Retrieval of the aerosol optical and microphysical properties using GRASP, over Magurele, Romania

Mariana Adam[1], Simona Andrei[1], Livio Belegante[1], Razvan Pirloaga[1], Gabriela Ciocan[1], Milagros E. Herrera[2]
[1]*National Institute of Research and Development for Optoelectronics - INOE 2000*
Str. Atomiştilor nr 409, Măgurele, România, 077125
[2]*GRASP-SAS, Villeneuve d'Ascq, 59655 Lille, France*
mariana.adam@inoe.ro

Abstract: Range Corrected Signal of an elastic backscatter lidar (at 355 nm, 532 nm and 1064 nm) and photometer's Aerosol Optical Depth and radiances (at 440 nm, 675 nm, 870 nm and 1020 nm) serve as input in GRASP model to retrieve the aerosol optical and microphysical properties. Several sets of simultaneously measurements in 2022 are analyzed. Collocated Doppler wind lidar is examined when available in terms of wind speed and direction. Hysplit trajectories are used to reveal the potential sources.

1. Introduction

GRASP (Generalized Retrieval of Aerosol and Surface Properties) algorithm [1] is employed to analyse simultaneously measurements of lidar and photometer data at Magurele, Romania. Aerosol optical and microphysical properties are analyzed to characterize the aerosol loading. Preliminary results are shown.

2. Datasets

Nine intervals over 2022 were selected for clear sky conditions. The range corrected signal (*RCS*) profiles were provided by SCC (Single Calculus Chain), HIRELPP module [2]. *RCS* profiles represent the average over the entire measurement interval (Table 1). They refer to elastic backscatter at 355 nm, 532 nm and 1064 nm and span from 700 m to 7000 m.

Table 1. Datasets

#	Date 2022	Time
1	25 Feb	11:16-15:04
2	22 Mar	13:08-16:21
3	23 Mar	02:59-06:30
4	24 Mar	09:13-13:50
5	5 Apr	08:08-13:16
6	12 May	09:53-14:03
7	1 Jun	03:25-04:55
8	3 Jun	07:20-11:00
9	19 Sep	10:31-12:40

The *RCS* profiles were translated into 60 range bins and normalized according to GRASP requirements [3]. Aeronet L2 products for *AOD* and almucantar files for radiances are used at 440 nm, 675 nm, 870 nm and 1020 nm, averaged over the same time interval. The radiances were normalized using the spectral solar irradiance as a function of time and wavelength created with the Naval Research Laboratory model for spectral and total irradiance [4].

3. GRASP retrievals analysis

The following three examples belong to an extended pollution event over 22-24 March 2022.

A strong dust pollution was observed for 22 March over Bucharest/Magurele which is assumed to come from the nearby plain at NE of Bucharest (Baragan plain). High dust load at ground level was observed in Bucharest and reported by authorities. Figure 1 shows the extinction profiles where we see the large contribution in Planetary Boundary Layer (PBL) from coarse mode at 532 nm and 1064 nm. Figure 2 shows the column microphysical and optical properties where high values of *VSD* (volume size distribution) is observed for coarse mode. High absorption (*AAOD* and imaginary part of refractive index), low *SSA* and large *LR* were observed for coarse mode in UV and VIS range. Figures 3 and 4 show *RCS* at 1064 from a Nimbus ceilometer and wind direction from the Doppler wind lidar (DWL). The barbs showing the wind speed and direction are overlapped. The vertical black lines define the interval for lidar measurements. The wind

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

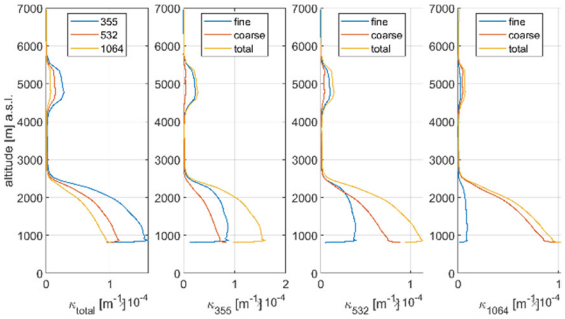

Figure 1. Aerosol total extinction coefficient at 355, 532 and 1064 nm (left), and by components at 355 nm, 532 nm and 1064 nm (following plots) for 22 March 2022.

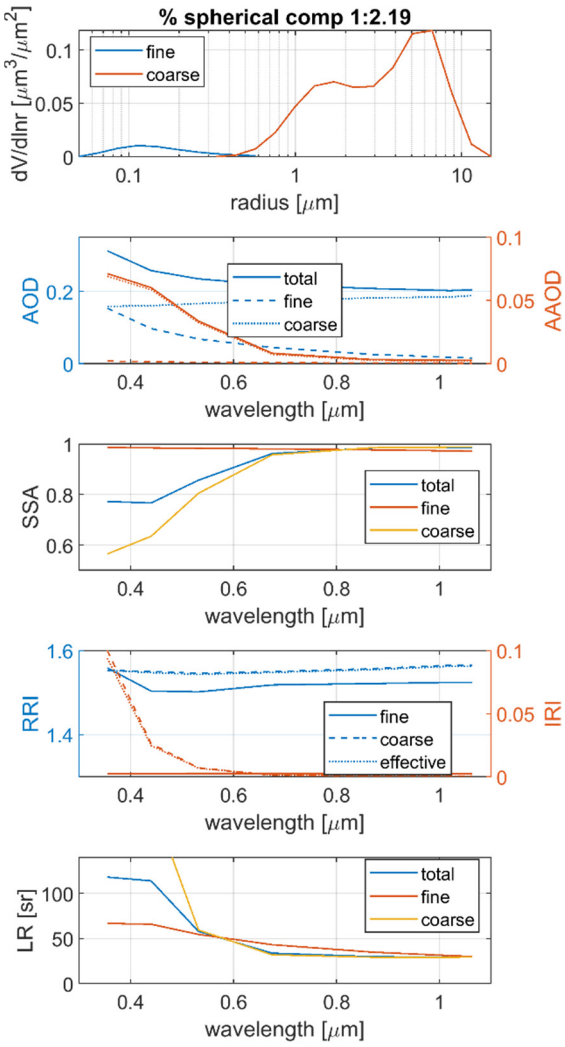

Figure 2. Column aerosol microphysical and optical properties for 22 March 2022.

direction was mainly from NE. The wind speed was strong (~20 m/s in average). The HYSPLIT backtrajectories at three levels in PBL (not shown) indicate the airmasses coming from NE direction (Ukraine and then NE Romania).

The next day (early morning) shows a low aerosol load (much lower *VSD*, lower *AOD* and

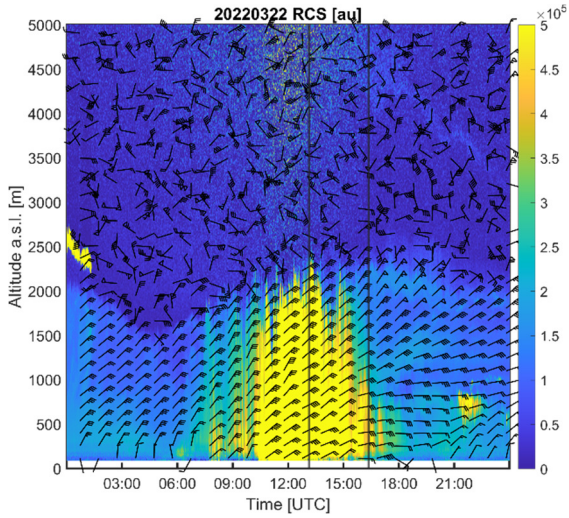

Figure 3. *RCS* at 1064 nm (ceilometer) and wind barbs (DWL) for 22 March 2022.

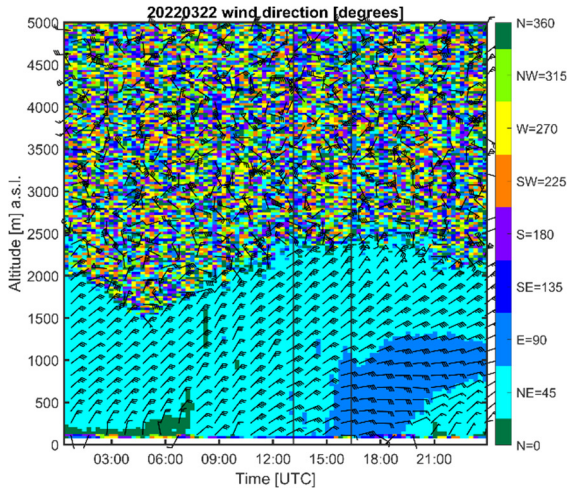

Figure 4. DWL wind speed and direction for 22 March 2022.

extinction profiles). Wind direction is the same as previous day while the wind speed is much lower except the upper region (1000 – 2000 m) (Figs. 5-8). Assuming similar meteorological conditions around the source (70 – 100 km), the decrease of the wind speed reduces the dust updrafts and its transport. The extinction profiles show a bigger contribution of the fine mode at 355 nm and 532 nm in PBL while above PBL the fine mode is major. The HYSPLIT backtrajectories at two levels in PBL and at 3000 m above PBL (not shown) indicate the airmasses coming from NE direction (Ukraine and then NE Romania).

The aerosol load increases again on 24th. While the wind speed is much lower compared with previous days, the wind direction shows a cyclonic rotation which enhances the vertical turbulence in PBL (Figs. 9-12). The HYSPLIT

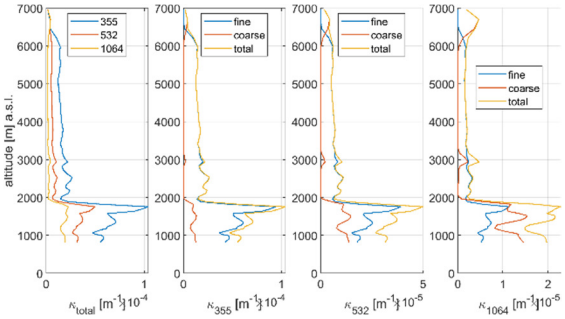

Figure 5. Aerosol total extinction coefficient at 355, 532 and 1064 nm (left), and by components and 355 nm, 532 nm and 1064 nm (following plots) for 23 March 2022.

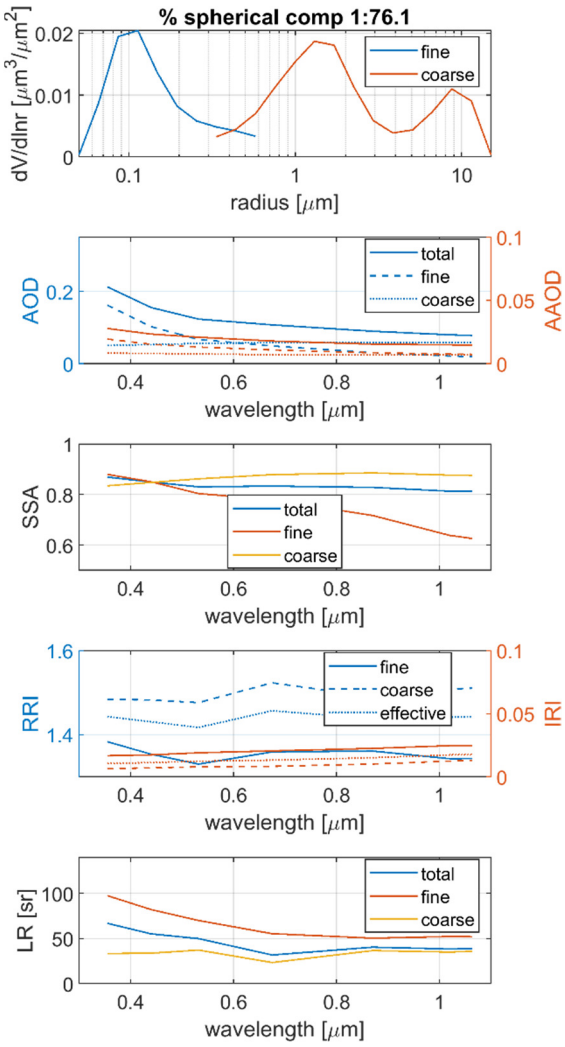

Figure 6. Column aerosol microphysical and optical properties for 23 March 2022.

backtrajectories at three levels in PBL (not shown here) indicate a shifting of the air mass circulation (Ukraine, NE Romania and then towards NW Romania before reaching our location). The aerosol mixture changed from previous day (see different refractive indices).

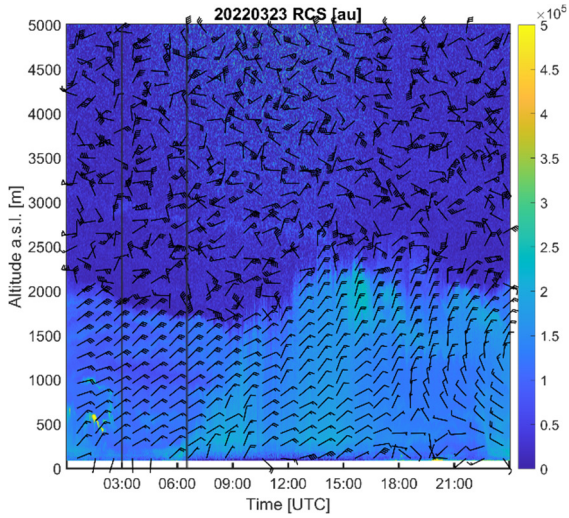

Figure 7. *RCS* at 1064 nm (ceilometer) and wind barbs (DWL) for 23 March 2022.

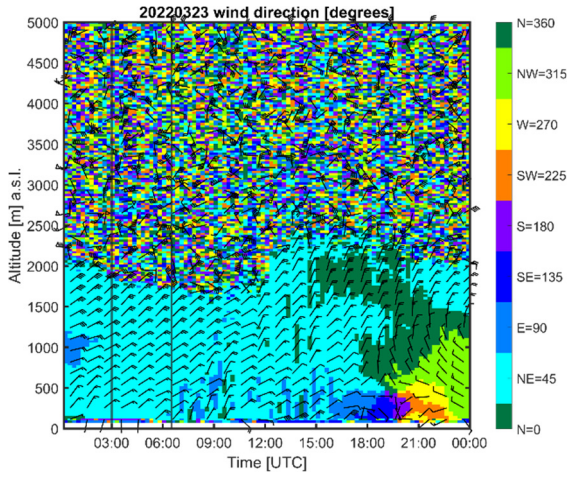

Figure 8. DWL wind speed and direction for 23 March 2022.

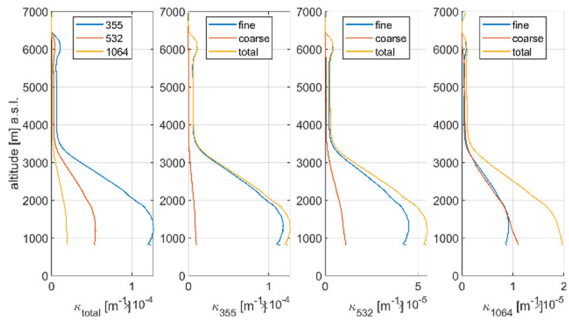

Figure 9. Aerosol total extinction coefficient at 355, 532 and 1064 nm (left), and by components and 355 nm, 532 nm and 1064 nm (following plots) for 24 March 2022.

4. Preliminary conclusions

The pollution event presented here (22-24 March 2022) is characterized by the GRASP output which revealed the dust pollution on 22nd

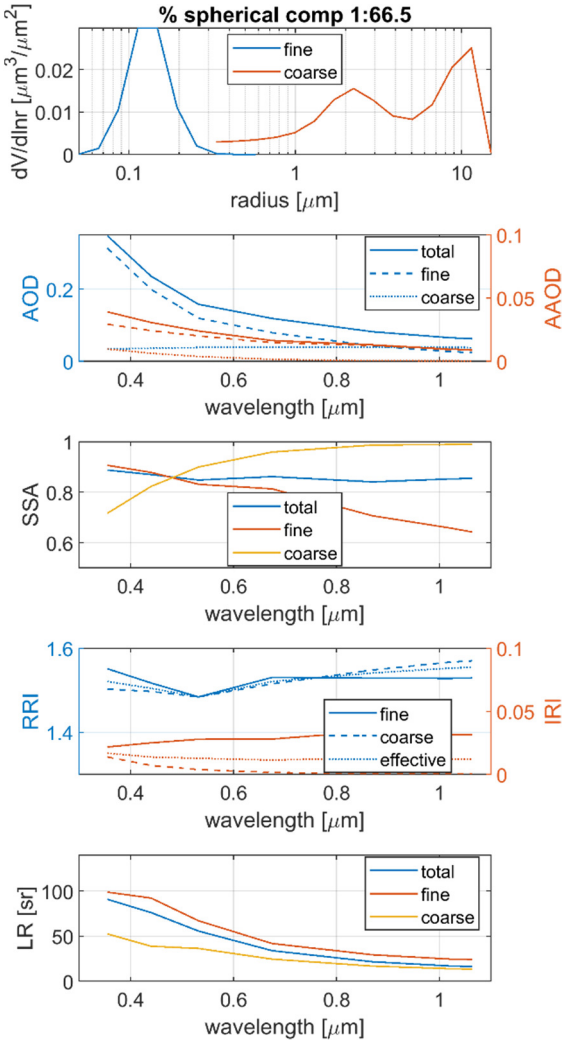

Figure 10. Column aerosol microphysical and optical properties for 24 March 2022.

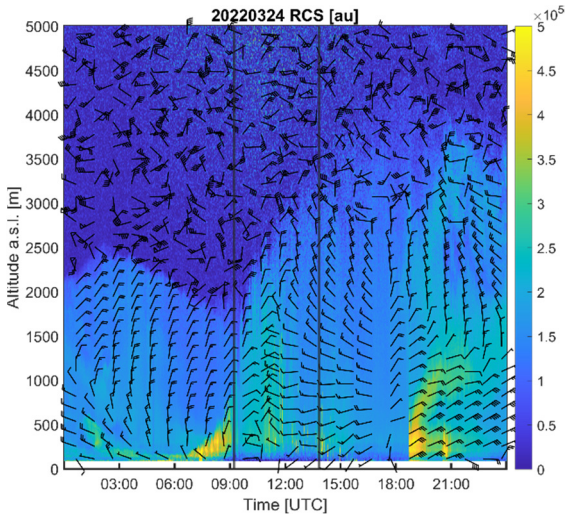

Figure 11. *RCS* at 1064 nm (ceilometer) and wind barbs (DWL) for 24 March 2022.

(big coarse mode in *VSD*, large *AOD* dominated by coarse mode). The following days are characterized by a mixture of fine and

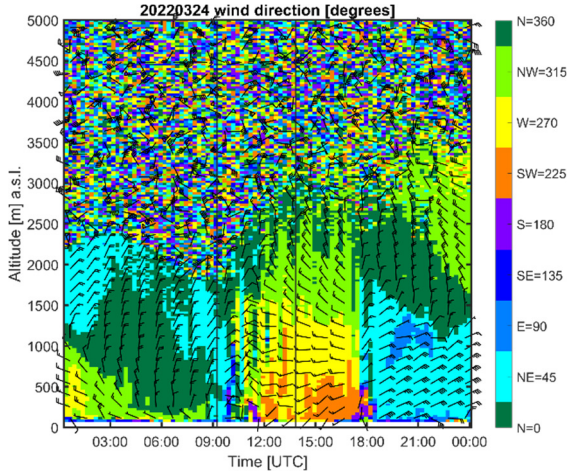

Figure 12. DWL wind speed and direction for 24 March 2022.

coarse mode, with larger *AOD* contribution from fine mode in the last day.

The other events will be discussed during conference. The extinction profiles will be compared with Klett method while the column variables will be compared with Aeronet retrievals. GRASP output variables will be thoroughly discussed based on optimum parameters in the settings.

5. Acknowledgements

This research was funded by the Romanian Ministry of Research, Innovation and Digitalization through ctr. no. PN 23 05 and 18PFE/30.12.2021 and UEFISCDI PN-III-P2-2.1-PED-2021-1938. Authors acknowledge AERONET-Europe/ACTRIS for calibration and maintenance services and NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport model used in this publication.

6. References

[1] Dubovik O, et. al, "A Comprehensive Description of Multi-Term LSM for Applying Multiple a Priori Constraints in Problems of Atmospheric Remote Sensing: GRASP Algorithm, Concept, and Applications", Front. Remote Sens. **2**:706851 (2021).

[2] D'Amico, G., et al., "EARLINET Single Calculus Chain – technical – Part 1: Pre-processing of raw lidar data", Atmos. Meas. Tech., **9**, 491–507 (2016).

[3] http://www.grasp-open.com/doc/

[4] http://doi.org/10.7289/V53776SW

[5] Pîrloaga, R., Adam, M., et al., "Ground-Based Measurements of Wind and Turbulence at Bucharest–Magurele: First Results", Remote Sens., **15**, 1514 (2023).