

A Polarimetric Lidar Extinction Method for Improved Dust Retrievals from EarthCARE

Zuhir Bona¹, Kenneth M. Tschorn¹, Alkistis Papetta¹, Konstantinos Fragkos¹, Emmanouil Proestakis², Konstantinos Rizos², Eleni Marinou², Vassilis Amiridis² and Franco Marenco¹

¹Climate and Atmosphere Research Centre (CARE-C), The Cyprus Institute, Nicosia 2121, Cyprus

²Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Athens 15236, Greece

Understanding and quantifying the role of atmospheric dust in the climate system remains a significant challenge in atmospheric sciences, primarily due to uncertainties in its four-dimensional (4D) global distribution. Although dust observations from ground-based networks, remote sensing platforms, and aircraft campaigns are available, coverage is sparse over the major dust source regions where emission and near-source transport occur.

The recently launched EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) mission provides high-resolution, globally distributed observations of aerosols, clouds, and radiative fluxes, and its ATLID instrument uniquely combines high-spectral-resolution and polarimetric capabilities at 355 nm. In this study, we propose and start developing the Polarimetric Lidar Extinction separation method for dust (POLIEXT-D), which extends the POLIPHON framework to exploit ATLID's aerosol intensive properties, in particular, the particle linear depolarization ratio and lidar ratio for separating dust and non-dust extinction (whereas POLIPHON is tailored for backscattering). Using EarthCARE Level 2 A-EBD and AC-TC products together with POLIEXT-D, we aim to derive a dust-specific product intended to support the construction of a 4D global dust climatology.

At this stage, the main focus is on data selection and quality assurance, before implementation of POLIEXT-D. This poster presents our current progress and outlines the next steps.

POLIEXT-D is built around the following equation $\alpha_d = \alpha_p \frac{S_d (\delta_p - \delta_{nd})(1 + \delta_d)}{S_p [(\delta_d - \delta_{nd})(1 + \delta_p)]}$ (derived from the POLIPHON equation $\beta_d = \beta_p \frac{(\delta_p - \delta_{nd})(1 + \delta_d)}{(\delta_d - \delta_{nd})(1 + \delta_p)}$ in Mamouri and Ansmann, 2014). For the lidar ratio of dust it is derived from the non-cloudy pixels dominated by bare dust ($\delta_d \geq 0.27$) in the current profile or in nearby profiles.

Depolarization inconsistency

Depolarization is a key parameter for classifying and separating the dust component of the backscatter and extinction, but as we see in Fig 1, we have a big number of unreasonable depolarization measurements (expected between 0 and 0.5 in most cases). This was also reported by Baars et al. (2026).

All analyses included use the Data from Base BA and at low resolution

Quality Control

We use AC-TC synergies target classification to filter cloud and rain bins with an extra buffer of 2 bins in all directions, then apply a sequence of per-bin quality control filters as listed in this table

QC Filter	Thresholds
Quality status	Good (0)
Lidar ratio	$0 \leq LR \leq 140$ sr
Depolarization error	≤ 0.3
Relative extinction error	$\leq 100\%$
Relative Backscatter error	$\leq 100\%$

Edge effect

As we see a lot of unphysical depolarization bins are at the edge between the aerosol layer and clear air, so we apply the following filter to remove those bins:

Bins with $\delta_p > 0.5$ or $\delta_p < 0$ And Inside a vertical window of ± 10 bins around clear air bins are removed



Contact information



Dust DN

References

Mamouri, R.E. and Ansmann, A., 2014. Fine and coarse dust separation with polarization lidar. Atmospheric Measurement Techniques, 7(11), pp.3717-3735.
Baars, H., et al., 2026. Validation of EarthCARE/ATLID aerosol profiling products with ground-based PollyNET lidars – case studies. EGU sphere [preprint], pp.1–XX. <https://doi.org/10.5194/egusphere-2026-1490>

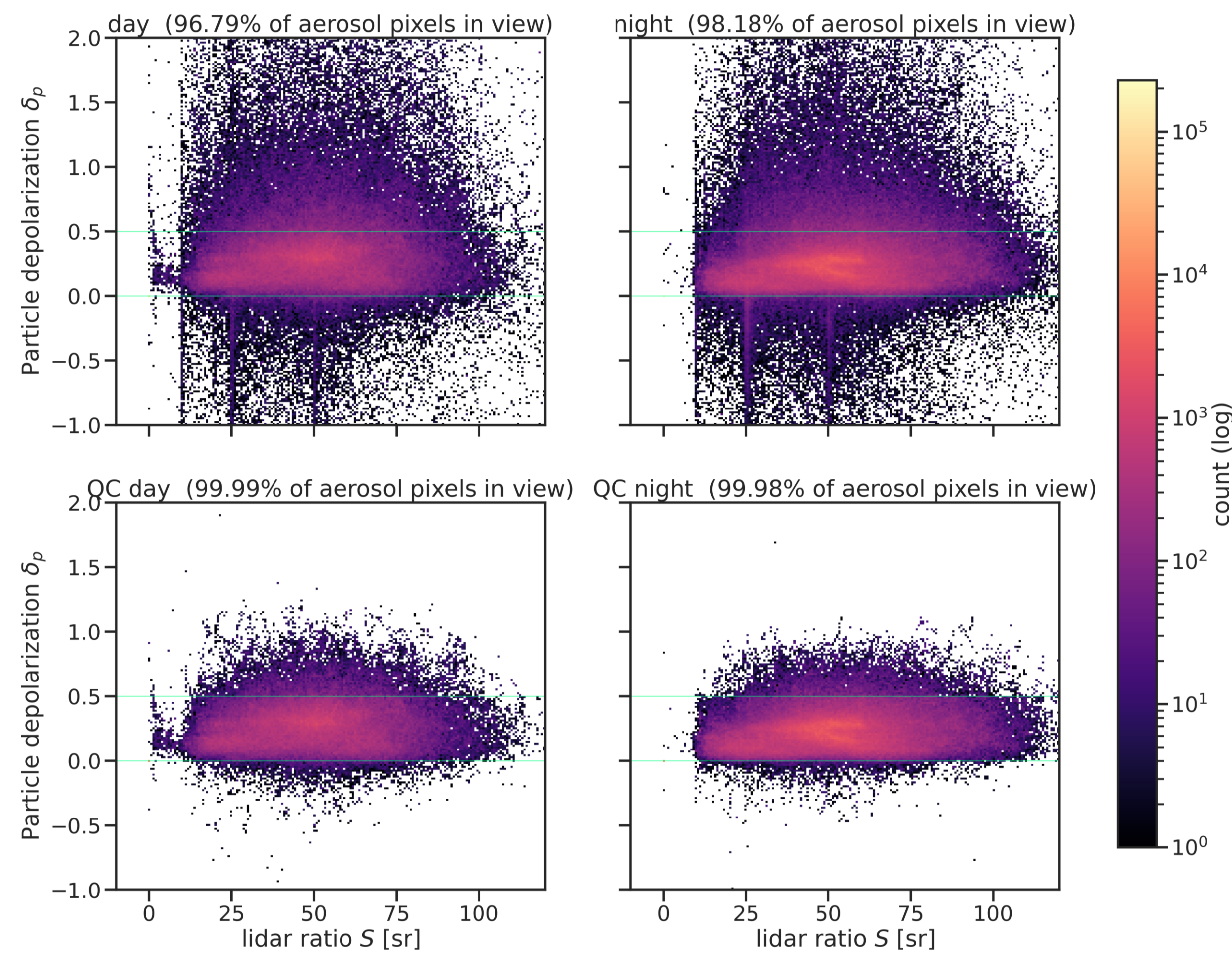


Fig 1: Particle depolarization vs Lidar ratio from 18-day and 23-night orbit over EMME region during April 2025 before and after QC

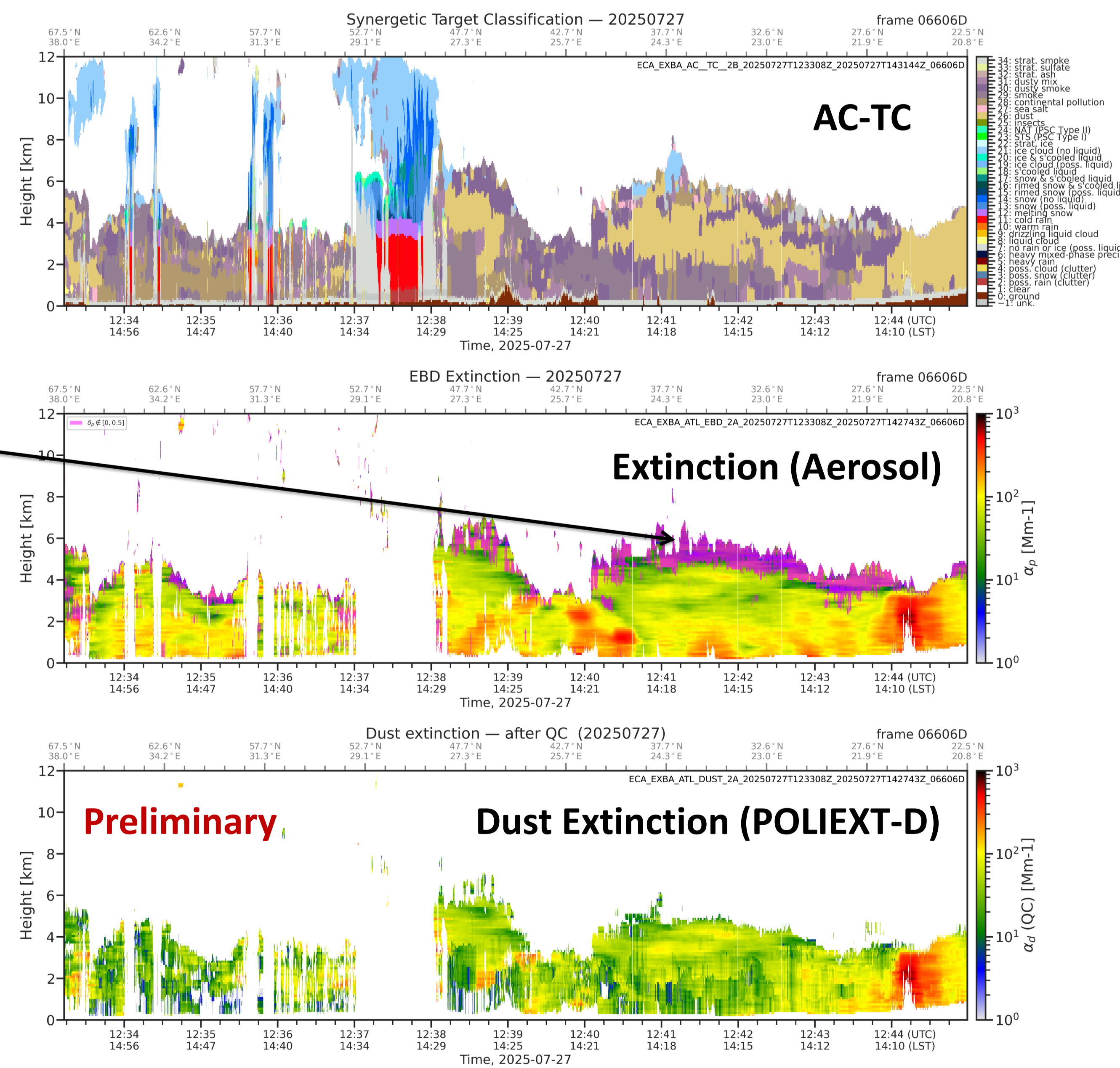
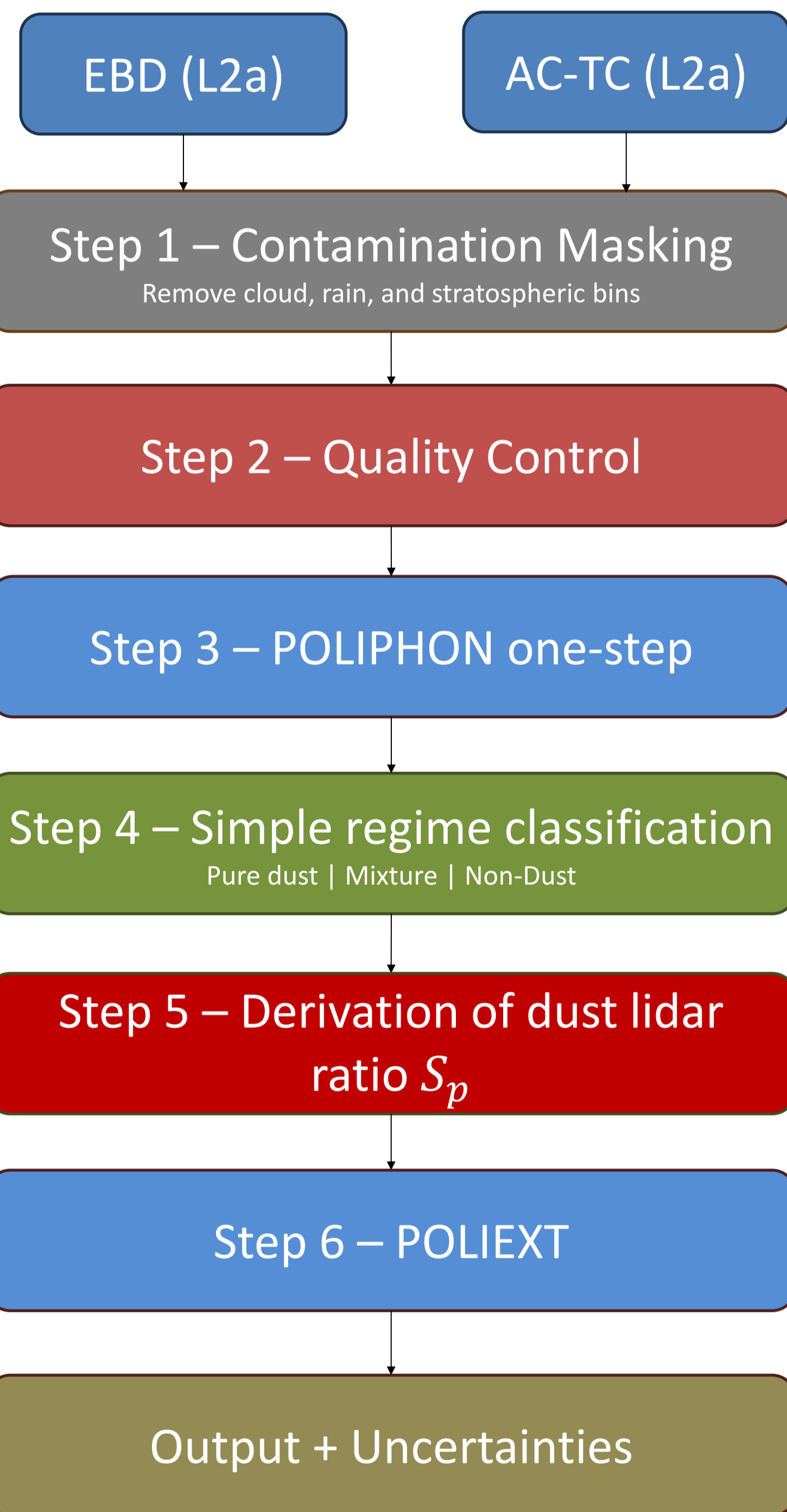


Fig 2: Target Classification, Extinction and Dust Extinction plots for frame 06606D on 2025/07/27, with unphysical depolarization range (negative or > 0.5) highlighted, showing edge effect

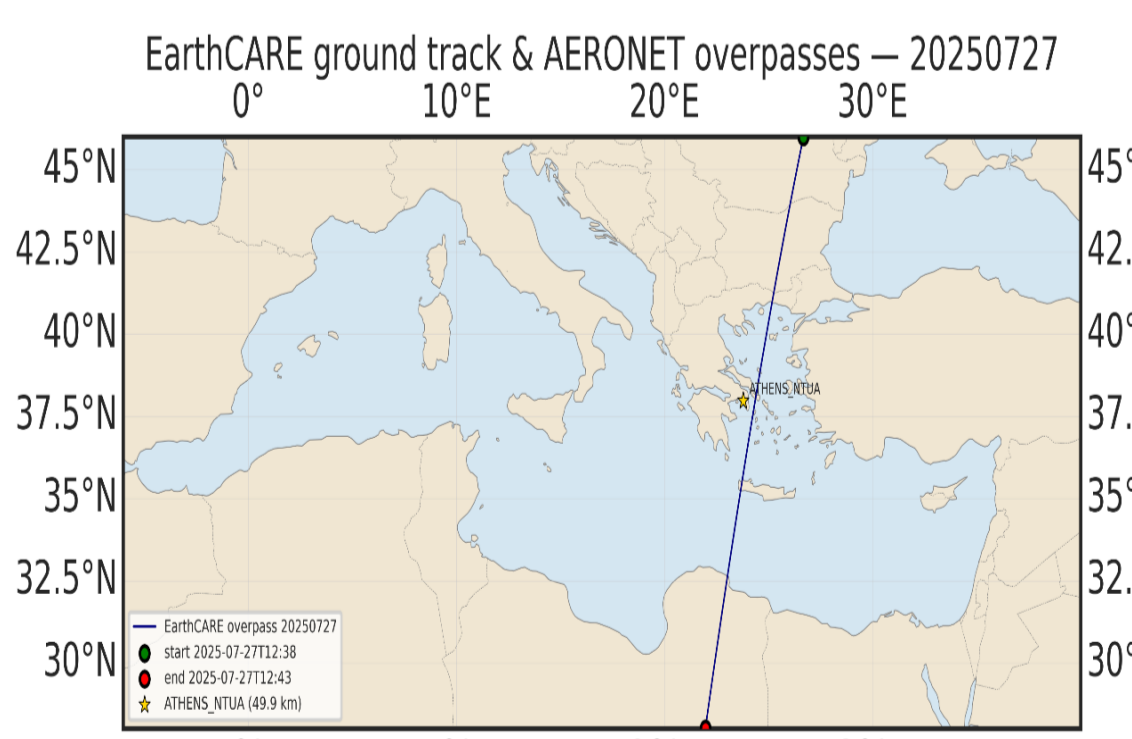
Key Parameters

Backscatter coefficient $\beta_p(z)$ [$m^{-1} sr^{-1}$]
Extinction coefficient $\alpha_p(z)$ [m^{-1}]
Lidar ratio $S = \alpha/\beta$ [sr]
Particle linear depolarization ratio $\delta_p = \beta_{\perp}/\beta_{\parallel}$

Key assumptions	$\lambda = 355nm$
Dust LPDR δ_d	0.27
Non-Dust LPD δ_{nd}	0.05



Dust Product pipeline flow



Future Outlook

We will continue refining and testing the quality-control thresholds, as this work is still ongoing. The developed product will then be validated through comparisons with ground-based measurements acquired during dust events, as well as UAV observations where available.

Acknowledgments

This research is supported by the Dust-DN project, which received funding from the European Union's Horizon Europe Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No 101168425, as well as two national agencies: UKRI in the United Kingdom and SERI in Switzerland. Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.