



Overview of L2 aerosol products produced by ESA and JAXA

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2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop

17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

EarthCARE (Earth Clouds, Aerosols and Radiation Explorer)



- ✓ Joint Japanese (JAXA)-European (ESA) satellite mission
- ✓ Improve the understanding of cloud-aerosol-radiation interactions
- ✓ Four sensors:
 - **ATLID** (Atmospheric Lidar: 355nm HSRL with dep. Measurement function) **MSI** (Multi-spectral imager: 0.66, 0.865, 1.61, 2.2, 8.8, 10.8, 12.0 um) **CPR** (Cloud Profiling Radar: 94GHz)
 - **BBR** (Broad-band radiometer: SW (0.2-4um), Total (0.2-50um)
 - => Observe Global / 3D distribution of Aerosols, Clouds, and Radiation
 - => Provide information on Aerosol and Cloud effects on atmospheric radiation

<u>Aerosols</u>

- Vertical / Layer / Columnar Optical/Microphysical/Radiative properties: extinction, depolarization, AOT
- Aerosol type: Dust, Smoke, Continental Pollution, Sea-salt
- Aerosol component: Sea-salt, Carbonaceous (Light-absorbing), Water soluble, Dust
- ✓ L1 products are generated by each sensor development organization (JAXA for CPR and ESA for others)
 ✓ L2 products are generated by different algorithms by JAXA or ESA, respectively.

=> We attempt to summarize the L2 products briefly, contrasting the ESA and JAXA L2 products, here.

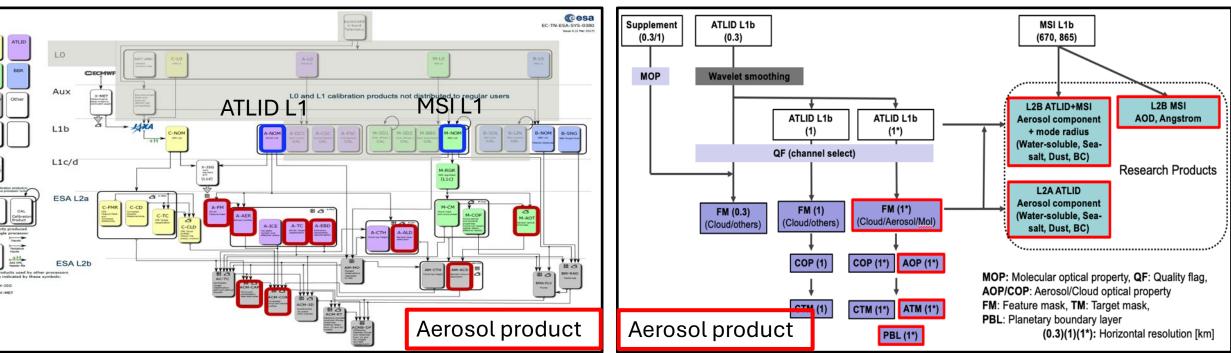
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Aerosol products (1)



JAXA processing chain for Aerosol products

ESA processing chain for all products



- \checkmark Aerosol products are basically created using ATLID L1 and MSI L1.
- \checkmark There are standalone (ATLID or MSI) and synergy (ATLID-MSI) products.
- \checkmark There are similar products at ESA and JAXA, as well as unique products at both.
- \checkmark The aerosol products created lead to atmospheric radiation assessments in the processing chain.

Aerosol products (2)



Product	ESA	JAXA
Vertical profiles		
Feature mask	\checkmark	\checkmark
Extinction/Backscatter/Lidar ratio/Depolarization	\checkmark	\checkmark
Particle type	\checkmark	\checkmark
Aerosol fraction	\checkmark	
Aerosol component		\checkmark
Vertically integrated, Columnar		
Extinction/Backscatter/Lidar ratio/Depolarization	\checkmark	
Particle type	\checkmark	
Layer height	\checkmark	
AOT / Angstrom	\checkmark	\checkmark
PBL height	\checkmark	\checkmark

Overview of ESA L2 products Cloud-top, vertically integrated, layerwise Vertical profiles A-TC - A-AER Aerosol Aerosol Aerosol fraction A-ALD Aerosol layer height/depth and classification Aerosol type A-ICE Optical thickness Extinction Laver-mean extinction-to-backscatter ratio A-EBD Extinction-to-backscatter ratio Layer-mean particle linear depolarisation ratio A-CTH Particle linear depolarisation ratio Ångström exponent C-CLD **Cloud and precipitation** C-TC Extinction M-CM loud and precipitation Extinction-to-backscatter ratio loud-top height, phase and type M-COP Effective radius Optical thickness M-AOT iquid, ice, rain water content Effective radius AM-CTH Snow rate and median diameter iquid, ice, rain water path AM-ACD Rain rate and median drop size Surface snow rate Cloud/precipitation fraction AC-TC Surface rain rate Cloud/precipitation classification BM-RAD ACM-CAP Radiation Radiation ACM-COM Broadband radiances Radiative fluxes at TOA ACM-RT **Radiative fluxes** Broadband radiances at TOA BMA-FLX Heating rates Overview of ESA L2 products Overview of JAXA L2 products CPR_ECO Cloud-top, vertically integrated, layerwise Vertical profiles CPR_CLP ATL_CLA Aerosol Aerosol Boundary layer height Aerosol species MSI_CLP Aerosol optical thickness Extinction, backscatter, lidar ratio CPR DOP Ångström exponent Depolarisation ratio CPR RAS Mode radius **Cloud and precipitation** CPR_VVL Cloud phase Cloud and precipitation ATL_ARL Optical thickness Refractivity MSI_ICE Effective radius Doppler velocity MSI ARL Cloud-top temperature, pressure, Extinction AC CLP and height Cloud mask, cloud particle type liquid, ice water path ACM CLP Effective radius, optical thickness Liquid/Ice/rain/snow water conten ALL_RAD Radiation Rain/snow rate AC_MRA Radiative flux at TOA/BOA Vertical air motion AC_RAS Aerosol direct radiative Forcing < Sedimentation velocity at TOA/BOA AC_VVL Mass ratio (2D ice/IWC) AM_ARL Radiation ACM_CDP Radiative heating rate ACM_RAS ACM_VVL

ACM ICE

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Wehr et al. AMT, 2023

Algorithms (AMT Special Issue ...)





EarthCARE Level 2 algorithms and data products

Editor(s): Ulla Wandinger, Pavlos Kollias, Anthony Illingworth, Hajime Okamoto, and Robin Hogan

The EarthCARE satellite (Earth Cloud, Aerosol and Radiation Explorer) is a joint ESA-JAXA mission due for launch in 2023, carrying a Doppler cloud profiling radar (CPR), a high spectral-resolution atmospheric lidar (ATLID), a multi-spectral imager (MSI) and a broadband radiometer (BBR). A large number of cloud, aerosol, precipitation and radiation data products will be produced, some derived from individual EarthCARE instruments and some from the synergy of multiple instruments. This collection of papers will document the theoretical basis for the EarthCARE Level 2 algorithms and evaluate their performance. An innovative aspect that links a number of the papers together is the use of realistic 3D test scenes, 6000 km in length, with cloud, precipitation and aerosol fields from a high-resolution cloud-resolving model and an aerosol transport model, from which observations by the four Earth CARE instruments have been simulated using state-of-the-art instrument simulators. This approach has enabled these algorithms to be evaluated and compared on a common dataset. The special issue is limited to invited papers describing official ESA or JAXA retrieval algorithms and their evaluation, plus several closely related papers.

Download citations of all papers

Bibtex

EndNote

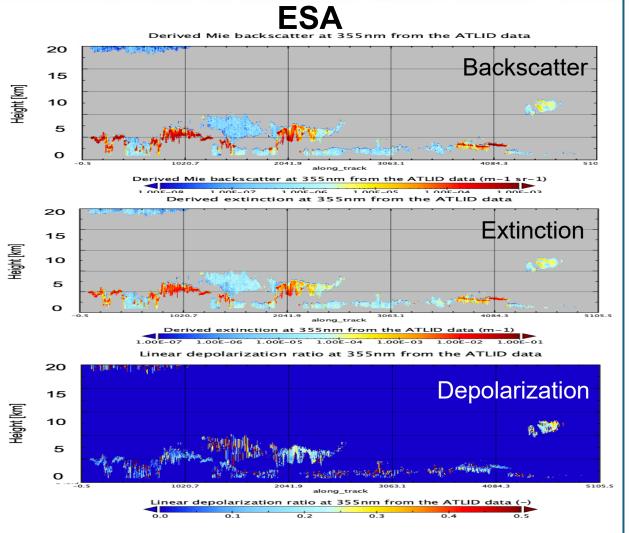
√Contains all product and algorithm descriptions

✓ Note that the algorithms on JAXA research products are described in the JAXA ATBD: <u>https://www.eorc.jaxa.jp/EARTHCARE/do</u> cument/doc_index_e.html.

✓ Note that, even if they are similar parameters, the algorithms for signal processing (averaging and smoothing), numerical solution methods, and thhresholds differ between the two algorithms (see AMT special issue and ATBD).

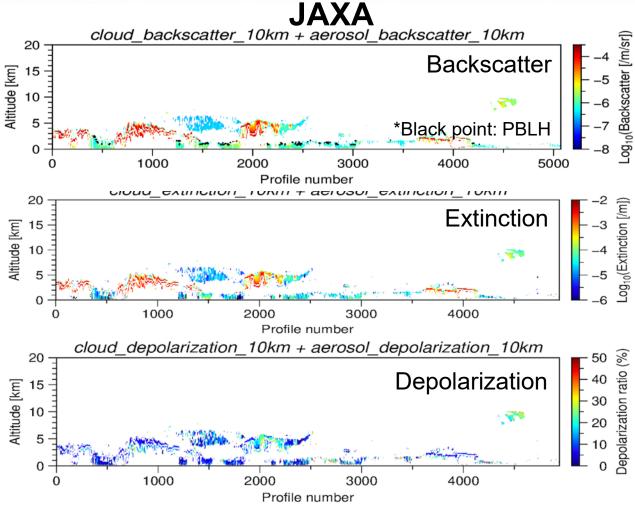
Particle Extinction / Backscatter / Depolarization (Example of ESA/JAXA Common parameter)





*A-AER/EBD :Variable spatial resolution (Low/Middle/High) presented by Donovan et al. on Tuesday

ECA_EXAC_ATL_EBD_2A_20241220T161753Z_20241220T214544Z_03201B.h5



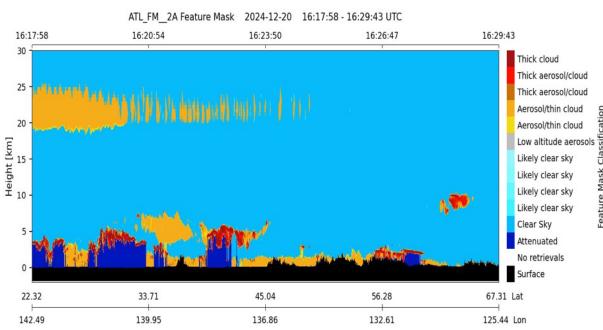
* Fixed resolution : 10km/100m horizontal/vertical resolution for Aerosol product. Note that wavelet analysis is used for denoising L1 data to improve L2 quality.

ECA_J_ATL_CLA_2AS_20241220T1617_20241220T1629_03201B_vAa

Feature mask (Example of ESA/JAXA Common parameter)



ESA

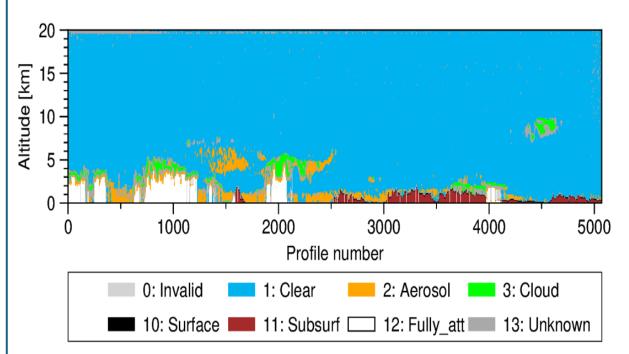


Feature types:

Cloud (Thick / Thin), Aerosol (Thick / Thin) Low altitude aerosol Clear-sky (five levels)

Attenuated, No retrieval, Surface

*Simple classification products are also provided



JAXA

Feature types:

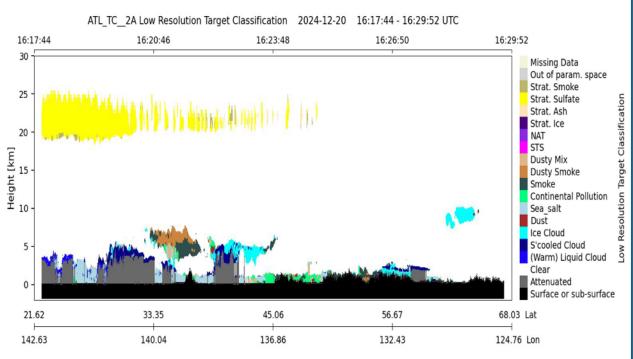
Cloud Aerosol Clear-sky Attenuated, Invalid (No retrieval), Surface, Subsurface

ECA_J_ATL_CLA_2AS_20241220T1617_20241220T1629_03201B_vAa

Particle type (Example of ESA/JAXA Common parameter)

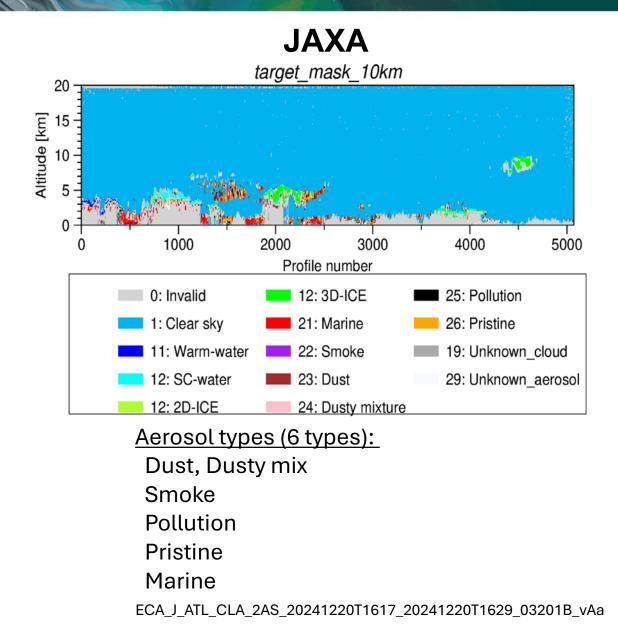


ESA



<u>Aerosol types (9 types):</u> Dust, Dusty mix Smoke, Dusty smoke Continental Pollution Sea salt Stratosphere Smoke / Sulfate / Ash

ECA_EXAC_ATL_TC_2A_20241220T161753Z_20241220T214544Z_03201B



Different parameter at ESA / JAXA

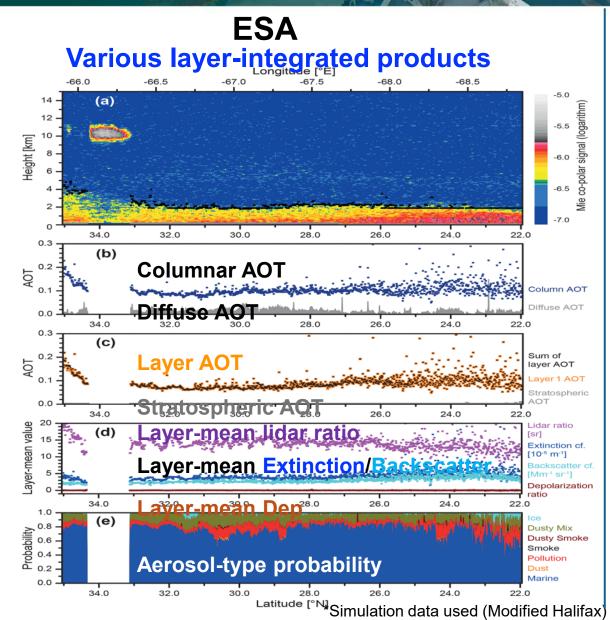
de

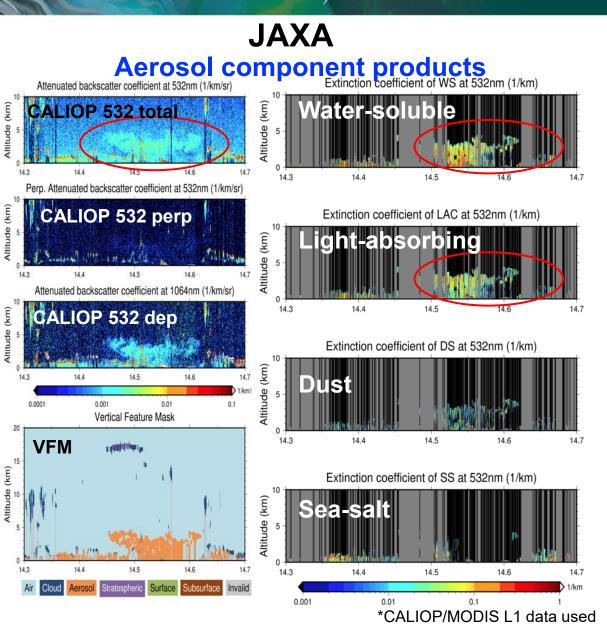
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Altitude

(For example ...)







Summary



We have briefly summarized the L2 aerosol products provided by ESA JAXA at the present time.

Aerosol products are basically created using ATLID L1 and MSI L1, there are standalone (ATLID or MSI) and synergy (ATLID-MSI) products.

There are similar products for ESA and JAXA (e.g., Feature mask, extinction/backscatter/depolarization, Aerosol type, AOT/Angstrom ...), as well as unique products at both (e.g., various layer-integrated products for ESA; Aerosol component product for JAXA). It should be noted even if they are similar parameters, the algorithms for signal processing (averaging and smoothing), numerical solution methods, and thresholds differ between the two algorithms (see AMT special issue and ATBD).

ESA/JAXA product (algorithm) cross-comparisons are being carried out, and initial results are presented in the following (presented by Wandinger et al.)