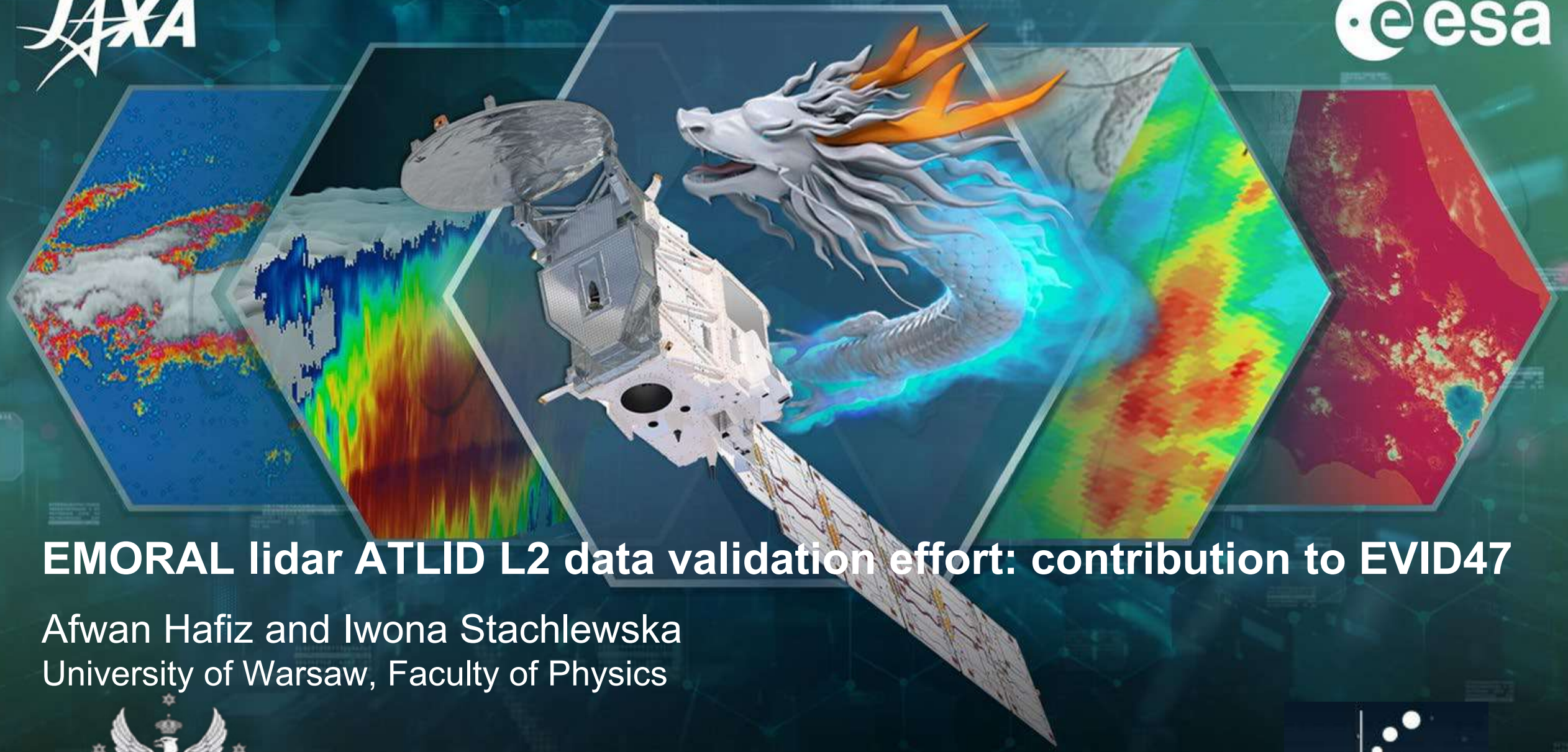


EMORAL lidar ATLID L2 data validation effort: contribution to EVID47

Afwan Hafiz and Iwona Stachlewska
University of Warsaw, Faculty of Physics

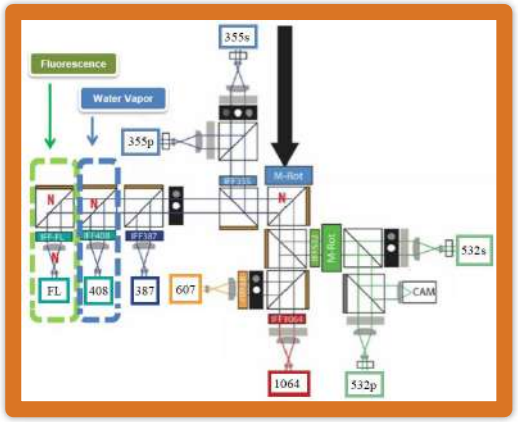
2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

Instrument

355 532 1064 pulsed laser wavelengths

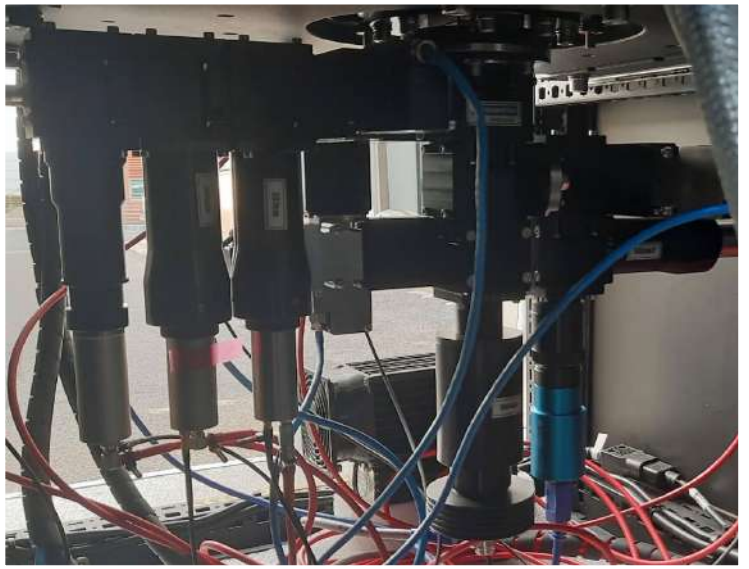
355 -p,-s	387	
532 -p,-s	408	470
1064	607	

Detection Configuration:
$(3\beta, 2\alpha, 2\delta$ + WV + Fluo.)



EMORAL

ESA Mobile Mie-Raman Polarization and Fluorescence Lidar



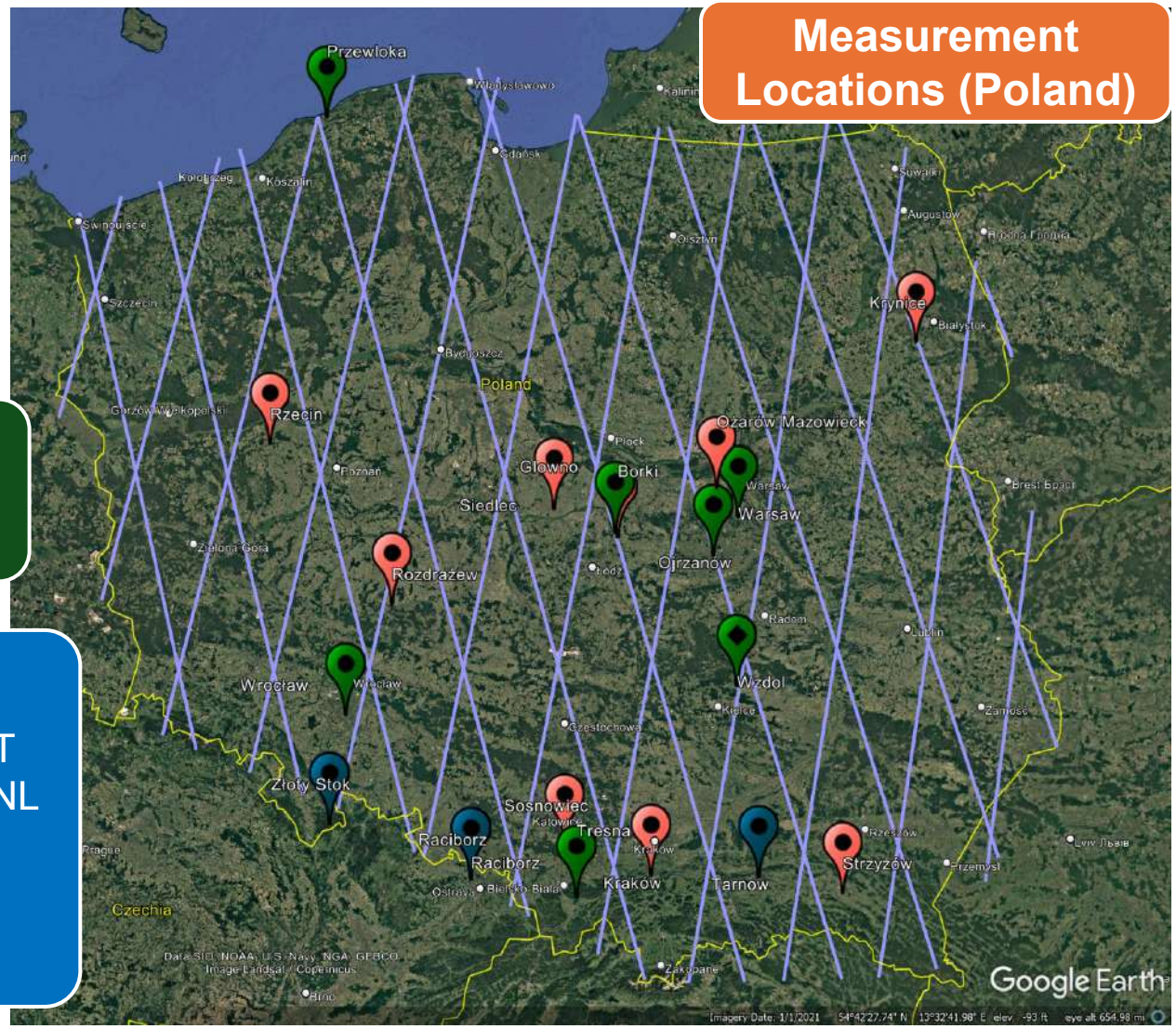
Goals

- EMORAL observations for EarthCARE
- Measurement collected for overpass:
  - as close as possible
  - in different environments

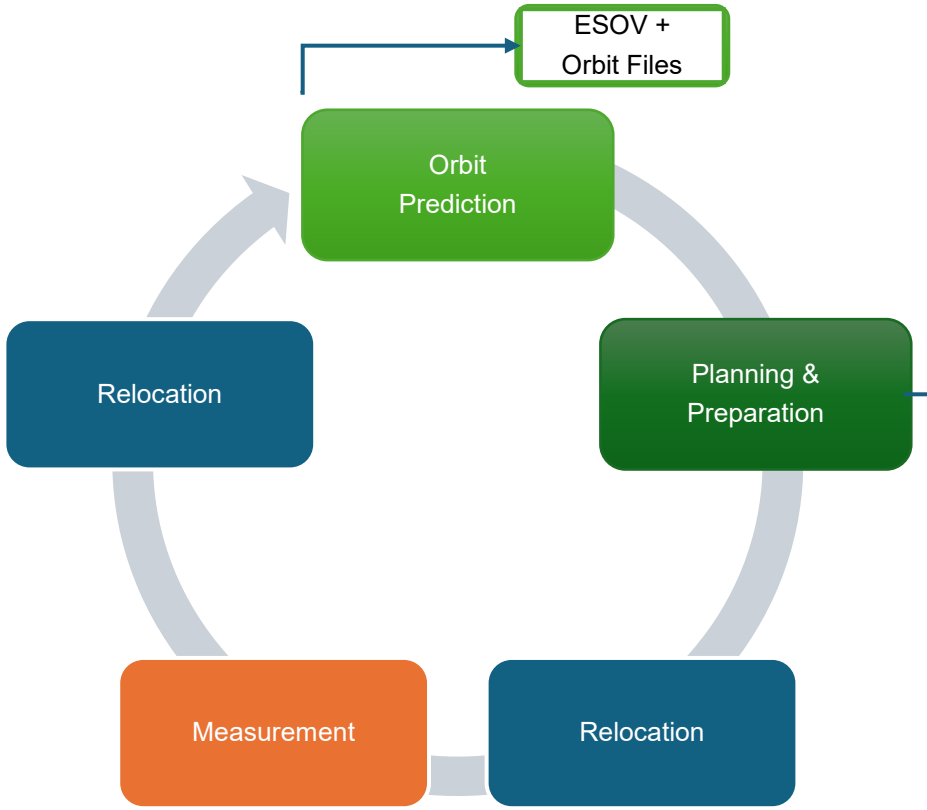
EarthCARE/EMORAL collocation measurements (thanks to hosts)

Outside of Poland:
- ESA-ESRIN, CNR-ISMATR, IT
- ESA ESTEC, KNMI-CESAR, NL
- FTMC, LT
- INOE, RO
- Raymetrics, Greece

Measurement Locations (Poland)



Overpass Campaigns



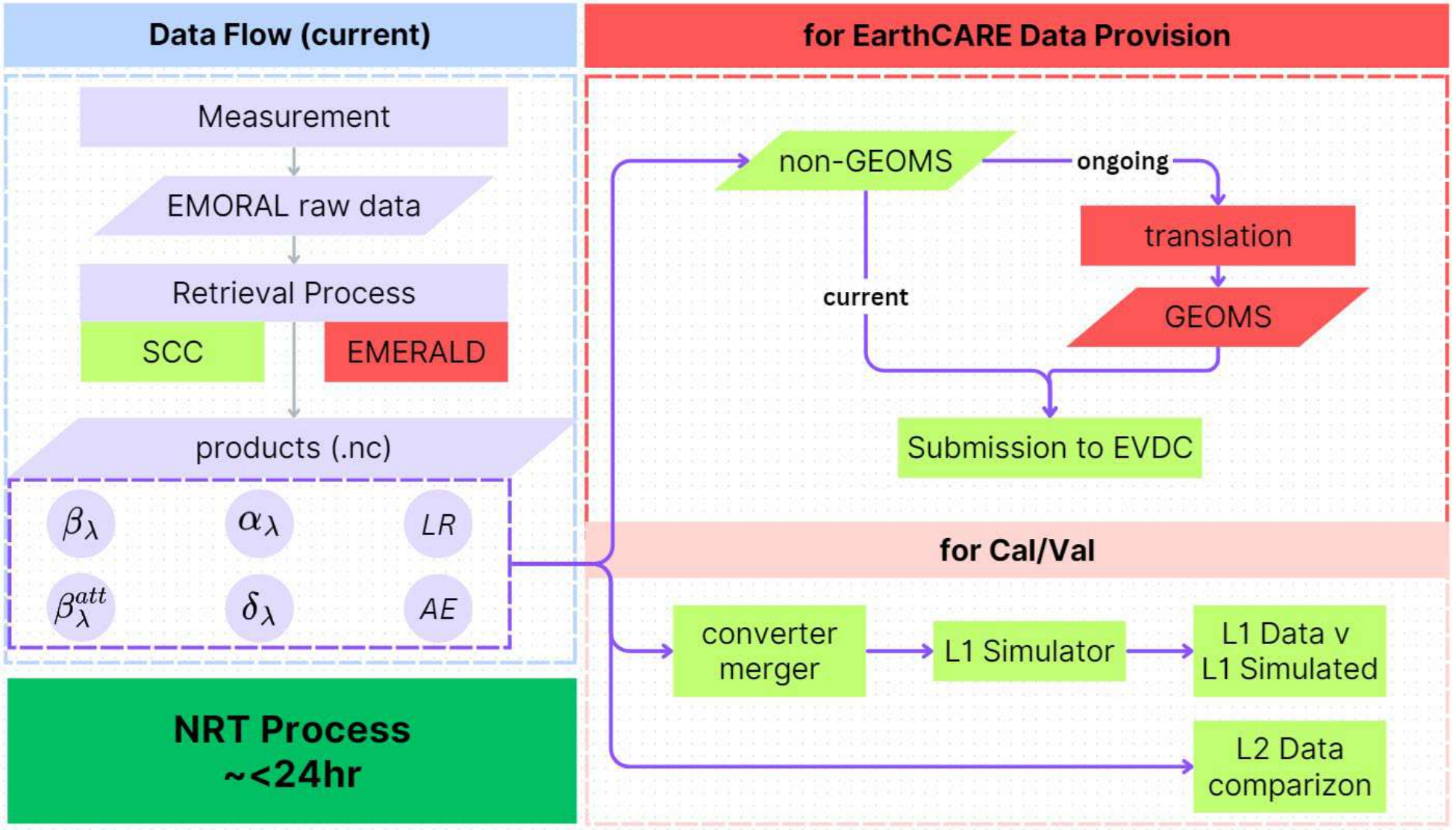
ECVT Page

Start Time (UTC)	End Time (UTC)	Orbit #	LON	LAT	Location
2024-08-25T00:17:36Z	2024-08-25T00:17:49Z	1370	17.090144	51.104589	Wroclaw (mobile, nearby)
2024-08-28T13:27:16Z	2024-08-28T13:27:29Z	1425	17.090144	51.104589	Wroclaw (mobile, nearby)
2024-10-19T13:14:13Z	2024-10-19T13:15:32Z	2234	19.206600	49.745600	Tresna (mobile, nearby)
2024-10-23T00:12:17Z	2024-10-23T00:13:35Z	2288	16.898600	54.577200	Przewloka (mobile, nearby)
2024-10-24T13:32:29Z	2024-10-24T13:33:30Z	2312	16.898600	54.577200	Przewloka (mobile, nearby)
2024-10-28T13:09:54Z	2024-10-28T13:11:17Z	2374	20.861900	50.982100	Wzdol Rzadowy (mobile, nearby)
2024-11-19T00:00:37Z	2024-11-19T00:02:45Z	2708	20.7354	52.0113	Ojrzanow (mobile, nearby)

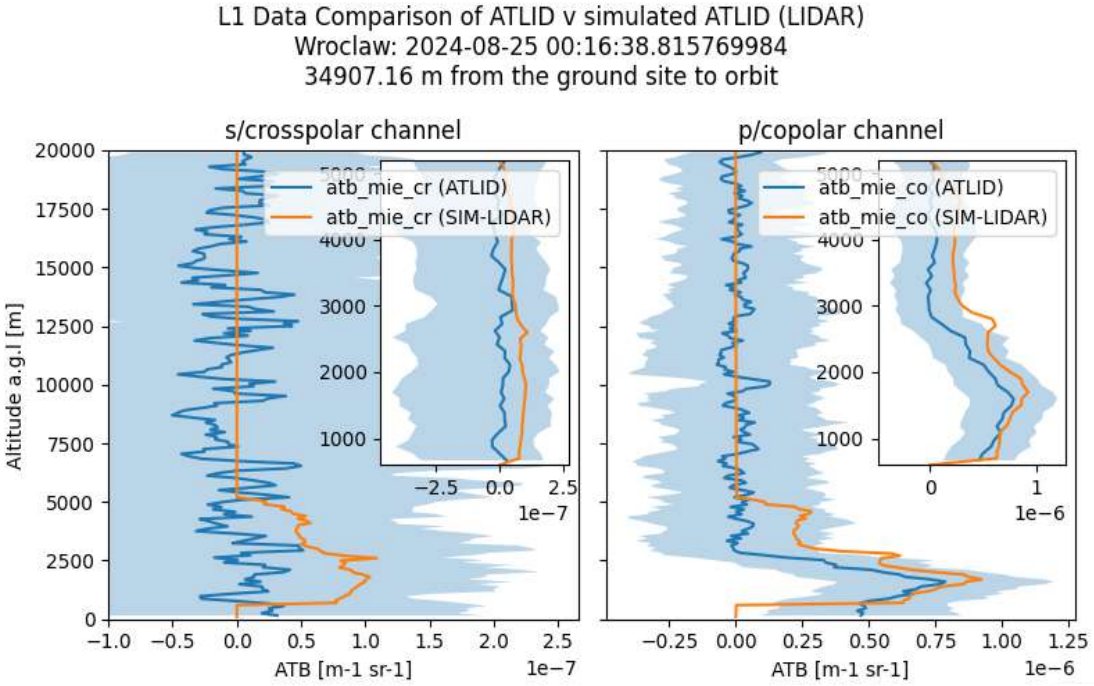
ESA Requirement:
± 6 hours from overpass time
Below <1km orbit

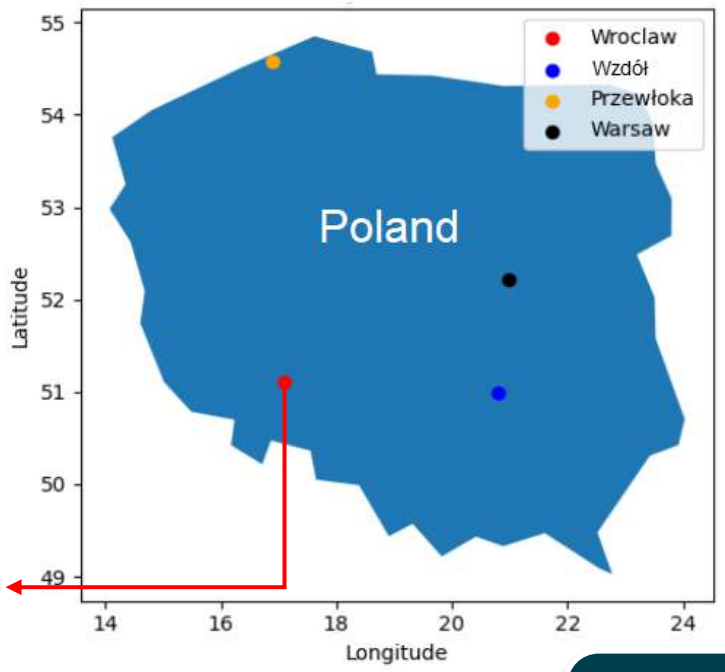
Real distance to orbits ranging from
<0.2km to 40km

Data Flow


Data Flow (current)
for EarthCARE Data Provision
Measurement
EMORAL raw data
Retrieval Process
SCC
EMERALD
products (.nc)
β_λ
α_λ
LR
β_λ^{att}
δ_λ
AE
NRT Process
~<24hr
non-GEOMS
ongoing
translation
GEOMS
current
Submission to EVDC
for Cal/Val
converter
merger
L1 Simulator
L1 Data v
L1 Simulated
L2 Data
comparizon

EMORAL v ATLID L1 Comparison





- SARA Atmo-Access TNA with EarthCARE overpasses at University of Wroclaw, West-Southern Poland
- Several days of measurements
  - Rare 3 Overpasses: 19/8 bad weather, 25/8 nighttime, 28/8 daytime
  - ++ Information on the atm. conditions

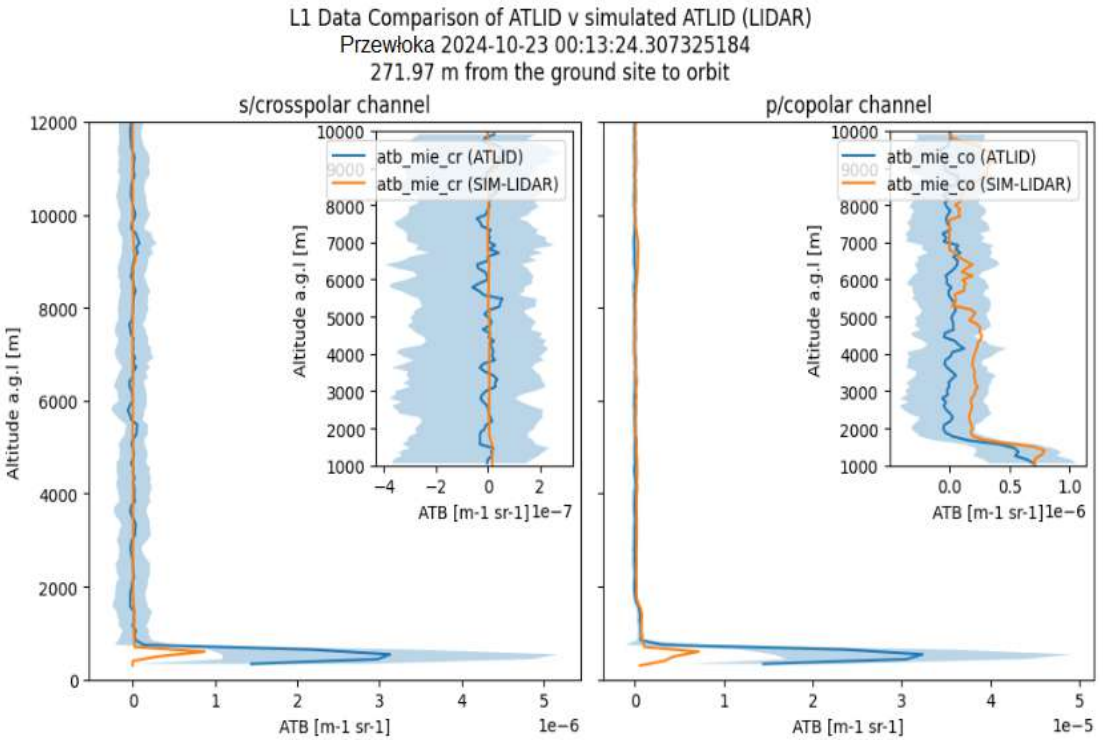
Comparison:
- ***ATLID values lower*** for both channels
- Similar shape for co-polar
- Noisy for cross-polar channel

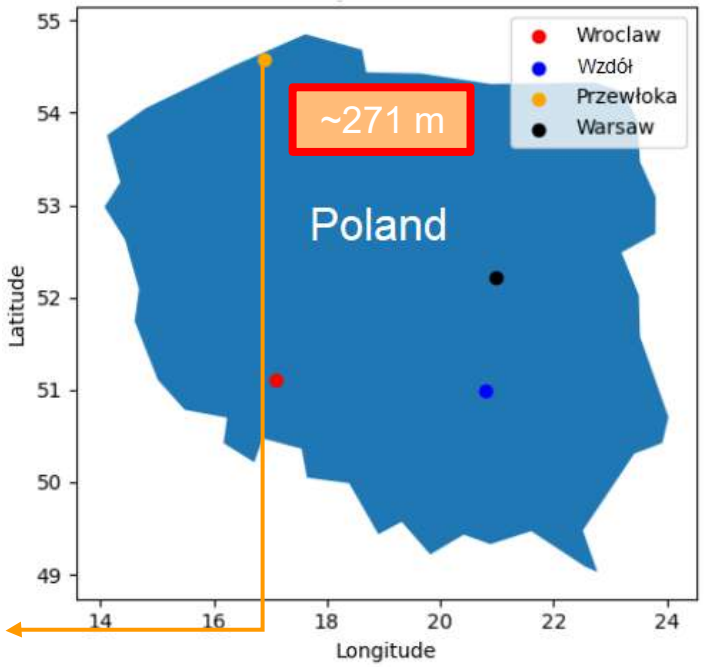
Case:
- Distance is bigger with real orbit **~20km → ~35km**

L1-tool Input (only nighttime):
- 1h profile (during overpass)
- Filtered to 5100 m
- More filters criteria for future comparison

ATLID Data:
- Distance ~34.9km
- Average 18 profiles
- 35.1 km radius from ground-based site

EMORAL v ATLID L1 Comparison





- Dedicated Overpass Campaign in Przewłoka, North Poland
- 2 Overpasses close in time:
  - 23/10 nighttime (fog very close to surface)
  - 24/10 daytime

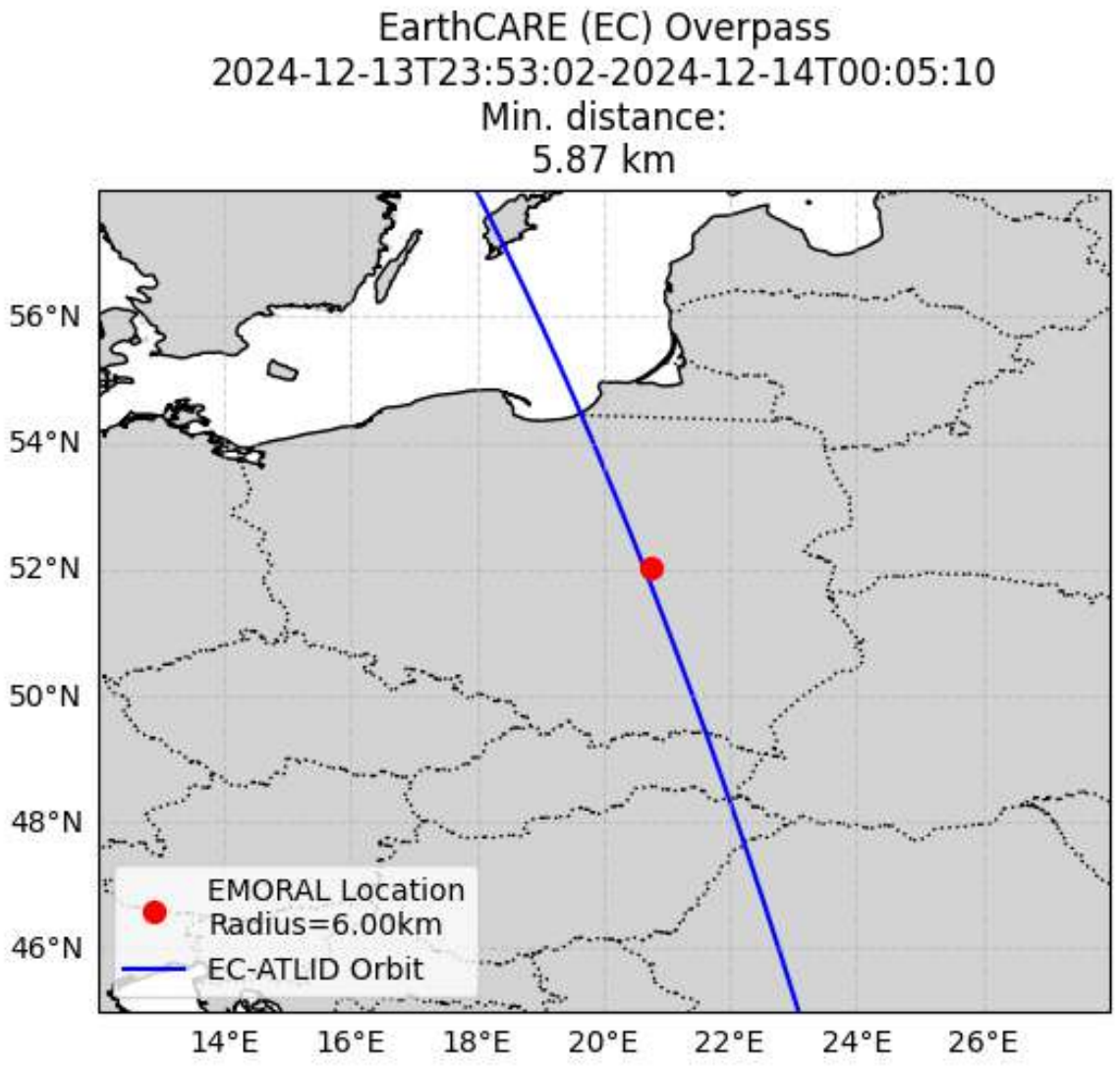
Case:
- Distance is closer with real orbit **~1km → ~0.3km**

Comparison:
- Similar shape at low altitude (fog layer), ATLID with lower values
- Similar shape for co-polar above fog
- Cross-polar weak signals (both atlid and emoral)

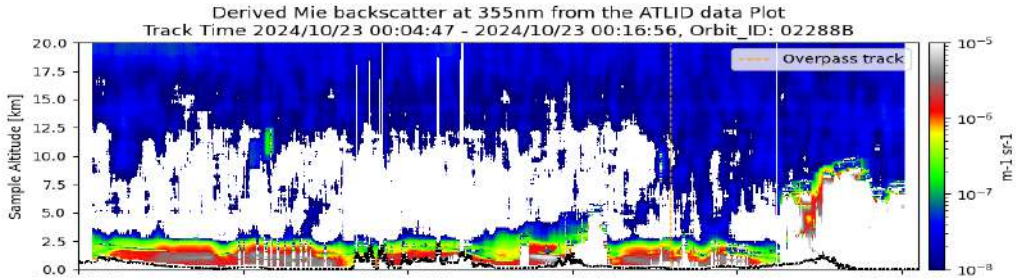
L1-tool Input (only nighttime)**:**
- 1h profile (during overpass)
- Layer (cloud/fog) close to surface

ATLID Data:
- Average of 14 profiles
- 2 km radius from ground-bassed site

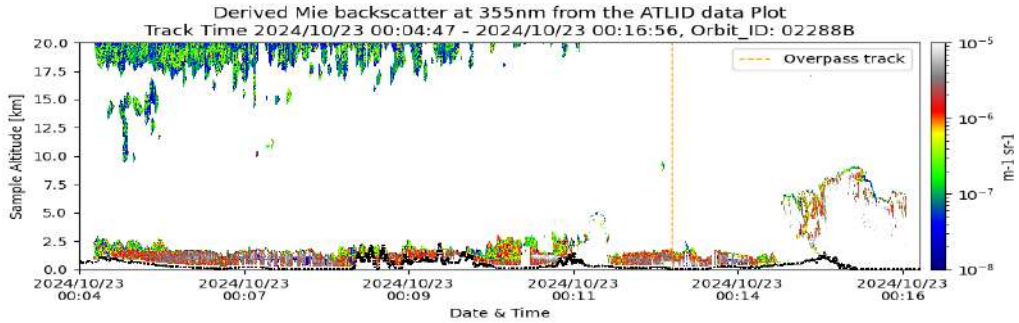
EMORAL v ATLID L2 Comparison



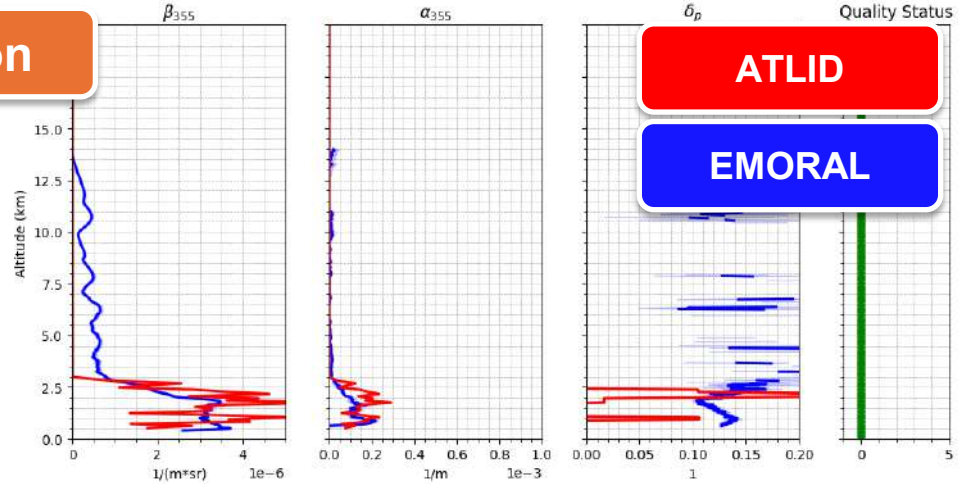
A-AER



A-EBD

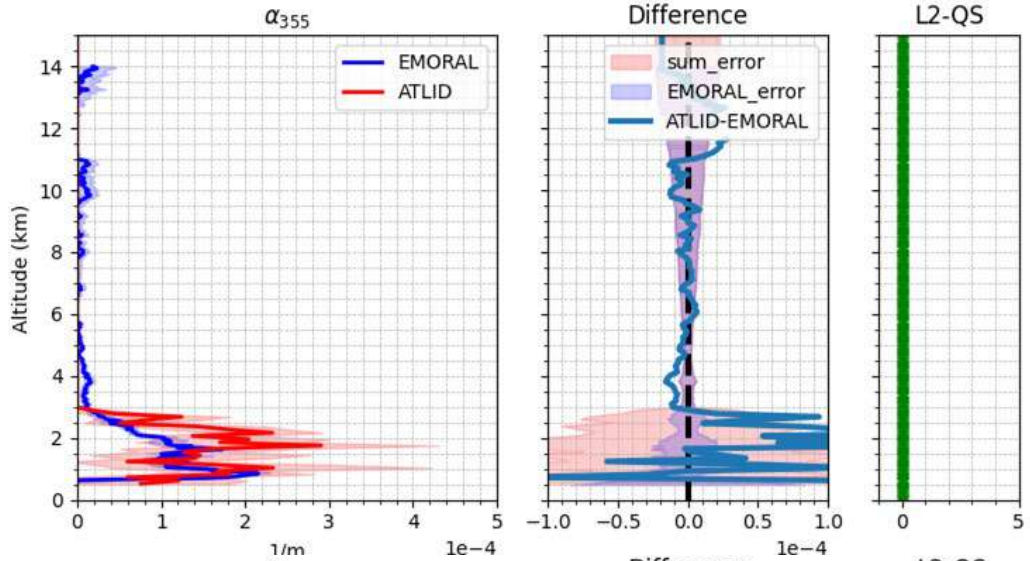


Comparison



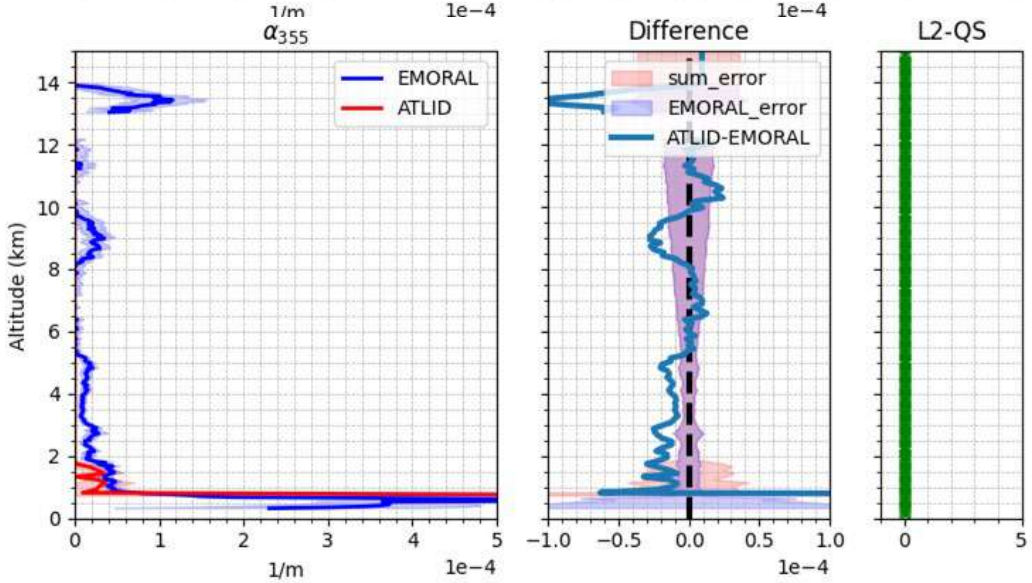
L2: Extinction Coeff. Comparison

A-EBD



Lidar Data Comparison between EMORAL ELDA vs AC-ATLID L2_EBD Products
AE-Overpass Time: 2024-08-25 00:16:35.784540032 | Min. Distance: 35.14 km
EMORAL-Measurement Time: 2024-08-24T23:59:05Z - 2024-08-25T00:58:44Z

Wroclaw:
- Realistic values below 3km
- Discrepancy could be the differences in residual layer (mineral dust intrusion from Sahara)
- Absolute difference above the layer as expected

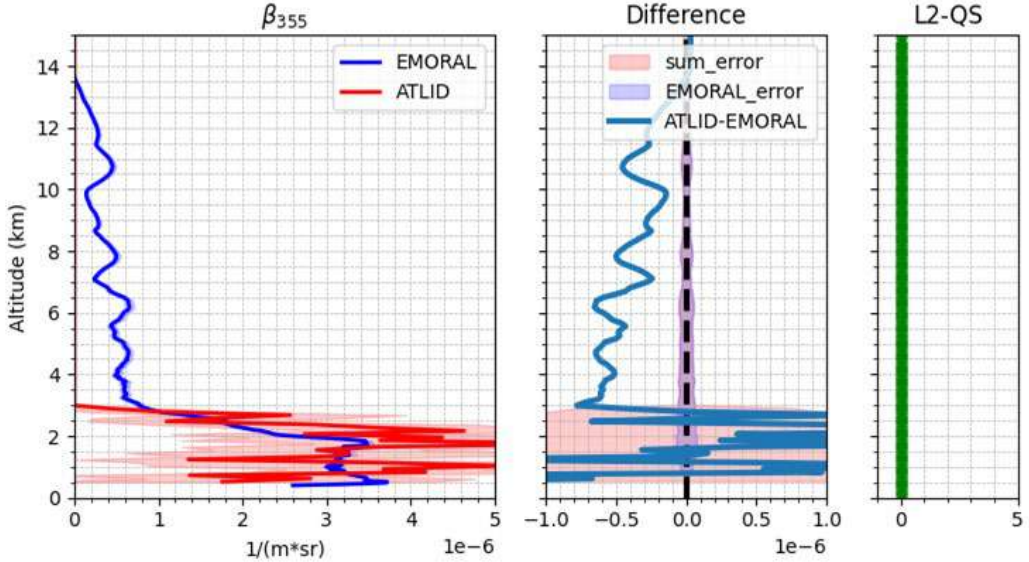


Lidar Data Comparison between EMORAL ELDA vs AC-ATLID L2_AER Products
AE-Overpass Time: 2024-10-23 00:13:21.276066688 | Min. Distance: 0.40 km
EMORAL-Measurement Time: 2024-10-22T23:59:58Z - 2024-10-23T00:35:21Z

Przewloka:
- ATLID peak in fog (close to surface) much stronger
- Above the fog layer the general shape os similar, but ATLID has lower values

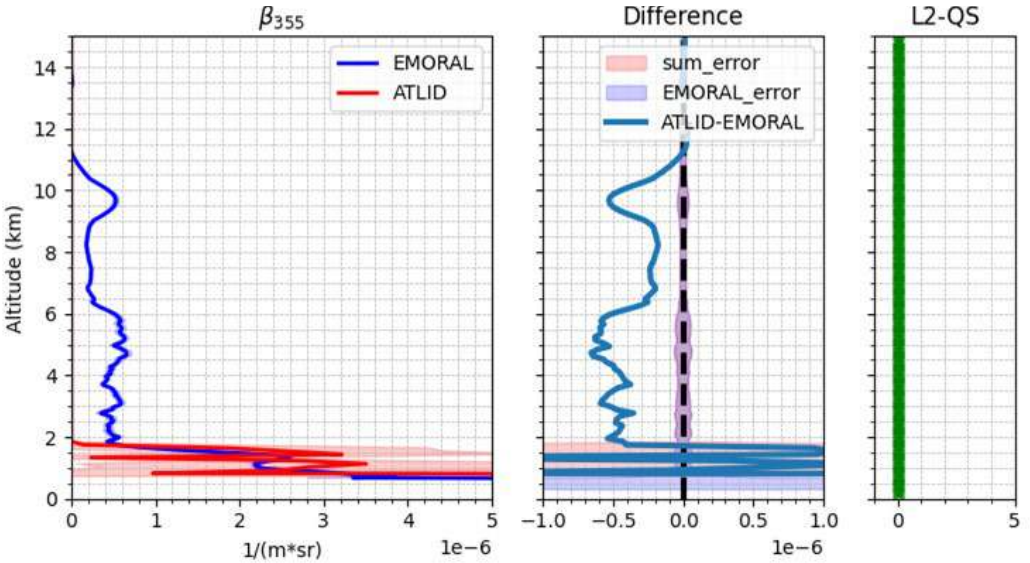
L2: Backscatter Coeff. Comparison

A-EBD



Lidar Data Comparison between EMORAL ELDA vs AC-ATLID L2_EBD Products
AE-Overpass Time: 2024-08-25 00:16:35.784540032 | Min. Distance: 35.14 km
EMORAL-Measurement Time: 2024-08-24T23:59:05Z - 2024-08-25T00:58:44Z

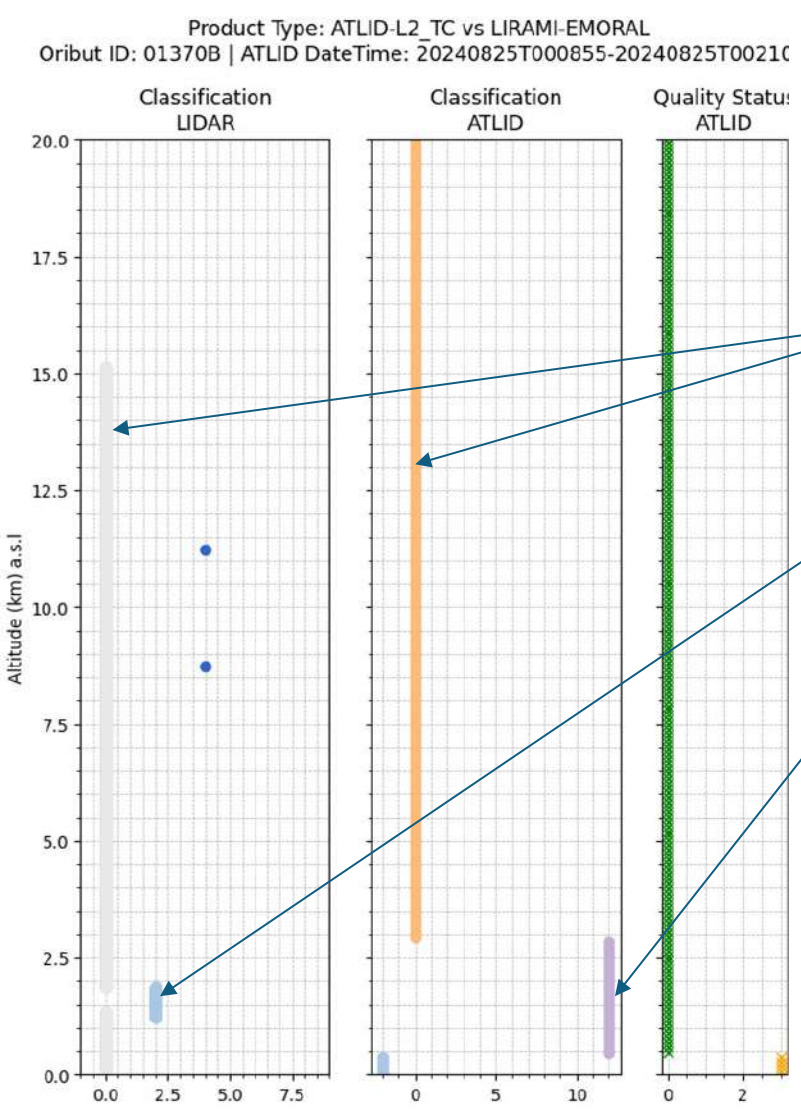
Wroclaw:
- ATLID has realistic values below 3km
- ATLID has signal is noisy (unstable)



Lidar Data Comparison between EMORAL ELDA vs AC-ATLID L2_AER Products
AE-Overpass Time: 2024-10-23 00:13:21.276066688 | Min. Distance: 0.40 km
EMORAL-Measurement Time: 2024-10-22T23:59:58Z - 2024-10-23T00:35:21Z

Przewloka:
- The shape of profiles at fog is good (below 2km)
- ATLID has signal is noisy (unstable)

L2: Classification Comparison



Wroclaw city centre (<30 km)

Clear

Partially non-spherical aerosol

Continental Pollution

A-TC

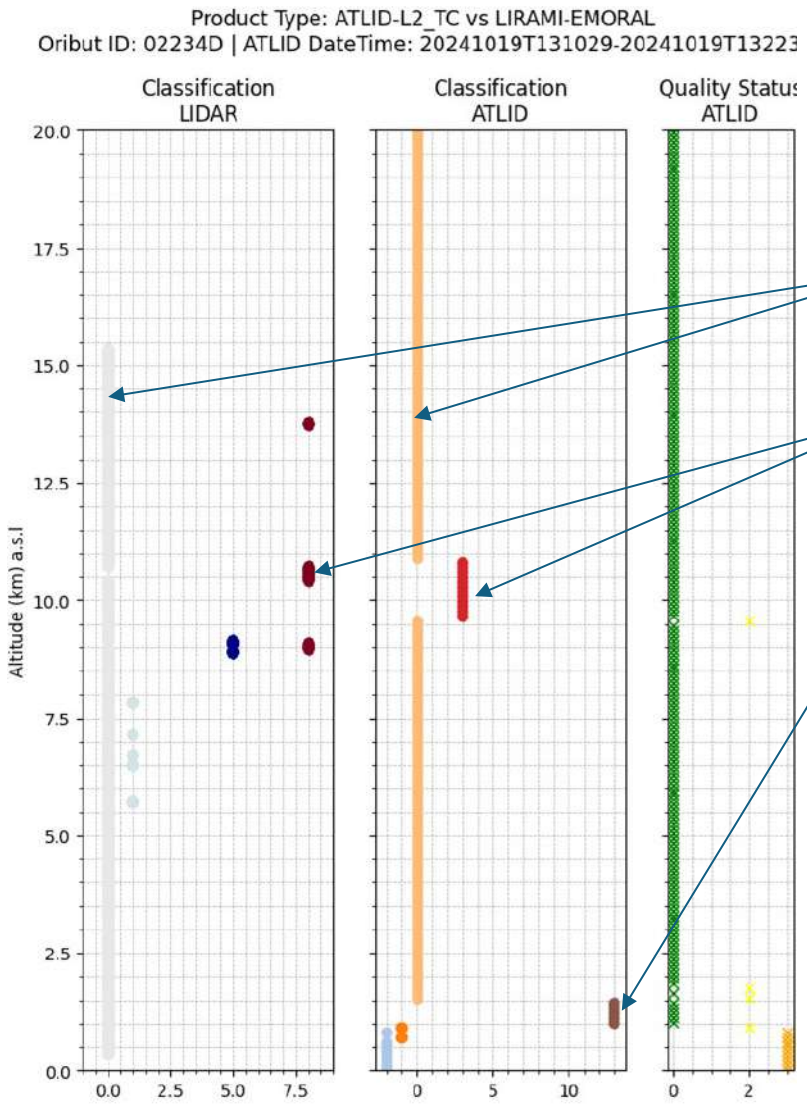
Classification ATLID
- Missing Data
- Surface or sub-surface
- Noise in both Mie and Ray Channels
- Clear
- (Warm) Liquid Cloud
- (Supercooled) Liquid Cloud
- Ice Cloud
- Dust
- Sea_salt
- Continental_Pollution
- Smoke
- Dusty_smoke
- Dusty_mix
- STS
- NAT
- Stratospheric Ice
- Stratospheric_Ash
- Stratospheric_Sulfate
- Stratospheric_Smoke
- Unknown, Aerosol Target has a very low probability (no class assigned)
- Unknown, Aerosol classification outside of param space
- Unknown, Aerosol classification outside of param space
- Unknown, Strat. Aerosol Target has a very low probability (no class assigned)
- Unknown, Strat. Aerosol classification outside of param space
- Unknown, PSC Target has a very low probability (no class assigned)
- Unknown, PSC classification outside of param space

LIRAMI
Wang et al. 2020

Classification EMORAL
- Molecules/No signal
- Fine spherical aerosol
- Partly non-spherical aerosol
- Fine non-spherical aerosol
- Coarse spherical aerosol
- Coarse non-spherical aerosol
- Liquid cloud
- Mixed-phase cloud
- Ice cloud

Quality Status
- Good: Nominal
- Likely Good, but possibly degraded or low SNR
- Likely Bad
- Bad or unusable retrieval (e.g. lidar signals effectively attenuated)
- Missing or bad L1 data

L2: Classification Comparison



Tresna moutains (<25km)

Clear

Ice Cloud

Smoke

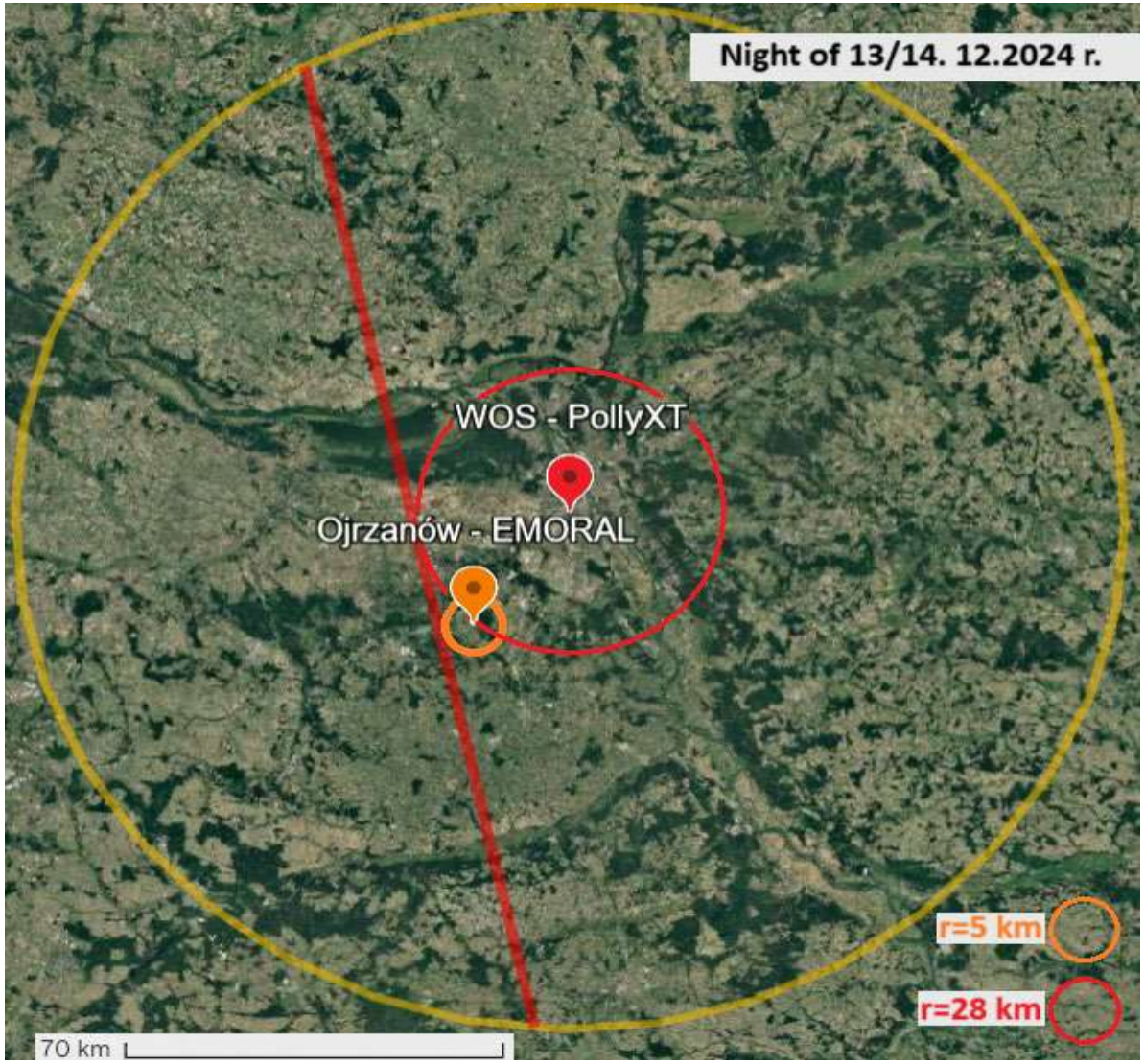
A-TC

Classification ATLID
- Missing Data
- Surface or sub-surface
- Noise in both Mie and Ray Channels
- Clear
- (Warm) Liquid Cloud
- (Supercooled) Liquid Cloud
- Ice Cloud
- Dust
- Sea_salt
- Continental_Pollution
- Smoke
- Dusty_smoke
- Dusty_mix
- STS
- NAT
- Stratospheric Ice
- Stratospheric_Ash
- Stratospheric_Sulfate
- Stratospheric_Smoke
- Unknown, Aerosol Target has a very low probability (no class assigned)
- Unknown, Aerosol classification outside of param space
- Unknown, Aerosol classification outside of param space
- Unknown, Strat. Aerosol Target has a very low probability (no class assigned)
- Unknown, Strat. Aerosol classification outside of param space
- Unknown, PSC Target has a very low probability (no class assigned)
- Unknown, PSC classification outside of param space

Classification EMORAL
- Molecules/No signal
- Fine spherical aerosol
- Partly non-spherical aerosol
- Fine non-spherical aerosol
- Coarse spherical aerosol
- Coarse non-spherical aerosol
- Liquid cloud
- Mixed-phase cloud
- Ice cloud

Quality Status
- Good: Nominal
- Likely Good, but possibly degraded or low SNR
- Likely Bad
- Bad or unusable retrieval (e.g. lidar signals effectively attenuated)
- Missing or bad L1 data

L2: Special Case



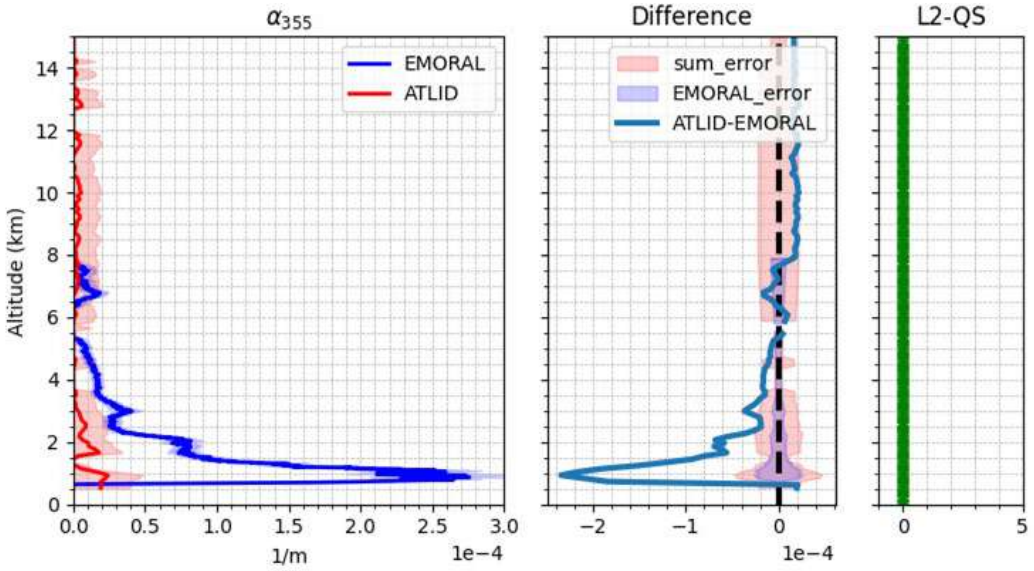
Highlight Campaign:
Overpass: 13 Dec 2024 ~ 1:00 UTC

2 lidars vs ATLID

PollyXT (<30km)
(Warsaw, Urban)

EMORAL (<6km)
(Ojrzanow, Rural)

L2: Extinction Coeff. Comparison



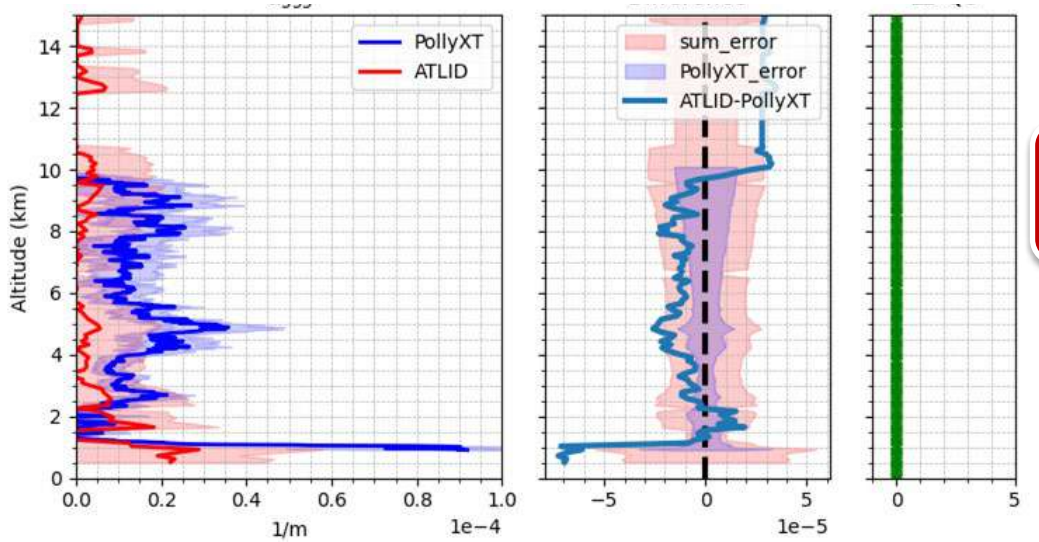
Lidar Data Comparison between EMORAL ELDA vs AC-ATLID L2_AER Products
AE-Overpass Time: 2024-12-14 00:00:55.357325440 | Min. Distance: 5.87 km
EMORAL-Measurement Time: 2024-12-13T22:59:05Z - 2024-12-13T23:58:45Z

A-AER

EMORAL (<6km)
(Ojrzanow, Rural)

13/14 December 2024

ATLID - underestimates values



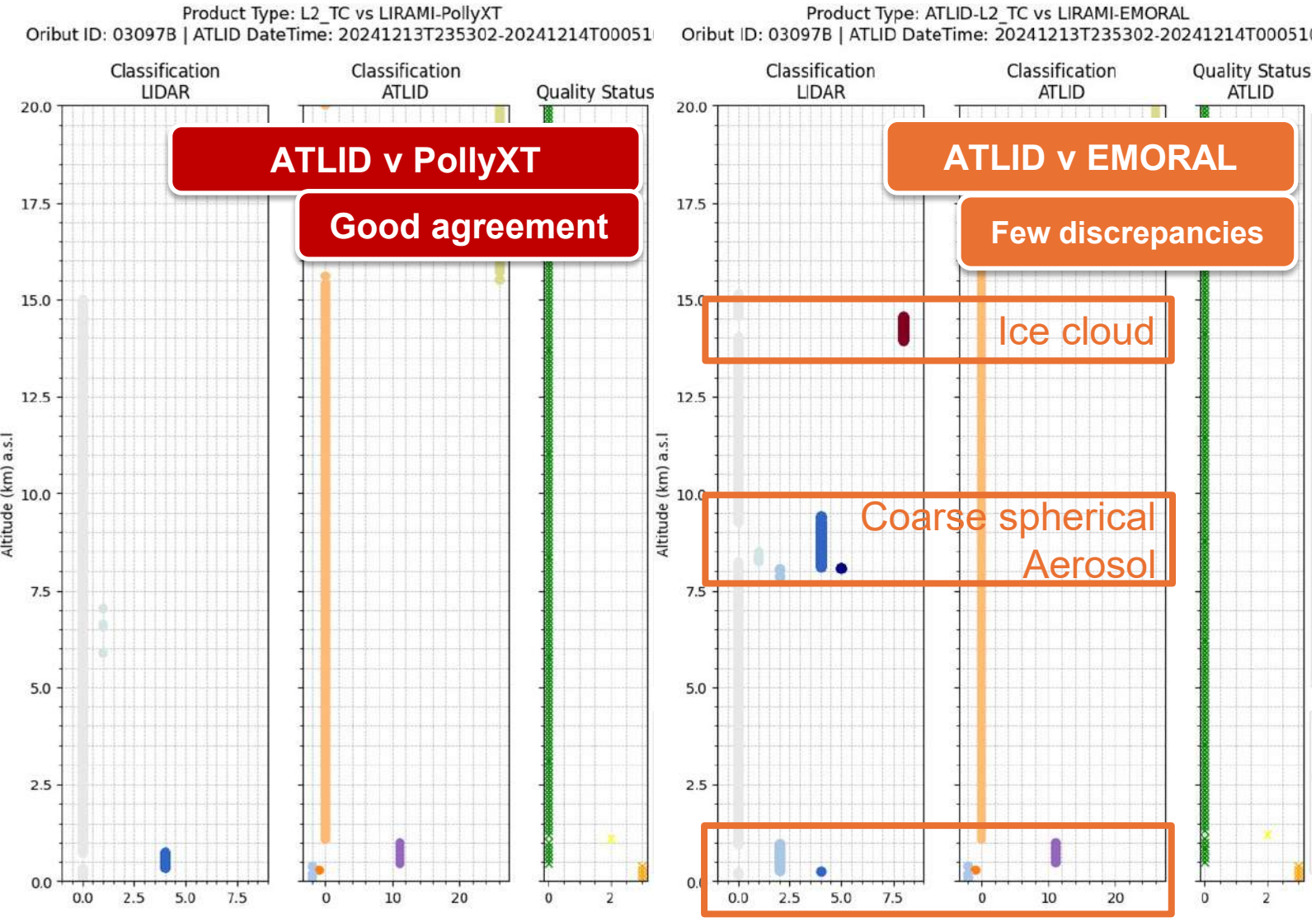
Lidar Data Comparison between PollyXT ELDA vs AC-ATLID L2_AER Products
AE-Overpass Time: 2024-12-14 00:00:57.770354560 | Min. Distance: 27.29 km
PollyXT-Measurement Time: 2024-12-13T23:30:00Z - 2024-12-14T00:29:30Z

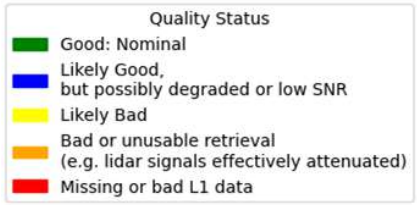
PollyXT (<30km)
(Warsaw, Urban)

ATLID-EMORAL
Distance: Closer
Difference: Larger

ATLID-POLLYXT
Distance: Further
Difference: Smaller

L2: Classification Comparison





Summary & Future Work

Challenges for L2 Data Comparison

- Unavailability of some of the ATLID-L2 data
- Constraints for daytime SCC EARLINET products => no extinction coefficient (no Raman channels on)
- So far comparison focus on low altitudes
- ATLID generally has lower values
- Vertical resolution different between EMORAL (higher) and ATLID (lower)

Future Work:

- Process and compare the rest of the collected data and work on the statistic
- Continue the work using available ESA Tools but also exploring further SCC evaluation and our in-house developed software EMERALD.
- Special focus for overpasses in vicinity of other lidar systems (e.g. PollyXT-UW in Warsaw, PL).

Status:

- 10 overpass cam[paigns condicted
- Internal Cal/Val workflow and tools are set
- Better understanding of ATLID data (which one to use)
- All data uploaded to EVDC repository within 1 day
- GEOMS preparation close to finalization
- Laser head in refurbishment
- Intensive operation planned from May 2025

Aknowledgement

RS-Lab Team at the University of Warsaw, Faculty of Physics, Institute of Geophysics:
L. Janicka, D.M. Szczepanik, M. Karasewicz, R. Fortuna, Z. Rykowska, P. Poczta, I.Okraska, D. Wang

Lidar development was led by I.Stachlewska University of Warsaw in collaboration with G.Georgoussis Raymetrics S.A., V.Freudenthaler LMU, V.Amiridis NOA, and G.Tzeremes, D.Schuettemeyer, P.Ribes, J.v.Bismarck, ESA
For support with QA/OC we thank D.Nicolae, L.Belegante ACTRIS-CARS at INOE, L.Mona, G.D'Amico EARLINET-SCC at CNR-IMAA, and A.M.Fjaeraa EVDC-ESA

We would like to thank the Opto-Electronics section (TEC-MME) at the European Space Research and Technology (ESTEC) of the European Space Agency (ESA) for providing the ESA Mobile Raman Lidar (EMORAL) that was rebuild within “Technical assistance for Polish Radar and Lidar Mobile Observation System (POLIMOS)” funded by ESA-ESTEC Contract no. 4000119961/16/NL/FF/mg.