
# Validation of ATLID JAXA L2a products using airborne lidar measurements during the PERCUSION campaign

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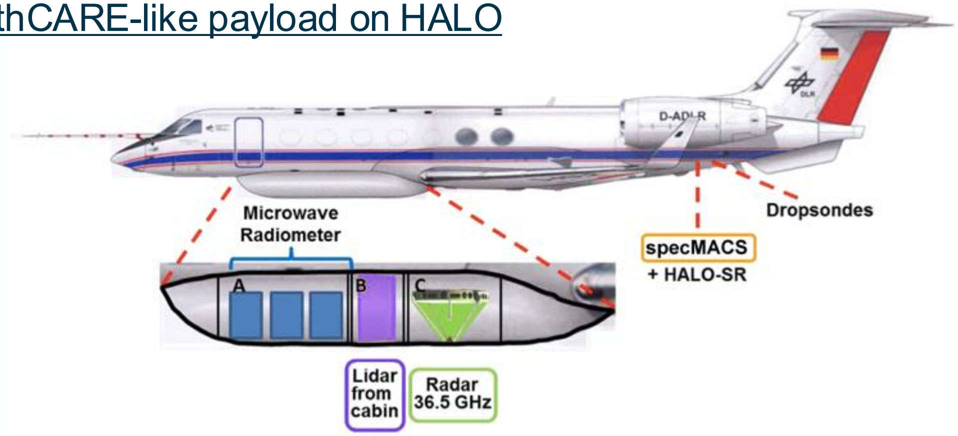
# WALES lidar and HALO PERCUSION campaign

- Airborne lidar is an essential tool for the ATLID validation particularly for cloud profiles because ground-based lidars are difficult to observe the same clouds frequently and to retrieve optical properties near the cloud top
- This study validate JAXA ATLID L2a (ATL_CLA) aerosol and cloud products using the WALES lidar onboard the HALO research aircraft during the PERCUSION campaign

EarthCARE-like payload on HALO

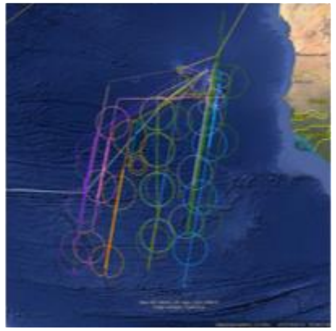



**Scientific Instruments**

**HSRL-Lidar (WALES, 532 nm – Wirth et al. 2009)**
**Cloud Doppler Radar (MIRA, 35 GHz – Ewald et al. 2019)**
Hyper-Spektral Imager (specMACS – Ewald et al. 2016)
Broadband Aircraft Radiometer (BACARDI – Ehrlich et al. 2023)

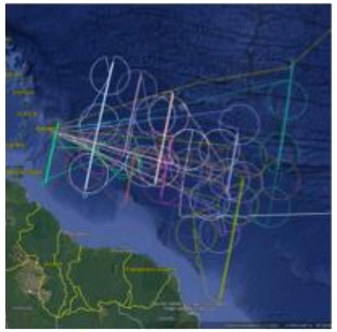
HALO PERCUSION campaign

**Sal, Cape Verde**



**8 August – 6 September 2024**
- 10 EC underflights
- Coordination with
  - Mindelo ground station
  - ATR and King Air (in-situ)
  - RV METEOR

**Barbados**



**6 – 29 September 2024**
- 11 EC underflights
- Coordination with
  - BCO ground station
  - RV METEOR

**Oberpfaffenhofen**

**5 – 19 November 2024**
- 12 EC underflights
- Coordination with
  - ACTRIS ground stations
  - BAe (FAAM)

(quoted from Groß et al., EarthCARE workshop in 2025)

# Selection of aerosol and cloud layers for intercomparison analysis

### Aerosols (10 cases)

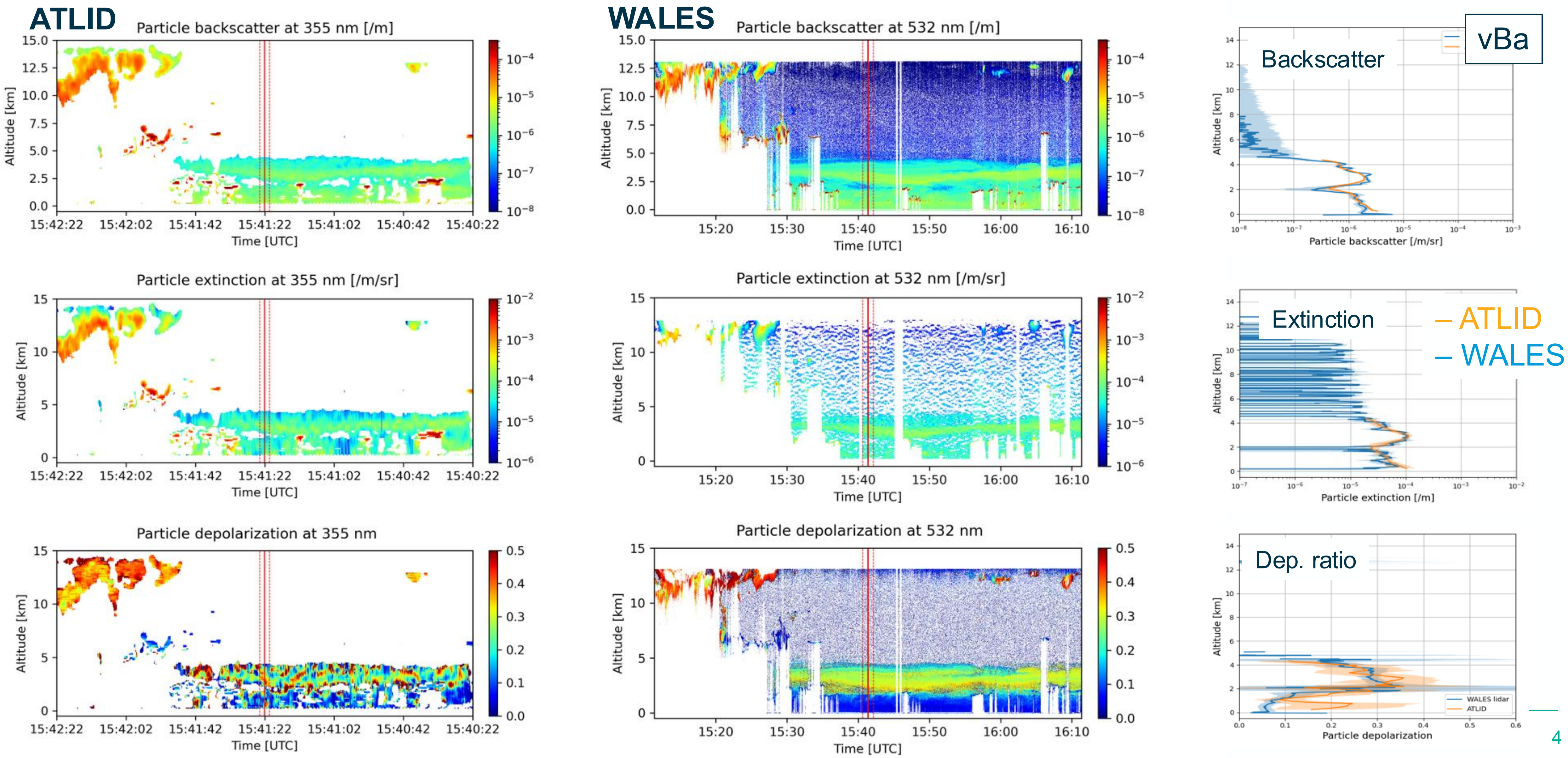
| Date | orbit & frame | Height range | Scene |
|---|---|---|---|
| 2024-08-13 | 1193E | 1.1 – 4 km | dust |
| 2024-08-22 | 1333E | 0.5 – 4 km | dust, sea salt |
| 2024-08-25 | 1380E | 3 – 5 km | dust |
| 2024-08-27 | 1411E | 0.5 – 3.5 km | dust, sea salt |
| 2024-08-31 | 1473E | 1.5 – 2.8 km | dust |
| 2024-09-21 | 1801E | 0.2 – 0.8 km | dust |
| 2024-09-28 | 1910E | 0.5 – 2 km | sea salt |
| 2024-11-05 | 2499E | 1.6 – 2 km | thin dust<br>(the Pacific Ocean) |
| 2024-11-07 | 2531D | 0.7 – 1.2 km | sea salt |
| 2024-11-19 | 2716D | 0.2 – 1 km | sea salt<br>(mixed with dust?) |

*Dust listed above is Saharan dust except for 2024-11-05

### Ice clouds (12 cases)

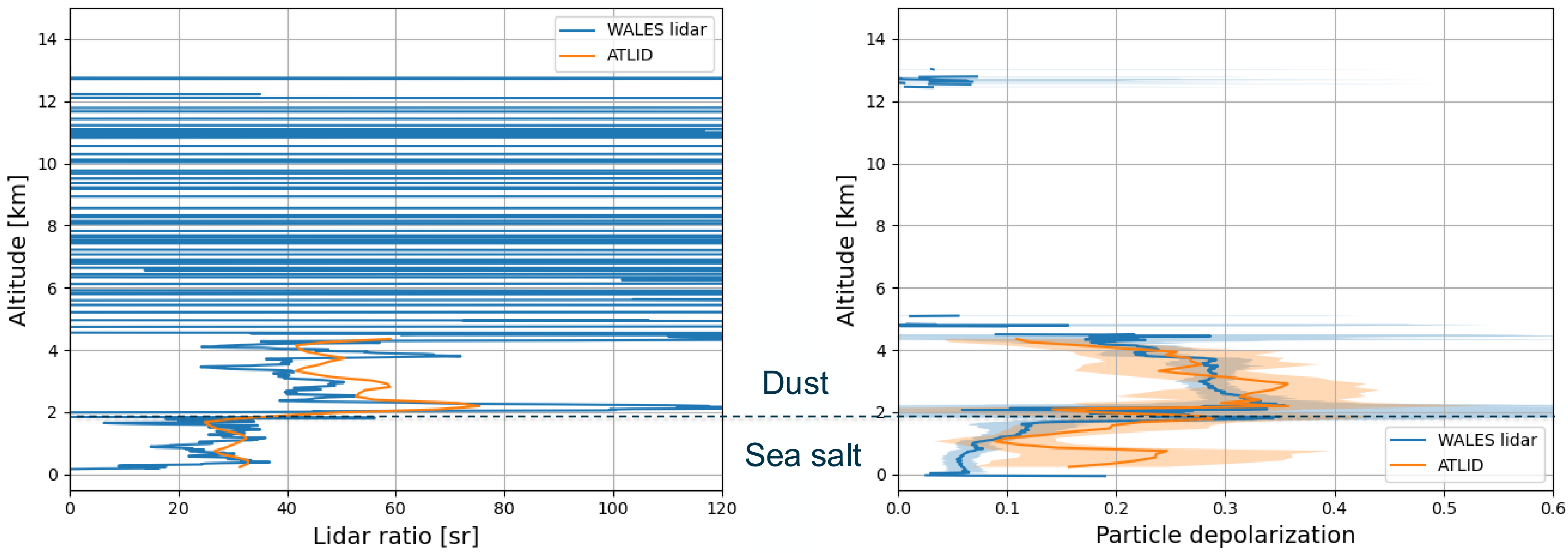
| Date | orbit & frame | Height range |
|---|---|---|
| 2024-08-29 | 1442E | 11 – 12.5 km |
| 2024-09-03 | 1520E | 10.5 – 12 km |
| 2024-09-07 | 1583E | 11 – 12.5 km |
| 2024-09-09 | 1614E | 12.1 – 13 km |
| 2024-09-19 | 1770E | 11 – 12.5 km |
| 2024-09-23 | 1832E | 11 – 12 km |
| 2024-11-05 | 2499D | 9 – 10 km |
| 2024-11-07 | 2530D | 4.5 – 4.9 km |
| 2024-11-12 | 2608C/D | 5 – 9 km |
| 2024-11-14 | 2640C/D | 5 – 9.5 km |
| 2024-11-16 | 2670C/D | 6 – 9 km |
| 2024-11-16 | 2671C/D | 7 – 9 km |

# Comparison between ATL_CLA and WALES (2024.08.22, 1333E, Saharan dust and sea salt)



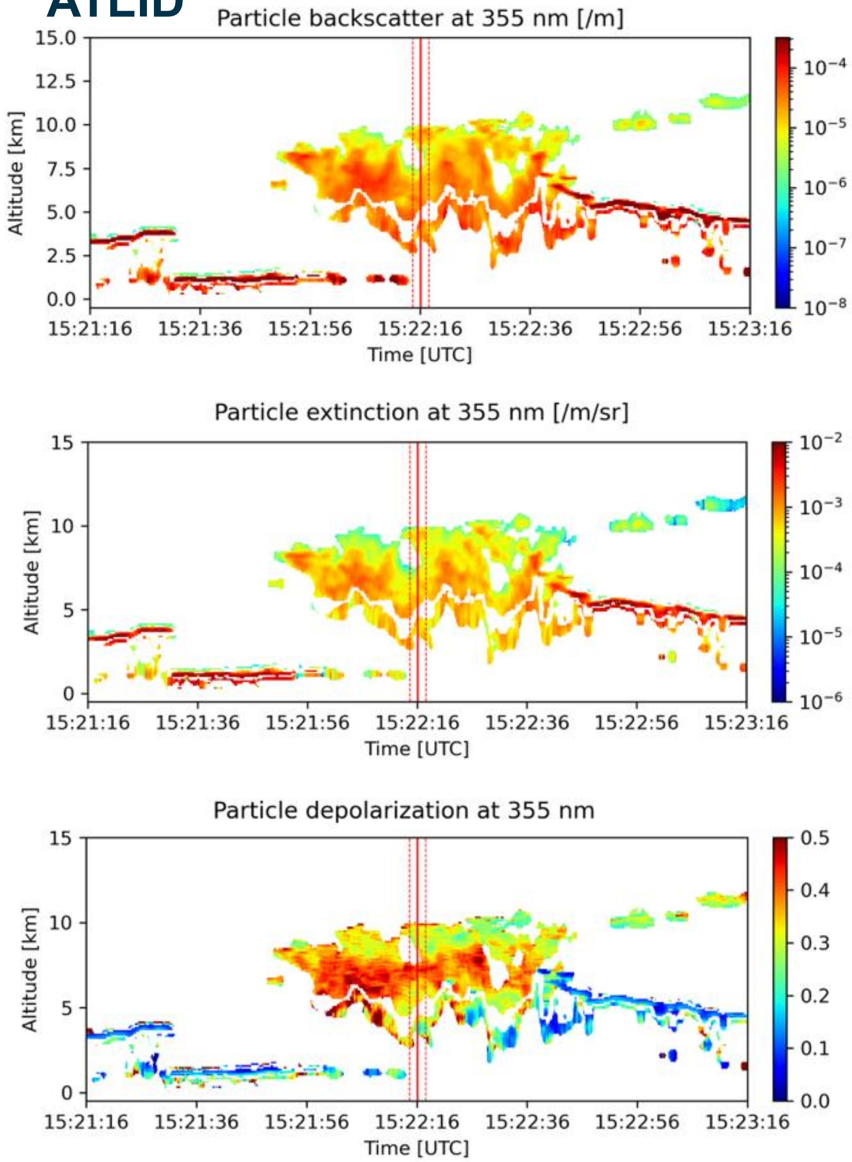
# Comparison between ATL_CLA and WALES (2024.08.22, 1333E, Saharan dust and sea salt)

- Clearly capture the boundary between dust and sea salt by both lidars
- Good agreement in the depolarization ratio for dust

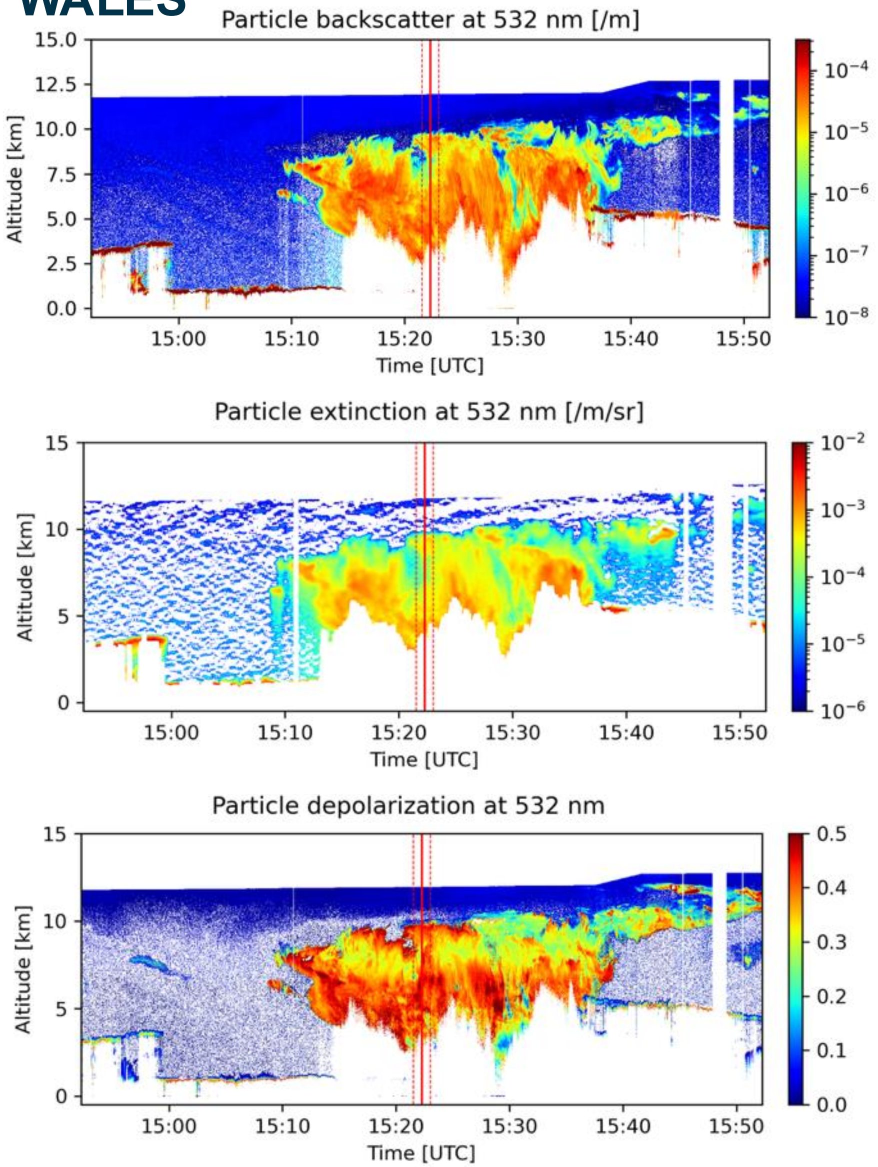


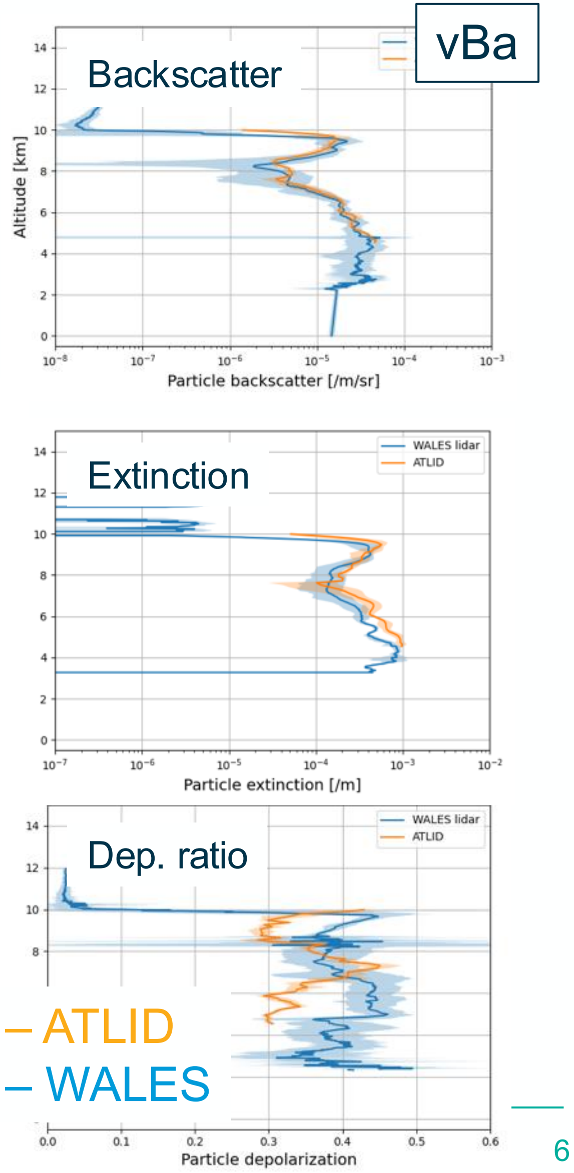
# Comparison between ATL_CLA and WALES (2024.11.14, 2640C/D, ice cloud case)

## ATLID



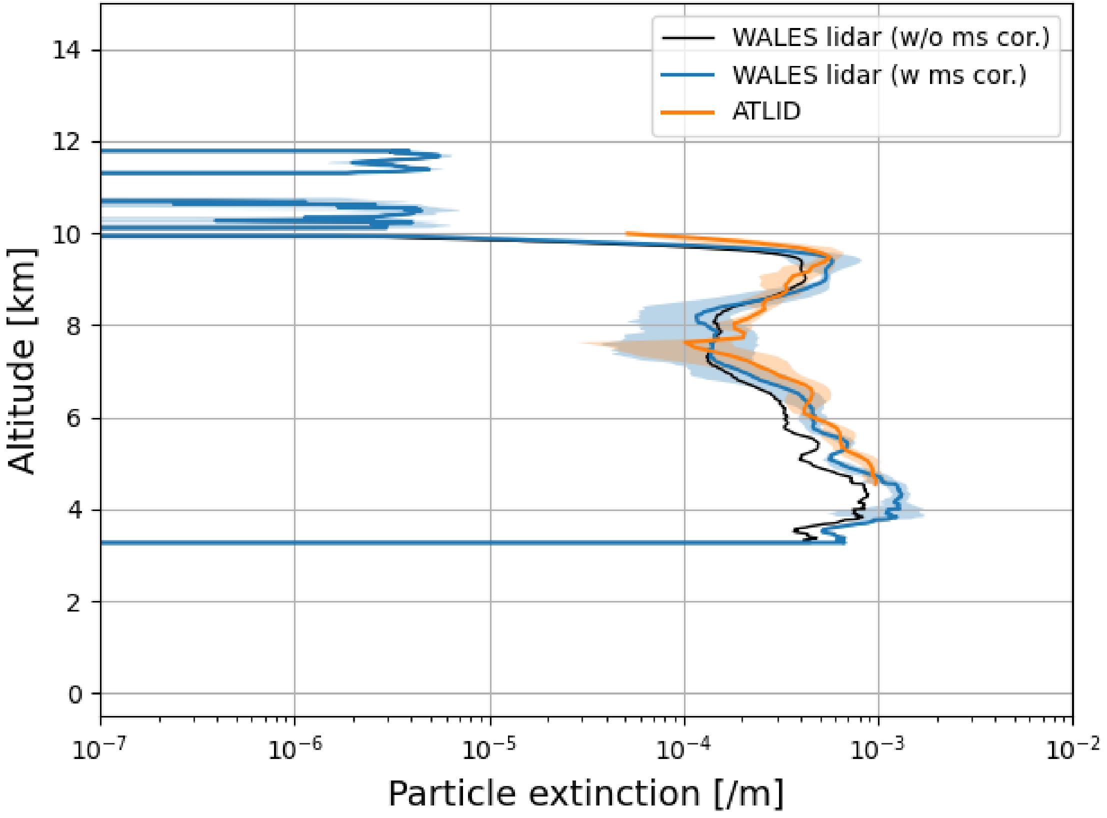

## WALES



# Comparison between ATL_CLA and WALES (2024.11.14, 2640C/D, ice cloud case)

- Extinction profiles have a good agreement after the multiple scattering correction for WALES lidar

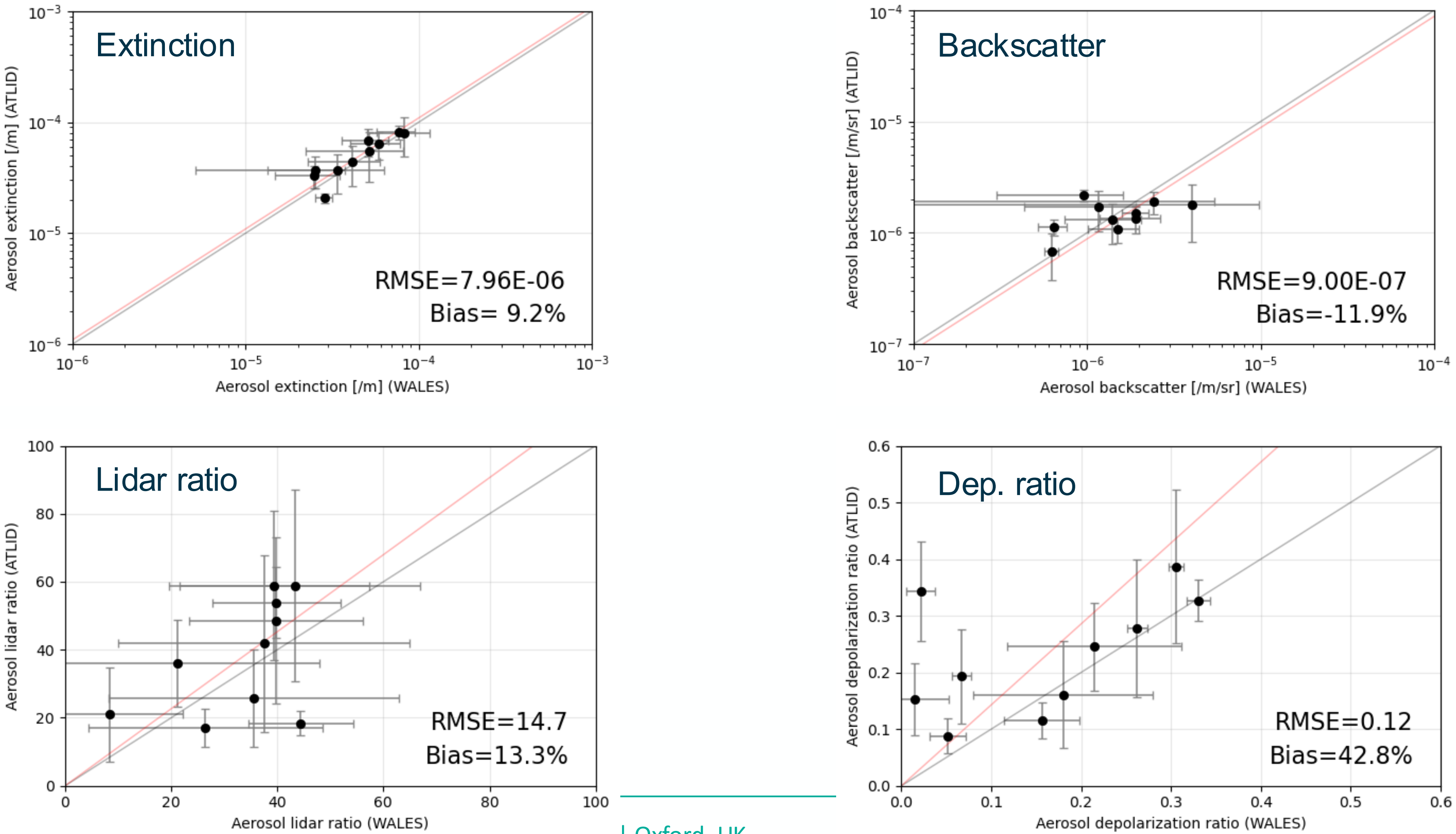



(simple MS correction with η = 0.6 is employed in the ATL_CLA algorithm)

# Evaluation of ATL_CLA aerosol products

- Excellent agreement for aerosol extinction and backscatter is spite of different wavelengths
- Depolarization ratio for the regime of low depolarization ratio should improve in vCa

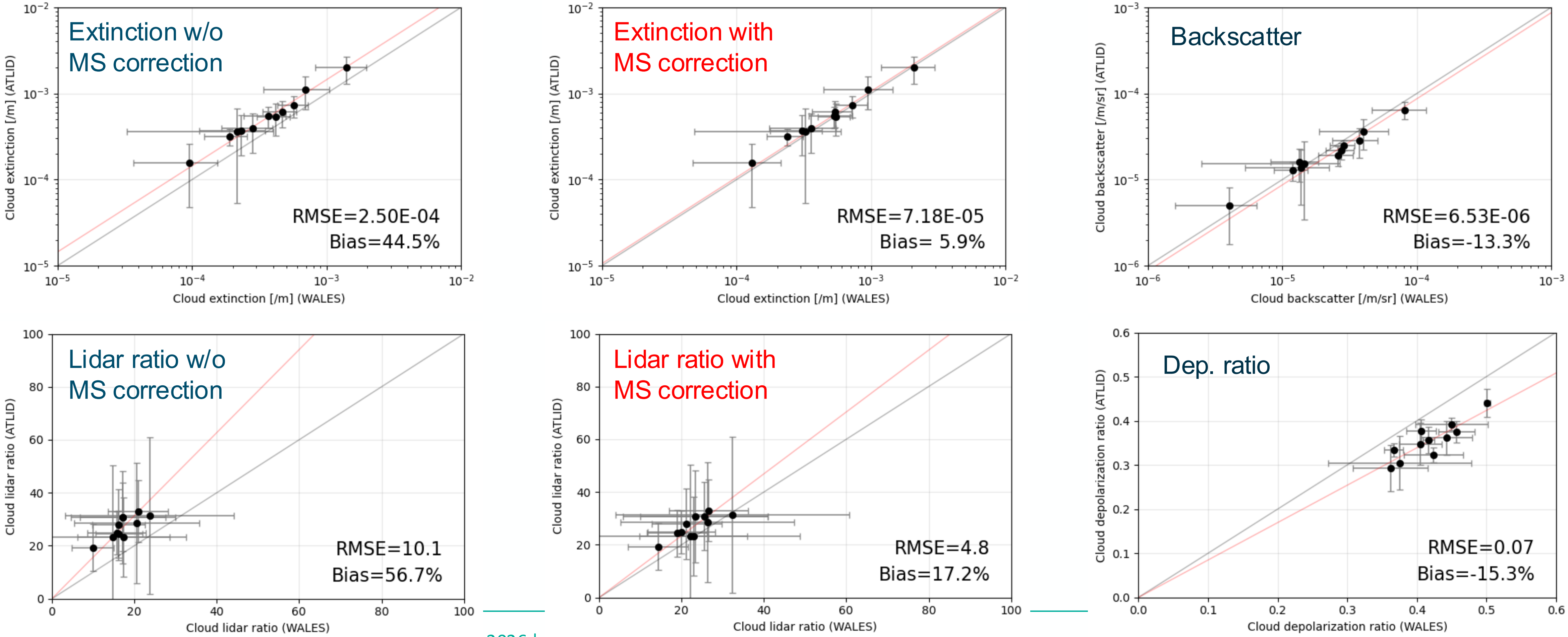
vBa



# Evaluation of ATL_CLA cloud products

- ➢ Extinction and lidar ratio well matched after the multiple scattering correction for WALES lidar
- ➢ Depolarization ratio for cirrus clouds is underestimated by ~15%

vBa



# Conclusions and future tasks

- ATL_CLA products have excellent agreements with WALES lidar data despite different wavelengths
  - After the multiple scattering correction for WALES lidar, cloud extinction well matched with ATL_CLA
  - Errors in all optical properties passed the JAXA target accuracy

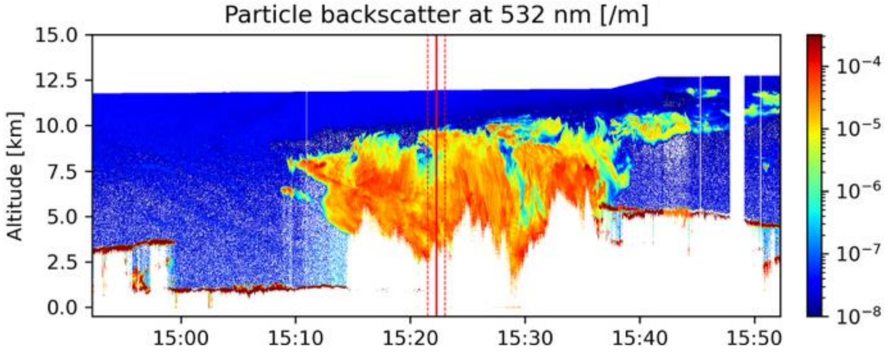
| | $\alpha_{aerosol}$ | $\beta_{aerosol}$ | $LR_{aerosol}$ | $\delta_{aerosol}$ | $\alpha_{cloud}$ | $\beta_{cloud}$ | $LR_{cloud}$ | $\delta_{cloud}$ |
|---|---|---|---|---|---|---|---|---|
| Estimated error | 9.2% | -11.9% | 13.3% | 42.8% | 5.9% | -13.3% | 17.2% | -15.3% |
| Target accuracy (JAXA plan) | ±20% | ±50% | ±100% | ±70% | ±15% | ±50% | ±65% | ±100% |

- Future tasks
  - Validation of ATL_CLA cloud feature mask product using the WALES lidar
  - Comparison analysis using the latest baseline (CA) and ESA L2a products

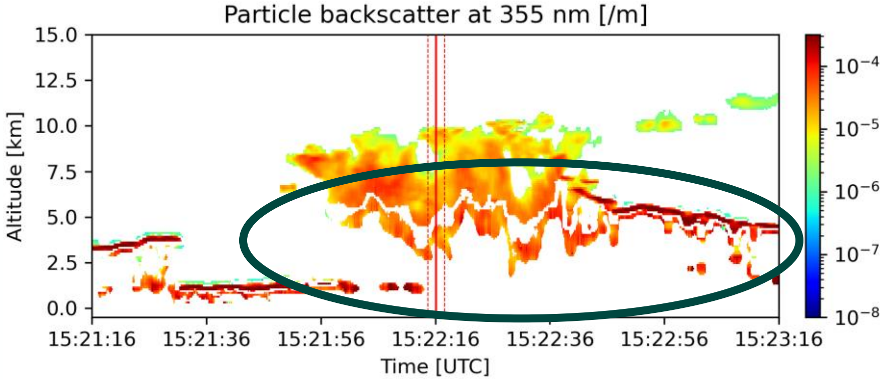
# Validation of ATL_CLA feature mask

- WALES lidar data can be used for the evaluation of ATL_CLA feature mask product, showing misclassification of cloud and aerosol where signal attenuation is significant

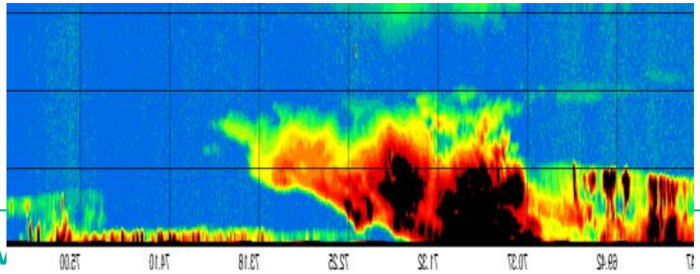
WALES



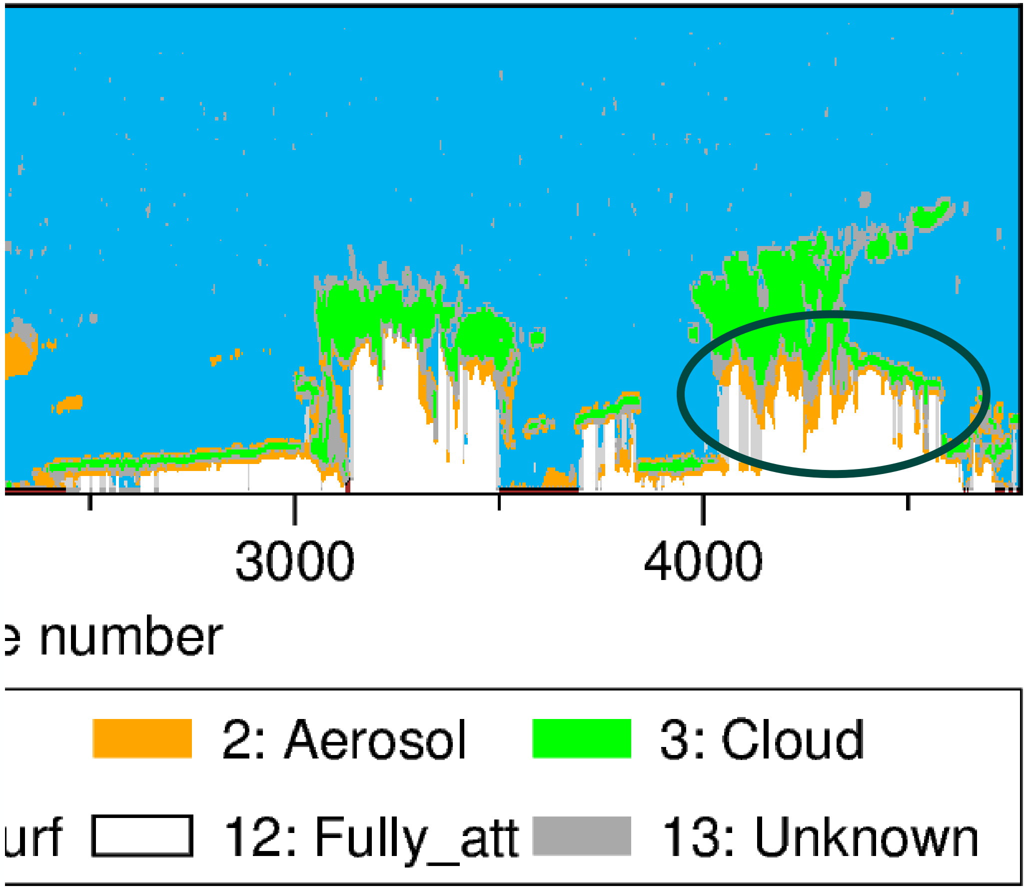

ATLID




CPR



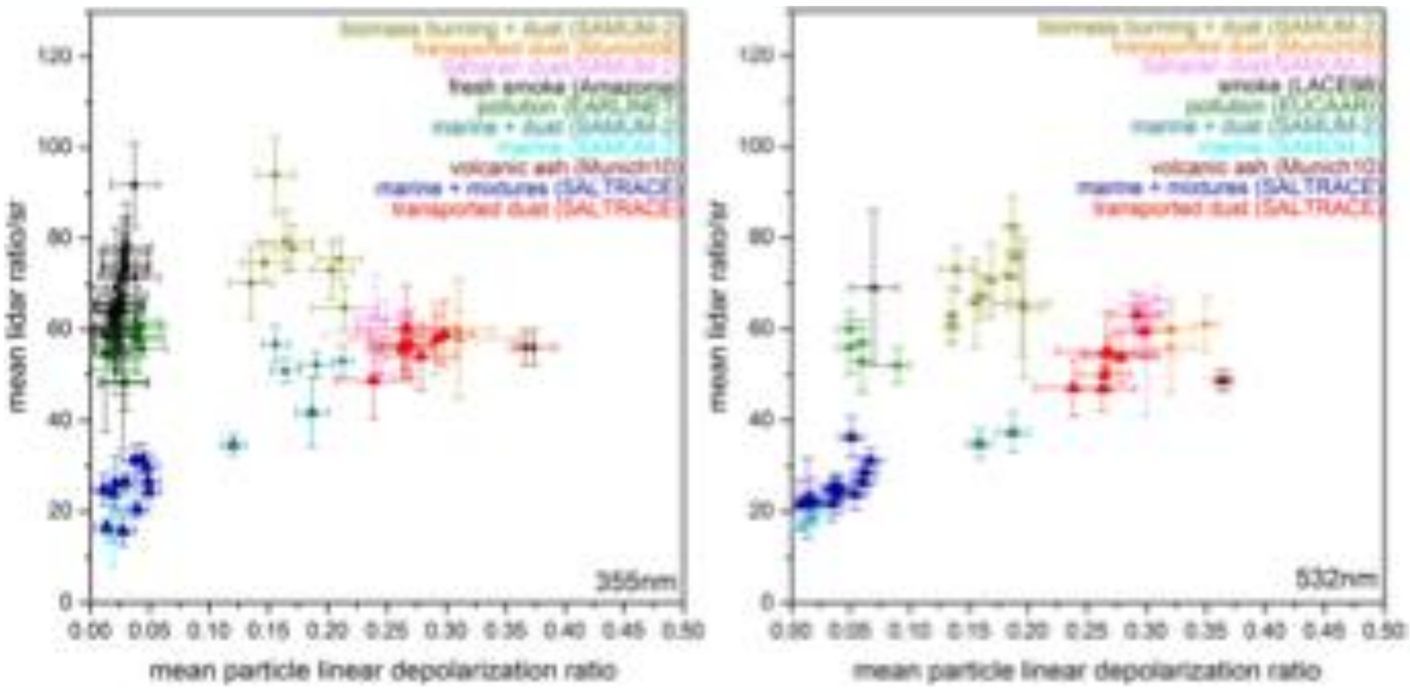
ATL_CLA feature mask (10km) 2024.11.14 2640C



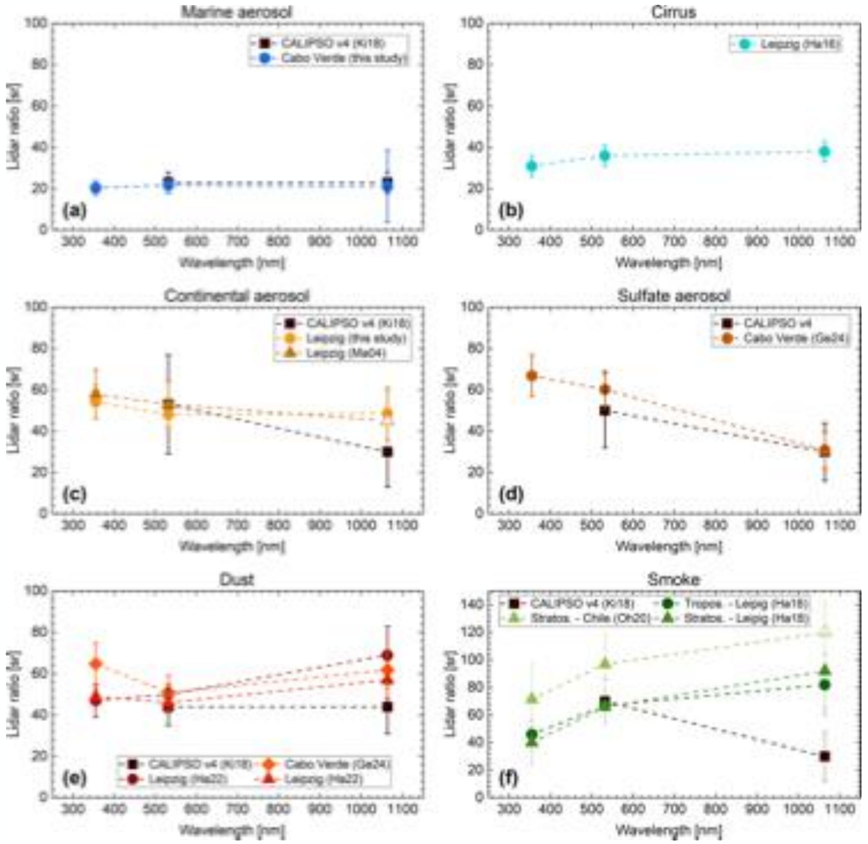
# Wavelength dependence of δ and LR between 355 and 532 nm



- Depolarization ratio for dust and sea salt is slightly lower for 355 nm than 532 nm from the previous studies
- Lidar ratio for dust and sea salt is almost the same at 355 nm and 532 nm

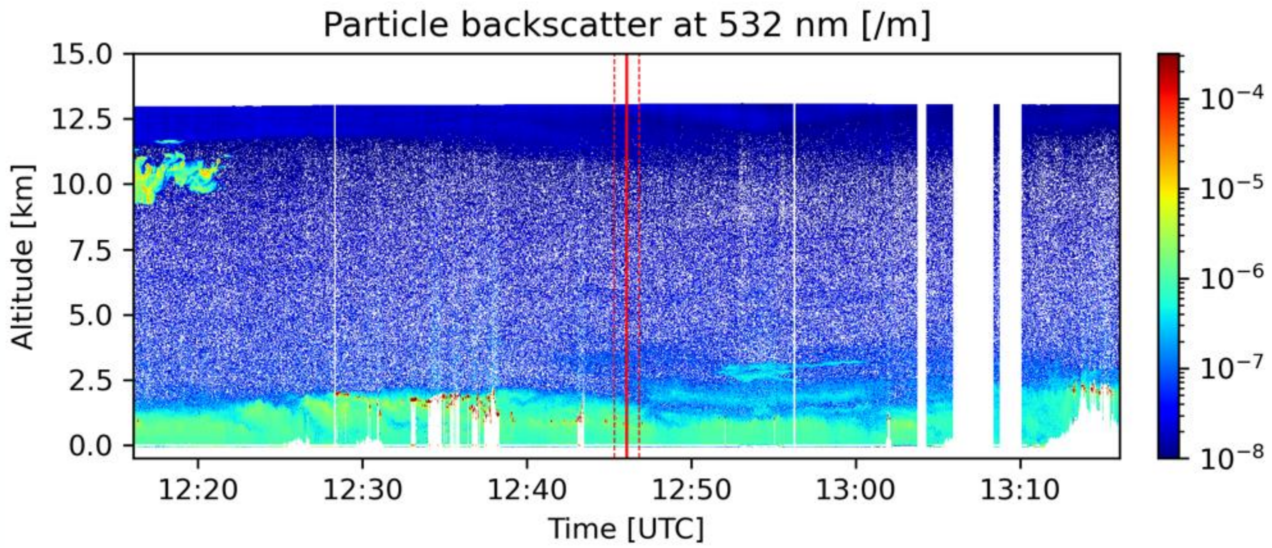


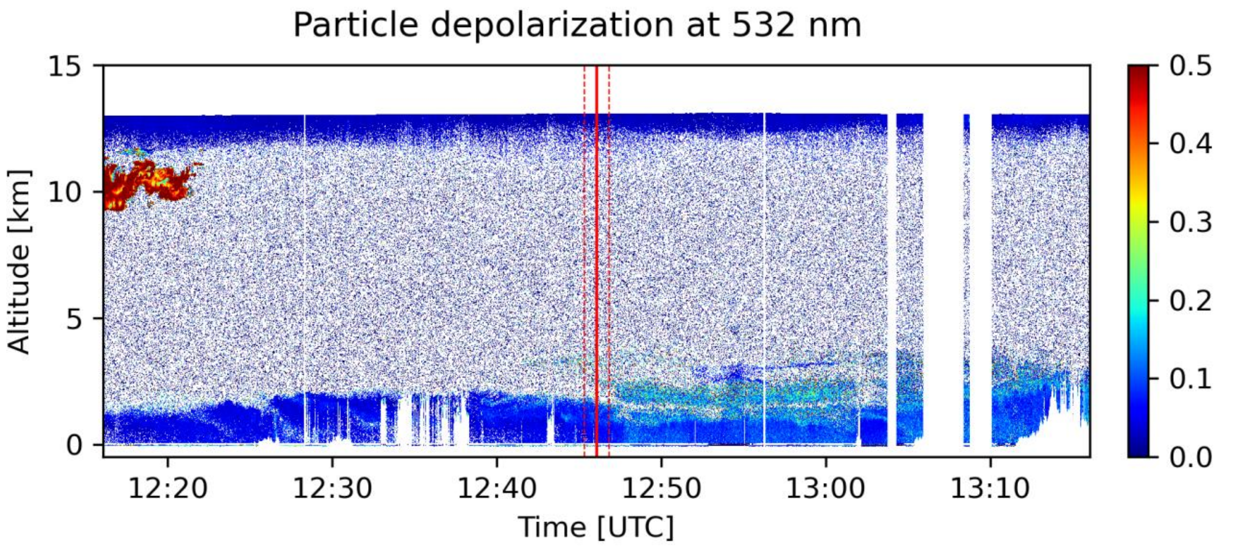

Groß et al., 2015, ACP




Harrig et al., 2025, ACP

# 2024.11.19 (2716D, sea salt case)




Cloud contamination in WALES lidar
=> Need to remove clouds while averaging