# Cal/Val synergies for desert dust modeling studies

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on behalf of the National Observatory of Athens

2nd ESA EarthCARE Validation Workshop

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# Cal/Val synergies for improving desert dust modeling

The synergy of ground-based / airborne / EarthCARE collocated measurements from Cal/Val campaigns can be used beyond the Cal/Val objectives



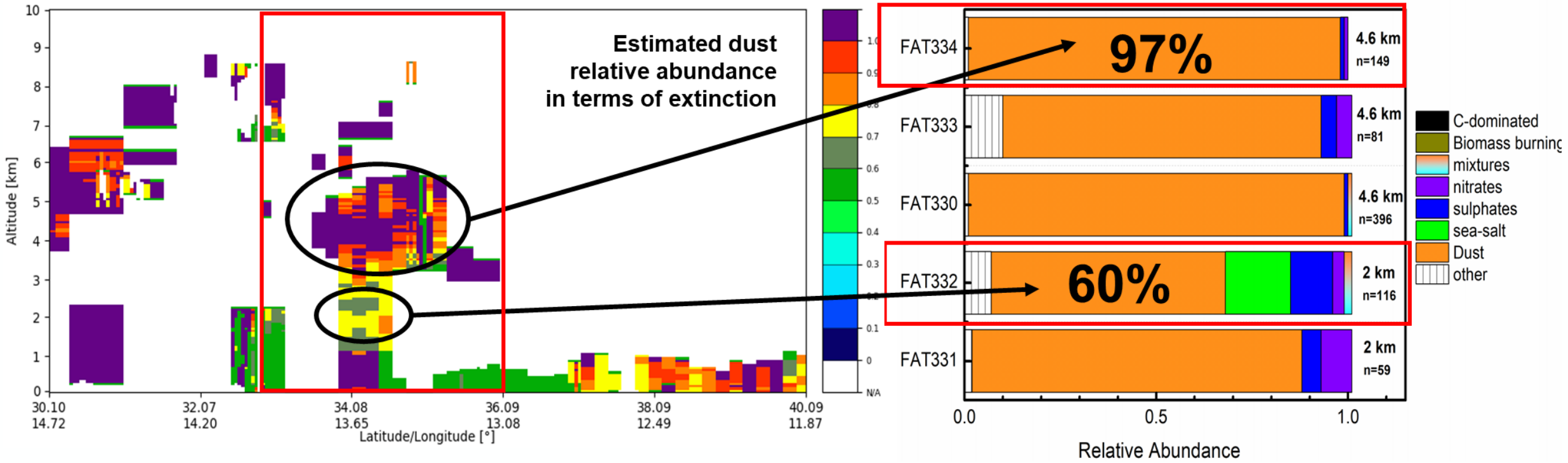
# Potential Applications for desert dust research

**Development and evaluation of new products from EarthCARE. Here, we discuss the potential for deriving products for desert dust research that can be used to:**

- **Develop climate datasets by bridging EarthCARE with CALIPSO:** Dust can be distinguished from other aerosol types through depolarization and has weak wavelength dependence for dust.
- **Use** for data assimilation in **SDS-WAS** systems
- **Support** studies on new parameterizations for **representing physical processes** in desert dust models
- **Develop a dust deposition product**, critical for studies on biogeochemical cycles
- **Perform closure studies for the radiative impact of dust** and associated impacts on atmospheric dynamics
- **Promote data assimilation of intensive properties such as the Depolarization and Lidar Ratio** would improve representation of the aerosol optical properties in CAMS.

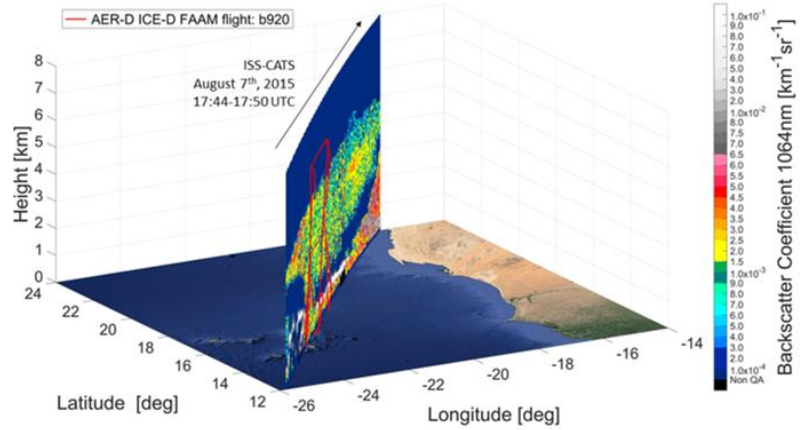
# Dust products from Cal/Val campaigns

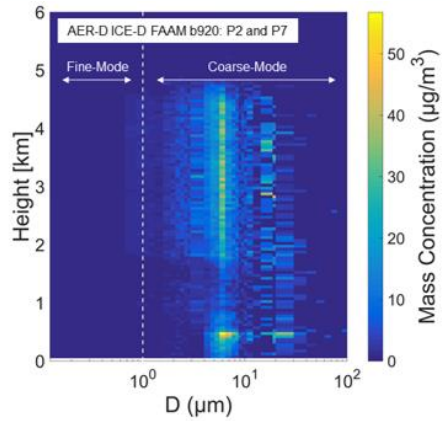
Derivation and validation of the CALIPSO pure-dust product (**A-CARE** ESA study based on **A-LIFE** and **ACTRIS** experimental campaigns)

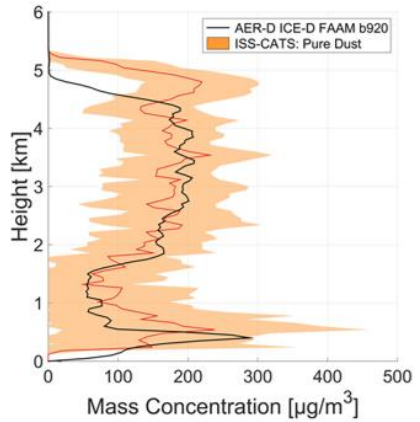


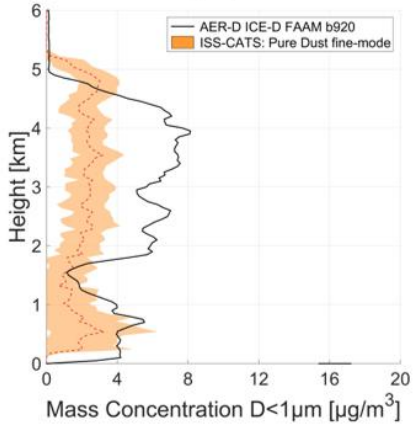
# Fine/coarse dust product

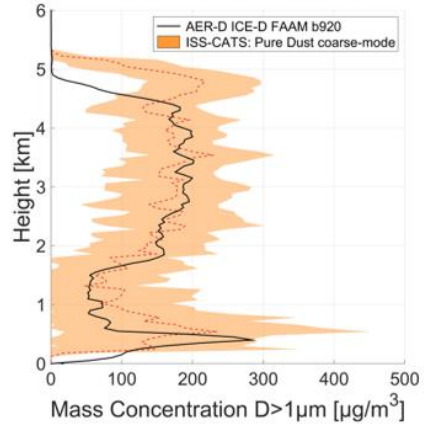
## Derivation and validation of the CALIPSO pure-dust fine/coarse product (AER-D campaign in Cape Verde)



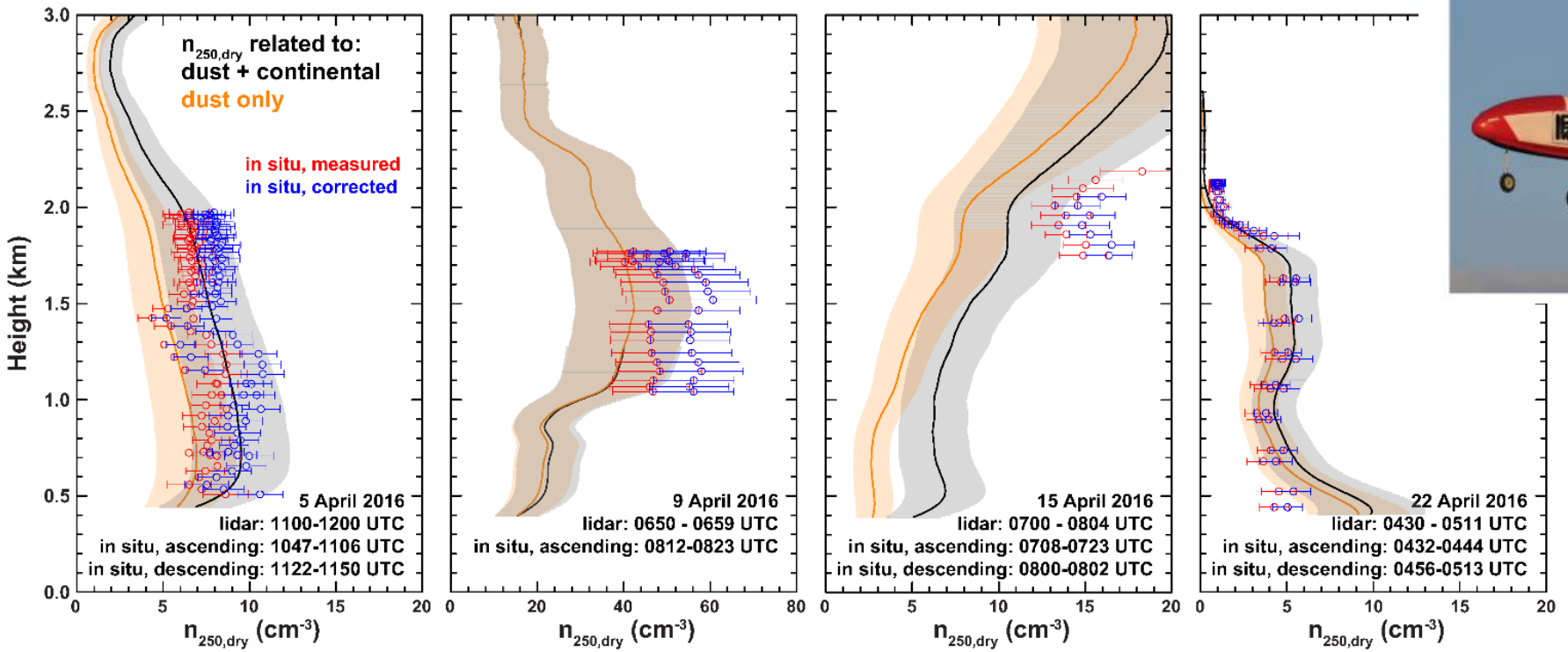



# Dust IN product

## Derivation and validation of the CALIPSO IN product (BACCHUS Cyprus campaign)



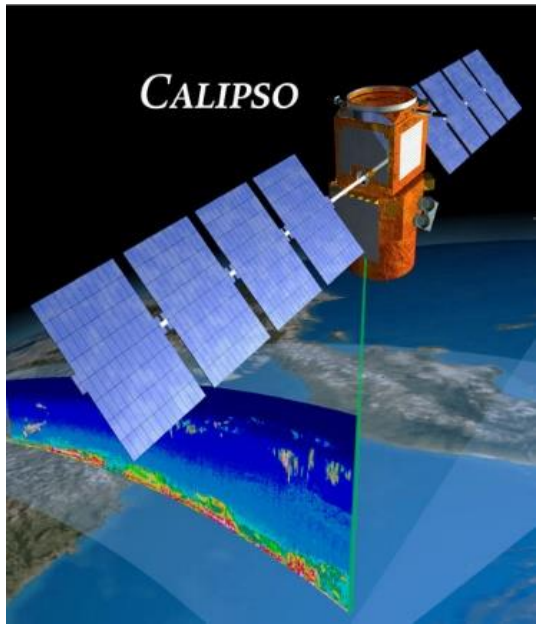


**Marinou et. al, ACP, 2019**

Good agreement between the in-situ and lidar-derived $n_{250}$ within the lidar uncertainties

# Bridging EarthCARE with CALIPSO (LIVAS)

Bridge EarthCARE dust product with corresponding CALIPSO product. Feasible due to the weak wavelength dependence (355-532nm) for dust and trustworthy aerosol typing through depolarization (ESA-LIVAS study)



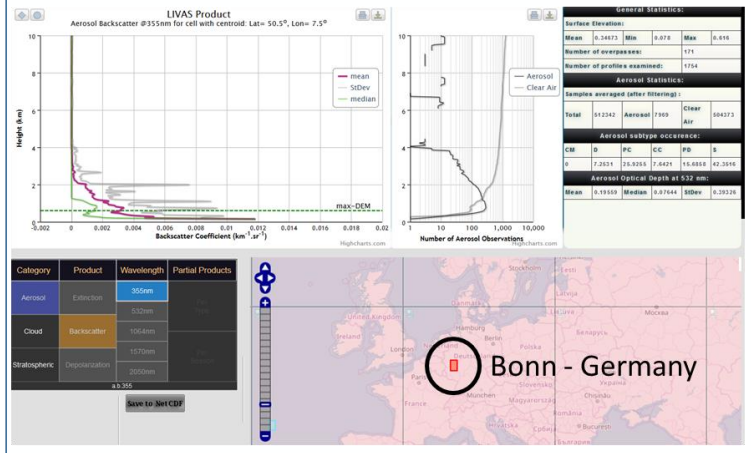

***CALIOP observations at 532 nm***
*→ Quality Filtering →*
*→ Conversion Factors →*
***→ CALIOP at 355 nm***


Chemistry and Physics

IVAS: a 3-D multi-wavelength aerosol/cloud database based on ALIPSO and EARLINET

## The *LIVAS* project

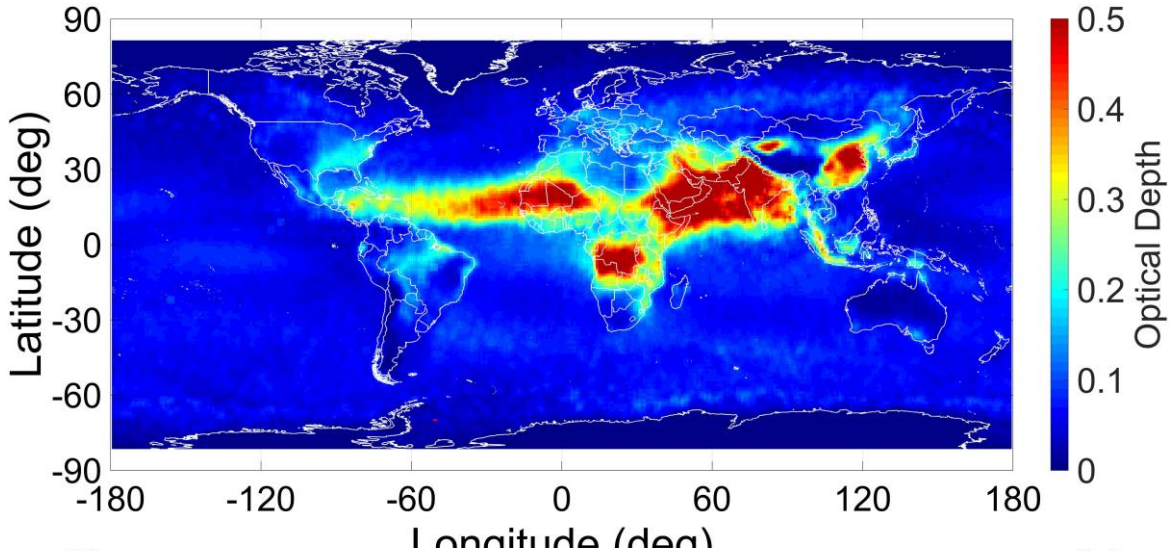
**Lidar Climatology of Vertical Aerosol Structure for Space-Based Lidar Simulation Studies**

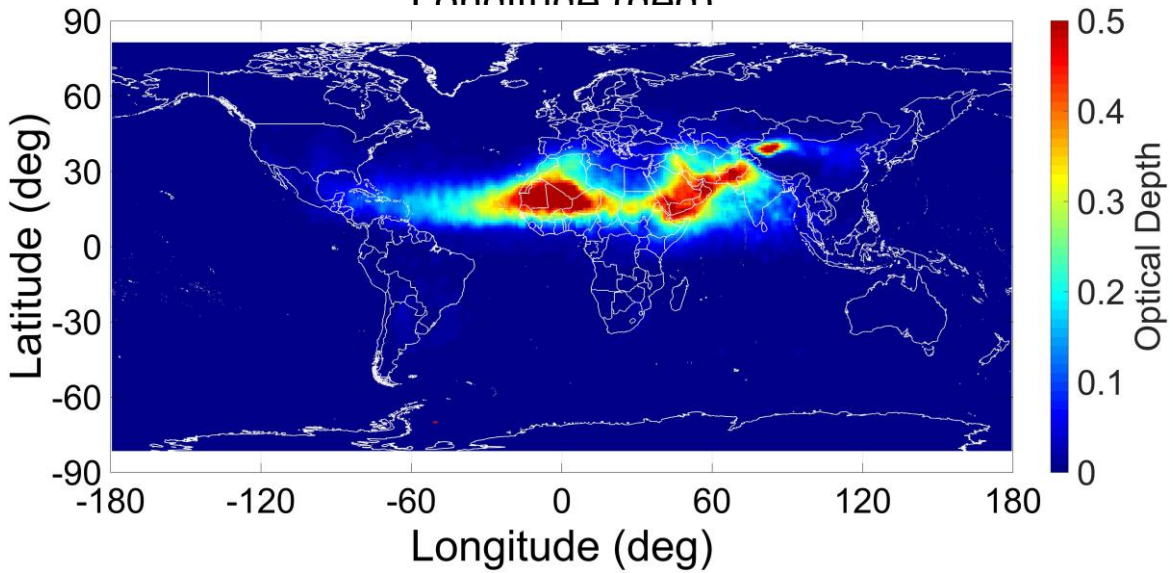


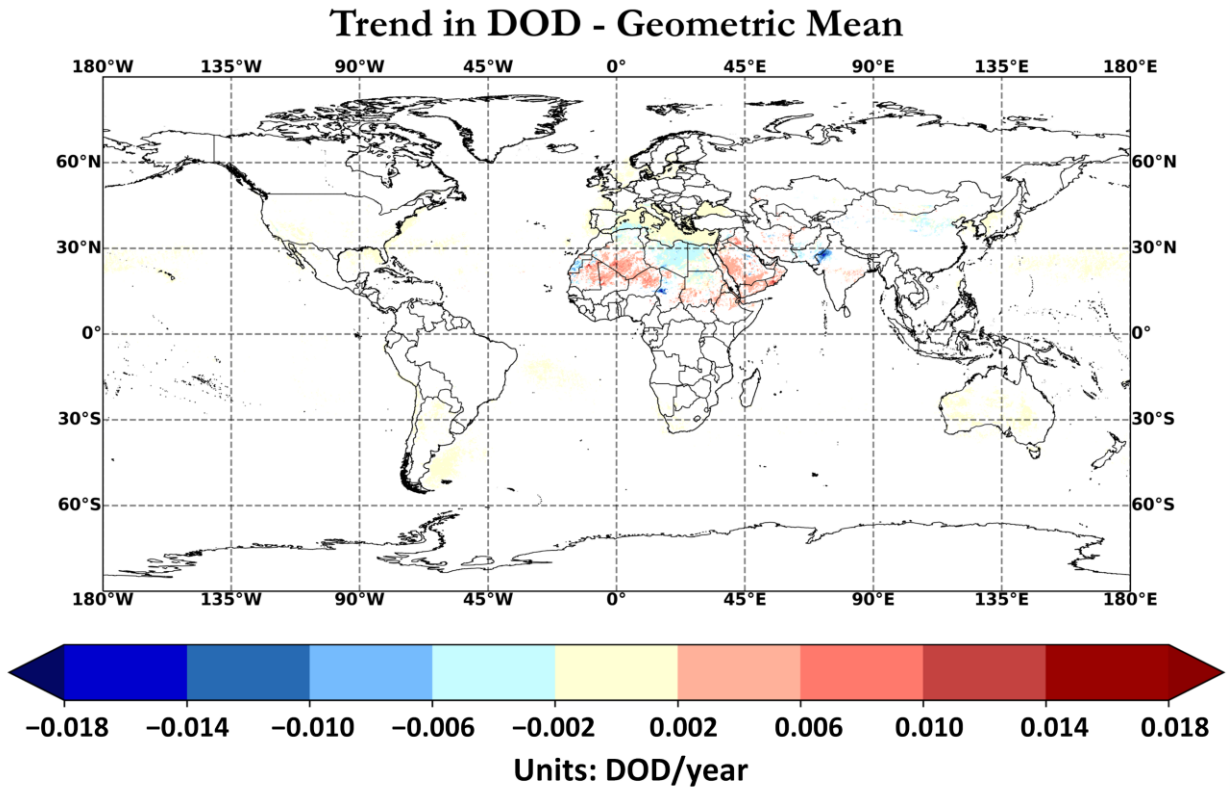

esa ACTRiS EARLINET imaa TROPOS Leibniz Institute for Tropospheric Research

*Source: http://lidar.space.noa.gr:8080/livas/climatology.html*

# Bridging EarthCARE with CALIPSO (LIVAS)



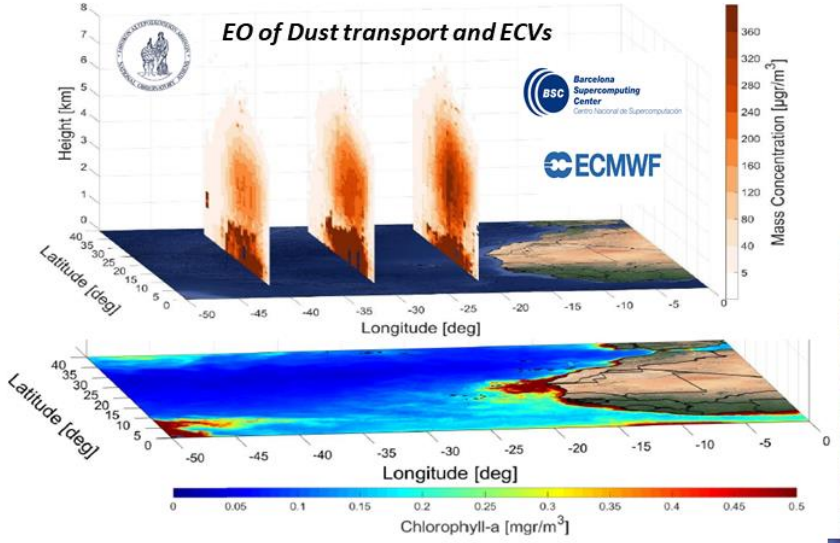

# Dust deposition studies

Derivation of dust deposition product using aerosol profiling from EarthCARE (being applied for ESA using CALIPSO in DOMOS study)

Dust-Ocean modelling & Observing Study (ESA-AO/1-10546/20/I-NB)

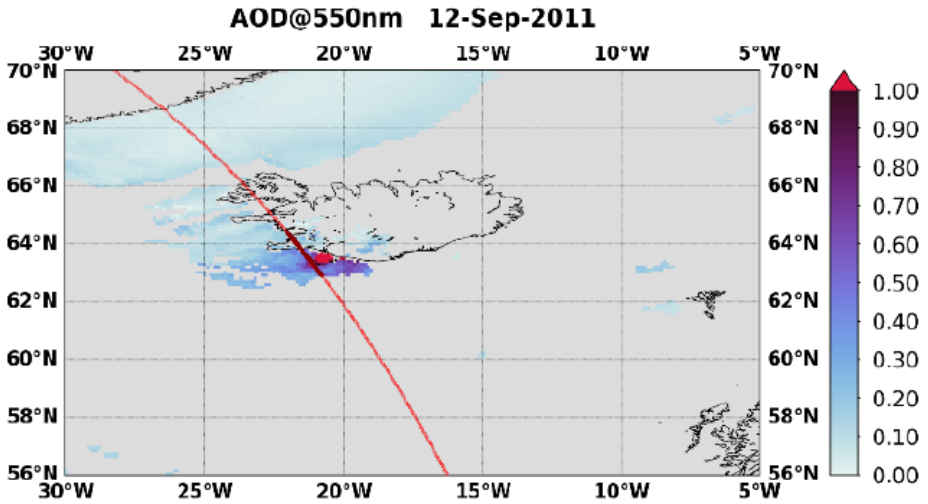
**Effects of dust depositions on open sea productivity:**

- Dust depositions drive a series of complex biogeochemical processes.
- Mineral dust includes iron (Fe) that dissolves to produce nutrients.
- Upwelling of N and P and surface depositions of Fe are the main nutrients in open sea.
- **Fishery :** Changes in phytoplankton and algae affect local fishery properties.
- **Climate Change:** Phytoplankton removes $CO_2$ (green gas) from the atmosphere.



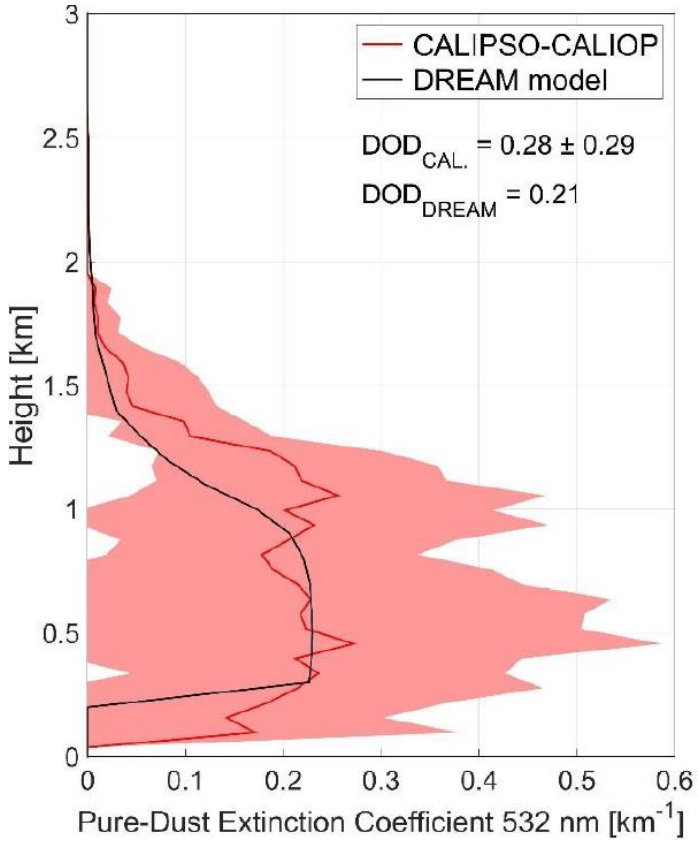


# New dust sources (including anthropogenic)



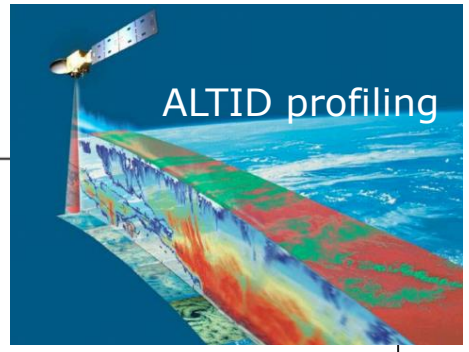

MODIS–Aqua AOD at 550 nm representing dust pattern over the period of 11–13 September 2011. The red line on the 12 September image shows the only available CALIPSO overpass

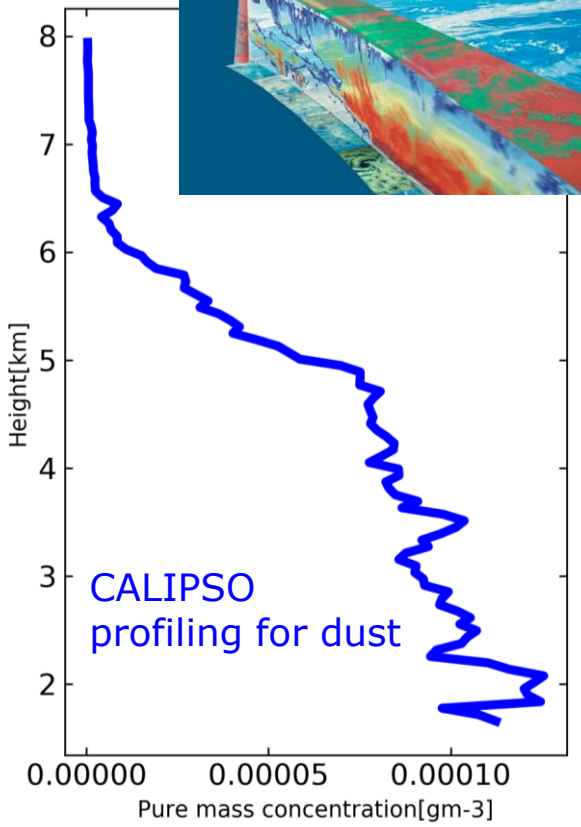
Cvetcovic et al. – ACPD

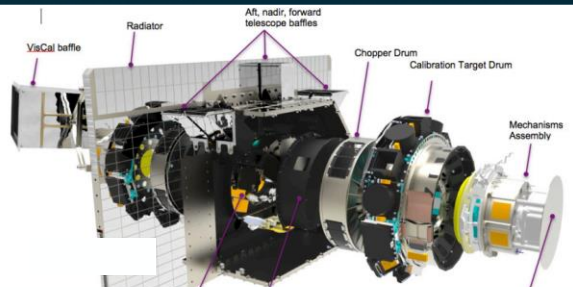



CALIPSO-based pure-dust and DREAM pure-dust extinction coefficient at 532 nm vertical profiles averaged over the CALIPSO path for 12 September 2011.

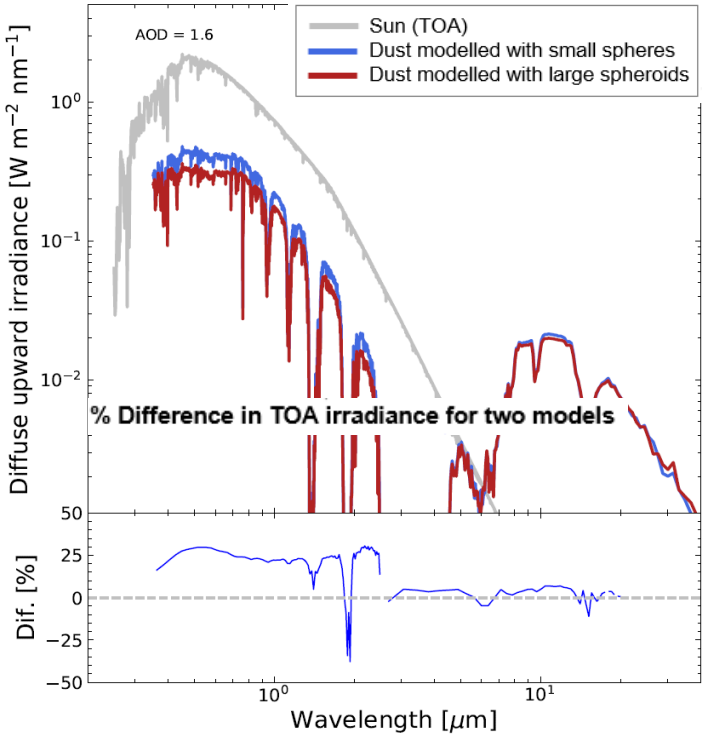
# Radiative impact of dust in models – Closure studies

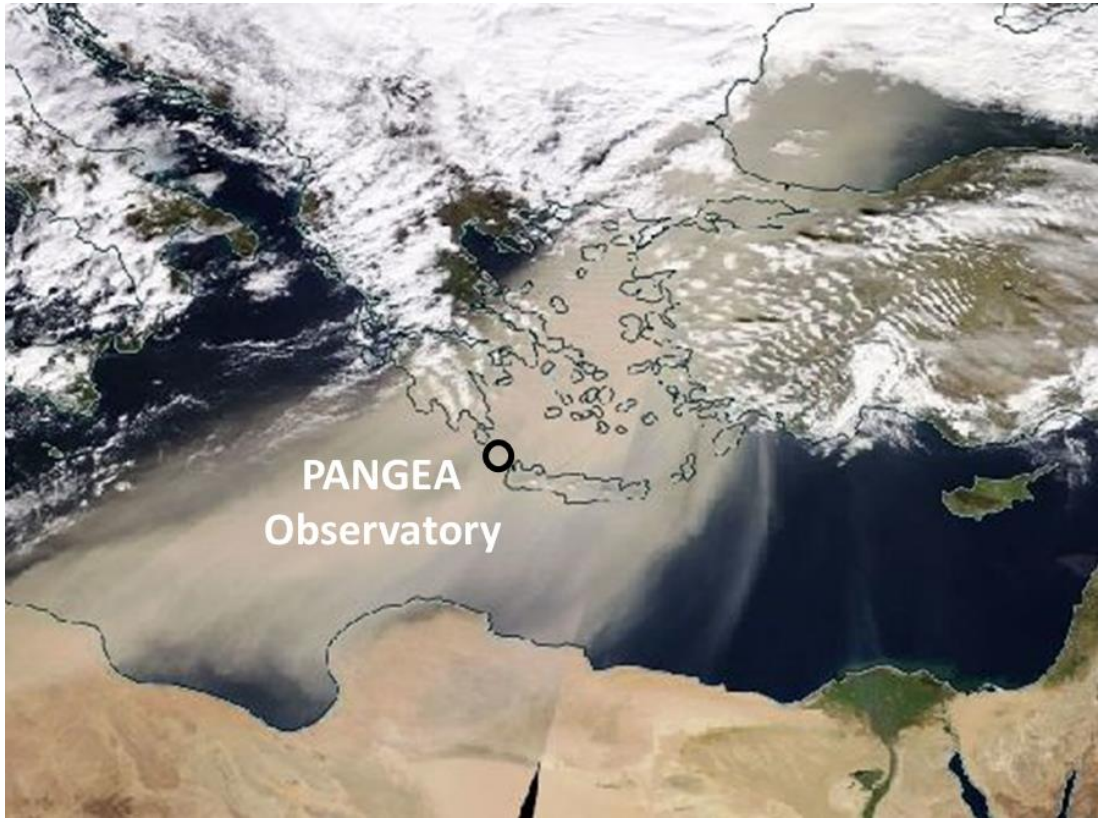


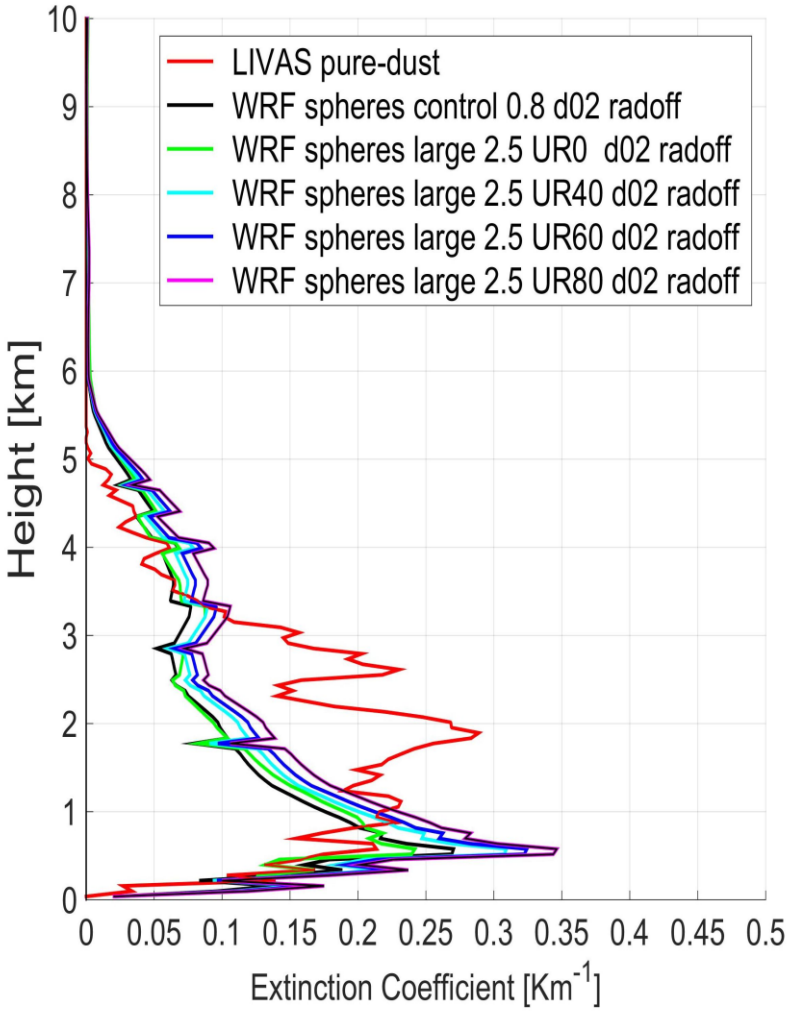




BBR: TOA radiances in SW and LW

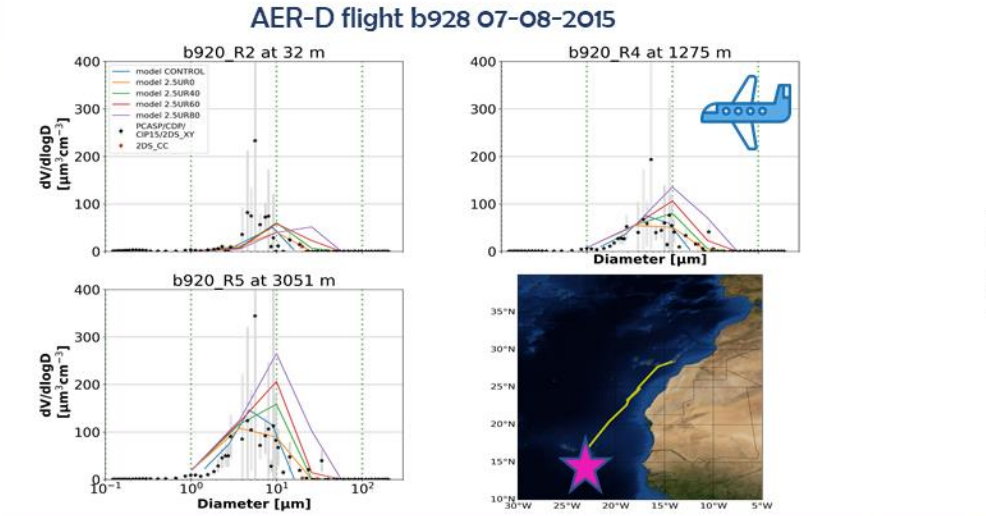


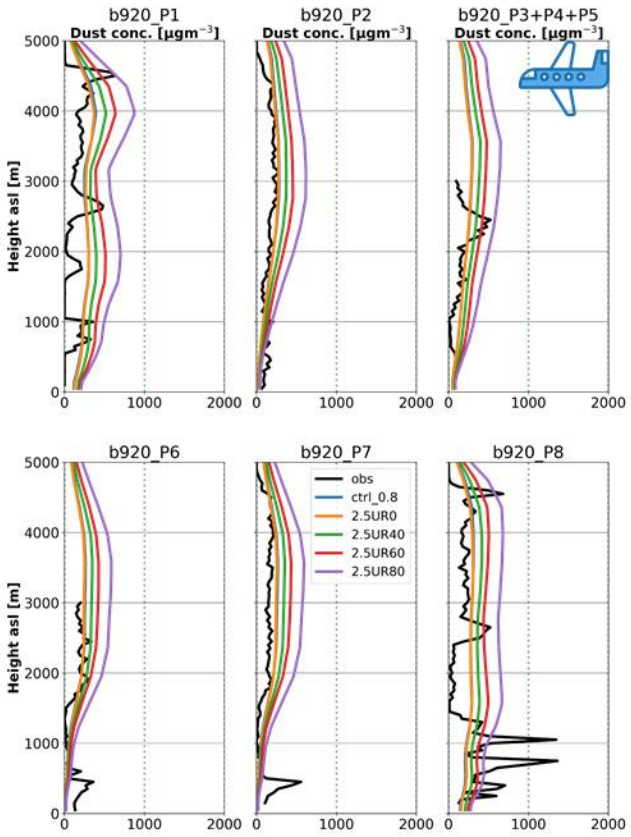



# Evaluation of dust models and new parameterizations

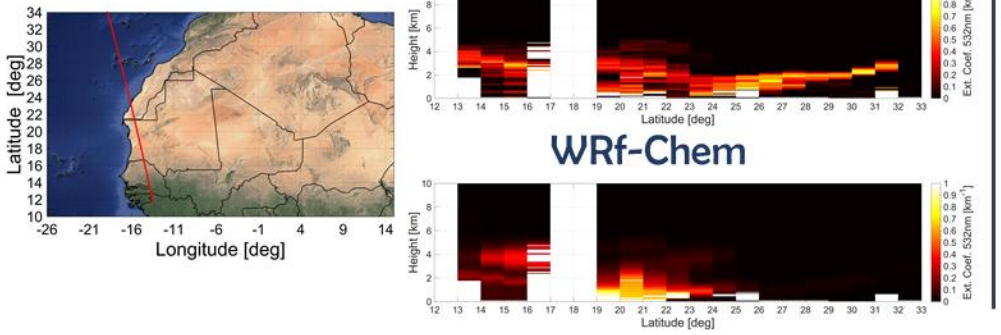



## (B) Evaluating the model performance using observed PSD and Profiles during AER-D/ICE-D

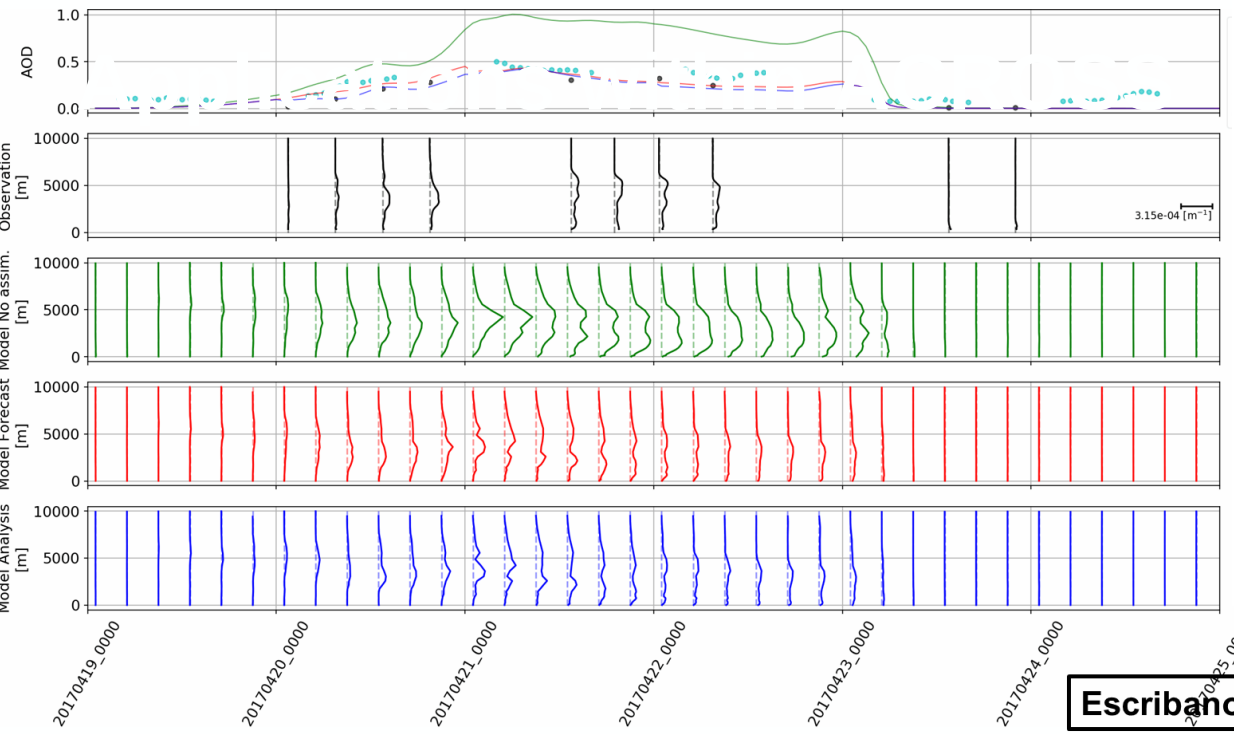


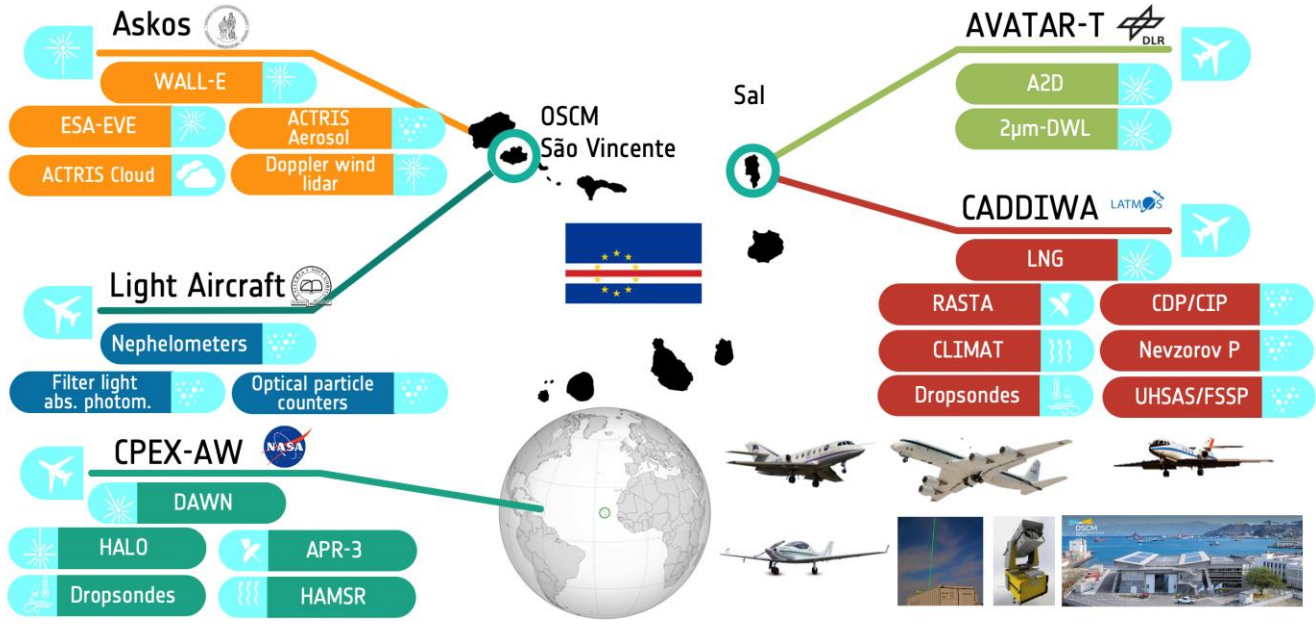




## (C) Evaluating the model performance with Satellites



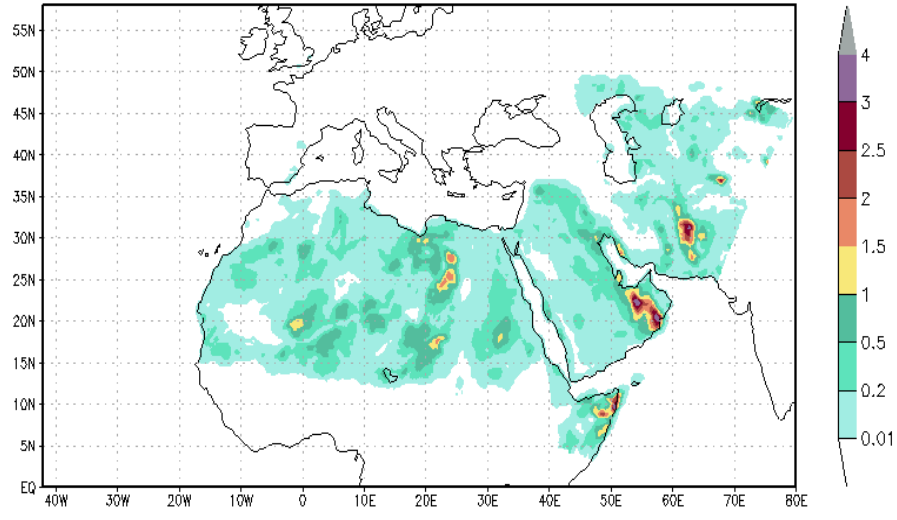
# Data assimilation for improving dust transport forecasts




**Escribano et al., to be submitted**

Dust Load (g/m²)



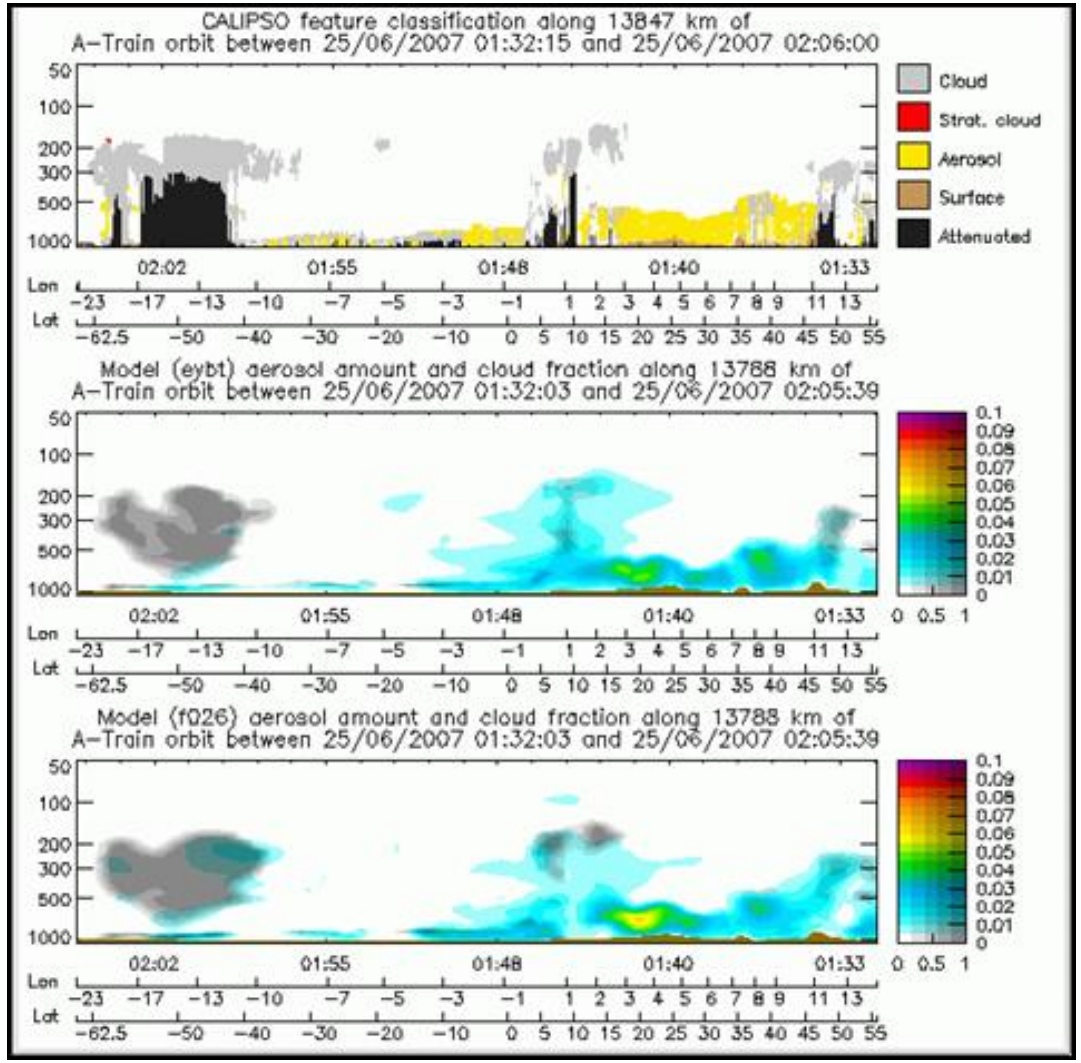
# CAMS data assimilation (slide from Angela Benedetti)

- Experimental assimilation of lidar backscatter has been successfully demonstrated in the CAMS system.
- What is adjusted is the aerosol total mass, while the optical properties are  kept constant
- Developing the assimilation of lidar ratio in which the optical properties are modified during the minimization would be a revolutionary step

**CALIPSO Feature mask**

**Model forecast**

**AOD assimilation**



# Conclusions: what is needed from the Cal/Val campaigns

- Ground-based aerosol remote sensing (multi-wavelength lidars, sunphotometers, polarimeters)
- Airborne in-situ measurements of size distributions, absorption, analysis of samples, CCN/IN (deploying drones and research aircrafts)
- Surface in-situ for dust and deposition (including buoys)
- Surface radiation measurements (BOA, i.e. BSRN)