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Validation of EarthCARE ATLID aerosol products using ACTRIS-EARLINET and ship measurements

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The Atmospheric Lidar (ATLID) onboard EarthCARE is a high spectral resolution lidar system operating at 355 nm. ATLID is able to measure aerosol and cloud extinction and backscatter unambiguously due to its high spectral resolution. The ATLID level 2a products from ESA include feature mask, particle extinction coefficient, backscatter coefficient, lidar ratio, particle liner depolarization ratio profiles and some aerosol/cloud layer properties derived from the profiles. We evaluated the ATLID L2a version EXBA to EXBC aerosol products from August 2024 to May 2026.

1. Introduction

We have validated the ATLID version EXBA - EXBC AER and EBD products with collocated ground-based ACTRIS measurements. We use the hourly ACTRIS lidar products in EVDC (ESA Validation Data Center) that have already been selected at the EarthCARE overpass time at the sites. The ATLID profile that has the shortest distance (<100 km) to the an ACTRIS site and within the one hour of the ACTRIS measurements is used for the comparison.
We also compared the EarthCARE ATLID and MSI aerosol optical thickness products with Sunphotometer measurements during the R.V. Maria S. Merian cruise on 28 October 2025.

2. Compare ATLID AER, EBD products with Cabauw UV-lidar products

The AER and EBD L2a products are the output of the A-PRO processor from ESA. Here we show the improvement of AER and EBD products in the reprocessed version EXBA at Cabauw on 15 April 2025.

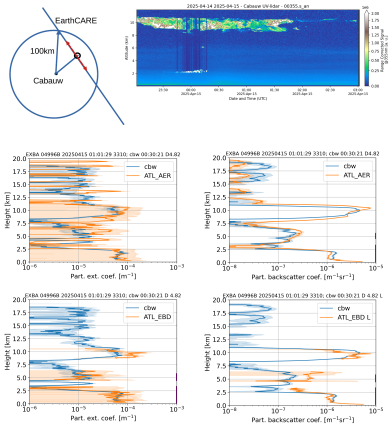

Figure 1. *Comparison of AER, EBD extinction coefficients and backscatter coefficients version EXBA with UV lidar measurements at Cabauw, the Netherlands. The overpass time is at 01:01:09 UT 20250415. Cabauw measurement is the average from 00:30:21 to 01:30:21 UT. The closest distance is 4.82 km.*

Good agreement between ATL_AER and ATL_EBD data with Cabauw UV lidar aerosol extinction coefficient and backscatter coefficient profiles. The Cabauw UV lidar extinction coefficients for the cirrus around 10 km can be improved.

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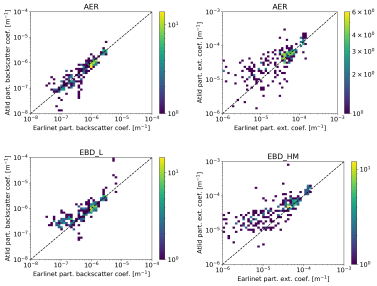


Figure 2. *Comparison of AER, EBD extinction coefficients and backscatter coefficients with UV lidar measurements at Cabauw for collocated measurements within 30 km distance and 1 hour time interval from August 2024 to May 2026. EBD_L: low resolution data, EBD_HM: averaged high resolution profiles. No average in height.*

3. Compare ATLID product with ACTRIS lidar products

We analysed all available collocated EarthCARE and EARLINET data in EVDC from August 2024 to May 2026 for the reprocessed version EXBA and the NRT version up to EXBC. As shown in Fig. 3, the AER aerosol extinction coefficients, backscatter coefficients, EBD resolution extinction coefficients and backscatter coefficients have good linear correlation with the ACTRIS products. Most data points are close to the 1:1 line.

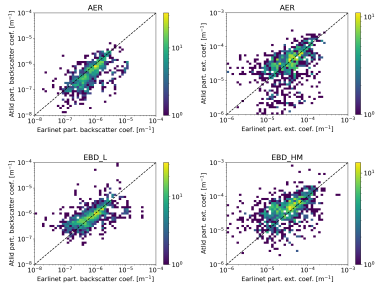


Figure 3. *Scatter plots of EarthCARE AER, EBD extinction coefficients and backscatter coefficients vs. ARCTRIS measurements for aerosols. EarthCARE data are version EXBA and newer from August 2024 to May 2026. Collocation distance is 30 km.*

Acknowledgment:
EUMETSAT is acknowledged for the partly sponsorship of the MSM140/2, MSM141/2 campaigns. The captains and crews on Maria S. Merian and the Leitstelle Deutsche Forschungsschiffe at the University of Hamburg are acknowledged for the supports. The EARLINET data were downloaded from the EVDC.

4. CARD-UP/DN campaigns

The campaigns **C**ross-Equator **A**tlantic **R**eference **D**ata (of atmospheric aerosol, clouds, water vapour and trace-gases for satellite retrieval and model evaluations) – **D**ow**N**ward and **UP**ward in latitude was carried out by the research vessel Maria S Merian. The dates and routes of the campaigns are in the campaign logo (Fig.4). During these two campaigns, atmospheric data for aerosol, trace-gases and clouds over oceans are collected to address the need for reference data over oceans by satellite remote sensing and global modelling The reference data are used for the validation of recently launched satellites, such as MTG-S1, Metop-SGA1, and EarthCARE. We have got two EarthCARE (daytime) overpasses on 26 and 28 October 2025 in the CARD-DN campaign. The closest distances were 6 and 4 km for these two overpasses. We show the results for the overpass on 28 October in Figs. 4, 5.

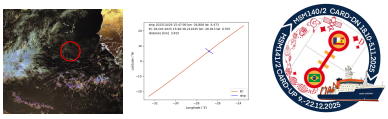
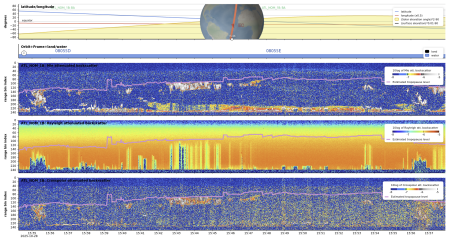


Figure 4. *(Left) FCI RGB image 20251028 16:10, a screen shot from EUMETView, (middle) EarthCARE and MSM collocations on 28 October 2025. (Right) MSM 140/2, MSM141/2 campaign logo.*



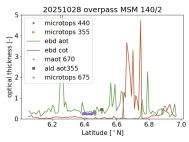


Figure 5. *(Up) ATLID L1B images close to the overpass time at 15:46 UT on 2025-10-28. Screen shot from ESA MAAP timeline viewer. (Left) Intercomparison of AOTs.*

As shown in Fig. 5, at the overpass on 28 October there were some cirrus clouds at about 12 km and aerosol layer from the ocean surface to 3 km. The AOT measured by Microtops at 440 nm was converted to 355 nm. The EBD high resolution extinction coefficient profile at the closest overpass was integrated to calculate the AOT and COT (e.g. ebd aot, ebd cot). The 'ald aot355' was taken from the ATLID ALD product. The 'maot' was taken from the MSI AOT product.

5. Summary

We found that the ATLID version EXBA AER and EBD backscatter and extinction coefficients are improved compared to the previous versions. We demonstrated the contributions of ship measurements to the EarthCARE aerosol validation.