

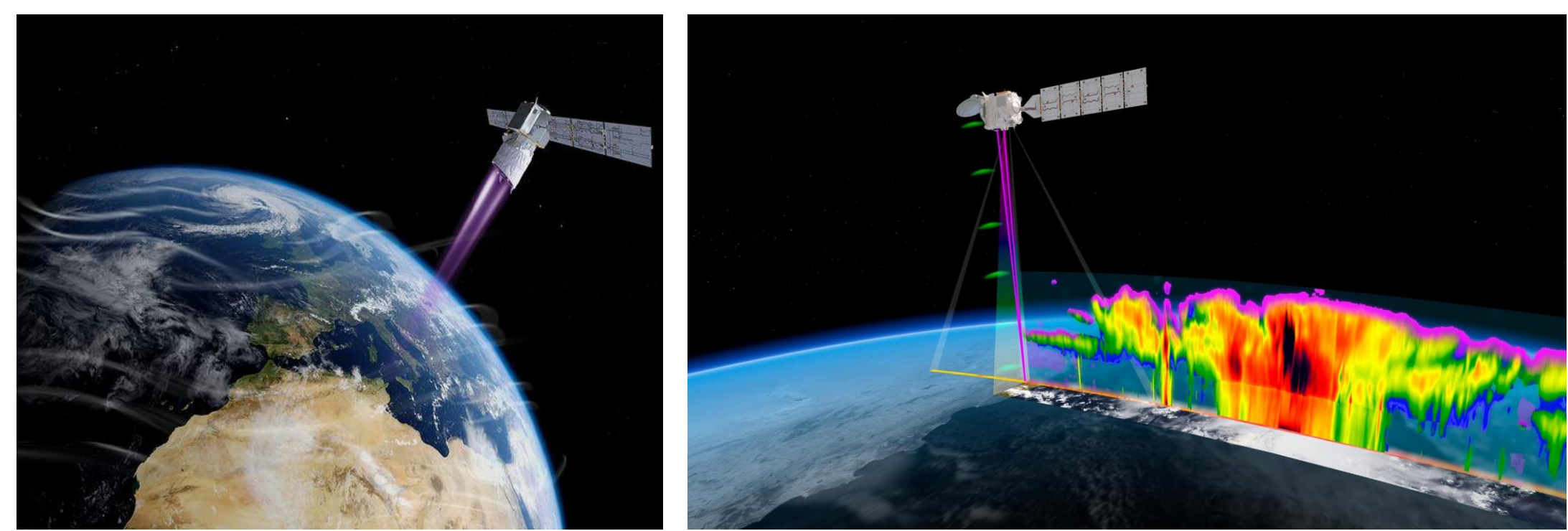
PANGEA observatory for the validation of Aeolus, EarthCARE & DQ1 Aerosol Products

Karipis A.¹, Voudouri K.A.^{1,2}, Marinou E.¹, Tsihla M.¹, Rizos K.¹, Siomos N.⁴, Tsikoudi I.^{1,3}, Paschou P.¹, Peletidou G.², Kouklaki D.¹, Tsekeri A.¹, Balis D.², and Amiridis V.¹, Dai G.⁵, Wenrui L.⁵, Sun K.⁵
¹National Observatory of Athens, Athens, Greece, ²Aristotle University of Thessaloniki, Thessaloniki, Greece, ³National and Kapodistrian University of Athens, 15772 Athens, Greece, ⁴Meteorological Institute, Ludwig Maximilian Universität München (LMU), Munich, Germany
⁵Ocean University, Qingdao, China
*Corresponding Author e-mail: kavoudou@noa.gr



Introduction

Validation of satellite products ensures products accuracy, characterizes their uncertainties and provides confidence in scientific and operational exploitation of the data. Suborbital collocated measurements play a key role. Ground-based lidar systems and networks such as ACTRIS (actris.eu), EARLINET (data.earlinet.org), and POLLYNET (polly.tropos.de), provide collocated measurements for the evaluation of Aeolus, ATLID, and ACDL lidar and aerosol products.



Objective

Use of PANGEA observatory and ESA eVe reference system for the Cal/Val of Aeolus, EarthCARE and DQ1 satellite lidar products.

Ground-Based Instrumentation:

• PANGEA PollyXT lidar:

- $3\beta + 2\alpha + 2\text{LR} + 2\delta$
- 24/7 measurements
- Member of EARLINET, POLLYNET, GAW

PANGEA Site



• ESA eVe lidar

- Linear and circular polarization
- $\beta + \alpha + \text{LR} + \delta$ at 355 nm
- Ground-based mobile platform and ESA's reference for satellite Cal/Val



Methodology

Collocation criteria:

- Ground-based lidar measurements ± 1.5 hours from satellite overpass
- Overpasses falling within 100 km from lidar location

Validation approach:

- Case-by-case analysis
- Profile statistics to identify long-term or height-sensitive anomalies.

EarthCARE:

- **Products:** A-NOM, A-EBD, A-TC
- **Tools:** Python tools tailored for EarthCARE validation with ground based lidar systems. Publicly available at:

AEOLUS:

- L2A Products: (co-polar) $\beta + \alpha$ + (co-polar) LR
- Aeolus detects only the co-polar component of backscattered lidar signal
- Conversion of ground-based lidar profiles (β and LR) to Aeolus-like profiles for the comparisons

$$\beta_{\text{Aeolus like}} = \frac{\beta}{1 + \delta_{\text{circular}}}$$

ACPPV

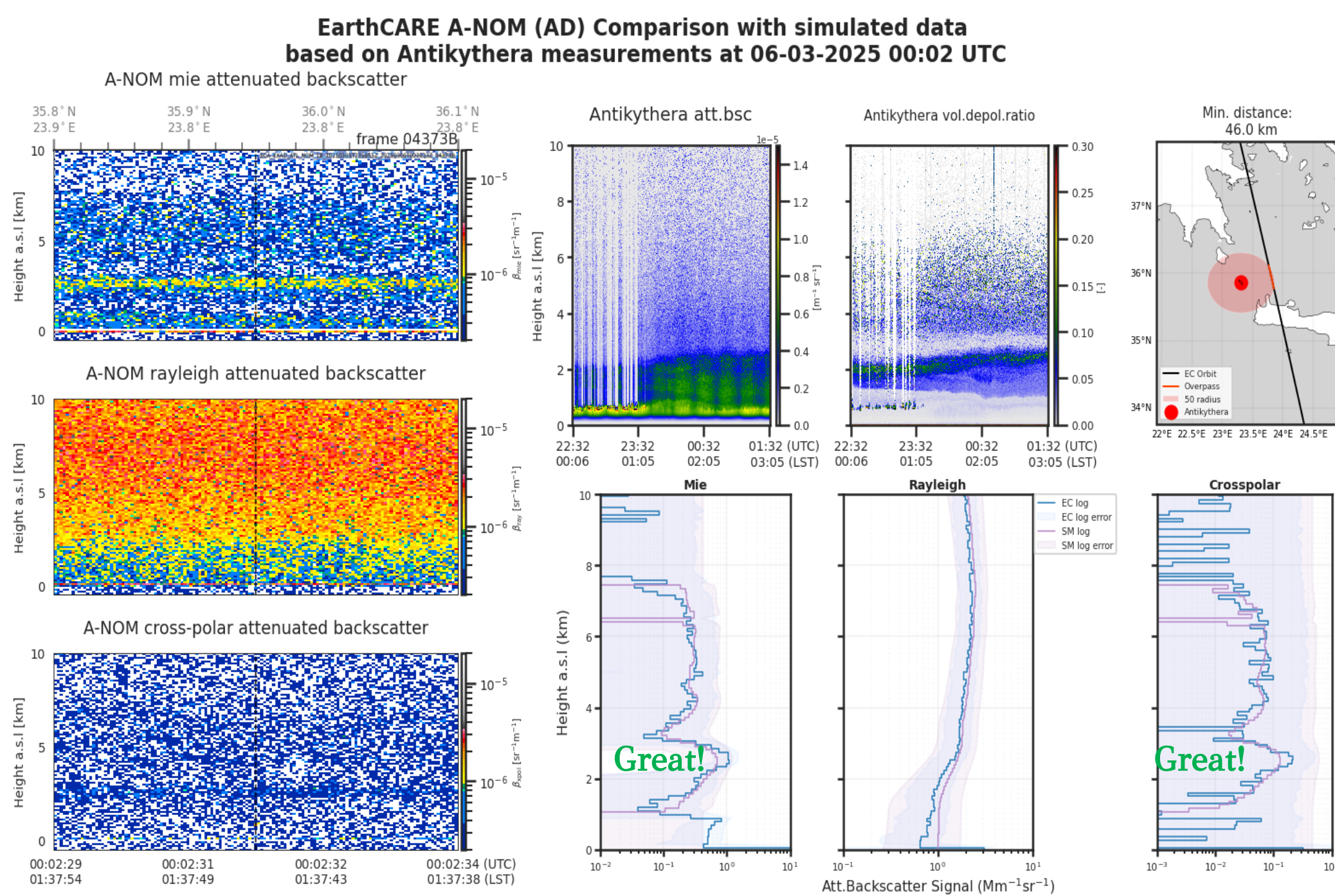
The comparison is aligned with the CEOS Best Practice Protocol for the validation of Aerosol, Cloud, and Precipitation Profiles (ACPPV)

DOI: 10.5281/zenodo.15025627

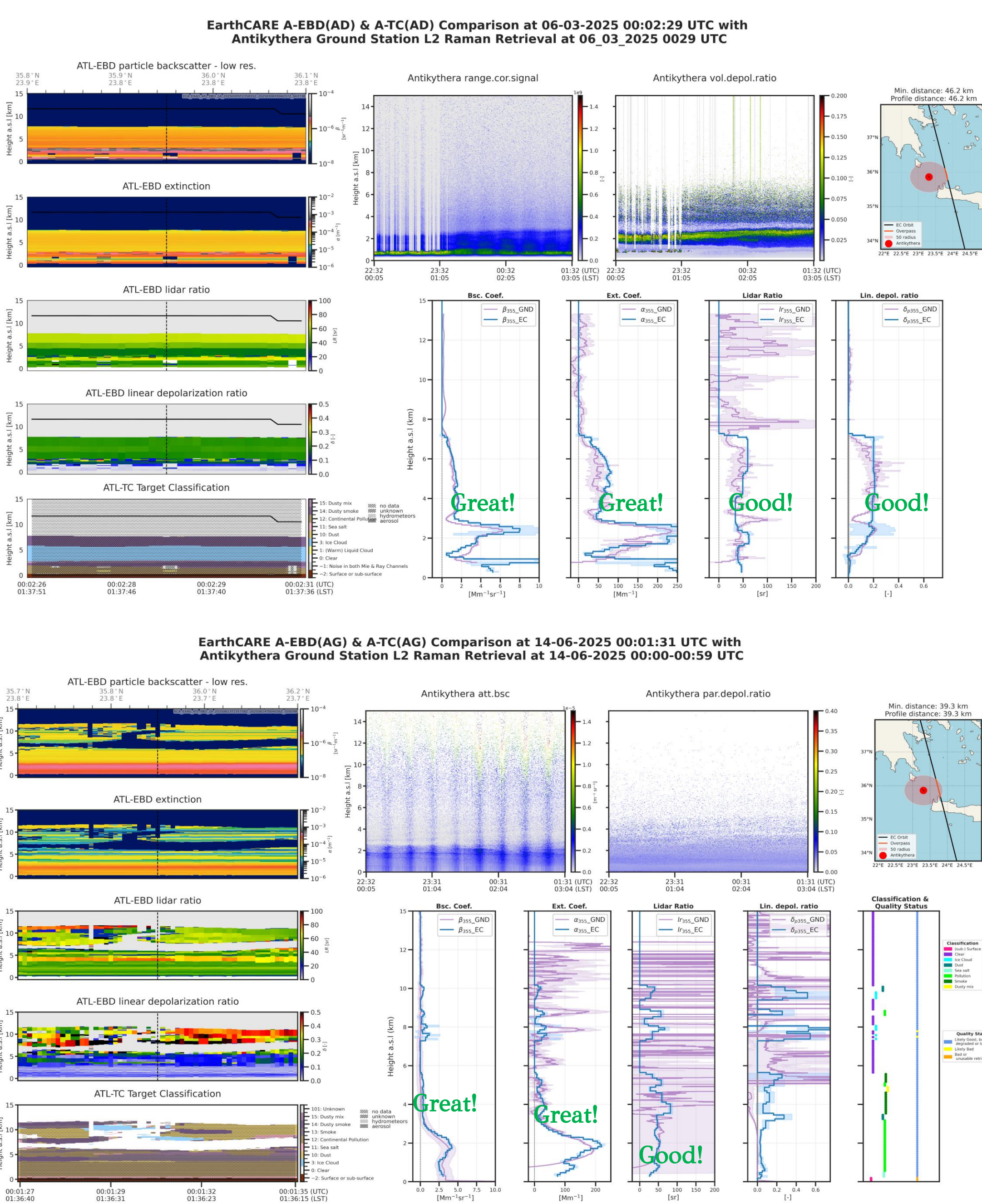


EarthCARE Validation results:

Case-by-case comparisons L1 comparison :



Case-by-case comparisons L2 comparison :



Main results:

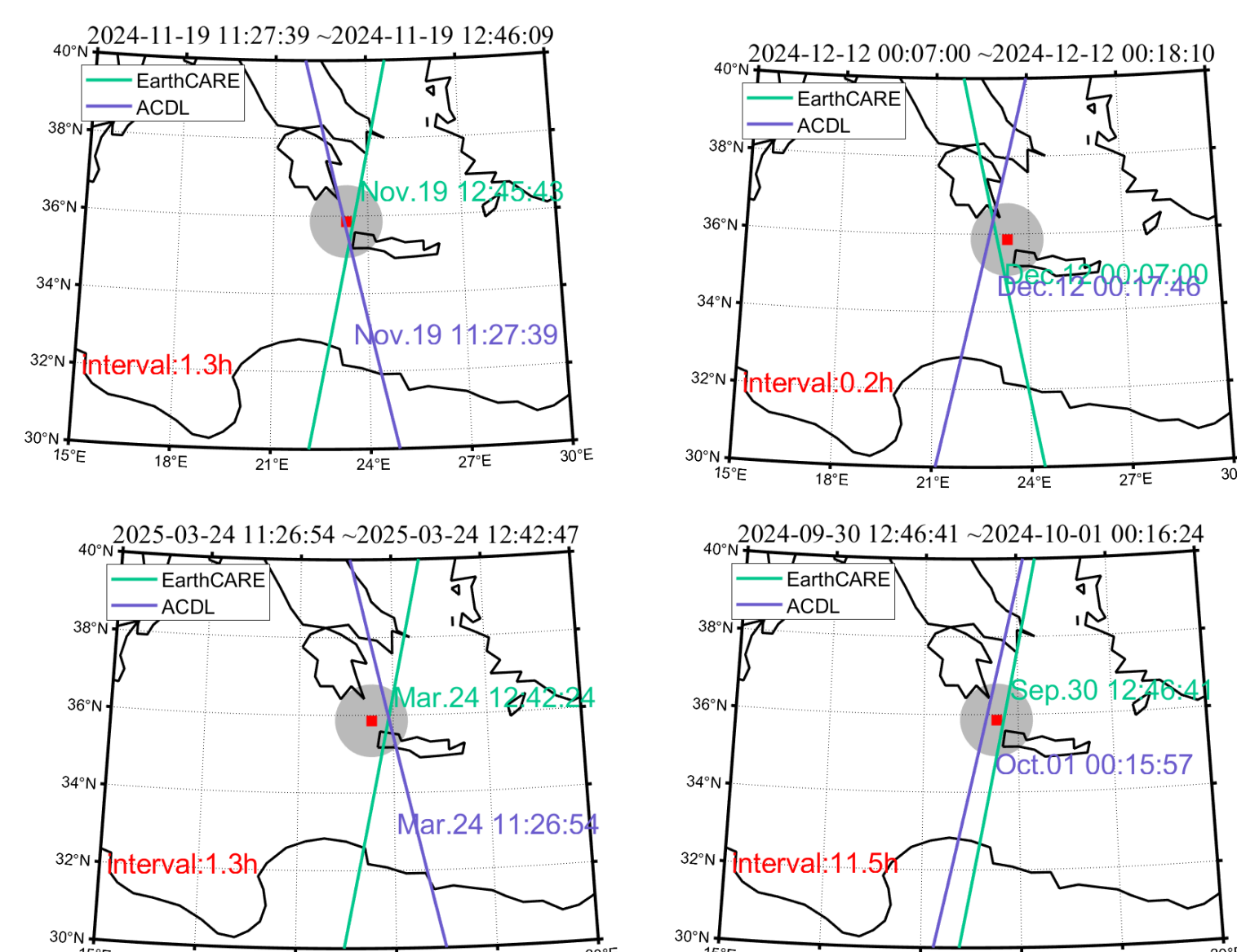
□ L1: A-NOM intercomparison:

- ✓ Good agreement in Mie and Rayleigh
- ✓ ATLID shows noisy cross-polar signals
- ⚠ Cross-polar issue already known; needs improvement

□ L2: A-EBD, A-TC intercomparison:

- ✓ Very good layer detection
- ✓ Very good agreement in backscatter and extinction coefficients
- ⚠ Depolarization ratio needs further refinement
- ⚠ Improvement potential in A-TC

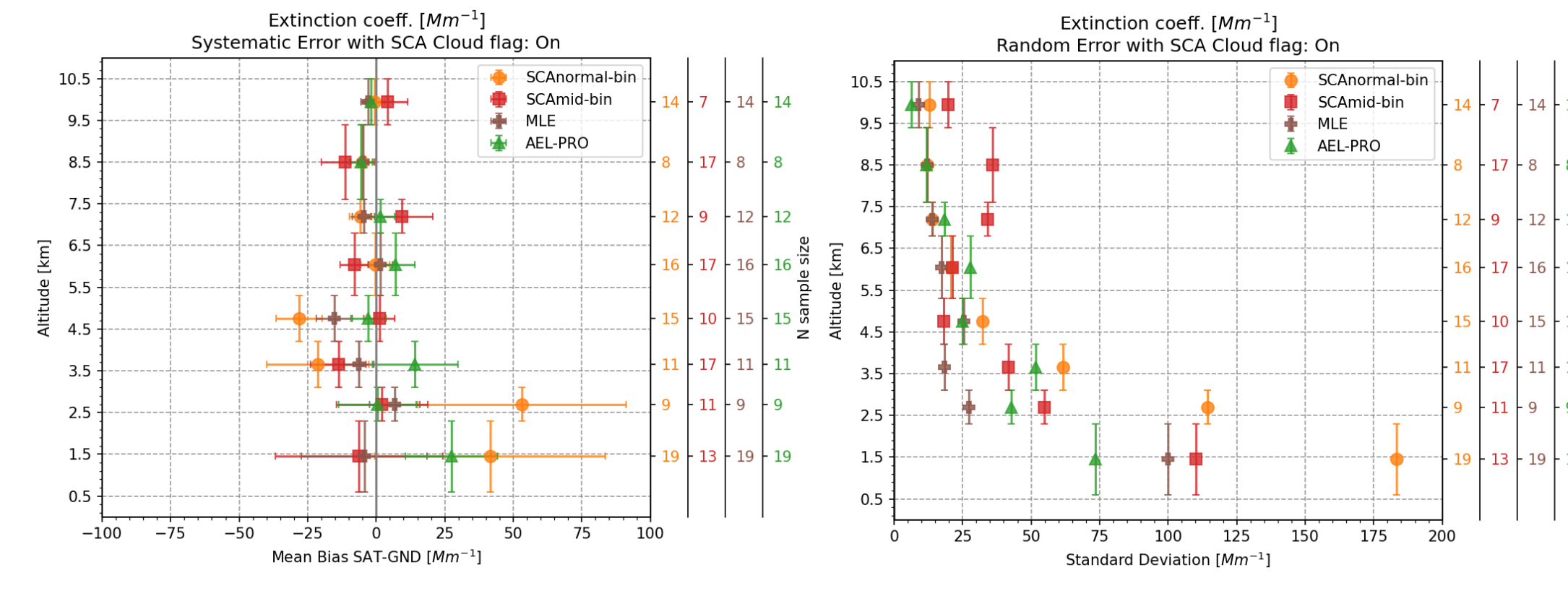
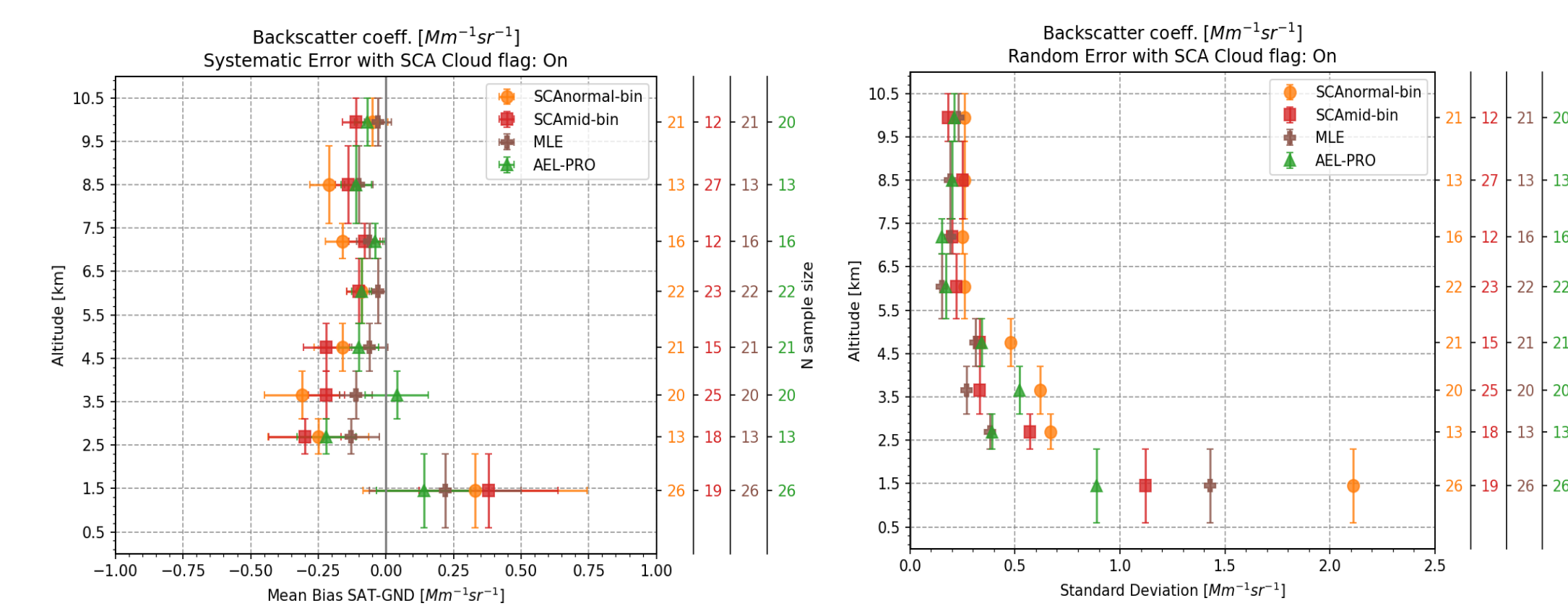
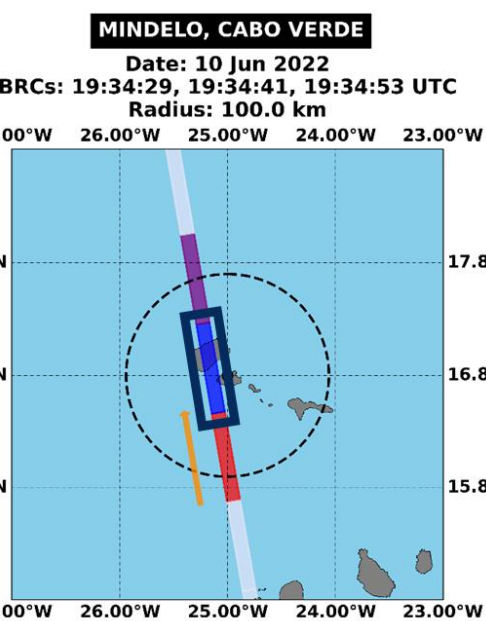
EarthCARE and DQ1 joint overpasses over Antikythera



Aeolus Validation results:

Statistical analysis:

- 14 eVe-Aeolus collocated measurements at Cabo Verde (ASKOS campaign; 2021 & 2022)
- Aeolus L2A products from SCA (all resolutions), MLE and AEL-PRO algorithms
- Cloud free profiles for eVe and Aeolus (SCA cloud product)



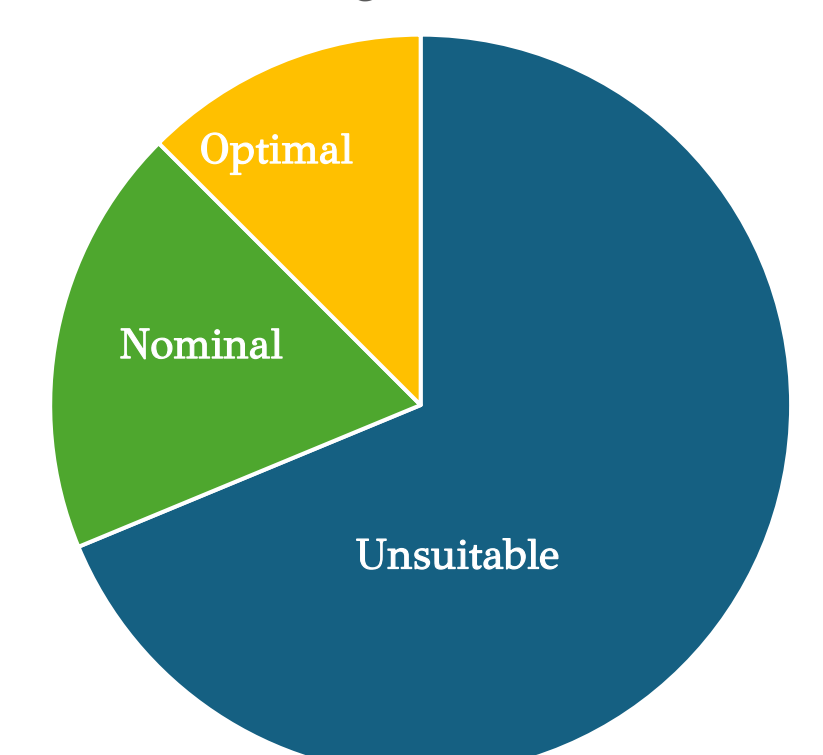
Main results:

- ✓ β : Validated as the most accurate L2A product (systematic errors $< 0.4 \text{ Mm}^{-1}\text{sr}^{-1}$; random errors $< 2 \text{ Mm}^{-1}\text{sr}^{-1}$)
- ⚠ α : Higher noise & variability product (systematic errors $< 53 \text{ Mm}^{-1}$; random errors $< 183 \text{ Mm}^{-1}$)
- ⚠ β and α : Larger discrepancies at lower altitudes (higher atmospheric variability, PBL inhomogeneities) and higher aerosol loads (increased noise due to enhanced attenuation of Aeolus signals)
- ✓ More consistent performance for β and α from MLE and AEL-PRO
- ⚠ Lidar Ratio: noisiest L2A product with extreme errors and variability for all algorithms

Conclusions & Future Work

- The PANGEA Climate Observatory (NOA) is a key Mediterranean facility supporting advanced Cal/Val services for atmospheric composition.
- Showcased successful validation activities for EarthCARE and Aeolus, using ground-based PANGEA and ESA eVe lidar observations.
- Continue the EarthCARE Cal/Val activities with PANGEA observations and targeted eVe lidar measurements
- Expand our Cal/Val activities to DQ1 aerosol products, aiming for consistent cross-mission comparisons.

EC - DQ1 16 joint AKY overpass categorization



Acknowledgments:

This research was financially supported by the EarthCARE DISC project, funded by the European Space Agency under Contract No. 4000144997/24/I-NS, and by the PANGEA4CalVal project (Grant Agreement 101079201) funded by the European Union