5th European Lidar Conference

10-12 Sep. 2025, University of Warsaw, Poland

DUAL-FIELD-OF-VIEW DEPOLARIZATION APPROACH USING THE POLLY^{XT} RAMAN LIDAR: CHARACTERIZATION OF AEROSOL-CLOUD INTERACTIONS IN THE SEMI-ARID CLIMATE OF CYPRUS.

Chrysostomou C.[a, b], Jimenez C.[c], Mamouri R. E.[a, b], Nisantzi A.[a, b], Hadjimitsis D.[a, b], and Ansmann A.[c]

a. ERATOSTHENES Centre of Excellence, Franklin Roosevelt 82, 3012, Limassol, Cyprus

b. Department of Civil Engineering and Geomatics, Cyprus University of Technology, Archiepiskopou Kyprianou 30, 3036, Limassol, Cyprus

c. Leibniz Institute for Tropospheric Research (TROPOS), Permoserstraße 15, 04318, Leipzig, Germany

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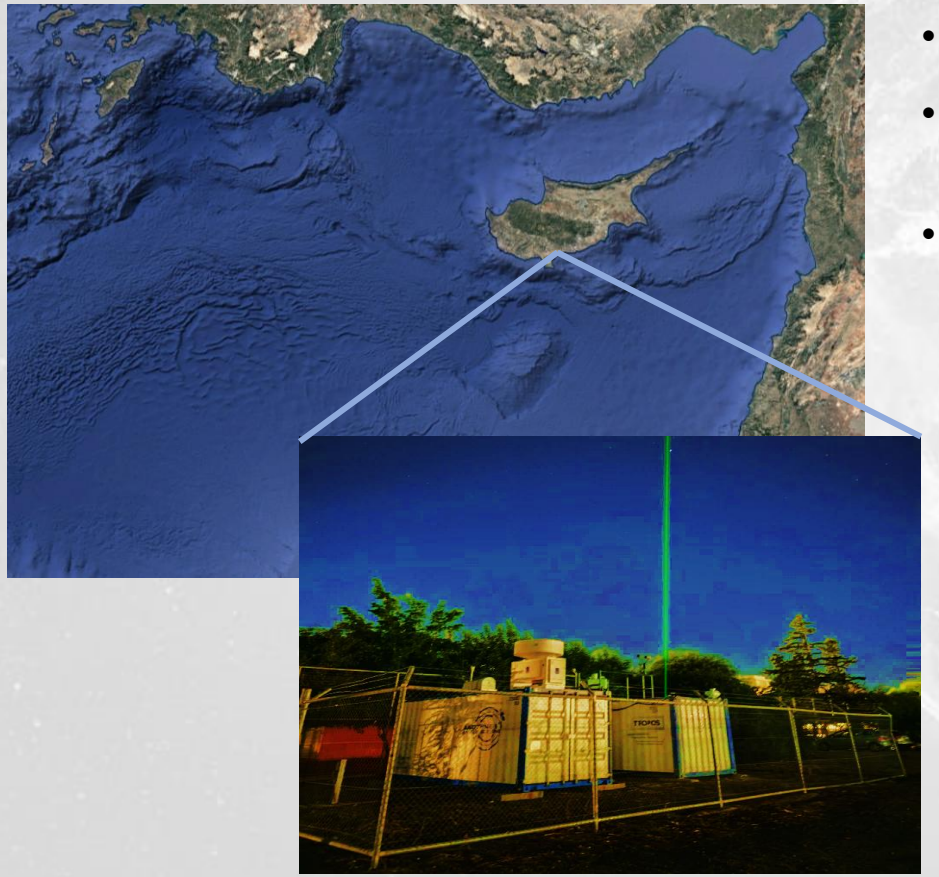
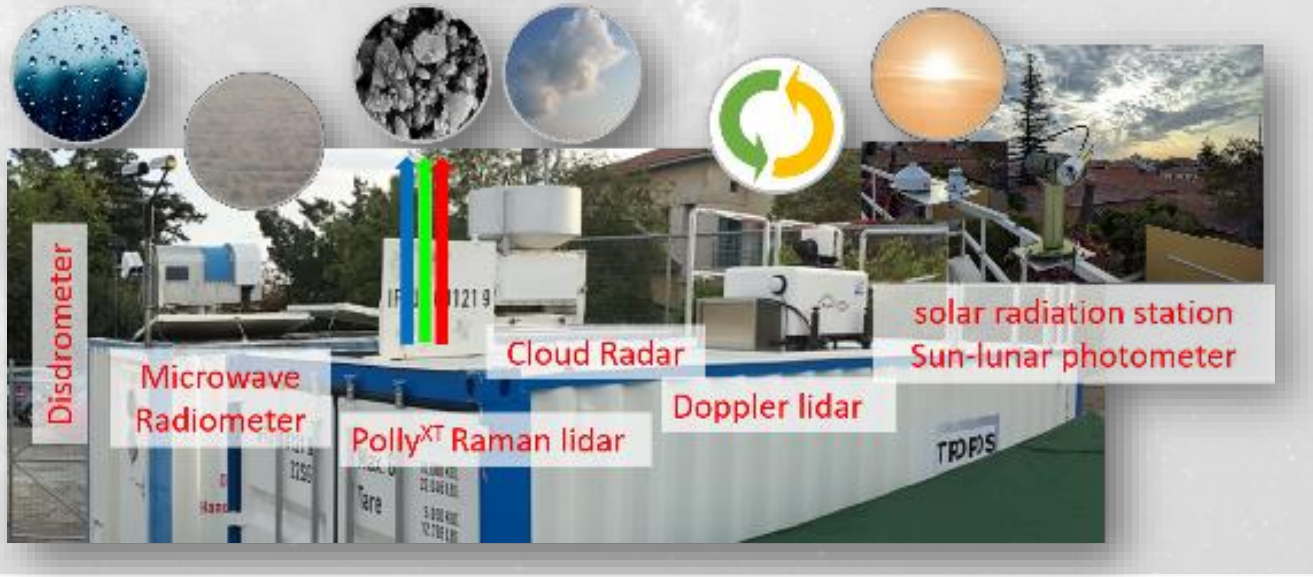
Cyprus Atmospheric Remote-Sensing Observatory (CARO) National Facility



- **Ground-based station located in Limassol**
- **Consists of an aerosol remote sensing (ARS) and a cloud remote sensing (CRS) observational platforms.**
- **Offers complete insights into the atmospheric dynamics, the aerosol load in the atmosphere, as well as the dynamics of the clouds.**



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Polly^{XT} Raman Lidar

→ Multi-wavelength lidar system used for detailed atmospheric profiling

→ It operates at 355, 532 and 1064 nm (day and night), capable of measuring the Raman-shifted molecular signals at 387, 407, 607 nm (only during the night)

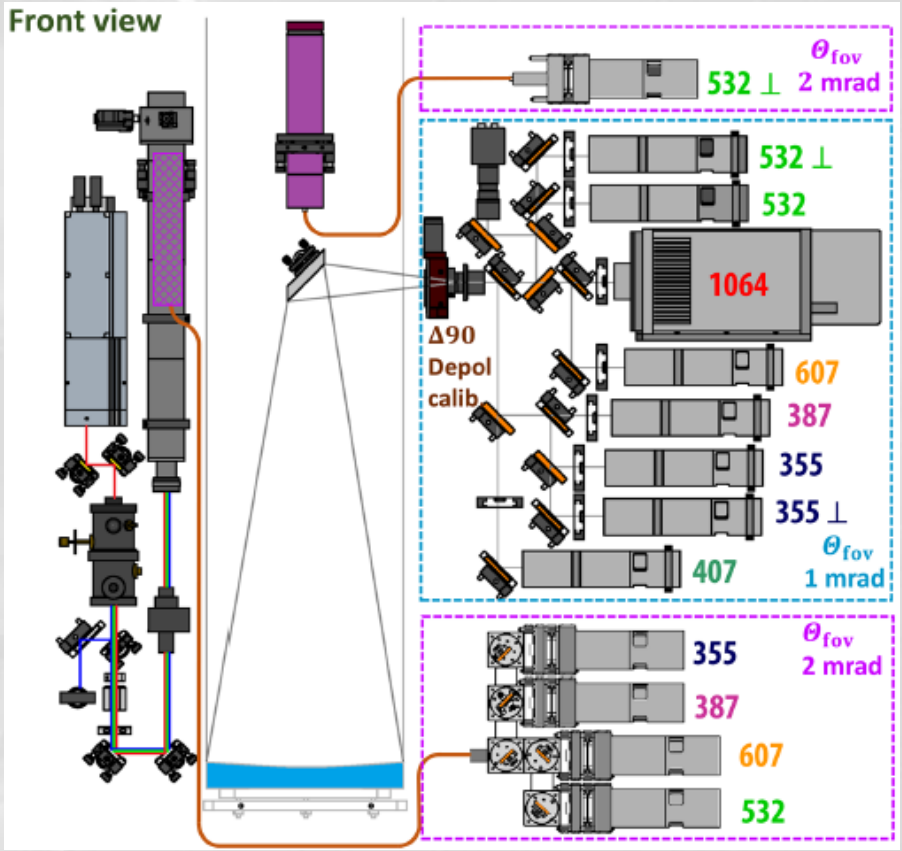
→ It can measure in two different field-of-views:

8 far-range channels (1mrad)

5 near-range channels (2mrad)

→ Derives the backscatter (β) and extinction (α) coefficients

→ Volume depolarization ratio (δ) at 355 and 532 nm



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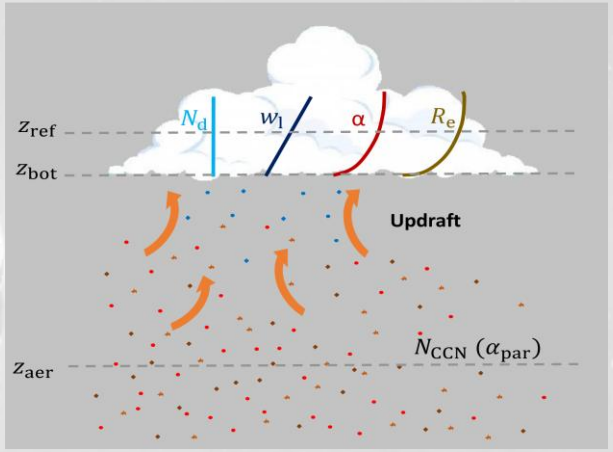
Dual-Field-of-View (DFOV) Polarization Lidar Technique

→ This method was developed by Jimenez C. et al., 2020a, 2020b, as a follow-up development of the DFOV Raman lidar technique (Schmidt et al., 2013).

Derives crucial information about the microphysical properties of liquid-water clouds, such as:

- Droplet number concentration (N_d)
- Effective radius of the droplets (R_e)
- Liquid Water Content (w_l)
- Cloud extinction coefficient (α)



→ Along with the synergistic use of a Doppler Lidar and by applying the POLIPHON method *(Mamouri and Ansmann, 2014, 2016),* the impact of the vertical wind and of the aerosol type on the microphysical properties of the droplets in the cloud base region of liquid water clouds can be studied extensively.

Therefore, this method can significantly contribute to Aerosol-Cloud Interaction (ACI) studies that, according to the latest IPCC report, still remain one of the most uncertain radiative forcing parameters.

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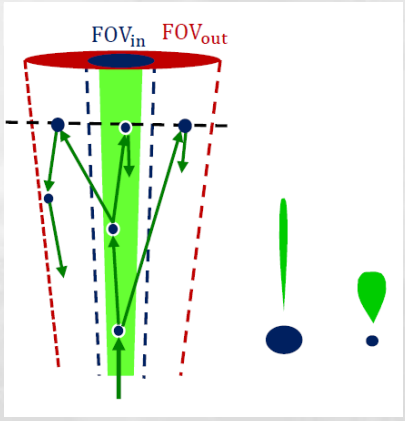

When the lidar beam enters the cloud, it enters a region where multiple scatterings occur due to the presence of droplets

↓

The light gets backscattered from greater angles as well

↓

The plane of the electric field changes → **The polarization of the received light is different!!**

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Dual-Field-of-View (DFOV) Polarization Lidar Technique

→ By using the second telescope with the wider Field-of-View we are able to detect and record these multiple scatterings.

→ Use of 532 nm (total and cross) channels of both FOVs to determine the depolarization that each one records.

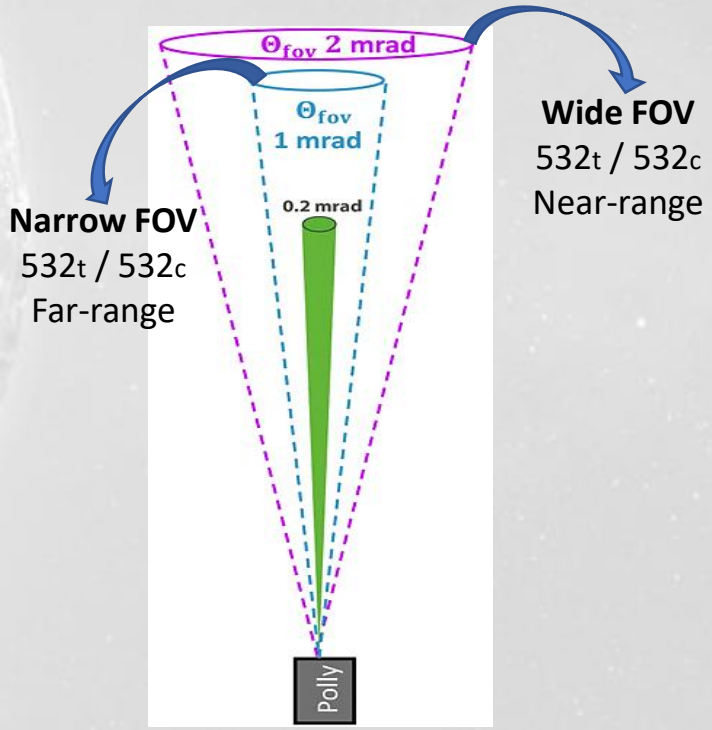
$$\overline{\delta}_{rat} = \frac{\delta_{in}}{\delta_{out}}$$

$$R_e(z_{ref}) = R_0 + R_1 \times \overline{\delta}_{rat} + R_2 \times \overline{\delta}_{rat}^2 + R_3 \times \overline{\delta}_{rat}^3$$

$$\alpha(z_{ref}) = \alpha_0(R_e, z_{bot}) + \alpha_1(R_e, z_{bot}) \times \overline{\delta}_{in} + \alpha_2(R_e, z_{bot}) \times \overline{\delta}_{in}^2$$

$$w_l(z_{ref}) = \frac{2}{3}\rho_w \alpha R_e$$

$$N_d(z_{ref}) = \frac{1}{2\pi k}\alpha R_e^{-2}$$



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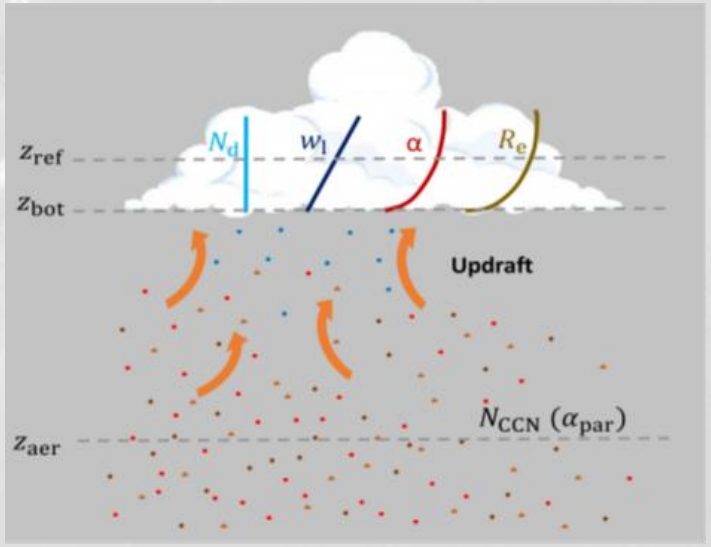

Aerosol-Cloud Interaction (ACI) parameter

$$E_{ACI,\alpha_{par}}(N_d, \alpha_{par}) = \frac{dlog(N_d)}{dlog(\alpha_{par})}$$

$$E_{ACI,N_{CCN}}(N_d, N_{CCN}) = \frac{dlog(N_d)}{dlog(N_{CCN})}$$

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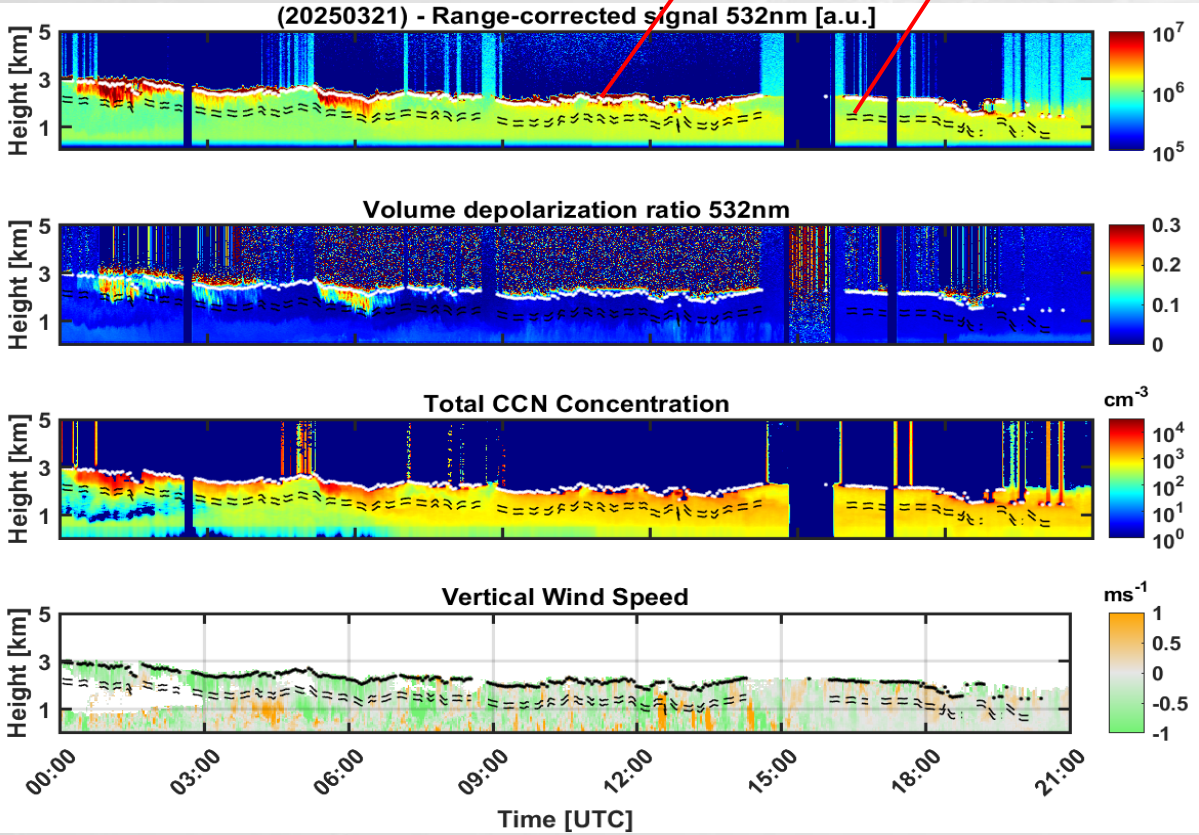
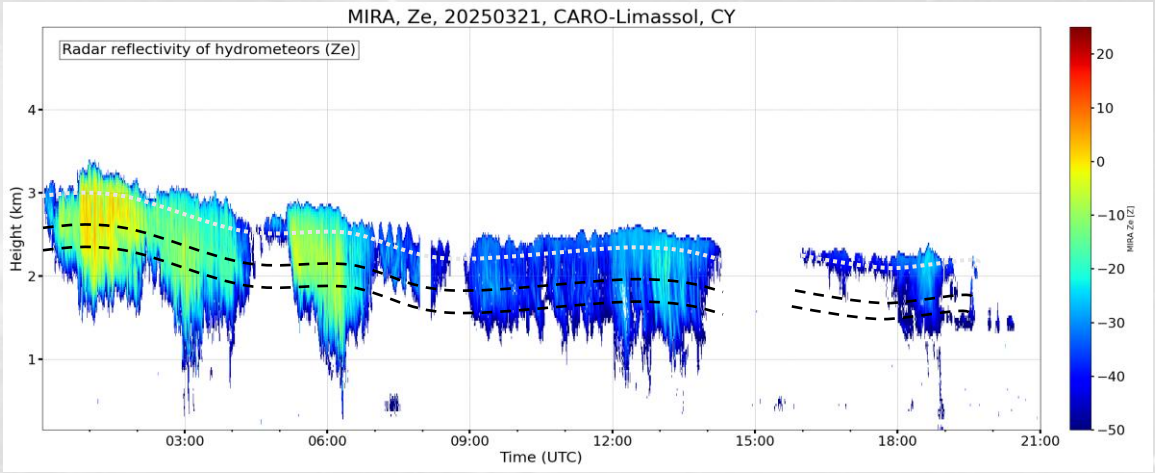
CBH ~ 2-3 km
T ~ -5 °C

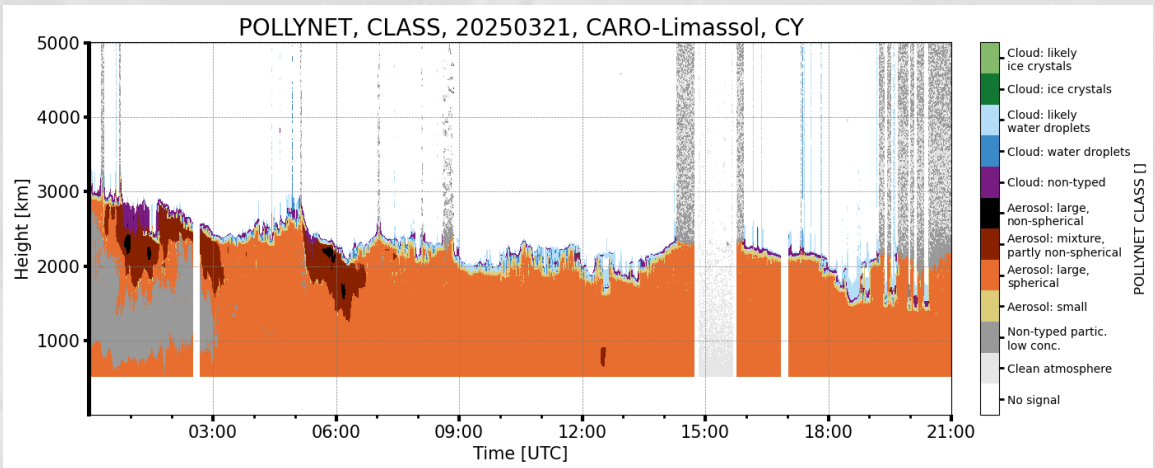
Averaging
Heights: 700 – 900 m
RH : 60 – 80%

Cyprus Cases

21 Mar. 2025 – marine particles & local pollution







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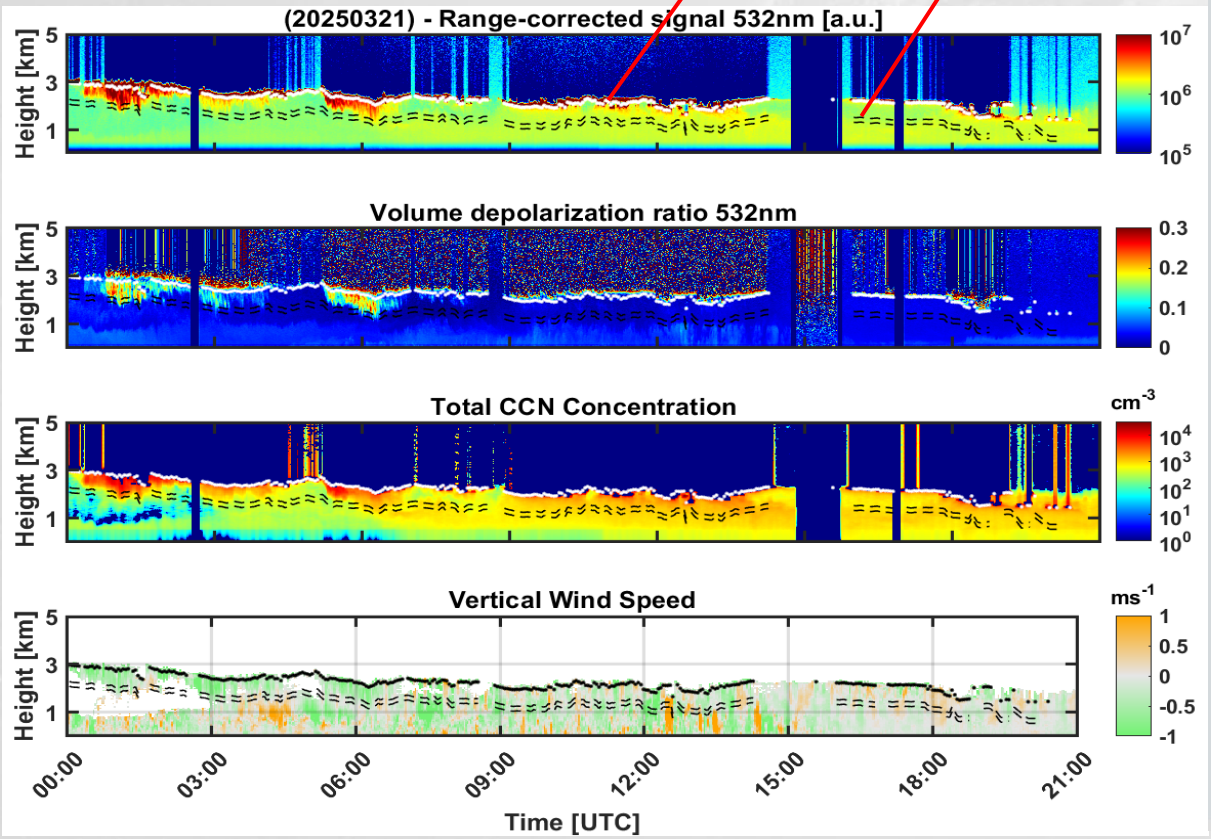

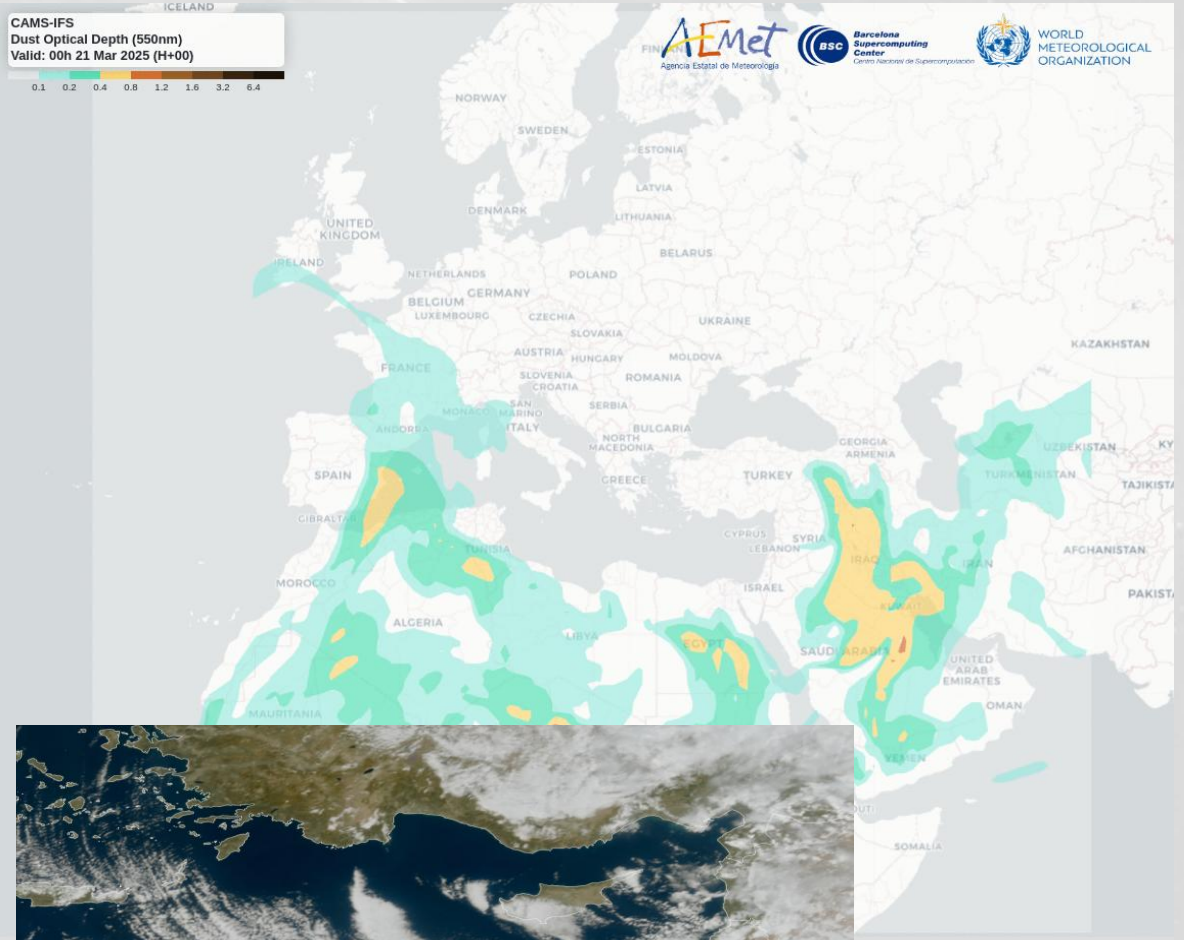

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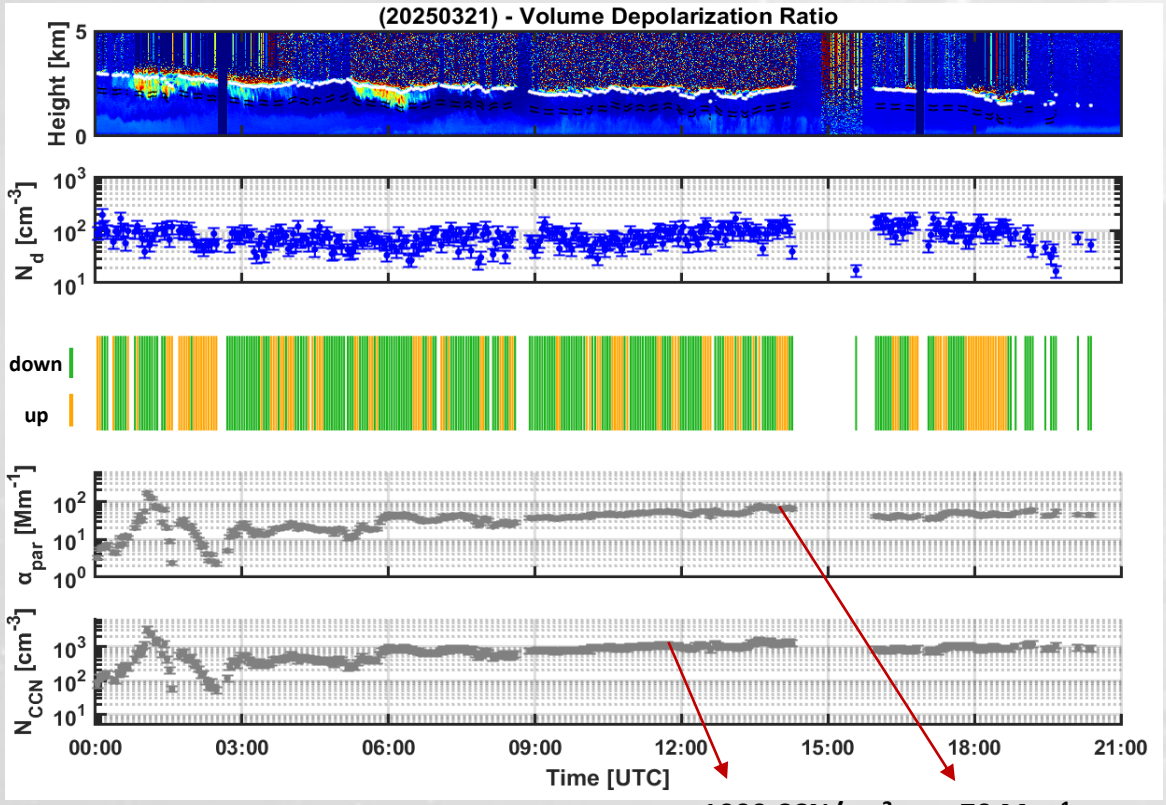
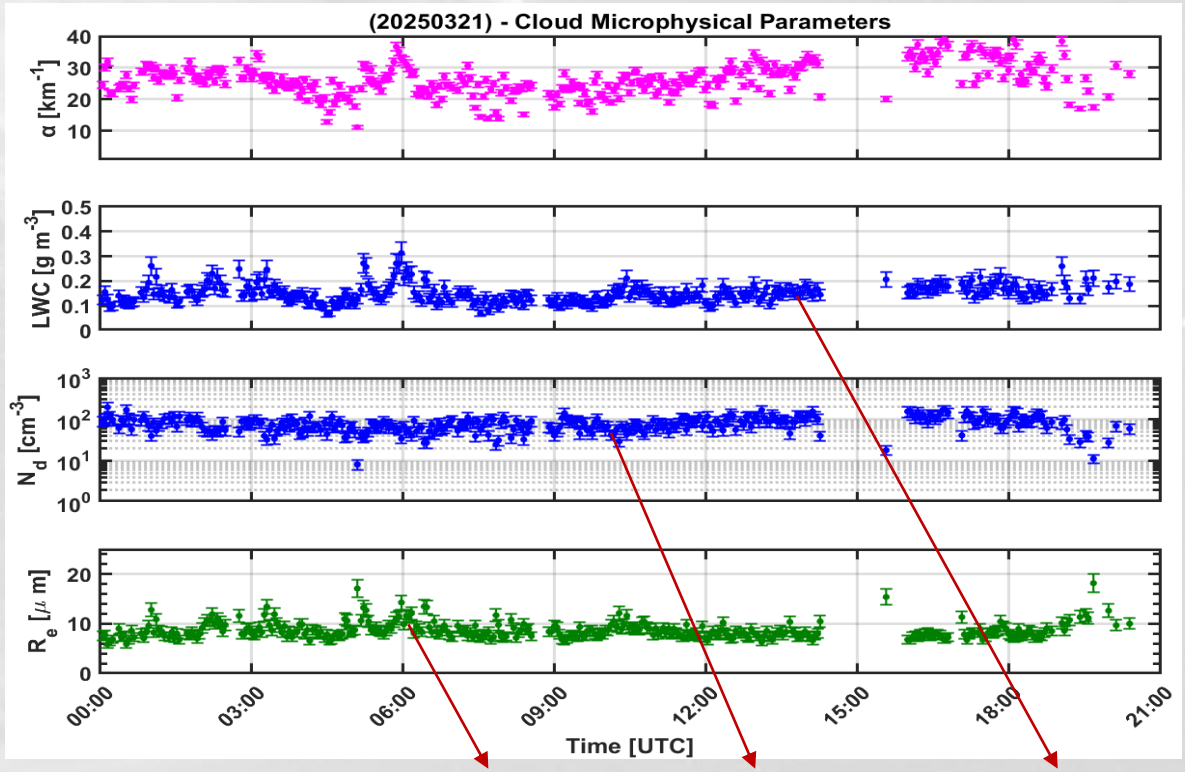


~ 1000 CCN/cm³ ~ 70 Mm⁻¹



~ 10 μm < 100 cm⁻³ 0.1-0.2 g/m³

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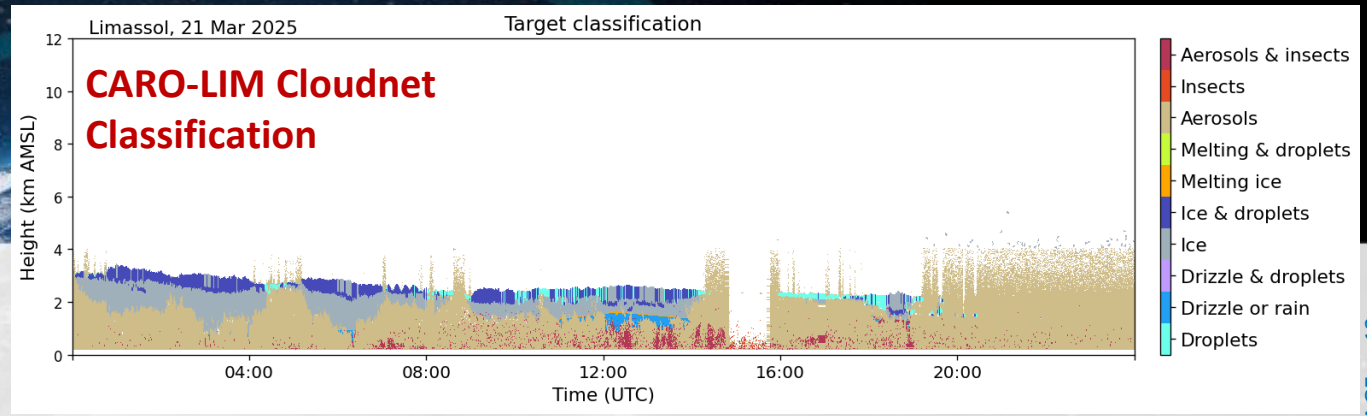

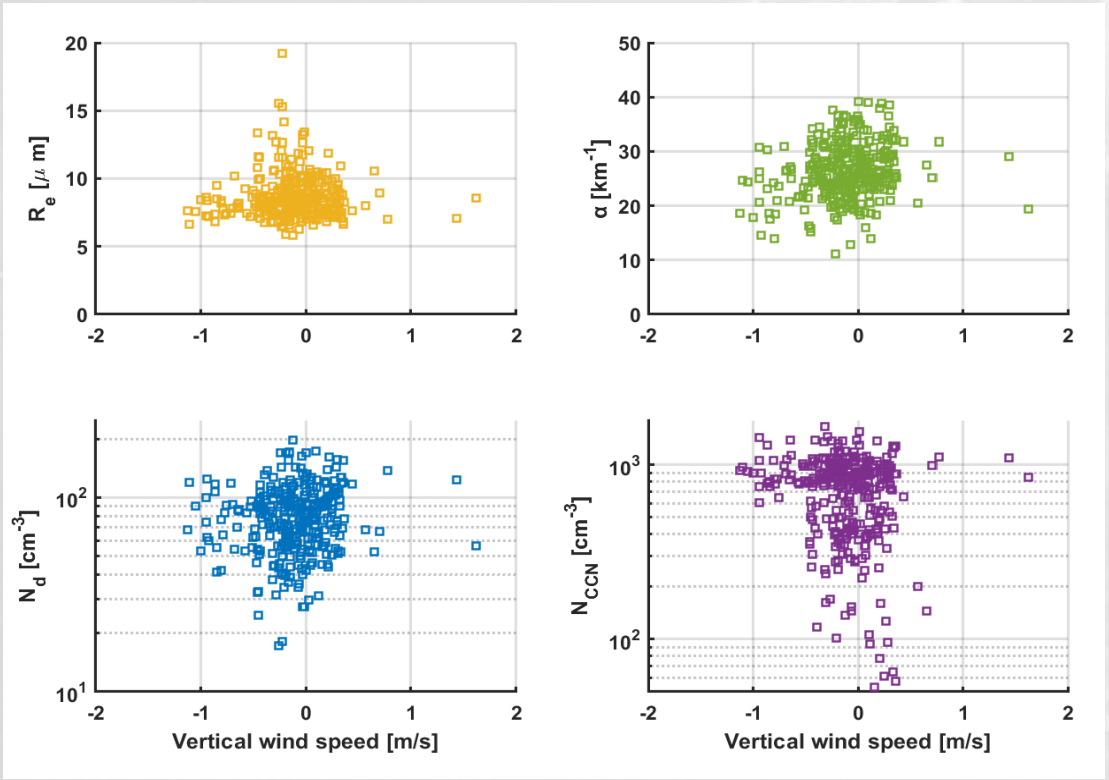

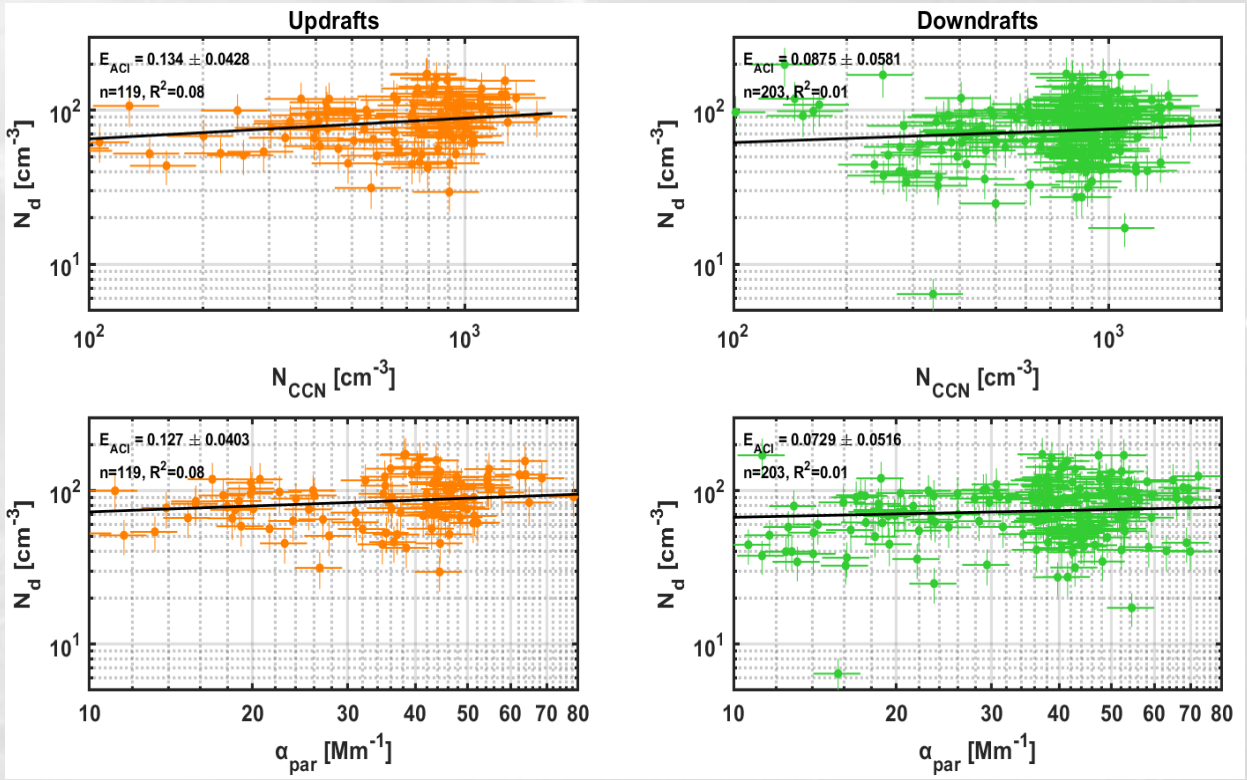

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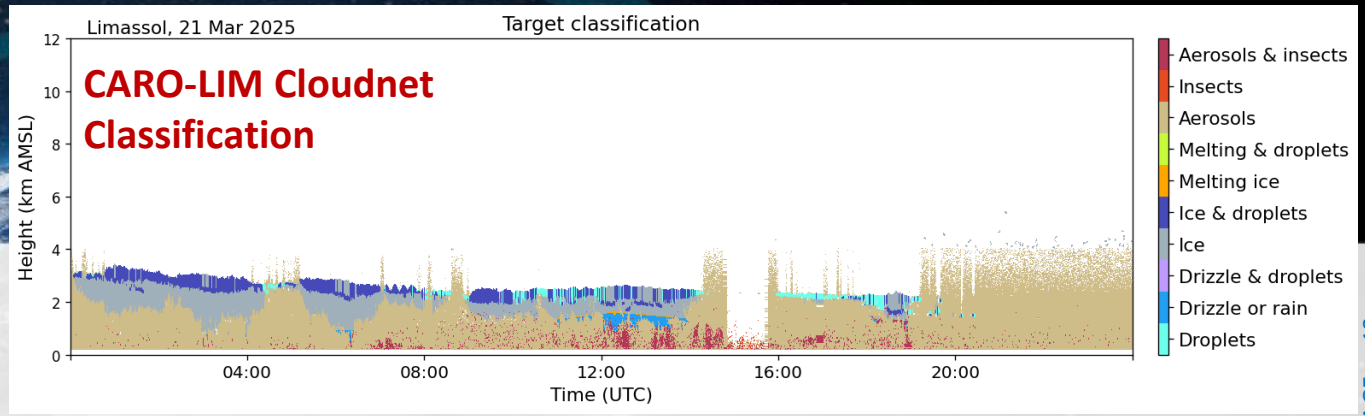

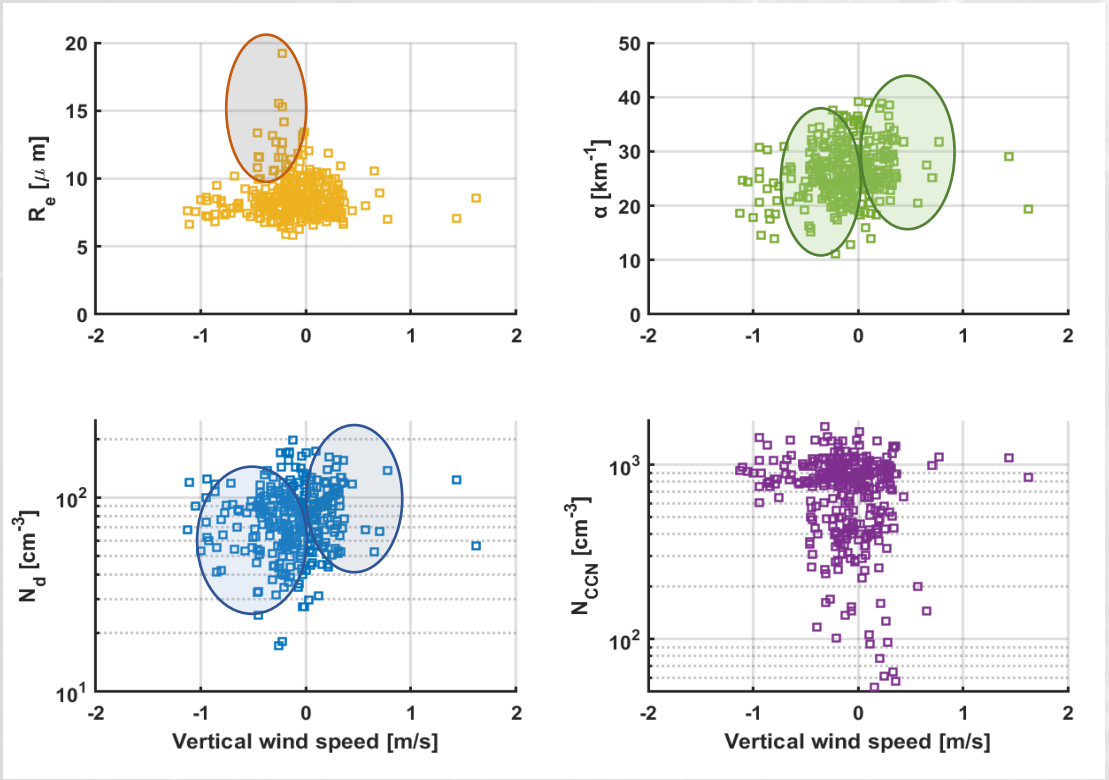

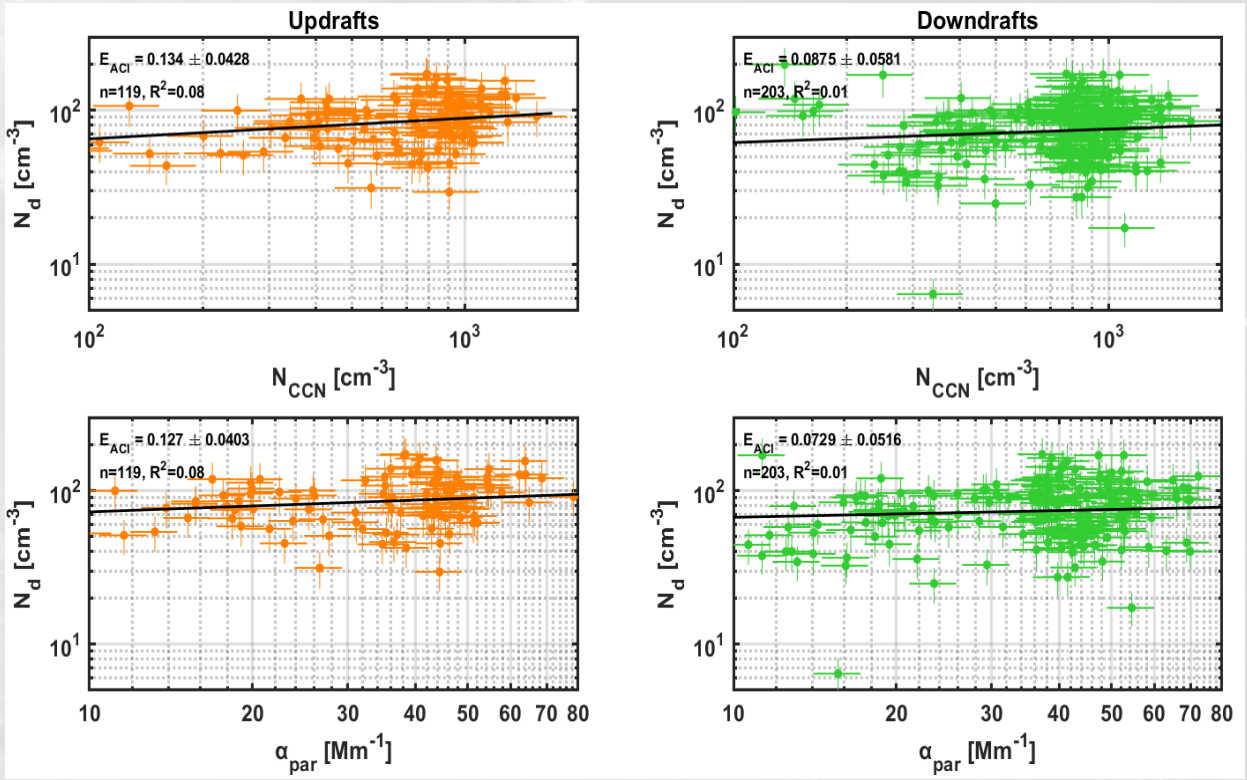

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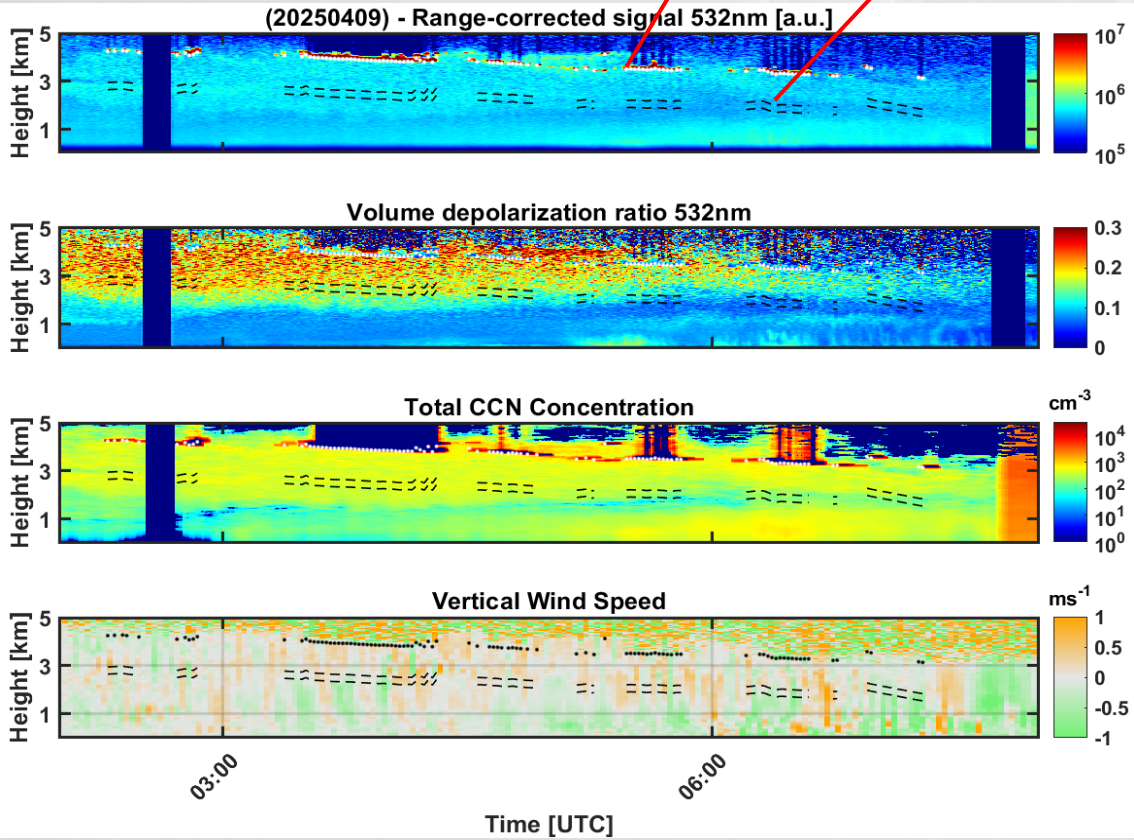
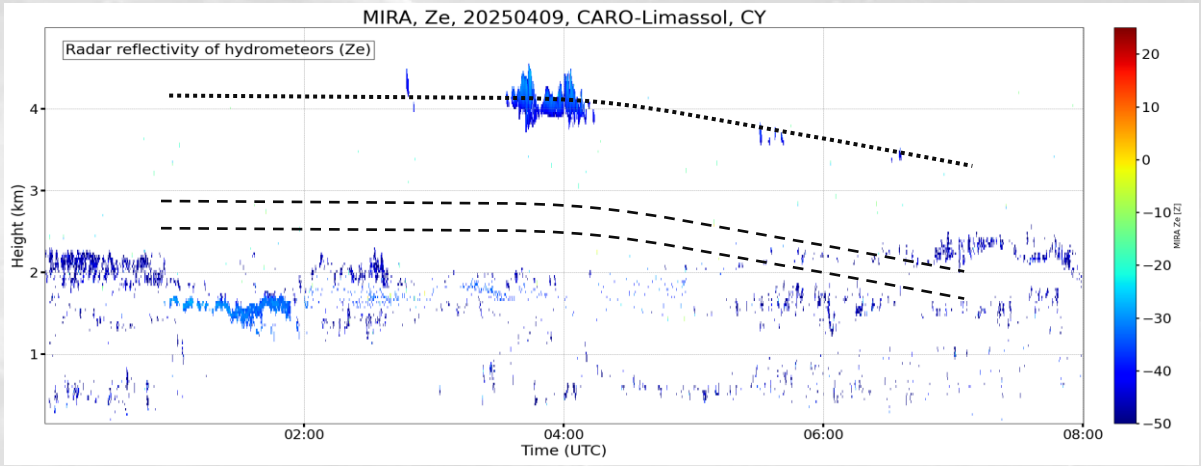
CBH ~ 3-4 km
T ~ -5 °C

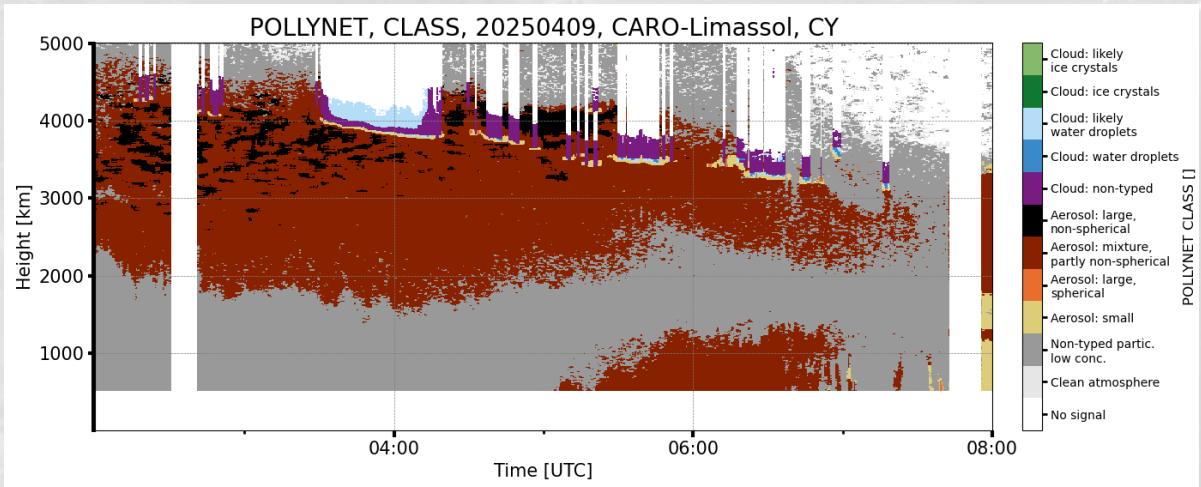
Averaging
Heights: 1400 – 1100 m
RH < 50%

Cyprus Cases

09 Apr. 2025 – Presence of Saharan Dust







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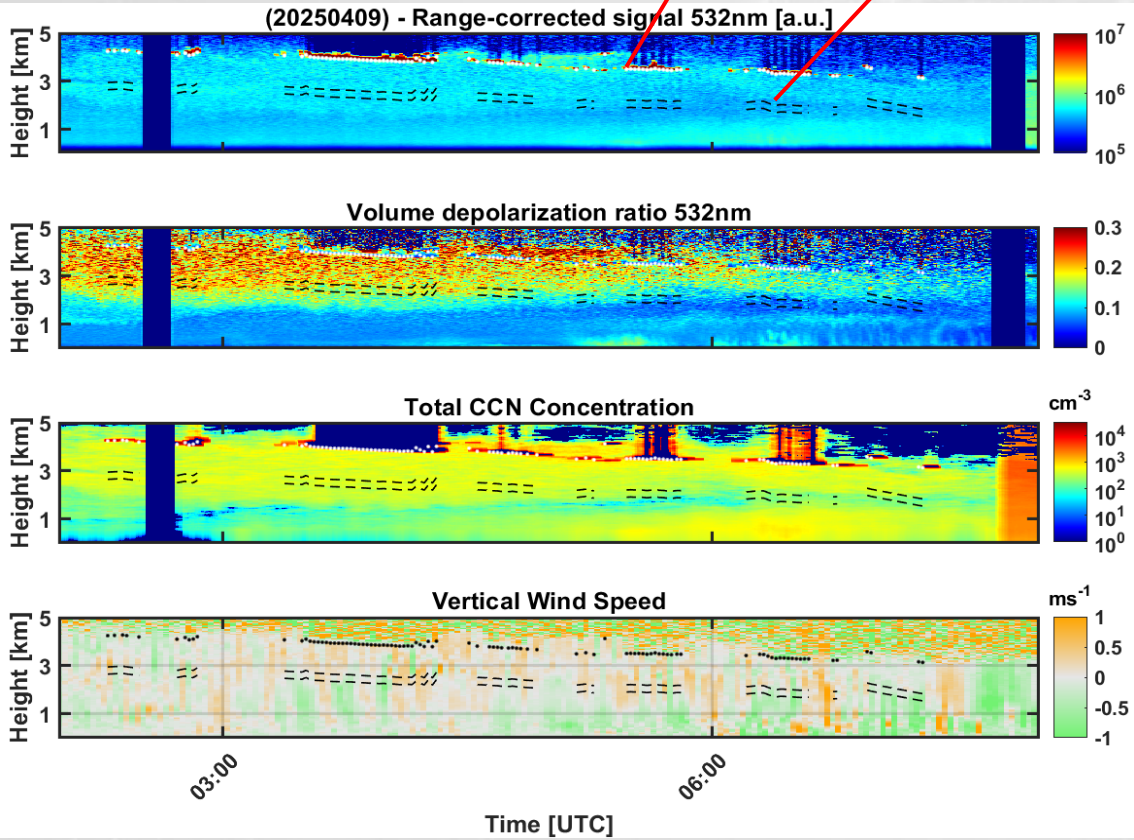

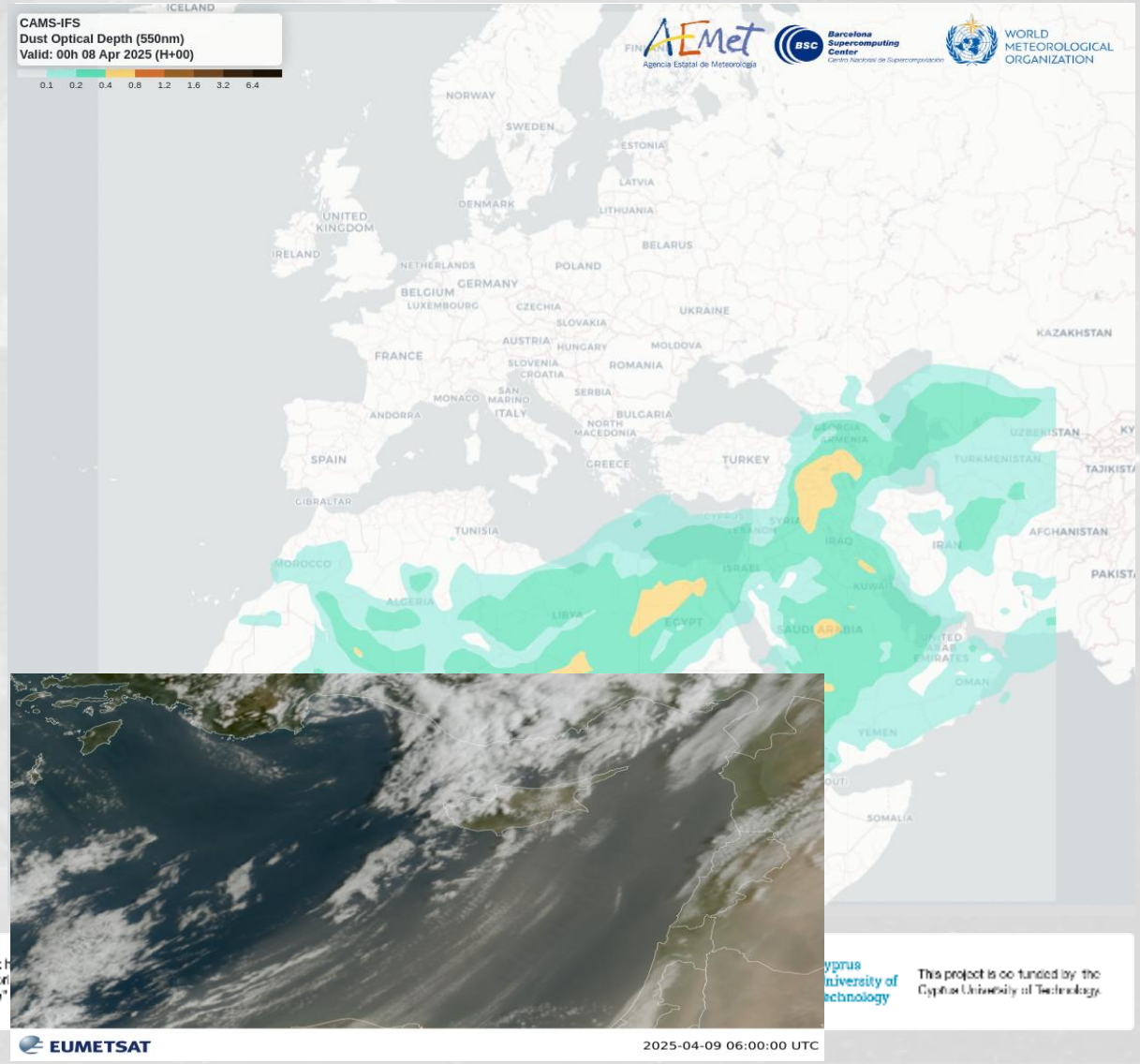

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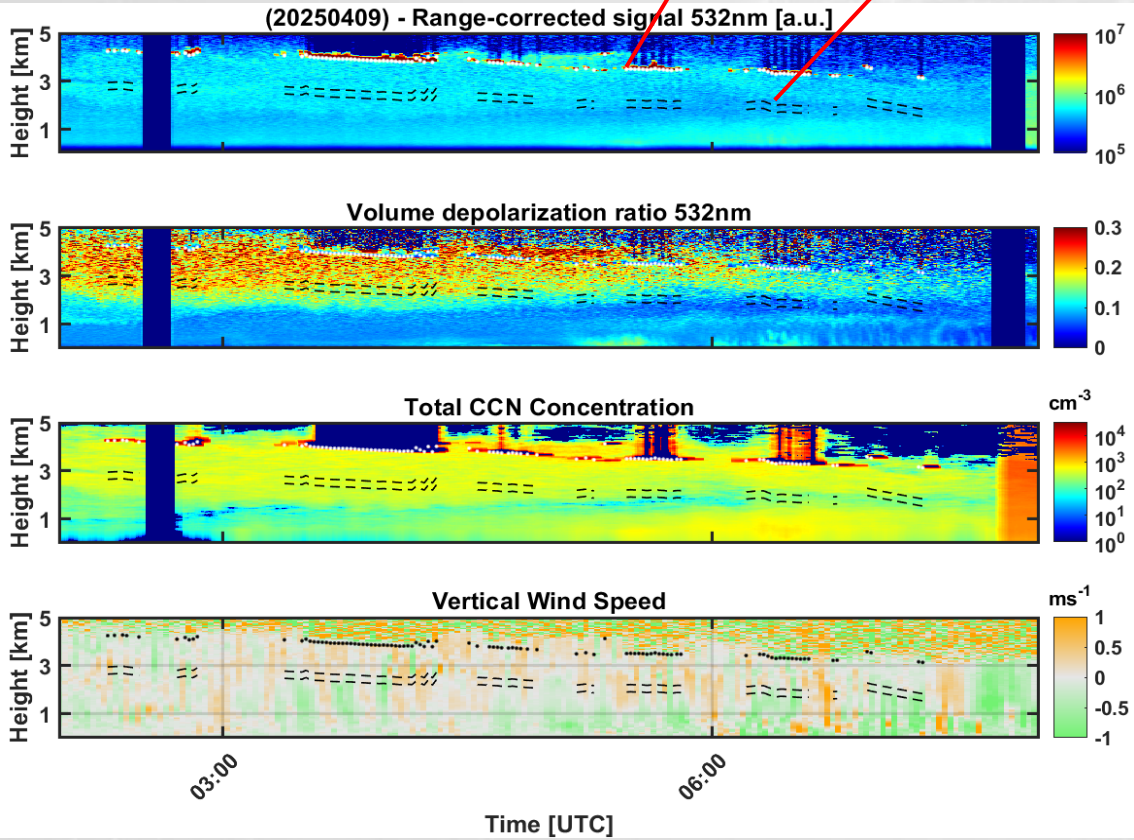

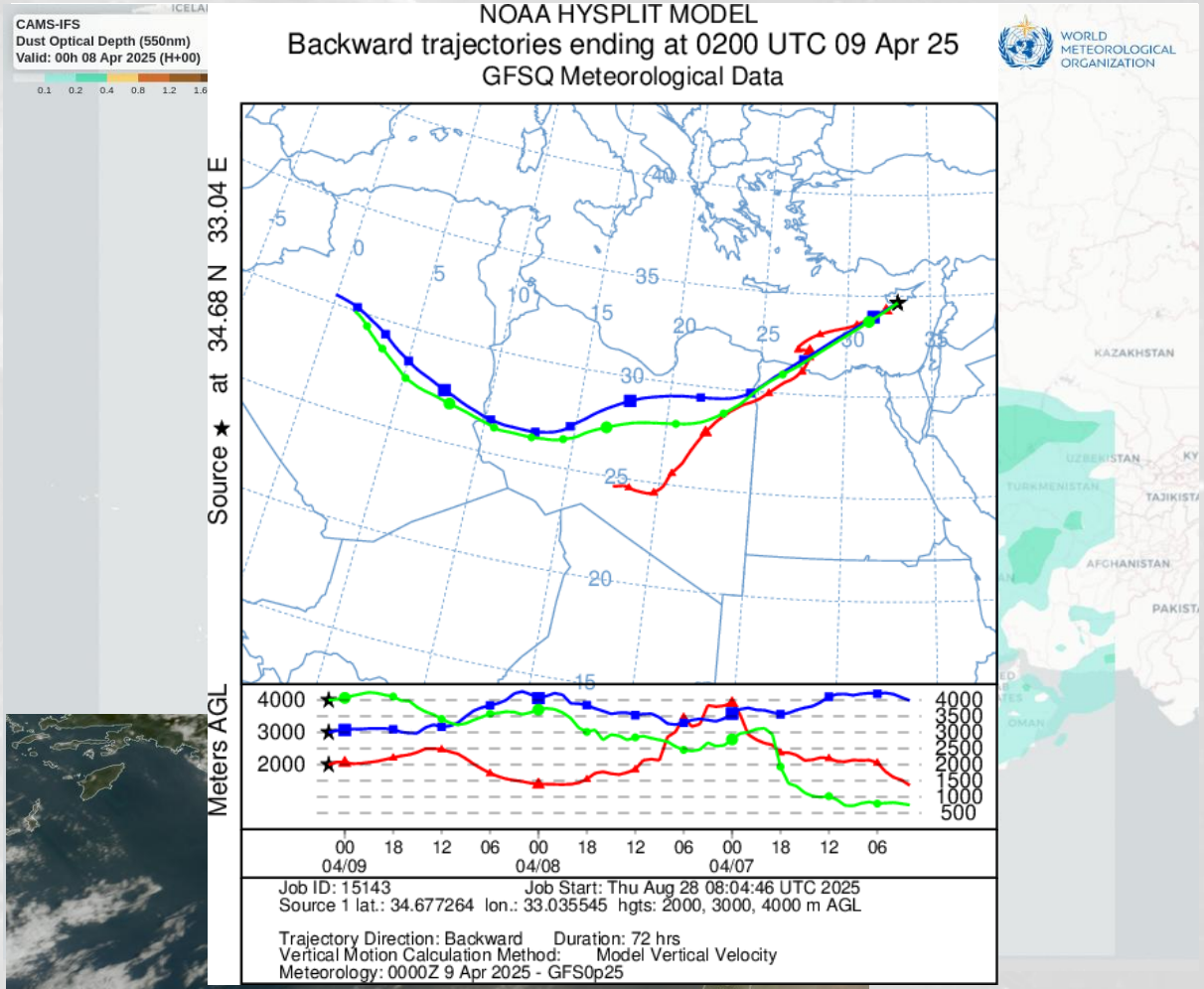

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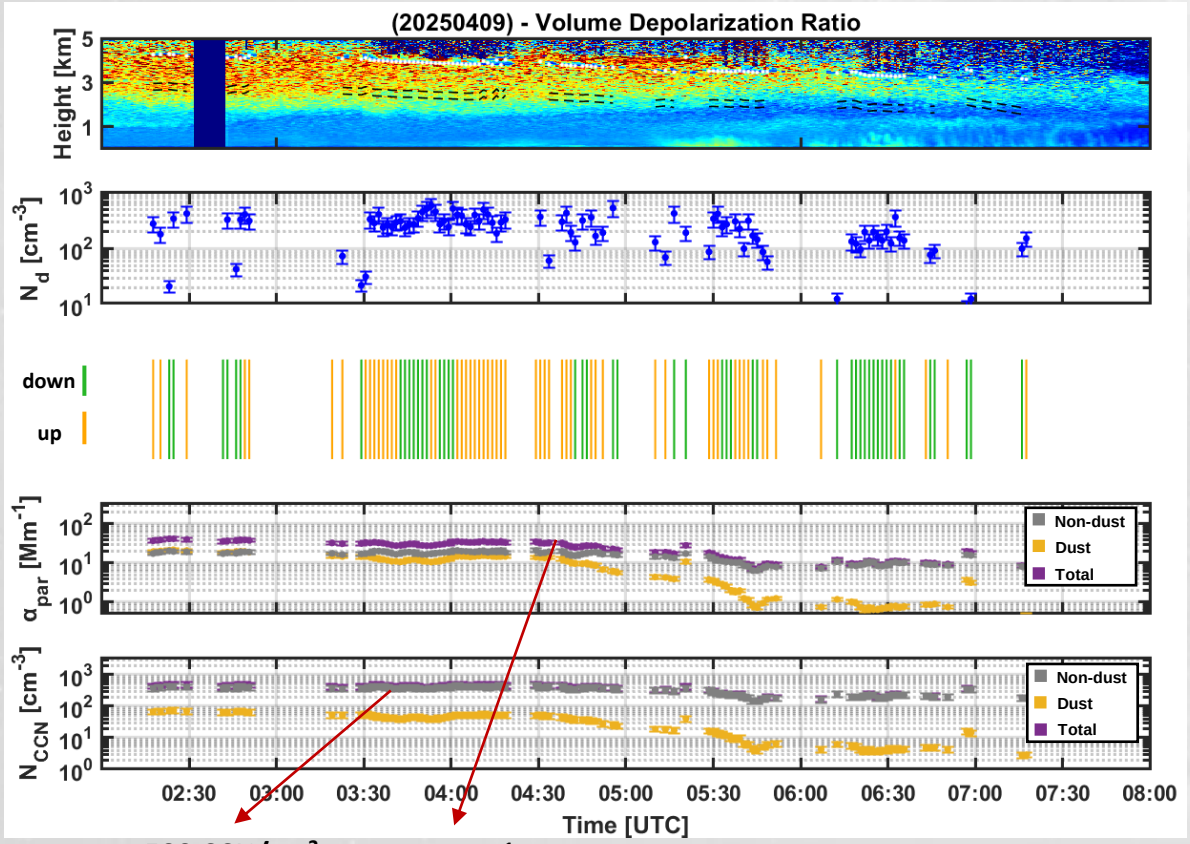
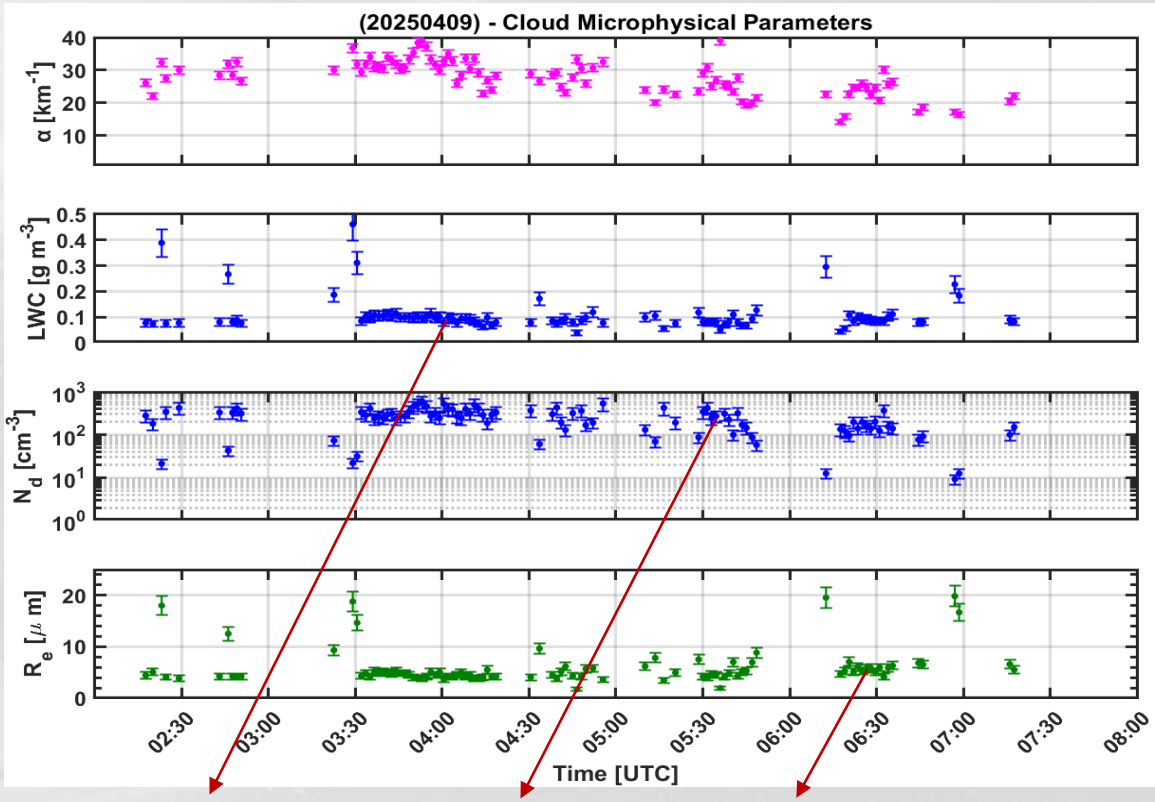


~ 500 CCN/cm^3 ~ 40 Mm^{-1}



~ 0.1 g/m^3 > 100 cm^{-3} ~ 5 µm

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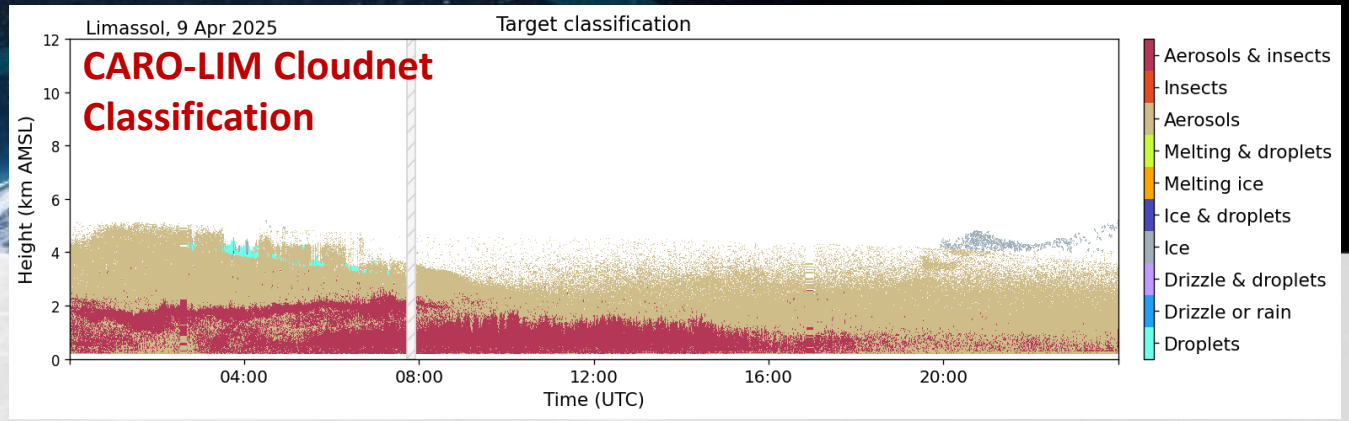

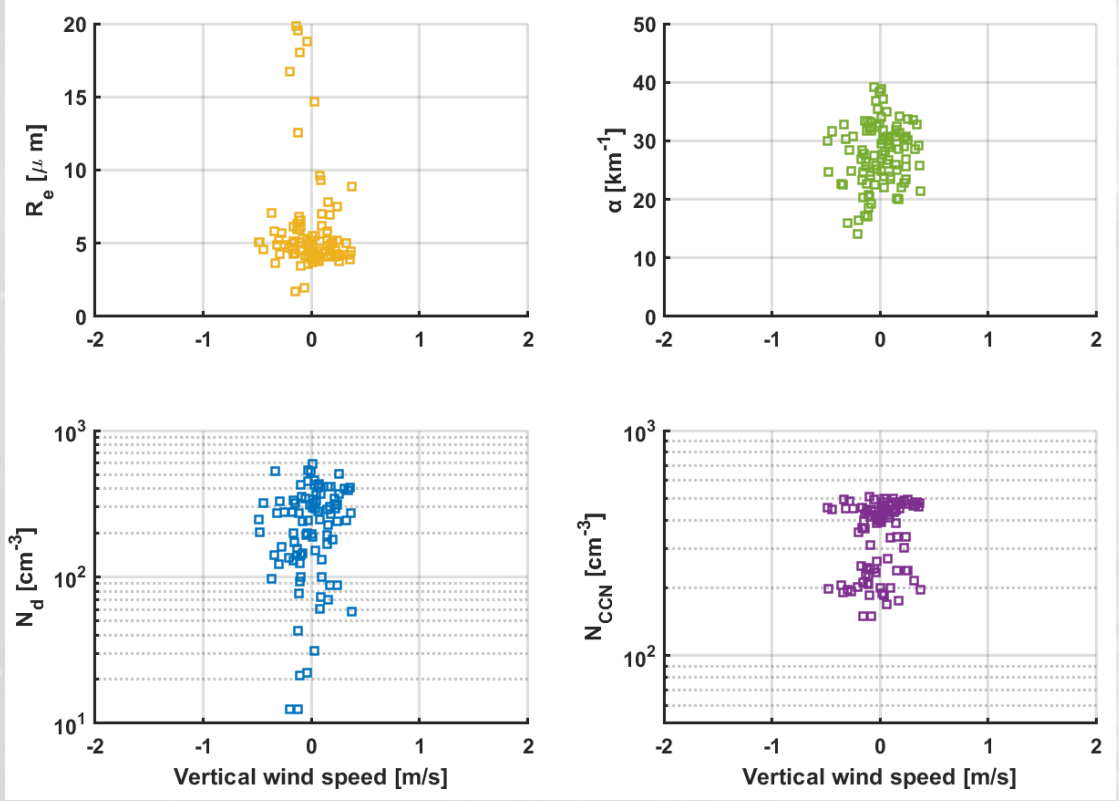

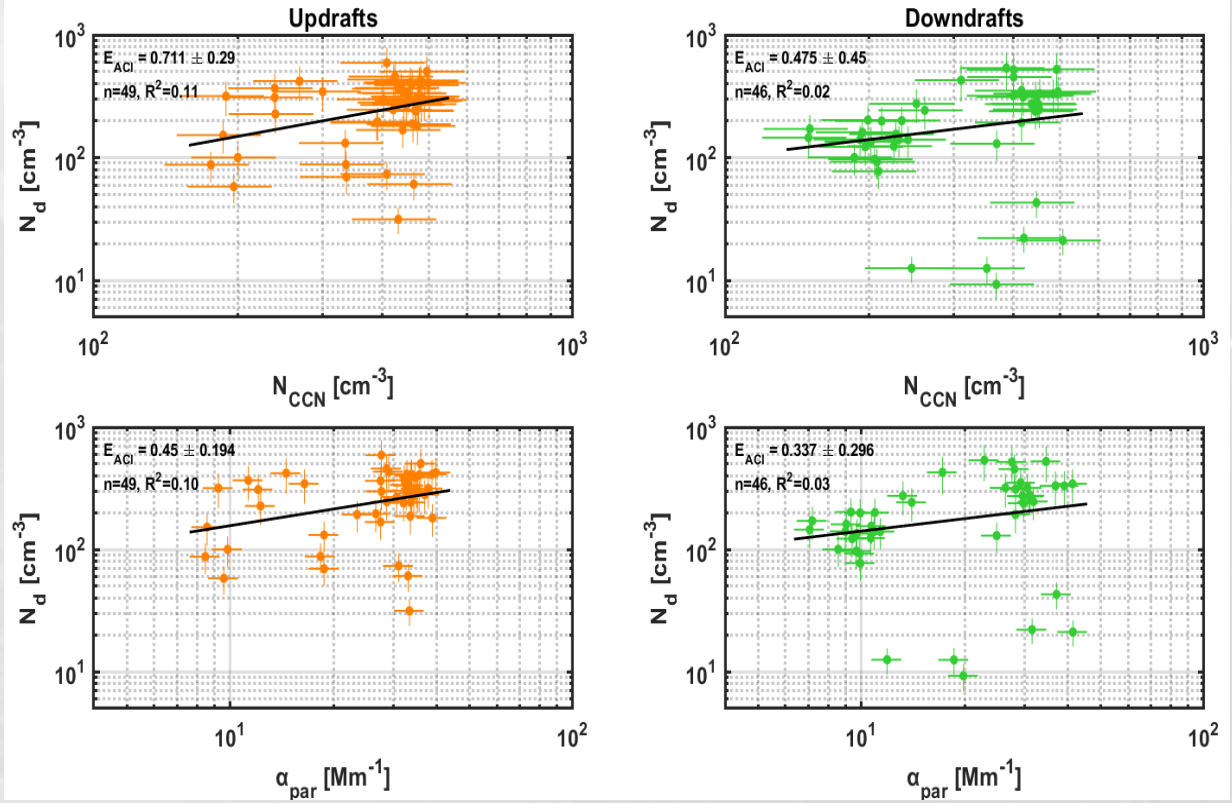

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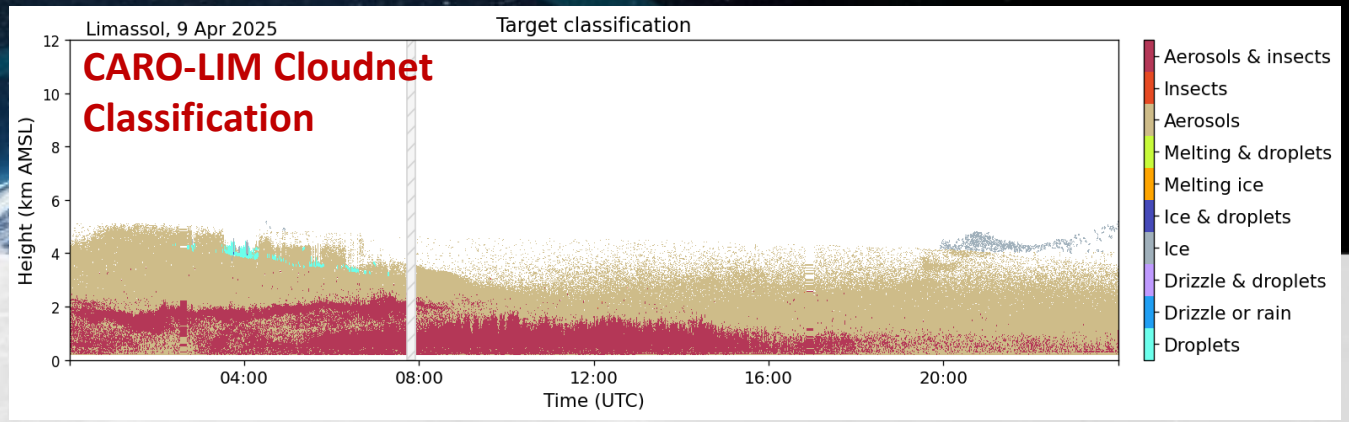

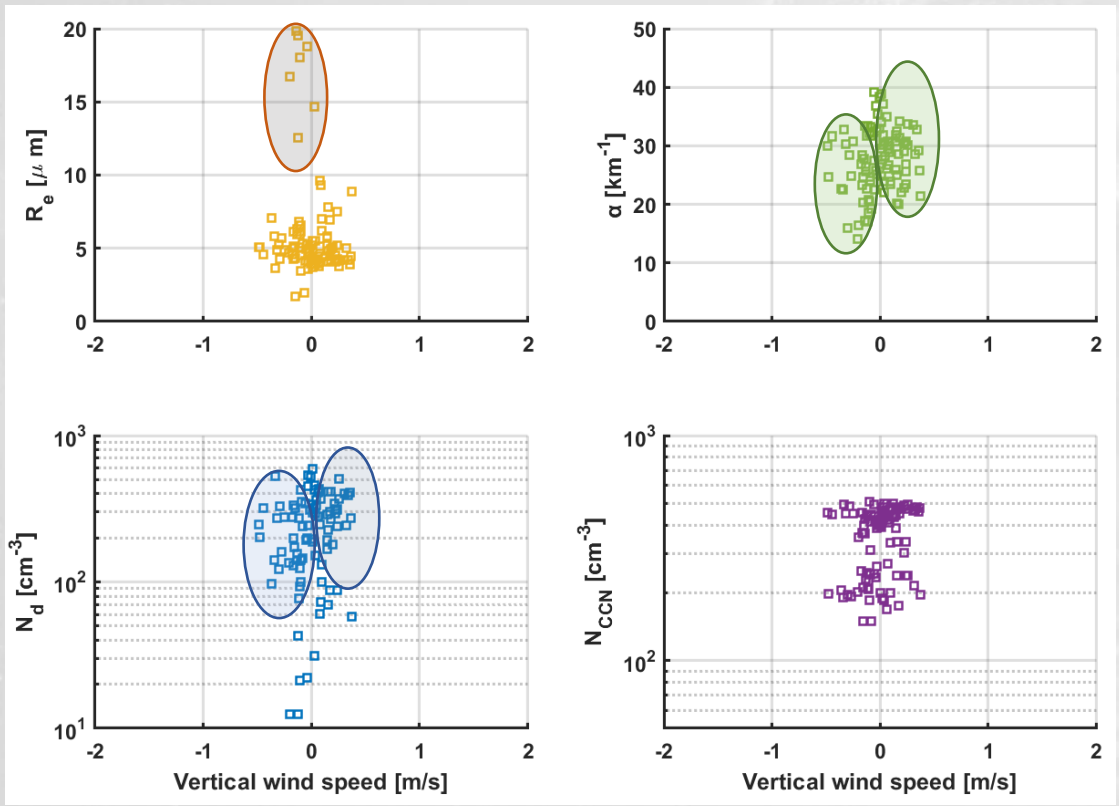

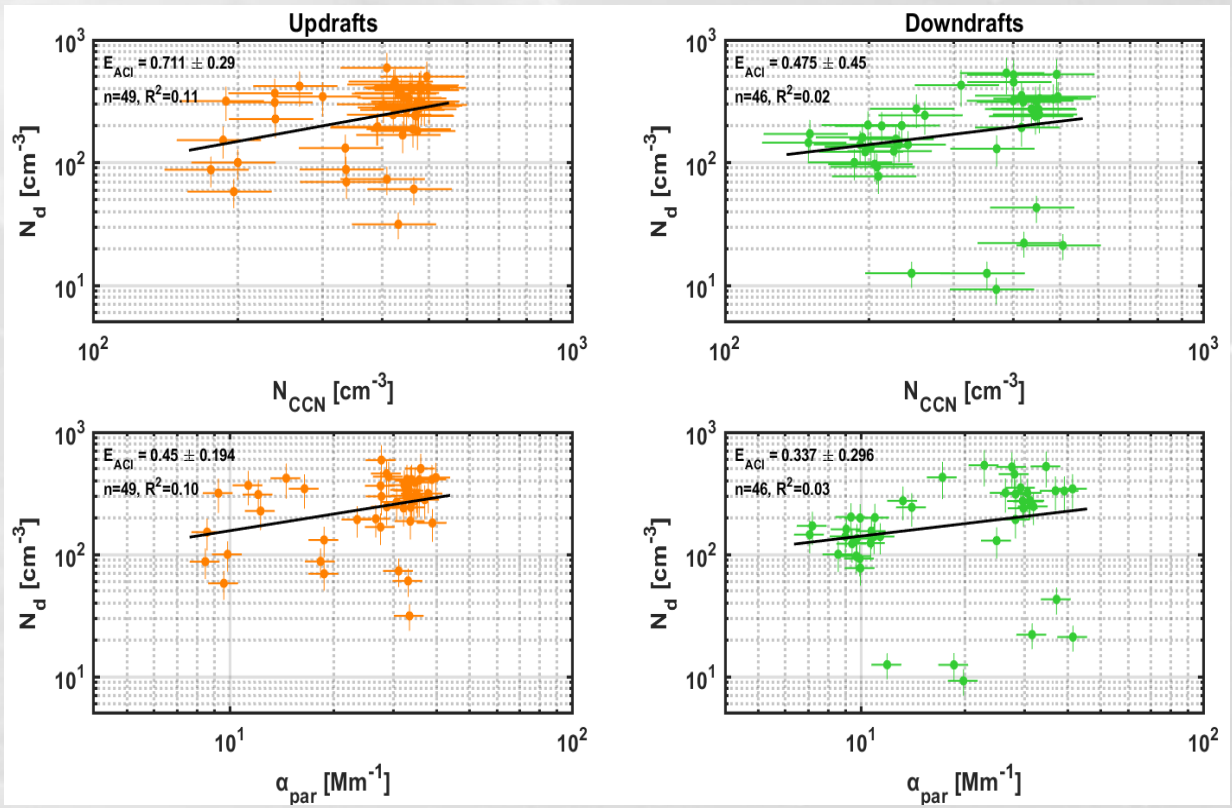

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Conclusions

→ The DFOV Depolarization approach gives crucial and in-detail information of the aerosol-cloud interactions, just by using lidar products

→ In general, smaller droplets were found in dust cases, as well as higher droplet number concentration (N_d)

→ The way that the behaviour of the vertical wind (updrafts or downdrafts) affects droplet generation needs to be further studied, so general conclusions cannot be drawn on the relationship between N_d and N_{CCN} /α_{par} at this stage, but these preliminary results of the E_{ACI} suggest that the vertical wind plays a non-negligible role in droplet formation processes and that dust acts as an efficient CCN.

Cloud Microphysical Parameter	Marine Case	Dust case
α [km^{-1}]	20 – 30	20 – 40
LWC [g/m^3]	0.1 – 0.2	< 0.1
N_d [cm^{-3}]	~ 100	>> 100
R_e [μm]	~ 10	~ 5

ACI Parameter	$E_{ACI,N_{CCN}}(N_d, N_{CCN})$	$E_{ACI,\alpha_{par}}(N_d, \alpha_{par})$
Marine Case	0.134 ± 0.0428	0.127 ± 0.0403
	0.0875 ± 0.0581	0.0729 ± 0.0516
Dust Case	0.711 ± 0.290	0.450 ± 0.194
	0.475 ± 0.450	0.337 ± 0.296

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Thank you!!

contact@eratosthenes.org.cy

eratosthenes.org.cy

@ERATOSTHENESCoE / #ERATOSTHENESCoE

ADDRESS
82, Franklin Roosevelt,
3012, Lemesos, Cyprus

CONTACT US
+357 25 002 908

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