Seasonal Variability of Intrinsic and Extrinsic Aerosol Optical and Physical Properties from the Eastern North Atlantic (ENA) Aerosol Observing System (AOS) in 2016 and 2017

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Introduction

The Eastern North Atlantic (ENA) Atmospheric Radiation Measurement (ARM) Facility is located on Graciosa Island (39°N, 28 °N), in the remote Azores archipelago. Throughout the year, the region is subject to strong meteorological variability, mainly due to the Polar front activity during the winter and seasonal northward migration of the North Atlantic subtropical high during the summer, which can affect aerosol composition and concentration. In the present study, we assess the monthly and seasonal variability of aerosol optical and physical properties at the ENA during the year 2016 and 2017.

Instrumentation and Data

The Aerosol Observing System (AOS) at the ENA ARM facility provides continuous, high resolution measurement of *in situ* aerosol physical, optical and chemical properties. In this study, dry aerosol light absorption (B_{abs}) and scattering (B_{sca}) coefficients were determined for submicron (PM_1) and sub-10 µm (PM_{10}) diameter size cuts using a 3 wavelength Particle Soot Absorption Photometer (PSAP) (464, 529, 648 nm) and Integrating Nephelometer (TSI, model 3563) (450, 550, 700 nm). Absorption coefficients were corrected according to Virkkula et al. 2010. Scattering coefficients were converted to the working wavelengths of the PSAP using a SAE of 550-700 nm. The light extinction coefficients (B_{ext}) for PM_1 and PM_{10} were calculated by combining B_{abs} and B_{sca}. Intensive aerosol optical properties of Absorption and Scattering Angstrom Exponent (AAE and SAE) were calculated between 464 and 648 nm. B_{ext} were also directly measured in the AOS with a 1 wavelength CAPS (630 nm). Preliminary analyses on the comparison of the PSAP+Neph B_{ext} and CAPS B_{ext} show good correlation (**Fig. 1**).

The total particle concentration and the chemical composition of the non refractory PM_1 are also presented. Particle number concentrations from 10 nm – 1 µm are measured using a Condensation Particle Counter (CPC). Submicron chemical mass concentration of organics, sulfate, nitrate, ammonium and chloride are presented from the Aerosol Chemical Speciation Monitor (ACSM).

Meteorological measurements collected at the AOS inlet are also presented. Here we present three surface meteorological parameters: temperature (°C), wind speed (m/s) and wind direction

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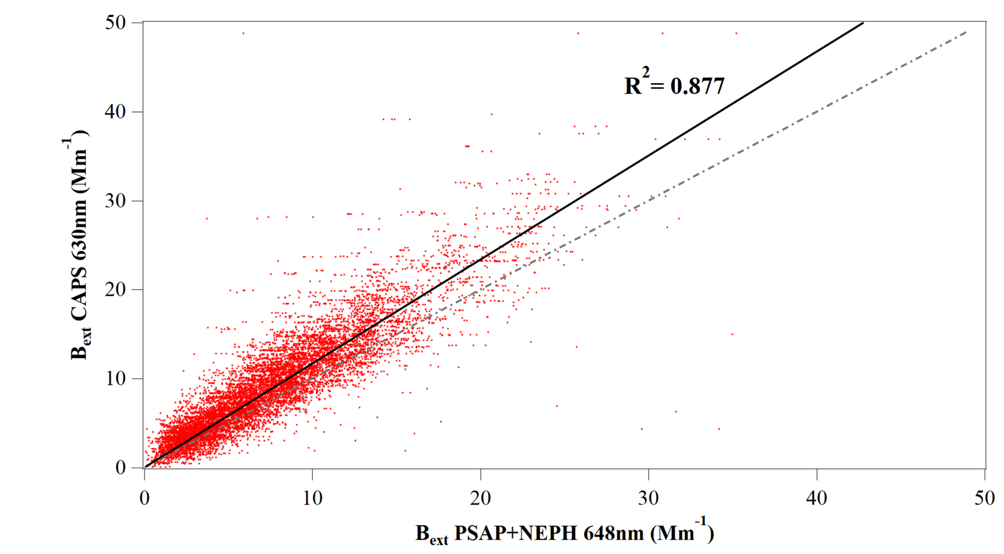

Figure 1. PM_1 scatter plot of measured B_{ext} from the CAPS versus B_{ext} from the PSAP B_{abs} plus nephelometer B_{sca} for the month of January 2017. Linear regression indicates a R^2 of 0.877.

Aerosol Optical Properties

Total aerosol B_{abs} (**Fig. 2**), B_{sca} (**Fig. 3**) and B_{ext} (**Fig. 4**) indicate a seasonal trend in PM_1 and PM_{10} extensive aerosol optical properties during the 2 year period of study. Throughout the year, the total aerosol B_{abs} is dominated by the submicron fraction (~60% from PM_1) and the B_{sca} is dominated by the supermicron fraction (~70% from PM_{10}).

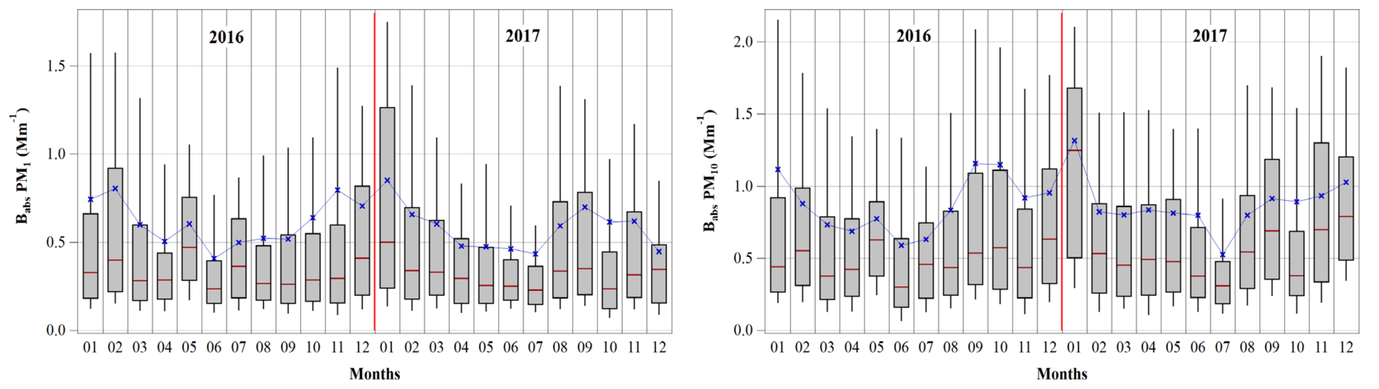

Figure 3. Absorption Coefficient (Mm^{-1}), 648nm, Months 2016 and 2017, (A) PM_1, (B) PM_{10}, calculated using PSAP 1minute data. MEDIAN and PERCENTILE (box bottom 25%, box top 75%, whisker bottom 10%, whisker top 90%), AVERAGE (blue).

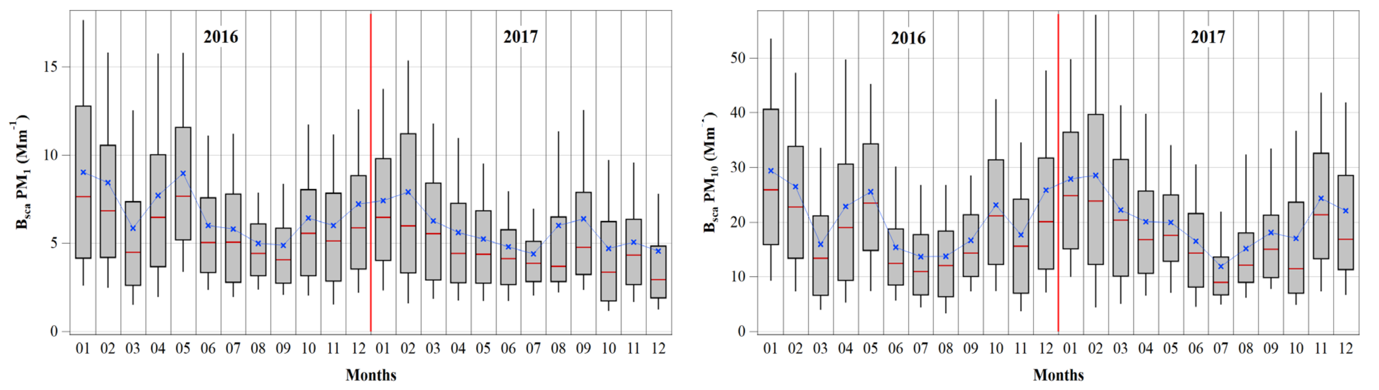

Figure 4. Scattering Coefficient (Mm^{-1}), 648nm, Months 2016 and 2017, (A) PM_1, (B) PM_{10}, calculated using NEPH 1minute data. MEDIAN and PERCENTILE (box bottom 25%, box top 75%, whisker bottom 10%, whisker top 90%), AVERAGE (blue).

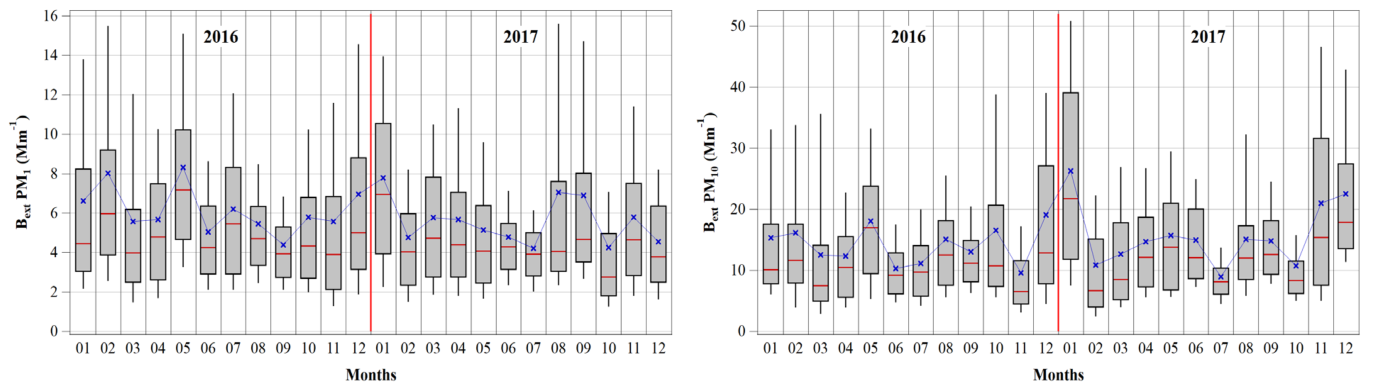

Figure 5. Extinction Coefficient (Mm^{-1}), 648nm, Months 2016 and 2017, (A) PM_1, (B) PM_{10}, calculated using B_{abs} and B_{sca} 1minute data. MEDIAN and PERCENTILE (box bottom 25%, box top 75%, whisker bottom 10%, whisker top 90%), AVERAGE (blue).

Meteorology

Surface temperature exhibits a marked seasonality with a minimum average of 14.2 °C in February 2016 and a maximum average of 22.8 °C in August 2016.

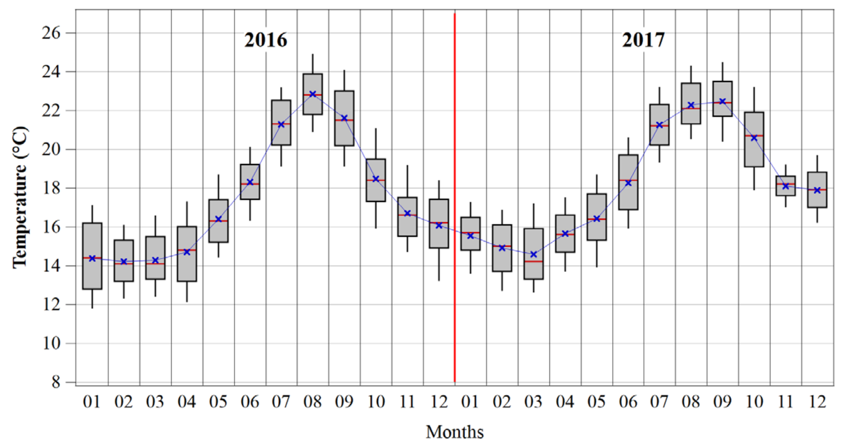

Figure 5. Wind Speeds (m/s). MEDIAN and PERCENTILE (box bottom 25%, box top 75%, whisker bottom 10%, whisker top 90%), AVERAGE (blue).

Surface wind speeds in summer are weaker then in the other seasons. Throughout the year the predominant wind direction is SW with the exception of the fall where predominant wind range from E to SW.

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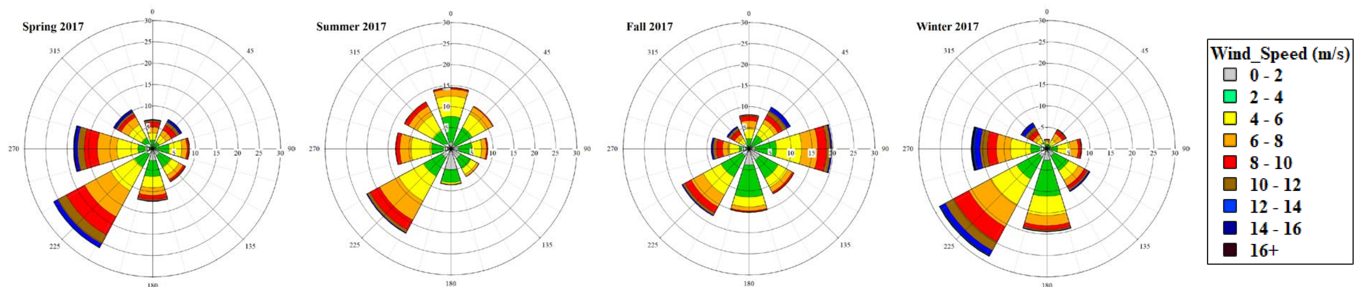


Figure 6. Seasonal surface wind rose plots for the year 2017. The colors indicate the wind speeds while the length of the radial bars is the frequency of different wind speed in percentage.

Intensive Aerosol Properties

A seasonal variation in both PM_1 and PM_{10} was also found for the intensive aerosol optical properties light absorption and scattering Angstom exponents (AAE and SAE). The greatest AAE and smallest SAE during the winter indicates the presence of large diameter mixed absorption particles while the highest SAE during the summer reveal the dominance of small diameters particles.

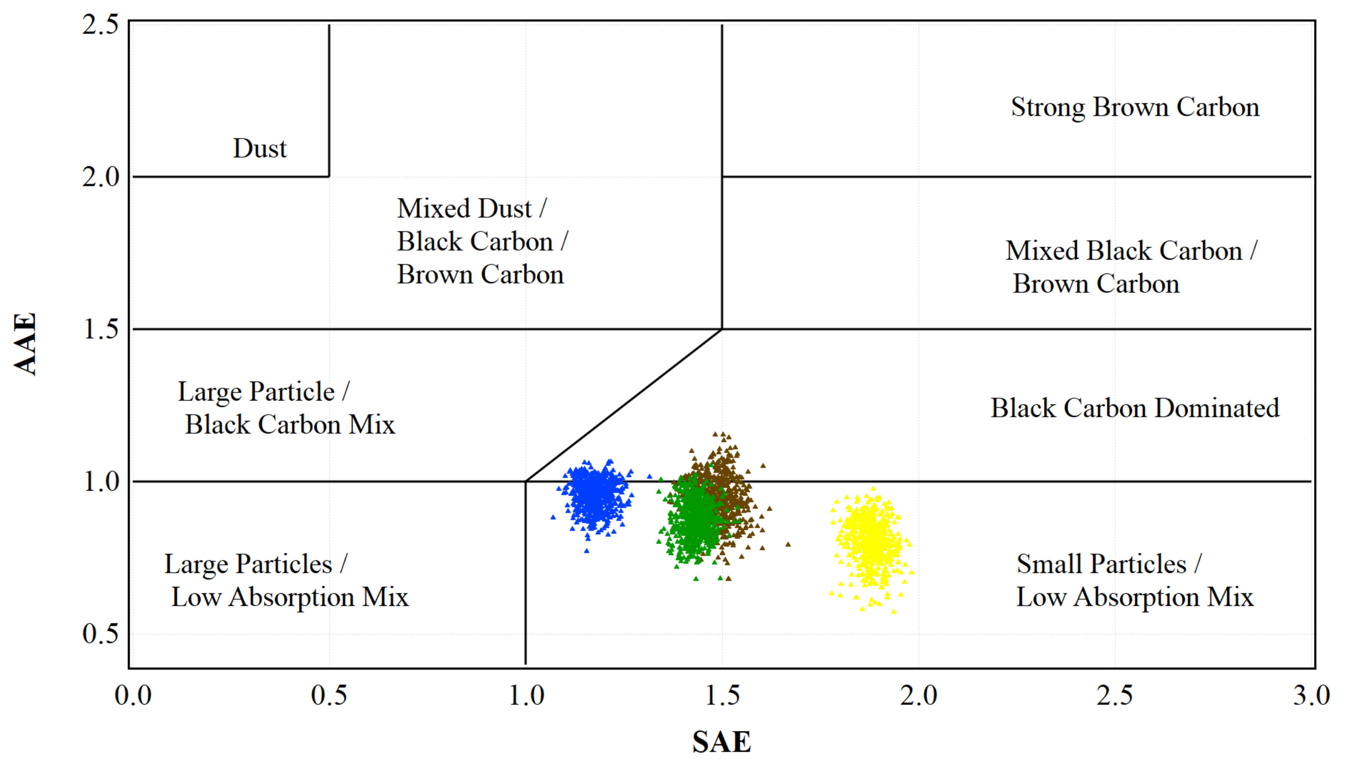


Figure 7. Seasonal variability of Absorption Angstrom Exponent (464 – 648 nm pair) vs Scattering Angstrom Exponent scatter plot (464 – 648 nm pair) for PM_1 particles of daily average in spring 2016+2017 (green, 03.04.05), summer 2016+2017 (yellow, 06.07.08), fall 2016+2017 (brown, 09.10.11) and winter 2016+2017 (blue, 01.02.12) following the scheme suggested by Cappa et al., Atmospheric Chemostry and Physics, 2016.

Aerosol Physical Properties

Total particle concentration varies throughout the year with median monthly concentrations of 205 – 545 cm^{-3}, peaking in the springtime.

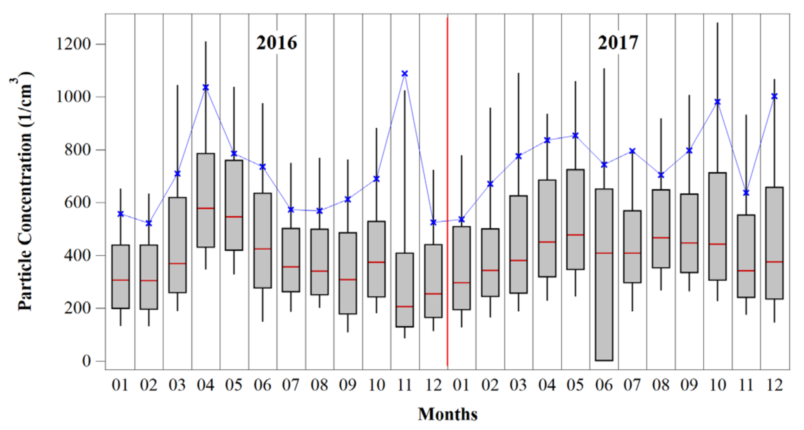
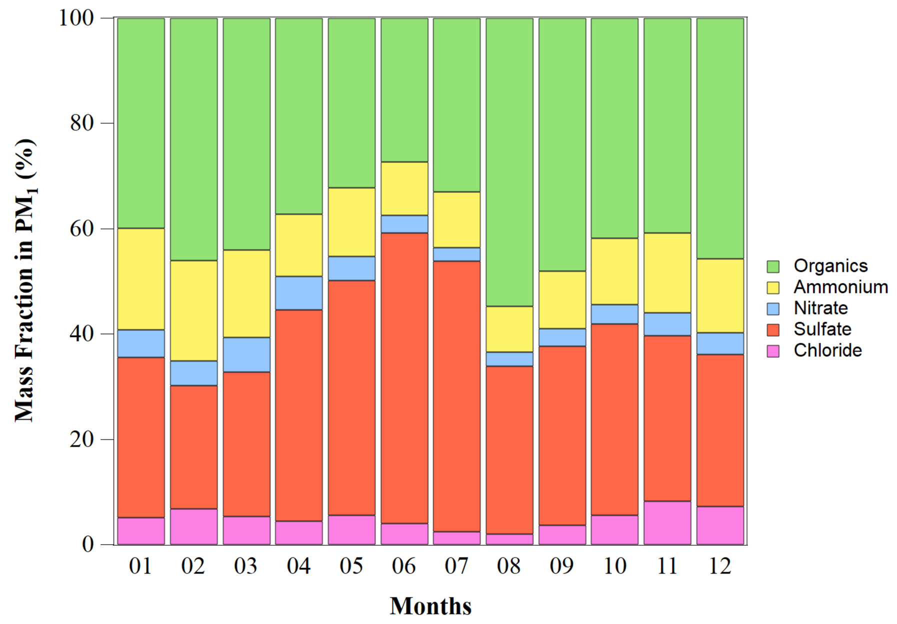


Figure 8. Total Number Concentration (1/cm^3) MEDIAN and PERCENTILE (box bottom 25%, box top 75%, whisker bottom 10%, whisker top 90%), AVERAGE (red).



Preliminary results reveal that the total mass fraction of non-refractory PM_1 is dominated by the organic and the sulfate fractions with peaks in sulfate concentration during late spring/early summer.

Figure 9. Ammonium, Nitrate, Sulfate , Chloride, Total Organics contribution (%) to the Total Mass of non-refractory PM_1, Months 2017

Conclusions

- Aerosol optical properties show marked monthly variability and annual trend. This could be explained by changes in meteorological conditions and emission sources throughout the year to the site at ENA.
- Future investigations concerning aerosol size from the UHSAS and analyses of local emissions from the ENA supplementary site will help to explain the aerosol variability observed by the ENA AOS.