AEROsol CLASSification based on multiwavelength Lidar data (AEROCLASS)

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Introduction and motivation

Observations of aerosols are important for improving understanding of climate, weather, and particle transport and air quality. Aerosols are the most uncertain elements in the evaluation of radiative effect, due to their temporal and spatial variation, the diversity in shape and type, ranging from desert dust, biomass burning aerosols to urban pollution (Hess et al. 1998).

This project allowed the PI to access the knowledge and instrumentation at Potenza and provided training. In particular, the stay at Potenza was for the PI a unique opportunity for training in the interpretation and application of Raman lidar data. The outputs of the study will be used for his PhD thesis, the classification of aerosol types and their preponderance in the southern Romania, near Bucharest city will be a valuable product of this PhD thesis.

Scientific objectives

The main objective of this project was to obtain an aerosol characterization based on data derived from a multiwavelength Raman lidar system in synergy with other ground based instruments and different tools.

The first part of the TNA focused on data quality assurance. The next step was to learn the principles and how to use the single calculus chain (D'Amico et al., 2012) in order to calculate the aerosol extinction and backscatter coefficients profiles and moreover the related extensive parameters from lidar data. Microphysical properties of the aerosol layers were calculated using the inversion methodology developed by Igor Veselovskii (Veselovskii et al., 2013). In order to determine the trajectories of air masses and to estimate the source of long-range transported aerosol, we used the HYSPLIT and FLEXPART models.

Reason for choosing station

CIAO - CNR-IMAA Atmospheric Observatory is a leading station in the EARLINET network, operating a reference LIDAR system, being also one of the stations actively implicated in the development of the Single Calculus Chain (SCC), which is used by the stations in EARLINET network in order to process the available LIDAR data in a similar and quality assured way. The state of the art infrastructure available and the high quality of the human resource makes this station the best choice for the project.

Method and experimental set-up

During this TNA activity we used one case study in order to obtain relevant information needed for the aerosol characterization: a Saharan desert dust intrusion over Romania measured with two LIDAR systems:

1. COLI – a 532 elastic LIDAR located at the Faculty of Environmental Science and Engineering, Babeș Bolyai University of Cluj Napoca, operated by the PI;
2. RALI – a multiwavelength RAMAN LIDAR located at National Institute of R&D for optoelectronics INOE 2000, at Magurele, near Bucharest, an EARLINET station.

The single calculus chain (SCC) developed in the framework of EARLINET was used to calculate the aerosol extinction and backscatter coefficients profiles and the related extensive parameters: particle depolarization, color and lidar ratios, as well as Angstrom exponent, from the measurements obtained with the multiwavelength RALI system. For measurements made with the COLI system we obtained only the backscatter coefficient profile.

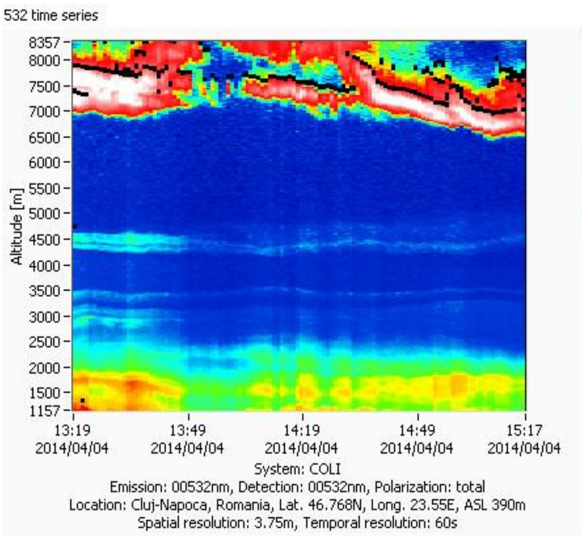
The inversion methodology developed by Igor Veselovskii (Veselovskii et al., 2013) was used to obtain the microphysical properties of the aerosol for the Bucharest data set.

In order to determine the trajectories of air masses and to estimate the source of long-range transported aerosol, we used the HYSPLIT and FLEXPART models for both data sets.

Preliminary results and conclusions

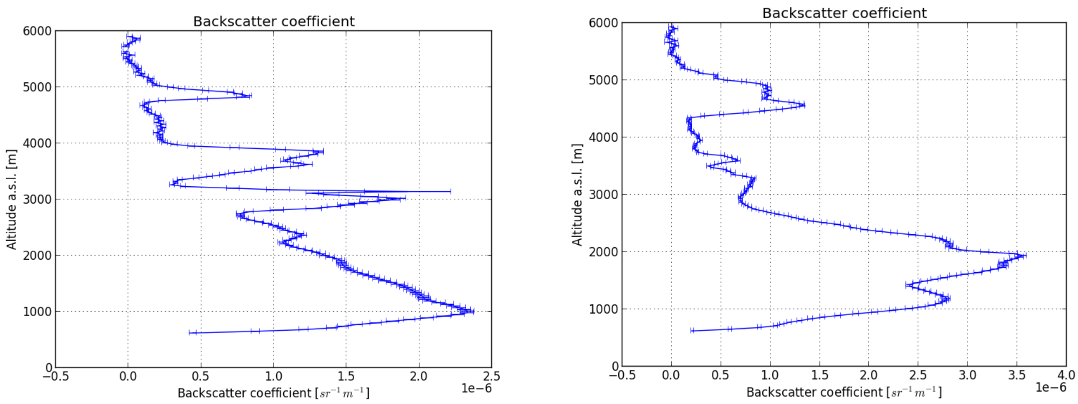
The measurements used during the TNA project were taken in 2nd and 4th of April, 2014 at the same hour for every location. We used one data set from 2nd of April (starting at 14: 00 UT) and 3 data sets from 4th of April (starting at 10:00, 13:20 and 17:00 UT). The measurements time was aprox. 2 hours for each set. During this period a Saharan desert dust intrusion was predicted over the two sites. According to the RCS signals from the measurements sets we detected aerosol layers up to 5 km (see fig. 1)

Fig. 1 RCS signal for Cluj site for 4th of April, 13:20



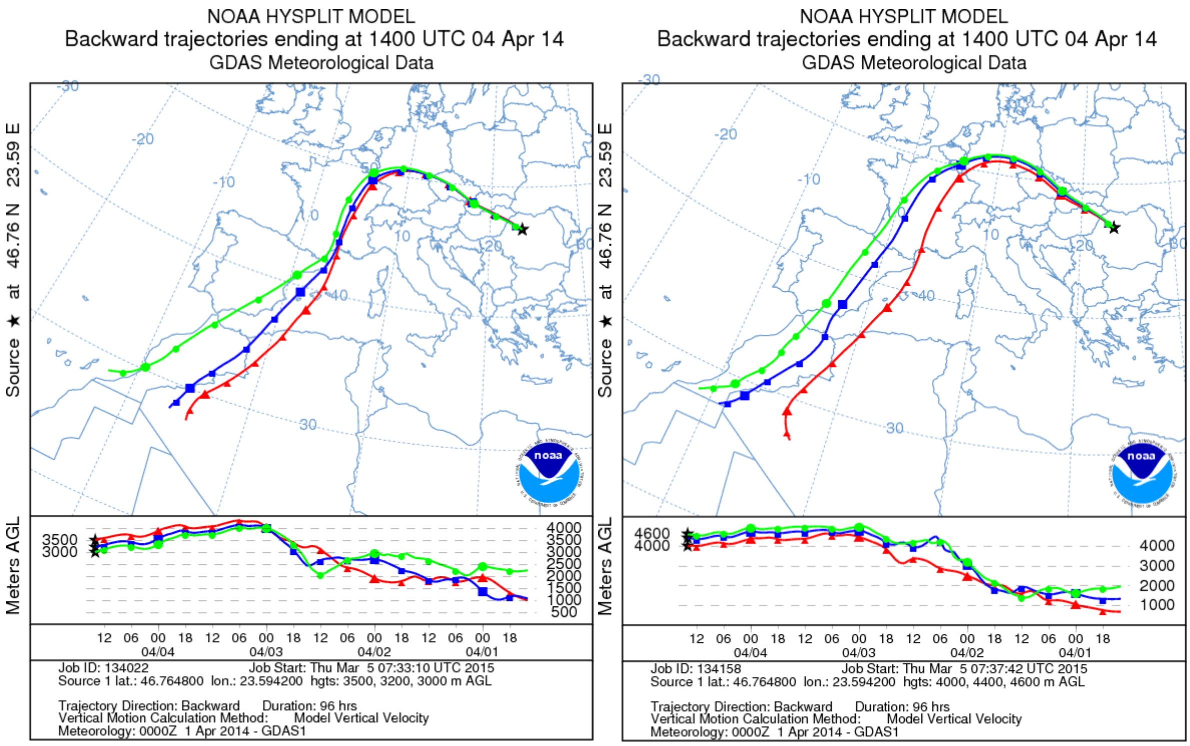
During the TNA project we created an SCC account for the Cluj Napoca LIDAR station which enables the data processing using the EARLINET Single Calculus Chain in order to obtain the backscatter profile for our measurements (see fig. 2)

Fig. 2: Backscatter profiles for Cluj measurements 4th of April, 10:00 UT (left) and 13:20 UT(right)



HYSPLIT back-trajectories were computed in order to estimate the source of the long-range transported aerosol. We present the results from Cluj for 4th of April, 13:20 UT. (Fig. 3) showing the Saharan origin of the aerosol layers between 3 and 4,5 km.

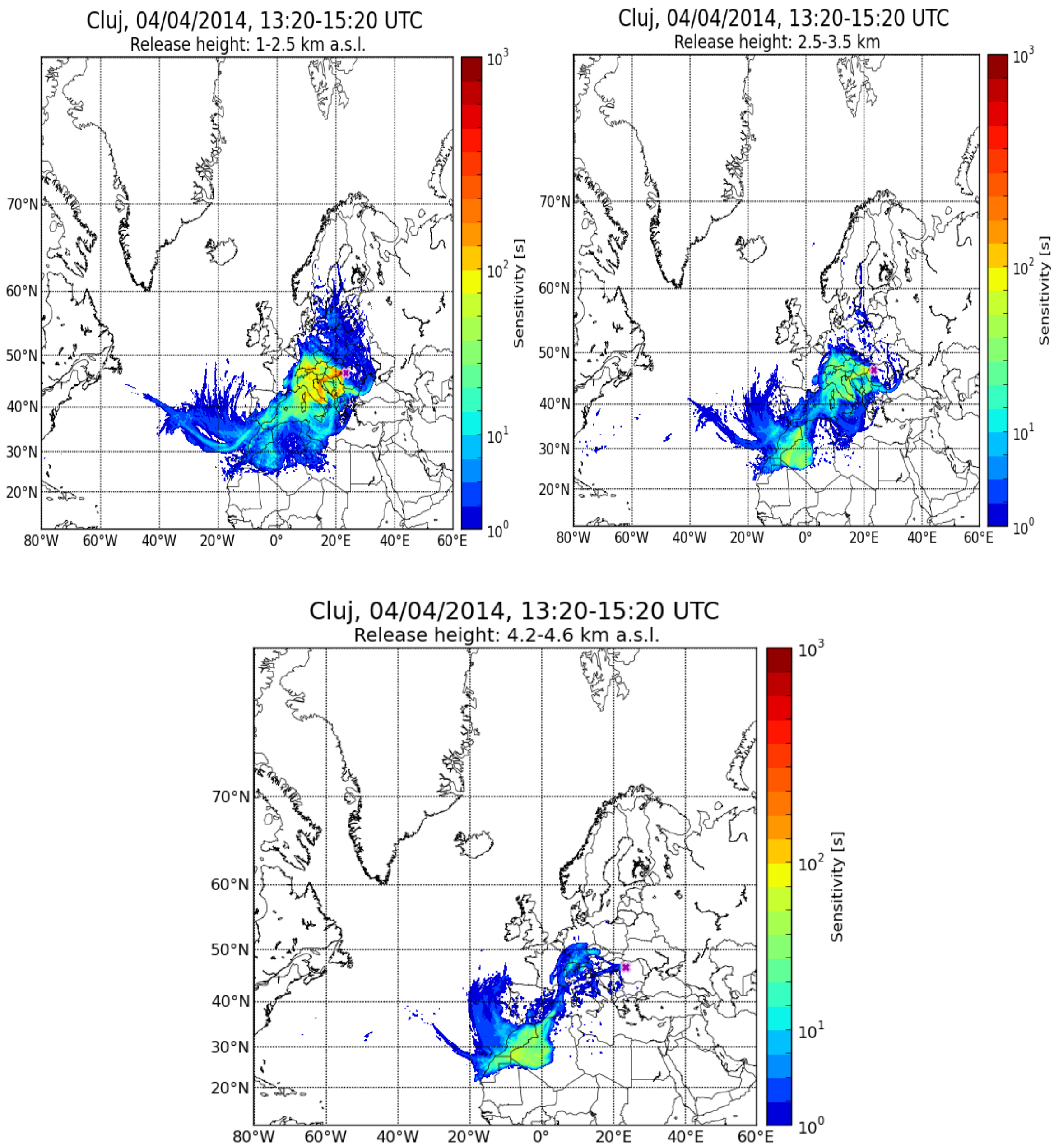
Fig. 3: HYSPLIT 96 h back-trajectories ending at Cluj, 4th of April, 14:00 UT



The back-trajectories for the other measurements showed similar results, the air masses passing above Saharan desert at low altitudes, inside the PBL.

Also we used FLEXPART model in order to obtain the emission sensitivity for different aerosol layers observed above the Cluj station. The emission sensitivity is proportional to the residence time of the particles over a unit area. At low altitudes (1 – 2,5 km) we can see the predominant influence of local continental aerosols, at upper altitudes (4,2 – 4,6 km) we can observe a predominant desert dust influence and between them a mixed desert with continental influence. (see Fig. 4)

Fig. 4: FLEXPART sensitivity, Cluj, 04.04.2014, 13:20-15:20 UT, for different altitudes: a) 1 – 2,5 km (upper left); b) 2,5 – 3,5 km (upper right); c) 4,2 – 4,6 km; (down)



For the Bucharest measurements we were able to directly analyze the obtained aerosol extinction and backscatter coefficients profiles and the related extensive parameters, since the station is already an EARLINET member.

In order to calculate the microphysical properties of the aerosol using the Veselovskii code, for input data we need 5 aerosol profiles: 3 backscatter coefficients (for 355, 532 and 1064 nm) and 2 extinction coefficients (for 355, 532 nm). Thus we had available data only for Bucharest site, and we analyzed the data from 4^{th} of April, starting at 16:50 UT. We converted the total volume concentration into total mass concentration considering the density of the dust ρ=2,65 g/cm^3. We obtained a maximum value of 65 µg/m^3 with mean values of 20 -40 µg/m^3 inside the dust layer. Our results are in good agreement with the results presented by Nicolae et al. (2014), which state that the total mass concentration in the aerosol layer reached a maximum value of 120 µg/m^3 with mean values of 30 – 40 µg/m^3.

Outcome and future studies

We obtained good results in using the synergy of different available tools in order to characterize and obtaining useful information regarding the origin and properties of a given type of aerosol, in our case, the desert dust.

Following the results obtained, we will continue our study in applying the aerosol characterization, considering other aerosol types present over Romania like continental – urban or fire smoke.

Also we expect the publication of a peer review journal paper.

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