

IDENTIFICATION OF LONG-RANGE TRANSPORT OF AEROSOLS OVER AUSTRIA USING EARLINET LIDAR MEASUREMENTS

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ABSTRACT

The aim of the study is to identify the paths of the long-range transported aerosols over Austria and their potential origin, and to estimate their properties, using lidar measurements from EARLINET stations closest to Austria from Germany and Romania and aerosol transport models. As of now, there is no lidar station in Austria. The study is part of a project to estimate the usefulness of a lidar station located in Vienna, Austria.

1 INTRODUCTION

Aerosols are produced locally, with given properties; they are then transported over short-to long-distances, usually in turbulent movements. Transport and dispersion of aerosols depend on aerosols' properties, on meteorological conditions, and on surface properties. During transport, aerosols can also mix with other atmospheric, so more sources contribute to the aerosol budget in a given place.

Lidar systems are useful tools to determine the properties of long-range transported aerosols and their vertical distribution [1-3]. EARLINET [4], a network of lidar systems with stations distributed over Europe, provides comprehensive ground-based lidar data for aerosol vertical distribution as well as aerosols' optical and microphysics properties, allowing a detailed study of long-range transported aerosols in Europe.

To identify the source regions of aerosols, a statistical analysis of back-trajectories can be performed. The back-trajectories analysis relates the aerosol mass loading changes at a receptor location to spatially-fixed sources, identifying the sources by a source – receptor matrix calculation [5].

Due to its geographical position in Central Europe, Austria is affected mainly by local and long-range transport of aerosols from variable

sources. Marine aerosols with sea-salt particles content are rarely observed above Austria, as the nearest sea, Adriatic Sea, is located at a distance of few hundred kilometers, so aerosols measured in Austria are predominantly continental aerosol.

The purpose of this analysis is to study the long-range transport of aerosols over Austria, assuming a receptor site at Vienna. The study is based on cluster analysis, using measurements from EARLINET lidar stations closest to Austria, MACC reanalysis data [6] and the FLEXPART aerosol dispersion model [7].

2 METHODOLOGY

The analysis has been performed for Vienna (48.21°N, 16.36°E) as receptor site, using data from the period March - May 2014. This period has been reported of Austria as “seventh warmest spring (March - May) in its 247-year period of record, at 1.5°C higher than the 1981–2010 average” [8]

The vertical distributions of aerosols over Vienna were obtained from MACC reanalysis data related to dust aerosol and smoke. Here, smoke was considered a mixture of organic matter, sulphate and black carbon.

For the cluster analysis, clusters with trajectories traversing over four EARLINET stations around Austria: Garmisch-Partenkirchen (47.47°N, 11.06°E), Munich-Maisach (48.20°N, 11.45°E), Leipzig (51.35°N, 12.43°E) (all stations located in Germany), and Bucharest (44.35°N, 26.03°E, Romania), were selected.

The contribution of the different aerosol sources was evaluated comparing the spatial distribution of the layers as determined from the lidar measurements with the FLEXPART forward and backward simulations for each observed aerosol layers. From the lidar measurements, the aerosol layers were calculated using a wavelet analysis applied on the derivative of back-scattering

coefficients. The transport of aerosols (dust or smoke) and the source-receptor sensitivity were calculated with the FLEXPART model using 6-hourly GFS meteorological data interleaved with operational forecasts every 3 hours. The model was run for 7 days using a backward simulation with a tracer released within a volume estimated from lidar measurements and MACC observations, where no lidar measurements were available (at receptor site). The tracer release period ranges were taken of the order of two hours when estimated from lidar measurements, and from one to three days when estimated from MACC observations.

The types of the aerosols in Vienna were estimated from the analysis of the aerosol layer optical properties obtained from lidar measurements, correlating the layers at the lidar stations with the FLEXPART transport layers in the cluster analysis.

The regions of the potential aerosol sources were taken from NASA Fire Information for Resource Management System (FIRMS) maps [9] for fire investigation, and Barcelona Supercomputer Center regional dust forecast model - BSC-DREAM8b [10], for dust investigation over Europe.

3 EVENT SELECTED

Figure 1 shows the mixed ratio of dust and smoke over Vienna for Mar - May 2014, extracted from MACC reanalysis data.

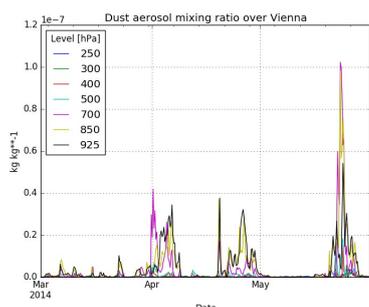


Figure 1 Dust aerosol over Austria, 1 Mar - 1 Jun 2014

Three events of dust aerosol over Austria are shown in Fig. 1: 30 Mar – 7 Apr 2014, 20 Apr – 29 Apr 2014 and 20 May – 26 May 2014. The data selected from these periods are correlated with lidar measurements from lidar stations.

4 RESULTS

For all cases, the cluster analysis was performed for two levels: 850 hPa (approx. 1200 m) and 750 hPa (approx. 3000 m)

Case 1: 30 Mar – 7 Apr 2014

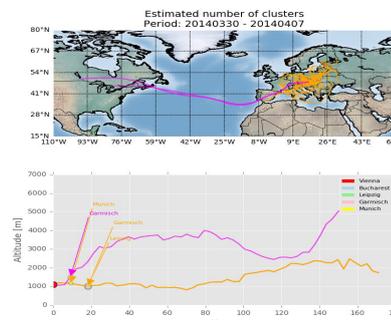


Figure 2 Cluster analysis applied on backtrajectories starting at 00:00 UTC, 850 hPa

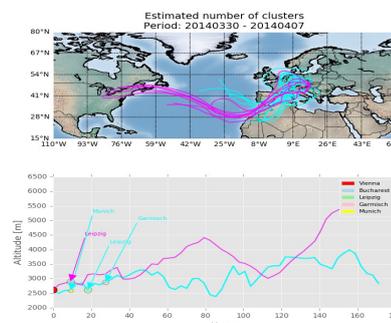


Figure 3 Cluster analysis applied on backtrajectories starting at 00:00 UTC, 700 hPa

There are two clusters with trajectories over German lidar stations started at 850 hPa (Fig. 2) and two clusters for trajectories started at 700 hPa (Fig. 3)

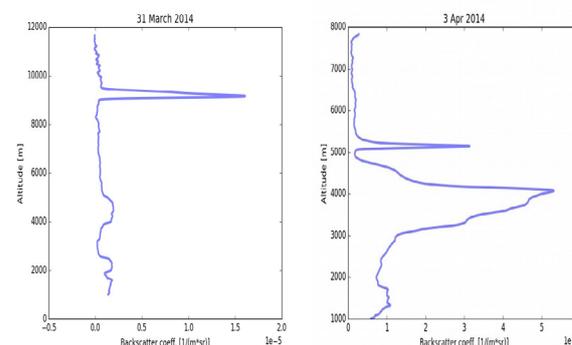


Figure 4 Garmisch lidar station: Backscatter coefficients at 313 nm, 31 March 2014, 11:30 UTC (left) and 3 Apr 2014 11:30 UTC (right)

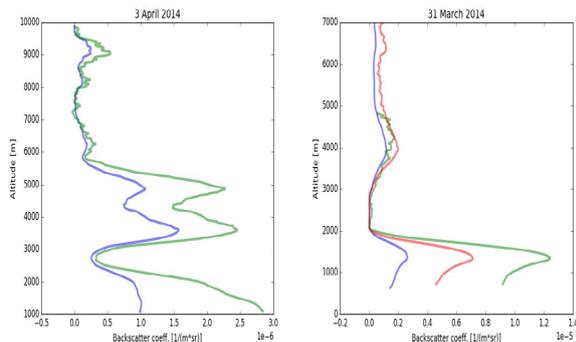


Figure 5 Leipzig lidar station: Backscatter coefficients at 1064 nm, 532 nm, 355 nm, 31 March 2014, 11:30 UTC (left) and 3 Apr 2014 18:30 (right), 532 nm and 355 nm

The dates selected and the altitudes for Vienna and the considered lidar stations measurements for this case are shown in Table 1. For the lidar stations, the first altitude is obtained from FLEXPART at the station coordinates, while the second altitude is obtained from the lidar measurements.

Table 1

Vienna		Lidar Station		
Date	Alt. (m)		Date	Alt. (m) model/lidar
1 Apr	2615	Leipzig	31 Mar	2950 / 3100
1 Apr	1115	Garmisch	31 Mar	1800 / 1900
1 Apr	1115	Leipzig	31 Mar	1250 / 1300
4 Apr	1115	Garmisch	3 Apr	1100 / 1200
4 Apr	2615	Leipzig	3 Apr	2800 / 3000
4 Apr	2615	Garmisch	3 Apr	2980 / 3100

Case 2: 20 Apr – 29 Apr 2014

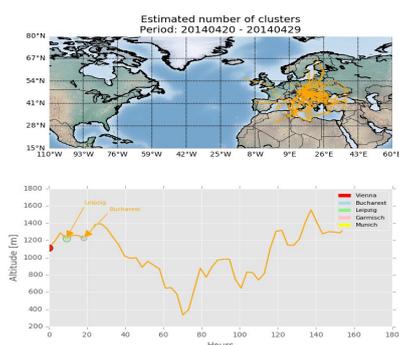


Figure 6 Cluster analysis applied on backtrajectories starting at 00:00 UTC, 850 hPa

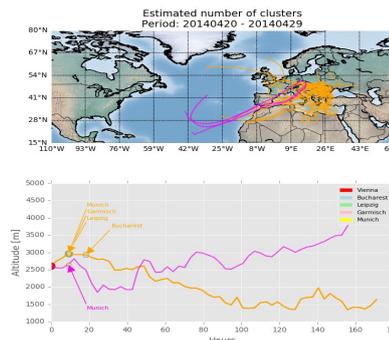


Figure 7 Cluster analysis applied on backtrajectories starting at 00:00 UTC, 700 hPa

There are only one cluster with trajectories started at 850 hPa (Fig. 5) and two clusters over all Earlinet lidar stations, trajectories started at 700 hPa (Fig. 6)

Table 2 shows, similar to Table 1, the results obtained for this case. The lidar measurements are performed at: 4:00 UTC Garmisch, 17:00 UTC Bucharest, 16:00 UTC Leipzig, 20:00 UTC Munich.

Table 2

Vienna		Lidar Station		
Date	Alt. (m)		Date	Alt. (m) model/lidar
27 Apr	2615	Bucharest	26 Apr	3100 / 3200
27 Apr	1115	Bucharest	26 Apr	1200 / 1000
25 Apr	2615	Leipzig	24 Apr	3000 / 3200
25 Apr	2615	Garmisch	24 Apr	2680 / 2800
25 Apr	2615	Munich	24 Apr	2800 / 2850
25 Apr	1115	Leipzig	24 Apr	1300 / 1200

Case 3: 20 May – 26 May 2014

For this case, a single cluster was identified for each of the two levels, 850 hPa and 700 hPa passing over Leipzig station. Table 3 shows the results obtained for this case.

Table 3

Vienna		Lidar Station		
Date	Alt.(m)		Date	Alt. (m) model/lidar
23 May	2615	Leipzig	22 May	2715 / 2600
23 May	1115	Leipzig	22 May	1120 / 1300

From the optical properties obtained from the lidar measurements, it results that the Case 1 is a mixture between dust and smoke particles. This

mixture could be possible due to the same transport pathway for both sources, from North America over West Sahara. The three-dimensional structure of the aerosol distribution revealed by the lidar systems, combined with MACC observations and the three-dimensional structure of the aerosol plume from FLEXPART aerosol transport model (see Figs. 8 and 9) confirm the presence of the two different components, smoke and dust coming from the two aerosol sources : smoke from North America (see Fig 10) and dust from Sahara (see Fig. 11). Case 2 and case 3 are Saharan dust intrusions over Europe.

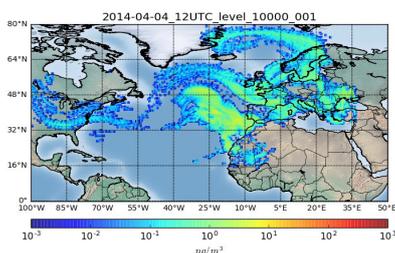


Figure 8 Integrated column , 4 Apr 2014

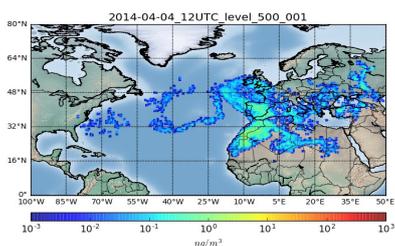


Figure 9 Footprint (500 m) , 4 Apr 2014

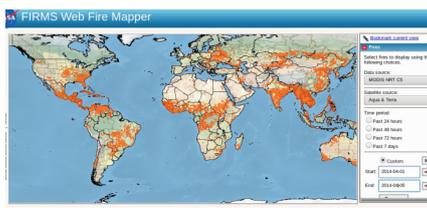


Figure 10 FIRMS , 1 Apr - 5 Apr 2014

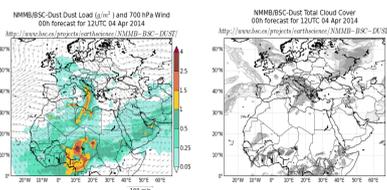


Figure 11 Dust aerosol over Europe, 4 Apr 2014

5 CONCLUSIONS

This study of aerosols over Austria, based on a cluster analysis of aerosol layers determined from lidar measurements correlated with layers from the FLEXPART model revealed an influence of long-range transport (combined or alternated) of Saharan dust and aerosols emissions of wildfires from North America. Two cases of dust and one case of mixture of dust from Sahara and smoke from biomass burning from American wildfire were identified for the period analyzed, Spring 2014.

ACKNOWLEDGEMENTS

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