



Validation of ATLID L1 products using airborne measurements with the research aircraft HALO during the PERCUSION campaign: Comparison of different L1 Baseline versions

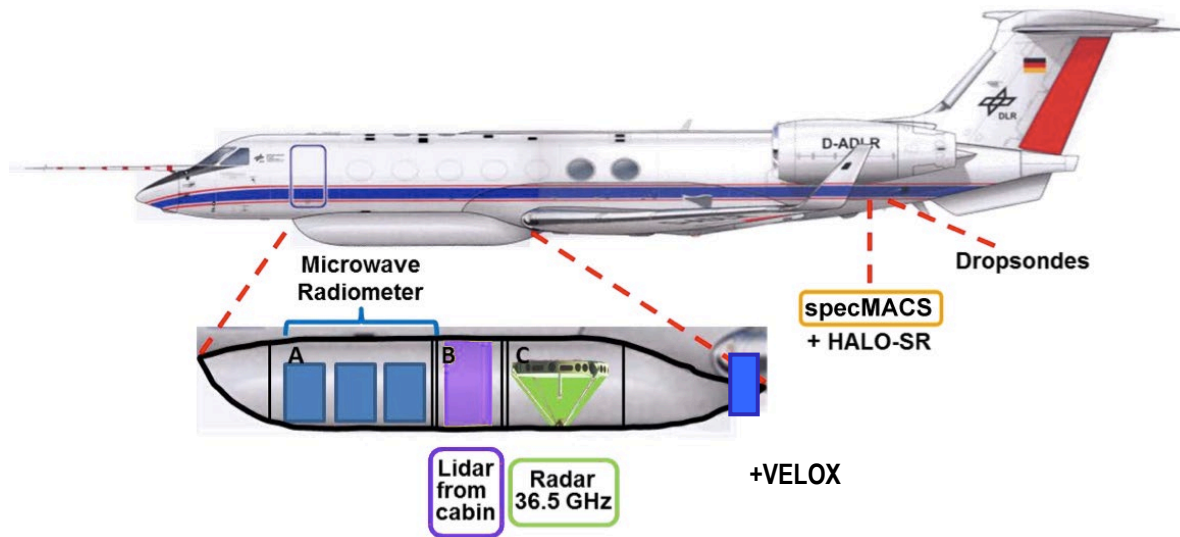
*Martin Wirth and Silke Groß
German Aerospace Center (DLR)*

2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy



EarthCARE-like payload on HALO

- G550, max. alt 16 km / max. range: 8000 km
- In operation since 2012
- operated by DLR



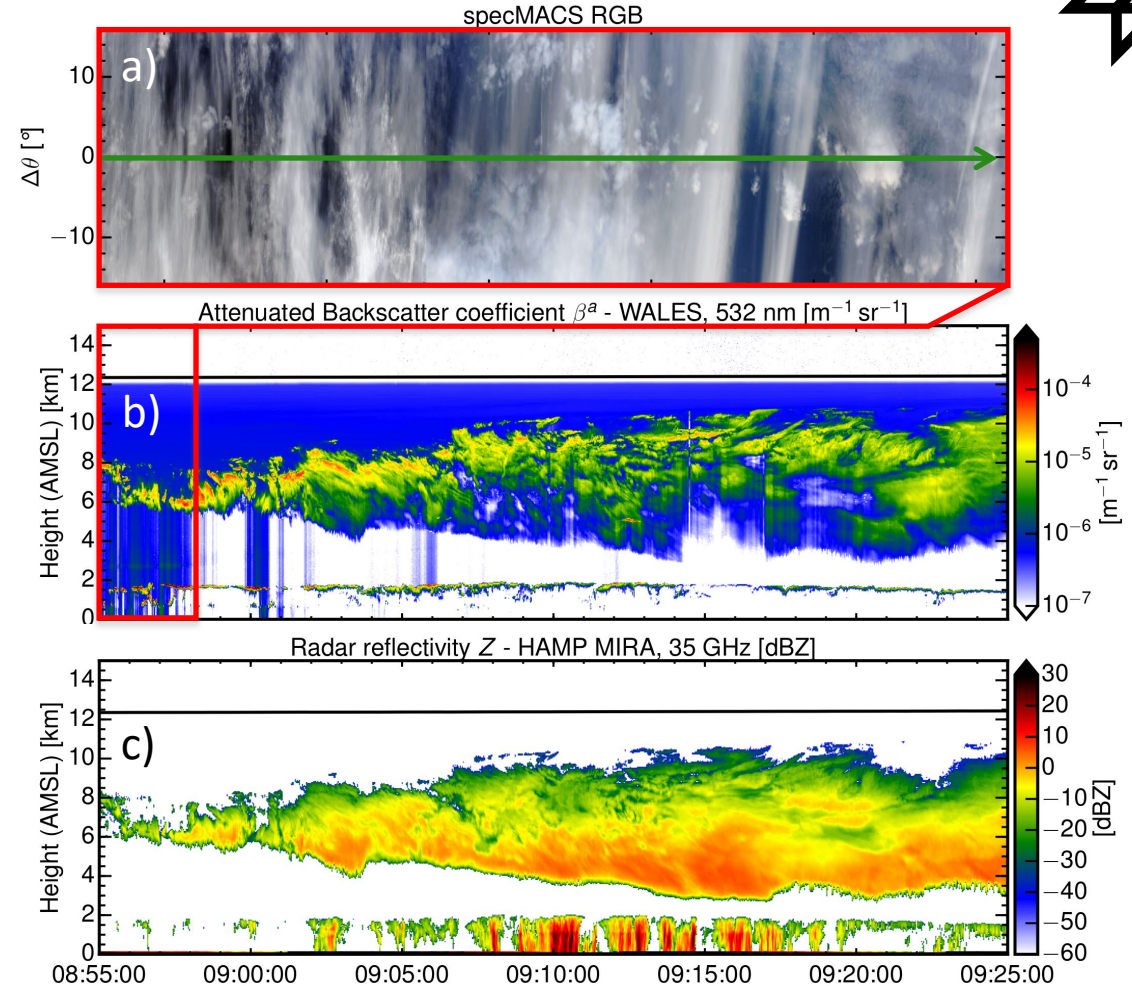
Scientific Instruments

HSRL-Lidar (WALES, 532 nm – Wirth et al. 2009)

Cloud Doppler Radar (MIRA, 35 GHz – Ewald et al. 2019)

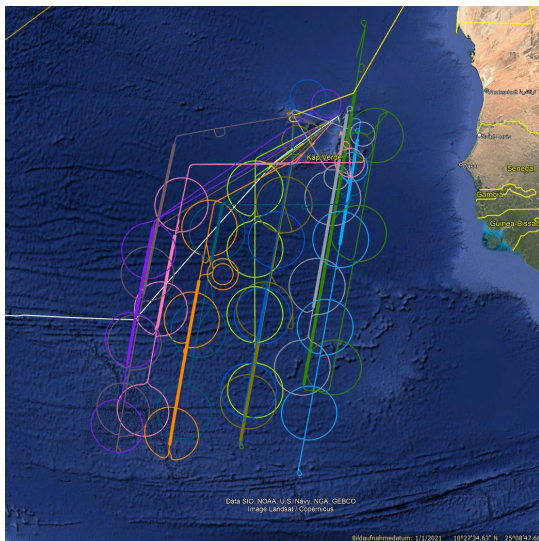
Hyper-Spektral Imager (specMACS – Ewald et al. 2016)

Thermal Infrared Imager (VELOX – Schäfer et al. 2014)



3 Location
30 Flight
33 Under passes
290 Flight hours

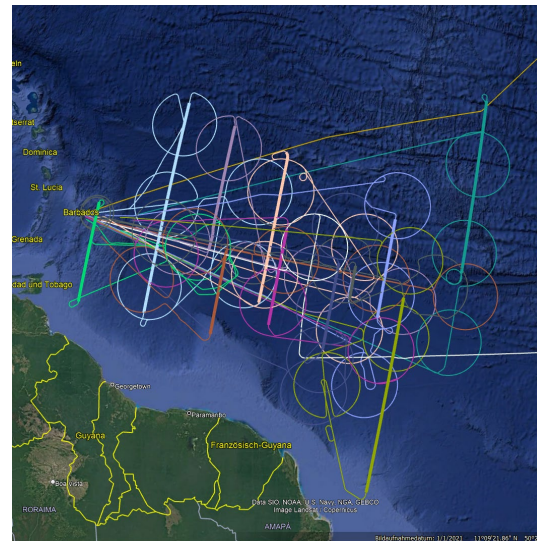
Sal, Cape Verde



8 August – 6 September 2024

- 10 EC underflights
- 4 overpasses over Mindelo ground station
- 3 coordinated flights (curtain) with ATR (2 direct EC overpass)
- 3 coordinated flights (curtain) with King Air (1 direct EC overpass)
- Coordination with METEOR

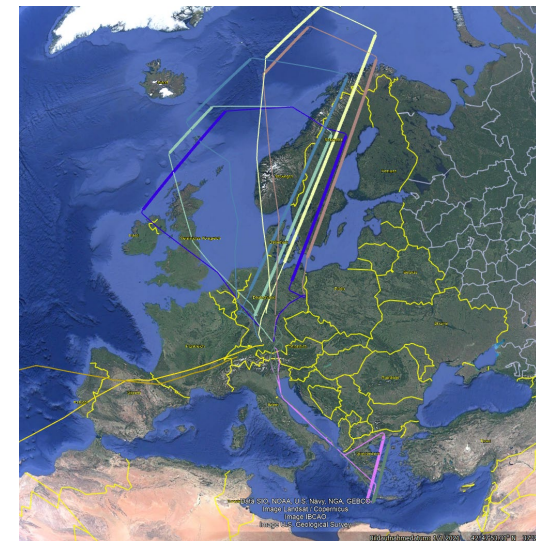
Barbados



6 – 29 September 2024

- 11 EC underflights
- 3 (+1) flights coordinated with PACE
- Overpasses/measurements near BCO ground station
- various METEOR overpasses

Oberpfaffenhofen



5 – 19 November 2024

- 12 EC underflights
- 2 overpasses (each) Lindenberg, Leipzig, Jülich, Munich, Antikythera
- 1 coordinated flight (profile) with BAe (FAAM)

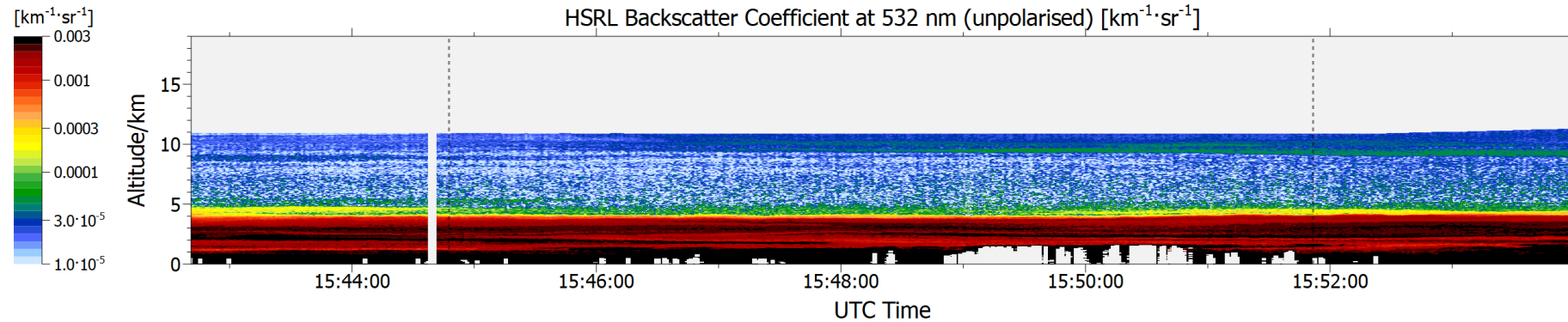
ATLID L1 Comparison – 13 Aug. 2024 (Sal; dust/mixture)



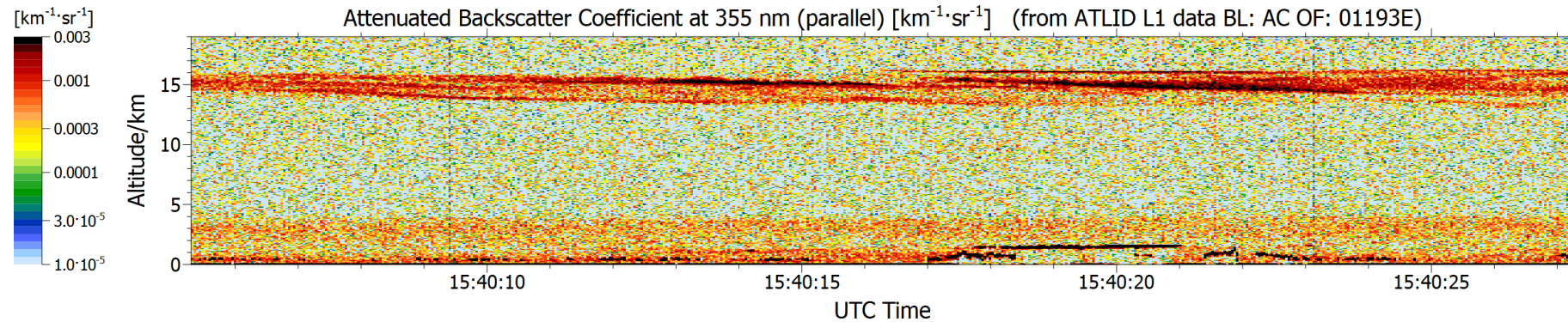
ATLID / WALES Comparison PERCUSSION 2024-08-13

Data average: WALES at: 15:48:20.362 ATLID at: 15:40:16.28 over ± 50.00 km (mean track distance: 1.10 km, mean temporal distance: 484.1 s)

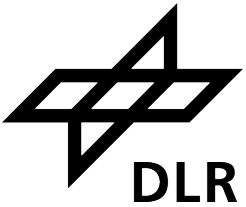
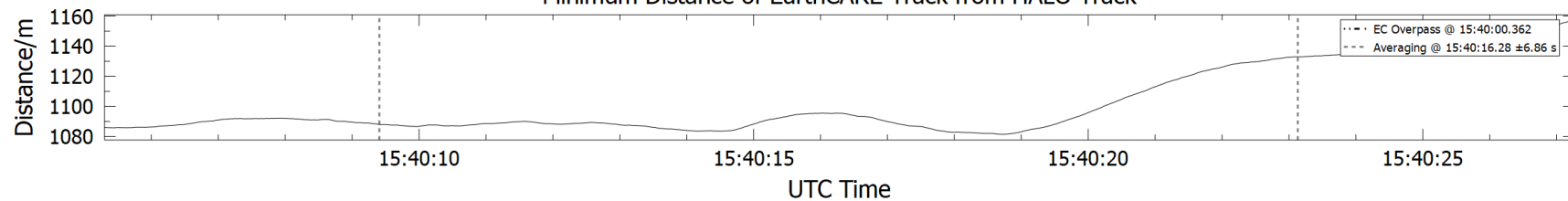
HSRL Backscatter Coefficient at 532 nm (unpolarised) [$\text{km}^{-1} \cdot \text{sr}^{-1}$]



Attenuated Backscatter Coefficient at 355 nm (parallel) [$\text{km}^{-1} \cdot \text{sr}^{-1}$] (from ATLID L1 data BL: AC OF: 01193E)



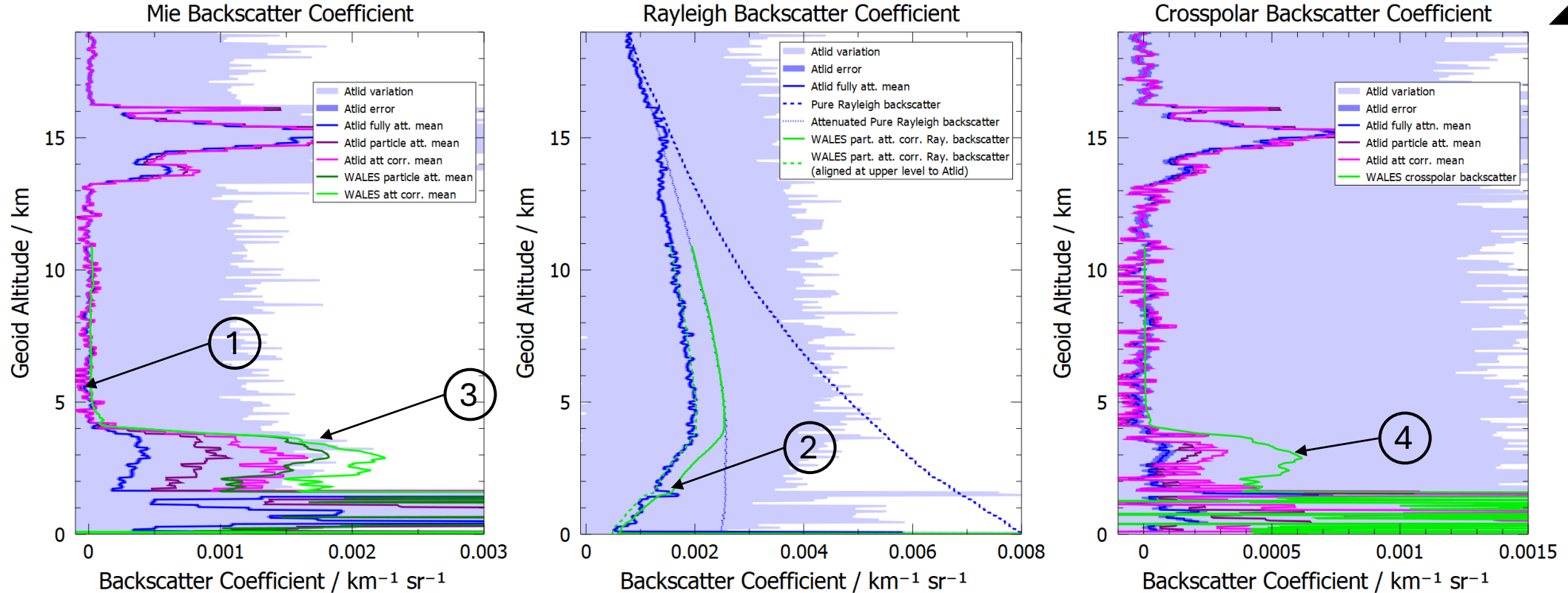
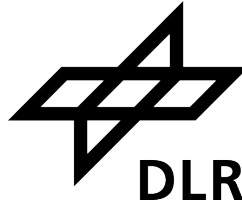
Minimum Distance of EarthCARE Track from HALO Track



ATLID L1 Comparison – 13 Aug. 2024 (Sal; dust/mixture)



ATLID: original data (BL: AA OF: 01193E)



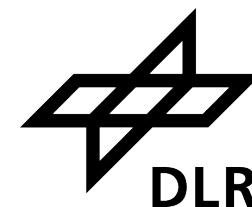
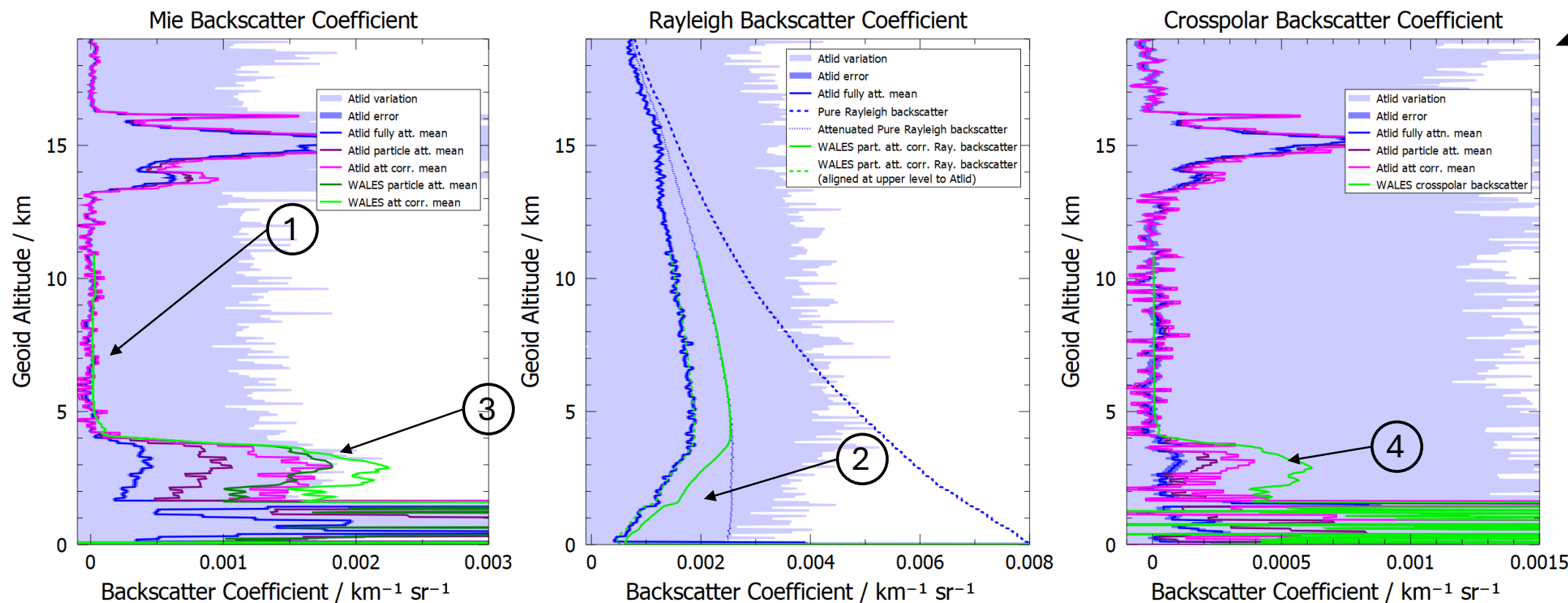
1. Mie signal slightly below zero in clean atmosphere region
2. Rayleigh signal shows cross talk from marine boundary layer clouds
3. Lower backscatter within dust layer (should be equal or slightly higher for 355 nm signal)
4. Depolarization significantly lower than WALES measurement (wavelength dependence has to be checked)



ATLID L1 Comparison – 13 Aug. 2024 (Sal; dust/mixture)



ATLID: released data (BL: AD OF: 01193E)

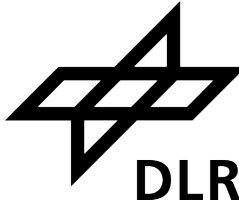
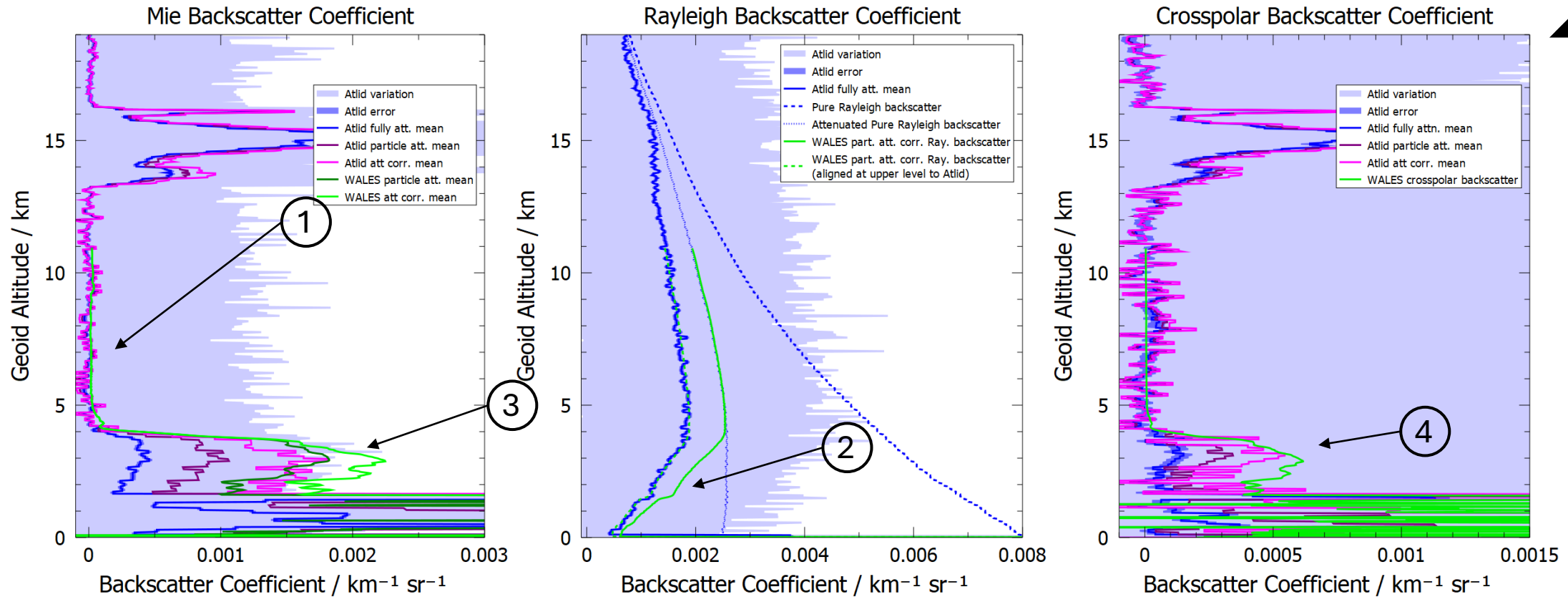


1. Still: Mie signal slightly below zero in clean atmosphere region
2. Improvement: Cross talk significantly improved
3. Improvement: Increased backscatter within dust layer
4. Improvement: Depolarization increased in dust layer (but still lower than WALES)





ATLID: preview of AE (BL: ZZ OF: 01193E)



1. Still: Mie signal slightly below zero in clean atmosphere region (No change compared to AD)
2. No change compared to AD
3. No change compared to AD
4. **Improvement:** Depolarization further increased in dust layer



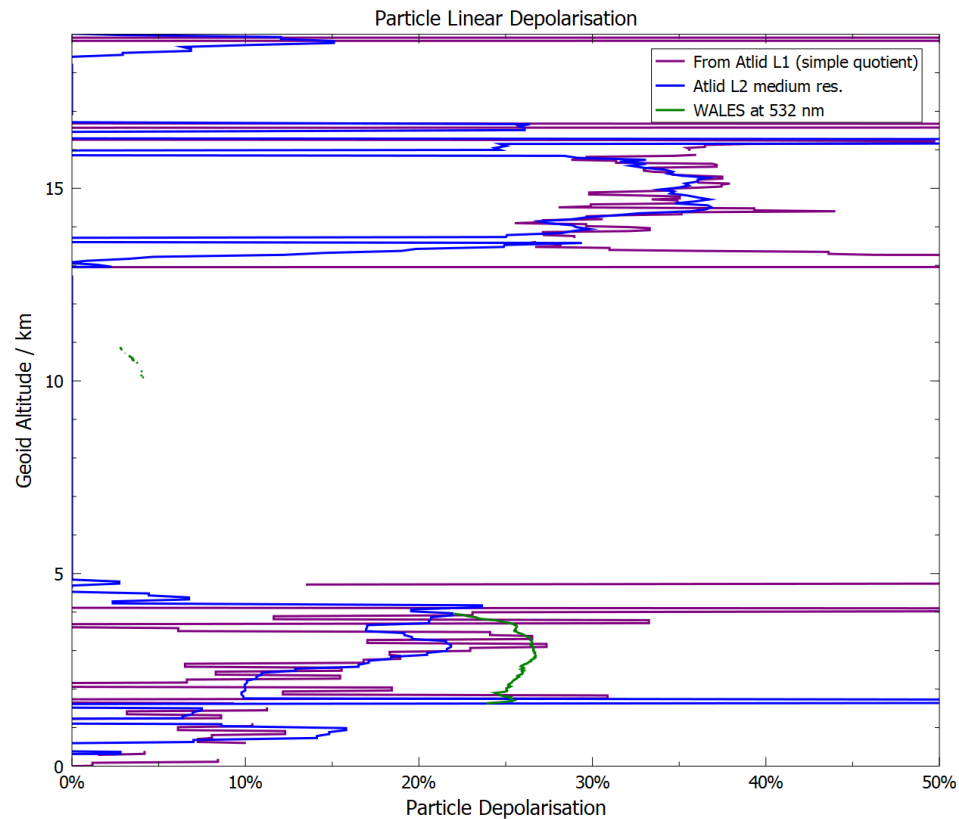
ATLID L1 Comparison – 13 Aug. 2024 (Sal; dust/mixture)



ATLID: released data (BL: AD OF: 01193E)

ATLID / WALES Comparison PERCUSION 2024-08-13

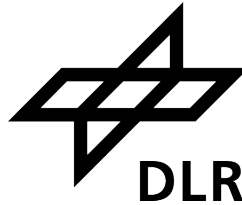
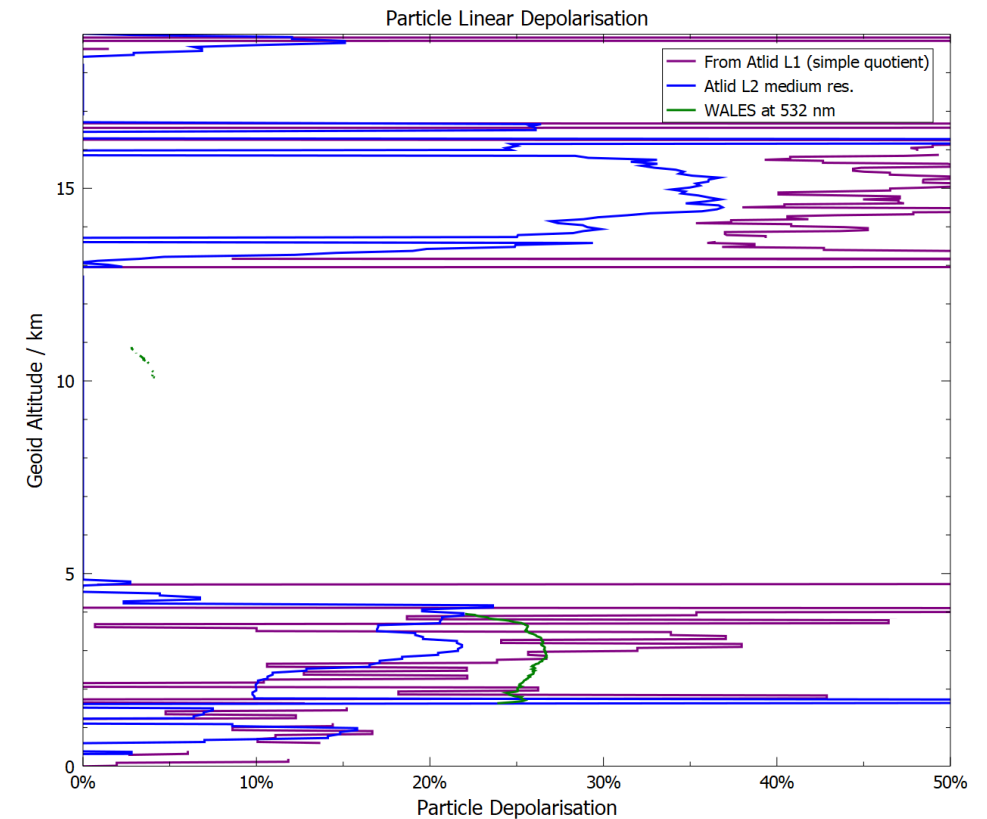
Data average: WALES at: 15:48:20.362 ATLID at: 15:40:16.28 over ± 50.00 km
mean track distance: 0.90 km, mean temporal distance: 484.1 s
from ATLID L1 data BL: AD OF: 01193E L2 data BL: AD OF: 01193E



ATLID: preview data (BL: ZZ OF: 01193E)

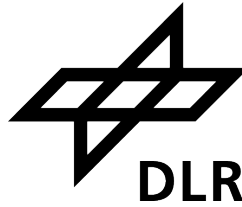
ATLID / WALES Comparison PERCUSION 2024-08-13

Data average: WALES at: 15:48:20.362 ATLID at: 15:40:16.28 over ± 50.00 km
mean track distance: 0.90 km, mean temporal distance: 484.1 s
from ATLID L1 data BL: ZZ OF: 01193E L2 data BL: AD OF: 01193E



Latest changes to the cross-polar signal move particle depolarization into the expected range!

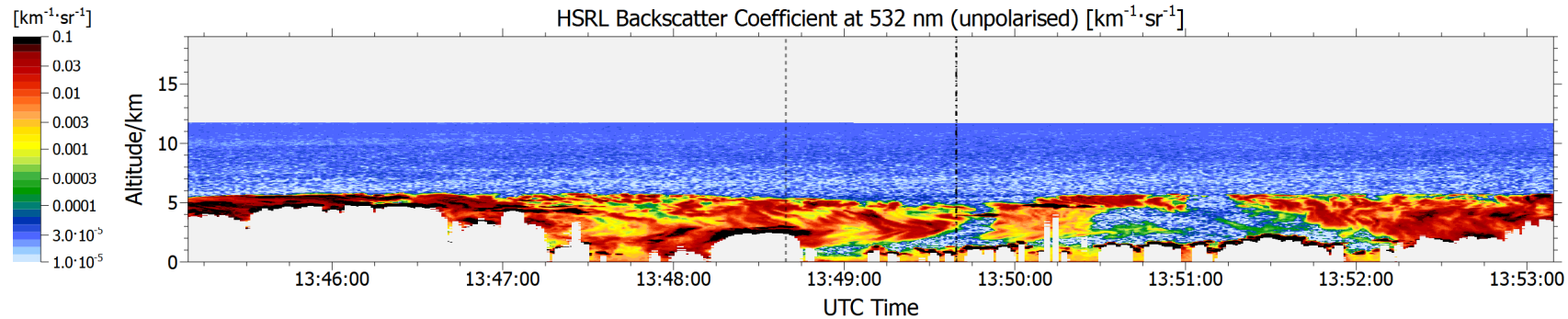
ATLID L1 comparison – 14 Nov. 2024 (OP; ice cloud)



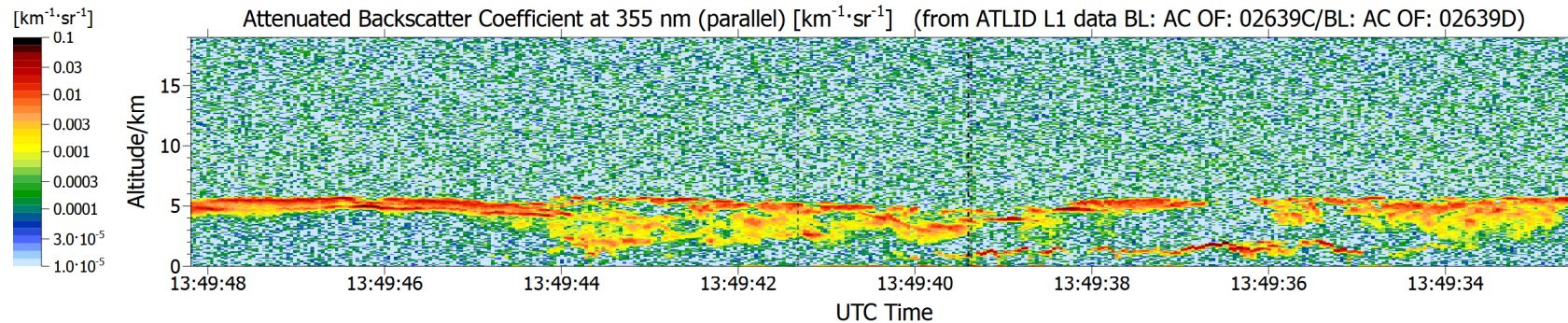
ATLID / WALES Comparison PERCUSION 2024-11-14

Data average: WALES at: 13:49:09.396 ATLID at: 13:49:40.346 over ± 7.00 km (mean track distance: 0.25 km, mean temporal distance: 31

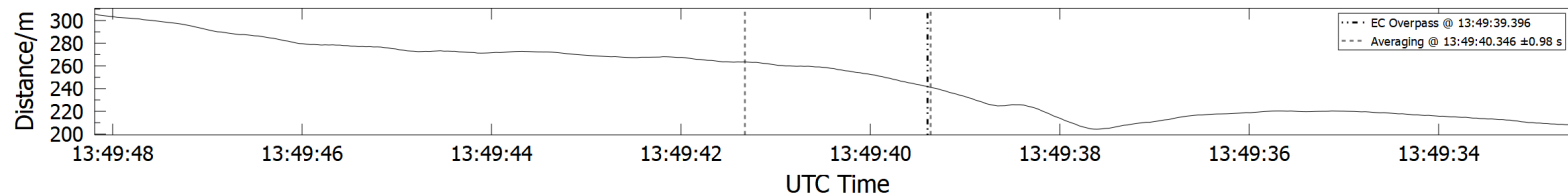
HSRL Backscatter Coefficient at 532 nm (unpolarised) [$\text{km}^{-1} \cdot \text{sr}^{-1}$]



Attenuated Backscatter Coefficient at 355 nm (parallel) [$\text{km}^{-1} \cdot \text{sr}^{-1}$] (from ATLID L1 data BL: AC OF: 02639C/BL: AC OF: 02639D)



Minimum Distance of EarthCARE Track from HALO Track

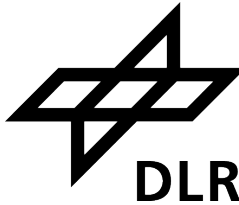
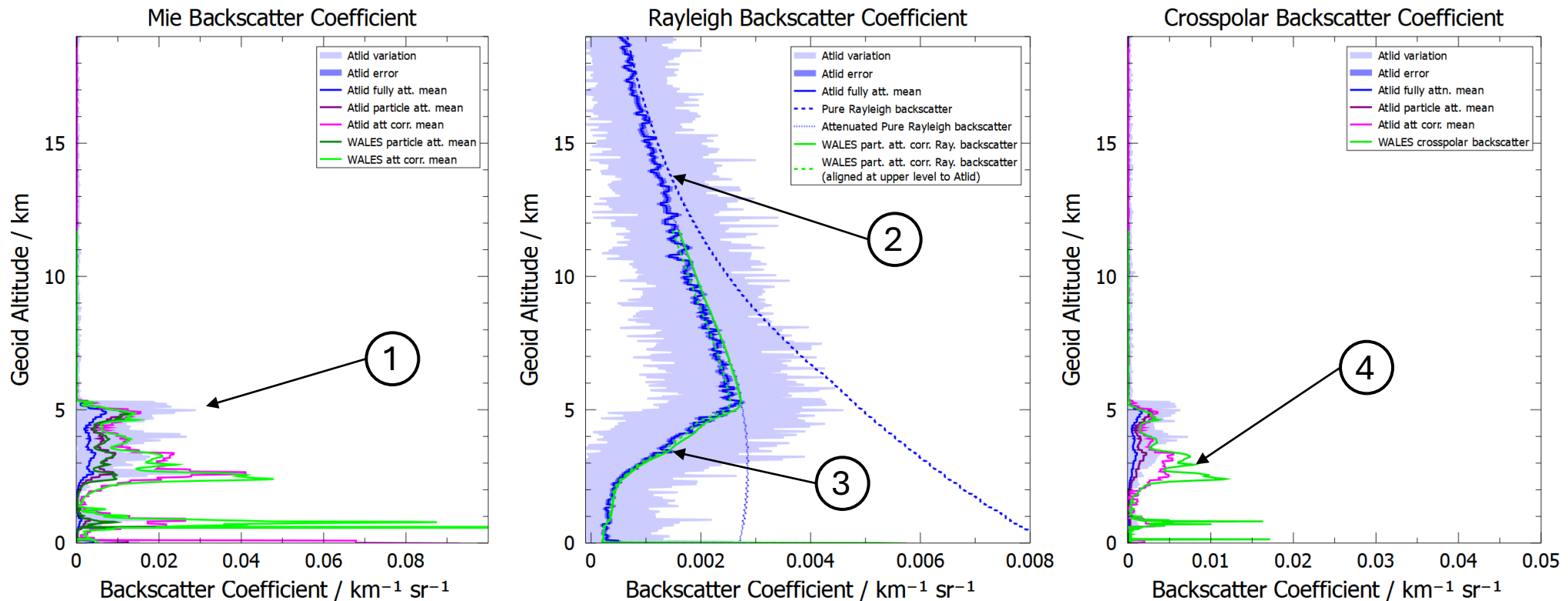


ORCESTRA

EarthCARE L1 comparison – 14 Nov. 2024 (OP; ice cloud)



ATLID: released data (BL: AD)



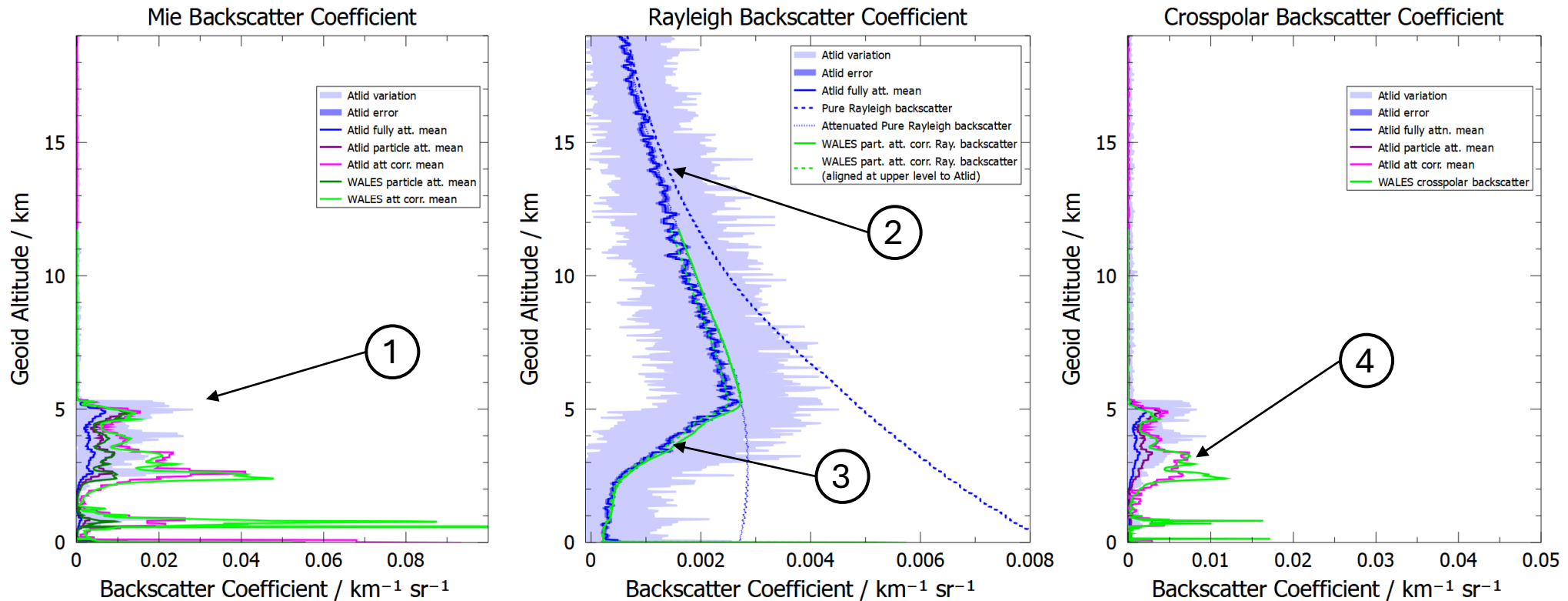
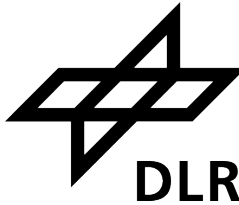
1. Comparable backscatter in (arctic) cirrus cloud, as expected
2. Some optical thickness (2%-4%) already at altitudes with no aerosol.
3. Rayleigh-profile shows very small but still visible crosstalk.
4. Depolarisation in cirrus lower than for WALEs profiles at 532 nm (but here still cmp. with baseline AC)



EarthCARE L1 comparison – 14 Nov. 2024 (OP; ice cloud)



ATLID: latest data (BL: AE)



1. No change AD -> AE
2. No change AD -> AE
3. No change AD -> AE.
4. Depolarisation in cirrus with AE now comparable to WALEs profiles at 532 nm





- Airborne remote sensing measurements performed in summer and fall 2024
 - Sal, Cape Verde in August 2024 (10 underpasses)
 - Barbados in September 2024 (11 underpasses)
 - Oberpfaffenhofen in November 2024 (12 underpasses)
- Comparisons of ATLID L1 data proof very good performance of EarthCARE
- Depolarisation too low (by 30%-50%) in early baselines. Should be fixed in new baseline AE.
- Sometimes still visible cross-talk from Mie to Rayleigh channel, but greatly enhanced from baseline AC on, but still not perfect in AE.
- Signals are sometimes significantly negative, or positive where they should be zero (e.g. below opaque clouds), even for baseline AE.