Air quality in the city of León: the role of air masses

M. Huertas, E.D Vicente, A.I Calvo and R. Fraile

Department of Physics, University of León, 24071 León, Spain
aicalg@unileon.es

INTRODUCTION

Air quality in urban areas has been modified by industrialisation (Aránguez et al., 1999), being influenced by atmospheric, climatic, and local topographic conditions (Inche, 2004). Air quality in urban areas is affected not only by the emission sources present in the city, but also by phenomena such as atmospheric dispersion and the transport of pollutants.(Aránguez et al., 1999). For this reason, it is crucial to know the transport routes of pollutants, the possible source regions, and their relative contribution to pollution levels in a city (Liu et al., 2013).

Regarding this transport routes, it is important to mention that, on many occasions, particles arrive at our latitudes from the Sahara desert. These Saharan dust intrusions cause and important increase of PM10 concentrations and contribute to exceedances of the daily European PM10 limit value (50 µg m^{-3}) (Figure 1).

Different scientific studies have revealed the relationship between the spatial and temporal variations of pollutants with the transport of air masses. In previous studies about contaminant transport, the HYSPLIT (Hybrid single-particle Lagrangian integrated trajectory) model has been widely used as a powerful tool to determine the origin of pollutants at a given arrival point.

This study presents an analysis of the influence of the origin of air masses on air quality in the city of León (Spain) during one year (2021). Furthermore, the impact of a Saharan dust intrusions on PM10 concentrations in this city has been studied in detail.

Figure 1. Photograph of the city of León (the cathedral is almost imperceptible) during the Saharan dust intrusion registered on 15 March 2022.

METHODOLOGY

STUDY ZONE

Figure 2. Location of León (coordinates 42º35'56''N 5º34'01''W)

DATABASE

- **Pollutant concentrations** (SO_2, PM10, NO, NO_2, NO_x and CO): obtained from two air quality stations of the Air Quality Network of Castilla y León:
  - Station 1- urban traffic station
  - Station 4 - background station
- **Back-trajectories:** Five days long back-trajectories for four different altitudes - 500 m, 1000 m, 1500 m and 3000 m a.g.l.- calculated with the HYSPLIT model.

STUDY PERIOD

From 1 January to 31 December 2021

ADITIONAL TOOLS

Models: **NAAPS** Stastistical program: **SPSS**

CLASSIFICATION OF AIR MASSES

Based on the daily HYSPLIT images, the category for each altitude was established taking into account the area of influence where the back trajectory had remained longer (except for the Saharan category, for which to pass through the North of Africa was enough to assign this category due to the important influence of this area on air quality).

Taking into account this classification at different altitudes, an air mass category was assigned to each day according to the following criteria (Calvo, 2009):

- The days in which at least at one of the four heights studied a Saharan origin was registered, the Saharan category was assigned.
- The rest of the days are assigned the air mass category corresponding to 500 m.

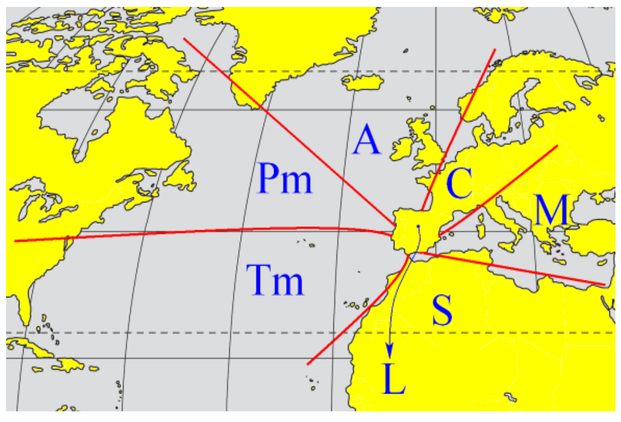

Figure 3. Zones of origin of air mases: Local (L), Saharan (S), Mediterranean (M), Continental (C), Artic (A), Polar maritime (Pm) and Maritime tropical (Tm) (Calvo et al., 2012).

RESULTS

AIR MASSES

The Polar maritime was the category with the highest percentage of occurrence, followed by the Arctic. On 17% of the days studied, Saharan dust reached the city of León, which could increase the concentration of suspended particles.

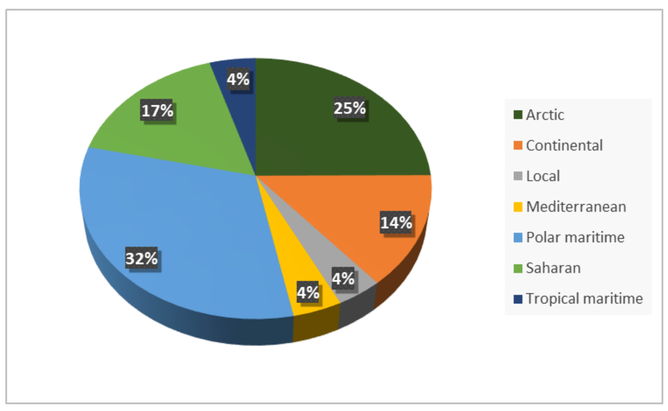

Figure 4. Percentage of occurrence of each category of air masses in León during 2021.

- In 2021, the maximum PM10 concentration in León was registered on 5 March.
- Daily concentrations of 97 µg/m^3 at station 1 and 85 µg/m^3 at station 4 were recorded.
- The category assigned to this day according to our classification of air masses is Saharan.
- The NAAPS model confirms the Saharan dust intrusion affecting León.

RELATION BETWEEN AIR MASSES AND POLLUTANT CONCENTRATIONS

Regarding mean concentrations:

At station 1, the highest PM10 concentration was registered when the mass entering the city has Saharan origin. However, for SO_2, the highest concentration is registered under Local air masses.

At station 4 the category with higher PM10 concentration is the Mediterranean and the Continental category registers the higher NO_2 mean concentration.

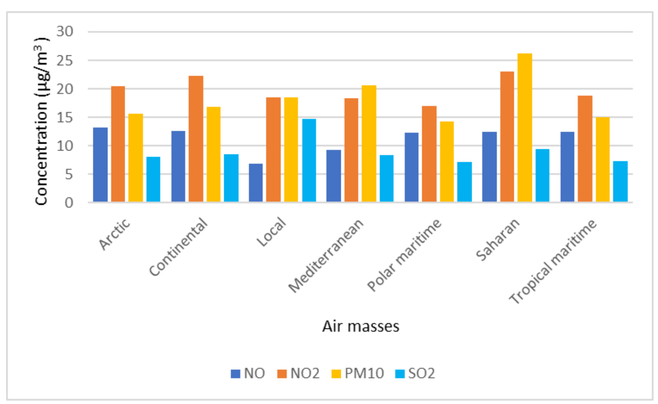

Figure 5. Mean concentrations of the four pollutants studied at station 1 for each category of air mass.

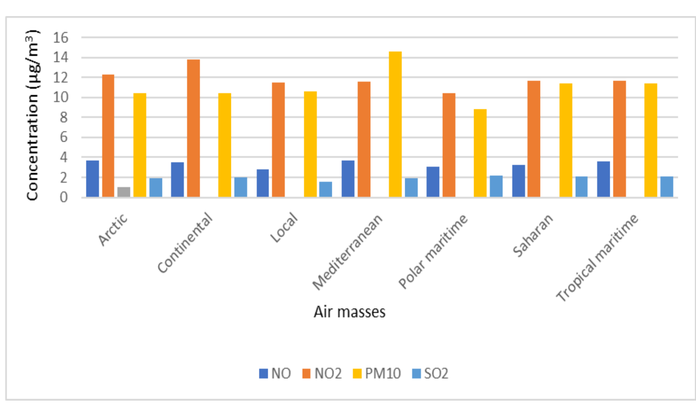

Figure 6. Mean concentrations of the five pollutants studied at station 4 for each category of air mass.

Table 1. Air masses between which statistically significant differences for PM10 concentrations have been registered (from station 1) (Kruskal-Wallis test, p <0.05).

AIR MASSES
Polar maritime-Mediterranean
Polar maritime-Saharan
Tropical maritime-Saharan
Arctic-Saharan
Local-Saharan
Continental-Saharan

CASE STUDY: SAHARAN DUST INTRUSION (5 MARCH 2021)

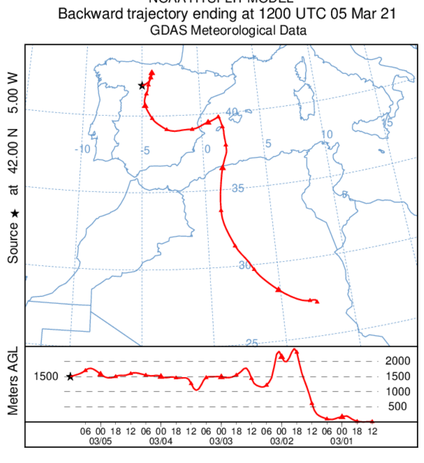

Figure 7. Five days long back-trajectories arriving at León on 5 March at 1500 m altitude.

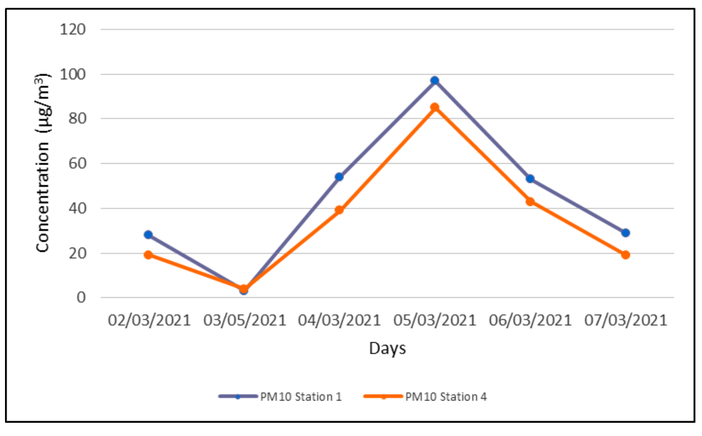

Figure 8. Evolution of PM10 concentrations from 2 to 7 March 2021 at stations 1 and 4.

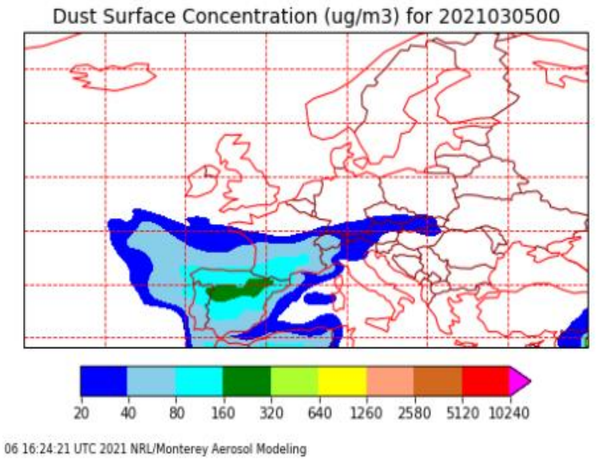

Figure 9. Surface particle concentration for 5 March 2021 at 0000 UTC, obtained from NAAPS model.

CONCLUSIONS

- The category of air masses with the highest occurrence in the city of León in 2021 was Polar maritime.
- The highest mean pollutant concentration was registered under different air masses in the stations 1 and 4. This fact should be analyzed further.
- The Saharan category shows statistically significant differences with almost all the rest categories for PM10 concentration in both air quality stations.
- Saharan dust intrusions are events that increase PM10 concentrations in the city of León.

ACKNOWLEDGEMENTS

This work was partially supported by the AEROHEALTH project (Ministry of Science and Innovation, Grant PID2019-106164RBI00, co-financed with European FEDER funds) and by the Junta de Castilla y Leon cofinanced with European FEDER funds (Grant LE025P20). The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model and/or READY website (https://www.ready.noaa.gov) used in this publication

REFERENCES

Aranguez, E. et al. Contaminantes atmosféricos y su vigilancia. *Rev. Esp. Salud Publica* [online]. 1999, vol.73, n.2 [citado 2022-08-07], pp.123-132.

Calvo, A.I., et al. (2012). Aerosol and Air Quality Research, 12, 856–878.

Inche, J. Gestión de la calidad del aire: causas, efectos y soluciones. *Instituto de Investigación de Ingeniería industrial–UNMSM. Lima, Perú*, 2004.

Liu, N. et al. (2013). Atmospheric Pollution Research, 4, 3, 306-314.