
# Evaluation and improvement of JAXA L2 algorithms to retrieve aerosol and cloud properties using ATLID

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# EarthCARE
# (Earth Clouds, Aerosols and Radiation Explorer)

- EarthCARE was successfully launched in last year; calibrated data (L1) and geophysical data (L2) are already publicly available.
- Joint Japanese (JAXA)-European (ESA) satellite mission to 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 clouds and aerosols and Radiation

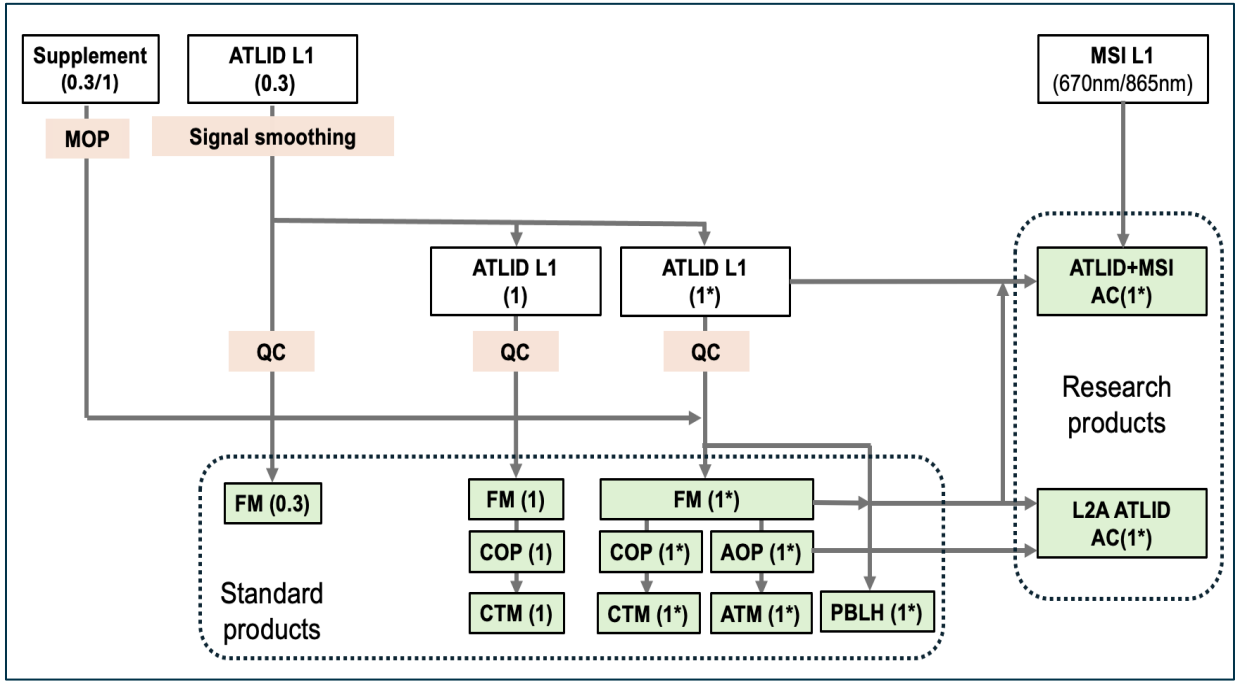
  => Provide information on Cloud and Aerosol effects on atmospheric radiation
- **L1 products** are generated by each sensor development organization (JAXA for CPR and ESA for others)
- **L2 products** are generated by different algorithms by JAXA or ESA, respectively.

# JAXA L2 ATLID products ATL_CLA (Standard+Research)

## ATL_CLA products

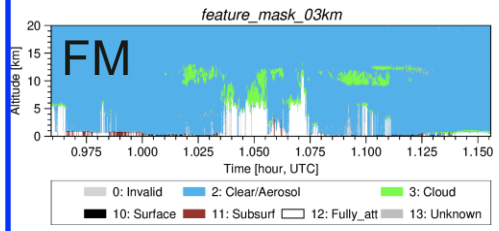
| | Parameter | Resolution |
|---|---|---|
| ATLID L2 (Standard) | **Feature mask [FM]**<br>Aerosol/Cloud/Clear-sky/Surface/Sub-surface/Fully-attenuated/Unknown | ΔZ = 0.1km<br>ΔH = 0.3km/1km/1km* |
| | **Aerosol target mask [ATM]**<br>Marine/Smoke/Dust/Dusty-mixture/Pollution/Pristine/Unknown | ΔZ = 0.1km<br>ΔH = 1km* |
| | **Cloud target mask [CTM]**<br>Warm-water/Super-cooled-water/3D-ice/2D-plate/Unknown | ΔZ = 0.1km<br>ΔH = 1km/1km* |
| | **Aerosol optical property [AOP]**<br>(Extinction, Backscatter, Depolarization, Lidar ratio) | ΔZ=0.1km<br>ΔH = 1km* |
| | **Cloud optical property [COP]**<br>(Extinction, Backscatter, Depolarization, Lidar ratio) | ΔZ = 0.1km<br>ΔH = 1km/1km* |
| | **PBL height [PBLH]** | ΔH = 1km/1km* |
| ATLID L2 (Research) | **Extinction of aerosol components [AC]**<br>(Dust、Sea-salt、Water-soluble、Light-absorbing) | ΔZ=0.1km<br>ΔH = 1km* |
| ATLID-MSI L2 (Research) | **Extinction of aerosol components [AC]**<br>(Dust、Sea-salt、Water-soluble、Light-absorbing) | ΔZ=0.1km<br>ΔH = 1km* |
| | **Mode radii (Fine and Coarse) [AC]** | ΔH = 1km*<br>(Columnar mean) |

## Algorithm flow (v2.1)

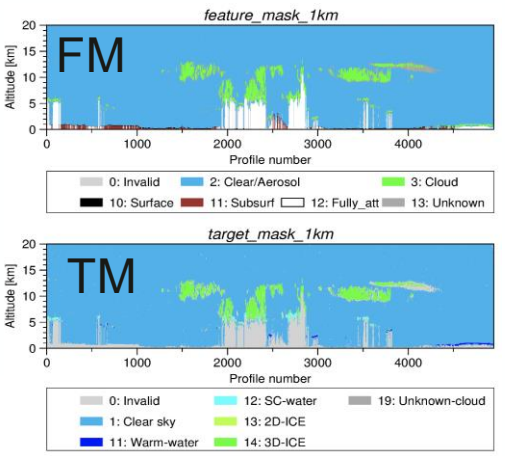


# JAXA ATL_CLA products (Standard & Research)

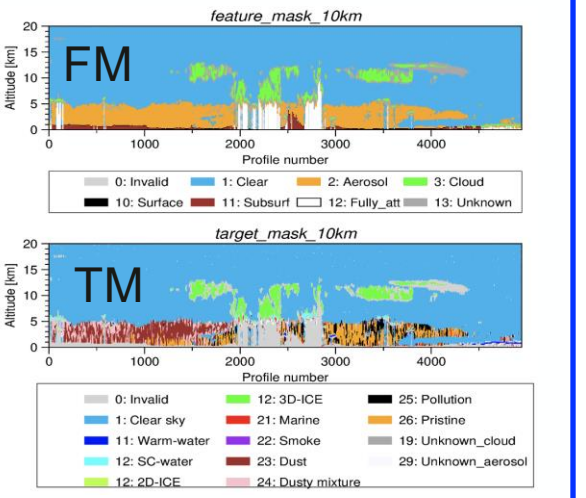
ΔH=0.3km




ΔH=1km

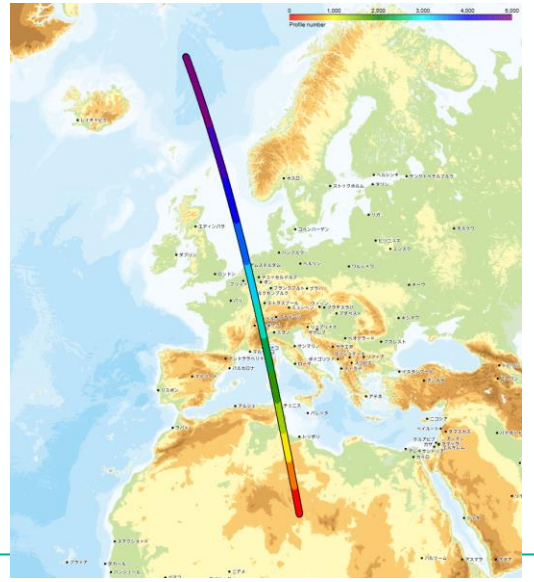


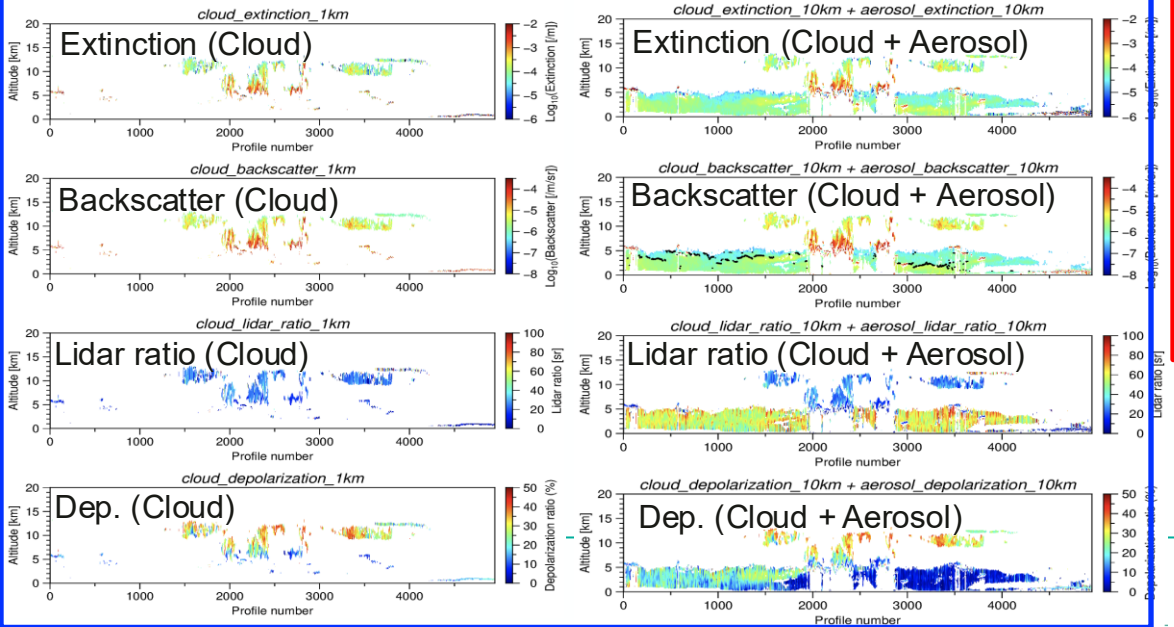

ΔH=10km



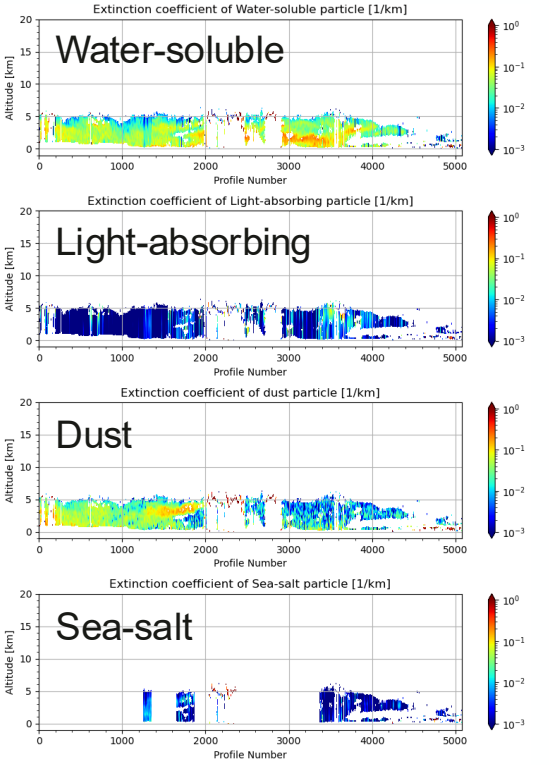

【Standard products】

2024/09/02 1495B





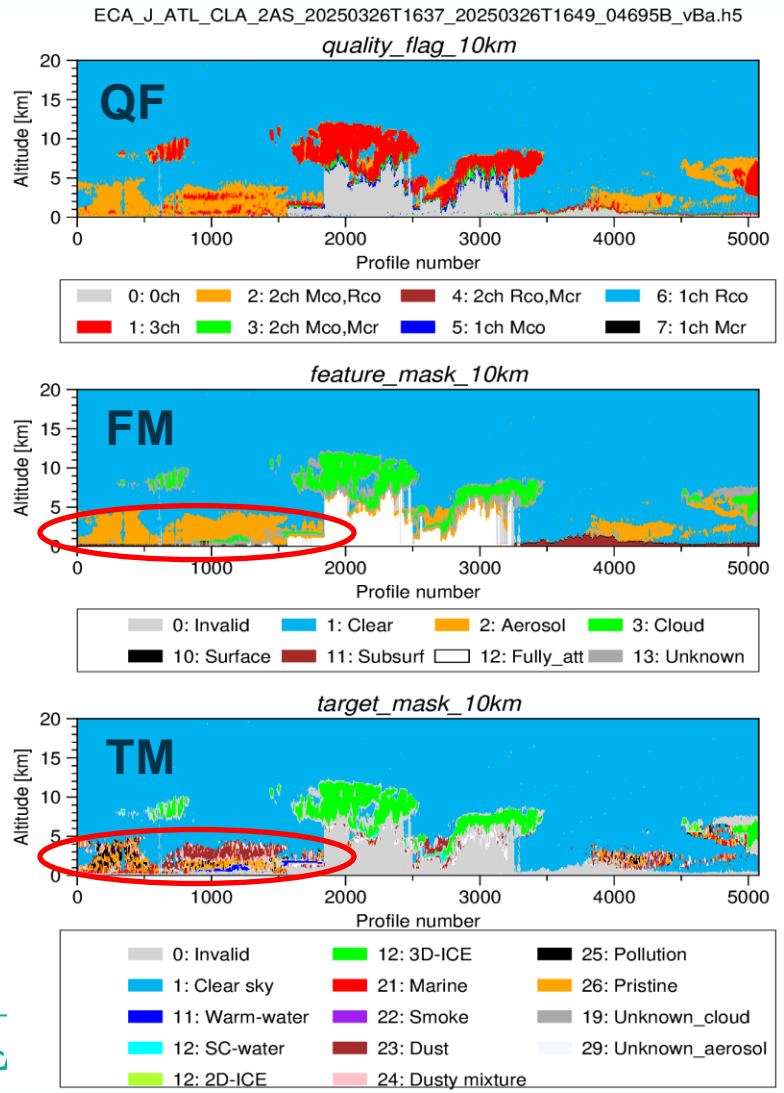

ΔH=10km

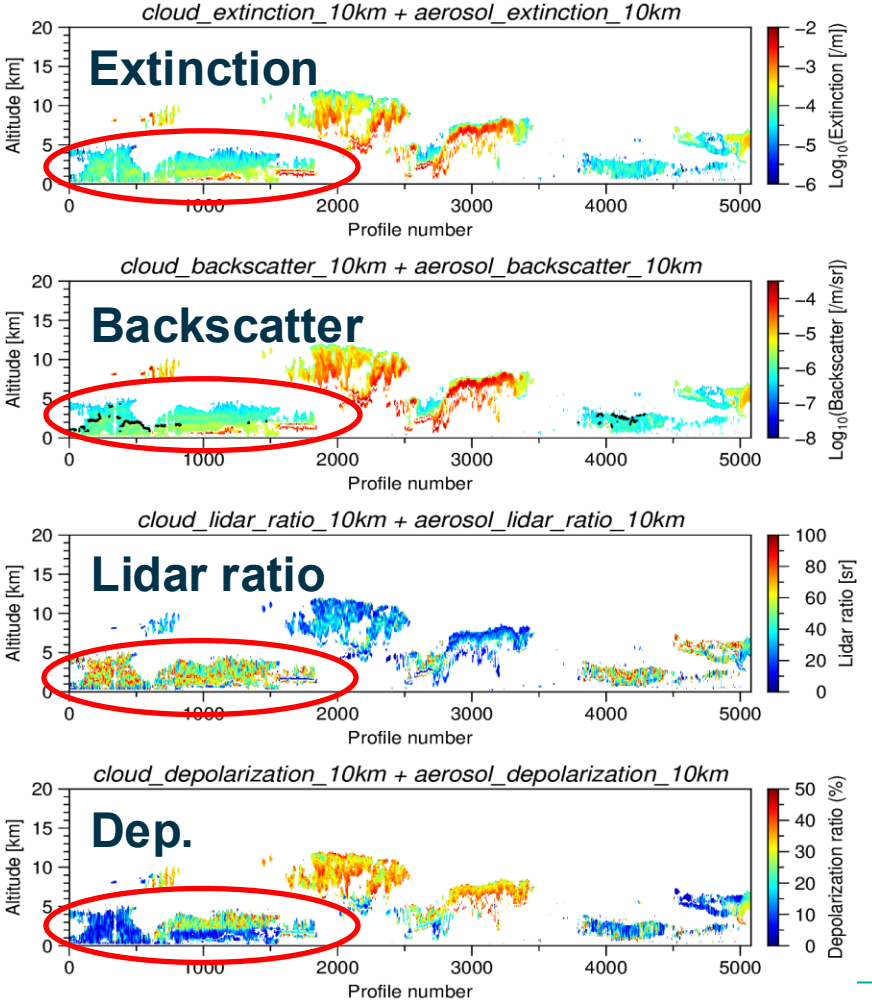



【Research products】

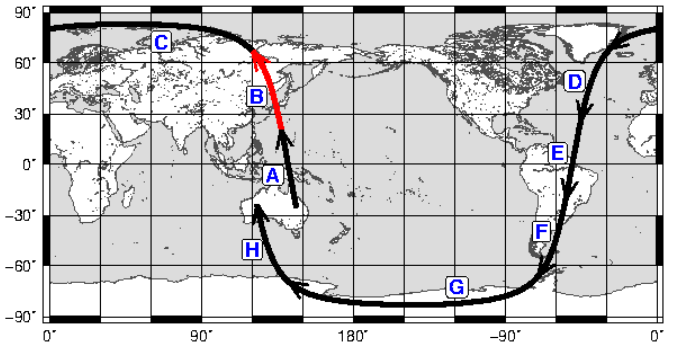
# Example: Asian dust event (26 Mar. 2026)

Asian dust (High dep.) & Mixture of Korean Smoke (Low dep.)? Around Japan (26 March 2025, 04695B)

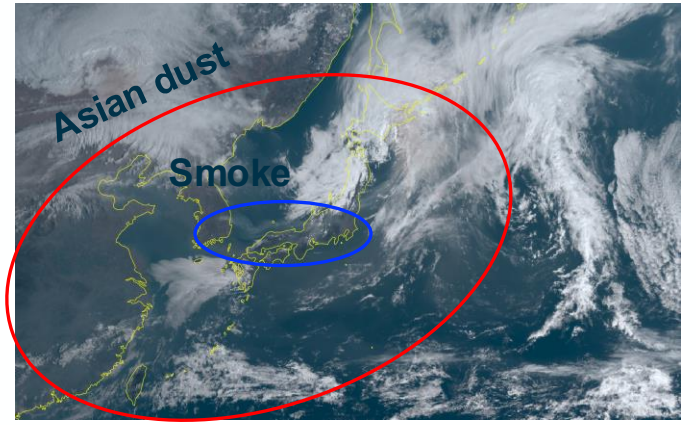



## Orbit of the EarthCARE

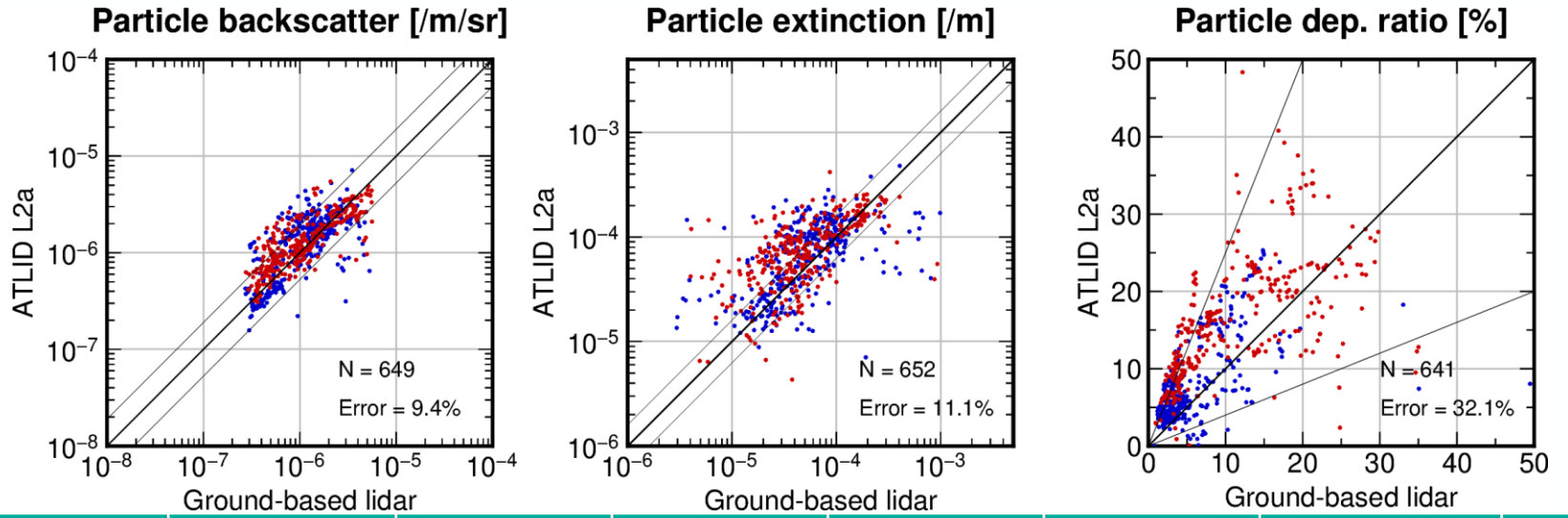



## Himawari Visible image (00UTC 26 Mar. 2025)



# Validation with ground-based lidars

- Good agreement for aerosol products
- Validation of cloud products with airborne lidar data : ***Talked by Jin (T221) in this evening***




| | Feature mask | Aerosol backscatter | Aerosol extinction | Aerosol dep. ratio | Target mask | PBL height | Cloud backscatter | Cloud extinction | Cloud dep. ratio |
|---|---|---|---|---|---|---|---|---|---|
| Estimated error | ~12% | ~10% | ~11% | ~32% | --- | ~110m | --- | --- | --- |

- Direct comparison with ground-based HSRL and Raman lidars
- Average ATLID data within a 50 km radius of ground-based lidar site
- Period: 2024.09 – 2025.08 (1-year)

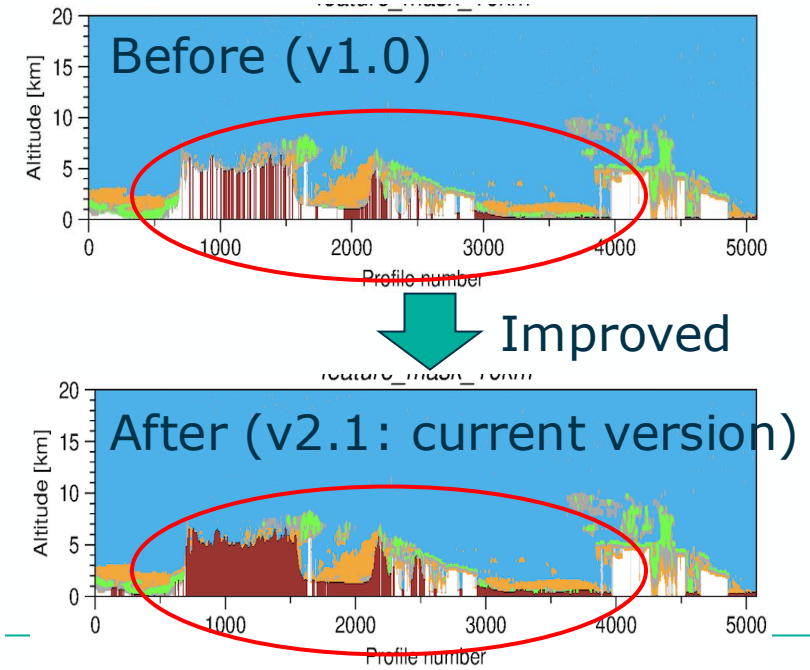
* Validation analysis covering an extended period is currently underway

# JAXA L2 Algorithm improvements (1)

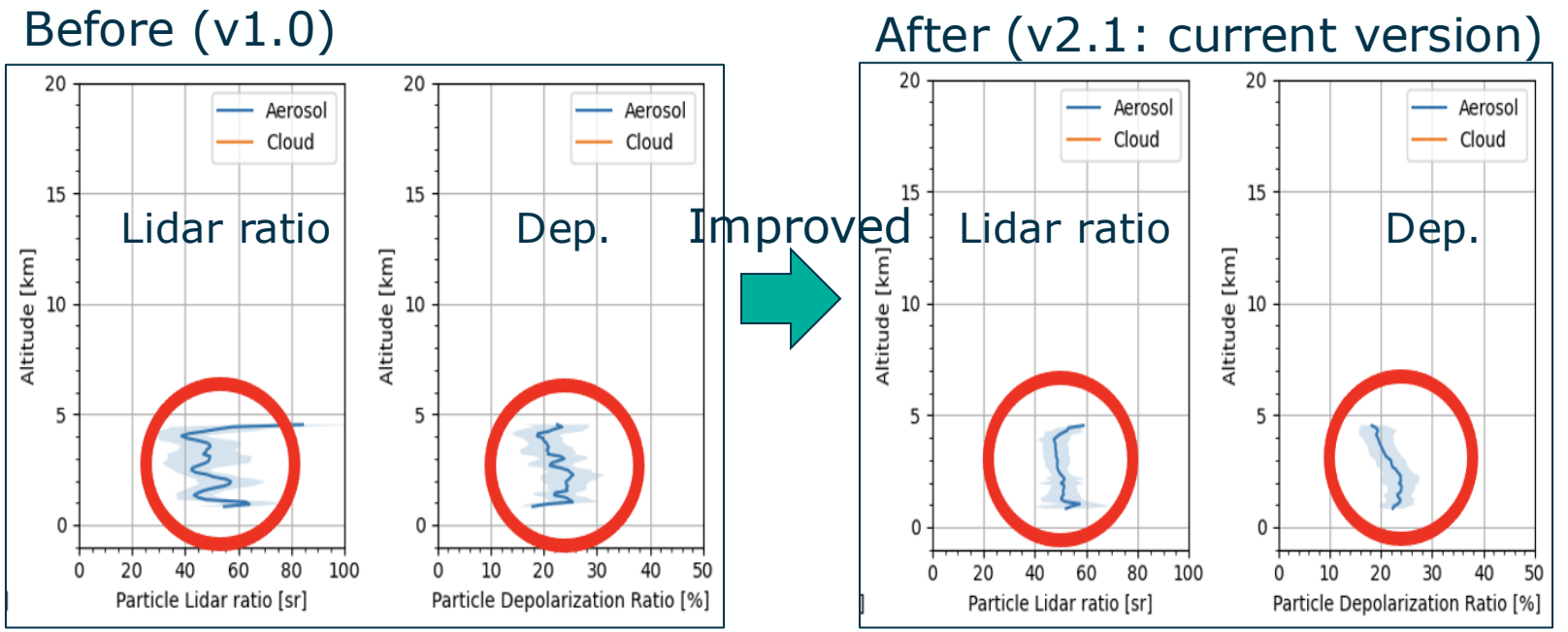
Ground validation studies have identified the following issues for the algorithms, and we are proceeding with these improvements sequentially.

**Issue 1)** Surface detection failure
(This leads to misdetection of cloud layer)
**Issue 2)** Fluctuation in depolarization ratio and lidar ratio.
Issue 3) Aloud/aerosol misclassification
Issue 4) Refining the handling of unknown layers
Issue 5) Misclassification between pristine and marine aerosols

## Issue 1 ) Surface detection failures

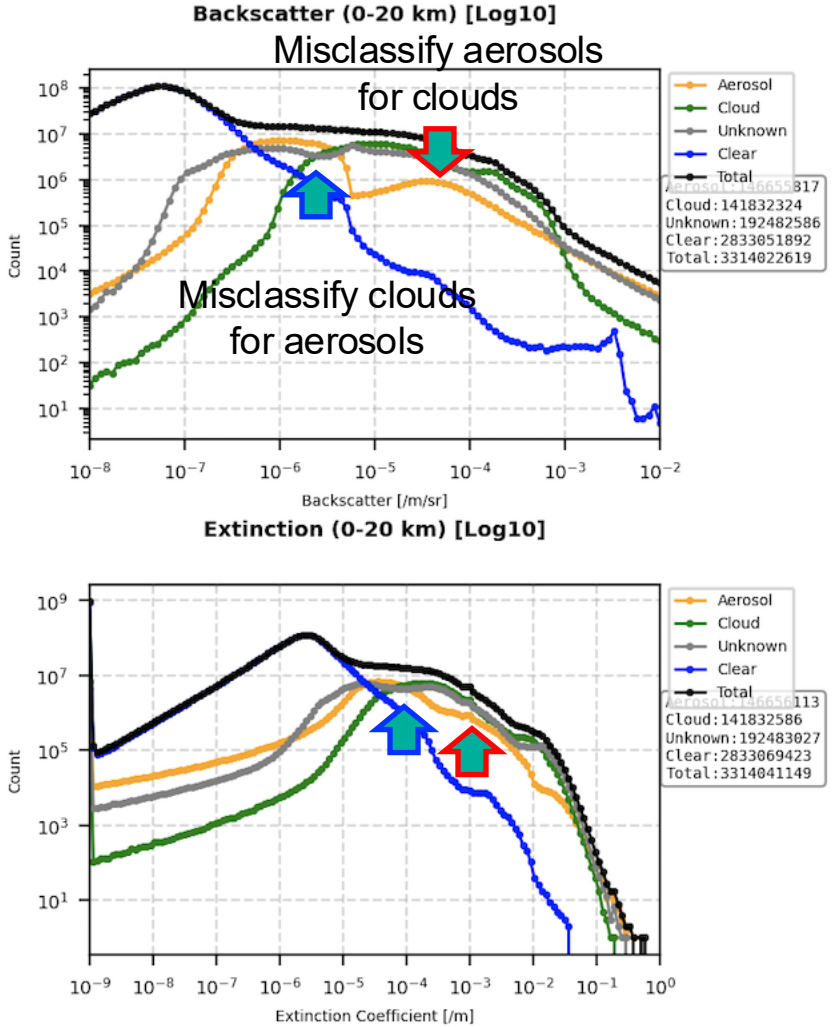



## Issue 2 ) Fluctuation in dep. and lidar ratio

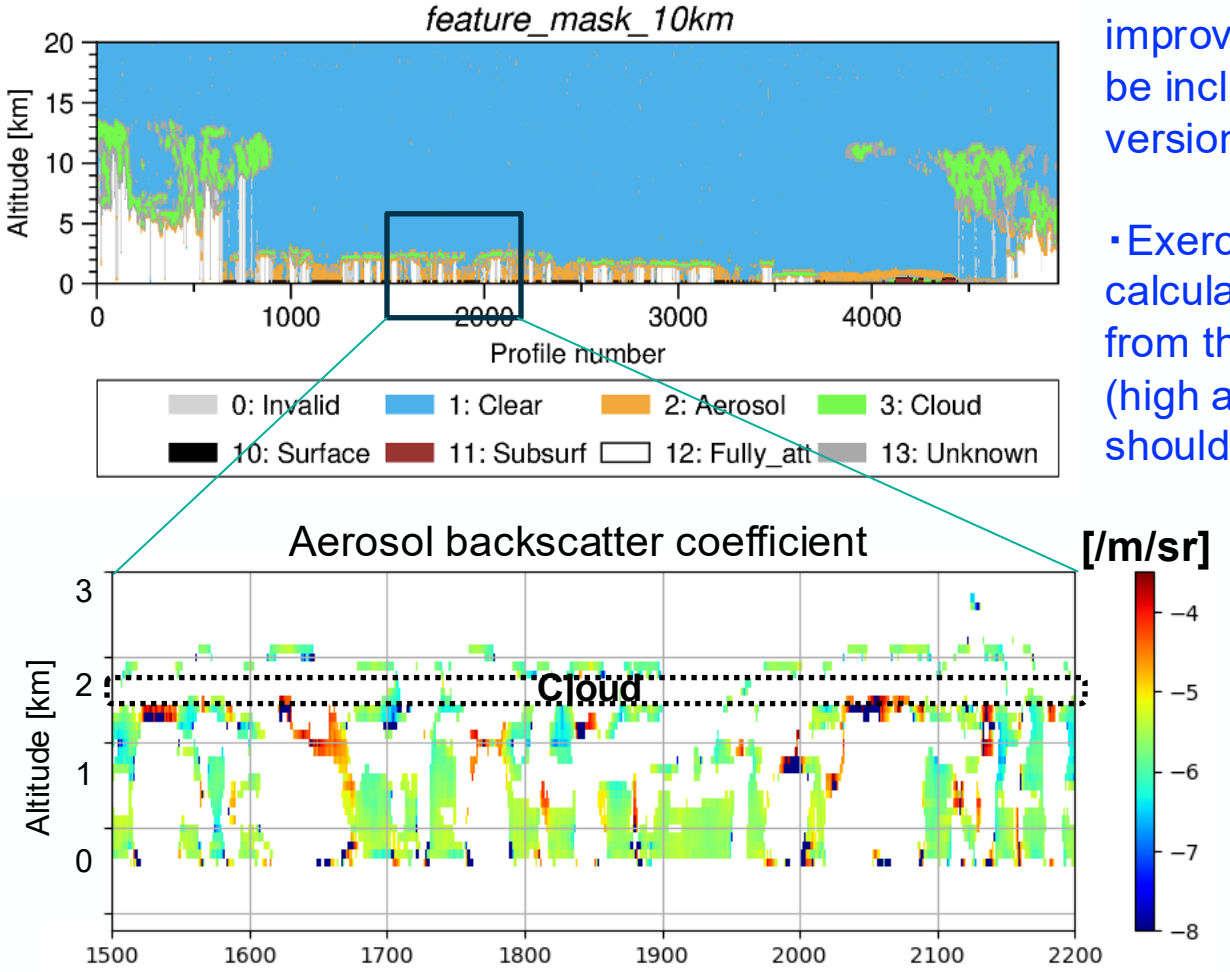


# JAXA L2 Algorithm improvement (2)
# -- Feature mask --

## Count number of feature mask for one month (Mar. 2025)




## Example of clouds being misclassified as aerosols (Mar. 1, 2025 (04295F))



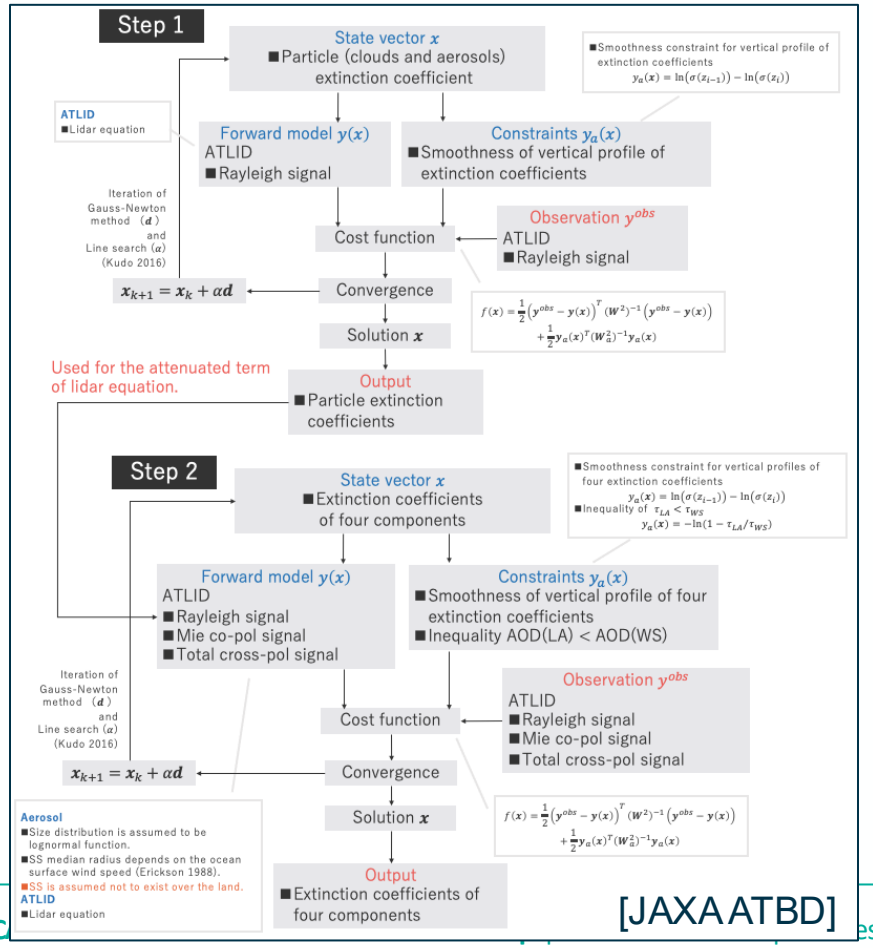

- We are currently working on improvements, and these will be included in the next version.
- Exercise caution when calculating AOT using data from the current version (high aerosol extinction should be excluded).

# Aerosol component (JAXA L2 Research Product)

## Retrieved parameters

- Extinction for Water-soluble (WS), Sea-salt (SS), Dust (DS), Light-absorbing (LA) aerosols **[ ATLID /ATLID-MSI ]**
- Columnar-mean fine-mode and coarse-mode radii **[ ATLID-MSI ]**

### Algorithm flow




[JAXA ATBD]

### Retrieval procedure

(Step 1): The extinction coefficients of clouds and aerosols are retrieved from the Rayleigh signals.

(Step 2): The extinction coefficients of four components are retrieved from all the ATLID L1 data.

### Assumption of aerosol components

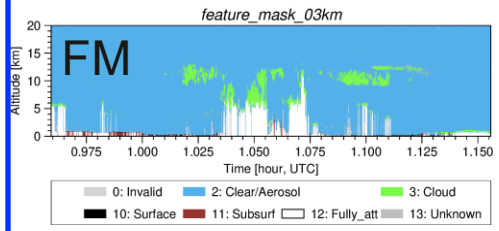
- Aerosols consist of four components (WS, LA, DS, and SS).
  => External mixture of four components.
- Different sizes and light absorbing characteristics (Table).

**Optical models for aerosol components used in the algorithms**

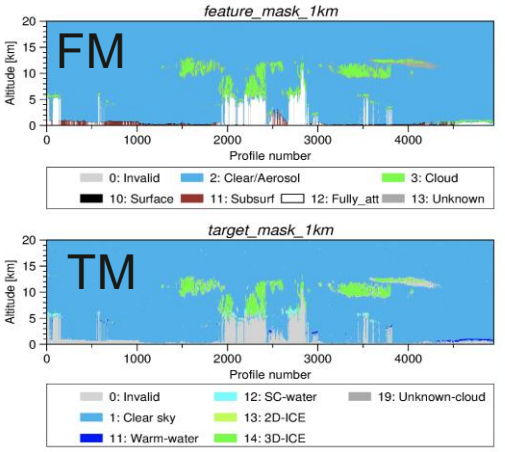
| Component | Water soluble (WS) | Light absorbing (LA) | Dust (DS) | Sea salt (SS) |
|---|---|---|---|---|
| | External mixture of sulfate, nitrate, organics, etc. (Hess 1998) | Internal mixture of non-spherical soot and WS particles | Desert dust | Sea salt |
| Particle shape | Sphere | Voronoi model (Ishimoto 2019)  | Voronoi model (Ishi 2010)  | Sphere |
| Median radius | ~0.1 μm | ~0.1 μm | ~2.0 μm | ~2.0 μm |
| Depolarization | 0% | ~3% | ~47% | 0% |
| Lidar ratio | 61.4 sr | 156 sr | 68.4 sr | 12.2 sr |
| Single-scattering albedo | 0.97 | 0.45 | 0.76 | 0.99 |
| Asymmetry factor | 0.62 | 0.63 | 0.78 | 0.73 |
| Refractive index | Depend on relative humidity (Hess 1998) | Soot : Chang 1990<br>WS : Depend on relative humidity (Hess 1998) | Asian dust (Aoki 2005) | Depend on relative humidity (Hess 1998) |

# JAXA ATL_CLA products (Standard & Research)

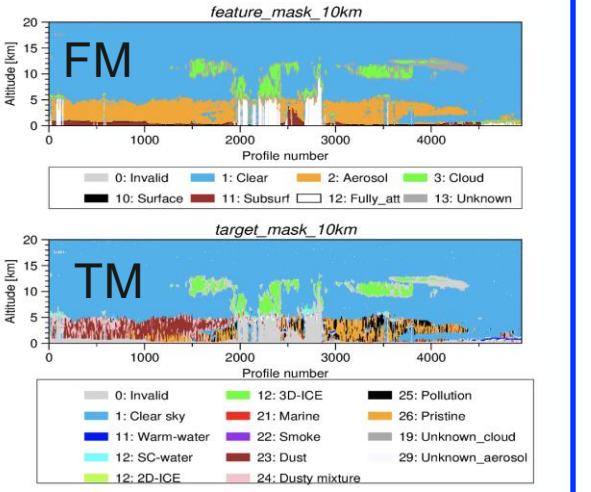
ΔH=0.3km




ΔH=1km

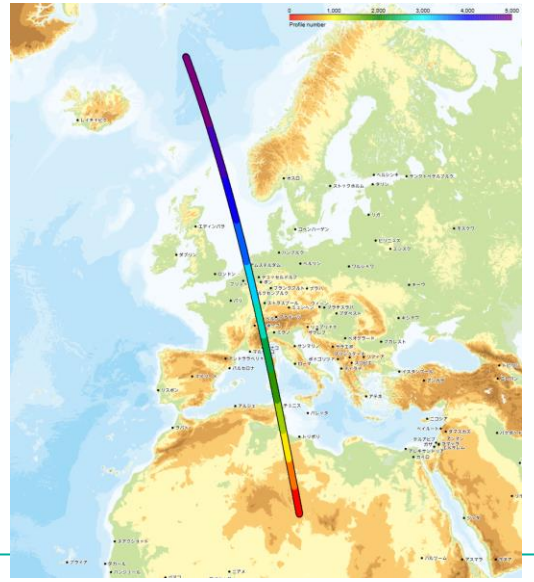


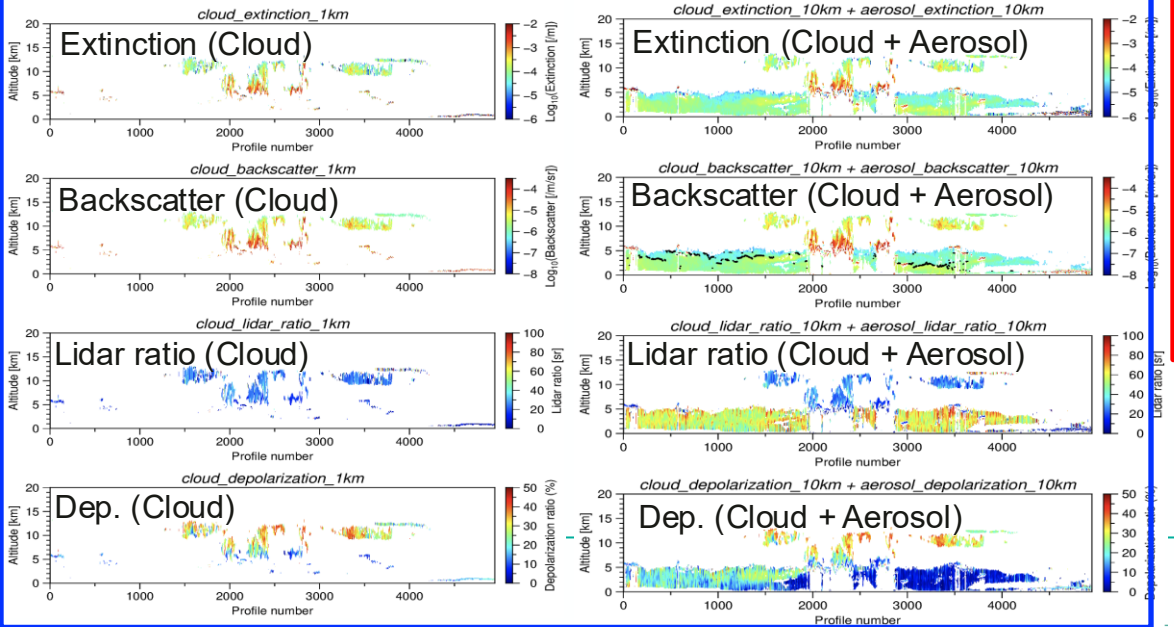

ΔH=10km



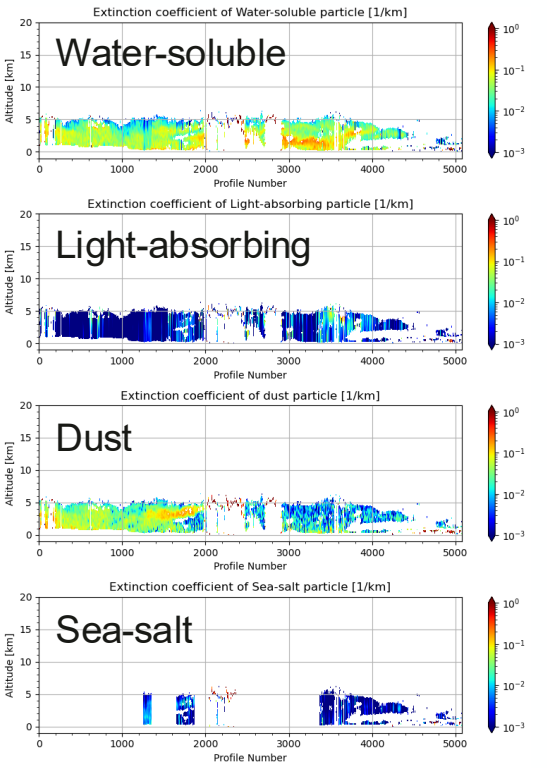

【Standard products】

2024/09/02 1495B






ΔH=10km

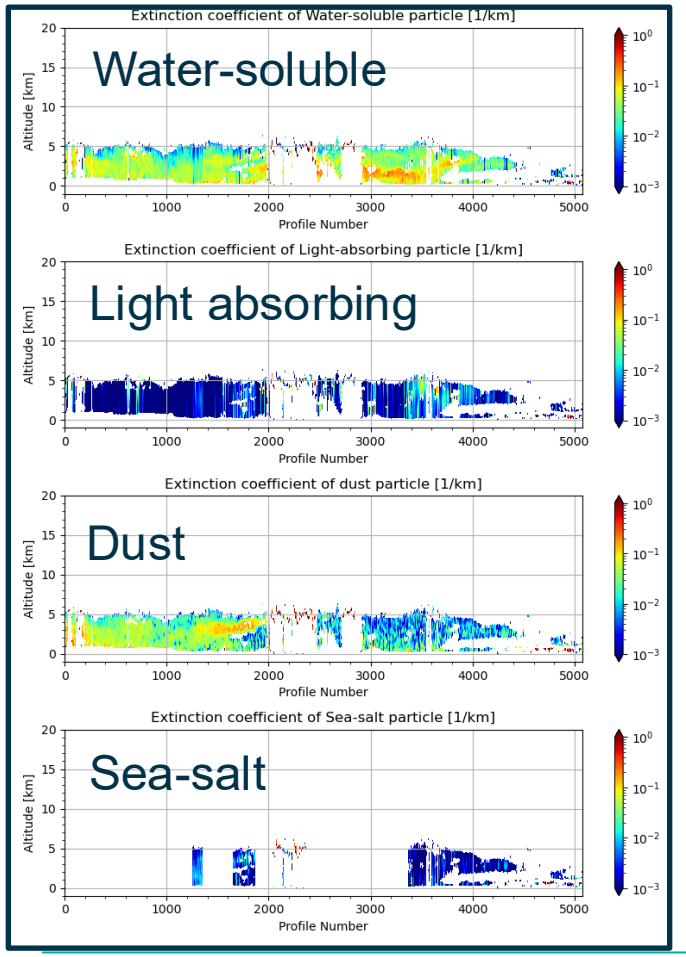



【Research products】

# JAXA L2 ATLID products (Standard & Research products)

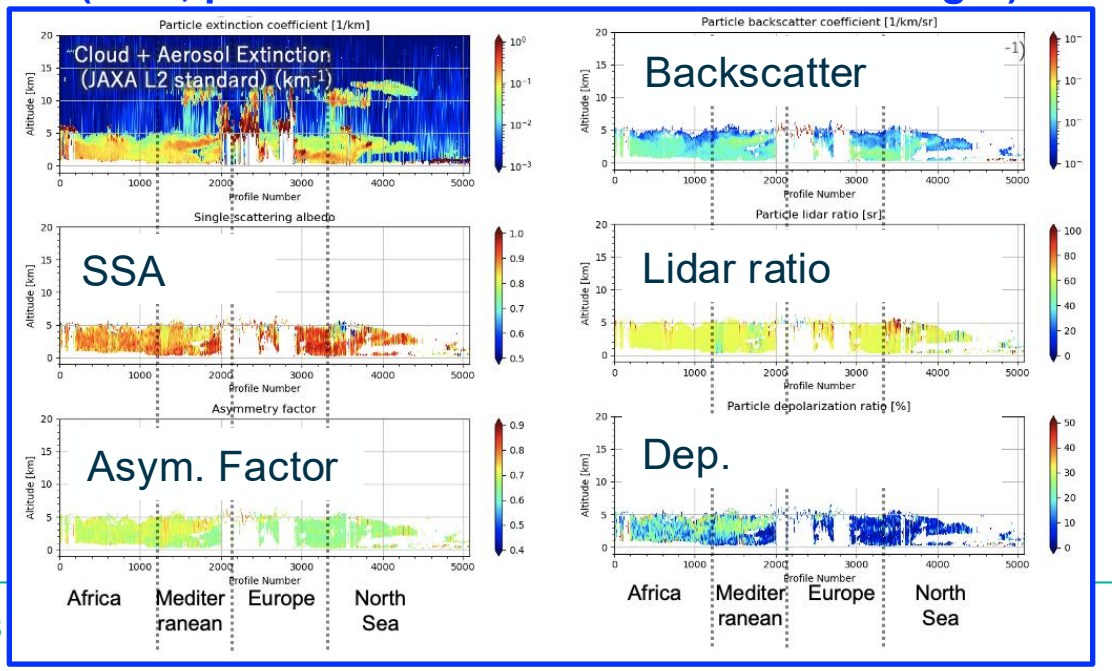
-- Aerosols over Africa ~ Europe ~ North Sea (Dust & Pollution) (2024/09/02 01495B ) --

## Aerosol component (Extinction)

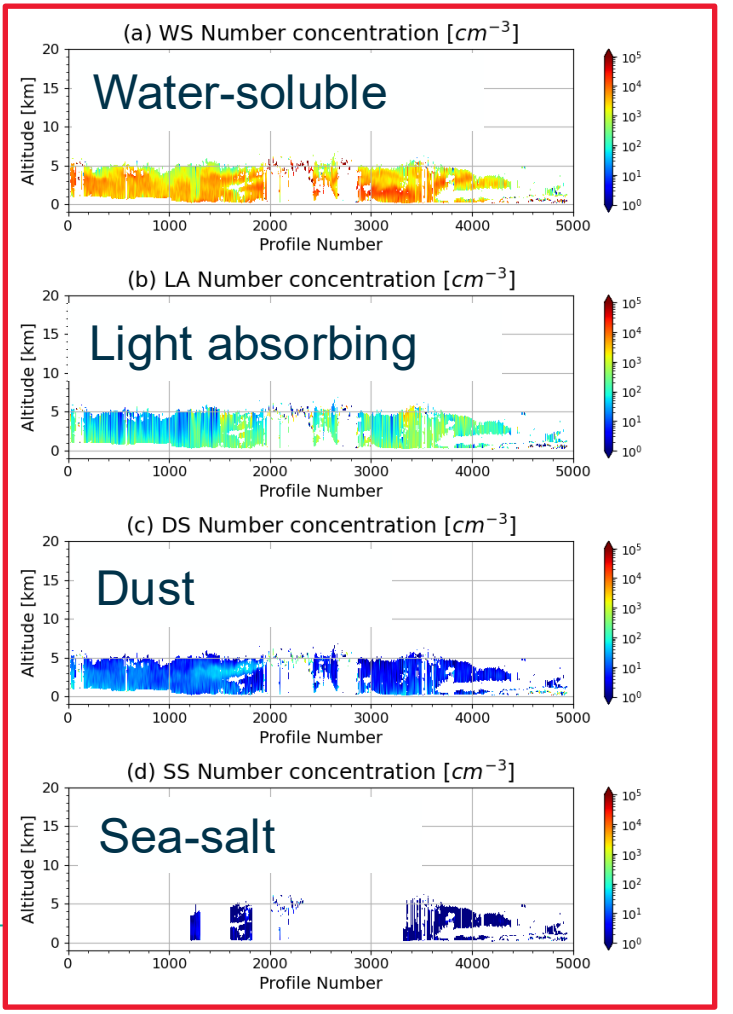



Calculation

## Radiative properties for each component & total aerosols (SSA, phase function… at various wavelength)




## Number concentrations for each aerosol component & total aerosols



# Summary

■ We have evaluated and improved aerosol and cloud retrieval algorithms using ATLID and MSI data (ATL_CLA), producing JAXA L2 standard and research products.

■ Algorithm improvements (especially, feature mask) are underway, and a reduction in product uncertainty can be expected going forward.

■ Aerosol component retrieval algorithms have been developed and its application to ATLID-MSI data is currently underway. The following aerosol studies will be conducted using aerosol component product (Research product)

- Evaluation of aerosol direct radiative effect (ADRE) for each component and total aerosols.
- Cloud-aerosol Interactions using aerosol microphysical properties (number concentration..) from ATLID and cloud microphysical properties from CPR
- Long-term trend of aerosol optical properties from CALIOP to EarthCARE.
- Data assimilation experiments