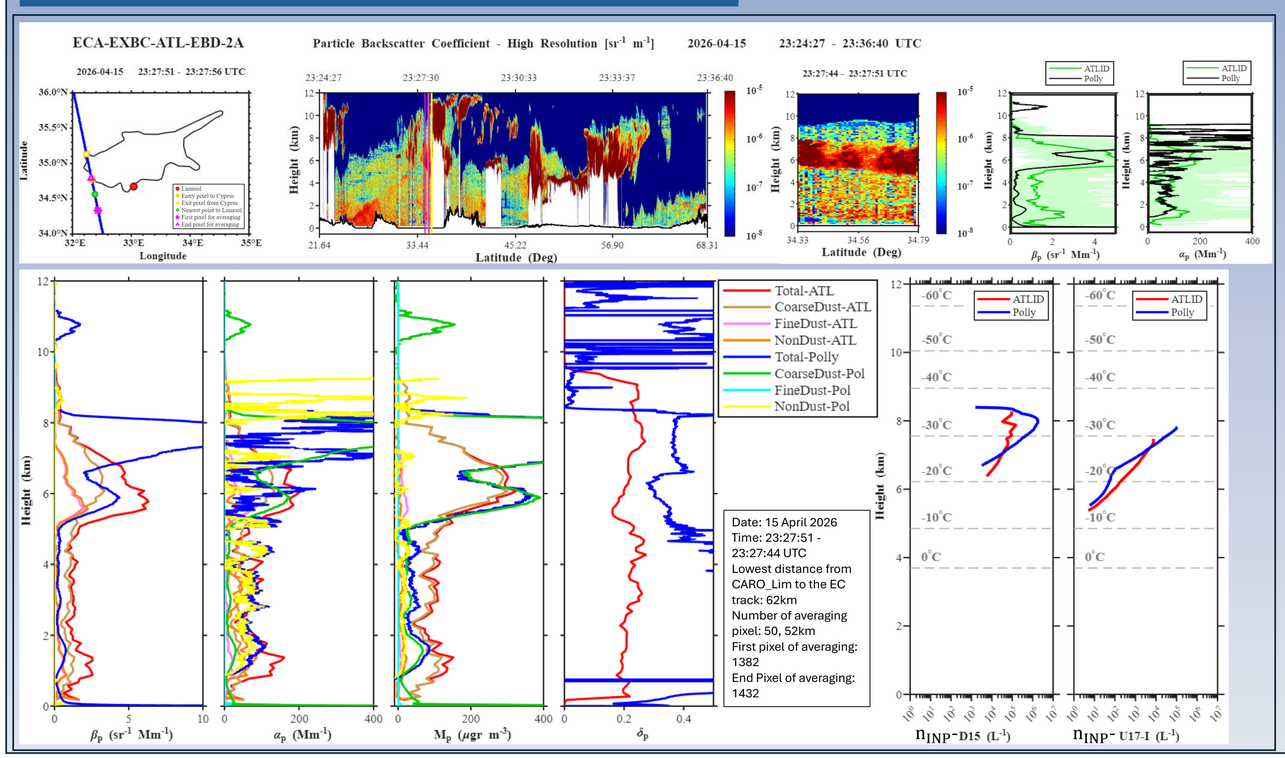
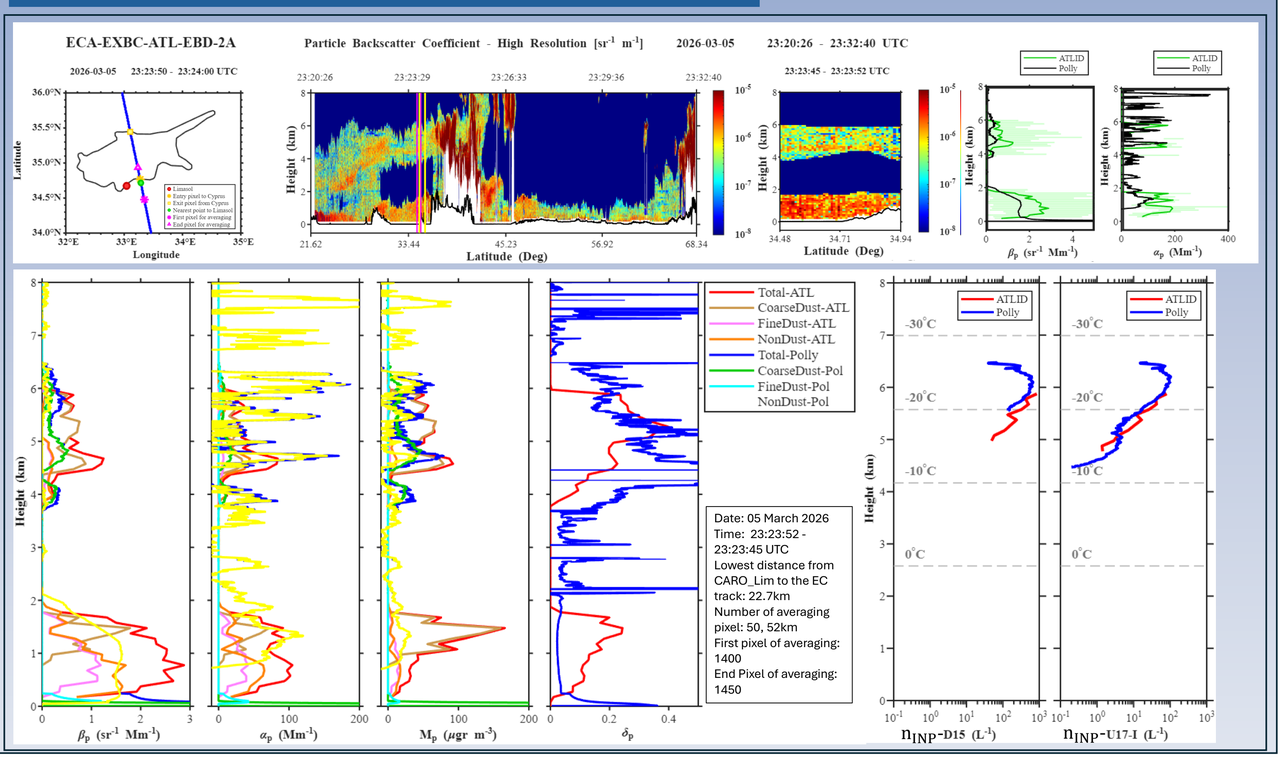


Fig 3- Schematic overview of the retrieval framework used to derive aerosol–cloud interaction (ACI) parameters from EarthCARE ATLID and PollyXT lidar observations. Dust-related microphysical properties are obtained using the POLIPHON method and combined with AUX_MET_1D meteorological profiles for INP retrieval, enabling a comparison of satellite- and ground-based ACI products.

Result: Dust event 15 April 2026



Result: Dust event 05 March 2026



Summary and Conclusion

- ATLID-derived n_{INP} profiles showed promising agreement with ground-based lidar retrievals, reproducing the main vertical structures and variability observed during the investigated dust–cloud events.
- The retrievals suggests that EarthCARE observations can support the investigation of aerosol–cloud interactions beyond ground-based monitoring sites, enabling the retrieval of INP-related information along the satellite track.
- Future work will focus on retrieving n_{INP} for other aerosol–cloud interaction scenarios, particularly wildfire smoke plumes, as well as evaluating relationship between retrieved n_{INP} with cloud ice properties derived from the ACM-CAP and ACM-COM products.

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