Extreme Saharan Dust Outbreak in March 2022: Impact on the air quality of NW Spain

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Introduction

The Iberian Peninsula, located relatively close to the Sahara desert, is a region prone to dust outbreaks, especially under specific meteorological conditions (Russo et al., 2020). In winter, dust outbreaks were scarce in this area, but in recent years they have occurred more often and with greater intensity (Fernández et al., 2019, López-Caravaca et al., 2021 and Oduber et al., 2019). These events have been responsible for exceeding the daily limit values (DLV) (50 µg/m3, according to the 2008/50/EC European Directive) for suspended particulate matter with an aerodynamic diameter under 10 µm (PM_{10}). In March 2022, one of these unusual events was recorded, impacting the NW of the Peninsula. This event was exceptional due to its intensity and geographical extension (at least not observed in the current century over mainland Spain), registering record levels of PM_{10} in many locations (García-Valero, 2022). The main aim of this work is to provide a deep characterisation of the chemical and optical properties of atmospheric aerosols sourced from the specific winter dust outbreak that affected the city of León (NW Spain) between 14 and 16 of March 2022.

Methodology

Sampling campaign

The sampling campaign was conducted from 1 to 31 of March 2022 downtown León, at a height of around 20 m above street level (42° 35´ 59.47" N 5° 34´ 34.329" W). It is an area with high traffic density, being representative of urban conditions.

Figure 1 – Images of the dust outbreak effect on the city of León between 14 and 16 of March 2022.

Analytical determinations

- Chemical characterisation of the particulate matter

PM_{10} concentration (by gravimetry)

Elements (PIXE technique)

Water soluble ions (ion chromatography)

OC – EC (thermal-optical method)

- Optical characterisation of the particulate matter

Aerosol-light absorption
Absorption Angström exponent
(Aethalometer)

Particle size distributions (0.018 – 1 µm)
(Scanning mobility particle sizer – SMPS)

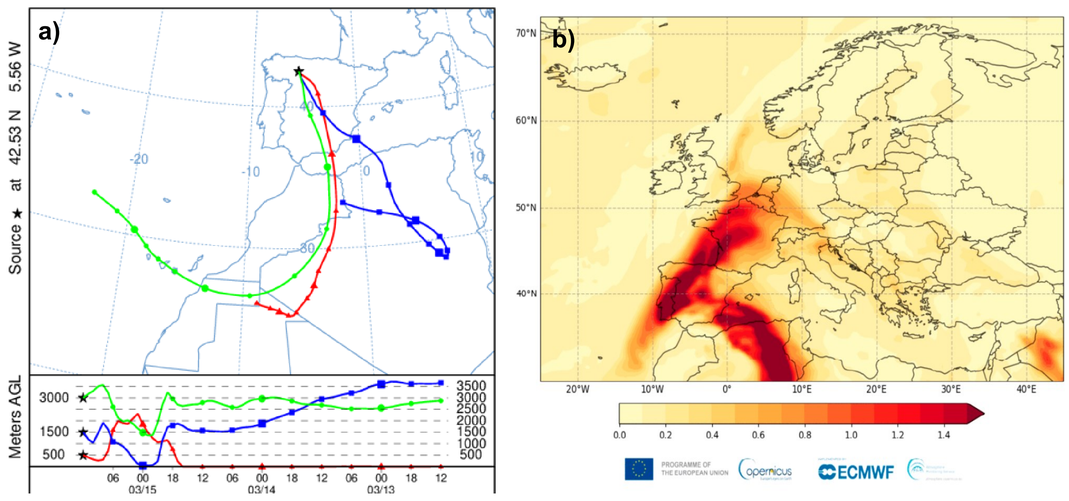

Figure 2 – a) 72h air-mass backward trajectories computed using the HYSPLIT model for three altitudes (500, 1500 and 3000 m), ending at León on 15 March; b) A forecast of the PM movement over the Iberian Peninsula for the 15 and 16 of March 2022. Source: https://atmosphere.copernicus.eu.

Results

- **The chemical characterisation showed an increase in the concentrations of some air pollutants.**

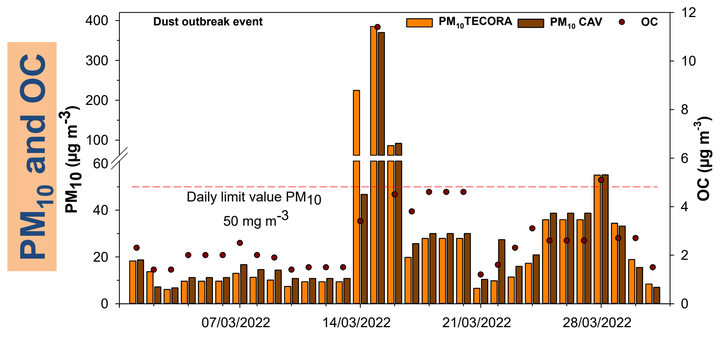

Figure 3 – PM_{10} and OC exceedances during the dust outbreak event.

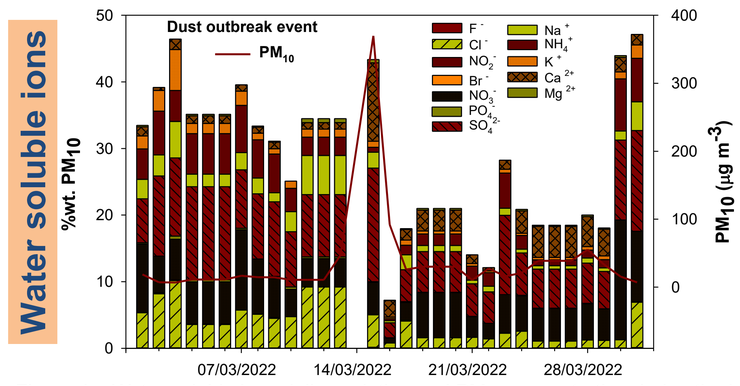

Figure 4 – Water soluble ions daily evolution and PM_{10} concentration during the intrusion.

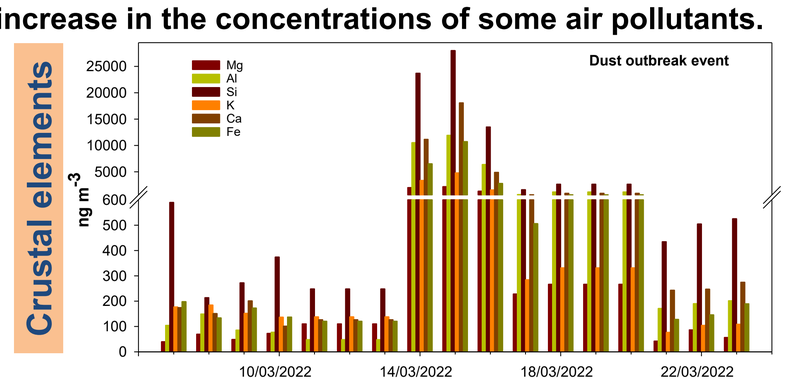

Figure 5 – Variation in the concentration of crustal elements during the event.

Table 1 – Daily evolution of the geometric mean of the particles.

Geometric mean

Date	Geometric mean (nm)
06/03/2022	45.68
07/03/2022	45.63
08/03/2022	46.12
09/03/2022	44.88
10/03/2022	40.76
11/03/2022	39.10
12/03/2022	41.34
13/03/2022	38.23
14/03/2022	51.34
15/03/2022	49.79
16/03/2022	45.46
17/03/2022	43.80
18/03/2022	44.15
19/03/2022	46.94
20/03/2022	49.63
21/03/2022	43.70
22/03/2022	42.43
23/03/2022	50.75

- **Estimation of iron concentration from aethalometer data.** Attention is focused on iron concentration results, because iron is a tracer for the iron oxides present in dust aerosol.

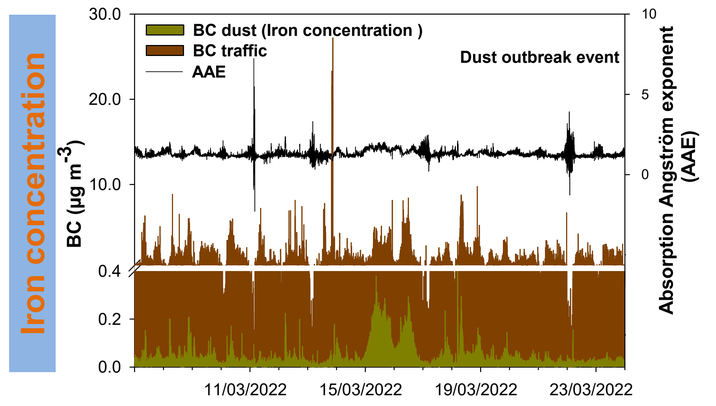

Figure 6 –Time series of the aethalometer data for black carbon (BC) and the estimated iron concentration after the application of two-component model (Fialho et al., 2006). Variation in the Absorption Angström Exponent (AAE).

Conclusions

- The backward trajectories confirms the existence of air masses from North Africa reaching the NW of the Iberian Peninsula especially on 15 March 2022.
- The PM_{10} daily concentration reached 370 µg m^{-3}, largely exceeding the limit values set (the mean concentration for the sampling period was 20 ± 12 µg m^{-3}).
- The OC daily concentration also increased, reaching 11 µg m^{-3}, presenting average values for the study period of 2.5 ± 1.1 µg m^{-3}.
- An important increase of the concentrations of crustal elements (Si, Ca, Al, Fe, K, and Mg) and of some water soluble ions (SO_4^{2-},Ca^{2+} and NO_3^-) associated with the increase of PM_{10} concentration was also observed.
- The estimated iron concentration (BC dust) is consistent with the presence of high quantities of dust during the event.
- A rise in the AAE is observed due to the absorption of UV and visible radiation by mineral dust.
- Finally, there is also a clear increase in the particles geometric mean on the days most affected by the outbreak event.

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