The Dependence of PM Size Distribution from Meteorology and Local-Regional Contributions, in Valencia (Spain) – A CWT Model Approach

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ABSTRACT

This paper combines an analysis of hourly air pollution measurements and daily meteorological data with backward air mass trajectories, in order to elucidate local/regional sources and processes (e.g., atmospheric dispersion/stagnation, dust resuspension, etc.) defining PM levels and size distribution in Valencia (Spain). Four size fractions of PM ($\text{PM}_{10}$, $\text{PM}_{\text{COARSE}} = \text{PM}_{10}-\text{PM}_{2.5}$, $\text{PM}_{2.5}$, and $\text{PM}_{1}$) were independently studied. No chemical/physical interactions among the four different size categories were assumed. Wind dispersion of $\text{PM}_{2.5}$ and $\text{PM}_{1}$ was indicated, whereas atmospheric stagnation conditions triggered the accumulation of fine particles, mainly produced from local combustion. Wind blown dust enhanced $\text{PM}_{\text{COARSE}}$ concentrations, particularly throughout warm periods when dry land facilitates dust resuspension. Hourly air mass trajectory points were analyzed by Concentration Weighted Trajectory (CWT) model and Potential Source Contribution Function (PSCF) on a $0.5^\circ \times 0.5^\circ$ resolution grid. The outcome of CWT model and PSCF identified Iberian Peninsula, France, North-West Africa and the Mediterranean as potential exogenous PM source areas. Extreme events of all PM fractions were primarily associated with the prevalence of South-South West airflows, whereas Saharan dust $\text{PM}_{\text{COARSE}}$ intrusions also emerged. The availability of hourly meteorological data and the analysis of the chemical species included in PM mass could further clarify the findings of this paper and remove uncertainties.

Keywords: $\text{PM}_{10}$; $\text{PM}_{2.5}$; $\text{PM}_{1}$; Potential source contribution function; Concentration weighted trajectory model.

INTRODUCTION

Airborne Particulate Matter (PM) is a major environmental problem in various urban areas of East-South East (E-SE) Spain, due to mineral, maritime and combustion emission sources (Querol et al., 2007; Santacatalina et al., 2010). High $\text{PM}_{10}$ (diameter less than or equal to 10$\mu$m) episodes in the area of Castello, were attributed variously to local, regional, and African dust intrusion events (Minguillon et al., 2007), whereas $\text{PM}_{2.5}$ (diameter less than or equal to 2.5 $\mu$m), $\text{PM}_{\text{COARSE}}$ ($\text{PM}_{10}-\text{PM}_{2.5}$) and $\text{PM}_{1}$ (diameter less than or equal to 1 $\mu$m) levels in the city of Elche, were strongly associated with traffic mainly during winter (Galindo et al., 2011). For the city of Valencia, an analysis conducted by Esteve et al. (2012), showed a moderate polluted atmosphere characterized by fine particles, whereas daily variations were attributed to traffic and the evolution of the boundary layer throughout the day. In addition, extreme particle episodes in Valencia can be induced from stagnant atmospheric conditions, due to the influence of anticyclonic systems (Segura et al., 2013).

Possible associations among PM and gaseous air pollutants or meteorological parameters, can reveal sources and processes affecting aerosol levels (Beckerman et al., 2008; Vardoulakis and Kassomenos, 2008; Yoo et al., 2011). In the Mediterranean basin, this approach was used in various publications: Poor correlations of PM with gaseous emissions ($\text{SO}_2$, $\text{NO}_2$) in Brindisi (Italy) during summer, in conjunction with positive correlations with temperature, were interpreted as markers of Sahara dust intrusions (Mangia et al., 2011). In Thessaloniki (Greece), positive correlation between particles and NOx provided evidence about higher combustion-related emissions during the cold season, whereas increased contribution of secondary particles was suggested during the warm season (Kassomenos et al., 2011). However, in order to distinguish local from transboundary PM contributions, air mass trajectories signifying the origin of the incoming air parcels are usually deployed. Riccio et al. (2007) and Borge et al. (2007), identified days with significant exogenous $\text{PM}_{10}$ contributions from North African countries in Naples (Italy) and Madrid (Spain) respectively. Major $\text{PM}_{10}$ transport in Thessaloniki can be clearly associated with air masses arriving from Central and Southern Europe (Makra et al., 2011).

This study combines an analysis of air pollution and meteorological data, along with air mass trajectories, in
order to provide a detailed overview of sources and factors affecting levels and size distribution of PM in the urban area of Valencia (Spain), during the years 2010–2012. Four size fractions of PM ($\text{PM}_{10}$, $\text{PM}_{\text{COARSE}}$, $\text{PM}_{2.5}$ and $\text{PM}_1$) were studied. Hourly air mass trajectory points were analyzed by Concentration Weighted Trajectory (CWT) model and Potential Source Contribution Function (PSCF) on a grid of $0.5^\circ \times 0.5^\circ$ resolution. The grid extends within the coordinate boundaries: $50.0^\circ \text{W–}40.0^\circ \text{E}/20.0^\circ \text{N–}60.0^\circ \text{N}$. Positive correlations among PM, NO$_2$ and SO$_2$, revealed local combustion emissions of particles, whereas regional sources of particulate air pollution were successfully localized by the implementation of CWT and PSCF. Atmospheric circulations favoring the accumulation of particles and the provocation of extreme events were also identified.

DATA AND METHODOLOGY

Data and Sampling Sites
The city of Valencia (Figs. 1(a) and 1(b)) is located on the South East (SE) coast of Iberian Peninsula in West Mediterranean. The city center is mainly residential and commercial, whereas industrial facilities are situated particularly to the West-South West (W-SW) suburbs (Fig. 1(a)). In addition, extensive rural areas exist around the city, whereas to the East lies the Mediterranean Sea. Valencia’s port is the largest in Spain and one of the busiest in the Mediterranean basin.

For the needs of this paper, three years (2010–2012) of hourly concentration data of PM$_{10}$, PM$_{2.5}$, PM$_1$, SO$_2$ and NO$_2$ ($\mu\text{gr m}^{-3}$), were obtained from a background monitoring station sited at the city’s Polytechnic University Campus. The station’s European code is ES1885A and all data were downloaded from the website of the European Union (EU) air quality database (http://www.eea.europa.eu/themes/air/air-quality/map/airbase). The sampling site is located at the North East (NE) boundaries of the city center (Fig. 1, Table 1), away from main congested traffic arteries, and thus was selected in order to facilitate the identification of both local and regional contributions. PM, SO$_2$ and NO$_2$ concentrations were recorded by the use of Differential Optical Absorption Spectroscopy (DOAS), Ultra Violet (UV) fluorescence and chemiluminescence analyzers respectively, expected to work within 15% of uncertainty bounds, according to EU regulations.

Daily values of Temperature (°C), Wind Speed (m sec$^{-1}$) and Atmospheric Pressure (hPa), covering the three year time interval 2010–2012, were also acquired from the European Climate Assessment & Dataset (ECAD) webpage (http://eca.knmi.nl/). These meteorological parameters were monitored at the International Airport of Valencia, localized 8 km to the West outside the city center (Fig. 1, Table 1). A short statistical description of meteorological and air pollution data is included in Table 2.

Methodology

Pearson Correlations
Pearson correlation coefficients were calculated, among hourly concentrations of distinct size fractions of PM ($\text{PM}_{10}$, $\text{PM}_{\text{COARSE}} = \text{PM}_{10} - \text{PM}_{2.5}$, $\text{PM}_{2.5}$ and $\text{PM}_1$) and gaseous air pollutants (SO$_2$, NO$_2$), aiming to identify local sources of PM production. NO$_2$ was primarily considered as a marker

![Fig. 1.](image)

Fig. 1. a) Map of Valencia. The blue dots mark the exact positions of the meteorological (Valencia Airport) and the air pollution (Valencia Polytechnic) stations. b) Map of Iberian Peninsula. The red dot marks the city of Valencia. c) Map of the studied grid area. The grid is surrounded by the black line. The red dot marks the city of Valencia.
of vehicular combustion (Vardoulakis and Kassomenos, 2008; Juda-Rezler et al., 2011), whereas SO2 was used as an indicator of industrial and household emissions (Vardoulakis and Kassomenos, 2008). However, the existence of Valencia’s large port, can also enrich the levels of PM, NO2 and SO2 (Beecken et al., 2014; Song and Shon, 2014), due to diesel burning in ship engines. The impact of ship emissions in air quality was previously reported in coastal Spanish cities as Barcelona and Algeciras (Viana et al., 2014).

**Table 1.** Geographical characteristics of the Meteorological (METE) and the Environmental (ENVI) station

| Station Name (EU Code)          | Type            | Area  | Longitude/Latitude | Altitude (AMSL) |
|--------------------------------|-----------------|-------|--------------------|-----------------|
| Valencia Polytechnic (ES1885A) | ENVI-Background | Urban | –0.3363° 39.4803°   | 7 m             |
| Valencia Airport               | METE            | Suburban | –0.4778° 39.4896° | 69 m            |

AMSL: Above Mean Sea Level.
In order to elucidate the influence of meteorological parameters on PM size distribution in Valencia, Pearson correlations were also computed between average daily concentrations of PM fractions and average daily temperature, wind speed and atmospheric pressure levels. This procedure was conducted on a daily basis, due to the absence of hourly meteorological data, and thus the results must be further clarified in the future. Average daily concentrations of PM were calculated only if at least 18 of each day’s 24 hourly concentration values were available, thus only 1019 out of 1096 days (approximately 93%) were studied. This restriction was set for reliability reasons.

The computation of all Pearson correlation coefficients, was performed separately during warm (April–September) and cold (October–March) periods of the selected years. This approach was preferred in order to identify potential seasonal alterations in the status of PM, due to the changes in human activities (e.g., traffic, domestic heating, etc.) and meteorological conditions (e.g., temperature).

### Table 2. Statistical description of hourly concentrations of airborne pollutants and daily meteorological parameters, during the time interval 2010–2012.

| Parameter       | Mean  | St. Deviation | Data Availability (%) |
|-----------------|-------|---------------|-----------------------|
| PM_{10} (μg m^{-3}) | 20.3  | 14.8          | 94.5                  |
| PM_{COARSE} (μg m^{-3}) | 7.3   | 7.7           | 94.5                  |
| PM_{2.5} (μg m^{-3}) | 13.0  | 10.0          | 94.5                  |
| PM_{1} (μg m^{-3}) | 10.1  | 8.8           | 94.4                  |
| SO_{2} (μg m^{-3}) | 3.1   | 1.7           | 81.1                  |
| NO_{2} (μg m^{-3}) | 25.4  | 22.0          | 93.8                  |
| Wind Speed (m sec^{-1}) | 3.4   | 1.7           | 100.0                 |
| Temperature (°C) | 17.4  | 6.4           | 97.6                  |
| Pressure (hPa)   | 1017.0| 6.6           | 100.0                 |

Concentration Weighted Trajectory (CWT) Model

Gridded air mass residence time data were then elaborated by Concentration Weighted Trajectory (CWT) model (Gogoi et al., 2011; Hidemori et al., 2014), aiming to produce a geographical overview of emission source areas, enriching PM levels in Valencia. CWT formula (Eq. (1)) yields a weighted concentration for each grid cell (i, j), based on the average daily PM levels measured at the sampling site, corresponding to the trajectories overflying across this grid cell (i, j):

\[
C_{ij} = \frac{\sum k \tau_{ijk} C_k}{\sum k \tau_{ijk}}
\]  

(1)

\[
W(i, j) = \begin{cases} 
1.0 & (3n_{ave} < n_{ij}) \\
0.7 & (1.5n_{ave} < n_{ij} < 3n_{ave}) \\
0.4 & (n_{ave} < n_{ij} \leq 1.5n_{ave}) \\
0.2 & (n_{ij} < n_{ave}) 
\end{cases}
\]  

(2)

\(C_{ij}\) is the Weighted Average Concentration (WAC) in a grid cell (i, j), \(C_k\) is the daily average concentration at the sampling site during day (k), and \(\tau_{ijk}\) is the number of trajectory points in grid cell (i, j), belonging to the 24 backward trajectories corresponding to day (k).

CWT algorithm was applied independently for each one of the studied PM fractions (PM_{10}, PM_{COARSE}, PM_{2.5} and PM_{1}), in order to distinguish the origin of air masses influencing PM size distribution in Valencia. Grid cells presenting raised \(C_{ij}\) values indicate potential source areas of PM, contributing to the total aerosol burden of Valencia (Salamalikis et al., 2015), depending on atmospheric circulation. Sporadic trajectory points, isolated in distant
grid cells, may induce highly uncertain extreme $C_{ij}$ values (Karaca et al., 2009; Kocak et al., 2011). For that reason, as the final step of CWT model, $C_{ij}$ values were multiplied with an arbitrary $W(i, j)$ weight function (Hsu et al., 2003; Wang et al., 2006). The applied weight function (Eq. (2)), is based on the relationship among the average number ($n_{ave}$) of trajectory points of all grid cells which contain at least one trajectory point and the number ($n_{ij}$) of trajectory points in the $(i, j)$ cell (Dimitriou and Kassomenos, 2014c).

In this paper, CWT model was applied in order to indicate the potential source areas and atmospheric pathways influencing PM levels and size distribution in Valencia. However, the determination of the chemical species contained in PM mass, could upgrade the results and specify the emission origin of the aerosols.

**Potential Source Contribution Function (PSCF) Model**

The findings of CWT model were supplemented with the outcome of Potential Source Contribution Function (PSCF), reflecting the likelihood of extreme PM events, in conjunction with air mass dwelling time above specific regions. PSCF values are provided by the following expression (Karaca et al., 2009; Polissar et al., 2001; Kong et al., 2013; Dimitriou and Kassomenos, 2015):

$$PSCF(i, j) = \frac{m(i, j)}{n(i, j)}$$

(3)

In Eq. (3), $n(i,j)$ is the total number of trajectory points contained in the $(i,j)$ cell, and $m(i,j)$ is the number of trajectory points in the $ij$th cell which belong to trajectories corresponding to exceedances of a daily threshold PM concentration value. Various threshold levels have been used in recent publications, extending from 60th percentile (Polissar et al., 2001) to 75th percentile (Karaca et al., 2009; Kong et al., 2013). In this study, a more strict definition of episodic extreme concentrations was adopted and thus the threshold criterion was set at the 85th percentile. PSCF model was separately implemented for PM10, PMCOARSE, PM2.5 and PM1, in order to identify sources and pathways possibly associated with extreme contributions of different size fractions of PM. The results of PSCF, were also multiplied with the same $W(i, j)$ weight function (Eq. (2)), in order to enhance statistical stability.

**RESULTS**

**Local PM Sources and Meteorology**

A Pearson correlation analysis was implemented among different size fractions of PM and gaseous air pollutants. Moderate positive associations were computed between PM and NO2, whereas the relationship among PM and SO2 was lower (Table 3). All correlations were statistically significant at the 0.01 level and thus the importance of combustion in the generation of particles was highlighted (Galindo et al., 2011; Juda-Rezler et al., 2011). In addition, higher PM-NO2 correlations reflect the increased contribution of traffic (Beckerman et al., 2008) in the total aerosol burden in Valencia in comparison with household/industrial PM emissions. During warm periods of the years 2010–2012, the correlation among all fractions of PM and gaseous pollutants were decreased (Table 3), probably due to the reduction of fuel combustion for domestic heating and transportation purposes.

| PM10 | PMCOARSE | PM2.5 | PM1 | SO2 | NO2 |
|------|----------|-------|-----|-----|-----|
| 1    | 0.755    | 0.892 | 0.813| 0.213| 0.446|
| 0.816| 1        | 0.377 | 0.248| 0.177| 0.351|
| 0.393| 0.178    | 1     | 0.976| 0.177| 0.388|
| 0.034| 0.171    | 0.852 | 0.178| 0.101| 0.273|
| 0.393| 0.139    | 0.946 | 0.178| 0.228|
| 0.274|

*All correlations are significant at the 0.01 level.
The influence of meteorological conditions (Wind speed, Temperature, Atmospheric pressure) on PM size distribution was also studied with a Pearson correlation procedure. Wind speed clearly anti-correlated with PM\(_{10}\) and principally with fine particles (PM\(_{2.5}\) and PM\(_{1}\)) suggesting atmospheric dispersion (Table 4) of combustion emitted PM fractions. In addition, positive associations of atmospheric pressure with PM\(_{10}\), PM\(_{2.5}\) and PM\(_{1}\) during cold seasons, signify the increment of fine PM concentrations due to the recirculation of polluted air: The influence of anticyclonic high pressure systems provokes atmospheric stagnation (Perez et al., 2008; Cheng et al., 2014). Yet, the relationship of PM\(_{\text{COARSE}}\) with wind speed during cold periods was non significant, while in warm seasons this correlation was significantly positive (Table 4), indicating the impact of wind blown dust (Vardoulakis and Kassomenos, 2008; Buchholz et al., 2014). This interpretation of the results is also supported by the enhancement of the positive correlation between PM\(_{\text{COARSE}}\) and temperature levels during warm seasons: High temperatures prevailing throughout dry and sunny days, remove the soil’s moisture, favoring dust resuspension (Vardoulakis and Kassomenos, 2008; Galindo et al., 2011; Mangia et al., 2011; Buchholz et al., 2014). Finally, the more frequent occurrence of Saharan dust intrusions during the warm seasons of the time interval 2010–2012 (Bilbao et al., 2014), may induce PM\(_{\text{COARSE}}\) episodes combined with highly elevated temperatures, justifying positive correlations (Galindo et al., 2011; Mangia et al., 2011).

Regional Contributions

Air mass residence time was analyzed by CWT and PSCF model, along with average daily concentrations of all the available PM fractions, in order to isolate regional sources of particulate air pollution affecting the city of Valencia. The produced WAC and PSCF values were plotted on surface maps, presented in Fig. 2 and Fig. 3 respectively.

**Concentration Weighted Trajectory (CWT) Model Outcome**

According to the results of the model, exogenous sources of total PM\(_{10}\) were mainly localized within Southern Iberian Peninsula, France, coastal North West (NW) Africa and the Mediterranean (Fig. 2(a)). Peak WAC levels for PM\(_{10}\) were associated with South–South West (S–SW) airflows, suggesting Saharan dust and Mediterranean spray transportation. In addition, areas of semi-arid land (Fig. 1(b)) and urban/industrial emission sources, existing in South–South East (S–SE) Spain, could also enrich PM\(_{10}\) levels in Valencia (Santacatalina et al., 2010).

Incoming air parcels, overflying across Iberian Peninsula, France, NW Africa and the Mediterranean, were also associated with the inflow of PM\(_{\text{COARSE}}\). However, maximum contributions of PM\(_{\text{COARSE}}\) were attributed to Northern airflows from Western France through NE Iberian Peninsula (Fig. 1(b)), where various anthropogenic and natural sources (e.g., semi-arid lands, forests) exist. Severe Saharan dust intrusions from areas located deeper in NW Africa [Mauritania, Mali and Algeria (Engelbrecht et al., 2014)] were also clearly revealed (Fig. 2(b)). Natural non combustion particulates are generally coarser and thus these findings are justified.

Clear similarities were observed among the spatial distribution and the relative contribution of regional PM\(_{10}\), PM\(_{2.5}\) and PM\(_{1}\) sources (Figs. 2(a), 2(c) and 2(d)). Fine particles represent a large proportion of PM\(_{10}\) (average daily PM\(_{2.5}/\)PM\(_{10}\) = 0.64) in Valencia, whereas a high percentage of PM\(_{2.5}\) is consisted from PM\(_{1}\) (average daily PM\(_{1}/\)PM\(_{2.5}\) = 0.76). Thus, the homogeneity of the surface maps was expected. Transferring of PM\(_{2.5}\) and PM\(_{1}\) from inside of the Iberian Peninsula, France, coastal North West (NW) Africa and the Mediterranean was indicated. Increased contribution of fine PM from S–SW directions was also emerged (Figs. 2(c) and 2(d)). Soil and sea spray particles more likely belong in the coarse fraction of PM (Almeida et al., 2005; Flament et al., 2011; Dimitirou and Kassomenos, 2014c), yet many previous studies which analyzed the chemical composition of fine PM, have revealed a substantial participation of dust and marine aerosols in PM\(_{2.5}\) mass (Rodriguez et al., 2011; Remoundaki et al., 2013; Engelbrecht et al., 2014).

Table 4. Pearson correlation coefficients among daily average concentrations of different PM fractions (PM\(_{10}\), PM\(_{\text{COARSE}}\), PM\(_{2.5}\) and PM\(_{1}\)) and daily meteorological parameters (Wind Speed, Temperature and Atmospheric Pressure) during a) Cold periods and b) Warm periods, of the years 2010–2012.

|                  | Wind Speed | Temperature | Pressure |
|------------------|------------|-------------|----------|
| PM\(_{10}\)      | −0.326     | 0.025\(^{a}\) | 0.204    |
| PM\(_{\text{COARSE}}\) | −0.057\(^{a}\) | 0.163 | 0.050\(^{a}\) |
| PM\(_{2.5}\)     | −0.406     | −0.056\(^{a}\) | 0.246    |
| PM\(_{1}\)       | −0.424     | −0.127     | 0.265    |

|                  | Wind Speed | Temperature | Pressure |
|------------------|------------|-------------|----------|
| PM\(_{10}\)      | −0.087\(^{a}\) | 0.234 | −0.002\(^{a}\) |
| PM\(_{\text{COARSE}}\) | 0.138 | 0.314 | 0.040\(^{a}\) |
| PM\(_{2.5}\)     | −0.255     | 0.099\(^{b}\) | −0.037\(^{a}\) |
| PM\(_{1}\)       | −0.319     | −0.036\(^{a}\) | −0.049\(^{b}\) |

\(^{a}\)All correlations are significant at the 0.01 level, except where noted: \(^{a}\)Correlation non significant, \(^{b}\)Correlation significant at the 0.05 level.
et al., 2014; Mantas et al., 2014). In addition, Saharan desert dust is very frequently mixed with particulate pollutants deriving from industrial activities in Northern Algeria, Eastern Algeria, Tunisia and Morocco (Rodriguez et al., 2011).

Potential Source Contribution Function (PSCF) Outcome

PSCF model was used aiming to identify PM source areas associated with daily episodes (15% highest) of fine and coarse particulate air pollution in Valencia. PSCF algorithm was also applied in order to verify the results of CWT model. Extreme events of all PM fractions were primarily associated with the prevalence of S–SW atmospheric circulation (Fig. 3). Episodic levels of PM\textsubscript{COARSE} were also connected with the arrival of air mass trajectories traveling through Western France and NE Spain, whereas the impact of Sahara dust outbreaks and Mediterranean spray was also emerged (Fig. 3(b)). A PSCF maximum for PM\textsubscript{2.5} and PM\textsubscript{1} was observed in central France (Figs. 3(c) and 3(d)), where major urban areas (e.g., Paris) and industrial facilities exist. In addition, extreme events of PM\textsubscript{2.5} and PM\textsubscript{1} corresponded to shorter trajectories, in comparison with PM\textsubscript{10} and PM\textsubscript{COARSE} episodes (Fig. 3), suggesting the arrival of slow moving air masses and thus atmospheric stagnation. Conclusively, the results of PSCF and CWT models were consistent (Fig. 2, Fig. 3), revealing similar PM source areas.

CONCLUSIONS

This paper combines an analysis of air pollution and meteorological data with air mass trajectories, in order to distinguish local and regional PM contributions, degrading air quality in Valencia (Spain). Air mass dwelling time was allocated on a grid of a 0.5° × 0.5° resolution, in order to be used as input to CWT and PSCF models, providing a more detailed localization and quantification of exogenous
contributions. Four size fractions of PM (PM\textsubscript{10}, PM\textsubscript{COARSE} = PM\textsubscript{10}–PM\textsubscript{2.5}, PM\textsubscript{2.5}, and PM\textsubscript{1}) were studied, aiming to identify possible differences in sources and parameters favoring the increment of fine and coarse aerosol levels. Each one of these PM categories was studied independently, without considering aerosol size evolution.

Strong Pearson correlations, calculated among different PM fractions, were considered as markers of common emission sources. However, secondary natural sources of PM\textsubscript{COARSE} were indicated, primarily during warm seasons. In addition, positive associations of PM, primarily with NO\textsubscript{2} and secondarily with SO\textsubscript{2}, respectively reflect the impact of vehicular and domestic/industrial combustion in aerosol production, whereas CO concentration data were not available. Yet, during warm seasons, PM–NO\textsubscript{2} and PM–SO\textsubscript{2} correlations were reduced, due to the drop of combustion emissions for domestic heating and transportation purposes. Wind dispersion of PM\textsubscript{2.5} and PM\textsubscript{1} was indicated, whereas atmospheric stagnation conditions triggered the accumulation of fine particles. On the contrary, PM\textsubscript{COARSE} concentrations correlated positively with wind speed, due to the effect of wind blown dust, particularly throughout warm periods when dry land facilitates dust resuspension.

The outcome of CWT model identified Iberian Peninsula, France, NW Africa and the Mediterranean as potential PM source areas, for all size fractions of aerosols, thus the incoming of dust, sea spray and combustion particulates is deduced. Peak transboundary contributions of PM\textsubscript{2.5} and PM\textsubscript{1} were associated with S–SW atmospheric circulation, whereas major contributions of PM\textsubscript{COARSE} were attributed to dust intrusions from the Sahara desert and also to Northern airflows through Western France and NE Spain. The results of PSCF, verified the findings of CWT model, as the highlighted potential source areas associated with extreme
PM events were coherent. In addition, elevated PSF values for PM$_{2.5}$ and PM$_{1}$ were isolated in central France, where major cities (e.g., Paris) are situated. Equidistant concentrations of PM$_{2.5}$ and primarily PM$_{1}$ were matched (from numerical calculations) with the prevalence of shorter slow moving all around trajectories, reflecting atmospheric stability.

The main objective of this paper was to identify sources and meteorological parameters, defining the levels and size distribution of airborne PM in Valencia. Moreover, regional contributions were studied separately from local emissions, by the use of CWT and PSF models, in order to indicate distinct atmospheric patterns associated with the addendum of particulates from exogenous sources. The impact of local PM emissions and meteorological factors was clearly revealed from a Pearson correlation analysis. Similar transboundary PM source areas were indicated by CWT and PSF, and thus the results were solidified. The main conclusions of this work can be used for the determination of emission reduction policies, whereas different states could collaborate for the containment of transboundary air pollution. The availability of hourly meteorological data could improve the findings of this paper and remove uncertainties. An additional step forward would also be the analysis of the chemical species included in PM mass, which would elucidate further the origin of PM emissions.

ACKNOWLEDGEMENTS

The author would like to thank the European Union (EU) Air Quality Database (Airbase), for the provision of air pollution data, and also the European Climate Assessment & Dataset (ECA&D) project, for the concession of meteorological data. The author gratefully acknowledges the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model used in this publication. Finally I would like to thank professor Pavlos Kassomenos for his guidance and support.

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