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Seasonal patterns of Saharan Dust detected over the central Mediterranean basin, at the High-altitude Monte Curcio GAW Station

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Abstract

The High-altitude Monte Curcio station is part of the Global Mercury Observations System (GMOS) as well as of the Global Atmosphere Watching (GAW) networks has been used since 2015 to gather high-temporal resolution, quality controlled data on atmospheric mercury, greenhouse gases and the physical-chemical properties of aerosols. The station is not influenced by local anthropogenic sources being instead able to intercept long-range transported air masses. These last may include industrial pollutants from continental Europe, sea spray from the surrounding Mediterranean Sea, volcanic ashes from the nearby Etna and Stromboli volcanoes as well as mineral dust from the Saharan desert. Among various atmospheric monitoring pollutants, 24-h PM_{10} and $PM_{2.5}$ samples were simultaneously collected. In total, about 300 samples have been gained, for both the finer and coarser size fractions of PM, and then analyzed by the thermo-optical method to quantify their Organic and Elemental Carbon concentrations (OC and EC). Starting from April 2016 until June 2017, an extensive and quite continuous data series on PM levels and its carbonaceous content was thus obtained for the first time at the southernmost part of Italy as representative for the regional area of the central Mediterranean basin. Mean background levels of $PM_{2.5}$ and PM_{10} were 5.6 ± 3.0 and 9.0 ± 6.0 μgm^{-3}, respectively, while the same reached the averaged levels of 13.7 ± 8.4 and 43.3 ± 32.4 $\mu g\ m^{-3}$ in conjunction with dust outbreaks. A clear seasonal pattern was identified with spring characterized by a major influence of Saharan intrusions both in terms of frequency and intensity,

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while no such events observed in winter. Synoptic and local wind fields were analyzed and discussed in terms of the observed PM seasonal variability. The availability of the carbon content provided insights about the possible association of OC to mineral dust contrarily to the EC component that was instead more influenced by wildfire events, that occurred a lot in summer and locally around our monitoring area. The comparison of carbon species and their share between the fine and coarse PM fractions resulted useful in discriminating the prevailing sources at our monitoring station.

Keywords: High-altitude station, Saharan Dust, Wildfires, Elemental Carbon

1. Introduction

The High-altitude Monte Curcio station is a Climatic-Environmental Observatory located in a strategic and isolated position within the Sila Grande area, one of the main three areas making-up the Sila National Park, in the southern Mediterranean basin (see Fig.1). The monitoring station is involved in various European, national, and international projects being part of the Global Mercury Observations System (GMOS), the High-altitude Climatic Observation System and Climate Station Network (NextDATA). It is also a regional station within the Global Atmosphere Watching programme of the World Meteorological Organisation (WMO/GAW). Within these projects, since 2015, the Monte Curcio Observatory produces quality controlled and high-temporal resolved data on atmospheric mercury, greenhouses gases as well as on the physical-chemical properties of aerosols (Dinoi et al., 2017). The operative station is situated at 1796 m a.s.l. (39.2° N 16.2° E) on a southern Appenine mountain peak with a completely free horizon, thus ensuring a high spatial representativeness for the measurements (Marinoni et al., 2016). It is interestingly placed on the middle of the Mediterranean basin, around 30 and 60 km from the Tyrrenian and the Ionian Sea, respectively. The station is not influenced by local anthropogenic sources being instead able to intercept long-range transported air masses. These last may include industrial pollutants from continental Europe, sea spray from the surrounding Mediterranean Sea, volcanic ashes from the nearby Etna and Stromboli volcanoes as well as mineral dust from the Saharan desert. Often, in summer, the large amount of vegetation and trees around the station is subject to intense wildfires, whose emissions have been detected with important changes in concentrations of some pollutants measured at the Monte Curcio station itself.

Fig. 1. The High-altitude Monte Curcio station and its localization within the Mediterranean basin

2. Methods

Among various atmospheric monitoring instruments, the station is equipped with the SWAM Dual Channel Monitor which is based on the β-attenuation method. 24-h PM_{10} and $PM_{2.5}$ samples were simultaneously collected, and then analyzed by the thermo-optical method to quantify their Organic and Elemental Carbon concentrations (OC and EC). In total, about 300 samples were collected. Starting from April 2016 until June 2017, a data series on PM levels was thus obtained as representative for the regional area of the central Mediterranean basin. The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model, by generating 96-h back-trajectories at the arrival heights of 1796 (m) and based on GDAS dataset, was used to study the air-mass origin. The Hysplit model together with the aerosol optical depth, deduced from the Navy Aerosol Analysis and Prediction System (NAAPS) developed by the Naval Research Laboratory (NRL), allowed the identification of dust outbreaks. Otherwise, the identification of wildfires occurring close to the site was done by integrating the NAAPS info with those resulting from the "Fire Information for Resource Management System" (FIRMS). The FIRMS archive distributes hotspot fire data based on satellite observation from the Moderate Resolution Imaging Spectroradiometer (MODIS).

3. Results

Over than **10%** of our collected samples resulted to be affected by Saharan intrusions with a concurrent increase in PM levels, which is particularly relevant to the coarser aerosol fraction (see Fig. 2). Mean background levels (**BKG**) were 5.6 ± 3.0 and 9.0 ± 6.0 μgm^{-3} for $PM_{2.5}$ and PM_{10}, respectively, while during North African dust outbreaks (NAF) the fine and coarse fractions reached values of 13.7 ± 8.4 and 43.3 ± 32.4 μgm^{-3}. Otherwise, during Wildfire (**WFR**) episodes, mean values of 9.6 ± 3.3 and 14.2 ± 4.6 μgm^{-3} were observed for the finer and coarser aerosol size fraction, respectively.

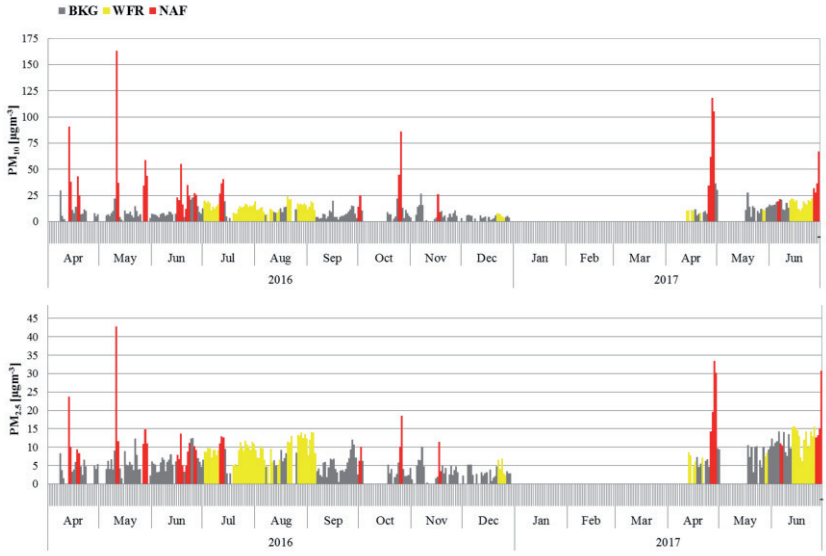

Fig. 2. Temporal evolution of PM_{10} and $PM_{2.5}$ daily concentrations recorded at Monte Curcio station
In red are highlighted days affected by Nord African (NAF) dust outbreaks, in yellow with wildfire (WFR) influence while Background (BKG) condition are reported in grey

A clear seasonal pattern was identified with spring characterized by a major influence of Saharan intrusions both in terms of frequency and intensity, while no such events were observed in winter.

Table 1. Mean levels of Elemental Carbon and Organic Carbon for both the finer and coarser particle fractions ($EC_{2.5}$ - EC_{10} and $OC_{2.5}$ - OC_{10}) recorded during Background (BKG), Nord African (NAF) and Wildfire (WFR) conditions

	$EC_{2.5}$ [ng/m^3]	EC_{10} [ng/m^3]	$OC_{2.5}$ [ng/m^3]	OC_{10} [ng/m^3]
BKG	81.9 ± 52.5	89.4 ± 47.7	544.0 ± 419.2	801.5 ± 548.7
NAF	132.9 ± 55.0	131.1 ± 57.6	765.5 ± 338.4	1774.4 ± 1100.6
WFR	165.0 ± 56.1	188.2 ± 69.2	1448.3 ± 473.1	1859.4 ± 556.5

The availability of the carbon content (see Table 1) provided insight into the possible association of Organic Carbon in the coarser PM fraction(OC_{10}) to mineral dust in contrast to Elemental Carbon that was instead influenced by wildfire events in both size fractions ($EC_{2.5}$ and EC_{10}). Therefore, the comparison of carbon species and their share between the fine and coarse PM fractions resulted useful in discriminating the prevailing sources at our monitoring station (Koulouri et al., 2008; Aymoz et al., 2004).

4. Conclusions

Even if further analysis will be carried out to better evaluate the chemical composition of PM samples and then quantify the contribution of Saharan dust and of wildfire emissions to the aerosol load at the High-altitude Monte Curcio station, our observations suggest that in presence of favorable weather conditions and during specific periods of summertime, the contribution of the two above mentioned natural sources on tropospheric PM concentrations cannot be neglected. Because in the future the strength and frequency of such phenomena, such as Saharan dust and wildfire emissions, could be affected by climate change, investigations on their impact in the southern Europe and the Mediterranean area still appears necessary.

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