

Introduction

The Eastern Mediterranean, particularly Cyprus, is influenced by the transport of air masses from the Sahara Desert and the Arabian Peninsula. Many studies have shown that some optical and microphysical characteristics of these two aerosol types differ.

The main objective of the present study is to investigate the optical and the microphysical characteristics of desert dust from both regions with the synergy of Polarization Polly^{XT} Raman Lidar and the Cimel sun/sky photometer.

The analysis is performed utilizing the Generalized Retrieval of Atmosphere and Surface Properties (GRASP) algorithm. GRASP is a highly flexible inversion algorithm applicable in a variety of domains, including observations from both active and passive remote sensing methods. The algorithm is based on the general principles of numerical inversion and atmospheric radiation modelling. Lopatin et al. (2013, 2021) first proposed the application of the GRASP algorithm, utilizing the synergy between multi-wavelength Lidar and the Aerosol Robotic Network (AERONET) sun/sky photometer observations.

Methodology & Data

Aerosol observations from the Polly^{XT} Polarization Raman Lidar and the CUT-TEPAK AERONET (Aerosol Robotic NETWORK) sun/sky photometer of the Cyprus Atmospheric Remote Sensing Observatory National facility (CARO NF) of ERATOSTHENES Centre of Excellence provide the vertical aerosol characteristics to the algorithm, while the sun photometer provides constraints on the quantity and type of aerosol. Saharan and Arabian Dust-dominated cases were analyzed with GRASP algorithm and compared with measurements from the instruments.

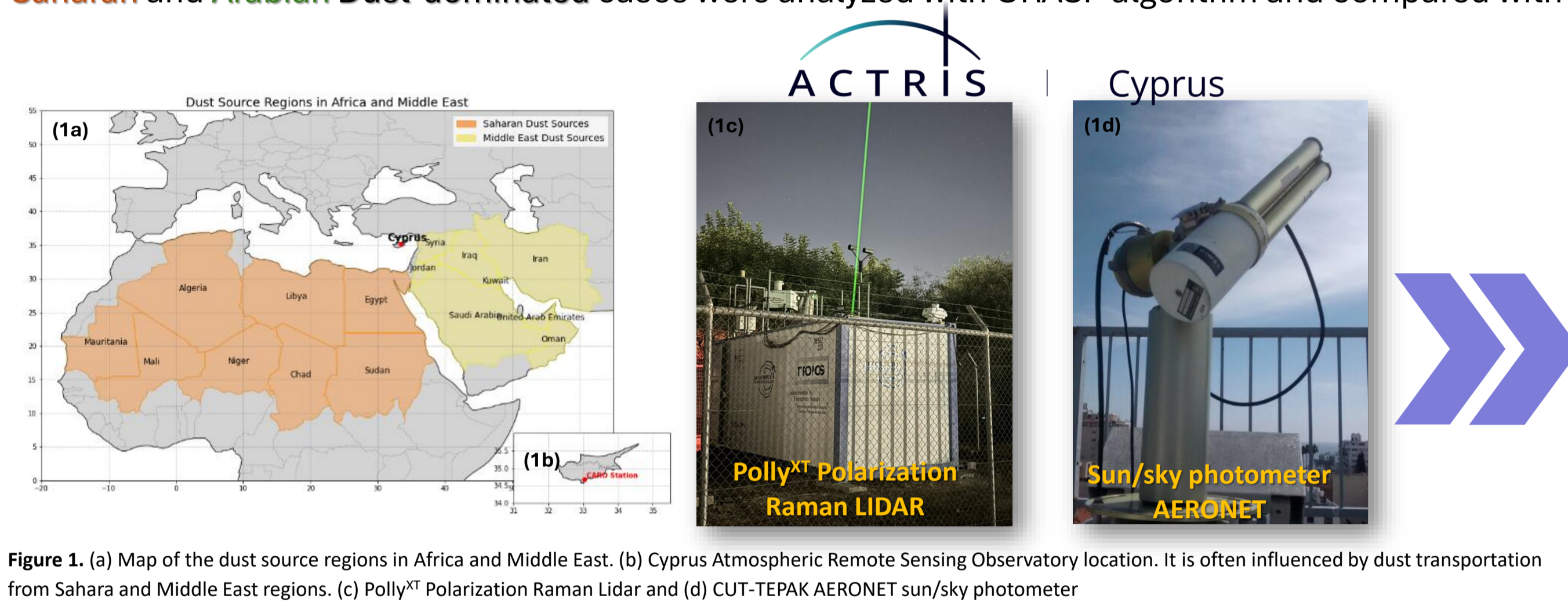


Figure 1. (a) Map of the dust source regions in Africa and Middle East. (b) Cyprus Atmospheric Remote Sensing Observatory location. It is often influenced by dust transportation from Sahara and Middle East regions. (c) Polly^{XT} Polarization Raman Lidar and (d) CUT-TEPAK AERONET sun/sky photometer

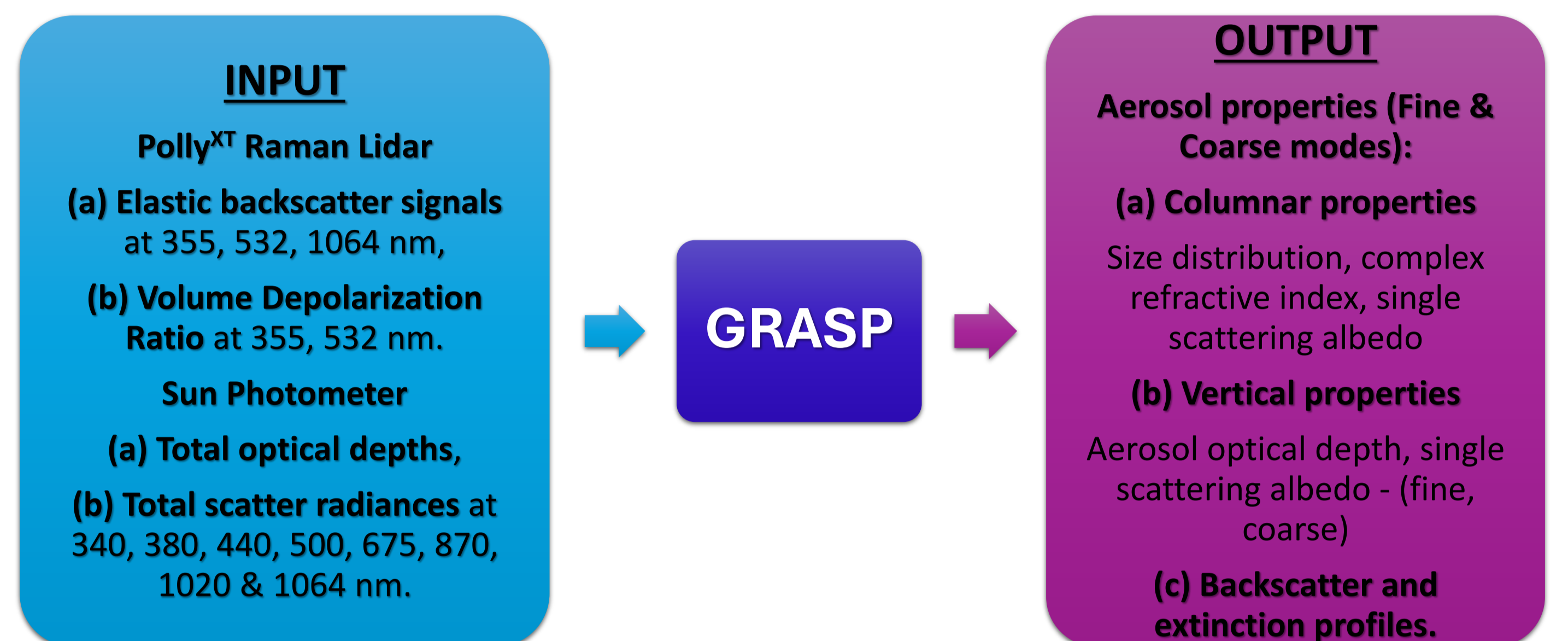


Figure 2: Input and output of the GRASP algorithm.

Results

Saharan DUST Case 25 May 2025

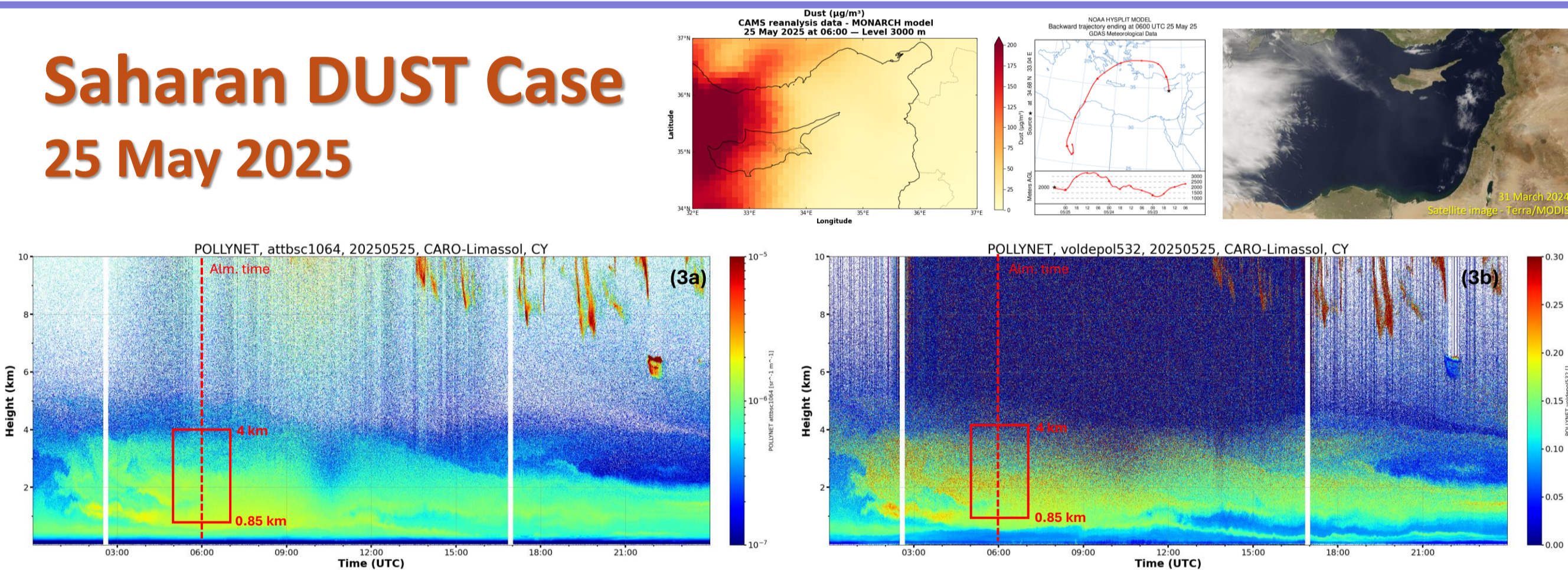


Figure 3: PollyXT lidar (a) Attenuated backscatter at 1064 nm (b) Volume linear depolarization ratio at 532 nm over Limassol, Cyprus, on 25 May 2025. Red borders indicate the region of the studied aerosol layer and dashed line the almucantar studied time.

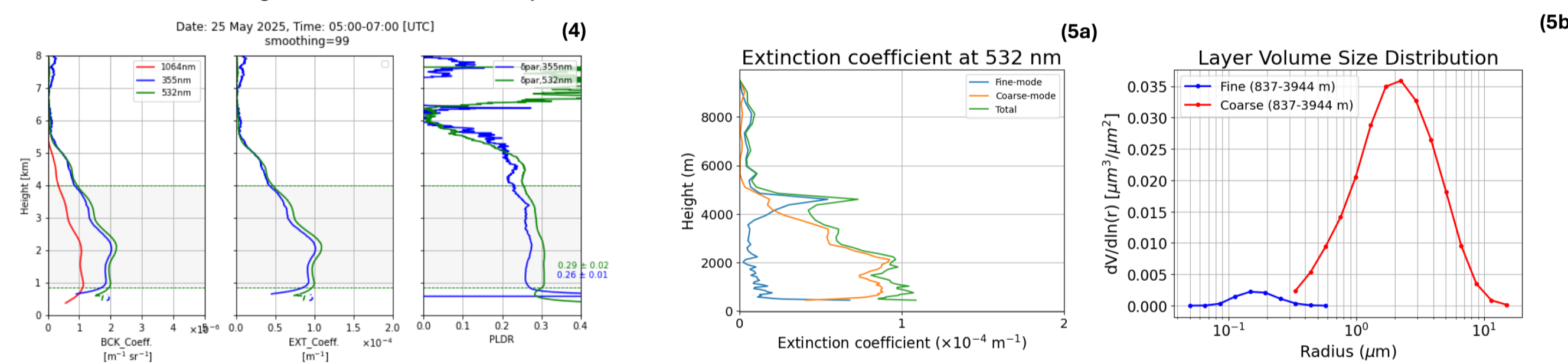


Figure 4: Vertical profiles of the backscatter coefficient, extinction coefficient, on particle depolarization ratio measured in Limassol, Cyprus 25 May 2025 from 05:00-07:00 UTC. Figure 5: (a) Vertical profile of the extinction coefficient at 532 nm of fine, coarse mode and total particles, (b) Layer Volume Size distribution of fine and coarse mode particles at 0.84-3.94 km vertically at the almucantar time 05:58:32, retrieved using GRASP algorithm.

Arabian DUST Case 31 March 2024

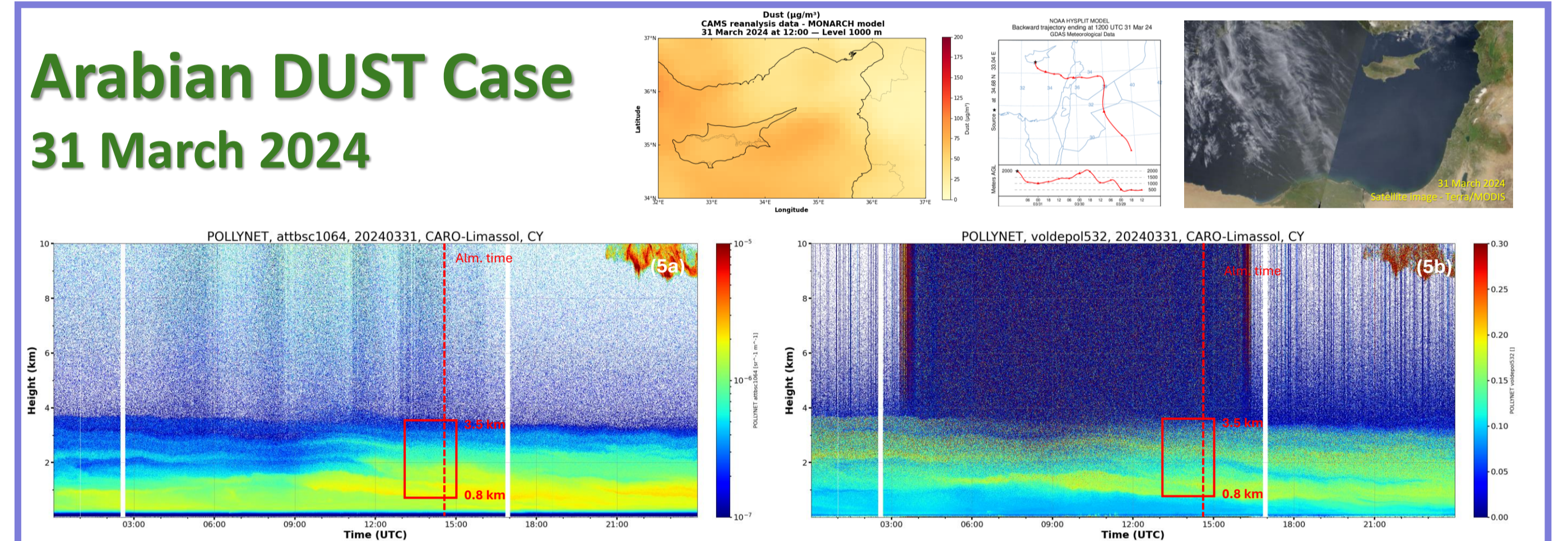


Figure 5: PollyXT lidar (a) Attenuated backscatter at 1064 nm (b) Volume linear depolarization ratio at 532 nm over Limassol, Cyprus, on 31 March 2024. Red borders indicate the region of the studied aerosol layer and dashed line the almucantar studied time.

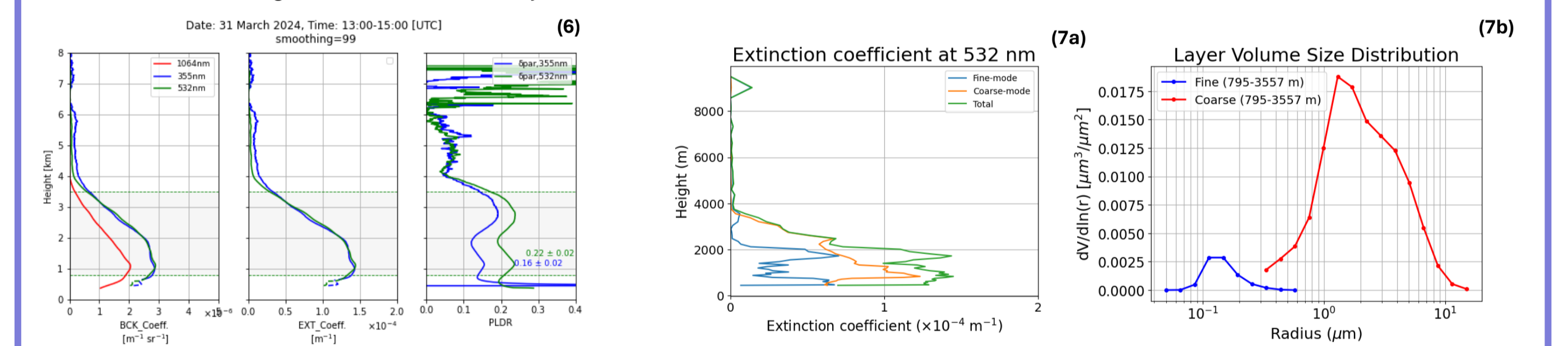


Figure 6: Vertical profiles of the backscatter coefficient, extinction coefficient, particle depolarization ratio measured in Limassol, Cyprus on 31 March 2024 from 13:00-15:00 UTC. Figure 7: Vertical profile of the extinction coefficient at 532 nm of fine, coarse mode and total particles, (b) Layer Volume Size distribution of fine and coarse mode particles at 0.79-3.56 km vertically at the almucantar time 12:55:08, retrieved using GRASP algorithm.

Layer information

Case	Time (UTC)	Almucantar time	Geo info		Optic info						Micro info			
			Layer height (km)	δ _{355 nm} [%] (LIDAR)	δ _{532 nm} [%] (LIDAR)	S _{355 nm} (sr) [*]	S _{532 nm} (sr) [*]	AOD _{532 nm} (LIDAR)	AOD _{532 nm} (GRASP)	AOD _F 532 nm (GRASP)	AOD _C 532 nm (GRASP)	SSA _F 440 nm (GRASP)	SSA _C 440 nm (GRASP)	SSA 440 nm (GRASP)
Saharan	05:00 - 07:00	05:58:32	0.85 - 4	0.26 ± 0.01	0.29 ± 0.02	50	50	0.274	0.237	0.024	0.212	0.756	0.982	0.951
Arabian	13:00 - 15:00	12:55:08	0.8 - 3.5	0.16 ± 0.02	0.22 ± 0.02	50	50	0.281	0.223	0.55	0.168	0.738	0.984	0.904

Columnar information

Case	Almucantar time	Geo info		Optic info			Micro info						
		Height	AOD _{440 nm} (GRASP)	AOD _{440 nm} (AERONET)	AE _{440-870 nm} (AERONET)	η _R F _{440nm} (GRASP)	η _I F _{440nm} (GRASP)	η _R C _{440nm} (GRASP)	η _I C _{440nm} (GRASP)	Reff _F (μm) (GRASP)	Reff _C (μm) (GRASP)	SSA 440 nm (GRASP)	
Saharan	05:58:32	05:58:32	Columnar	0.362	0.368 ± 0.009	0.224 ± 0.007	1.56	0.069	1.51	0.0004	0.178	2.526	0.913
Arabian	12:55:08	12:55:08	Columnar	0.306	0.291 ± 0.005	0.376 ± 0.0114	1.53	0.069	1.47	0.0001	0.153	2.512	0.887

Conclusions

Saharan and Middle East dominated cases were analyzed, utilizing Polly^{XT} Raman Lidar, sun-photometer and GRASP algorithm retrievals.

- ❖ The properties of size, sphericity, absorption and quantity of the three aerosol cases in the atmospheric column and in layers are presented.
- ❖ Agreement GRASP algorithm parameters with AERONET
 - Total SSA at 440 nm and AOD at 440 nm have Excellent agreement with AERONET measurements
- ❖ Additional information from GRASP algorithm
 - For Saharan and Arabian dust layers SSA property showed that fine particles are strongly absorbing and coarse nearly all scattering.
 - The columnar η_IC indicated non-absorbing coarse-mode particles and columnar η_IF indicated strongly absorbing fine-mode particles for both studied cases. This is consistent with the SSA for coarse particles.
 - The vertical profile of extinction coefficients for the fine, coarse mode and total particles. It revealed distinct particle mode dominance by aerosol type, characterizing the studied layers as follows: Saharan Dust - Coarse mode and Arabian Dust - Coarse mode. This highlights the importance on accurate layer aerosol classification.

**δ: Particle linear depolarization ratio; S (sr): Lidar ratio; AOD: Aerosol optical depth; AE: Angstrom Exponent; η_R: Real part of the refractive index; η_I: Imaginary part of the refractive index; Reff: Effective radius; SSA: Single Scattering Albedo; F: Fine-mode aerosols; C: Coarse-mode aerosols.