RAINFALL CHARACTERISTICS IN LEÓN IN 2016 AND 2017

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Nowadays, air pollution is one of the principal risk to human health and rain is the main sink of aerosol particles in the atmosphere, since it is the main process to mitigate pollution. Furthermore, the study of rainfall characteristics is crucial because it can provide information about present and future risks in an area, related to rain amount or intensity. That is why the use of models is critical to prevent damages by rain, hence the correlation between synoptic situation and rainfall characteristics can provide information to be used in models.

The study site is located at the campus of the University of León (León, Spain), a city placed in the Northwest of the Iberian Peninsula (42° 36' N, 05° 35' W and 838 m above sea level). León has a population of about 200,000 people, including the metropolitan area (population density close to 3300 inhab. /km^2).

According to the information provided by the the Meteorological State Agency (AEMET (http://www.aemet.es), León presents a Mediterranean climate with continental features. The climate is tempered by the proximity of the Cantabrian Mountain Range. León city is characterized by rain events irregularly scattered over the year, with minimum precipitation values in summer and peaks in spring and fall. The principal normalized values, in the last 35 years, are the following: annual mean precipitation is 556 mm and the temperatures are rather fresh, with an annual mean of 10.9 °C. The winter is cold with frequent frosts: 74 frost days per year, on average. The summer is tempered by the altitude, with maximum temperatures around 27 °C.

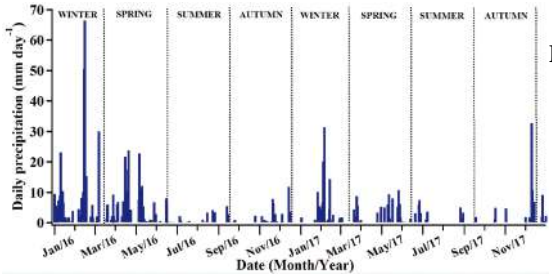
In order to know the characteristics of the precipitation in the city of León, rain was sampled during 2016 and 2017 using a Laser Precipitation Monitor (LPM) of *Thies Clima* which registered drops between 0.125 and 8 mm in 22 channels (Fig. 1A). The LPM determines the speed and volume of the hydrometeors from the duration and amount of laser signal emitted lost and detected in a sampling area of 228 × 20 mm^2. From the data provided by the LPM, the following rainfall variables were obtained every minute: precipitation intensity, accumulated precipitation, number of drops in 22 channels, mean and standard deviation of raindrop sizes.

Furthermore, a Circulation Weather Types (CWTs) classification was carried out based on Lamb (1972), to identify the weather type related to a peculiar synoptic situation in days with rain. Although the initial classification was applied to United Kingdom, this model has also been applied to the Iberian Peninsula in recent studies (Calvo et al., 2012). The pressure database required for the classification (Trigo and DaCamara, 2000) is available for the northern hemisphere in intervals of 5° of latitude and longitude (http://iri.columbia.edu/). Eight weather types are identified as "pure", characterized by

a specific predominant wind component: N, S, E, W, NW, SW, SE and NE. Other two of them are the so-called "non-directionals": "Pure anticyclonic" (A) and "Pure cyclonic" (C). As result of the combination of "non-directional" with "pure" types can obtain other 16 CWTs.

Between January 2016 and December 2017, 203 rainfall days occurred (129 in 2016 and 74 in 2017) with a total of 949.6 mm accumulated (611.6 in 2016 and 338.0 in 2017). Figure 1B shows the rain distribution throughout the sampling period, with a clear predominance of precipitation during spring and winter, representing more than 80% of the total annual volume. The rainiest day was 15/02/2016 with a precipitation of 66.4 mm, a mean raindrop diameter of 0.35±0.29 mm and a total of $6.2 \cdot 10^7$ raindrops $^{m-2}$.

A)



B)

Fig. 1.- A) *Laser Precipitation Monitor* (LPM) of *Thies Clima* used during the sampling campaign at León between January 2016 and December 2017; B) Daily rainfall time series at León between January 2016 and December 2017.

February was the rainiest month and with the two highest rain hourly intensities registered: 19.9 mm/h (15 February 2016 at 0700 UTC) and 12.8 mm/h (5 February 2017 at 0700 UTC).

Focusing on rain characteristics in the city of León, $3.23 \cdot 10^9$ drops m^{-2} have fallen in 2016 with a mean size of 0.36±0.20 mm and $1.06 \cdot 10^9$ drops m^{-2} in 2017 with a mean size of 0.35±0.19 mm. Table 1 shows a summary of the main characteristics of the raindrops recorded during the sampling period. The number of fallen raindrops in 2017 is one third of those fallen in 2016. This fact has a negative impact on the swept produced by rain in the atmosphere, with a lower scavenging on

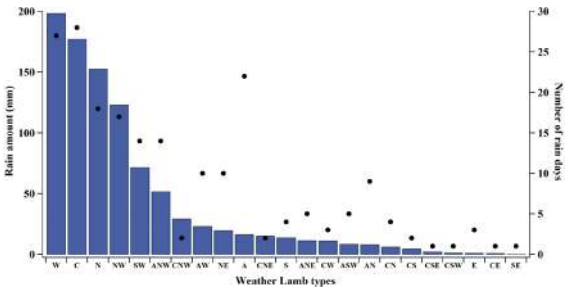


Fig. 3.- Summary of Weather Lamb Types during rain days in León 2016-2017. Black poins indicate the number of rain days of each Lamb Weather Type.

aerosol particles (Zikova and Zdimal, 2016). Hence, the lower amount of rain recorded in 2017 was an important factor to explain the more polluted atmosphere in 2017 than in 2016, as indicated by the Air Quality Network of Castilla y León data in León city.

Year	Number of raindrops (#/m2)	Number of rain days	Rain amount (mm)	Mean ± standard deviation raindrop diameter (mm)	PM10 concentration (µg/m3)
2016	3.23 109	123	611.6	0.36±0.20	19.9 ± 9.3
2017	1.06 109	80	338.0	0.35±0.19	23.7 ± 11.5
Total	4.29 109	203	949.6	0.36±0.19	21.8 ± 10.7

Table 1.- Summary of rain characteristics during the sampling in León 2016-2017 and PM10 concentration in the Station León1 from the Air Quality Network of Castilla y León.

Regarding to Lamb Weather Types during rain events, we can highlight the types W, C, N and NW with a rain amounts of 198.5, 177.4, 152.6 and 123.1 mm, respectively and 27, 28, 18 and 17 rain days. However, the maximum intensity occurred for the ANE category (19.9 mm/h) and the higher mean diameter was registered for the NE (0.43±0.25 mm). Figure 3 shows a summary of CWTs during the rain events. If we analyze the air origin during the rain events, based on CWTs, we can observe that N was the main air origin, with 98 rain days, and NE with 97 days. However, the air origin with a higher amount of rain accumulated on León was NW, with 185.3 mm in 36 rain days.

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References

- **Calvo, A.I., Pont, V., Olmo, F.J., Castro, A., Alados-Arboledas, L., Vicente, A.M., Fernández-Raga, M. and Fraile, R., 2012: Air masses and weather types: A useful tool for characterizing precipitation chemistry and wet deposition. *Aerosol Air Qual.* Res., 12, 856–878. doi:10.4209/aaqr.2012.03.0068**
- **Trigo, R.M. and DaCamara, C.C. 2000: Circulation weather types y their influence on the precipitation regime in Portugal. *Int. J. Clim.*, 20, 1559–1581. doi:10.1002/1097-0088(20001115)20**
- **Zikova, N. and Zdimal, V. 2016: Precipitation scavenging of aerosol particles at a rural site in the Czech Republic. *Tellus* B., 68, 1–14. doi:10.3402/tellusb.v68.27343**