Integrating chemical and optical properties of atmospheric aerosols depending on composition and sources; Link air quality-climate

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Large uncertainties still remain on the estimation of the radiative forcing of atmospheric aerosols, which originate from a huge variety of anthropogenic and natural sources. Depending on their physicochemical and optical properties atmospheric particles can scatter sunlight causing a cooling of the environment, whereas other particles, such as elemental carbon (EC), strongly absorb in the whole solar spectrum leading to a warming of the atmosphere. Therefore, further research on the mass scattering and absorption efficiency (MSE and MAE) of aerosols from different emission sources is strongly required, in order to better estimate their radiative forcing and quantify their effect on climate change.

Here we present a new approach aiming to quantify the contribution to scattering and absorption from PM pollutant sources, thus taking into account the mixing state of atmospheric aerosols. This method, based on Hand and Malm (2007), also allows for the reconstruction of scattering and absorption time series from chemical filter data in order to study temporal trends.

Daily PM chemical speciated data collected at three stations in NE Spain (Barcelona (BCN)-urban background and Montseny (MSY)-regional background during 2004-2014, and Montsec (MSA)-continental background during 2009-2014) were used to identify pollutant sources and their contribution to the measured mass of PM_{10} by means of the Positive Matrix Factorization (PMF) model. Then, MSE and MAE of the pollutant sources identified at each station by PMF were calculated by Multilinear regression analysis (MLR) between scattering/absorption and PM_{10} source contributions (Equation 1).

$$Sc^{\lambda}_{PM_{10}} = \sum \left(MSE^{\lambda}_{source} \cdot [source] \right)$$

Equation 1. Estimated total scattering as the sum of partial scattering contribution from pollutant sources.

Seven pollutant sources were identified at MSY and MSA and 8 sources at BCN from PMF model. As an example, monthly contribution to scattering and absorption at MSY was leaded by the seasonal variation of pollutant sources (Figure 1). Ammonium nitrate (AN) and ammonium sulphate (AS) exhibit large MSE (8.8 and 4.5 $m^2\ g^{-1}$), dominating scattering during winter, whereas in summer V-Ni bearing source (fuel oil, shipping) (8.0 $m^2\ g^{-1}$) and AS scattered light more efficiently. However, light absorption at 637 nm was found to be mainly dominated by the anthropogenic (traffic/industrial) source (0.87 $m^2\ g^{-1}$) followed by V-Ni bearing source (0.53 $m^2\ g^{-1}$), despite the fact these sources presented the lowest contributions to PM_{10} mass.

Measured scattering and absorption were satisfactory reconstructed at the three stations. Good agreement was found between estimated and measured absorption at BCN (R^2=0.8) and between estimated and measured scattering and absorption at MSY (R^2=0.88 and R^2=0.80) and MSA (R^2=0.92 and R^2=0.93). The calculated slopes were in all cases close to one. Decreasing trends were observed for the estimated scattering and absorption at the three stations over the last 10 years.

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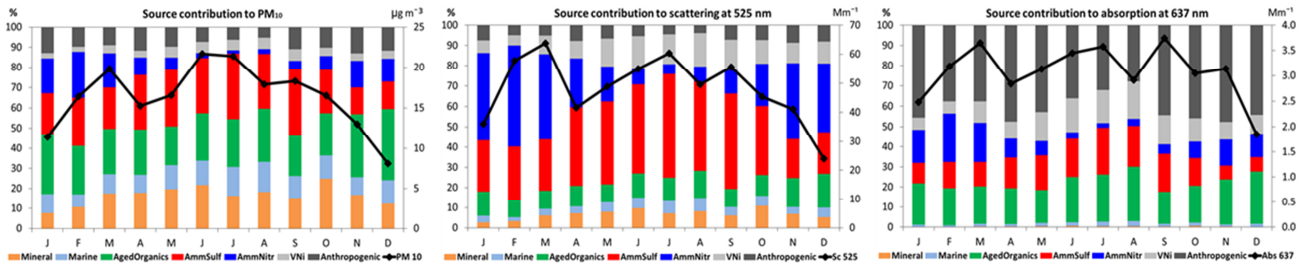

Figure 1. Monthly source contribution (%) to PM_{10}, scattering (525 nm) and absorption (637 nm) at MSY.