

PRELIMINARY ANALYSIS OF AEROSOLS OPTICAL PROPERTIES AT THE COASTAL SITE LAMEZIA TERME, IN CENTRAL MEDITERRANEAN AREA, INTEGRATING DIFFERENT DATA SET

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Abstract: Atmospheric aerosol particles are playing a major role in the global warming and climate change IPCC (2013). In fact, they affect the Earth's radiative balance directly by absorbing and scattering solar radiation and indirectly by acting as cloud condensation. In order to characterize the aerosol optical properties in the Mediterranean Basin, through observations carried out on the west coast of South Italy (Calabria Region, Italy), one year of light-scattering and absorption coefficient measurements are investigated. In this paper we present the first year of observations performed at the new CNR regional GAW-WMO station of Lamezia Terme (38.88 N, 16.24 W, 6 m a.s.l.). The annual variation and diurnal evolution of: total scattering coefficient (S_c), back scatter coefficient (BSc), Ångström exponent (Å), backscatter ratio (b), absorption coefficient - equivalent black carbon concentration (BC) and single scattering albedo (SSA) are presented. The average values over the period analyzed are respectively: $S_c=37\pm 16 \text{ Mm}^{-1}$ ($\lambda=550\text{nm}$), $\text{BSc}=5\pm 2 \text{ Mm}^{-1}$ ($\lambda=550\text{nm}$), $\text{Å}=1.5\pm 0.2$ (700nm/550nm) $b=0.15\pm 0.04$ ($\lambda=550\text{nm}$) and $\text{SSA}=0.93\pm 0.06$ ($\lambda=637\text{nm}$). The influence of meteorological parameters on the aerosol scattering properties are also analyzed. Decreases in SSA are observed with the occurrence of easterly wind, the sector characterized by local pollutant sources and during hours of the increased traffic density. In this study significant correlation coefficients are found between different aerosol optical properties.

Keywords: atmospheric aerosol particles, light-scattering, aerosol optical properties, nephelometer.

1. INTRODUCTION

In order to establish strategies for mitigating global warming and influence of anthropogenic activities, continuous monitoring of particulate is required. Atmospheric aerosol particles together with greenhouse gases and short lived gases, according to the IPCC (2013), are playing a major role in climate change affecting the Earth's radiative balance. In the GAW Regional Coastal Observatory in Lamezia Terme (38.88 LAT 16.24 LON, 6m asl) in Calabrian Region (Figure 1) Aerosol properties are continuously monitored in order to investigate natural and anthropogenic sources

affecting climate. The equipment allows us to detect different processes that influence aerosol properties in the



Figure 1. The site is located at 600 m from the coastline in open position into one of three main planes of the region. The area is flat but influenced by both Valley/mountain (anthropic pressure) and Land/sea breeze.

measurement site. In particular here we present some preliminary results of hourly and daily variation of several parameters (T. Lo Feudo et al 2015). We study the diurnal evolution of the scattering and backscattering coefficients, the Ångström exponent, absorption coefficient and Single Scattering Albedo, and relation with meteorological parameters (T. Lo Feudo et al 2015, U. Wandinger et al 2015, D. Contini et al 2014). The paper is organized as follows as this introduction, instrumentation and experimental set-up is described. The third section deal with some preliminary statistical analysis of the observation period here considering and the focusing on of a specific case study. Finally some conclusion close the paper.

2. DATA AND METHODOLOGY

2.1 EXPERIMENTAL SET-UP

The total aerosol and back-scattering coefficients were measured using a TSI MODEL 3563 three wavelength integrating nephelometer ($\lambda=450, 550, 700$ nm). The aerosol light-absorption coefficient was measured with Multi-Angle Absorption Photometer (MAAP) at 637nm. Both instruments were connected to a common PM10 isokinetic inlet, where laminar flow was assured. The time basis of data collection was 1 min and the zero signal was measured during 5min every hour. The nephelometer flow rate was fixed at 30 l/min, while the MAAP was running at 16.67 l/min. The nephelometer calibration was checked every three months with pure carbon dioxide and filtered air; the relatively uncertainty in the scattering coefficient reported in literature is 10%. The MAAP determines aerosol light absorption by illuminating a particle-loaded filter and measuring simultaneously the radiation passing through the filter and the back-scattered light at three different angles.

To determine circulation and main directions a wind lidar ZephIR 300®, operative since July 2013, is present in the site monitoring since at 10 vertical levels, from 10 m up to 300 m in different weather conditions. Wind speed and direction are averaged every 10 minutes.

2.2 DATA PROCESSING

We analysed the scattering and absorption data from 1 January 2014 to 31 May 2015. After validation and quality check, we calculated hourly and monthly averages. Based on the scattering and absorption coefficients we calculated three intensive properties: the hemispheric backscattering fraction (b), scattering Angstrom exponent (A), and the single scattering albedo (SSA). All three are dimensionless and independent of the amount of particles.

We calculated the b at the wavelengths of 450, 550 and 700 nm for the whole period during the nephelometer was active. We calculated the A for each pair of wavelengths: 700 and 450 nm (A, 700–450), 700 and 550 nm (A, 700–550), and 550 and 450 nm (A, 550–450) by using the equation:

$$b_{\lambda} = \frac{\sigma_{bsc}}{\sigma_{sc}} \quad (1)$$

In addition we have:

$$A_{\lambda_1-\lambda_2} = -\frac{\log\left(\frac{Sc, \lambda_1}{Sc, \lambda_2}\right)}{\log\left(\frac{\lambda_1}{\lambda_2}\right)} \quad (2)$$

Since the wavelengths of the Nephelometer and MAAP do not match, we calculated the scattering coefficient at the 637nm by using Angstrom power law.

$$\sigma = \sigma_{550} \left(\frac{637}{550}\right)^{-A(700-550)} \quad (3)$$

The SSA at 637nm was then calculated as,

$$SSA = \frac{\sigma_{sc}}{\sigma_{a,637} + \sigma_{sc,637}} \quad (4)$$

Where $\sigma_{a,637}$ is the absorption coefficient.

3. STATISTICAL ANALYSIS OF SEASONAL AND DIURNAL VARIATION IN LAMEZIA TERME

Monthly mean variation of scattering properties found at Lamezia Terme, during the period from 01.01.2014 to 30.03.2015 is shown in figure 2.

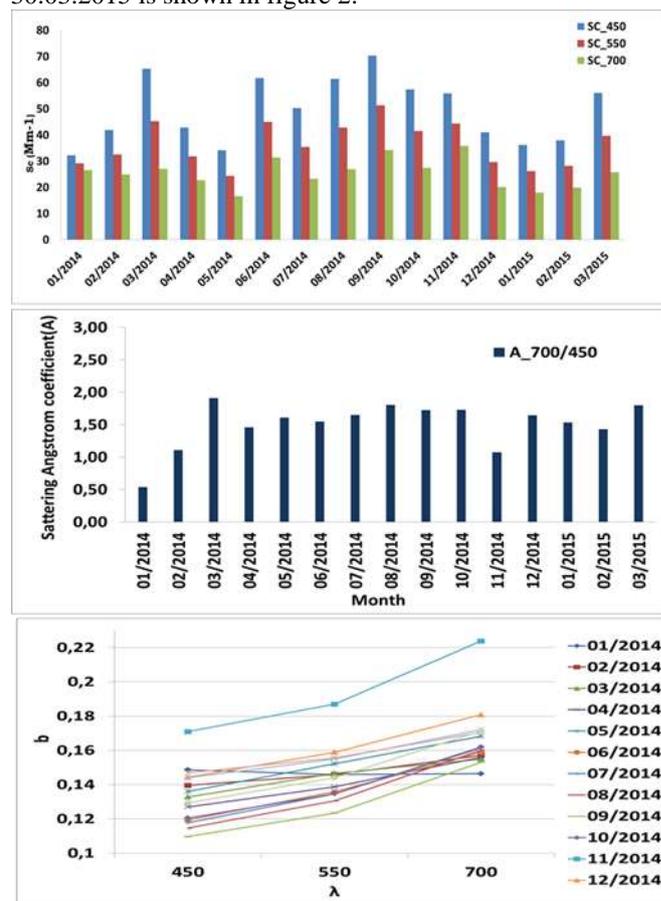


Figure 2. Monthly mean variation of scattering coefficient, Sc (up), Ångström exponent (center). Hemispheric backscattering fraction, b (down). Time period 01.01.2014-30-03-2015.

In Figure 2 the Scattering coefficients, the Ångström exponent and hemispheric backscattering fraction, b, were depicted.

In particular backscatter ratio is very useful characteristic parameter for describing the cooling effect of aerosol on climate, in fact, b is weakly dependent on concentration, and provides us wealth information on the optical characteristics of particles (Xu, J.et al, 2012).

The average values over the whole period analysed of the Sc, BSc, Å , b and SSA are respectively: $Sc=37\pm16$ Mm^{-1} ($\lambda=550nm$), $BSc=5\pm2$ Mm^{-1} ($\lambda=550nm$) and $\text{Å}=1.5\pm0.2$ (700nm/550nm), $b=0.15\pm0.04$ ($\lambda=550nm$) and $SSA=0.93\pm0.06$ ($\lambda=637nm$).



Figure 3. Seasonal mean variation of scattering coefficients at three wavelengths 450nm, 550nm and 700nm. Time period 01.01.2014- 30-03-2015.

Data processing methodologies, mentioned above, are used to compute optical parameters. In figure 3 we shown the seasonal average of scattering coefficient. During the summer and fall seasons, when wind regime is characterized by sea breeze, the mean seasonal of the scattering coefficient were higher than the winter season, due to the increase of sea spray aerosols from the Tyrrhenian Sea, also, we measured an increase of the absorption coefficient and organic concentration.

3.1 CASE STUDY: FEBRUARY 2015

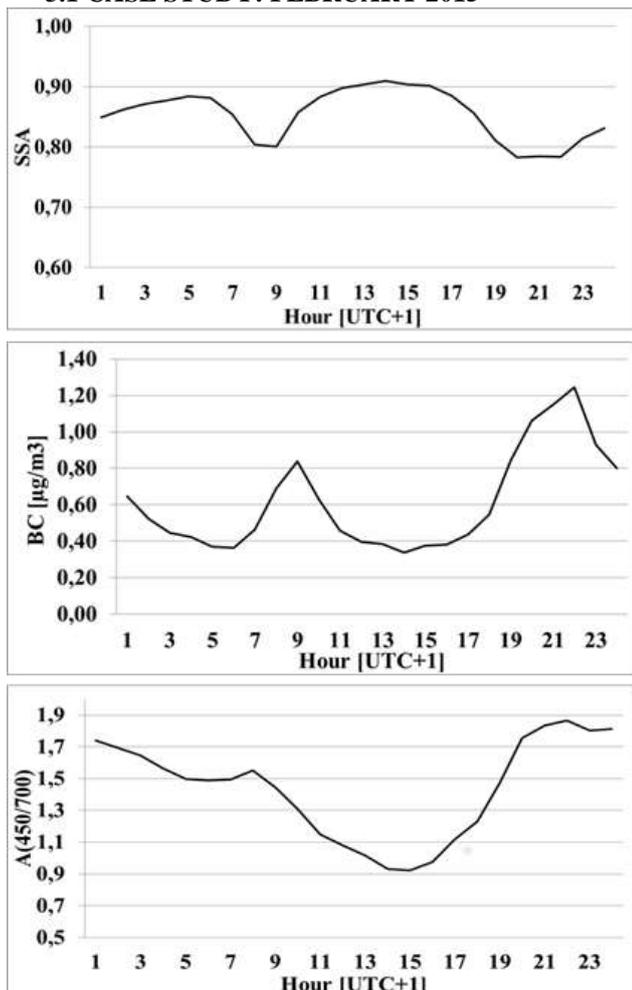


Figure 4. Case study February 2015. Hourly variation of aerosol optical properties of. Single scattering albedo, SSA

(up); BC mass concentration (center) and Ångström exponent (down).

To study a typical variation of optical properties of atmosphere we focus on February 2015 and we measured a diurnal and hourly mean variation of Sc, Bsc, A, BC concentrations and SSA parameters.

It's important to be studied the mean variation of previous parameters, during February 2015, as small biomass burning, occurred in our site, due to agricultural practices. small scale wood combustion in the rural and agricultural area.

Daily mean evolution of SSA (up), BC mass concentration (center) and Angstrom coefficient (down) were depicted in figure 4.

We clearly see the influence of marine breeze during the central hours of the day, bringing larger particles (Ang coeff. Decrease) into a typical urban daily variation with two peaks in the morning and evening time.

In figure 4 we shown Bsc coefficient (right) and BC mass concentration (left) as a function of wind direction. We could see that during early morning hours and in the evening hours the observed higher values are due to capping action of aerosols released from various anthropogenic activities and the incursion of sea spray on the site due to the breeze local regime.

The aerosol optical proprieties, backscatter at three-wavelengths, Bsc, A, SSA and BC mass concentration are characterized by different air mass circulation as well as function of local wind direction.



Figure 5. Lamezia Terme coastal site: Bsc coefficients (up) and BC concentrations (down) as a function of wind direction.

Therefore, the effects of regional sources on the aerosol optical and chemical properties are highlighted with easterly winds, characterized by land breeze system. In particular, how to depicted in figure 5, when wind blows from sector 30° to 90° the main contribution is due to anthropic

pollutants from urban city emissions (Lamezia Terme, 70.000 inhabitants); wind sector 120° to 180° are associated to pollutant emissions due to When the wind regime is characterized by sea breeze, from sector 220° to 300°, sea spray aerosol, due to the near Tyrrhenian Sea, favoured the increase of the absorption coefficient and organic concentration while single scattering albedo decreases

4 CONCLUSIONS

We examined aerosol optical properties at the CNR regional GAW-WMO station of Lamezia Terme (38.88 N, 16.24 W, 6 m a.s.l.) sited in a representative west coastal area of South Italy (Calabria Region, Italy) - Mediterranean Basin. One year round of light scattering and absorption coefficient aerosol observations carried out with a three wavelength nephelometer and an ethalometer, have been analysed. By interpreting the data set we were able to determine the monthly and diurnal variation of the aerosol scattering and absorption coefficients, singles scattering albedo, scattering Ångström exponent and the diurnal cycle of hemispheric backscattering fraction. When we inspected these parameters and results as a function of wind direction, we could see the effect of local sources on the aerosol optical and chemical properties. We conclude that the air masses from these sectors contained fresh, sooty and organics rich aerosol from anthropogenic and small biomass-combustion due to agricultural appliances, and sea-spray and marine aerosols from Tyrrhenian Sea.

5. REFERENCES

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