Analysis of a Saharan dust event in the Campania region by a combination of satellite observation, ground monitored data and CHIMERE modeling simulations

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Abstract

This paper is devoted to the study of an important Saharan dust event which occurred in southern Italy on April 14th to 17th 2018. The Sahara is the world's larger source of desert dust influencing air quality, human health, climate change, nutrient dynamics and biogeochemical cycles of both terrestrial and oceanic ecosystems. Saharan dust moves from Africa to Europe, Asia and America across the Mediterranean Sea, the Atlantic Ocean and the Red Sea. Italy is one of the Countries more often reached by Saharan dust, especially the southern part which is the area of interest of this paper. The dust event is here analyzed combining satellite observations (by MODIS), monitored data and CHIMERE simulations for the Campania region. MODIS images and monitored data well highlighted such event, while CHIMERE model allowed to get the spatial distribution of the total PM10 concentrations in the region, even though concentrations were slightly overestimated. Overall, results show that (i) such event was really intense especially on April 16th, which experienced the highest PM10 daily mean concentration of the year (114.9µg/m³) and (ii) the importance to employ an integrated approach to evaluate the whole impact of such kind of events in an area of interest.

Keywords: Saharan dust, Campania, CHIMERE model, MODIS images, PM10

1. Introduction

The problem of Saharan dust has become of great interest in the last years because it plays an important role in air quality, human health, climate change, nutrient dynamics and biogeochemical cycle of both terrestrial and oceanic ecosystems.
The Sahara is the world largest source of aeolian soil dust (Schütz et al., 1981; D'Almeida, 1987; Swap et al., 1996). The Saharan dust is composed by mineral dust with dimension smaller than 10µm (called PM10). It generally comes from Africa, but exact locations of source areas are not well known. Data from the Total Ozone Mapping Spectrometer (TOMS) suggest two major source areas: the Bodélé depression and an area covering eastern Mauritania, western Mali and southern Algeria (Goudie and Middleton, 2001), from which dust reaches far continents, from America to Europe, Asia and Africa itself. It has been estimated that approximately 12% of the Saharan dust moves northwards to Europe, 28% westwards to the Americas and 60% southwards to the Gulf of Guinea (Engelstaedter et al., 2006).
The Saharan dust transport needs a convective rising of air masses and then a subtropical jet stream. The transport can occur in cyclonic or anticyclonic circulation, driven by southern or trade winds. Italy, together with Spain, is one of the Countries more often reached from Saharan dust, hence the study of dust transport episodes in the Mediterranean area is a relevant topic both looking at synoptic meteorology and at environmental monitoring.
Saharan dust events have been studied all around the world to analyze their effects on climate change and human health. Dust may affects air temperature through the absorption and scattering of solar radiation (Li et al., 1996; Moulin et al., 1997; Alpert et al., 1998; Miller and Tegen, 1998) by modifying short wave solar radiation transmitted through to the Earth's surface and long wave infrared radiation emitted to space (Goudie and Middleton, 2001). Dust may also affect climate through its influence on marine primary productivity (Jickells et al., 1998), and there is some evidence that dust may cause ocean cooling (Schollaert and Merrill, 1998). Changes in atmospheric temperatures and concentrations of potential condensation nuclei may affect convectional activity and cloud formation, thereby modifying rainfall amounts (Bryson and Barreis, 1967; Maley, 1982).

Other studies analyze the health risks caused by the presence of dust in atmosphere. Recently, Zhang et al. (2016) quantitatively reviewed all the studies concerning the effect of dust storms on human health across the world, with attention to the reported underlying pathological processes behind such disorders. Human health effects of dust storms are respiratory disorders (including asthma, tracheitis, pneumonia, chronic obstructive pulmonary disease, allergic, rhinitis and silicosis), cardiovascular disorders (including stroke, arrhythmia, ischemic heart disease), dermatological disorders and, more rarely, conjunctivitis, exacerbated cough, reproductive disorders, headache, and infectious disease such as bacterial meningitis and diseases associated with transported micro-organism in desert dust.

In this context this paper is devoted to the evaluation of a severe Saharan dust event occurred on 14th to 17th April 2018. The attention is focused on the Campania region. The final aim is to evaluate the contribution of such Saharan dust event to the total level and spatial distribution of PM10 concentrations by means of CHIMERE model simulations and satellite observations, as well as and then in situ concentration data measured by the Regional Agency for Environmental Protection (ARPAC) automatic monitoring stations, located in 21 cities of Campania.

The paper is structured as follows. After the introduction, Section 2 describes the study area and presents a brief summary of the previous Saharan dust events occurred in the Campania region. Section 3 discusses the approaches employed here to study the Saharan dust event and Section 4 presents the analysis of data tailored to the quantitative evaluation of the event.

2. Description of the study area

2.1 The area of interest

Campania is one of the 20 Italian regions, located approximately at LAT 40°N and LON 14°E. It extends along Mediterranean Sea, in particular on Tyrrenian Sea, and it is one of the most rainy regions. 51% of the Campania territory is characterized by hills, 34% by mountains and 15% by alluvial plains (online.scuola.zanichelli.it). The central apenninic ridge, stretching from NW to SE, includes Matese Mt, with the Campania's highest peak: 2050m a.s.l., Taburno, Avella, Terminio, Cervialto, Alburno and Cerviati massifs. Moreover it is accompanied eastward by uplands and basins, such as Benevento, Montecalvo Irpino and Ariano Irpino.

Campania is also characterized by four important volcanic edifices: Roccamonfina, Vesuvio and Campi Flegrei and the volcanic complex of Ischia island along the Tyrrenian coast with maximum altitudes reaching about 1200m a.s.l. Campania main geological structure is represented by four structural elements (www.difesa.suolo.regione.campania.it):

- Tyrrhenian area, characterized by a thin continental shell and an oceanic shell;
- Apennine chain characterized by covering layers and filling sediments of basins located on advanced covering layers;
- Apennine foredeep characterized by plio-Quaternary sediments buried under Apennine layers;
- Foreland characterized by a Mesozoic carbonatic sequence, on continental shell, in deepening south-westward under Apennine layers.

From the administrative point of view, Campania has five provinces: Naples, Caserta, Avellino, Benevento and Salerno. Naples has an altitude of 148m a.s.l., Caserta of 68m a.s.l., Avellino of 348m a.s.l., Benevento of 13m a.s.l. and Salerno of 5m a.s.l. (http://dipsa.unibo.it/catgis).

2.2 Previous Saharan dust events in Campania

Major Saharan dust events have been analyzed and reported by ARPAC since 2014 (www.meteoarpac.it), indicating the presence of significant Saharan dust in Campania at least three times a year as summarized below.

In November and December 2014 there were two Saharan dust events that brought air temperature till 27°C (value more than 10°C above the seasonal mean temperature) thanks to Sirocco wind (www.eumetrain.org; www.gmes-atmosphere.eu).

Six Saharan dust events in February, March, April and May 2015 were also reported. In particular on March 24th and 26th there was the so called "red cloud" phenomenon with clouds full or Saharan dust that brought dust precipitations, and on May 14th and 15th another Saharan dust events brought air temperature till 30°C.

In 2016 there were three events in February, June and October. In particular, on February 16th and 17th the sky was completely yellow and temperature reached 25°C. On June 16th there were the sub-Saharan anticyclone on Libya and a perturbation from Spain that brought Saharan dust to Campania. In particular during this event, the limit value of PM10 concentrations of 50μm/m^3 has been exceeded. On October 15th there was a cold front on Italy predated by a soil flux from SSE with Saharan dust transport.
In 2017 there were six reported Saharan dust events in April, May, August, October and December. On April 26th and 27th there were a strong geostrophic wind on height and a low pressure center on height above Alps that supported a dust flux. On August 3rd, 4th and 5th, instead, there was an anticyclone on mid-central Europe that brought Saharan dust from Marocco and Algeria to Campania. On December 12th and 13th there was a strong Saharan dust event on Naples and Caserta with PM10 concentration value of 50μm/m^3.
Finally, in 2018 there were four Saharan dust events on March and April. From March 1st to 3rd and on April 4th and 5th the PM10 concentrations reached values of 100μm/m^3 in Naples thanks to Saharan dust. On April 14th to 17th the PM10 concentration reached values of 70-75μm/m^3 everywhere in Campania, with winds of 35m/s (www.meteoarpac.it).
Most of these events occurred in Spring and Autumn when the Westerlies hit the Mediterranean Sea and the Jet Stream reached Africa several times.

3. Methodology

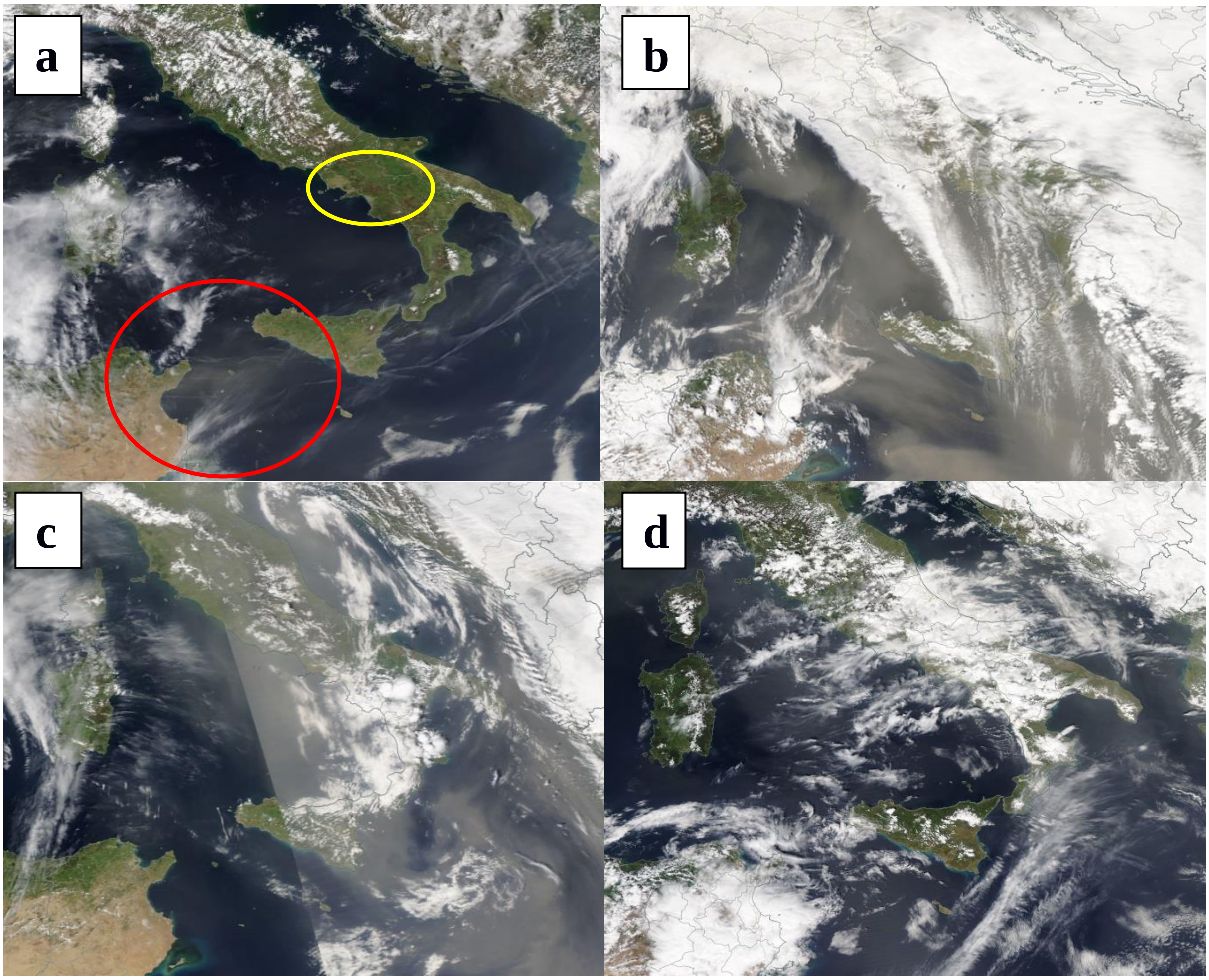
3.1 Available approaches for Saharan dust study

For the evaluation of the Saharan dust dynamic several tools are available such as satellite observations, modeling techniques and monitoring stations, which are briefly summarized below:
Satellite observations: they allow for an accurate reconstruction of dust areal distribution for the whole Mediterranean area. The most useful satellites are those with adequate time coverage and good spatial resolution. Satellite observations provide a unique vantage point from which to study the Earth system. Providing a vast range of observations-from measurements of atmospheric and ocean circulation to observations of ocean land productivity, to measurements of upper atmospheric temperatures, to space weather-satellites are sentinels of global system. Moreover they observe rapid changes, such a severe storms, floods, and even harmful phytoplankton blooms in the coastal ocean (National Research Council, 2003). MODIS (Moderate – resolution Imaging Spectroradiometer) is an extensive program by NASA using sensors on two satellites that each provide complete daily coverage of the earth. The data have a variety of resolutions: spectral, spatial and temporal. Because the MODIS sensor is carried on both the Terra and Aqua satellites, it is generally possible to obtain images in the morning (Terra) and the afternoon (Aqua) for any particular location. Night time data are also available in the thermal range of the spectrum (yceo.yale.edu/what-modis). Aqua and Terra satellite are part of the EOS (Earth Observation System) program by NASA and, with other satellites, provide long – term global observation of the land surface, biosphere, atmosphere and oceans. Thanks to Aqua it is possible to study precipitations, evaporation and cycling of water, instead Terra explores the connections between Earth's atmosphere, land, snow and ice, ocean and energy balance to understand Earth's climate and climate change and to map the impact of human activity and natural disasters on communities and ecosystems (www.nasa.gov).
Modelling simulations: for a long time, the trajectory method was used almost as an exclusive technique for studying the nature of dust movement in the atmosphere (e.g. Merril et al. 1985; Reiff et al. 1986; Martin et al. 1990). But the most serious deficiency of trajectory modelling is its disability to quantify temporal and spatial distribution of dust concentration in the atmosphere. Eulerian modelling is certainly a more sophisticate alternative. This approach requires use of an atmospheric model as a driving vehicle for dust concentration field (Nickovich, 1996). Several atmospheric models were developed by lots of meteorological world centers such as Barcelona Dust Forecast Center, L'Aquila University with FORECHEM model, Copernicus program and CEMEC (Campania's Climatologic and Meteorological Center) with CHIMERE model. CHIMERE is an Eulerian chemical transport model developed by Pierre Simon Laplace Institute and Lisa by CNRS and by French INERIS. It can be implemented on several integrated domains such as continental scale (thousands miles) or regional scale (100–200 km) with an horizontal resolution between 100km and 1–2km. CHIMERE reproduces the main chemical-physical phenomena about atmospheric pollutant (emission, diffusion, transport, chemical and photochemical reactions and depositions) and gives daily forecasts of ozone, dust and other pollutants. In every grid point are calculated mean cell concentrations that do not consider local effects due to small scale processes like urban canyon or crossroads.

Monitoring stations: fixed and mobile stations are characterized by an automatic instrumentation (analyzer) to control sulfur dioxide, nitrogen oxide, ozone, carbon monoxide and particulates concentrations. Air samples occur with time frequency and every instrument gives the concentration of a specific pollutant thanks to a characteristic analytic formula. An analyzer is usually characterized by an air aspiration system that takes air and puts it in a little box, called monitoring cell, that includes monitoring instruments.

3.2 Satellite observations

On NASA website archived images by MODIS of the study area, overlays and base layers of interest have been selected. The arrival of Saharan dust in Sicily on April 13th 2018 can be visualized in Fig.1a, showing place labels, coastlines, borders and roads as overlays, and corrected reflectance (true color) by Aqua as base layers. Images have been in particular extracted from the MODIS Dust website (https://worldview.earthdata.nasa.gov) selecting the area of interest, choosing the resolution, selecting day, month and year and simply downloading the images clicking on the appropriate icon.



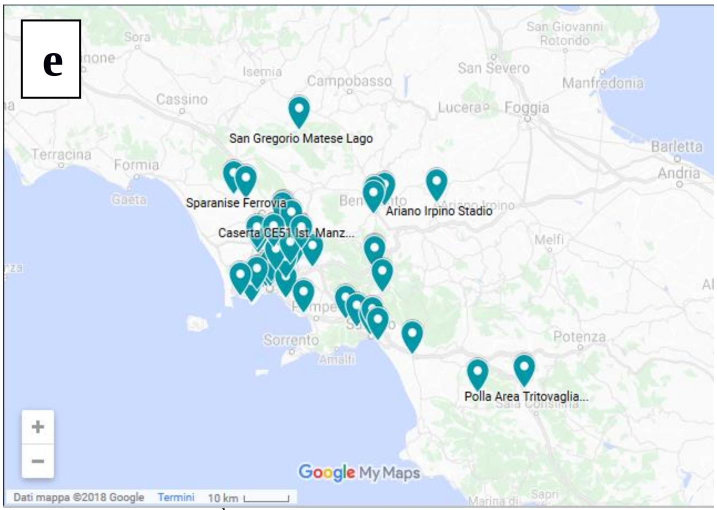


Fig.1 MODIS dust image of (a) April 13th 2018 at 01:30 p.m., clearly showing Saharan dust coming from Africa to Sicily (red circle) and Campania region (yellow circle), (b) April 15th 2018 at 01:30 p.m., clearly showing Saharan dust in all the Mediterranean Sea, (c) April 16th 2018 at 01:30 p.m., (d) April 17th 2018 at 01:30 p.m., (e) ARPAC monitoring stations located in the Campania region

3.3 CHIMERE modelling data

CHIMERE needs input data like meteorology, boundary conditions, emitting processors and domain and then solves chemical-physical transformations and diffusion equations to give pollutant atmospheric concentrations as output. In meteorological input there are 3D data (wind, temperature, density, specific moisture, model levels height, amount of liquid water in clouds, precipitable water and amount of ice) and 2D data (temperature at 2m, mixing height, friction velocity, Obukhov length, convective scale velocity, aerodynamic resistance, latent and sensible heat flux and precipitations). Boundary conditions are pollutant concentration values at domains boundary. These values can be taken from other models output on synoptic scale or from other CHIMERE model output with a domain bigger than the current simulation domain. For emitting processors there are two kind of files: LANDUSE and BIOFACT to calculate biogenic emissions, wet deposition, urban meteorological corrections, dust re-suspension and biogenic time emissions (Stortini M., 2006; ARPA-UMBRIA, 2009). Available CHIMERE data by ARPAC are time data for all the region. This products are NetCDF files on 25 hours (from the midnight of the current day to 1 am of the next day) for each day, three days ahead, so thanks to NCO (NetCDF Operator) has been possible to calculate the daily mean of PM2.5, PM10 and pDUST concentration products on Campania (LAT 41°N, LONG 13°E) from April 14th to 17th 2018 obtaining concentration maps and extracting data values to compare them with measured concentration data.

3.4 Monitored data

Campania monitoring network, managed by ARPAC, is characterized by 41 fixed automatic stations. Twenty monitoring stations are located in Naples, five in Avellino, four in Benevento, seven in Caserta and five in Salerno. Monitoring stations were installed in 1994 with the aim to evaluate how much the population is affected by pollutant emissions. For this reason, these stations were located in respect to orographic, urban and village characteristics. Monitoring pollutant are: nitrous oxides, carbon monoxide, aromatic hydrocarbons such as benzene, toluene, xylene, sulfur dioxide, ozone and particulates (PM10 and PM2.5). PM10 concentration values have been grouped in three quality classes to evaluate air quality:

1. 0-50µg/m³ good air quality
2. 51-75µg/m³ mediocre air quality
3. 76-100µg/m³ very bad air quality

In this work PM10 and PM2.5 concentrations daily data have been used to analyze the presence of Saharan dust from April 14th to 17th 2018 in Campania. Data were divided in two categories, background stations and urban stations, to show how much PM10 concentration values were influenced by industrial emissions or urban traffic. Data were also divided by districts calculating the arithmetic mean of data for every district obtaining five plots to compare PM10 and PM2.5 concentration trend, knowing that these concentrations show usually the same fluctuations. So the presence of Saharan dust is demonstrated when PM10 concentration is increasing whereas PM2.5 is almost constant. Moreover, this approach has been applied to PM10 and PM2.5 concentrations daily data for all the days of April 2018 and, with the same method, five plots to compare PM10 and PM2.5 concentration in every district have been created and other five to analyze the relationship between them. We have also analyzed time data of PM10 and PM2.5 concentrations of the last two days of the Saharan dust event (April 16th and 17th) in one station in which PM10 was greater than the others.

4. Results

4.1 Satellite observations

As shown in Fig. 1a on April 13th 2018 there was an incoming of Saharan dust from Tunisian coasts to Sicilian coasts and Tyrrenian Sea well documented by MODIS dust images. Saharan dust reached the Campania region and all the Mediterranean Sea on April 15th as shown in Fig. 1b
On April 16th and 17th 2018 there was the development and the end of the Saharan dust event on the Campania region (Fig. 1c,1d). Specifically, on April 16th 2018 Saharan dust crossed the southern Italy and moved eastward (Fig. 1c) leaving it on April 17th 2018 (Fig. 1d).
The study of synoptic situation is crucial to understand the Saharan dust behavior thanks to surface analysis and cloud coverage analysis (satellite observations with dust and natural color). On April 13th 2018 Italy and north Africa were interested by an high pressure, with a cold front that leaved Italy, then moving itself eastward leaving a low pressure center in north Africa on April 14th and cloud coverage increased in these two days. The low pressure interested southern Italy on April 15th reaching Sicily, southern Sardinia and Campania, increasing the cloud coverage. The presence of the Jet Stream (150/170km/h) from Africa to Italy is evident on Jet Stream 300hPa maps from www.meteociel.fr (Fig. 2). There was a northern wind flux from the Gulf of Sirte to Campania. Height wind at 600m reached 35m/s (126km/h) as shown in height wind maps by ARPAC windprofiler. On April 16th the Campania region was interested by a partial cloud coverage and a maximum wind speed of 24km/h, while on April 17th the low pressure center moved eastward to Adriatic coast with an high cloud coverage on central and southern Italy and intense precipitations (maximum value of 26,6mm in the city of Gragnano). Temperature values were higher of 4-6°C then previous days, reaching 26°C on April 15th (www.ancecampania.it; www.wetterzentrale.de; www.meteociel.fr).

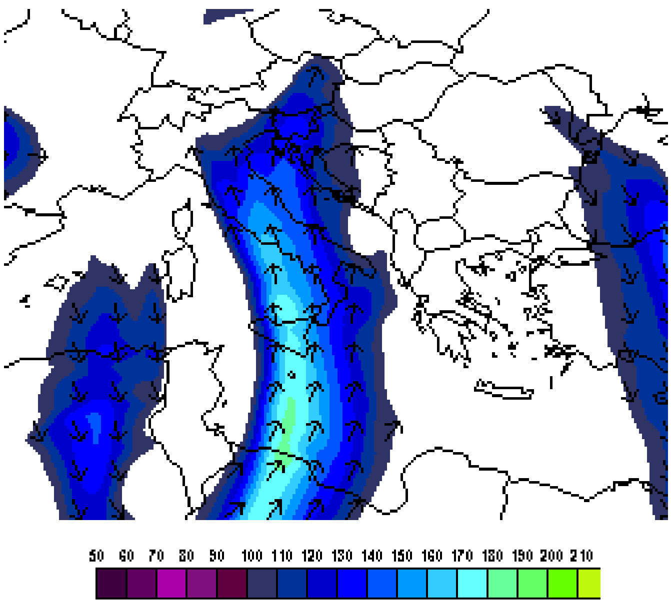


Fig. 2 Jet Stream 300 hPa map of April 15th 2018 at 02:00 p.m clearly showing an intense Jet Stream moving from Tunisian coasts to Italy

4.2 Monitored data

Considering 30 ARPAC monitoring stations, the only stations that have the PM10 indicator, it was possible to extract mean daily data of PM10 and analyze the concentration trend at each station. There is an evidence that on April 16th and 17th 2018 PM10 daily mean concentrations were greater than others as shown in Fig. 3a where it is also possible to observe that PM10 concentrations began to increase from April 13th, rapidly decreasing at the end of April 17th. Moreover, the same figure shows the presence of other Saharan dust events at the beginning and at the end of the month.

Since PM10 concentrations are influenced by the urban traffic, stations were divided in two categories: background stations (eleven) and urban stations (nineteen). Background stations are located far from the city center and from the automotive traffic, so it is expected that PM10 is composed mainly by natural dust. Fig. 3b,3c show high PM10 daily mean concentration values in all stations from April 14th to 17th. Fig. 3b shows the highest peak of PM10 concentration value of 114.9µg/m³ in the station of the Industrial Area of Acerra. In Fig. 3c there is a single high peak on April 12th with a value of 149.4µg/m³ corresponding to the station of the Industrial Area of Benevento, probably related only to the industrial emissions and not to a Saharan dust event.

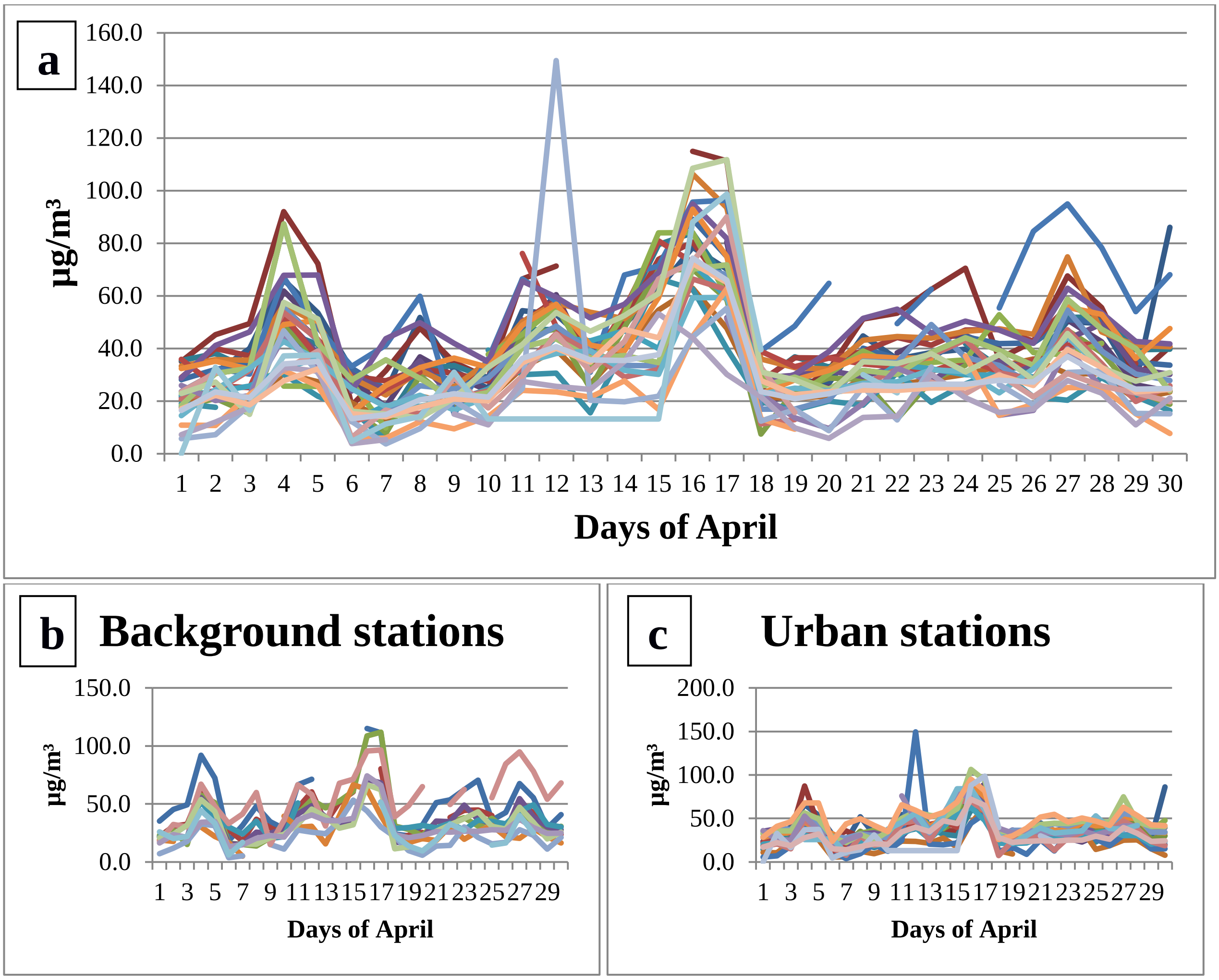


Fig. 3 a) PM10 daily mean concentrations obtained by (a) all the 30 ARPAC's monitoring stations, (b) background and (c) urban stations

Further, stations were divided by districts to compare PM10 and PM2.5 daily mean concentration values as shown in Fig. 4. PM2.5 kept its concentration values constant during all the month but PM10 had many peaks and every district had a peak from April 14th to 17th. In Naples there were PM10 daily mean concentration values of 83.3µg/m³ on April 16th and 71.1µg/m³ on April 17th. Other districts with very high daily mean concentration values were Caserta and Salerno, respectively, with 75.7µg/m³ and 76.7µg/m³ on April 16th and 66.2µg/m³ and 77µg/m³ on April 17th.

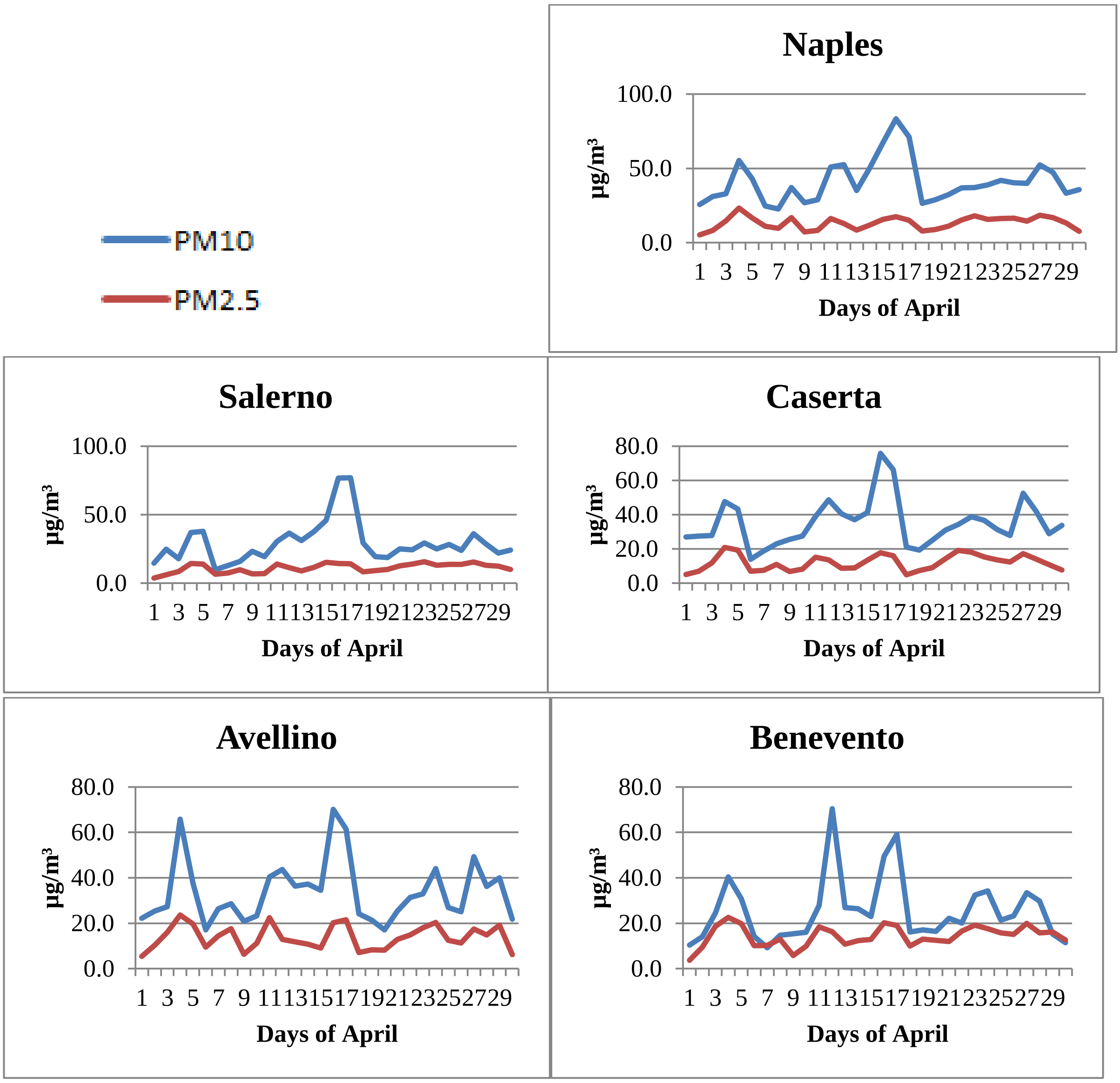


Fig. 4 PM10 and PM2.5 daily mean concentrations trends for every district of Campania region

To confirm the arrival of Saharan dust the amount of PM10 in respect of PM2.5 in every district was calculated using the formula $[1-(\overline{PM2.5}/\overline{PM10})]$ in Fig. 5.

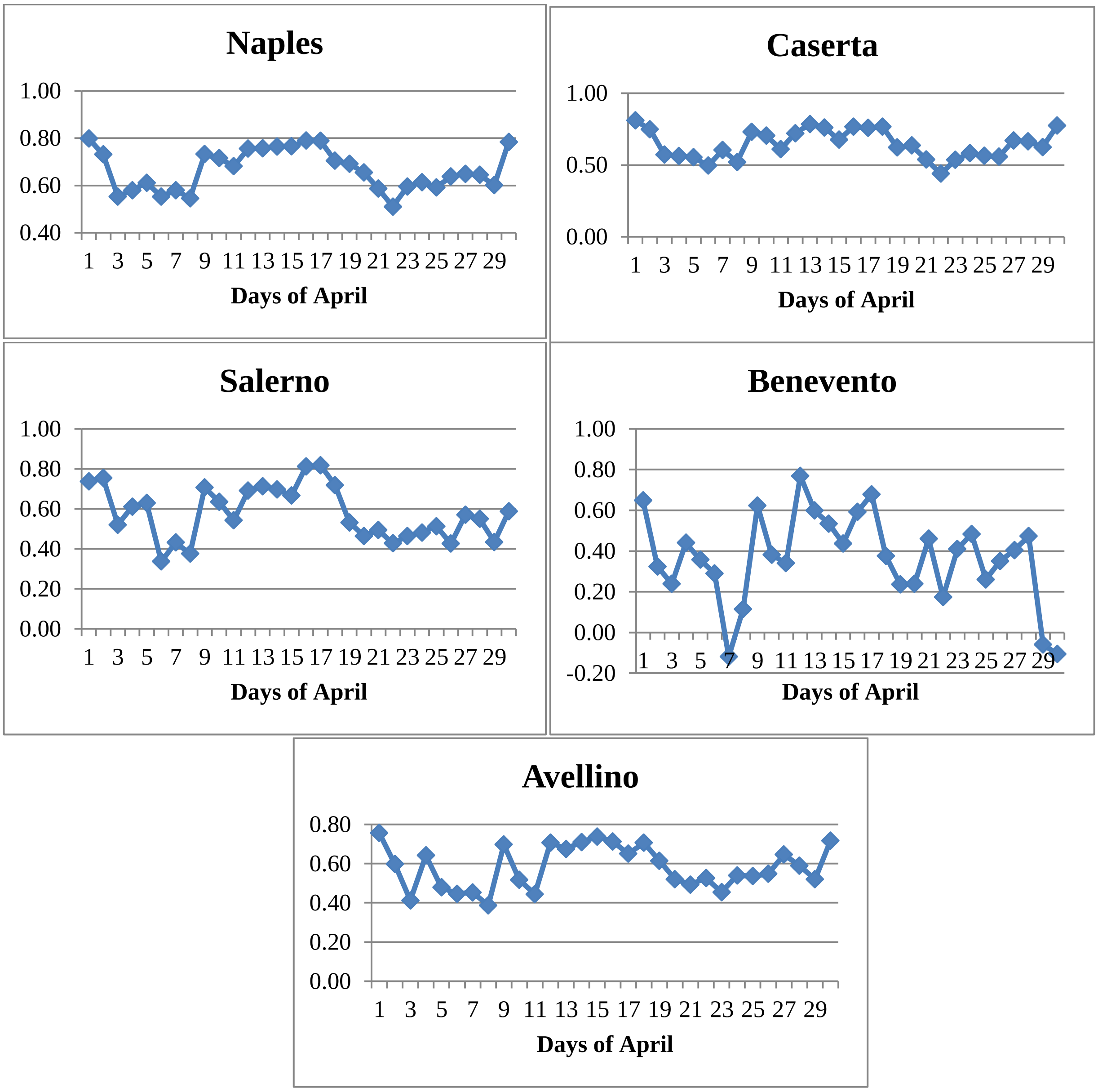


Fig. 5 Amount of PM10 in respect of PM2.5 on April 2018

Fig. 5 shows that PM10 mean daily concentration was generally greater than PM2.5, especially in the days when Saharan event occurred. Specifically, Naples map shows an amount of PM10 of 76% in respect of PM2.5 since April 12th 2018, so probably a small amount of Saharan dust occurred on Campania region also in the previous days.

4.3 CHIMERE simulations

4.3.1 Validation

A model validation procedure was followed to evaluate how well CHIMERE model simulated PM10 concentrations. To this aim, some statistical parameters were employed to compare observed and predicted PM10 concentration data (Hanna et al., 1991, 1993) such as the fractional bias (FB), the geometric mean bias (MG), the normalized mean square error (NMSE), the geometric variance (VG), the correlation coefficient (R) and the fraction of predictions within a factor of two of observations (FAC2):

$$FB = \frac{\overline{Co}-\overline{Cp}}{0.5(\overline{Co}+\overline{Cp})};\ MG = \exp\left(\overline{lnCo} - \overline{lnCp}\right);\ NMSE = \frac{\overline{(Co-Cp)^2}}{\overline{Co}\,\overline{Cp}};\ VG = \exp\left[\overline{(lnCo - lnCp)^2}\right];$$

$$R = \frac{\overline{(Co-\overline{Co})(Cp-\overline{Cp})}}{\sigma_{Co}\sigma_{Cp}};\ FAC2 = \text{fraction of data that satisfy } 0.5 \leq \frac{Cp}{Co} \leq 2$$

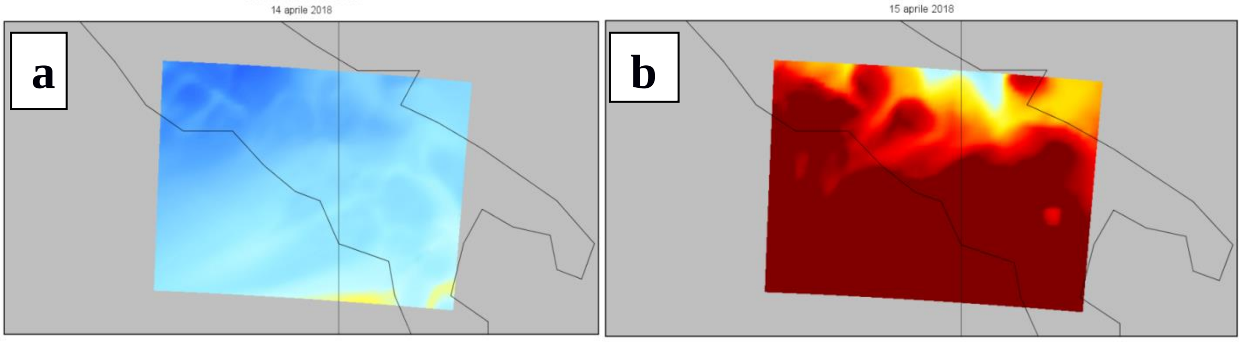
where:
Cp: model predictions;
Co: observations;
Overbar ($\bar{C}$): average over the dataset for all stations;
σ: standard deviation over the dataset for all stations
A perfect model would have MG, VG, R, and FAC2=1.0; and FB and NMSE=0.0. There have been proposed in the literature specific acceptable values of these parameters, such as NMSE≤1.5, -0.3≤FB≤0.3, FAC2≥0.5. Further, it should be noted that FB=0.67 would imply a factor of two mean underprediction, and FB=-0.67 would imply a factor of two mean overprediction; a factor of two mean bias would imply that MG=0.5 or 2.0, and a factor of four mean bias would imply that MG=0.25 or 4.0; then NMSE=1.0 implies that the root-mean-square-error is equal to the mean, while if NMSE becomes much larger than 1.0, it can be inferred that the distribution is not normal but is closer to log-normal; VG expresses the scatter of a log-normal distribution, which can be expressed as, say, ‘‘plus or minus 20%’’, or ‘‘plus or minus a factor of 10’’. For example, a factor of 2 scatter would imply a VG=1.6 and a factor of 5 scatter would imply VG=12 (Chang and Hanna, 2004).
Using the previous parameters, the following results have been obtained:

$$FB = -0.44;\ MG = 0.69;\ NMSE = 0.44;\ VG = 1.53;\ R = 0.56;\ FAC2 = 0.68$$

showing acceptable values of most of the parameters, even though FB implies an overestimation of the calculated concentrations.

4.3.2 CHIMERE maps

Fig. 6 shows four CHIMERE maps of PM10 daily mean concentration from April 14th to 17th 2018 in the Campania region to qualitatively compare observed data with CHIMERE simulations day by day. Fig. 6a shows that on April 14th 2018 PM10 daily mean concentration values were smaller than 50µg/m³ (light blue) in the Campania region, but it is possible to see dust (yellow) arriving from the south. Saharan dust arrived in the Campania region on April 15th with very high PM10 daily mean concentrations especially on Campania’s coasts with values greater than 100µg/m³, while it decreased in the northern area. Fig. 6c shows that the Campania region was almost totally covered by the Saharan dust on April 16th. PM10 daily mean concentrations were greater than 100µg/m³ (dark red), but PM10 concentration values were from 60 to 80µg/m³ (from yellow to light red) in some internal stations. Saharan dust concentration then decreased on April 17th but it was still high along the Campania’s coasts and smaller in the internal region.
Images clearly show that CHIMERE model overestimated PM10 daily mean concentration values from April 15th to 17th. However, the development of Saharan dust that moved eastward during the event was well represented.



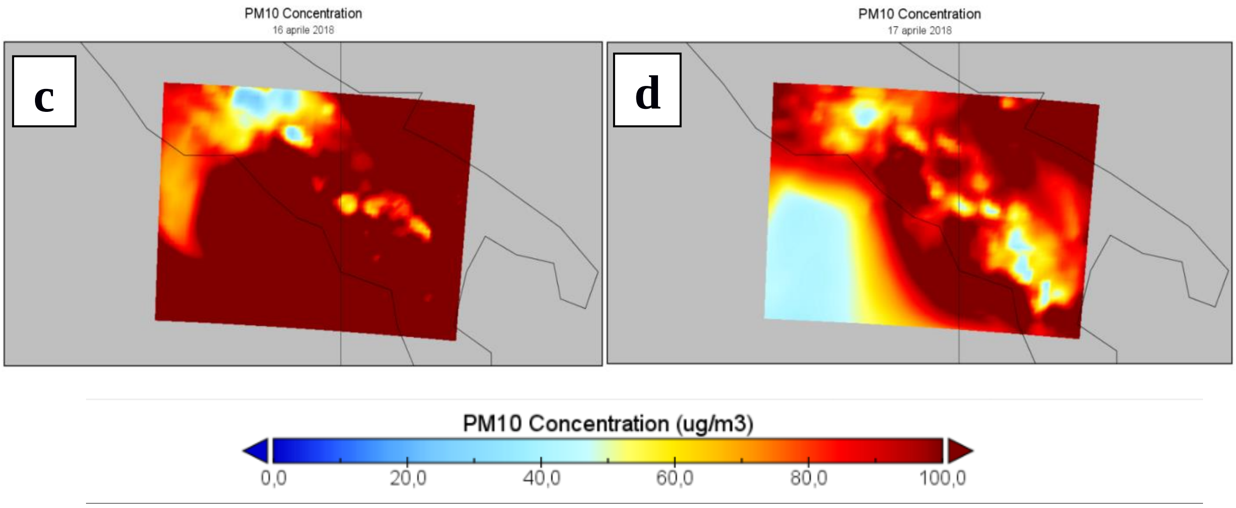


Fig. 6 CHIMERE maps of PM10 daily mean concentrations of April (a) 14th, (b) 15th, (c) 16th and (d) 17th 2018 of the Campania region

5. Conclusions

The Saharan dust that moved from north Africa to the Campania region on April 14th to 17th 2018 was a very intense dust event, with PM10 daily mean concentrations greater than most of those recorded and reported by APRAC in the same area during the last four years. This has been here confirmed by analyzing satellite observations and monitored data, as well as CHIMERE simulations. Specifically, the Saharan dust event started on April 13th with dust moving from Tunisian coasts to the Mediterranean Sea and on April 14th north Africa was interested by a low pressure field. The dust transfer was advanced by the low pressure center moving from Africa to the Mediterranean Sea on April 15th and by the intense northward Jet Stream. On April 16th the region was interested by a partial cloud coverage and a maximum wind speed of 24km/h, while on April 17th there were intense precipitations with a slight decrease of concentrations with respect to previous days. Monitored data showed that PM10 daily mean concentrations were very high especially on April 16th, decreasing in the next day.

Main conclusions achieved from this study are:

- on April 13th to 17th 2018 Saharan dust event occurred in the Campania region (southern Italy) as shown by Aqua-MODIS images;
- PM10 daily mean concentration values, which were measured by monitoring stations located in the region, started to greatly increase on April 15th 2018 with 71.3µg/m³ reaching the greater value of 114.9µg/m³ on April 16th and decreasing on April 17th;
- CHIMERE model simulations showed the spatial distribution of the Saharan dust that interested all the Campania region with very high PM10 daily mean concentration values. Such simulations were validated using statistical parameters which showed an acceptable quality, even though with a slight overestimation.

Thanks to the combination of different approaches it was possible to evaluate both qualitatively (through the spatial distribution) and quantitatively (through the absolute values) the Saharan dust event and its main aspects which characterized the Campania. A similar method could be used by the Regional Agency for Environmental Protection ARPAC to get a complete overview of the future Saharan dust events that are expected to occur in the Campania region.

Acknowledgments

I would like to acknowledge prof. Riccardo Buccolieri for the support during all this work and ARPAC for providing me with data and information about the event.

References

Alpert, P., Kaufman, Y.J., Shay-El, Y., Tanre, D., da Silva, A., Schubert, S., Joseph, J.H., 1998. Quantification of dust-forced heating of the lower troposphere. Nature 395, 367–370

ARPA UMBRIA, 2009, Scenari emissivi e di concentrazione in Umbria. Applicazione modello CHIMERE, relazione tecnica

A.S. Goudie, N.J. Middleton, 2001, Saharan dust storms: nature and consequences, Earth-Science Reviews 56 (2001) 179–204

Bryson, R.A., Barreis, I.A., 1967. Possibilities of major climatic modifications and their implications: northwest India, a case for study. Bulletin of the American Meteorological Society 48, 136–142

Chang J.C. and Hanna S.R., 2004, Air quality model performance evaluation, Meteorol Atmos Phys 87, 167–196 (2004)

Engelestaedter S., Tegen I., Washington R., 2006, North African dust emissions and transport, Earth Sci Rev vol. 79

Hanna SR, Strimaitis DG, Chang JC (1991) Hazard response modeling uncertainty (A quantitative method), vol. I: User's guide for software for evaluating hazardous gas dispersion models; vol. II: Evaluation of commonly-used hazardous gas dispersion models; vol. III: Components of uncertainty in hazardous gas dispersion models. Report no. A119=A120, prepared by Earth Tech, Inc., 196 Baker Avenue, Concord, MA 01742, for Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall Air Force Base, FL 32403; and for American Petroleum Institute, 1220 L Street, N.W., Washington, D.C., 20005

Hanna SR, Chang JC, Strimaitis DG (1993) Hazardous gas model evaluation with field observations. Atmos Environ 27A: 2265–2285

Jickells, T.D., Dorling, S., Deuser, W.G., Church, T.M., Arimoto, R., Prospero, J.M., 1998. Air-borne dust fluxes to a deep water sediment trap in the Sargasso Sea. Global Biogeochemical Cycles 12, 311–320

Li, X., Maring, H., Savoie, D., Voss, K., Prospero, J.M., 1996. Dominance of mineral dust in aerosol light-scattering in the North Atlantic trade winds. Nature 380, 416–419.

Maley, J., 1982. Dust, clouds, rain types and climatic variations in tropical north Atlantic. Quaternary Research 18, 1–16.

Martin D., Bergametti G., Strauss B., 1990, On the use of the synoptic vertical velocity in trajectory model: validation by geochemical tracers, Atmos. Environ.

Merril J. T., Black R., Avila L., 1985, Modelling atmospheric transport to the Marshall islands, J. Geophys. Res.

Miller, R.L., Tegen, I., 1998. Climate response to soil dust aerosols. Journal of Climate 11, 3247–3267.

Moulin, C., Guillard, F., Dulac, F. and Lambert, C.E., 1997, Long-term daily monitoring of Saharan dust load over ocean using Meteosat ISCCP-B2 data: 1. Methodology and preliminary results for 1983–1994 in the Mediterranean. Journal of Geophysical Research

National Research Council, 2003, Satellite observations of the Earth's Environment: Accelerating the Transition of Research to Operations. Washington, DC: The National Academies Press.

Nickovich S., 1996, Modelling of dust process for the Saharan and Mediterranean Area, Enviromental Science and Tecnology Library

Reiff J., Forbes G.S. Spieksma F.T., Reynders J.J., 1986, African dust reaching Northwestern Europe: a case study to verify trajectory calculations, J. Clim. Appl. Meteorol.

Schollaert, S.E., Merrill, J.T., 1998. Cooler sea surface west of the Sahara Desert correlated to dust events. Geophysical Research Letters 25, 3529–3532.

Schutz, L., Jaenicke, R., Pietrek, H., 1981. Saharan dust transport over the North Atlantic Ocean. In: Pewe, T.L. (Ed.), Desert Dust. Geological Society of America, Special Paper, vol. 186, pp. 87–100.

Stortini M., 2006, La meteorologia e la diffusione degli inquinanti, ARPA SIM

Swap, R., Ulanski, S., Cobbett, M., Garstang, M., 1996. Temporal and spatial characteristics of Saharan dust outbreaks. Journal of Geophysical Research 101 (D2.), 4205–4220.

Xuelei Zhang, Lijing Zhao, Daniel Q. Tong, Guangjian Wu, Mo Dan and Bo Teng, 2016, A systematic Review of Global Desert Dust and Associated Human Health Effects, Atmosphere, 7, 158