Optical properties of atmospheric aerosols in León (Spain)

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INTRODUCTION

Nowadays, there is a clear evidence that aerosols directly and indirectly impact on thermodynamic processes and radiative fluxes of the Earth's atmosphere (Andreae & Rosenfeld, 2008). Aerosols influence atmospheric radiative balance (Fig. 1) directly through the interaction of radiation and particulate matter, such as scattering and absorption, and indirectly some act as cloud condensation and ice nuclei. Aerosol properties depend on the size of the particles and some of them, like the optical properties, to a large extent (Hinds, 1999)

This study aims to analyze the optical properties of aerosol particles estimated from aerosol size distributions during one year in León (Spain) (Fig. 2). Furthermore, monthly evolution of density and refractive index of aerosols were also studied.

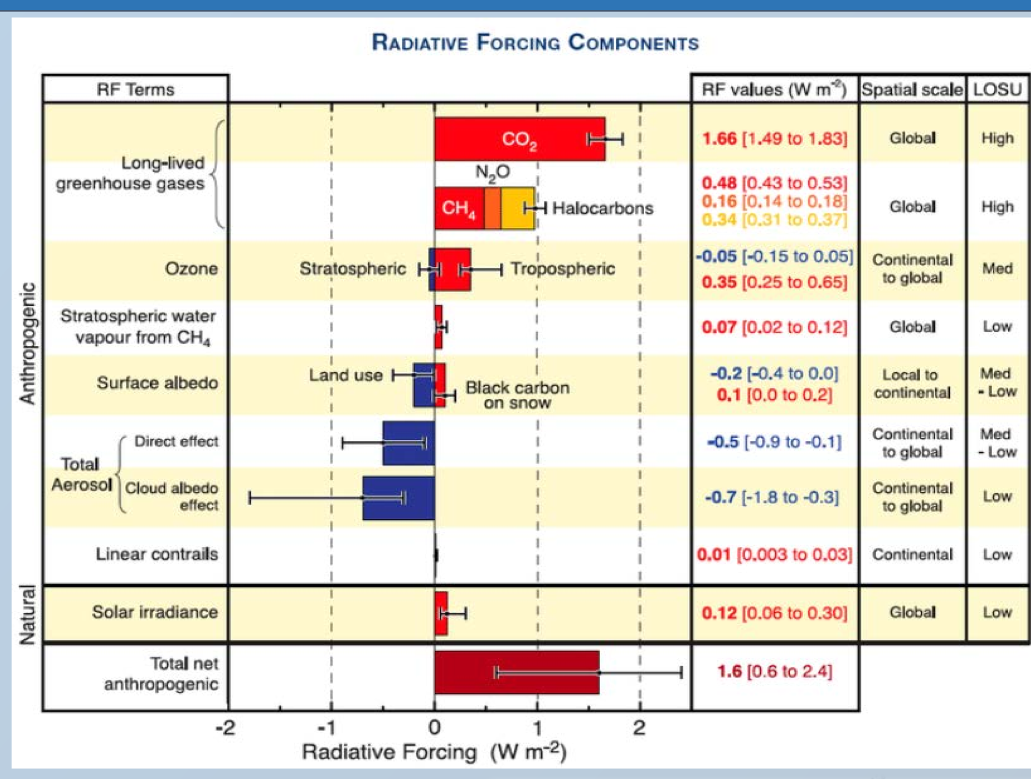


Figure 1. Global average of radiative forcing in 2005 for CO_2, CH_4, N_2O and other important components and mechanisms (IPCC, 2007).

START: March 2016 → END: February 2017 → LOCATION: LEÓN (SPAIN) → 200,000 dwellers → 838 m a.s.l.

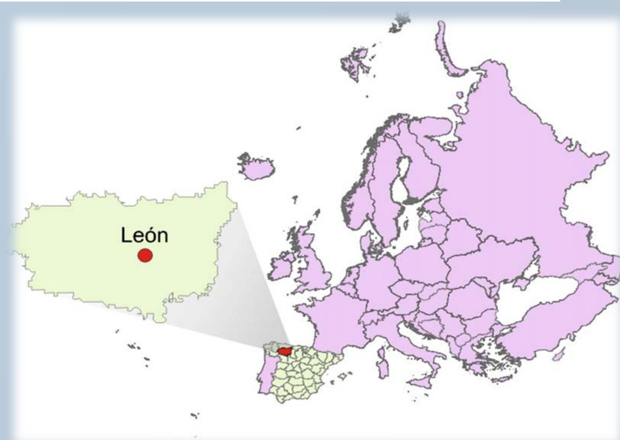
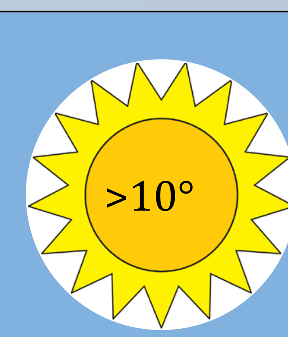


Figure 2. Geographical location of the study area.

EXPERIMENTAL



1. Determination of the hours with a **solar elevation** angle **above 10°**. (https://www.suneartтools.com).

2. **Particle size distributions** have been obtained with an optical spectrometer PCASP-X. Diameters range between **0.09 and 27.8 µm** in 31 channels.

Fine mode
Coarse mode
Total

3. Definition and characterization of aerosol size modes during the hours with a solar elevation angle above 10°

4. Daily PM_{10} filter samples were collected during the sampling campaign. They were analyzed for carbon, ions and trace elements.

The complex refractive index and the density were computed from the chemical composition (Levin et al., 2010)

Scattering
Absorption
Extinction
Backscattering

5. **Optical properties** were obtained for 3 different wavelengths (**440nm, 670nm, 870nm**).

Optical parameters were: mass efficiencies of scattering (**MSE**), absorption (**MAE**), extinction (**MEE**) and backscattering (**MBSE**).

RESULTS

Table 1. Monthly refractive index and density of aerosol particles in León between March 2016 and February 2017.

Month-Year	Refractive index m = n – ki	Density (g cm⁻³)
March 2016	1.557-0.012i	1.826
April 2016	1.561-0.013i	1.963
May 2016	1.557-0.011i	1.902
June 2016	1.564-0.015i	1.735
July 2016	1.545-0.006i	2.029
August 2016	1.547-0.006i	2.053
September 2016	1.552-0.008i	2.154
October 2016	1.560-0.013i	1.821
November 2016	1.556-0.012i	1.842
December 2016	1.559-0.013i	1.792
January 2017	1.550-0.009i	1.952
February 2017	1.544-0.007i	2.023

- The **density** in the summer months increases with a **maximum** in September of **2.154** g cm⁻³.
- The **imaginary** part of the refractive index in **summer** months varies between **0.006 and 0.008**, that means that the aerosols present have the capacity to absorb the radiation (Table 1).

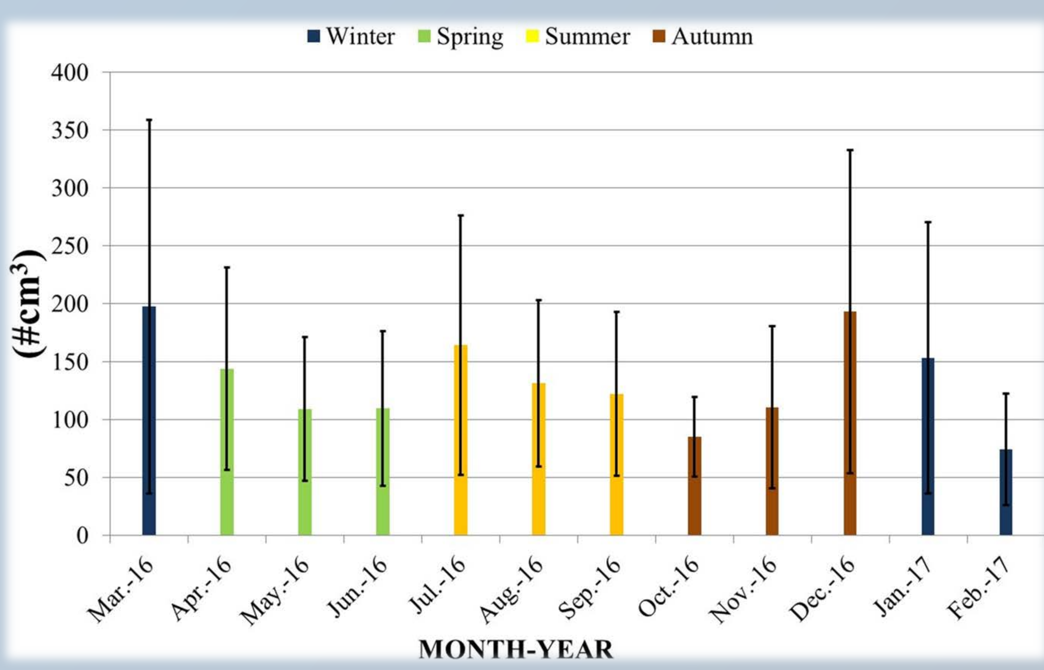


Figure 3. Monthly evolution of the number of particles per cm⁻³ in the study period. The different seasons have been identified by colors.

Higher particle concentration in winter and autumn (Fig. 3)

- Temperature decrease
- Greater use of heating devices
- Intensification of the road traffic.
- Reduction in mixing layer thickness

The particle size distribution showed a greater number of particles smaller than 3 µm in winter compared to the other seasons (Fig. 4).

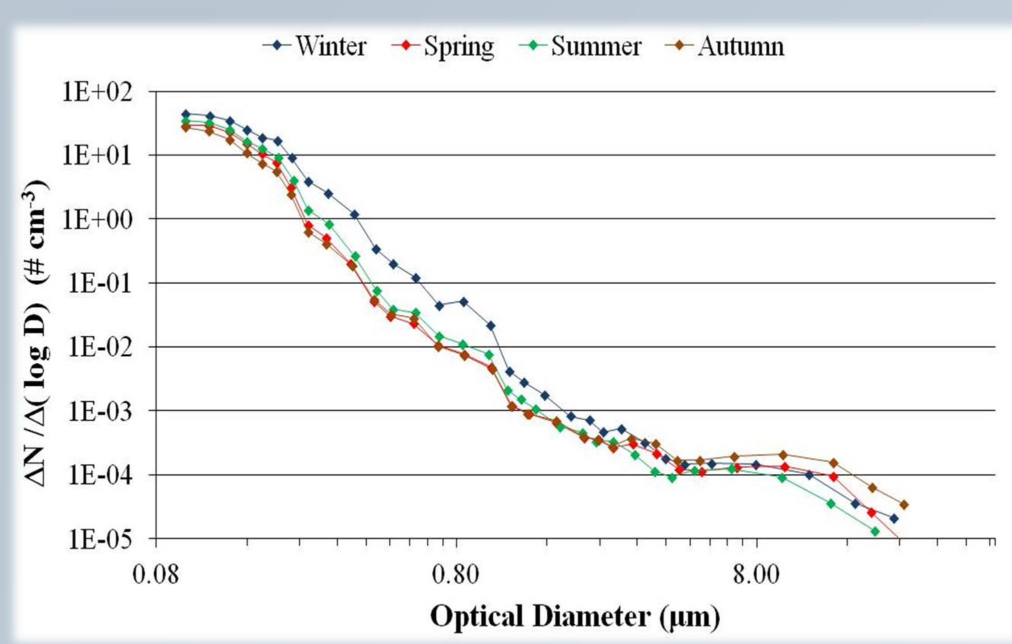


Figure. 4. Aerosol size distribution of particles in spring, summer, autumn and winter .

Table 2. Monthly PM_{10} concentration in two air quality stations in León. % of increase in the concentration of the traffic station compared to the background.

Month/Year	PM_{10} (µg m⁻³) StationE1 (TRAFFIC)	Station E4 (BACKGROUND)	Increase (%)
March/16	17	11	55
April/16	13	7	86
May/16	14	10	40
June/16	17	11	55
July/16	20	15	33
August/16	20	15	33
September/16	23	17	35
October/16	22	11	100
November/16	24	11	118
December/16	31	16	94
January/17	30	15	100
February/17	24	12	100
Annual	21	13	62

The highest values for **MSE, MAE, MEE** and **MBSE** were reached in winter for 440 nm, with values of 3.3±2.3, 0.3±0.1, 3.5±2.4 and 0.1±0.1 Mm⁻¹, respectively (Fig. 5).

Domestic heater devices → High traffic intensity → Lower altitude of mixing layer thickness

Saharan dust intrusions increase the number of particles, promoting **higher values** of the optical parameters in summer (Alonso-Blanco et al., 2018) (Fig. 5).

The increase in traffic, the use of heating devices and the reduction in the mixing layer thickness promote high PM_{10} concentrations in the winter months (Table 2).

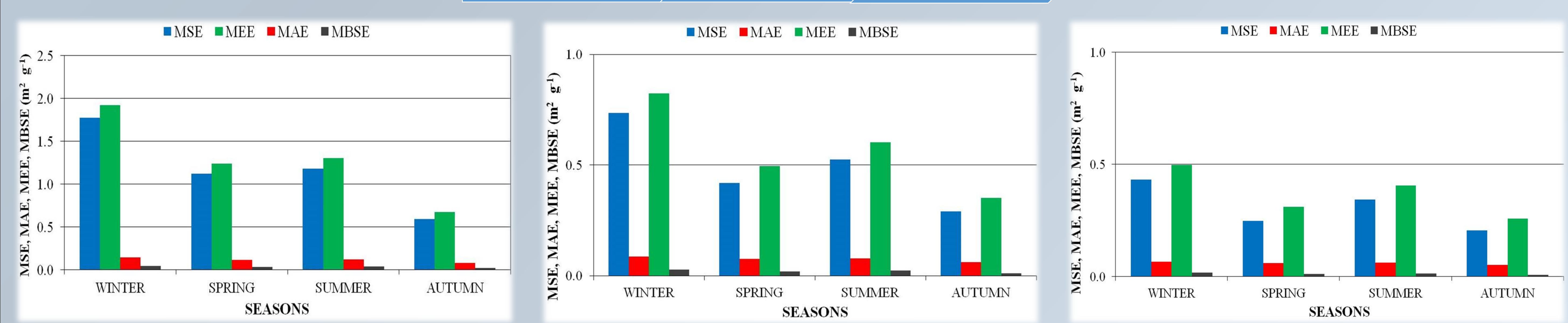


Figure 5. Mass efficiencies of MSE, MAE, MEE and MBSE as a function of three different wavelengths (440 nm, 670 nm, 870 nm respectively) for summer, autumn, winter and spring.

Conclusions

- The density of the particles in León was higher in the summer months with values higher than 2 g cm⁻³.
- In summer, aerosol particles presented a higher capacity to absorb the radiation.
- The highest values for MSE, MAE, MEE and MBSE were reached in winter for 440 nm.
- These results, together with those obtained from the ultrafine mode, will be implemented in the Global Atmospheric Model (GAME) to analyze the effect the evolution of aerosol particles on the radiative forcing.

Acknowledgements

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