TRANSITION FROM CALIPSO TO EARTHCARE; CAN WE USE EARTHCARE MEASUREMENTS TO CONTINUE CALIPSO LONG-TERM STUDIES ON THE IMPACT OF AEROSOLS ON CIRRUS CLOUDS?

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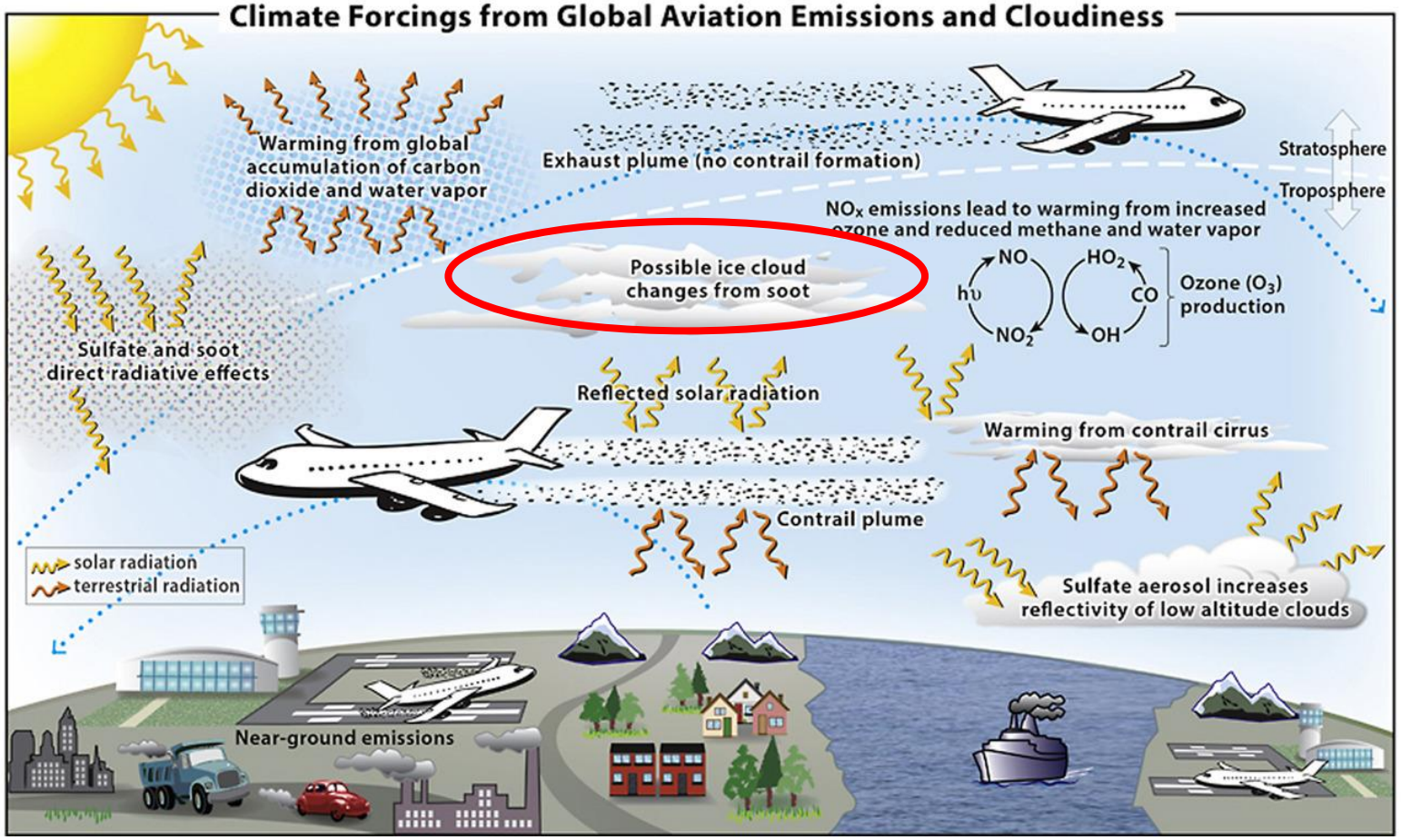
CLOUD–AEROSOL INTERACTIONS & THEIR IMPACTS IN THE EARTH SYSTEM

earth care disc

NASA

DLR

Motivation

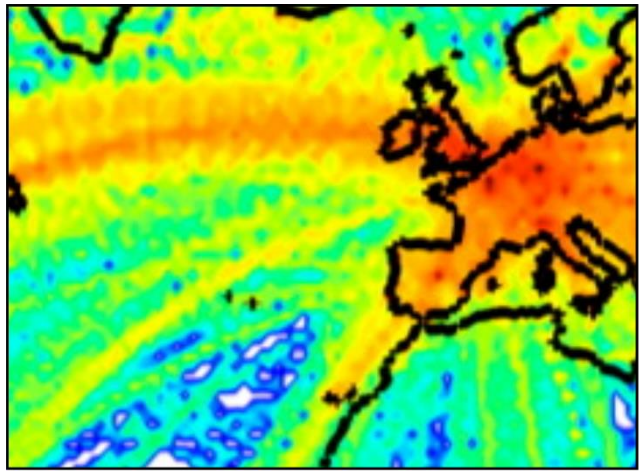


Very low level of understanding of aviation induced aerosol-cloud interaction. → No best estimate!

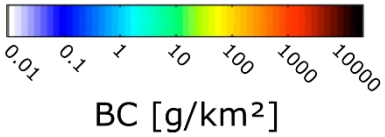
Source: Lee et al., 2021

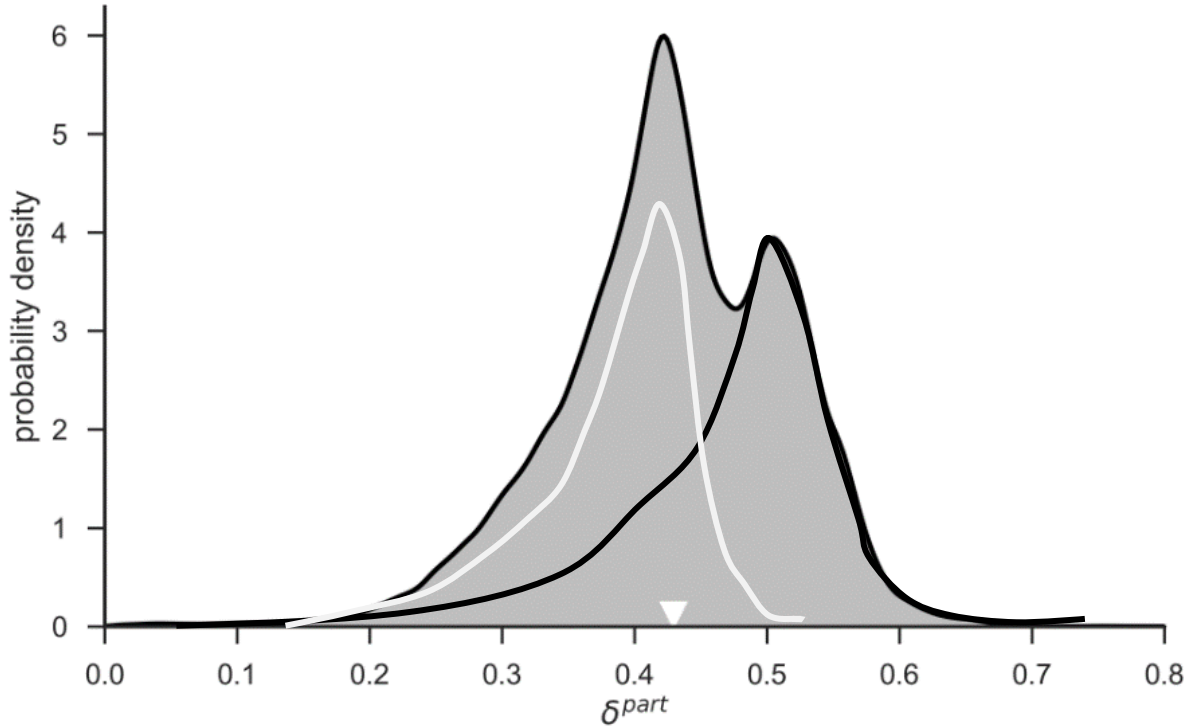
Motivation

Particle depolarization ratio of mid-latitude cirrus clouds



Stettler et al., 2013



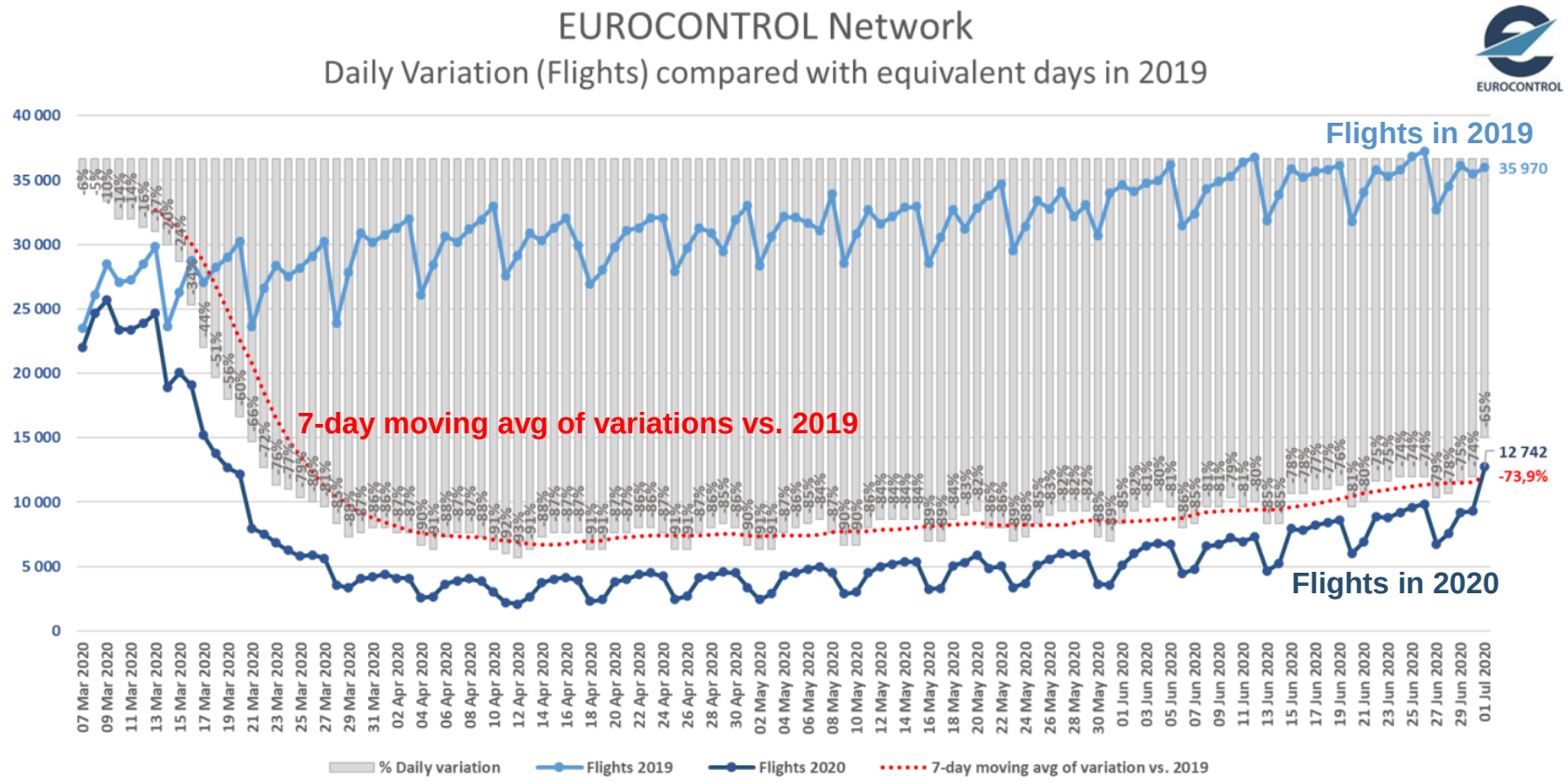


→ **Higher PLDR for cirrus clouds formed in air traffic regions**

Urbanek et al., 2018

Aviation induced aerosol effect on cirrus clouds

Reduced aviation over Europe in 2020 – unique opportunity ‘natural laboratory’



During the first COVID lockdown in Europe, civil aviation was significantly reduced:

→ up to more than **90% reduction in April 2020** compared to the equivalent days in 2019.

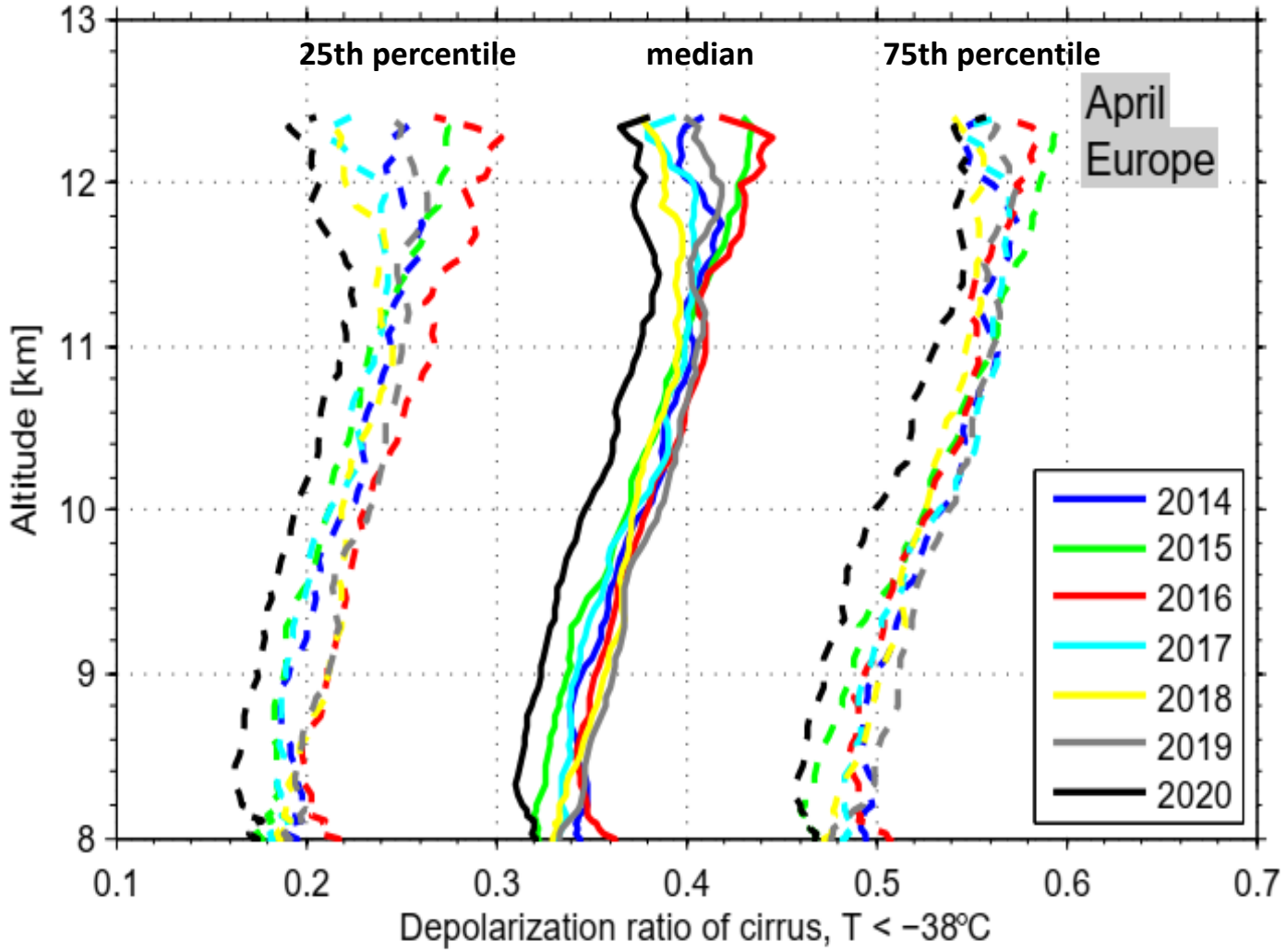
→ The lockdown period provides unique condition to study the effect of air traffic on cirrus cloud properties.

→ Using CALIPSO satellite lidar measurements to investigate changes in cirrus cloud properties

Source: https://www.eurocontrol.int/

Aviation induced aerosol effect on cirrus clouds

Changes in cirrus optical properties



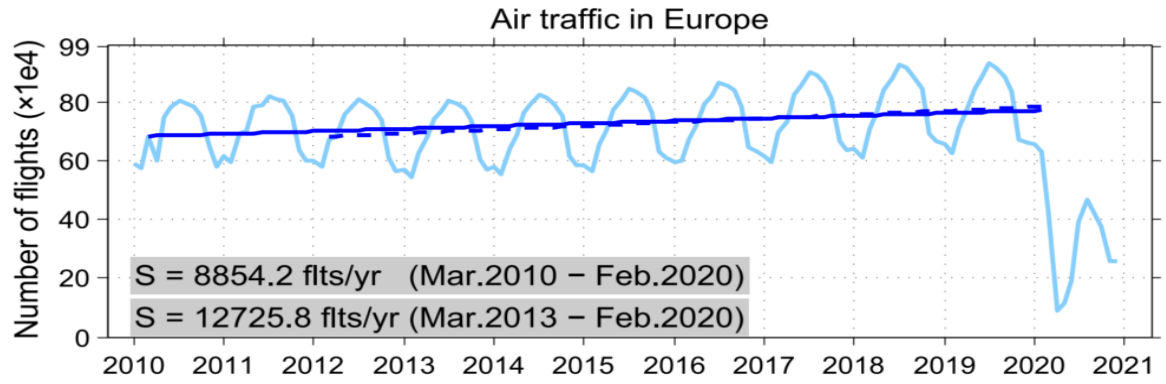
→ The **PLDR values increase with altitudes** for all cases

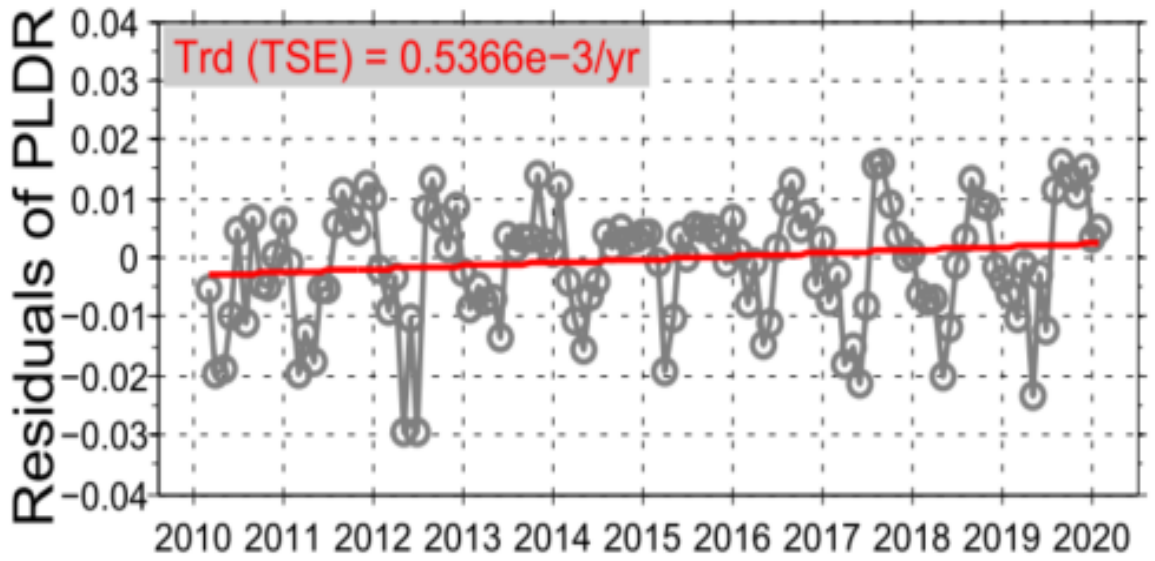
→ **Reduced PLDR in 2020 for all altitude range from 8 to 12 km (T < -38°C)**

Li and Groß, 2021

Aviation induced aerosol effect on cirrus clouds

Long-term study of aviation effect on cirrus cloud properties





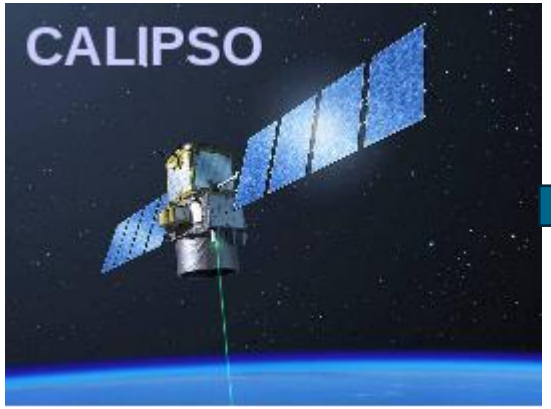
- Number of flights (and **CO2 emission** from aviation) **increased over last 10 years**
- Flight altitude and altitude of cirrus clouds increased
- Height/Temperature corrected residuals of **PLDR show increase over last 10 years**

→ **Correlation between PLDR and numbers of flights / CO2 emission from aviation**

Li and Groß, 2022

Two decades of active remote sensing from space

But: continuous data not available



no overlap

2006 – 2023 (NASA)
CALIOP
VIS/IR Backscatter Lidar

Backscatter (532, 1064 nm)
Color ratio (532/1064 nm)
Depolarization ratio (532 nm)

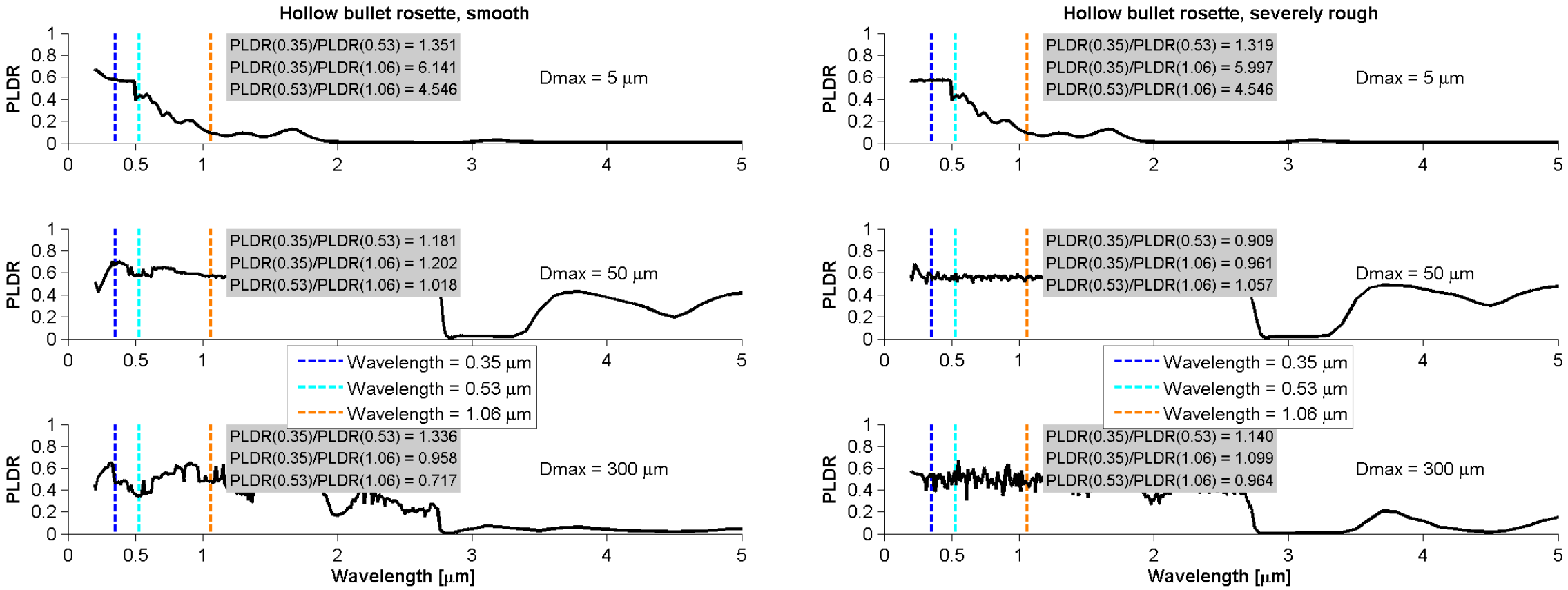
2024+ (ESA/JAXA)
ATLID
UV HSRL

Extinction (355 nm)
Backscatter (355 nm)
Lidar ratio (355 nm)
Depolarization ratio (355 nm)

Courtesy: U. Wandinger (TROPOS)

Depolarization calculation

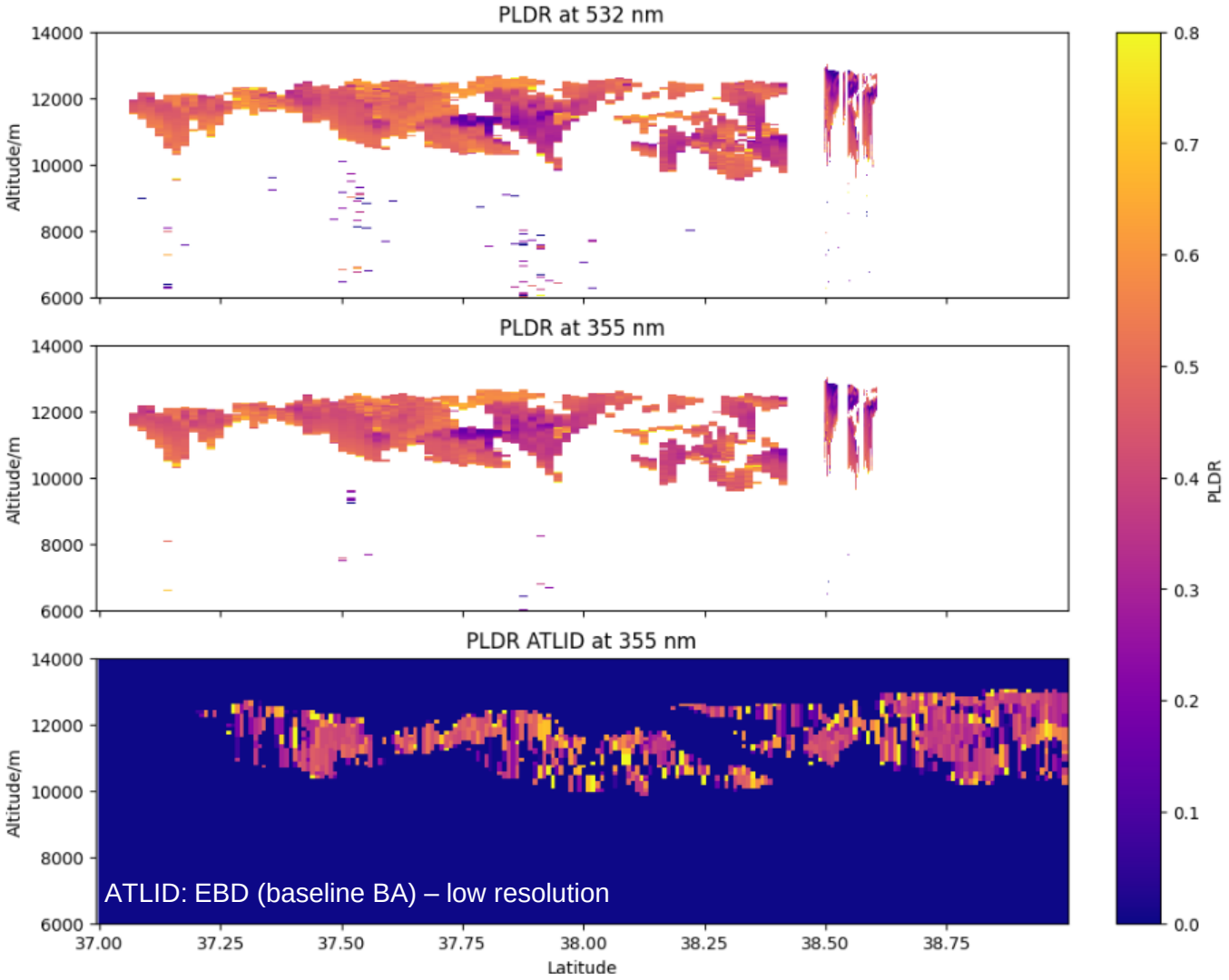
Using scattering calculation to determine theoretical value of PLDR

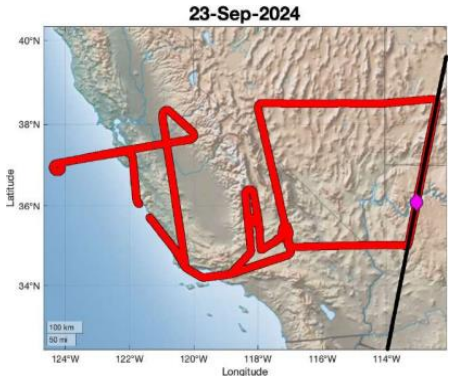


→ **Further impact expected from particle shape (e.g. Hexagonal column instead of Hollow bullet rosette)**

Multi-wavelength airborne lidar measurements

Using measurements of NASA's HSRL-2 (Hair et al., 2008)





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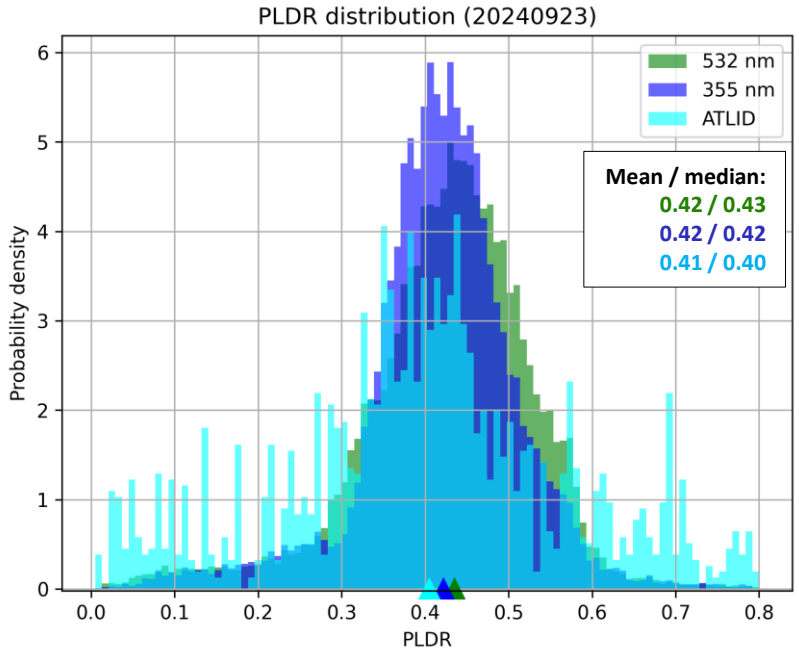

HSRL-2 data provided by NASA (collaboration with J. Hair, T. Shingler, C. Hostetler)

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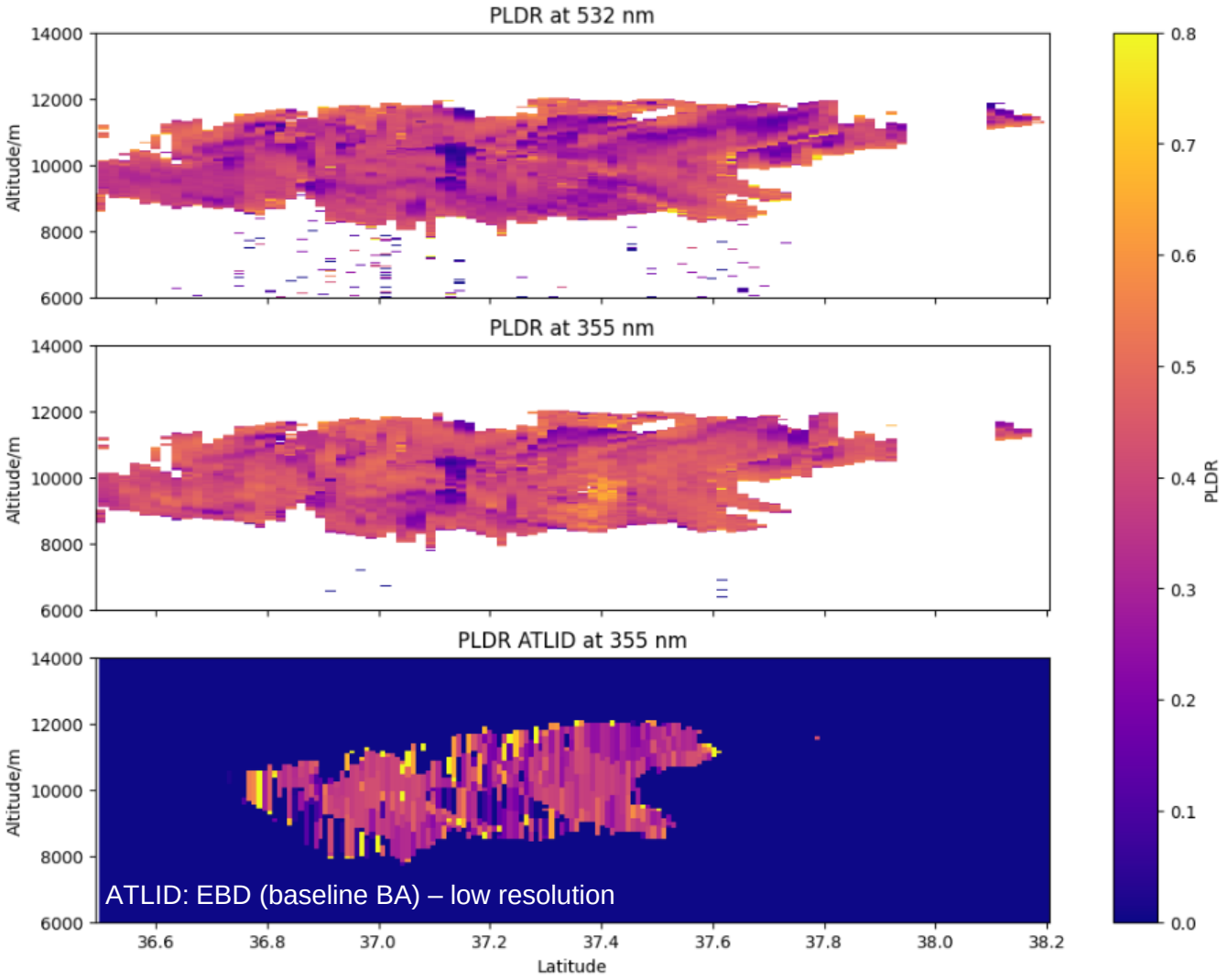

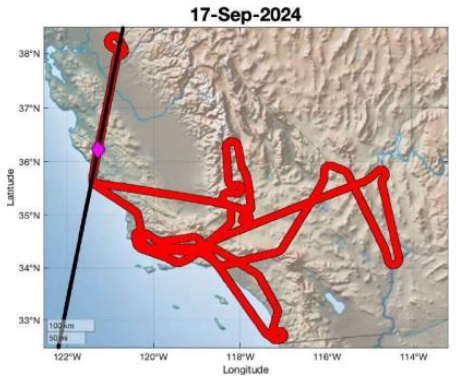

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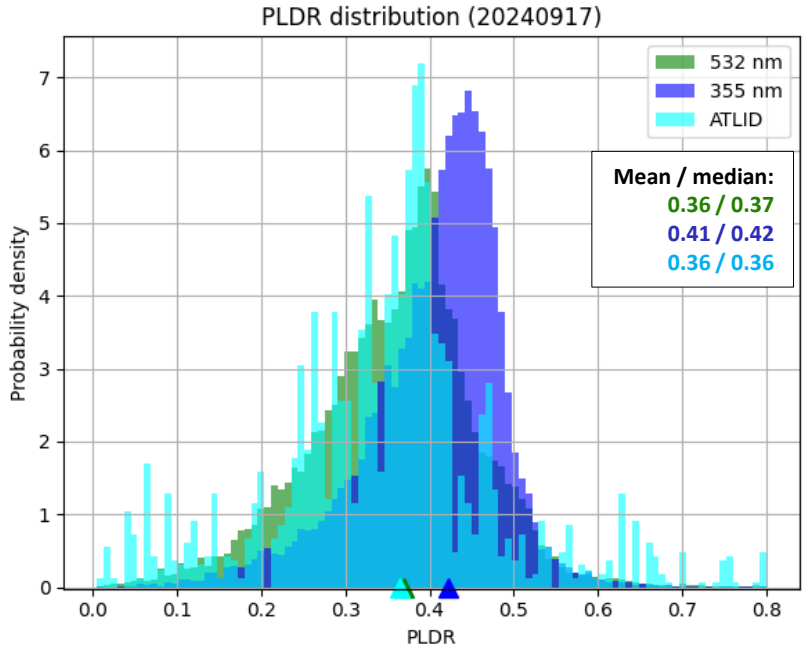

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Summary

- Changes in cirrus PLDR at 532nm found for clouds affected by aviation induced aerosol
- CALIPSO studies during COVID-19 period (reduced aviation) confirmed these findings
- Changes in CALIPSO Cirrus PLDR over Europe ML-region found; this is correlated to air traffic
- CALIPSO ended 2023; EarthCARE started 2024 → no direct overlap
- Using aircraft and satellite lidar measurements
  - Analysis of NASA's HSRL-2 data and A-EBD (BA) data not yet give conclusive result (prelim. results)
  - WALES (airborne lidar) and A-EBD/A-AER comparisons ongoing

→ Further investigations of wavelength dependence and EarthCARE PLDR ongoing

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