Influence of meteorological parameters on air pollutant concentrations in León, Spain

F. Oduber*, C. Blanco-Alegre, A.I. Calvo, A. Castro, S. Sainz, A, Martínez, R. Fraile

Department of Physics, IMARENAB, University of León, 24071 León, Spain
* fodup@unileon.es

XXXV JORNADAS CIENTÍFICAS DE LA ASOCIACIÓN METEOROLÓGICA ESPAÑOLA
"Predicción de Tiempo y Clima orientada a impactos"
19º Encuentro Hispano-Luso de Meteorología

INTRODUCTION

The presence of pollutants in the atmosphere may cause a negative impact on human health and the environment. The main air pollutants are carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), ozone (O_3) and particulate matter (PM). The correlation between the air pollutant concentrations and the weather variables provides valuable information about the emission sources and leads to a better understanding of the processes responsible for the spatial and temporal distribution of air pollutants. This enables policy makers to establish mitigation measures. The aim of this work is to find the relationship between the concentrations of the main pollutants and the meteorological variables (including weather types) that characterize the atmosphere in León.

STUDY AREA AND METHODOLOGY

The present study was carried out in León city, located in the northwest of the Iberian Peninsula (42° 36′ N, 05º 35′ W and 838 m above sea level). The climate in León city is Mediterranean type with continental features. In 2016, the mean annual temperature, relative humidity, precipitation and days with precipitation of more than 1 mm were 11 ºC, 68%, 488 mm and 82 days, respectively (www.aemet.es).

✓ The data available, for two air quality stations, in the Air Quality Network of Junta of Castilla y León (www.servicios.jcyl.es/esco) for the period between 1 January and 31 December, 2016 were used (**Fig.1**):

- Station 1: An urban traffic station located in San Ignacio de Loyola Avenue (05° 35'14"W 42° 36'14"N).

- Station 4: A background station located in the Coto Escolar (05° 33'59"W 42° 34'31"N).

Fig. 1. Map of León city (Spain) and location of both air quality stations (Station 1 and Station 4).

✓ In León, the winds come predominantly from the third and fourth quadrants (**Fig. 2**), i.e.: the predominant directions are between NW and SW. Winds from the first quadrant are remarkably light (between 0.6 and 1.4 m s^{-1}), while those from the SW are the most intense (3.4 m s^{-1}).

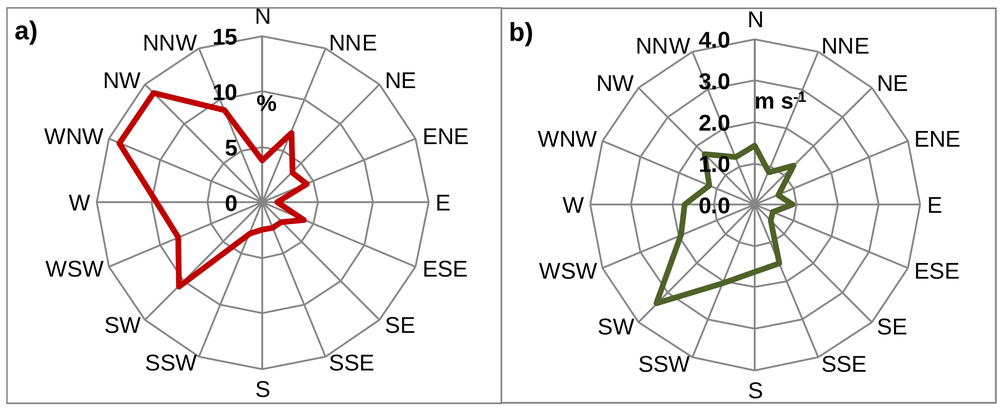

Fig. 2. Frequencies of a) wind direction and b) wind speed.

RESULTS AND CONCLUSIONS

✓ Station 1 shows higher pollutant mean concentrations than station 4 (**Fig. 3**), for sure due to the large contribution of traffic and urban heating systems near the station. Additionally, station 1 shows a mean CO concentration of 0.3 ± 0.2 mg m^{-3} and station 4 shows a mean O_3 concentration of 54 ± 0.2 µg m^{-3}.

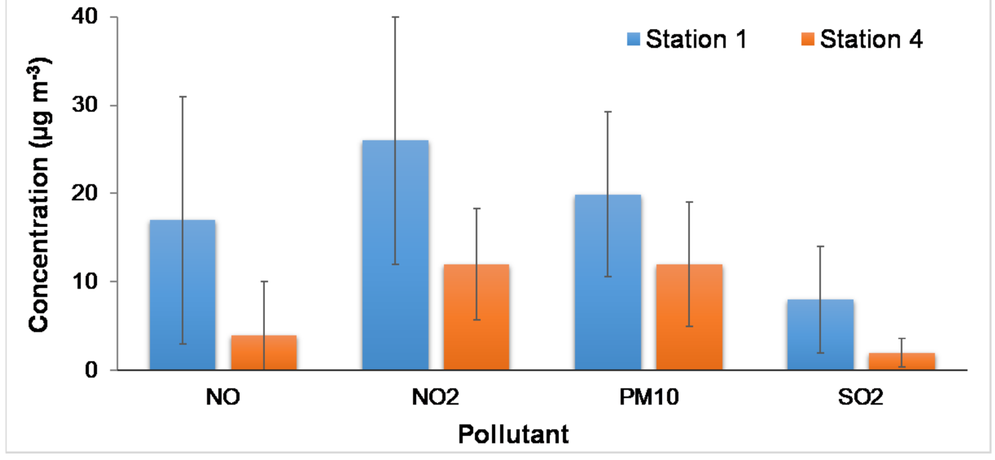

Fig. 3. Pollutant mean concentrations in 2016.

✓ A Circulation Weather Types classification (CWTs) (Lamb, 1972) shows that during 2016 (**Fig. 4**):
- The CWTs were mainly anti-cyclonic (66 days).
- Followed by a purely directional type, northeasterly (42 days).
- And a purely directional type, northerly (34 days).
- In general, the increases in the pollutant concentrations are recorded in anti-cyclonic weather type.

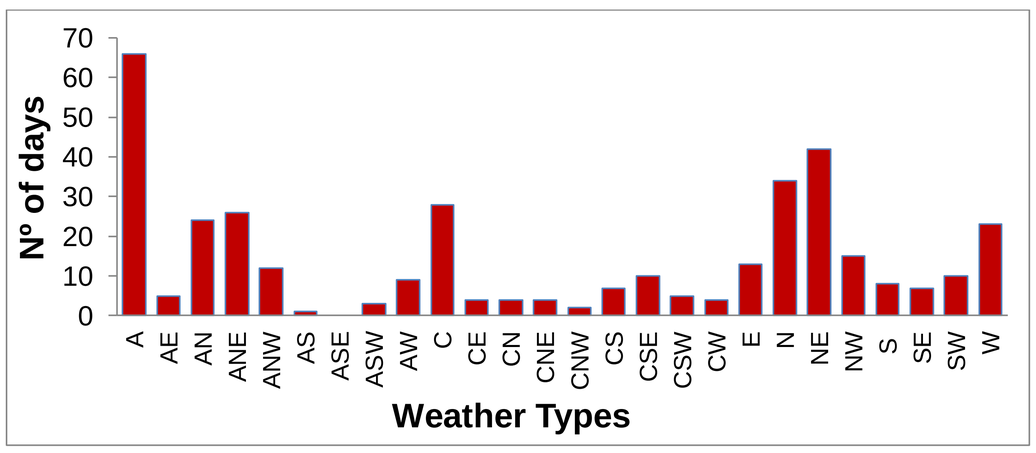

Fig. 4. Weather types in León in 2016

❖ The principal source of particles is located close to the sampling point (Fig. 5). Also, the Pearson correlation coefficient shows, in both cases, a positive significant correlation between PM_{10} and NO, NO_2 and CO, that reflects the road traffic emission as a common origin.

❖ There are differences in the PM_{10} concentrations registered in both stations, probably due to the different category of both stations: traffic (station 1) and background (station 4). Thus, station 1 is highly influenced by the emissions from the vehicles in the proximities and also by the domestic heating devices that are in the vicinity (mainly during cold months).

✓ The correlation between pollutant concentrations and meteorological parameters (mean temperature (T), minimum temperature (T_{Min}), maximum temperature (T_{Max}), relative humidity (RH), wind speed (ws) and accumulate precipitation (P)) was made using the nonparametric Pearson correlation method (**Table 1**):

- In general, the P and RH are negatively correlated with the pollutant concentration, suggesting that the removal by condensation or wet deposition is favored.

- T and T_{Max} were positively correlate with O_3 concentration, which is an indicator of photooxidation processes.

- ws has a negative correlation with the pollutant concentrations, indicating that when the wind speed is high there are a major dispersion of the pollutants, causing the reduction of the concentration, except for CO and O_3.

Table 1. Pearson correlation coefficients between pollutant concentrations and meteorological parameters.

	Station 1					Station 4				
	CO	NO	NO_2	PM_{10}	SO_2	NO	NO_2	O_3	PM_{10}	SO_2
ws	,200**	-,294**	-,352**	-,515**	-,363**	-,297**	-,393**	,194**	-,507**	-,120*
Prec.	,116*	-,127*	-0.089	-,303**	-,224**	-,144**	-,164**	0.040	-,334**	-,181**
T_{Min}	-,641**	-,426**	-,151**	-0.044	,111*	-,389**	-,339**	,532**	,229**	-,185**
T_{Max}	-,640**	-,253**	-0.059	,152**	,259**	-,225**	-,157**	,499**	,431**	-0.011
T	-,678**	-,338**	-0.100	0.081	,214**	-,305**	-,241**	,541**	,374**	-0.08
RH	,474**	,189**	0.020	-,153**	-,213**	,230**	0.052	-,566**	-,403**	-,106*

** p < 0,01; * p < 0,05.

✓ A decrease in PM_{10} concentration with the increase of the wind speed was observed for both stations (**Fig. 5**). This behavior is confirmed by the negative significant correlation observed between ws and PM_{10} concentrations (**Table 1**). The highest atmospheric pollutant concentration is linked to traffic (e.g., SO_2, PM_{10}) in urban sites and to the low ws (Elminir, 2005).

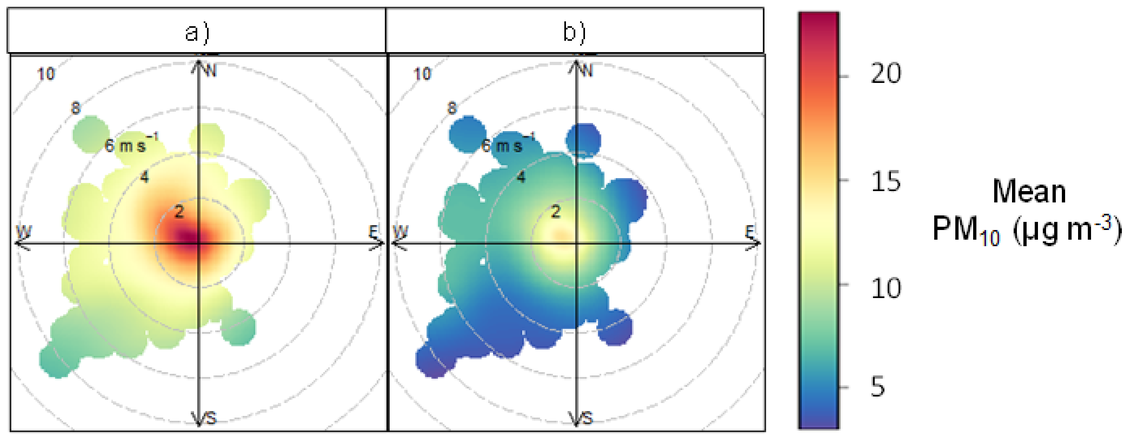

Fig. 5. Polar Plots (PM_{10} concentration as a function of wind speed and direction) for a) station 1, b) station 4.

REFERENCES

Elminir HK, 2005: Dependence of urban air pollutants on meteorology. Sci Total Environ. 350, 225–237.
Lamb HH, 1972: British Isles weather types and a register of the daily sequence of circulation patterns 1861-1971. Her Majesty's stationery office.

ACKNOWLEDGEMENTS
This work was partially supported by the Spanish Ministry of Economy and Competitiveness (Grant TEC2014-57821-R), the University of León (Programa Propio 2015/00054/001) and AERORAIN project (Ministry of Economy and Competitiveness, Grant CGL2014-52556-R, ERDF co-financed). F. Oduber acknowledges the grant BES-2015-074473 from the Spanish Ministry of Economy and Competitiveness. C. Blanco-Alegre acknowledges the grant FPU16-05764 from the Spanish Ministry of Education, Culture and Sport. Beatriz Martinez Panero patiently collaborated in data processing.