Validation of EarthCARE ATLID L2 ESA and JAXA data products over Poland using mobile EMORAL (EVID47) and stationary PollyXT-UW (EVID05) lidars

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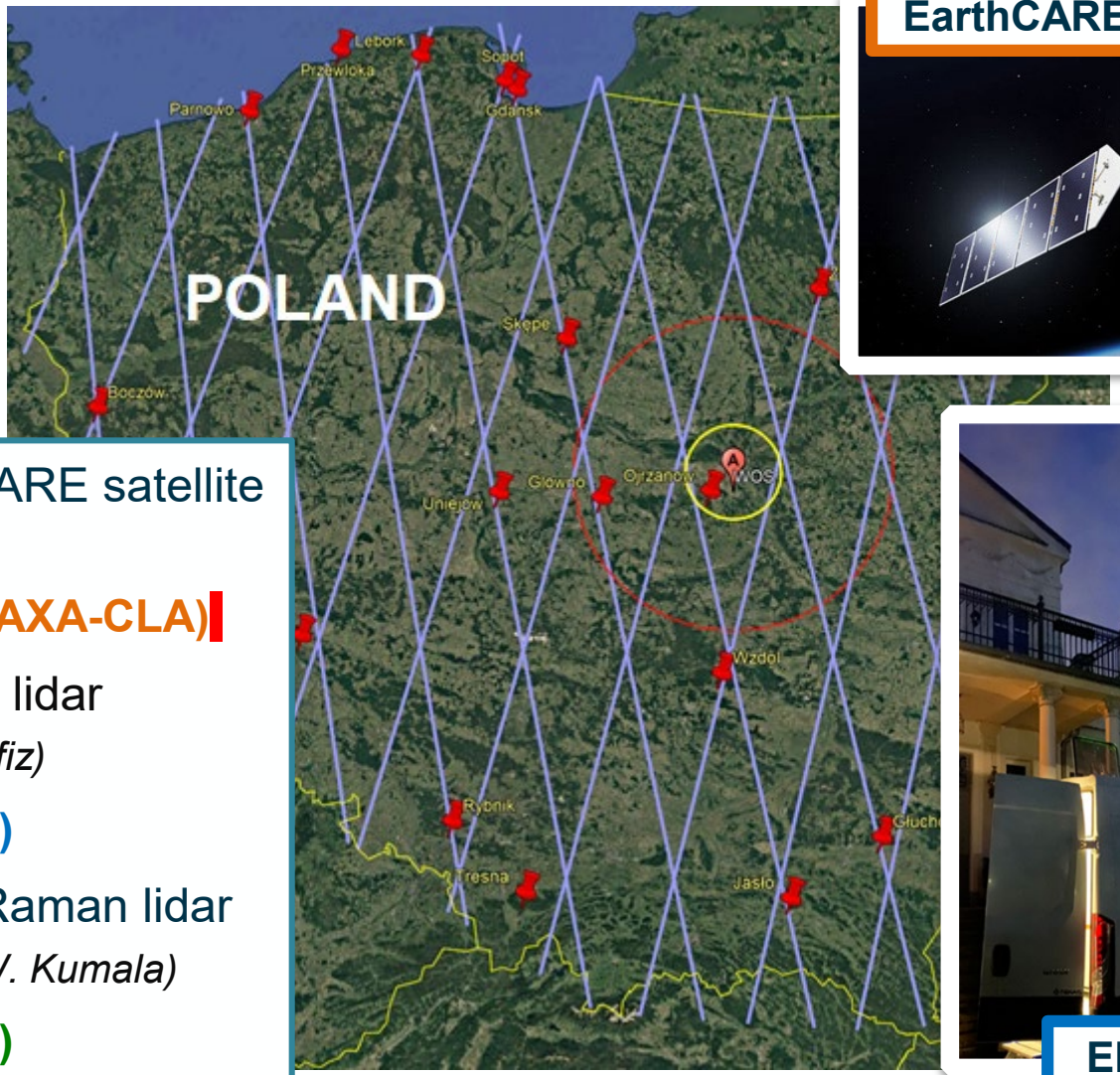
UNIVERSITY OF WARSAW

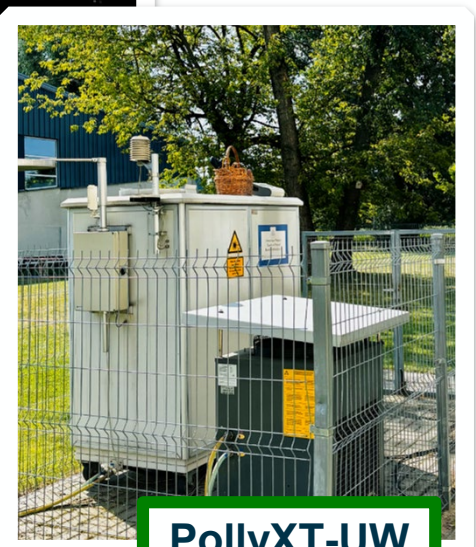
INOE 2000

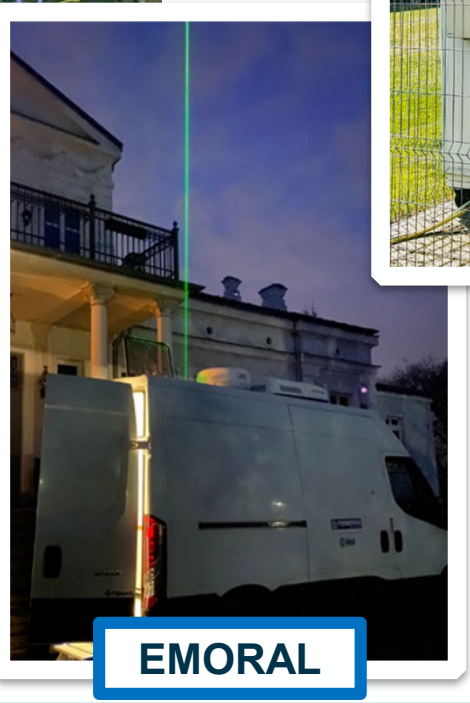
TROPOS
Leibniz Institute for Tropospheric Research

Goal of this study

Validation of ATLID ESA-EBD and JAXA-CLA products using EMORAL and PollyXT-UW

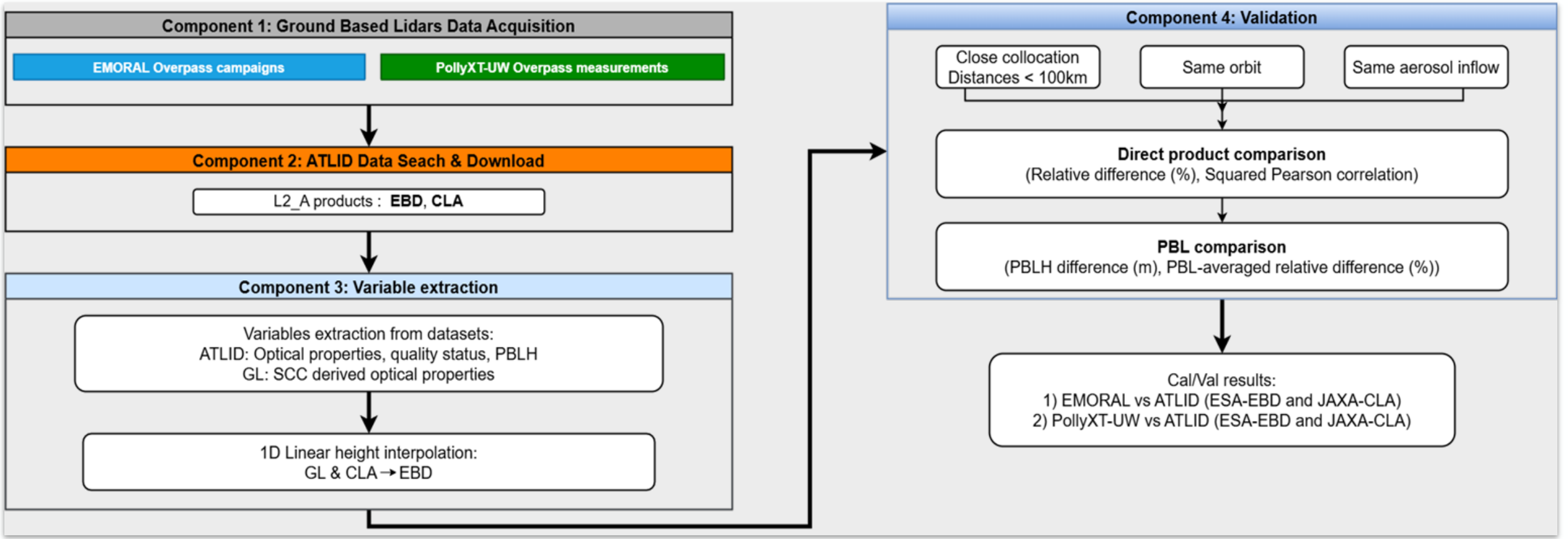






- **ATLID** HSRL lidar on EarthCARE satellite
  - **354.8 nm**
  - **L2 Products (ESA-EBD vs JAXA-CLA)**
- **EMORAL** mobile Mie-Raman lidar
  (I.S. Stachlewska, L. Janicka, A. Hafiz)
  - **β_p, α_p, δ_p at 355 nm (EVID47)**
- **PollyXT-UW** stationary Mie-Raman lidar
  (I.S. Stachlewska, D. Szczepanik, W. Kumala)
  - **β_p, α_p, δ_p at 355 nm (EVID05)**

Comparison scheme

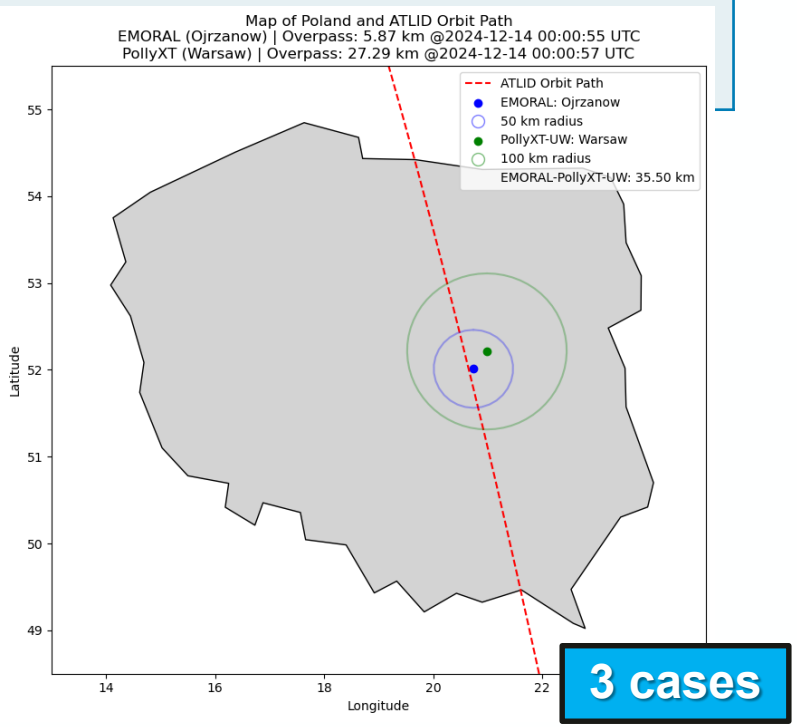


Methodology: case studies

Close collocation

Direct comparison to single ATLID orbit in close co-location:

- d(ATLID, EMORAL) < 50 km
- d(ATLID, PollyXT-UW) < 100 km
- d(EMORAL, PollyXT-UW) < 100 km

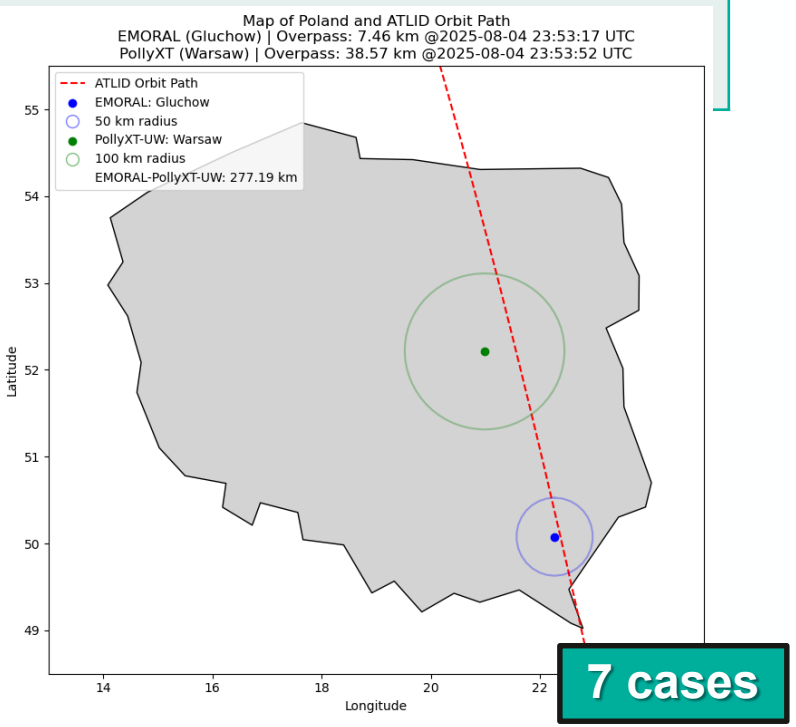


3 cases

Same orbit

Direct comparison to single ATLID orbit with distant location:

- d(ATLID, EMORAL) < 50 km
- d(ATLID, PollyXT-UW) < 100 km
- d(EMORAL, PollyXT-UW) > 100 km

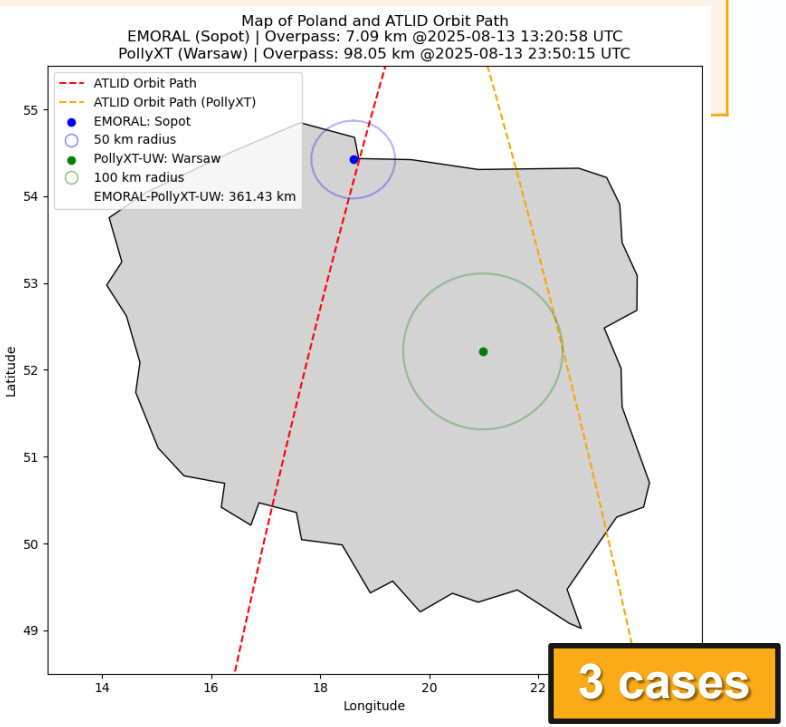


7 cases

Same aerosol inflow

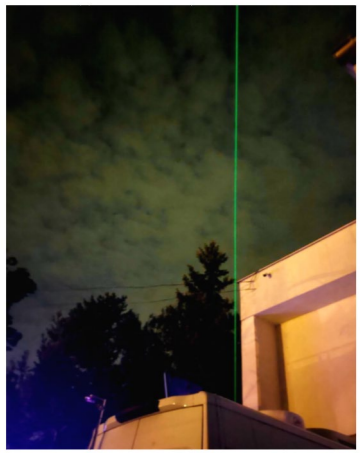
Direct comparison to different ATLID orbits for similar air mass & aerosol:

- d(ATLID, EMORAL) < 50 km
- d(ATLID, PollyXT-UW) < 100 km

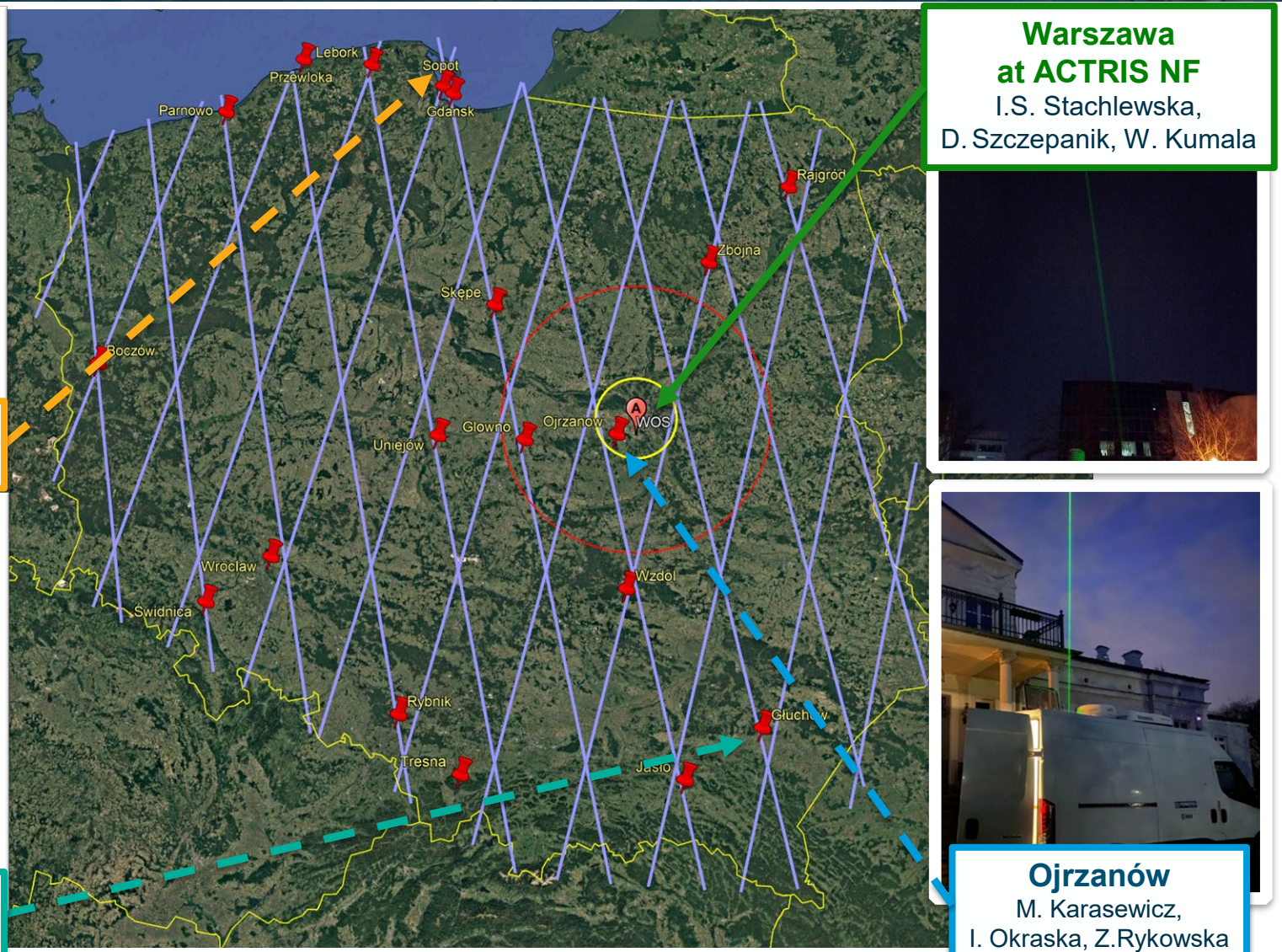


3 cases

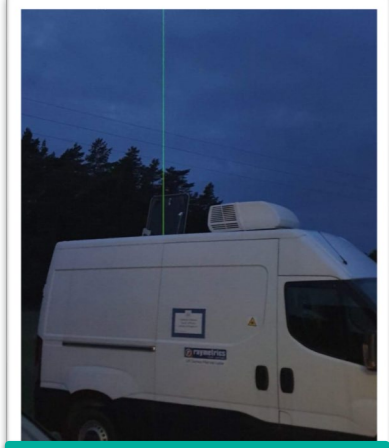
Overpass measurements



Sopot
K. Gabzdyl, R. Fortuna



Warszawa
at ACTRIS NF
I.S. Stachlewska,
D. Szczepanik, W. Kumala



Głuchów
L. Janicka, M. Szczyrba

Ojrzanów
M. Karasewicz,
I. Okraska, Z.Rykowska

Period:
August 2024 – August 2025

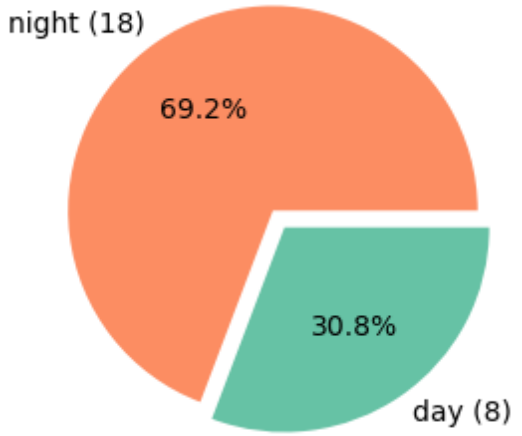
PollyXT-UW
116 ATLID overpasses
68 retrieved datasets
26 analyzed for this study
9 PBL comparison

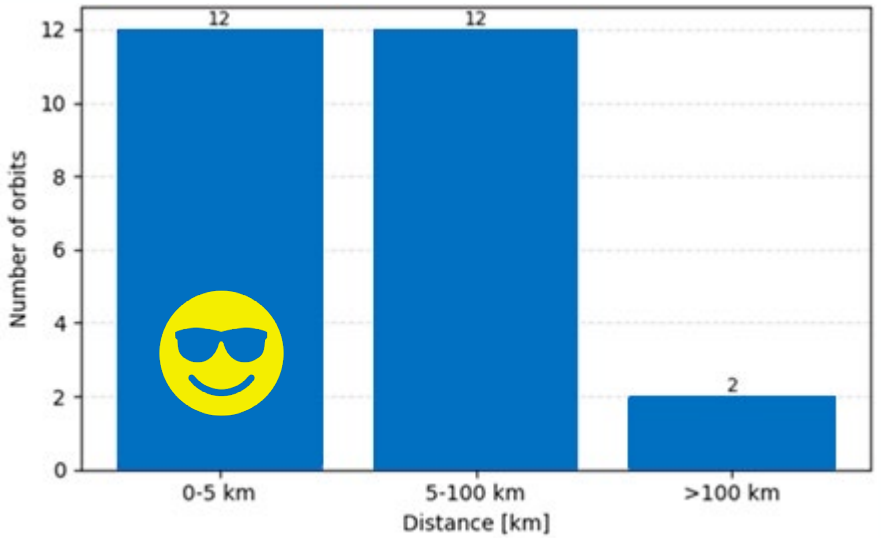
EMORAL
27 overpass campaigns
26 analyzed
14 PBL comparison

General statistics

Baseline version
EBD = BA
CLA = CB

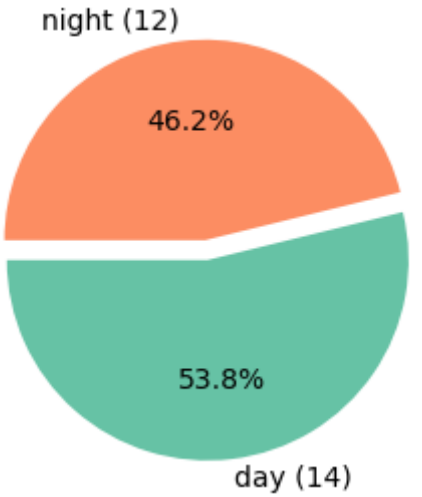
Season / Type	Urban	Rural
Winter	0	2
Spring	0	3
Summer	7	9
Fall	0	5





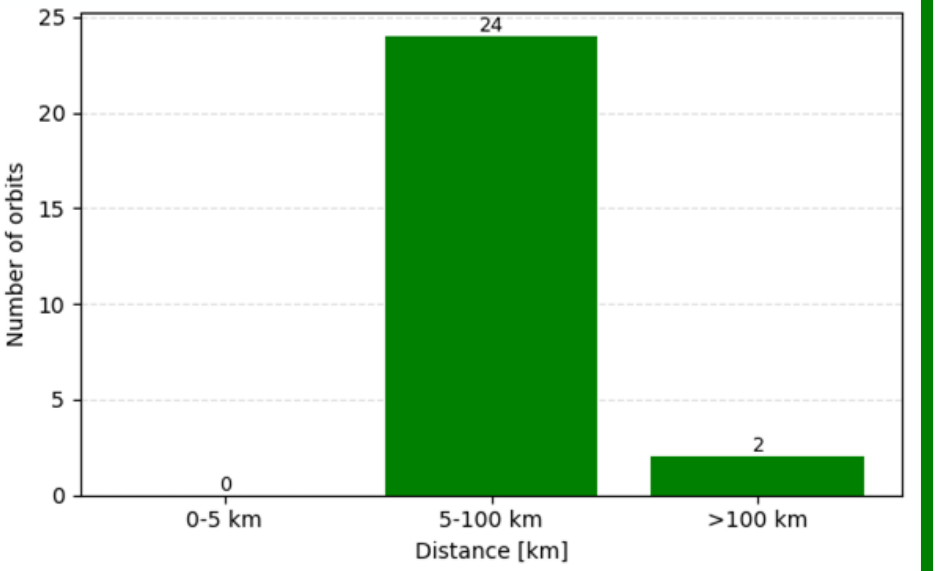
EMORAL

Day- & night-time overpasses distribution



Baseline version
EBD = BA
CLA = CB

Atmospheric scenarios			
Clear sky	*Dust inflow*	*BB inflow*	*Clouds*
15	6	3	*Low*: 9 *Mid*: 2



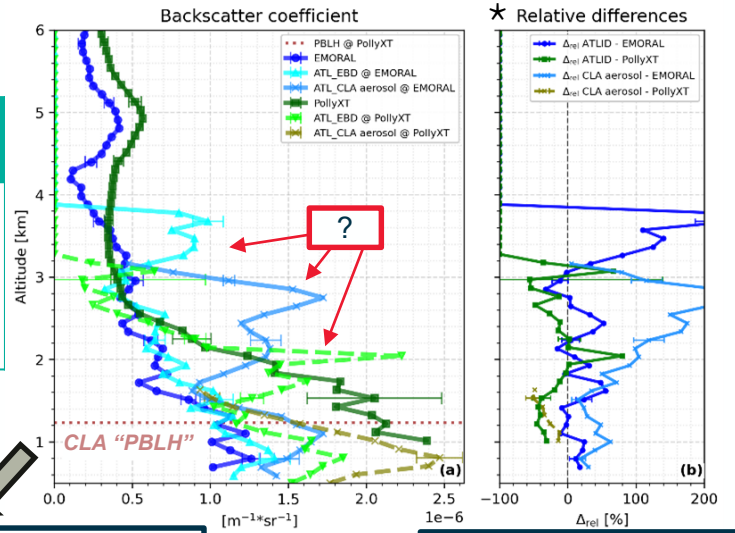
PollyXT-UW

Same orbit scenario – backscattering

Głuchów nighttime overpass - ATLID ascending orbit (ID 6738)

Data filtration

- ✓ ATLID profile with minimum distant to **Ground Lidar (GL)**
- ✓ ATLID data passes quality check



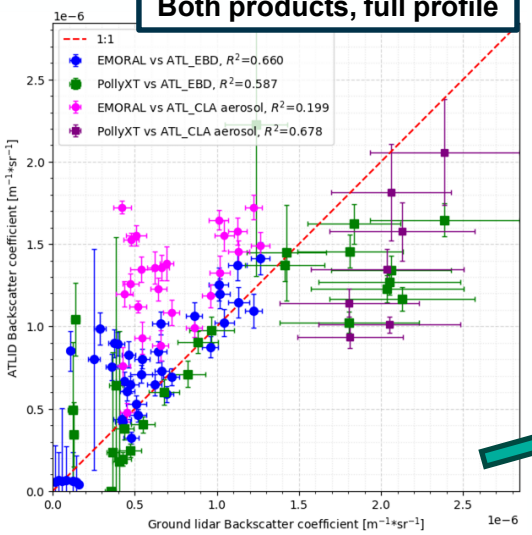
EMORAL & ATLID Głuchów - blue colors
PollyXT-UW & ATLID Warsaw - green colors

a) *Backscatter coefficients*

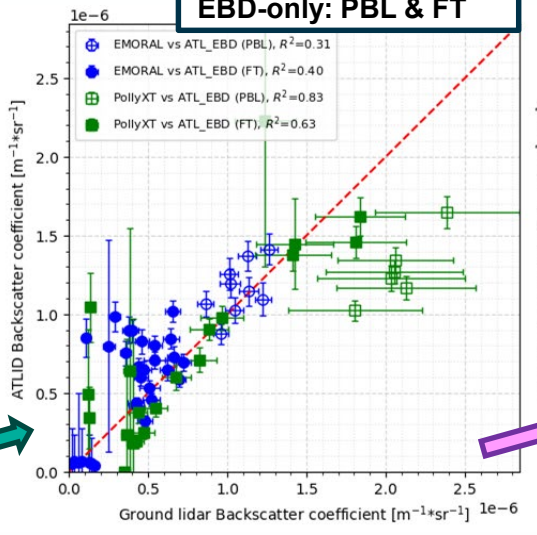
b) *Relative differences**

$$\Delta_{rel} = \frac{ATLID - GL}{GL} \cdot 100[\%]$$

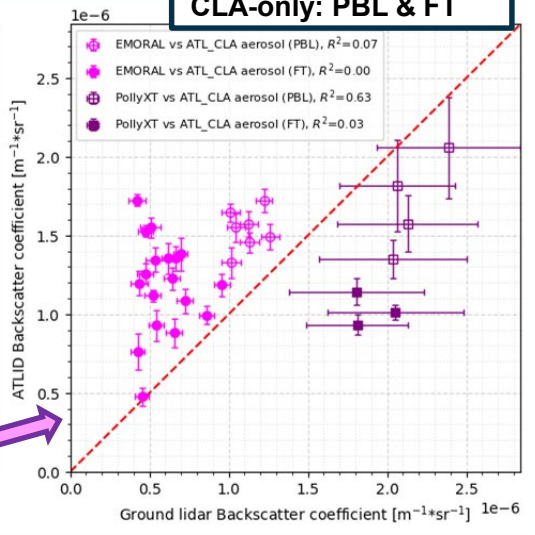
Both products, full profile



EBD-only: PBL & FT



CLA-only: PBL & FT



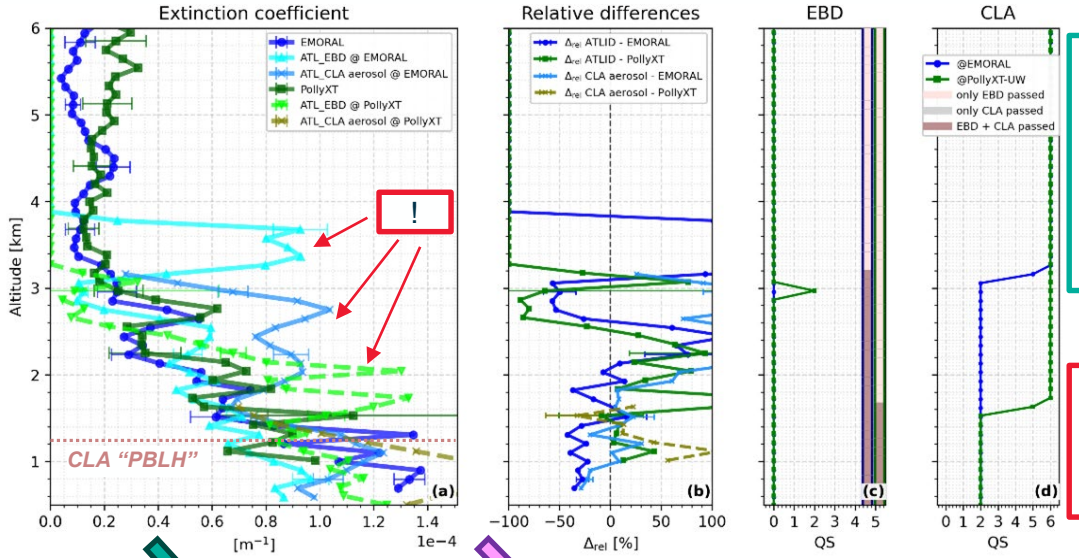
6738 Overpass Time:
EMORAL: 04/08/2025 23:53:11 UTC
PollyXT-UW: 04/08/2025 23:53:59 UTC
6738 Overpass distances:
ATLID – EMORAL: 7.46 km (!)
ATLID – PollyXT-UW: 38.57 km

Layer present or not?
both EBD and CLA detect a layer, although with different altitude, thickness, and backscatter intensity;
no corresponding feature is observed by EMORAL nor PollyXT-UW.

PBL variability: urban–rural dependence of ATLID products?
- Głuchów (rural): EBD ≈ EMORAL; CLA overestimates
- Warsaw (urban): CLA ≈ PollyXT-UW; EBD underestimates

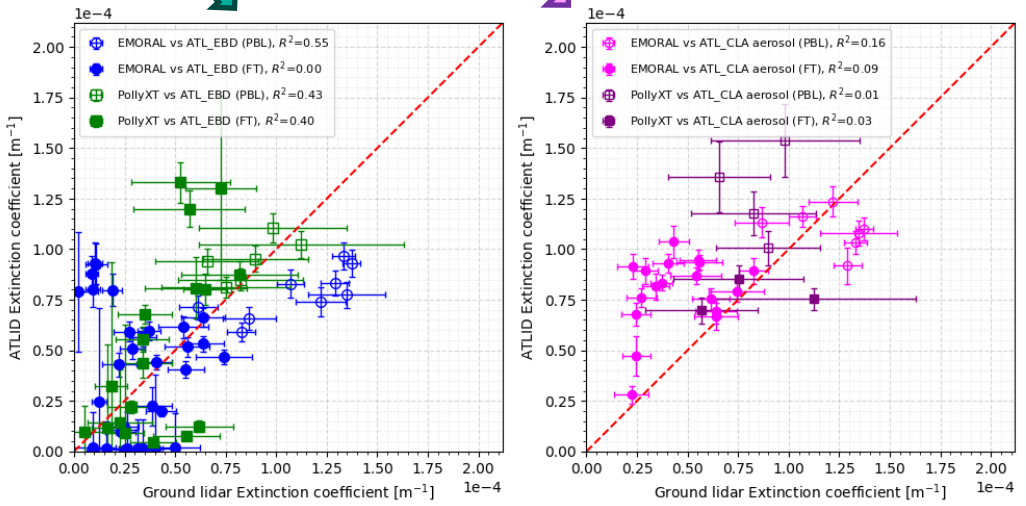
→ Is CLA better suited for urban PBLs backscattering, while EBD performs better over rural environments?

Głuchów case – Extinction



High extinction profiles from Ground Lidars (GL) with a good agreement

ATLID detected the same layer also in extinction!



For extinction, the pattern in PBL is reversed: EBD shows better agreement in urban environments and CLA agrees better over rural sites

Relative difference [%]: ATLID vs EMORAL			
backscatter		***extinction***	
EBD	***CLA***	***EBD***	***CLA***
12,65 ± 10,68 **(!)**	42,35 ± 10,72	-25,35 ± 8,74	-2,23 ± 10,46 **(!)**

Relative difference [%]: ATLID vs PollyXT-UW			
backscatter		***extinction***	
EBD	***CLA***	***EBD***	***CLA***
-26,59 ± 15,81	-4,91 ± 22,36 **(!)**	17,58 ± 45,81 **(!)**	68,90 ± 67,58

PBLH [km] comparison		
Product type	**ATLID vs EMORAL**	**ATLID vs PollyXT-UW**
ATLID @ CLA[1]	N/A[3]	1.23 km
ATLID @ manual[2]	1.40 ± 0.15 km	1.40 ± 0.15 km
GL @ manual[2]	1.60 ± 0.15 km	1.60 ± 0.15 km

[1] PBLH retrieved from "pbl_heigh" variable available in ATL_CLA
[2] PBLH evaluated manually from the backscatter profiles
[3] N/A = "pbl_height" variable is empty in "ATL_CLA"

Same aerosol inflow case

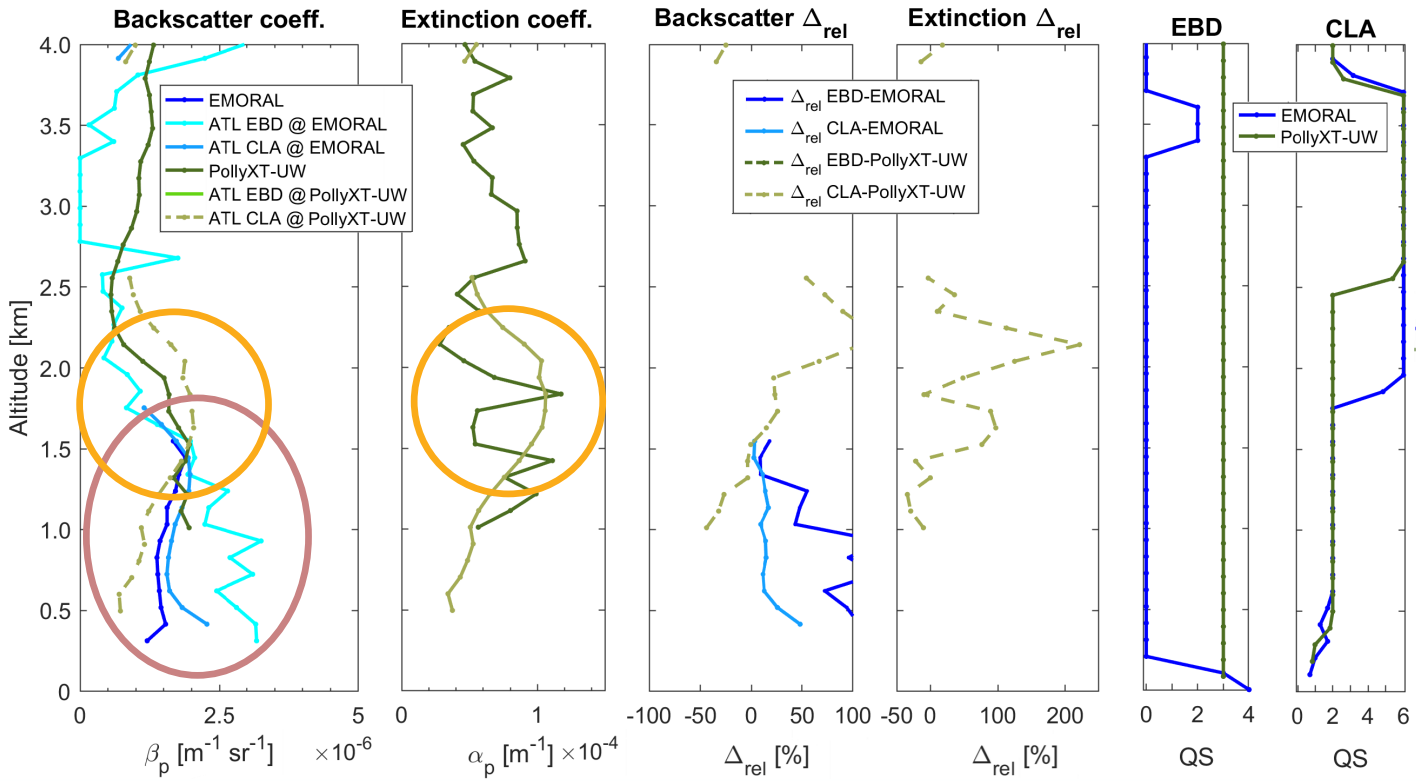
Same aerosol inflow case - 13 August 2025

EMORAL in Sopot (urban) - daytime

ATLID overpass orbit ID 6871, time: 13:22:52 UTC, distance: 7.59 km

PollyXT-UW in Warsaw - nighttime

ATLID overpass orbit ID 6878, time: 23:50:24 UTC, distance: 92.54 km



Challenge: Limited number of cases available for this study; additional constraints from:

- Meteorological conditions / availability of SCC products
- NaN-valued EBD and CLA profiles
- Bad-quality ATLID data

Urban–Rural dependence of ATLID products?

- **Backscattering:**

- Sopot (urban): CLA ≈ EMORAL, EBD overestimates

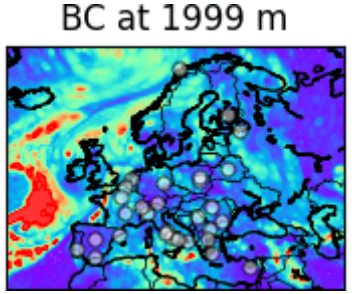
- Warsaw (urban): CLA ≈ PollyXT-UW; EBD ? (bad quality)

- **Extinction:**

- Warsaw (urban): CLA ≈ PollyXT-UW; EBD – no data

Warsaw - Visible, slightly shifted aerosol layer. Most probably mixture of biomass burning aerosol!

BBBC-derived black carbon concentration confirms the presence of an absorbing aerosol layer near 2 km altitude.



Source: https://atmo-access.nilu.no/FWD_IRISCC_BBBC.py

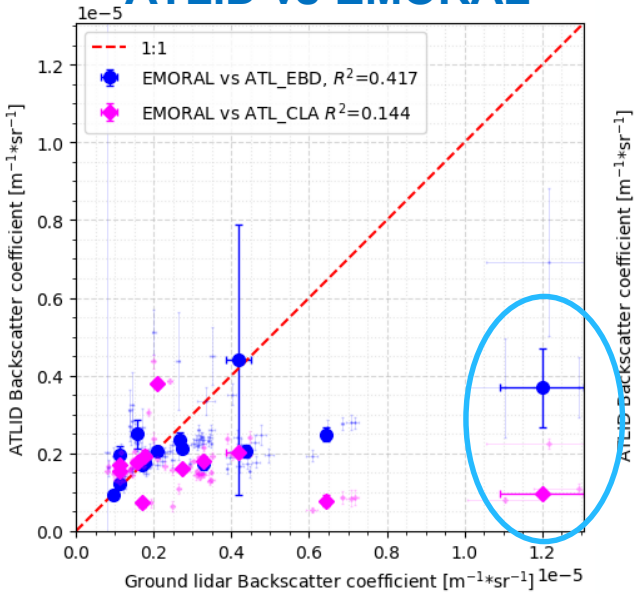
Summary PBL-average

Backscatter comparisons

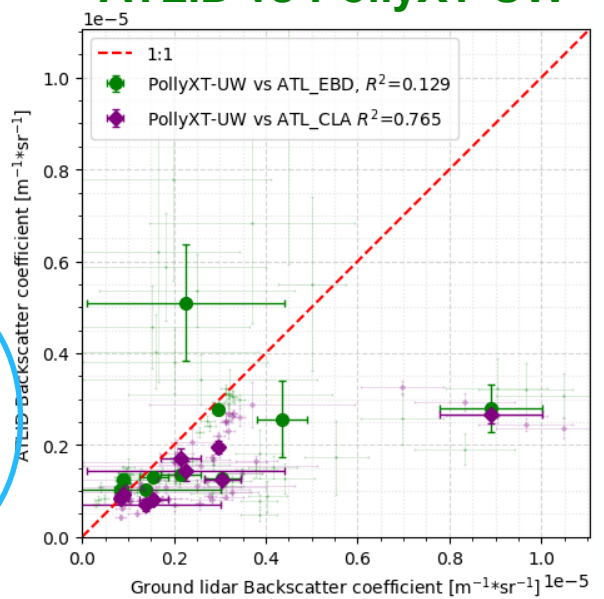
Extinction comparisons

NOTE: 1 point → 1 PBL-average of selected profile and variable

ATLID vs EMORAL



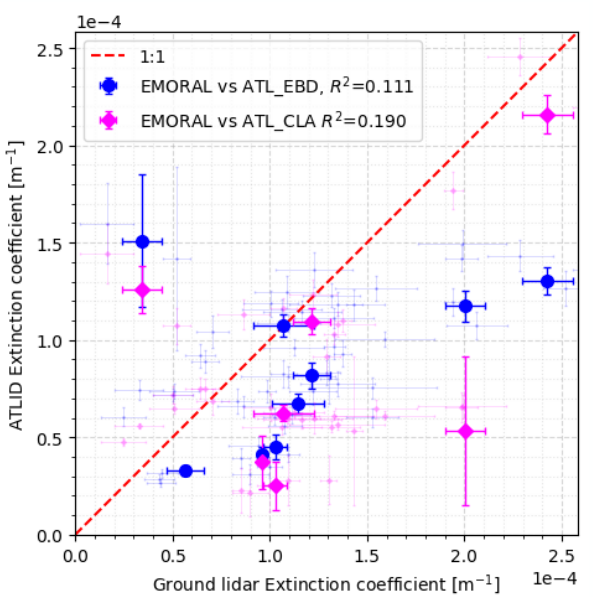
ATLID vs PollyXT-UW



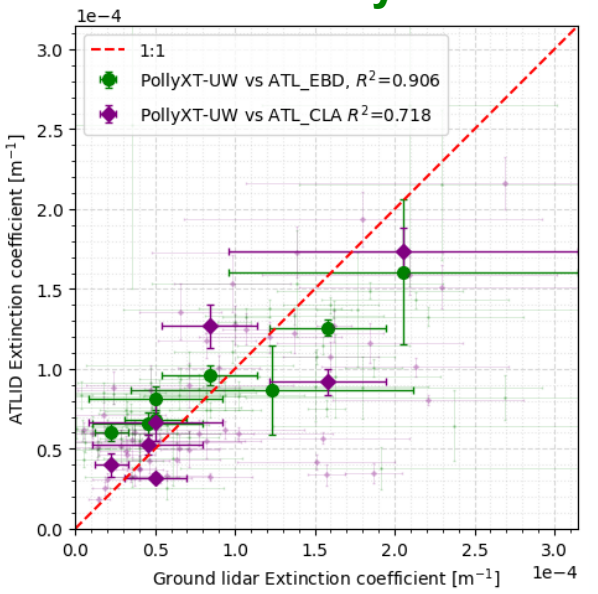
Both EBD & CLA: low correlation; **EBD (0.42)** higher than **CLA (0.14)**

Low correlation with **EBD (0.13)** while high with **CLA (0.77)**

ATLID vs EMORAL



ATLID vs PollyXT-UW



Low correlation with both **EBD (0.11)** and **CLA (0.19)**

High correlation with both **EBD (0.9)** and **CLA (0.72)**

Reminder: What are the limitations of our analysis?
a) Weather-dependent availability of ground lidars measurements
b) Different data coverage among ATLID products (particularly for CLA)
c) Ground lidars overlap region close to PBLH

More data points (PBL-average) desired for a better statistical analysis.
→ Now we show current status!

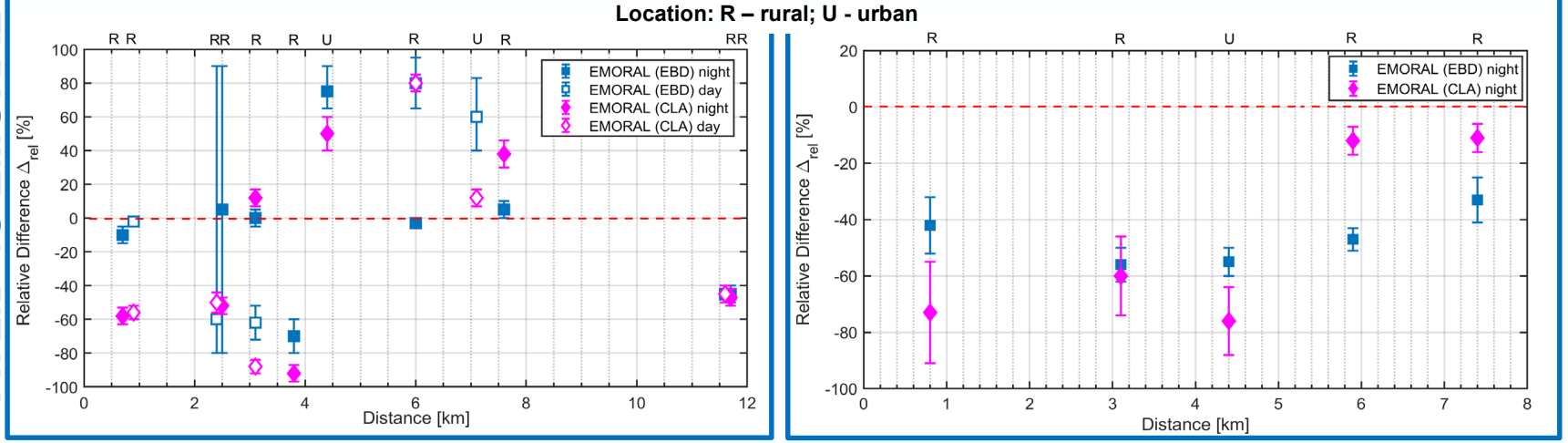
PBLH-average comparison

PBL-average backscatter

PBL-average extinction

Main message:

ATLID vs EMORAL



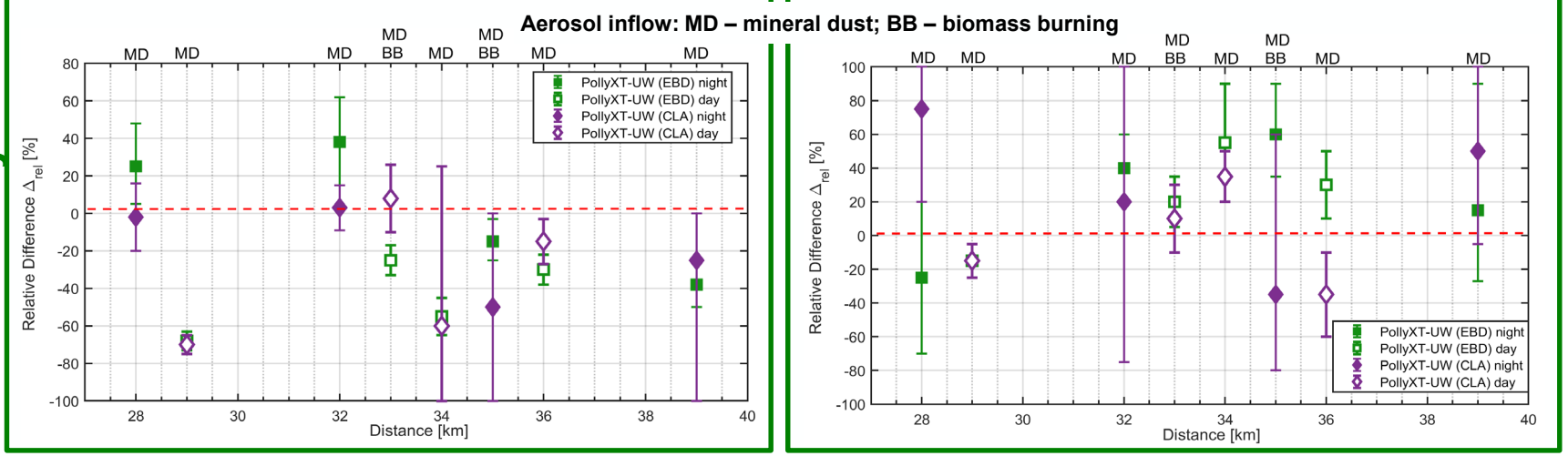
Backscatter:

- PBL-averaged difference:
  6 of 14 < 20%
  9 of 14 < 80%
- **Urban sites:** Δ_{rel} CLA **<** Δ_{rel} EBD
  (more points desired!)
- **Rural sites :** Δ_{rel} CLA **≥** Δ_{rel} EBD
  (one exception)

Extinction:

- ATLID (EBD & CLA) underestimate

ATLID vs PollyXT-UW



Backscatter:

- PBL-averaged difference:
  6 of 9 < 50%
  8 of 9 < 80%
- Δ_{rel} CLA **≤** Δ_{rel} EBD (one exception)

Extinction:

- Significant errors in some cases
- Both **EBD (6 of 8)** and **CLA (5 of 8) overestimated**
- No pattern visible regarding aerosol presence influence

Closing Remarks

Comparisons	Backscatter	Extinction
EMORAL vs ATLID	**- Profile shapes → Good agreement** - PBL-average: • Low R^2 (<0.4) • ATLID tend to underestimate during nighttime and overestimate at daytime	**Profile shapes → Good agreement** PBL-average: • Low R^2 (<0.2) • ATLID tend to underestimate the values (nighttime)
PollyXT-UW* vs ATLID	**- Profile shapes → Similarities observed** but with differences in values regarding the city heat-island influence; **- Significant error values** **- PBL- average**: • 6 of 8 cases - ATLID **underestimated**	**- Profile shape → similar but with visible shifts of layers** might be due to the distance **- Significant error values** **- PBL - average**: • 6 of 8 cases ATLID **overestimated**
EBD vs CLA (PBL-average)	**Main challenge:** • **Less data points available in CLA aerosol data to compare** **EMORAL (mostly rural areas):** • R^2 higher for EBD (R^2 =0.42) than for CLA (R^2 =0.14) • In most cases (10 of 14) Δ_{rel} CLA > Δ_{rel} EBD **PollyXT-UW (urban, city center):** • Much higher R^2 for CLA (R^2 =0.77) than EBD (R^2 =0.13) • In most cases (6 of 8) Δ_{rel} CLA < Δ_{rel} EBD • CLA underestimate less than EBD	**Main challenge:** • **Less data points available in CLA aerosol data to compare** • **No Extinction for daytime (EMORAL)** **EMORAL (mostly rural areas):** • R^2 higher for CLA (R^2 =0.19) than for EBD (R^2 =0.11) → opposite to bacskcattering • CLA underestimate more than EBD (3 of 5) **PollyXT-UW (urban, city center):** • Higher R^2 for EBD (0.9) than CLA (0.72) → opposite to backscattering

**Note the large distance between PollyXT-UW and ATILD and the unique location of PollyXT-UW close to the city center*

Acknowledgements

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Ministerstwo Nauki i Szkolnictwa Wyższego

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