Poster ID: 62

Dust aerosols and mixed-phase cloud glaciation: Insights from a synergy of reanalyses & satellite observations

Sarah Brüning[1], Martin Stengel[1], Daniel Robbins[2]

[1] Deutscher Wetterdienst (DWD), Offenbach, Germany (**Sarah.Bruening@dwd.de**), [2] RAL Space, Rutherford Appleton Laboratory, Harwell, United Kingdom

Motivation

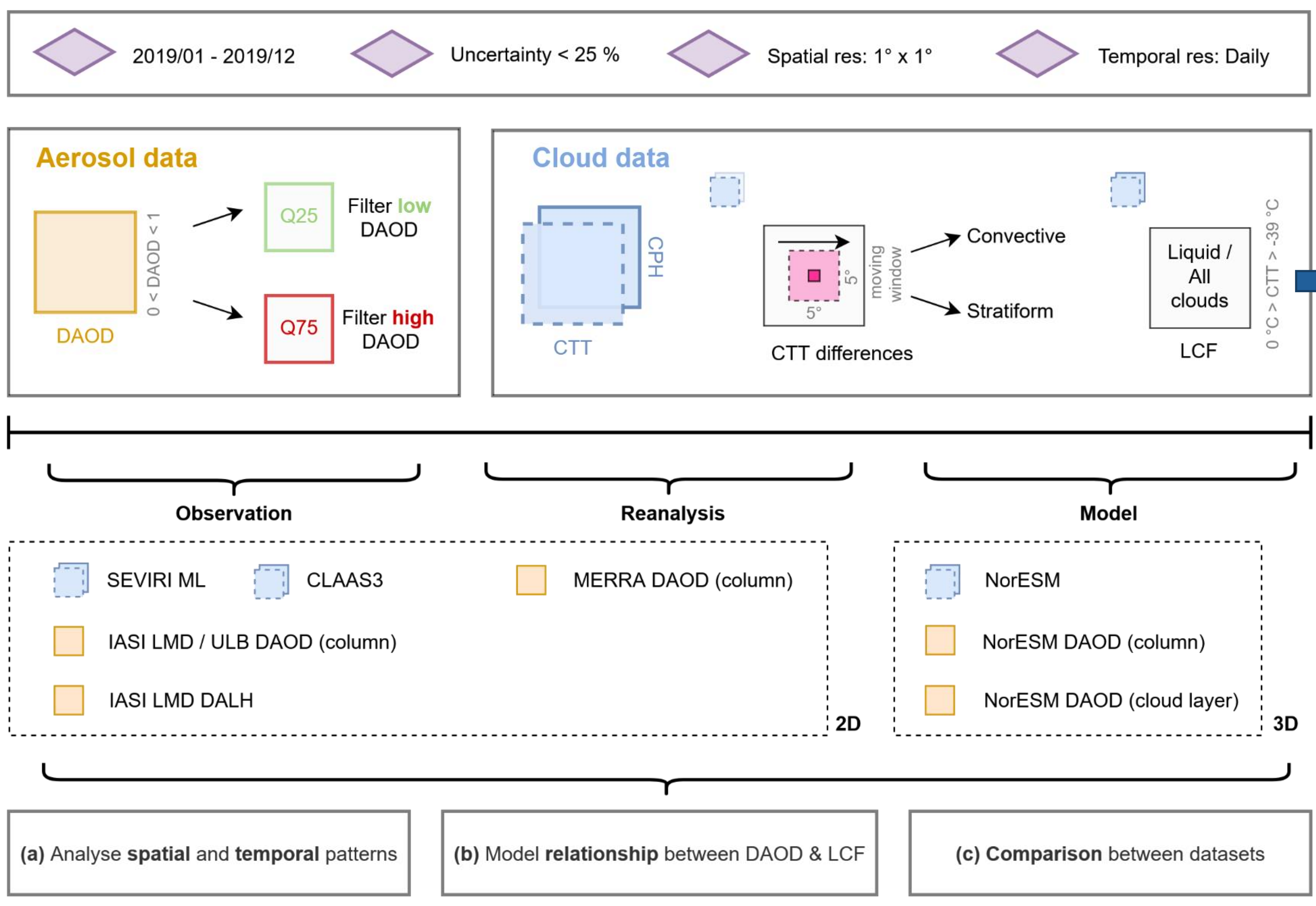
This study is part of **SATACI**, an ESA-funded cross-ECV project focused on aerosol-cloud interactions (**ACI**). While mineral dust is considered a dominant INP source and can initiate heterogeneous freezing, observational evidence remains limited. In a first step, we compare the inferred **relationship between dust concentration and cloud glaciation** based on column-integrated information from satellite and reanalysis data.

Research questions

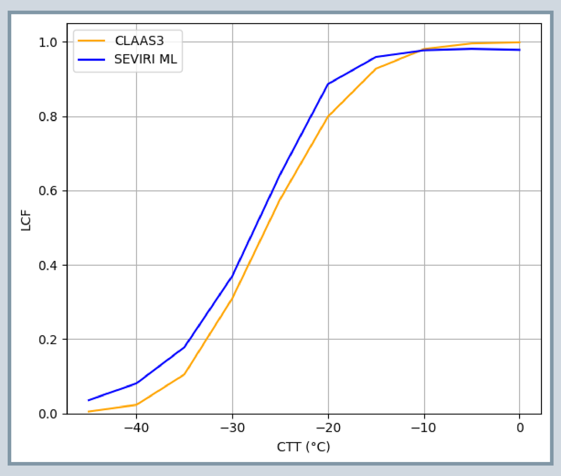
In this study, we focus on the relationship between **dust aerosols** and mixed-phase **cloud glaciation** in the temperature range between 0 °C and -39°C (approximated by changes of the **Liquid Cloud Fraction / LCF**). We aim to improve our understanding **how ACI effects differ between datasets,** answering in particular:

1) How do **DAOD** effects on cloud glaciation differ between **satellite & reanalysis** data?
2) What is the **impact** of spatial, temporal, or meteorological **confounders**?

Data & methods

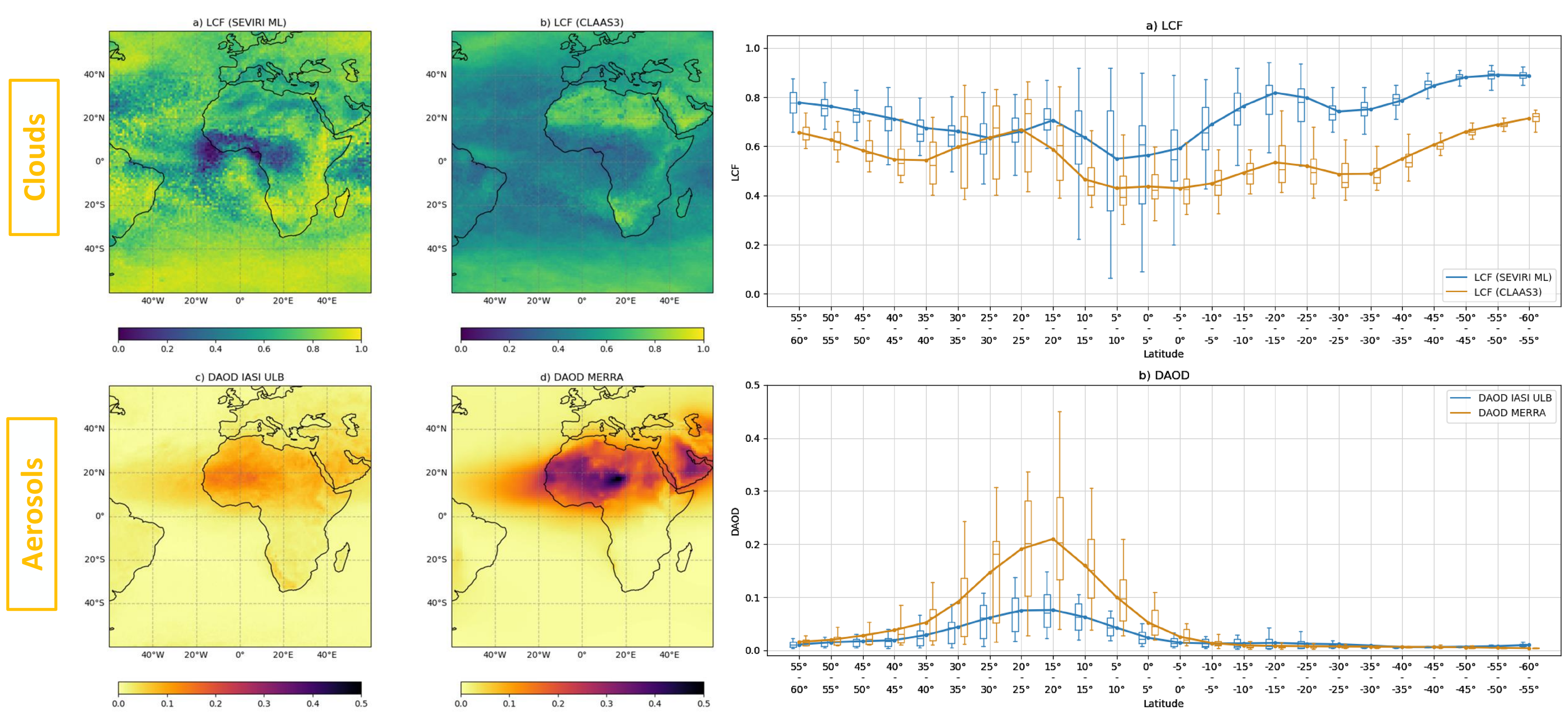


Ratio of liquid cloud phase (**CPH**) to all cloudy pixels for cloud top temperatures (**CTT**) between 0 °C and -39 °C
→ Daily resolution
→ Ranges from **0 (all ice)** to **1 (all liquid)**



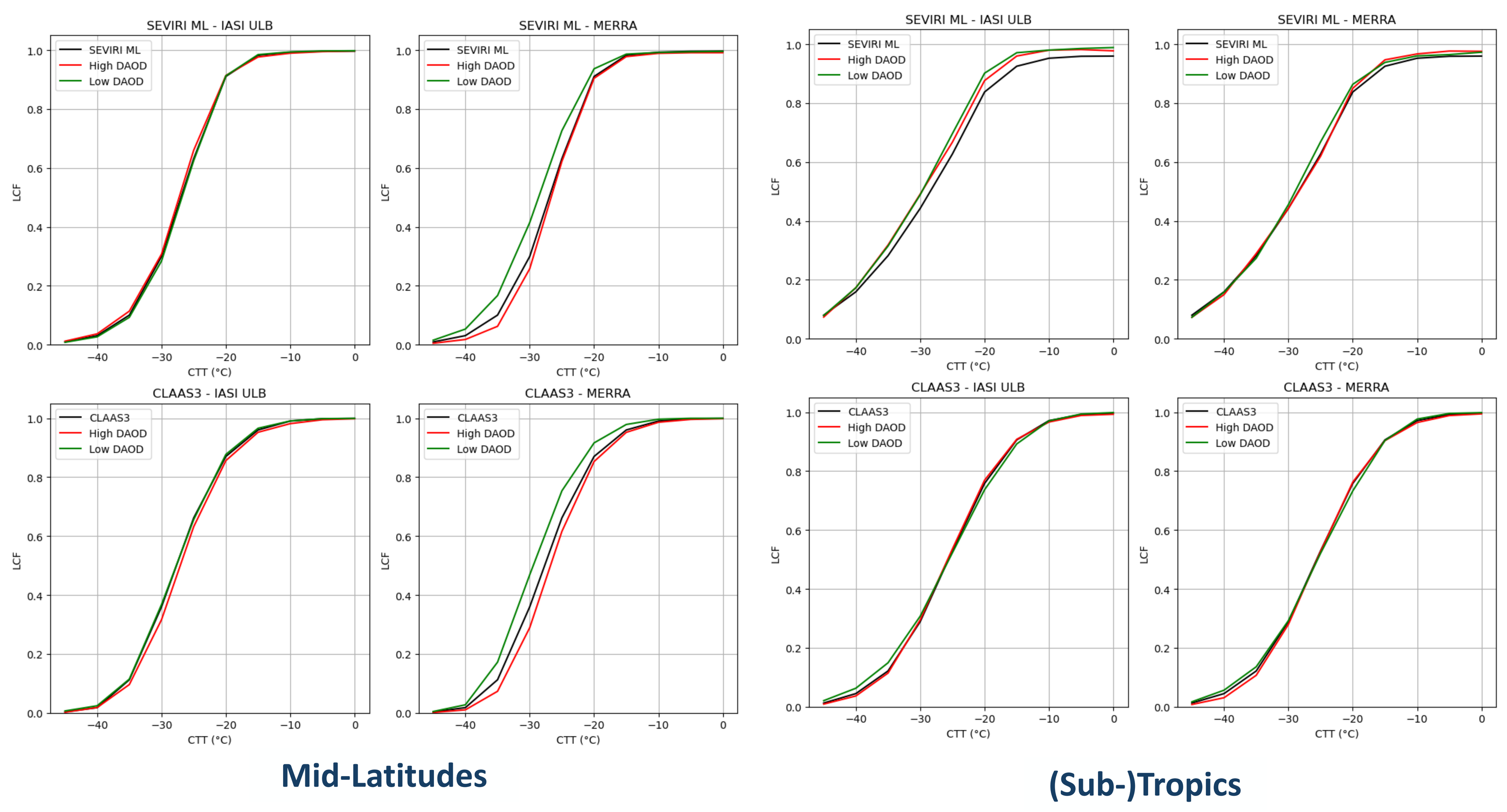
Average liquid cloud fraction

Aerosol & cloud product comparison



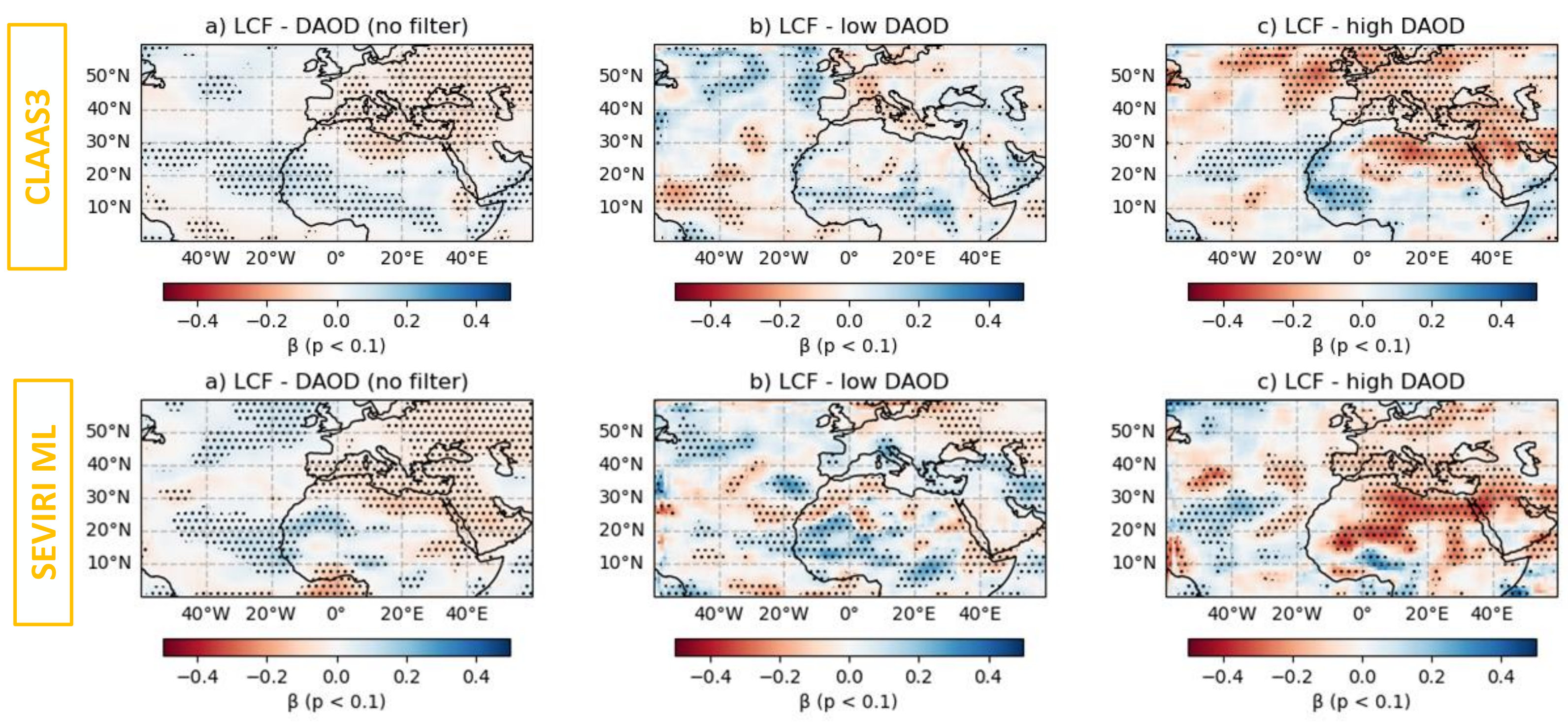
The spatial distribution of cloud (**LCF**) properties reveals differences between the satellite products across almost all regions. A higher LCF for **SEVIRI ML** compared to **CLAAS3** may arise from differences in the cloud phase (CPH) retrieval. For the satellite-based dust AOD (**DAOD IASI ULB**), values are lower than for **MERRA** reanalysis. However: Filtering the **most uncertain** values from IASI ULB substantially reduces the DAOD peaks over dust sources regions.

Sensitivity of cloud glaciation to dust aerosol



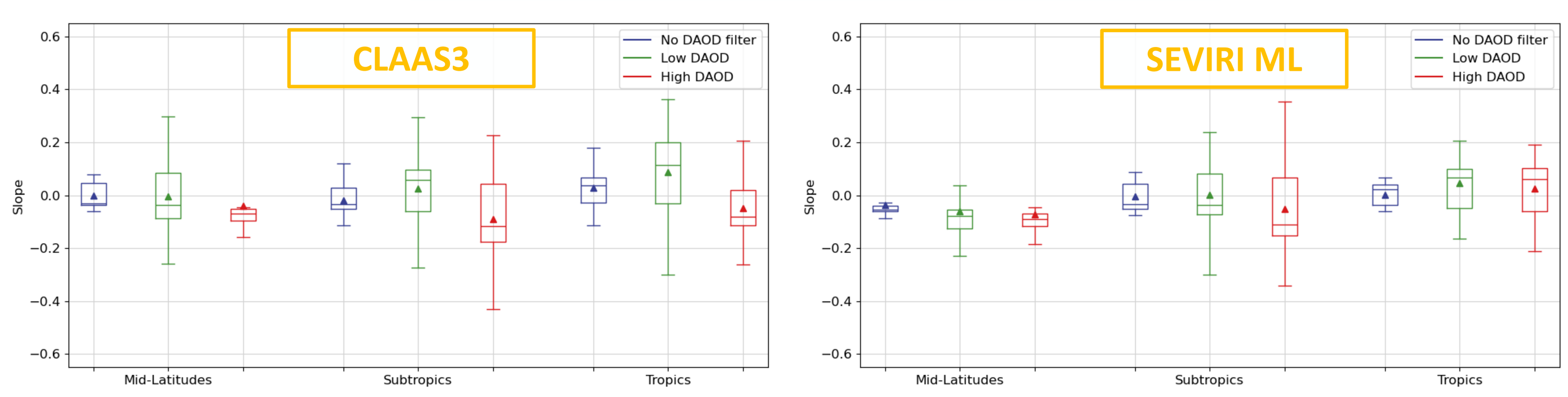
Our **preliminary results** show that the computed LCF **non-monotonically increases** with a higher cloud top temperature (CTT). High DAOD generally reduces LCF and promotes earlier glaciation, though their relationship is characterized by substantial **spatial variability** and a strong **dependence** on the **dataset**. For satellite-based DAOD (IASI ULB), the effect is considerably smaller than for MERRA reanalysis data.

Relationship between cloud glaciation & dust aerosol



Based on the time series of each pixel, we compute the **slope** for LCF ~ ln(DAOD) within a moving-window (3° x 3°). We compare the output of the regression for CLAAS3 and SEVIRI ML cloud data based on the whole time series **(a)**, a subset of low DAOD **(b)**, and a subset of high DAOD **(c)**.

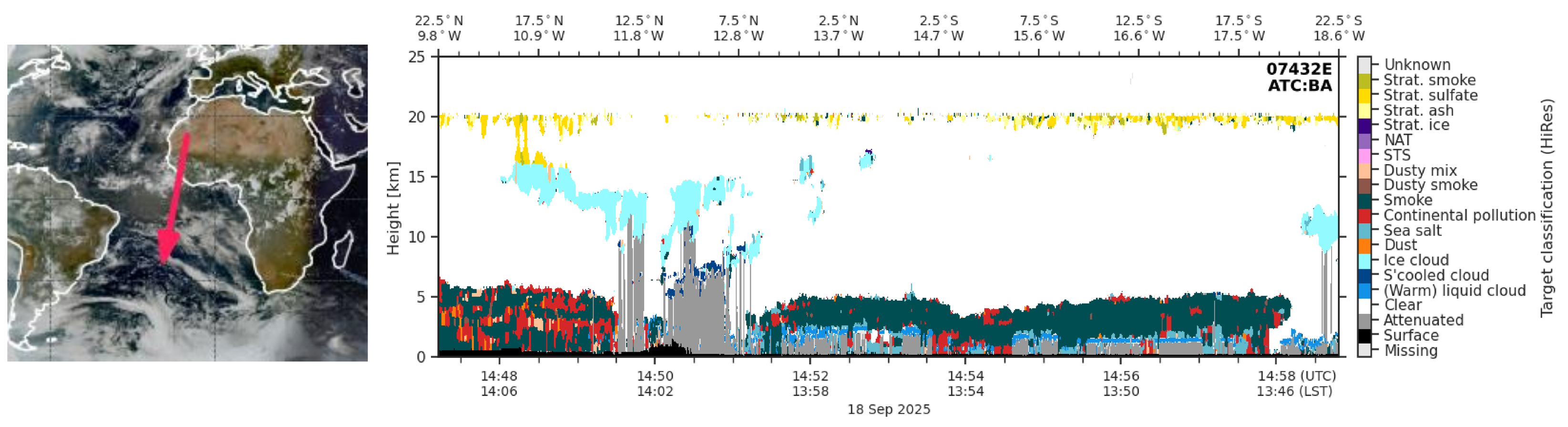
Regional DAOD effect



Summary

- Robust **ACI** estimates require high-quality satellite products
  → Relationship may **differ considerably** between datasets (not only slopes, but also spatial patterns)
  → Need for **comparative** analysis & use of synergistic effects
- Analysis of dust effect **in the mid-latitudes more consistent** (comparable to previous research)
  → Overall: Higher DAOD relates to lower LCF
  → But: High regional variability & overlaying effects, i.e., in **subtropical** & **tropical** regions (e.g., over Sahara)

- Include **vertical matching** to assess relationship for **interacting cloud** and **aerosol** layers
→ Use **EarthCARE** cloud and aerosol classification (AC-TC)



Open question:
Can we achieve a sufficient **coverage** of **interacting dust aerosol** and **mixed-phase cloud** pixels in EarthCARE to estimate their relationship?

References

Choi, Y. S., Lindzen, R. S., Ho, C. H., and J. Kim: Space observations of cold-cloud phase change. Proceedings of the National Academy of Sciences , 107 (25), 11211-11216, 2010.
Costantino, L., and F.-M. Bréon: Analysis of aerosol-cloud interaction from multi-sensor satellite observations, Geophys. Res. Lett., 37, L11801, doi:10.1029/2009GL041828, 2010.
Han, C., Hoose, C., Stengel, M., Coopman, Q., and Barrett, A.: Sensitivity of cloud-phase distribution to cloud microphysics and thermodynamics in simulated deep convective clouds and SEVIRI retrievals, Atmos. Chem. Phys., 23, 14077–14095, https://doi.org/10.5194/acp-23-14077-2023, 2023.
Villanueva, D., Stengel, M., Hoose, C., Bruno, O., Jeggle, K., Ansmann, A., and U. Lohmann: Dust-driven droplet freezing explains cloud-top phase in the northern extratropics. Science. 2025 Jul 31;389(6759):521-525. doi: 10.1126/science.adt5354, 2025.

EarthCARE 2026 Science and Validation workshop

8–12 June 2026 | Rhodes House | Oxford, UK