

African dust contribution on the PM10 daily exceedances occurred in Apulia region.

Lorenzo Angiuli ¹, Roberto Giua ¹, Simona Loguercio Polosa ¹, Angela Morabito ¹

¹ Arpa Puglia, r.giua@arpa.puglia.it

Abstract: The air quality 2008/50/EC directive allows providing evidence of PM10 daily limit value exceedances due to natural sources, which are not to be considered for the purpose of the directive. In this work the African outbreaks, affecting the PM10 exceeding events occurred in Apulia region during 2010, are identified as follows. The PM10 daily concentrations were measured by the regional air quality monitoring stations, and complemented with meteorological maps, air mass back-trajectories, aerosol satellite retrievals, dust model simulations, ground measurements of aerosol optical properties. To quantify the daily net African dust load in PM10, we applied a methodology designed by the European Commission and based on the analysis of PM10 levels time series from regional background stations.

Keywords: mineral dust, Saharan outbreaks, PM10 daily limit value.

1. Introduction

The Italian peninsula, as well as the whole Mediterranean basin, is subjected to frequent Saharan dust events, especially during the summer season. The EU Air quality Directive 2008/50/CE allows providing evidences that the exceedances are due to natural sources. In this case, these exceedances are not considered as such for the purpose of the directive. In this study, for the 2010 main dust events occurred in Apulian region and identified on a daily resolution (Pederzoli et al. 2010), the daily net African dust load in PM10 has been quantified using a statistical methodology designed by the European Commission (Escudero et al., 2007). In this work we evaluated the occurrence of the PM10 exceedances, caused by African dust outbreaks in Apulia, and the mean annual contribution of African dust to PM10 levels at air quality monitoring sites.

2. Materials and Methods

The combined use of several sources of information allowed the identification of main Saharan dust outbreaks for Apulia region in 2010. A first discrimination of days with dust intrusions was carried out analyzing the daily series of PM10 concentrations as measured at *Cerrate* and *Ciuffreda*, the two regional background air quality monitoring stations. They are located in areas (figure 1a) far from urban and industrial areas so the anthropogenic contribution to PM10 concentration at these stations can be considered negligible. To confirm the saharan dust transport for each selected day, the 5-day isentropic back-trajectories at three different altitudes (750, 1500 and 2500 m.a.g.l.) were computed using HYSPLIT model with modeled vertical wind velocity. In addition, determination of the meteorological conditions causing the African dust outbreaks over Apulia region was carried out inspecting the NCEP synoptic

meteorological reanalysis during the period of dust outbreaks. The presence of dust over Apulia was also confirmed by looking at the maps of dust surface concentrations modeled by BSC-DREAM8b and by NAAPS global aerosol model. The satellite measurements have been used to detect the presence of atmospheric dust. In particular, the evolution of aerosol optical properties, like the Aerosol Optical Depth (AOD) and related Angstrom Exponent (α) at 550nm from Modis-Terra and Modis-Aqua satellite retrievals over the Mediterranean area, have been analyzed. Usually high AOD values combined with low α values are typical of Saharan dust (Pace et al., 2006). These values on Apulia region were also compared with the α and AOD values measured in the same days by an AERONET sun-photometer at Lecce.

The European Guidelines (Council of the European Union, 2011) propose a validated methodology for the quantification of the daily African PM10 load during dust outbreaks. This methodology is based on the subtraction of the daily regional background level from the PM10 concentration values at regional background stations. The daily regional background is obtained by computing a monthly 40th percentile to the PM10 time series at a regional background station, after a prior exclusion of the data of the days with African dust transport.

3. Results

In 2010 the PM10 exceedances due to Saharan dust outbreaks occurred on Apulia region only during winter and summer. The mechanism of mineral transport is different for the two seasons. In summer in North Africa the low precipitation level and the very high temperature are very favourable conditions for the massive resuspension of huge quantities and for the advection at different altitudes (up to 4-6km). In winter some sporadic Africans outbreaks may occur caused by depressions resulting in intense winds over the Saharan area. The description of the single summer event, identified by this methodology, is shown in the following figures. Figure 1b reports the daily series of PM10 concentrations measured at *Cerrate* and *Ciuffreda* between June 10th and June 22th. The data show an evident increase in the concentrations till June 16th. A similar trend was reported in all other PM10 monitoring stations.

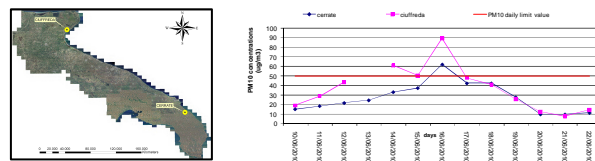


Figure 1 a) Rural background monitoring sites in Apulia region; b) Daily serie of PM10 concentration measured at Cerrate (LE) and at Ciuffreda (FG).

The meteorological analysis by the synoptic charts (not shown) has revealed for the 11th of June a 850 hPa african anticyclone on the North Africa, in gradual expansion on southern Italy until June 14th. In the following days this high-pressure system moves eastward continuing to affect Apulia up to June 20th, when the arrival of north Atlantic low pressure renews the air masses.

The transport of dust from Sahara up to June 20th is confirmed by a 5-day isentropic back-trajectories analysis computed at three different altitudes (750m, 1500m and 2500

m a.g.l.) using the HYSPLIT model. In figure 2a,b,c the back-trajectories with starting time 12 UTC on June 14th, June 16th and June 20th are shown.

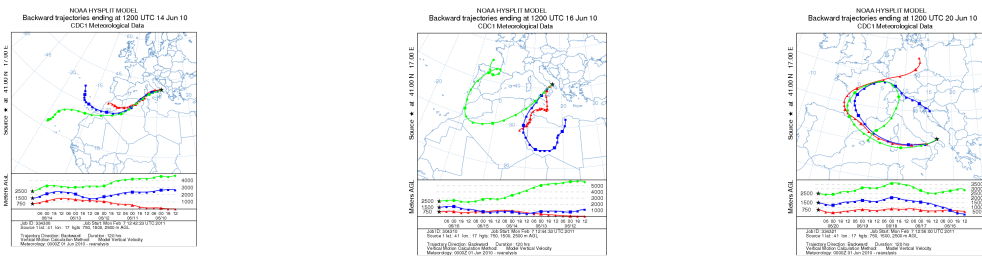


Figure 2 120-hours back-trajectories at 1200 UTC at 750m, 1500m, 2500m on a)14th, b)16th and c) 20th June .

The Saharan dust presence on Apulia is confirmed by satellite aerosol retrievals. Figure 3a,b,c shows the evolution of Aerosol Optical Depth (AOD) at 550 nm over the Mediterranean area, with grid resolution 1 degree x 1 degree, retrieved by MODIS-Terra for June 14th, 16th and 20th. Large amounts of dust (AOD>0.6) are observed as expected on June 14th and 16th, while on June 20th the AOD values are reduced significantly. Figure 4a,b shows the series of AOD and related α , as derived from observation by an AERONET sun-photometer at Lecce. AOD increases between June 11th and 20th, while the related Angstrom exponent (α) in the same period is reduced. Values of α greater than 2.0 indicate the presence of fine mode particles (e.g., smoke particles and sulfates), while values of α near zero indicate the presence of coarse mode particles such as desert dust. The Saharan dust event is also predicted by the BSC-DREAM8b model and by NAAPS Model. Maps of PM ground concentration in $\mu\text{g}/\text{m}^3$ from June 10th to 21th have been analyzed (not shown). The daily evolution of PM surface concentration over Apulia region, predicted by these models, is qualitatively quite similar to the trend of PM10 concentrations measured by air quality monitoring stations.

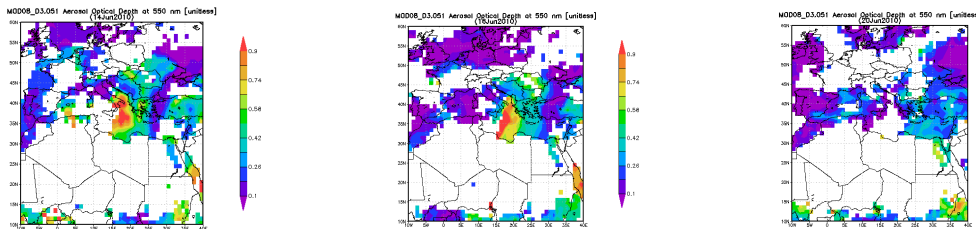


Figure 3 Maps of Aerosol Optical Depth (AOD) at 550 nm as retrieved by MODIS on a) June 14th, b) 16th and c) 20th.

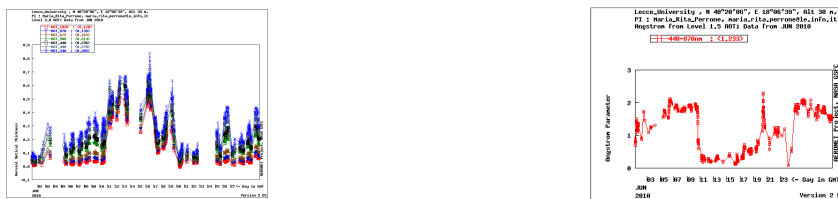


Figure 4 Series of a) AOD at different wavelengths and Angstrom exponent measured

by sun photometer in June 2010. In Table 1 for each province of Apulia is reported the range of the occurrence of the PM10 daily exceedances and the range of the mean annual contribution to PM10 levels at air quality monitoring sites, caused by the main African dust outbreaks occurred during 2010.

Range of African dust contribution	BARI	BRINDISI	FOGGIA	LECCE	TARANTO
Occurrence of PM10 daily exceedances (%)	25 - 86	13 - 88	50 - 100	21 - 75	32 - 100
Mean annual of PM10 concentration ($\mu\text{g}/\text{m}^3$)	0.14 – 0.55	0.75 – 1.06	0.22- 0.43	0.67 – 0.98	0.60 – 1.13

Table 1 Range of the occurrence of the PM10 daily exceedances and range of the mean annual contribution to PM10 levels, for each Apulia province.

4. Concluding remarks

In this study we carried out i) the identification, on a daily resolution, of the 2010 main dust events occurred in Apulian region, ii) the quantification of PM10 exceedances caused by African dust outbreaks, iii) the mean annual contribution of African Dust to PM10 levels at air quality monitoring sites. In 2010 the PM10 exceedances due to Saharan dust outbreaks occurred on Apulia region only during winter and summer. As expected, the lowest percentages of African episodes are observed at monitoring stations where the local anthropogenic emissions (traffic, industrial, heating) are greater. In conclusion, in 2010 the mean annual contributions to PM10 levels were below or around $1\mu\text{g}/\text{m}^3$.

References

- Council of the European Union (February 2011), Commission staff working paper establishing guidelines for demonstration and subtraction of exceedances attributable to natural sources under the Directive 2008/50/EC on ambient air quality and cleaner air for Europe.
- Escudero M., Querol X., Pey J., Alastuey A., Perez N., Ferreira F., Alonso S., Rodriguez S., Cuevas E. (2007) A methodology for the quantifications of the net African Dust load in air quality monitoring networks, *Atmospheric Environment*, 41, 5516-5524.
- Pace G., di Sarra A., Meloni D., Piacentino S., Chamard P (2006) Aerosol optical properties at Lampedusa (Central Mediterranean). 1. Influence of transport and identification of different aerosol types, *Atmospheric Chemistry and Physics*, 6, 697-713.
- Pederzoli A., Mircea M., Finardi S., di Sarra A., Zanini G. (2010) Quantification of Saharan dust contribution to PM10 concentrations over Italy during 2003-2005, *Atmospheric Environment*, 44, 4181-4199.