ACTRIS/EARLINET insights for EarthCARE's aerosol classification

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Aim:

- **Evaluate EarthCARE aerosol classification scheme using targeted case studies**
- **Ground-truth**: the ACTRIS/EARLINET database (Pappalardo et al., 2014; data.earlinet.org) and the predominant aerosol types identified by HETEAC-flex (Floutsi et al., 2023)
- ACTRIS / EARLINET database:
  - Products: Particle backscatter, extinction, lidar ratio, and depolarization ratio profiles
  - >33 stations over Europe, ensuring optimal spatio-temporal coverage and,
  - to account for seasonal changes, and variability in aerosol types
  - 16 ACTRIS Stations included in the evaluation: Antikythera (AKY), Barcelona (BRC), Bucharest (INO), Cabauw (CBW), Clermont-Ferrand (PUY), Dushanbe (DUS), Hohenpeissenberg (HPB), Granada (GRA), Kuopio (KUO), La Reunion (RUN), Leipzig (LEI, ARI), Lille (LLE), Limassol (CYC, LIM), Mindelo (CVO), Potenza (POT), Thessaloniki (THE), Warsaw (WAW).
  - **Time period: August 2024 – August 2025.**

Methodology

Step1. Aerosol layer detection

- EARLINET Single Calculus Chain/LTOOL (Siomos et al., 2018)
  - **WCT applied on 1064nm backscatter profile**
  - **Potential features (bases/tops) identified**
  - **Layers are created by matching bases with tops**
- All available wavelengths are used, **next step**: special focus to 355 nm - the operating wavelength of EarthCARE
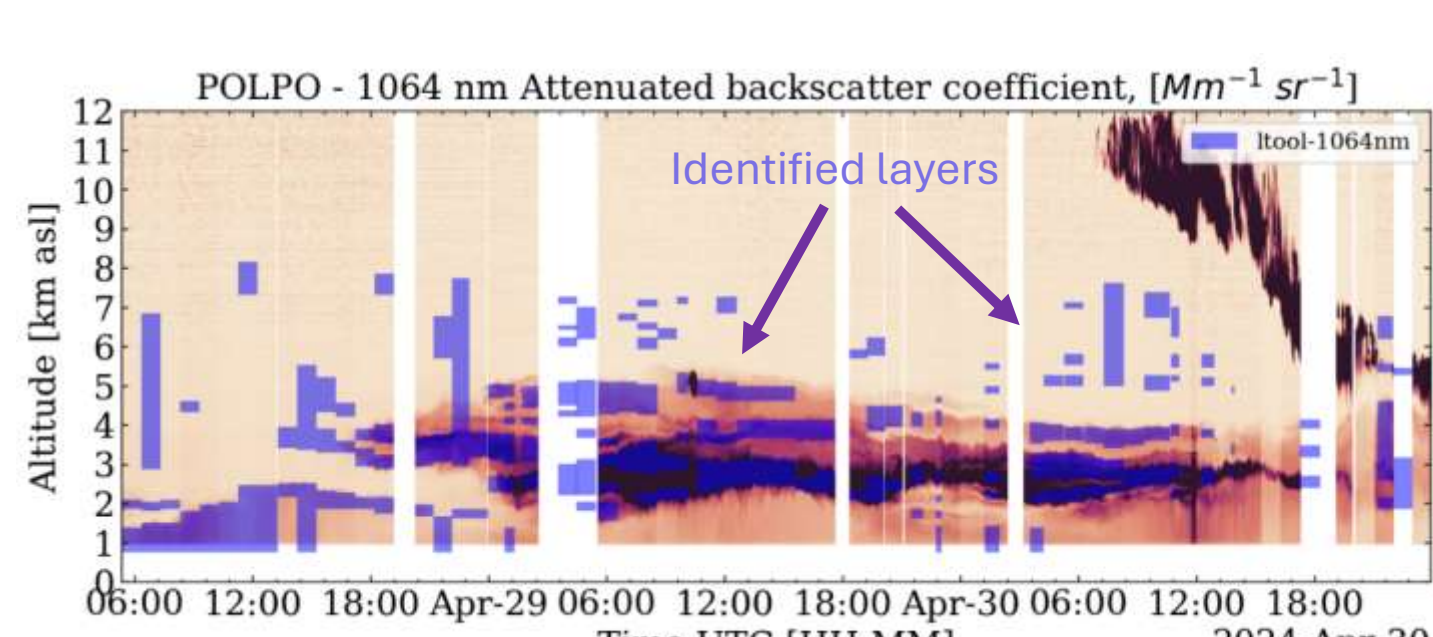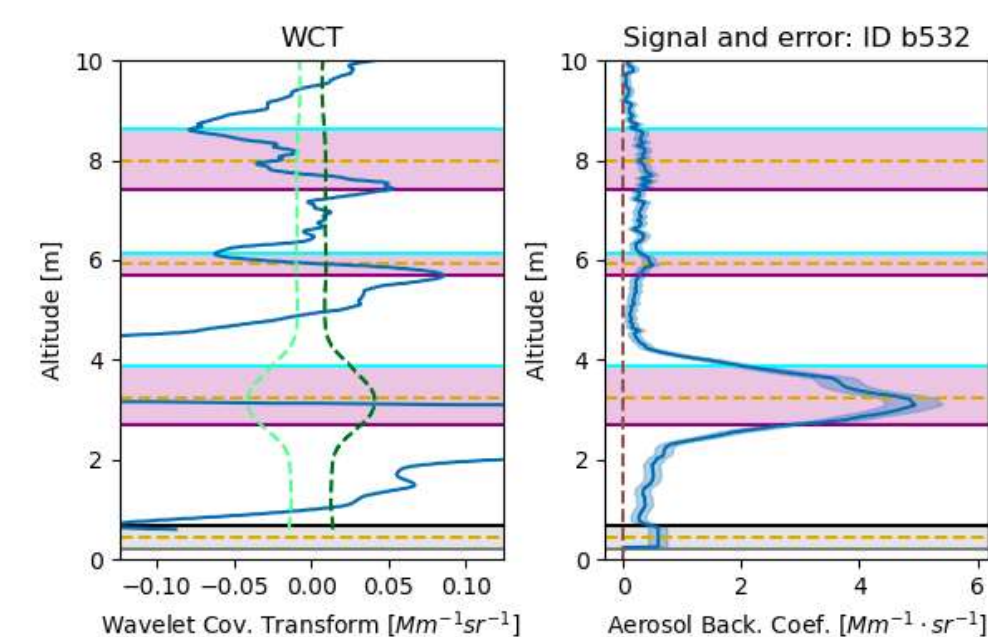
- **Layering detection (LTOOL) – mean-layer intensive**
- EARLINET dataset

- **Classification scheme**
  - HETEAC-flex (Floutsi et al., 2023)

- **Different retrieval modes**
- Intensive parameters

- **Aerosol types**
  - Fine Spherical Absorbing (FSA), Fine Spherical Non Absorbing (FSNA), Coarse Spherical (CS), Coarse Non Spherical (CNS) & mixtures

Retrieval mode	Parameters
1	δ_{355}, S_{355}
2	δ_{532}, S_{532}
3	δ_{355}, S_{355}, $\mathring{A}_{355/532}$
4	δ_{532}, S_{532}, $C_{\beta532/1064}$
5	δ_{355}, S_{355}, δ_{532}, S_{532}
6	δ_{355}, S_{355}, $\mathring{A}_{355/532}$, δ_{532}, S_{532}, $C_{\beta532/1064}$

Following ACPPV guidelines:
- ☐ Overpass time within 90 min from the ground station
- ☐ Overpass distance less than 100 km. In case of special events (e.g. volcanic ash, fire smoke, desert dust advection), longer distances are allowed

Comparison with HETEAC – the Hybrid End-To-End Aerosol Classification model of EarthCARE
Products: A-EBD and A-TC, baselines BA and the latest available

Identified layers

POLPO - 1064 nm Attenuated backscatter coefficient, $[Mm^{-1} sr^{-1}]$

Total Statistics:
  Total: **256** collocated measurements (1 measurement id per overpass)
  Successfully processed: **171**
    Retrieval 1: **48**
    Retrieval 2: **6**
    Retrieval 3: **6**
    Retrieval 4: **46**
    Retrieval 5: **11**
    Retrieval 6: **54**
  Not processed:
    Low quality: **53**
    Other (LTOOL failure, Heteac failures, files issues): **32**

Total measurements
- 67% Processed
- 21% Not Process./Low quality
- 12% Not Process./Other
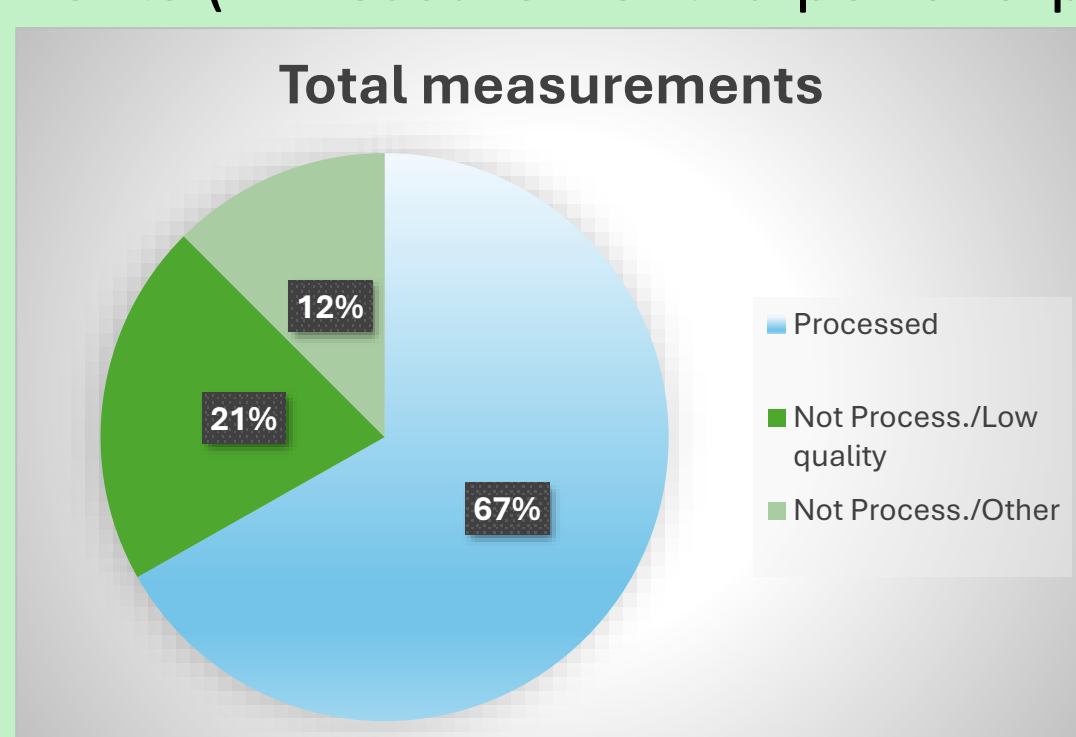
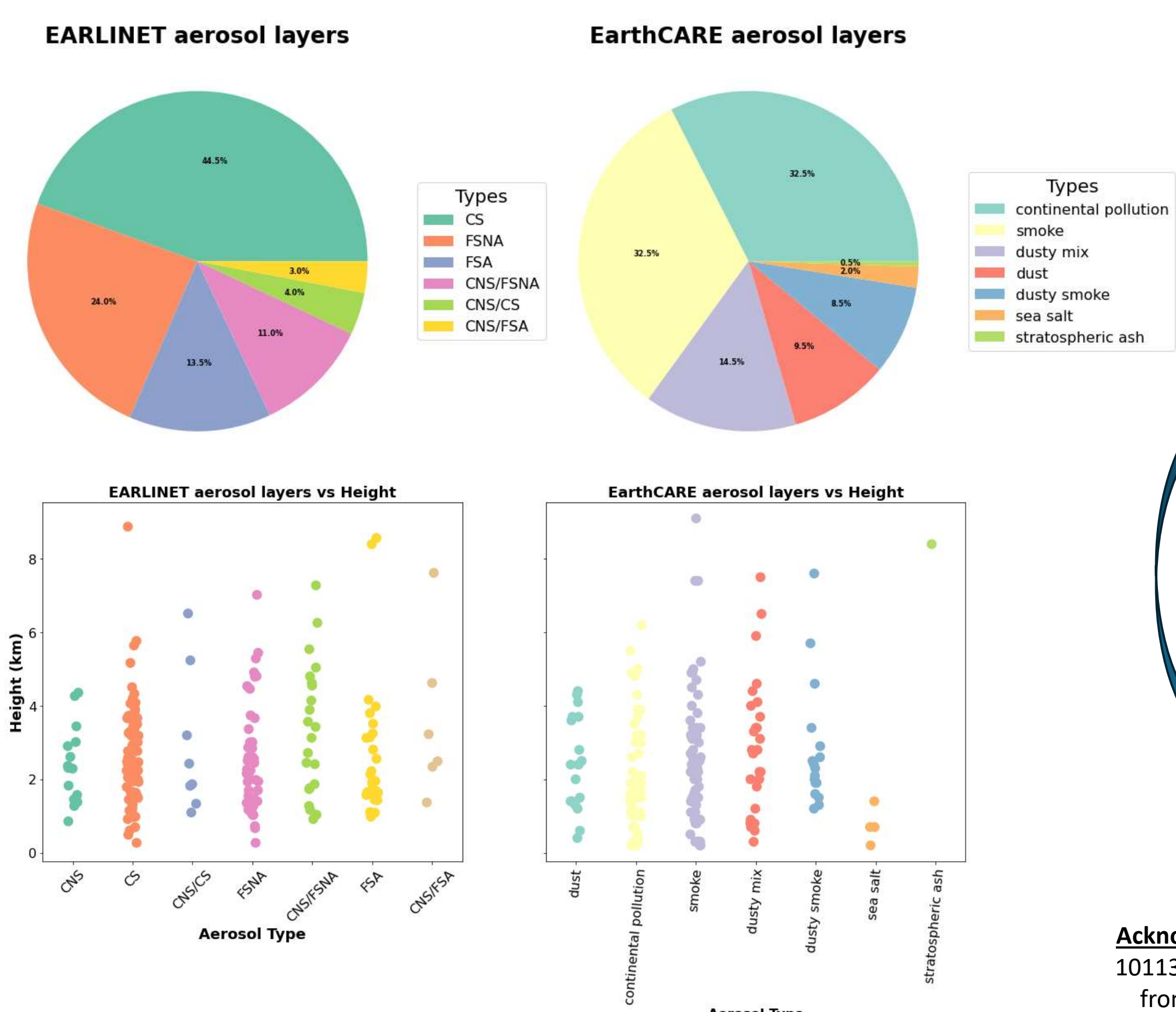**394 layers retrieved**
Global minimum layer height: **0.3 km**
Global maximum layer height: **13.5 km**
  CS: 163
  FSA: 46
  FSNA: 63
  CNS: 36
  CNS/CS: 22
  CNS/FSA: 11
  CNS/FSNA: 32
  FSA/FSNA: 0
  FSNA/CS: 0
  Not typed: 16

Homogenizing the aerosol classes

A-TC aerosol types (Wandinger et al., AMT, 2023)	HETEAC Flex
Dust	**CNS, CS/FSNA**
Sea salt	**CS, FSNA/CS (salt mix)**
Continental pollution	**FSNA, CNS/CS**
Smoke	**FSA, FSA/FSNA**
Dusty smoke	**CNS/FSA**
Dusty mix	**CNS/FSNA, CNS/CS**

Aerosol types identified by both HETEAC-flex & EarthCARE classification scheme

EARLINET aerosol layers

EarthCARE aerosol layers

Types:
- continental pollution
- smoke
- dusty mix
- dust
- dusty smoke
- sea salt
- stratospheric ash

Types:
- CS
- FSNA
- FSA
- CNS/FSNA
- CNS/CS
- CNS/FSA

EARLINET aerosol layers vs Height

EarthCARE aerosol layers vs Height

EARLINET vs EarthCARE aerosol types

EARLINET aerosol types (merged) \ EarthCARE aerosol types (merged)	continental pollution	pure dust or dust mixtures	sea salt	smoke
FSA	4	8	0	14
CS	24	20	0	26
CNS	1	13	0	0
FSNA	26	8	0	14

HETEAC-flex mixtures: CNS/FSNA, CNS/CS, CNS/FSA

EarthCARE merged pure dust or dust mixtures: dust + dusty smoke +dust mix

☐ The findings are preliminary as this activity is still ongoing.
☐ We plan to confirm with a backtrajectory analysis that the same air was sampled by both sensors.
☐ Fine-tune LTOOL algorithm / test other layer-identification solutions.
☐ Integrate new correlative measurements.
☐ Automate the processing/visualization chain.