APICE

WP3.2 – REPORT FROM MARSEILLE REGION

THE CURRENT REPORT IS A COLLABORATION OF

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Project confinancé parle Fonds Européen de Développement Régional

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SUMMARY

University of West Macedonia redacted five reports for each region which participates in APICE project: Barcelona, Marseille, Venice, Genoa and Thessaloniki. In each report, there is a brief presentation of each region and port area. An analysis of the air quality in each area for the last years follows and the interest is focused on PM10. Meteorological conditions influence is also examined. With the scope of the study of the port's contribution to the air quality of each city, these reports prepare the next steps of an inter-comparison campaign and an air long monitoring campaign for a source apportionment study as also for modeling activities and socio-economic trends. The present report refers to the port of Marseille.

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1. INTRODUCTION

The current report has been redacted in lines of APICE program (Common Mediterranean strategy and local practical Actions for the mitigation of Port, Industries and Cities Emissions). APICE project develops its actions within 5 study areas of 4 MED space Countries belonging to the regions of Veneto and Liguria (Italy), Provence-Alpes-Côte d'Azur (France), Cataluña (Spain) and Central Macedonia (Greece) and involve some of the most important port-cities of Mediterranean space. The project areas show common features related to the port-areas systems (in terms of harbor-industrial district organization) and present the same problems of air-pollution affecting seriously not only the populated urban centers but also the whole natural ecosystems and the cultural heritage (the project territories count several Sites of Community Importance & Special Protection Areas in their surroundings, as well as UNESCO sites).

The report includes a description of the air quality and meteorology network in Marseille region. Furthermore, a brief analysis of the air quality during the last years is included. The interest is focused on the Port of Marseille, which has an ideal geographical position for north/south and east/west trade. One of its strengths is that all goods are conveyed by pipeline, gas line, land, rail or river. Monthly, daily and hourly PM10 variations were examined for the year 2009. A discussion about PM10 limit values excesses as well as the effect of meteorological parameters to PM10 levels is also included. Finally, a description of the national and international framework follows.

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2. PARTNERS PRESENTATION

PORT AUTHORITY OF MARSEILLE (GP2M)

The Port of Marseilles took advantage of its unique geographical position to develop a full range of specialized terminals and become the largest versatile port in southern Europe. In 1998, Marseilles was the first port to hold the ISO 9002 international certification for all the port's shipping service facilities. The "Marseilles Global Port" strategic project and the Marseilles Port Authority business plan for the 3rd millennium were adopted.

GREAT MARINETIME PORT OF MARSEILLE (GPMM)

The port features two harbors, the 400-hectare “East Harbor” within the city of Marseille and the “West Harbor” located 40km from Marseille at Fos, on a unique, impressive 10,000-hectare site.

As a general cargo port, the various types of traffic include crude oil and oil products (oil, gas and chemical products), general cargo (containers and other packaging), dry bulk (minerals and cereals) and liquid bulk (chemicals and food).

The Port also caters for passenger traffic from cruises and regular shipping lines to Corsica and North Africa.
Its geographical position in Mediterranean Sea and the quadrimodality from which it benefits (river, rail, road, and pipeline) sets it as natural gateway to the European markets.

Port activity generates 41,300 jobs in total, including 1,500-strong workforce within the Port Authority, Grand Port Maritime de Marseille.

General statistic information is described below:

- Versatile GLOBAL PORT: 24 activities (VS, VL, Passengers, Oil products, cruises, RN, containers etc.)
- 1st port in France with a total of 83 million tons in 2009
- 3rd oil port worldwide after Rotterdam and Houston
- 4th European port after Rotterdam, Antwerp and Hamburg
- 1,500 employees for a turnover of 172 million euro
- It is a general purpose port given its 24 different activities distributed along its entire area stretching from Marseilles to Port Saint Louis du Rhône via Martigues:

  - East docks (city of Marseilles): 392 hectares (1000 hectares including water stretches)
  - West docks (spared on 3 mains cities): 10,000 hectares
  - More than 60 kilometers of quayside in all
  - Distance of 40 km between the two docks
- 880,000 containers
- More than 2 million passengers including 639,000 cruise passengers
- More than 4 million roll-on/roll-off freight cargos
- More than 57 million tons of hydrocarbons are handled by the facilities
- One of the world's largest sectional dry docks - Form 10: 465 meters long, 85 meters wide, 11 meters draught

UNI OF PROVENCE – LCP

« Laboratoire Chimie Provence » (LCP) is a research unit (Unité Mixte de Recherche, UMR 6264) founded in 1st of January 2008 by the Université de Provence, Université de la Méditerranée, Université Paul Cézanne and the Centre National de la Recherche Scientifique.

This laboratory enables interactions among various skills in research teams, fostering efforts in the national and international competition. The unit is composed by: about 100 academic teachers and CNRS researchers, about 35 administrative, technical and engineering staff and around 100 non-permanent staff (PhD students, Post-Docs, invited scientists…). The research budget is over 2 Million Euros with more than 80% external funding through public or private contracts.

The LCP is composed of 11 independent research groups. One of the 11 research teams works on atmospheric chemistry. For more than 10 years, this team called “the Atmospheric Instrumentation and Reactivity (IRA)”, has established the atmospheric research in Marseille. The IRA group members researchers (13 researchers, 3 Post Doc and 11 PhD Students) who come from three independent teams but share activities in the field of atmospheric chemistry and physics. This interdisciplinary association between physicists and chemists is an important advantage of IRA.

The IRA research field includes:

- Heterogeneous reactivity to introduce multiphase of chemical and physical atmospheric processes, in the field and under controlled conditions

- Equipment design, innovation and development to record and study emissions of atmospheric or environmental interest. An important field of IRA/LCP, includes source apportionment and chemical characterization of emitted particles.

ATMO PACA

Atmo PACA is a non-profit association (created in 1982) that manages air quality network in south-eastern France.

In accordance with the French law on air quality dated in 30th of December 1996, Atmo PACA is the responsible organization for survey on air quality in PACA region. PACA's objectives are summarized in the following:

- Monitoring air quality, (measurements and modeling),
- Forecasting air quality and pollution peaks,
- Informing the public authorities and general public (daily or during an air pollution episode),
- introducing pollution mechanisms by realizing studies, and studying the connection among air quality, health and environment,
- Assessing the change of emission reduction, that contributes to reflexions on territory management.

The total budget of Atmo PACA for the year 2007 was 2.3 million of Euros and Atmo PACA employs nineteen persons. A close collaboration into the research laboratory of Atmo Paca, provides information which contributes in decision making. Atmo PACA broadcasts daily air quality indexes of Marseilles, Aix-en-Provence, Nice, Cannes-Grasse-Antibes, Toulon, Avignon, Aubagne and Hyères regions. In total, 52 stations equipped with 150 sensors measure the air quality in this area.

3. PORT PRESENTATION

The Port of Marseille is one of the oldest and busiest seaports in France. Marseille was founded as a trading port in 600BC by the Greeks. A railroad line was constructed from the port to Avignon and to Toulon in 1849 and 1859 respectively. During the rule of Napoleon III, the port's dock and storage areas were extended. In 1881, the Chamber of Commerce was appointed as the operator of the port's sheds, docks and equipment. The Chamber of Commerce became the Port of Marseille Authority (PMA) in April 1966. In 1970, Dry Dock 10, one of the largest in the world, was constructed at the port. A public container terminal was inaugurated by the PMA in 1994. The port played an important role in governing and maintaining the colonies during the French monarchy. Nazis occupied the port from 1942 to 1944, when it was liberated by Allied armies.

The Port of Marseille handles oil and bulk liquids, bulk solids such as minerals and grains. Controlled by the Marseilles Fos port authority, the port serves as a trade gateway to European markets. In 2009 it served more than 11,200 ship calls. The port consists of an east and a west basin. The east basin covers an area of 400ha while the west basin is spread over 10,000ha. The port's 980m deepwater quay is served by a river station at a maximum draft of 12.8m and three deepwater stations at a maximum draft of 16.5m. The port consists of three main harbors: Marseille, Lavera and Fos. Marseille handles passengers, general cargo, roll-on/roll-off activities and ship repairs. Lavera is used for oil chemicals and refined oil activities, while Fos harbour is used for crude oil and container-related activities.

The port transports over 100mt of freight annually. A pipeline is used to transport petroleum from the port to the Paris Basin. Around 1,500 people are employed in the port's area. As the port houses a large indoor fish market, commercial activities take place in the area. Chemicals, building materials, glass, soap, plastics, textiles, olive oil and sugar are also manufactured on the site.

The port's throughput in March 2010 was 7.99 million tons, including 219,000t of conventional and break bulk cargo. In July 2007 the Marseille Port Board provided €22m to construct a seventh mooring berth at the Fos petroleum terminal. The project is scheduled to be completed by mid-2011. The berth will be used for refined oil products. In March 2009, Shell and Vopak formed a joint venture, Fos Faster, to construct an LNG terminal at the port. The terminal will have an initial capacity of 8 billion cubic meters per annum (bcma) and it can be further expanded to produce 12bcma of gas. In March 2010, Hutchison Port Holdings acquired the contract for developing Marseille's Fos 4XL container terminal. The terminal is expected to be operational by 2018.

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The statistics for the year 2010 are presented in the following:

Port location: ***Marseille, France***

Type: ***Seaport***

Operator: ***Port of Marseilles-Fos***

Total throughput in the first quarter of 2010: ***21.5 million tons***

Container throughput (January-February 2010): ***159,202 20ft equivalent units***

Container volume (January-February 2010): ***2.39 million metric tons***

Conventional traffic (January-February 2010): ***310,000 metric tons***

Roll-off traffic (January-February 2010): ***490,000 metric tons***

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4. MONITORING NETWORKS

4.1 AIR QUALITY NETWORK

The French law on *air quality and rational energy using*, dated from December 30th, 1996, codified by L220-1 and following articles of Environmental Code, specifies that *State has to assure, with the supports of local authorities and companies, air quality monitoring*. In this way, State gives to AASQA (French Approved Association of Air Quality Monitoring), a survey and information mission about atmospheric pollution.

Each AASQA administrator board is composed by four corporations: representatives of State, of local authorities, of industrial companies, of consumer or environmental protection associations and of competent personalities.

In 2009, the national network regroups 34 associations. Over Provence Alpes Côte d'Azur Region (PACA region), air quality survey network is managed by AIRFOBEP and Atmo PACA. The French law, about *air quality survey* and *public information*, asks to AASQA to develop an air quality monitoring program. This obligation has to assure the comparison of air quality monitoring devices at the European scale, in application of European Directives and Convention on Long-range Transboundary Air Pollution. Each AASQA has developed, for five years, an air quality monitoring program. Programs defined by AIRFOBEP and Atmo PACA for 2005-2009 are available on their website[i]. A common program will be realized in 2010.

In total, 47 stations for AtmoPACA and 31 stations for AIRFOBEP equipped with 133 and 79 sensors respectively, measure the air quality in this area. The automated measurements transmitted to a Management Centre (in Marseille) are analysed, broadcast to the general public and can be used to alert the authorities in case of a pollution peak.
Atmo PACA participates to studies on the environmental impact of air pollution and provides expertise for designing air pollution abatement policies on the means that could be used to reduce the pollution. The stations measure, every 15 minutes, several pollutants such as particulate matters, NO and NO_2, CO, ozone, benzene, toluene, xylenes, SO_2, as well as climatic parameters : direction and speed of the wind, temperature, hygrometry. The measures can be done by three ways:

- Permanent measurements: whole of measures with a sufficient frequency to give a non-stop result and available in real-time
- Indicative measurements: whole of measures done with intermittence over one year,
- Sampling campaign: temporal measures over one local area to obtain some information about air quality state in this area.

[1] *AIRFOBEP website: http://www.airfobep.org/*

Atmo PACA website: http://www.atmopaca.org/

STATIONS

The following figures show the positions of stations at two different scales. The first one is the network over PACA region and the second is a focus over Marseille Province Metropolitan (MPM) region.

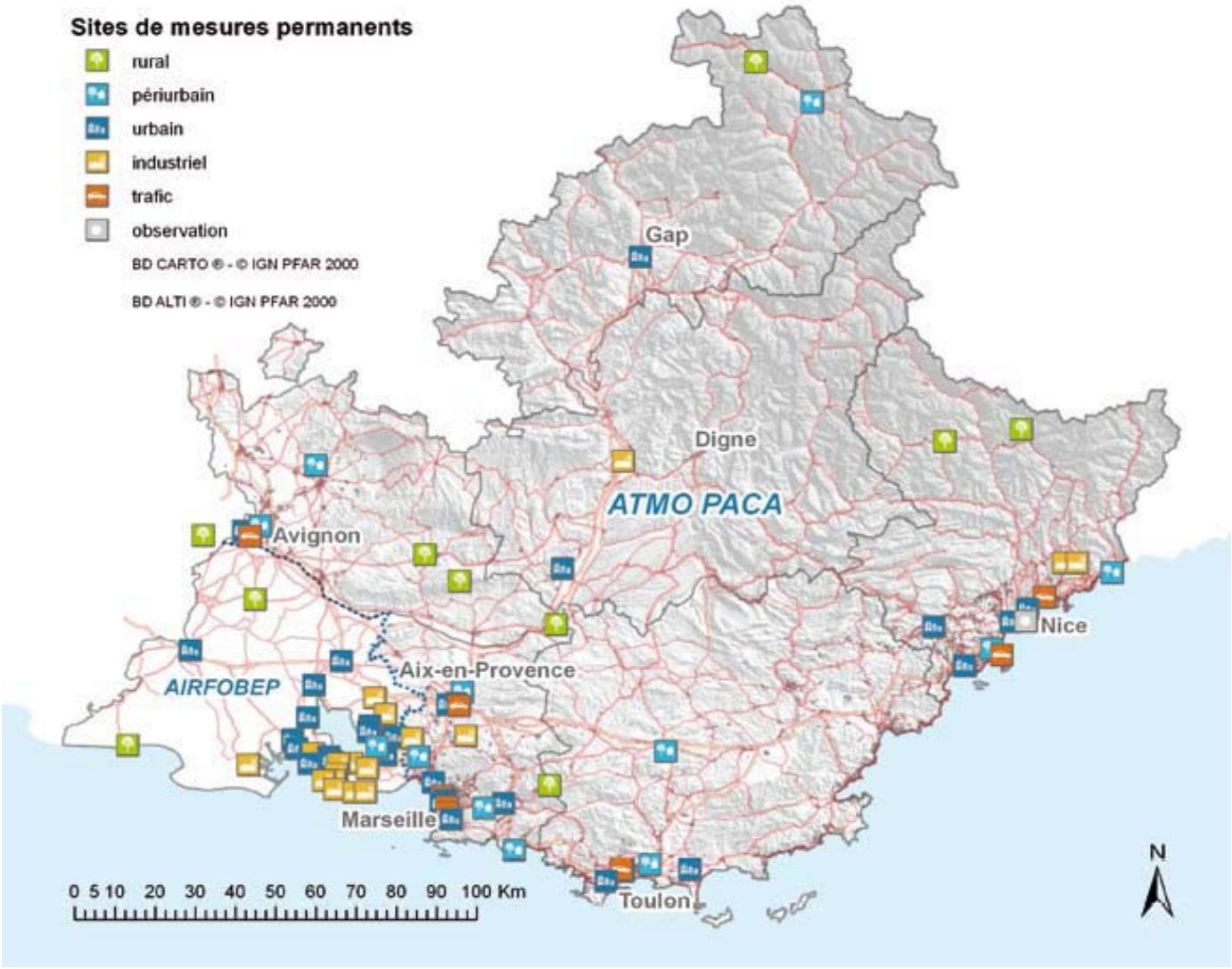

Figure 11 : Position of stations over PACA region

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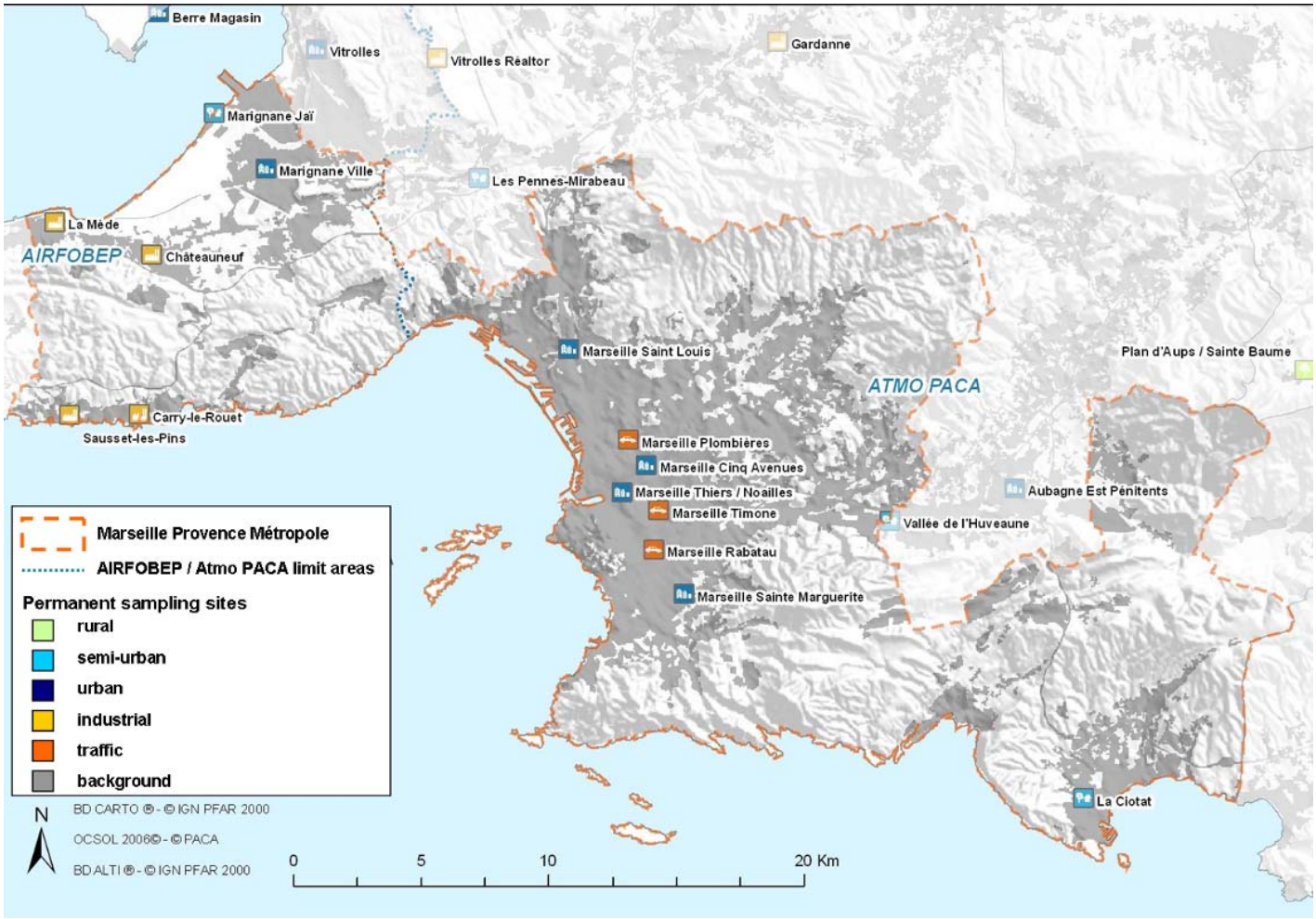

Figure 12: Position of stations over MPM area

POLLUTANTS MONITORED

Details of each station managed by AIRFOBEP and Atmo PACA are given in table 1, with their classification, measure type and pollutant measured.

Table 12 : details of stations managed by AIRFOBEP and Atmo PACA

Site type	
T	Traffic
I	Industrial
U	Urban
P	Suburban
R	Rural
O	Observation

Measure type	
	Permanent measurements
	Indicative measurements
	Permanent measurement for limit values

Inside PACA region, a special study over MPM area (Marseille-Provence-Métropole) allows a focus for Marseille and its surrounding. The figure 2 displays this area and shows the localization of stations inside. Table 2 gives the key-numbers of MPM area.

Aix-Marseille	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	HV	BTEX	CO
Marseille Plombières	T									
Marseille Timone	T									
Marseille Rabatau	T									
Marseille Cinq Avenues	U									
Marseille Saint Louis	U									
Marseille Thiers	U									
Marseille Ste Marguerite	U									
Vallée de l'Huveaune	P									
Pennes Mirabeau	P									
Aubagne Est Pénitents	U									
Aix Roy René	T									
Aix Ecole d'Art	U									
Aix Jas de Bouffan	U									
Aix Platanes	P									
Gardanne	I									

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Nice	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
Nice Pellos	T									
Nice Trafic	T									
Nice Urbain	U									
Cagnes Ladoumègue	U									
Nice Botanique	U									
Nice Périurbain	P									
Nice Aéroport	O									
Antibes Guynemer	T									
Cannes Broussailles	U									
Grasse Clavecin	U									
Antibes Jean Moulin	P									
Contes	I									
Peillon	I									

Toulon	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
Toulon Foch	T									
Toulon Chalucet	U									
La Seyne Genoud	U									
Toulon Arsenal	U									
La Valette du Var	P									
Hyères	U									
La Ciotat	P									

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Avignon	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
Avignon Semard	T									
Avignon Mairie	U									
Le Pontet	P									
Comtat Venaissin	P									

ZUR	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
ZUR Trafic	T									
Salon	U									
Arles	U									
Fréjus St Raphael	U									
Riviera Française	P									
ZUR Périurbain	P									
La Fare	I									

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ZI	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
ZI Trafic	T									
Martigues / L'Ile	U									
Martigues / ND des Marins	U									
Istres	U									
Vitrolles	U									
Marignane	U									
Miramas	U									
Berre-l'Etang	U									
Berre / Port	U									
Fos / Les Carabins	U									
Fos-sur-Mer	U									
Port-de-Bouc / Milan	U									
Port-de-Bouc / La Lèque	U									
ZI Périurbain	P									
ZI Périurbain	P									
Martigues / Le Pati	I									
Martigues / Lavéra	I									
Martigues / les Ventrons	I									
Martigues / Les Laurons	I									
Martigues / La Gatasse	I									
Martigues / La Couronne	I									

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ZR	Typo	SO_2	NO_2	O_3	PM10	PM2.5	HAP	ML	BTEX	CO
Gap Trafic	T									
Gap Commanderie	U									
Manosque	U									
Briancon	P									
Adréchas	R									
Cians	R									
Cadarache	R									
Saint–Rémy-de-Provence	R									
Stes-Maries-de-la-Mer	R									
Brignoles	R									
Plan d'Aups Ste Baume	R									
Apt	R									
Auribeau	R									
Château Arnoux St Auban	I									

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Table 13 : Brief description of survey areas by AIRFOBEP and Atmo PACA and of MPM area

	AIRFOBEP*	**Atmo PACA****	**MPM**
Inhabitant number	583 438	4 231 792	1 023 972
Survey area (km^2)	3 198	28 541	605

Over MPM area, the automatic sampling network is composed by 14 permanent sites with 34 sensors for O_3, SO_2, NO_2, CO and others. In addition, two mobile laboratories**,** one truck, one trailer, particle samplers for heavy metal and PAH, passive diffusion tubs and “canisters” (for NO_2, benzene, toluene, and VOC) and one laboratory for the measure calibration, level 2, in AIRFOBEP office, are used for sampling campaigns. Table 3 gives a review of measures over MPM area in 2009.

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Table 14 : Review of measures in 2009 over AIRFOBEP, Atmo PACA and MPM areas

	AIRFOBEP area		Atmo PACA area		Total	
	AIRFOBEP	**over MPM**	**Atmo PACA**	**over MPM**	**AASQA**	**MPM**
Sampling stations *	**31**	**5**	**47**	**6+2 (summer measures)**	**78**	**13**
Permanent measures	**79**	**12**	**133**	**22**	**212**	**34**
O_3	11 +1 (Auribeau)	1	29+5 (summer measures)	1+2 (summer measures)	46	4
CO	1	1	6	2	7	3
NO_2	6	1	26	6	32	7
SO_2	28	5	6	1	34	6
PM10	10	2	22(1)	4	32	6
PM2.5	1	/	7(2)	1	8	1
Hydrocarbon	1	/	/	/	1	0
Benzene (by passive tubs)	11+2 automatic	2	22	5	35	7
Heavy metals : Lead, Nickel, Arsenic, Cadmium	3	/	4	1	7	1
Hydrogen sulphide	2	/	/	/	2	0
PAH	2	/	4	1	6	1
Mobil laboratory	**1 regional +1 trailer**	**1 regional +1 trailer**	**2**	**2**	**4**	**4**

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Measurement calibration laboratory	**1 inter-regional**	**1**	**1 inter-regional**	**/**	**2**	**1**

** Only stations with more than 75% of available data for 2009 are displayed*

(1) With 5 sensors set up by particle correction kit *(2) with 7 sensors set up by particle correction kit*

4.2 METEOROLOGY NETWORK

Meteorological data are provided by Météo-France, the French network for meteorology and by stations of both air quality networks, AIRFOBEP and Atmo PACA. In this part, we report data for three stations, one inside Marseille, and two in the surroundings, at Marignane and Martigues. These stations are marked on the figure 3.

STATIONS

Meteorological data are provided by Météo-France, the French network for meteorology and the stations of both air quality networks, AIRFOBEP and Atmo PACA. In this part, we report data for three stations, one inside Marseille, and two in the surrounding, at Marignane and Martigues. These stations are marked on the figure.

Figure 3: Locations of Marseille, Marignane and Martigues stations.

5. MEASUREMENTS

5.1 POLLUTANTS

NITROGEN DIOXIDE (NO_2)

Nitrogen oxides (NO_x), including nitrogen monoxide (NO) and nitrogen dioxide (NO_2) are issue from the combination of oxygen and nitrogen at high temperature present in air or fuel. The direct emissions are mainly in the form of NO, instable compound quickly oxidized in NO_2. The main sources of NO_2 are traffic and industrial combustion installations. This pollutant is the main traffic pollution tracer in urban environment. Table 4 presents the reference and limit values for NO_2.

Table 15: NO_2 reference and limit values

Threshold type	**Time scale**	**Value [µg/m^3]**	**Application date**
Limit value for health protection *	Hourly mean	200, no more than 175 h per year	Until December 31st 2009
Pollution peak		200 no more than 18 h per year	Since January 1st 2010
Limit value for health protection * **Background pollution**	Yearly mean	40	
Quality objective *			Since 2002
Information / recommendation threshold for population*	Hourly mean	200	
Alert threshold for population *		400	

**issue from Environmental Code*

BACKGROUND POLLUTION

The annual concentrations of NO_2 over MPM area since 2006 are reported in figure 3. The concentration at three of seven sampling sites exceeded the yearly limit value for 2009 (42 µg/m^3), mainly due to highly traffic influence (sites of “Timone”, “Rabatau” and “Plombières”). The highest yearly mean is recorded at “Marseille Plombières” site with 83µg/m^3. For middle size cities, as Marignane or for some Marseille districts, the limit value was not exceeded.

POLLUTION PEAK

NO_2 maximal hourly concentrations over MPM area since 2006 are reported in figure 4. The hourly limit values (210µg/m^3 in 2009 and 200µg/m^3 in 2010) are exceeded for 2 of 6 sampling sites in 2009. Both sites are traffic stations (“Marseille Plombières” and “Marseille Rabatau”). NO_2 maximal hourly value is 356µg/m^3 at “Marseille Plombières” site. In 2009, the hourly limit value of 200µg/m^3 has been exceeded 20 times at this station. These excesses are mainly associated to stable meteorological conditions, frequently during winter, without wind and a thermal inversion, leading to pollutant accumulation.

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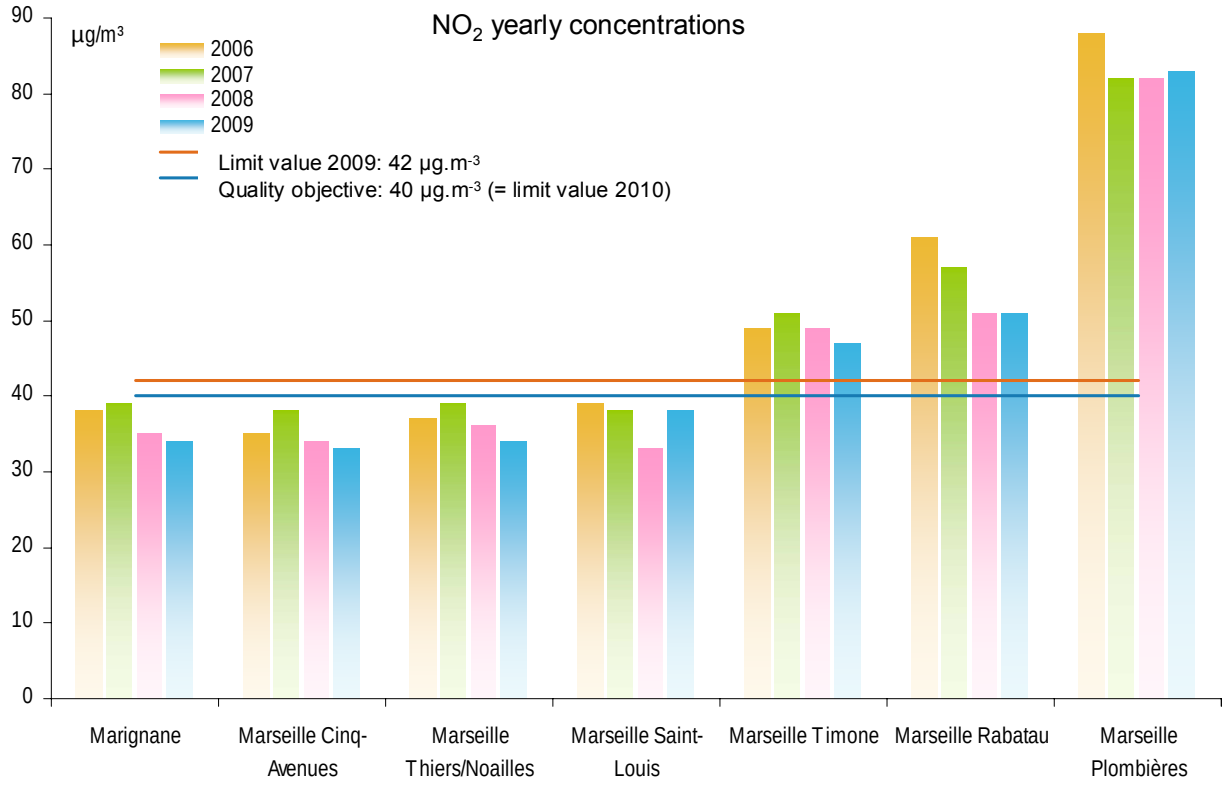

Figure 4: Yearly concentrations of NO_2 over MPM area since 2006

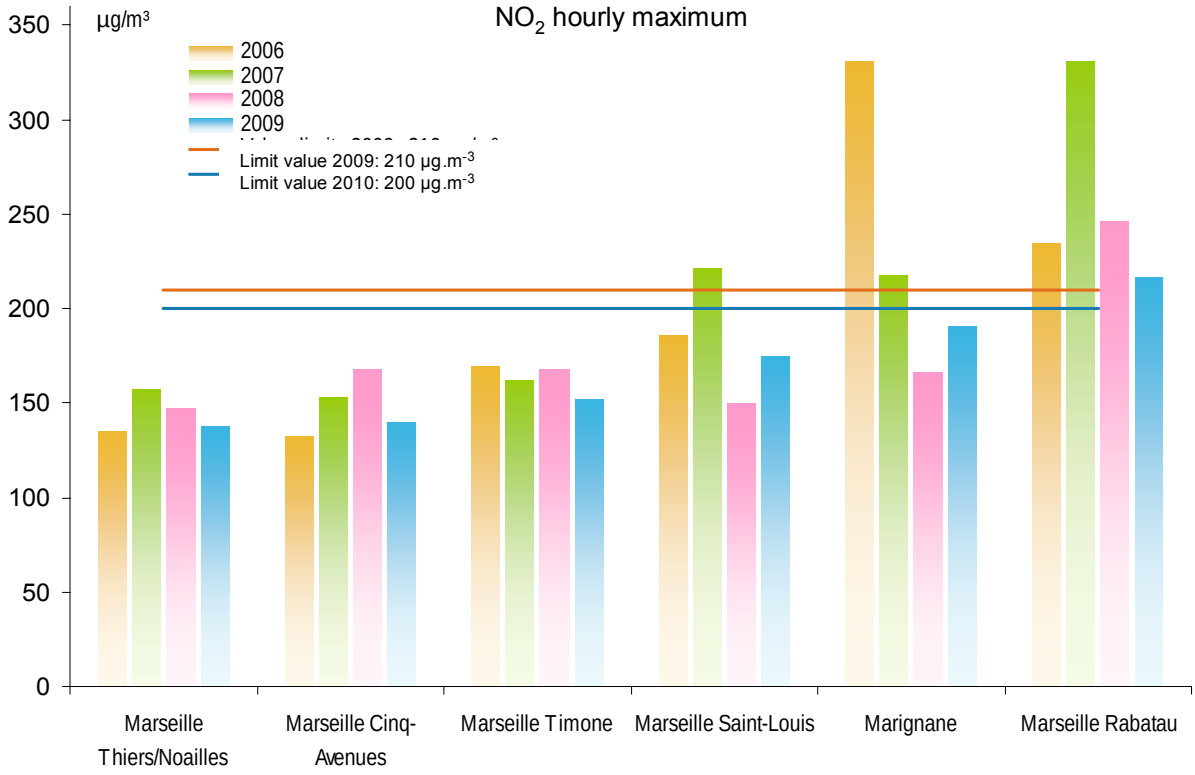

Figure 5: Maximal hourly concentrations of NO_2 over MPM area since 2006

Marseille city mapping, inside MPM, has been realized in 2005, from the report of studies over Marseille between 2001 and 2005 (figure 6). Pollutant emissions, sampling campaigns, soil occupation and meteorological data are considered for the geostatistic modeling, allowing a view of the mean pollution for each district. Deterministic modeling tools will give results with a smaller spatial and temporal resolution.

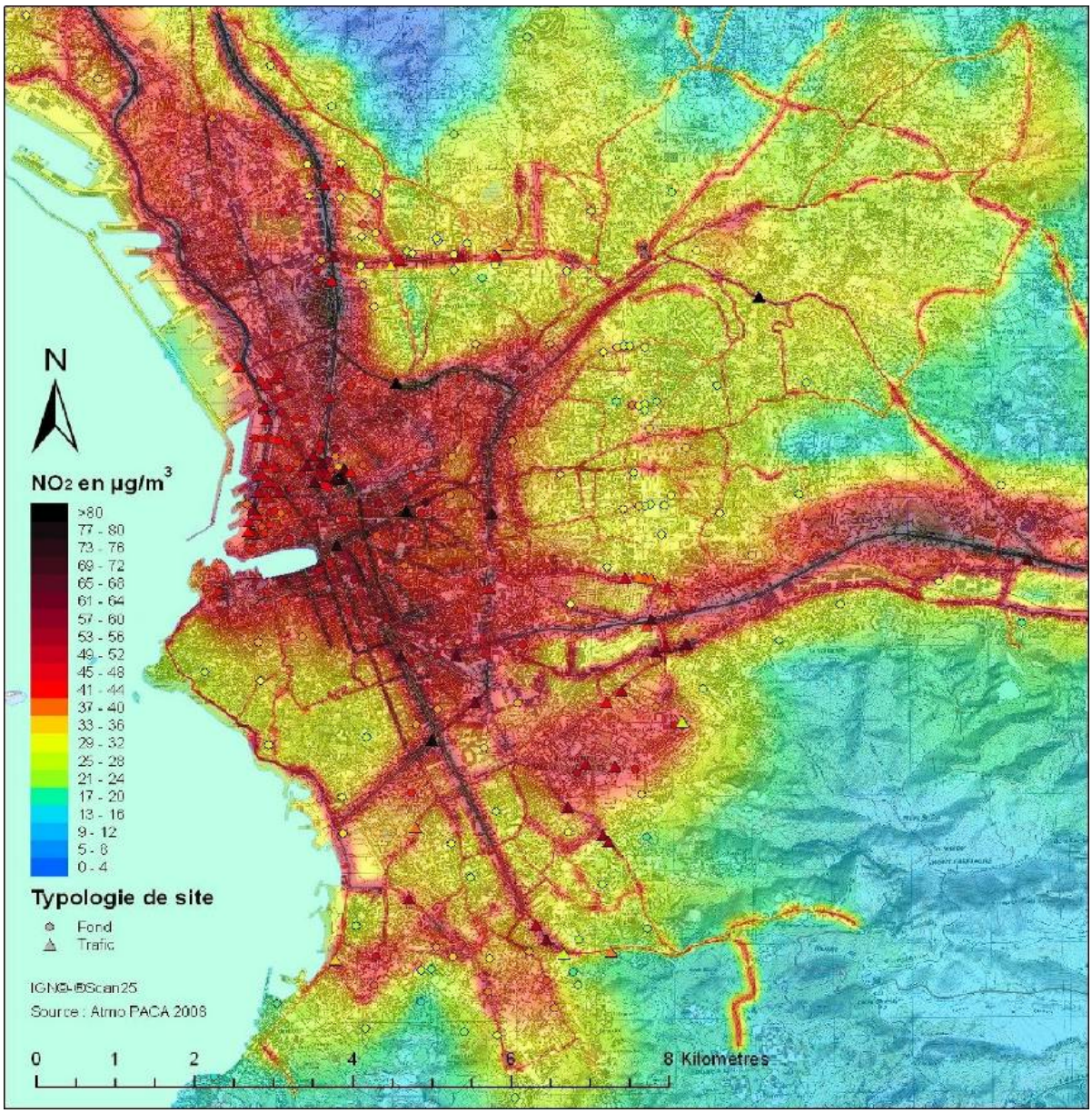

Figure 6: Pollution map of nitrogen dioxide in 2005 over Marseille.

LOCAL PROCEDURE FOR POPULATION INFORMATION - RECOMMENDATION

The local procedure starts when two stations over an area, with at least one background station, exceed the threshold value of 200µg/m^3/h. There are two areas over MPM: Marseille and its suburb ("Marseille agglomeration") and the eastern part of Berre pond ("Est étang de Berre"). Since May 21st, 2007, any local procedure for population information-

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recommendation has been started. The table 5 reports the whole of local procedures for population information-recommendation over MPM area since 2003.

Table 16 : Local procedure for population information-recommendation over MPM area since 2003

	2003	2006	2007
Marseille	July 11th and August 4th	January 11th	May 21st
Berre pond		January 11th	

SULFUR DIOXIDE (SO_2)

Sulphur dioxide is a gas mainly issues from industries and thermal plants. It mainly comes from fuel-oil and coal combustion after to have been oxidized to give SO_2. Sulphur dioxide is the main tracer for industrial pollution. Table 6 presents the reference and limit values to be applied for SO_2.

Table 17: SO_2 reference and limit values

Threshold type	**Time scale**	**Value [µg/m^3]**
Limit value for health protection *	Hourly mean	350, no more than 24 h per year
Pollution peak	Daily mean	125, no more than 3 days per year
Quality objective *	Yearly mean	50
Information / recommendation threshold for population*	Hourly mean	300
Alert threshold for population *	Hourly mean exceeded during 3 h	500

** Issue from Environmental Code*

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BACKROUND POLLUTION

The SO_2 yearly concentrations over MPM area since 2006 are reported in figure 6. In 2009, the concentration in the whole of sampling sites is lower than the quality objective (50µg/m^3). The highest yearly value is 9µg/m^3 for the "Sausset-les-Pins" site. Due to petrochemical activities and industrial emissions, the highest concentrations are recorded at sampling sites close to Berre pond border. SO_2 mean levels are stable and much lower than quality objective.

POLLUTION PEAK

The maximal hourly concentrations of SO_2 over MPM area since 2006 are reported in figure 7. Among 6 stations, only the "Châteauneuf-la-Mède" station records an hourly maximum higher than the limit value of 350µg/m^3, with 678µg/m^3. These peaks of SO_2 are due to fallout of industrial pollutant plumes. This limit value has not to be exceeded more than 24 hours per year.

Figure 8 reports the number of hours equal or higher than 350µg/m^3 over MPM area since 2006. For 2008 and 2009, all sampling sites respect the hourly limit value (24 hours). "Châteauneuf-la-Mède" station had exceeded this threshold of 350µg/m^3/h, six times in 2007.

Compared to 2007, the number of excess of 350µg/m^3 shows a great decrease with a number much lower than 24 hours. The daily limit value is also respected.

In 2009, no event has led to a local procedure for population information-recommendation over MPM area.

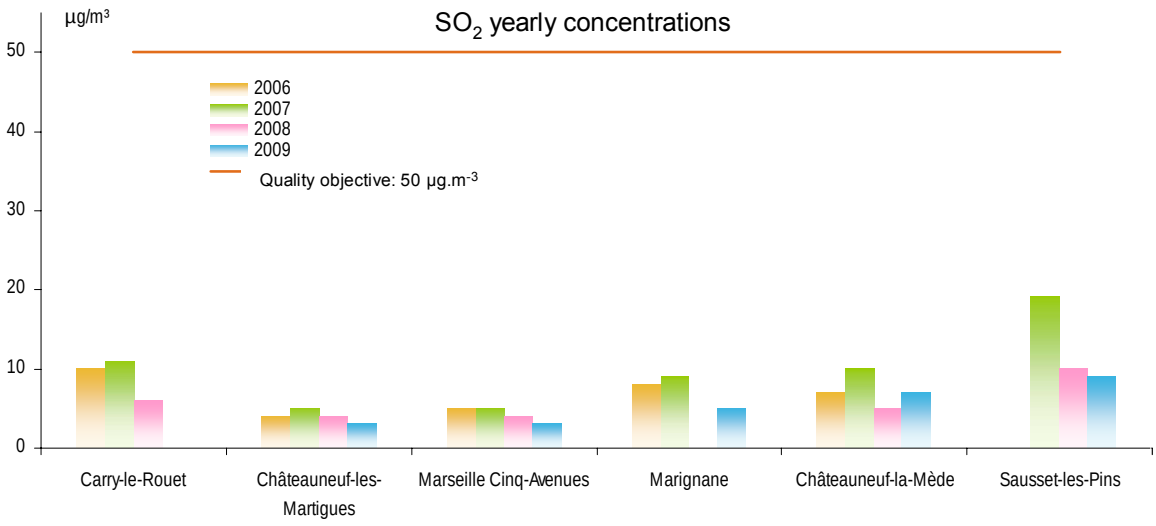

Figure 7: Yearly concentrations of SO_2 over MPM area since 2006.

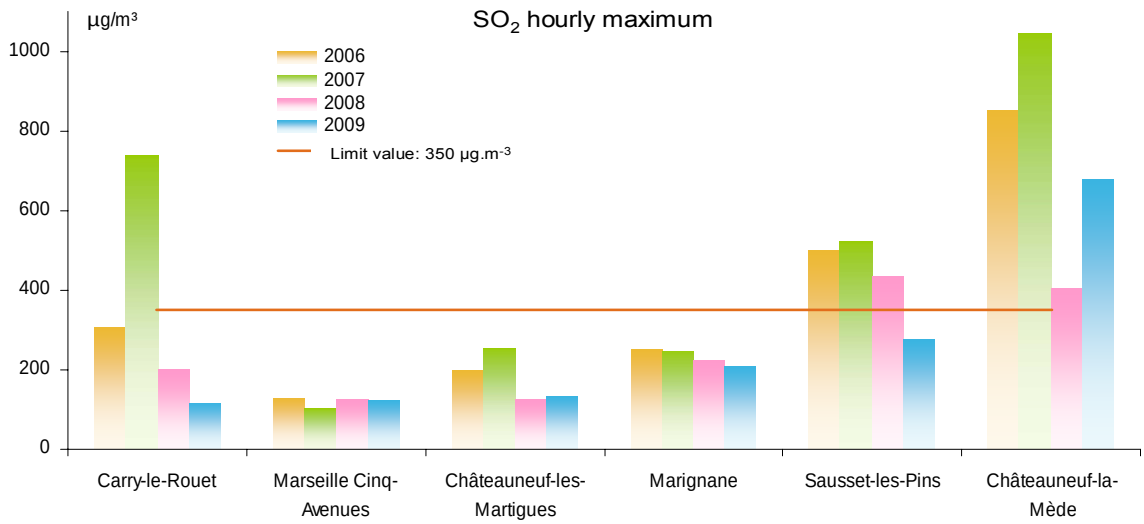

Figure 8: maximal hourly concentrations of SO_2 over MPM area since 2006

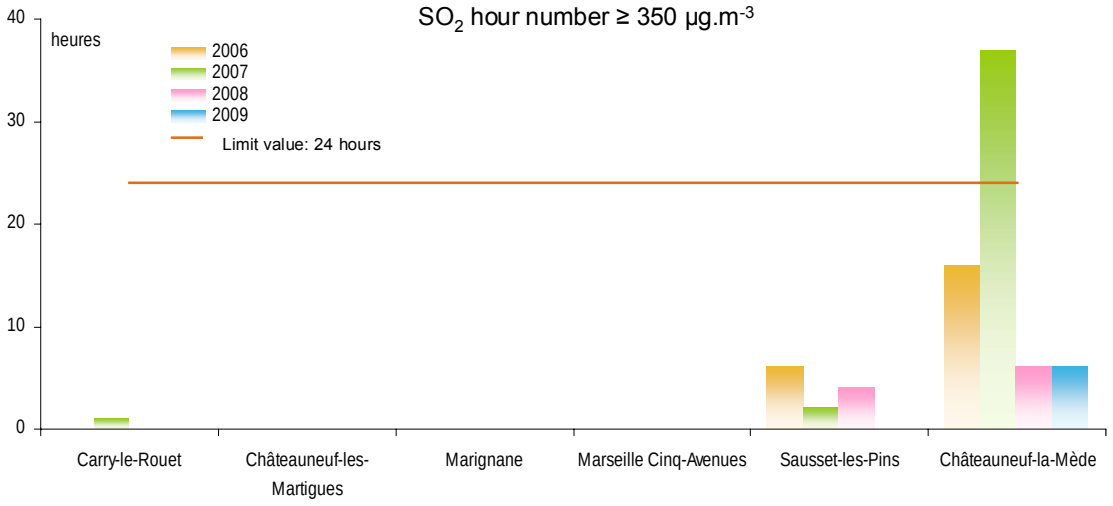

Figure 9: Hour number with a SO_2 concentration equal or higher than 350µg*m-3 over MPM area since 2006.

DECREASES OF SULFURIC EMISSIONS

STERNES (Temporal system normative and regulation framework for sulphuric emissions) is a system allowing a limitation of SO_2 emissions for the western part of department (Ouest des Bouches-du-Rhône). During forecasting or recording pollution events, STERNES system starting constrains industrial companies to respect some emission values. There are two levels:

Global STERNES: started the day before for the next day, when meteorological forecasts lead to a pollution event over the whole of Berre pond border,

Local directional or forecast STERNES: started by a report or a forecast of industrial plume fallout over cites.

Some details of different STERNES systems are reported in table 7. As reported in table 8, only one Global STERNES has been started in 2009 over MPM area, and any Directional STERNES.

Table 18 : Procedures of sulphuric emissions decreases

STERNES systems	**Global**	**Directional with forecast**	**Directional with report**	**Directional preventive**
Objective	To limit global pollution	To limit local pollution peak		
Based on	Meteorological forecasts		Measure > 350 µg/m^3/h + unfavorable wind direction	Measure > 600 µg/m^3/h
Industrial warning	6 h before	8 h before	After 5 min	
Period	12 h and more	5 h	3 h	From 3 to 5.5 h
Starting	Manual	Automatic		
Since	1991	summer 2009	1997	

Table 19 : Review of STERNES since 2003 to 2009 over AIRFOBEP survey area

	Global STERNES		Directional STERNES	
	Starting number	**Total hours**	**Starting number**	**Total hours**
2003	0	0	121	518 h 30
2004	1	21	115	443 h 15
2005	6	192	54	212 h 15
2006	7	168	84	347 h 75
2007	7	192	52	236 h 45
2008	6	168	20	85 h 45
2009	1	48	13	62 h 15

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OZONE (O_3)

Troposheric ozone is a secondary pollutant, issue from chemical transformation of NO_x and VOC, due to the solar action. This transformation leads to formation of gases named photochemical. Troposheric ozone is a tracer of this photochemical pollution. Table 9 presents the reference and limit values to be applied for O_3.

Table 9: O_3 reference and limit values

Threshold type	Calculation	Value [µg/m^3]	Application date
Objective value* **Background pollution**	8h moving mean	120, no more than 25 days per year with a mea nover 3 years	Since January 1st, 2010
Quality objective**	8h mean	120	Since 2002
Limit value for information-recommendation *	Hourly mean	180	
Warning limit value to start emergency plan**	Higher hourly mean during 3h	1er seuil : 240	
		2ème seuil : 300	
	Hourly mean	3ème seuil : 360	

issue from European Directive about ozone inside ambiant air, ** issue from law 2007-1479 dated October 12th, 2007, * issue from Environmental Code, **** issue from law 2003-1085 dated November 12th, 2003.*

BACKGROUND POLLUTION

Background levels for ozone since 2006 over MPM area are reported in figure 12. In 2009, all the sampling stations over MPM area, except for one, exceeded the limit value during more than 25 days. “Marseille Cinq-Avenues” sampling station reaches the quality objective: as the reactions between ozone and nitrogen oxides from traffic are very quick, ozone concentrations are lower at the city centre.

POLLUTION PEAK

The figure 11 compares maximal hourly concentrations recorded during 2008 and 2009 to the ones recorded during the 8 last years (from 2000 to 2007), for MPM sampling sites. The number of peaks during 2009 is higher than that during 2008, but lower than during the period 2000-2007. The maximum hourly value over MPM is recorded at "Sausset-les-Pins" sampling station (250 µg/m^3), quite higher than the limit value for information-recommendation of population (180 µg/m^3). During 2003 heat wave, at the same station an hourly maximal level of 417µg/m^3 was recorded.

Figure 12 shows the duration of the periods where ozone levels were equal or higher than the limit value for information-recommendation over MPM area since 2006. The sampling site of "Sausset-les-Pins", has the highest number of hourly excess in 2009 (46 hours). Figure 13 shows as an illustration, the classical movement of an air mass polluted with ozone, during a 4-hour period, on the August 7th, 2009.

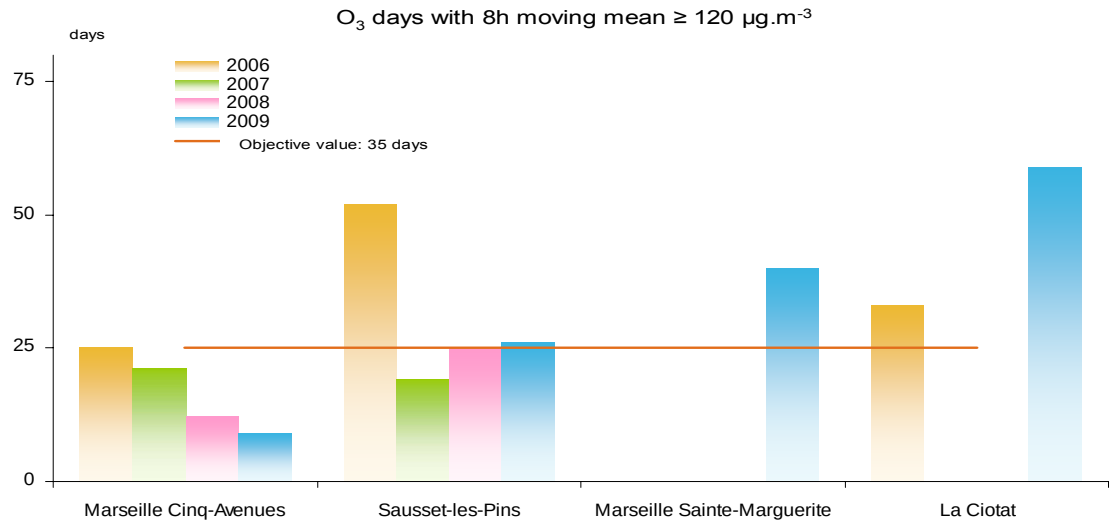

Figure 10: Background levels for O_3 over MPM area since 2006 calculated as the day number with an 8h moving mean equal or higher than 120µg.m^{-3}.

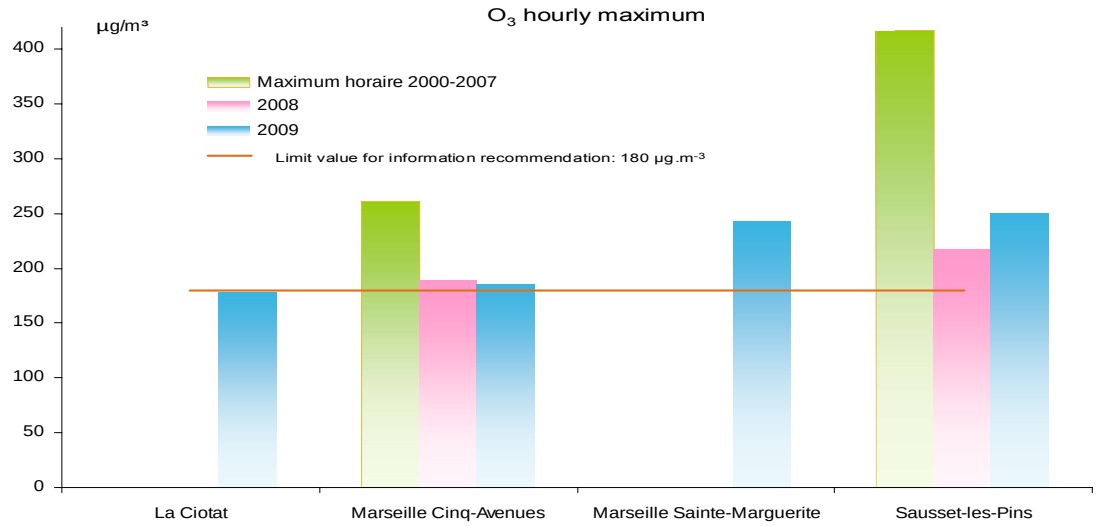

Figure 11: Maximal hourly concentrations recorded during 2008 and 2009 and during 2000-2007 period over MPM area.

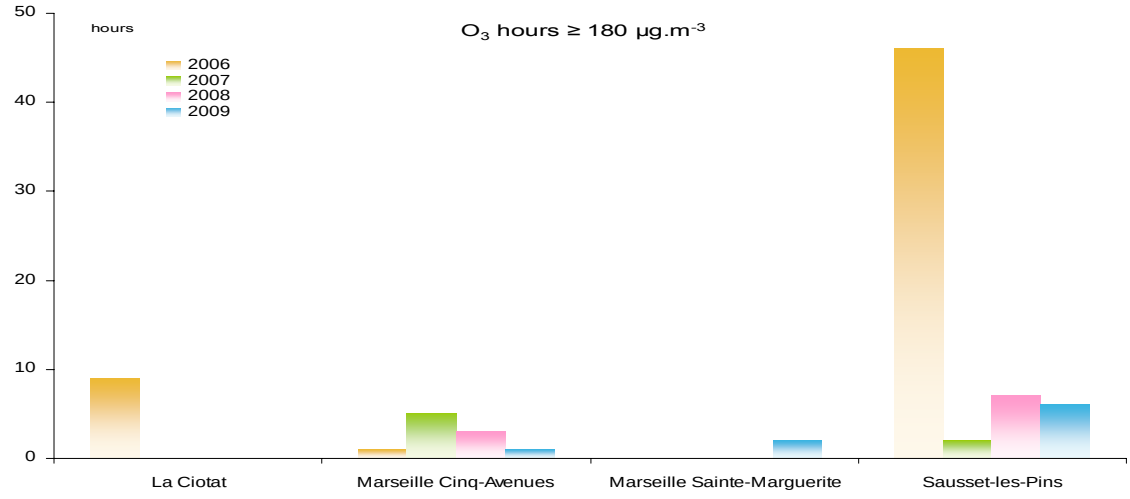

Figure 12: Hour number with O_3 concentrations equal or higher than 180µg.m^{-3} over MPM area since 2006.

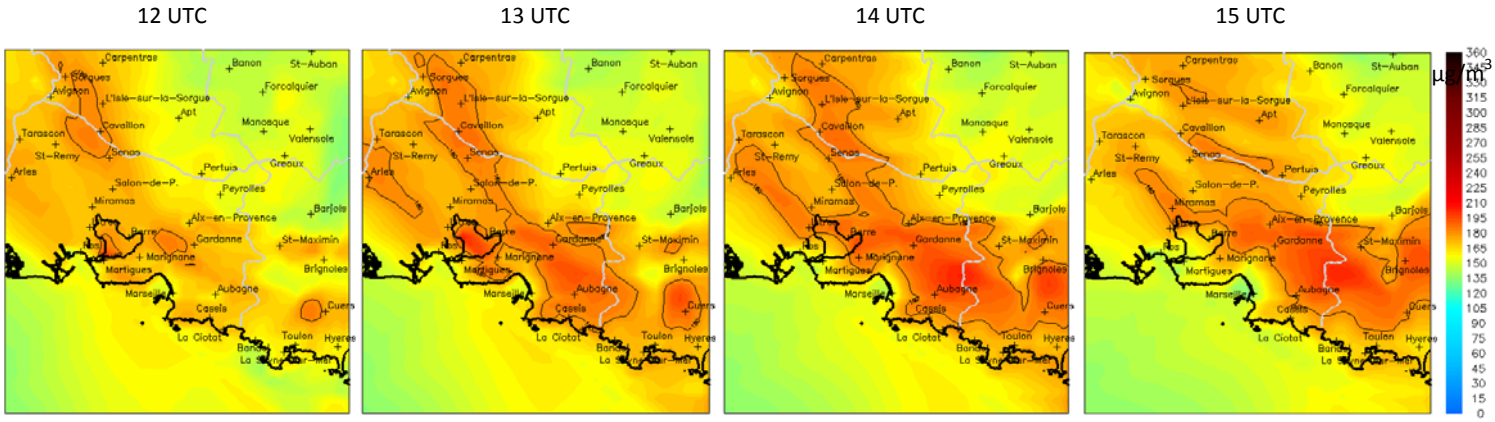

Figure 13: Illustration of movement of an air mass polluted with ozone during 4 h, August 7th, 2009.

PREFECTURAL PROCEDURE FOR POPULATION INFORMATION - RECOMMENDATION

Table 10 presents the number of days with ozone excesses (higher than 180µg/m^3/h) for towns inside MPM area. During the last three years, the number of days with a procedure of information-recommendation is significantly lower than during 2006. Meteorological conditions during summer were not sufficiently hot and dry to lead to a high ozone production. In case of an emergency plan, State requires decreases of ozone precursor emissions (VOC, NOx) for all emission sources (i.e. industries, transports). In 2009, departmental emergency plans have been applied for 18 days. MPM area has been involved in for 5 days, that is to say 30 % of information procedures, during upwind of ozone precursor emissions (western breeze).

Table 10: Review of days with an ozone excess over MPM area since 2006.

	2006	**2007**	**2008**	**2009**
Number of days with a prefectural procedure for population	35	21	19	18

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information-recommendation over Bouches-du-Rhône department				
Number of days with at least one excess of 180 µg/m^3/h over MPM area	20	4	8	5

SUSPENDED PARTICLES / PARTICLE MATTER (PM10 and PM2.5)

Suspended particles have both natural and anthropogenic origin. Human activities, as uncompleted combustion of fossil fuel, transport, agriculture and some industrial sectors as metallurgy lead to large emissions of particles. Elevated particles levels are found inside cities (with a major automobile influence inside heavy urban areas) and industrial areas. A part of these particles, named secondary, are formed in atmosphere by chemical reactions from precursor pollutants (as sulphuric and nitrogen oxide, VOC). PM10 are particles with a mean aerodynamic diameter lower than 10 µm and PM2.5 are "fine" particles with a mean aerodynamic diameter lower than 2.5 µm. Table 11 presents the reference and limit values to be applied for PM.

Table 11: PM reference and limit values

Threshold type		**Calculation**	**Value [µg/m^3]**
PM10	Limit value for heath protection* Pollution peak	Daily mean	50, no more than 35 days per year
	Limit value for heath protection* Background pollution	Annual mean	40
	Quality objective*		30
	Limit value for information-recommendation of population **	24h moving mean at 8h and 14h	80
	Limit value for warning population **		125
PM2,5	OMS recommended value	Yearly mean	10
	Value issue from French Environment Project		15

	Objective value***		25

issue from Environmental Code, **issue from Circular dated October 12th, 2007 and * value since January 1st, 2010 issue from European Directive of May 2008.*

Since January 1st, 2007, a –national- adjusted device for particulate matter sampling allows the measurement of particles' volatile part. By using this device, a global increase (of about 30%) of particulate matter levels overall French area has been recorded. This increase is due to *a better sampling of fine particles* and not to a significant decrease of air quality. In the following graphs, data for 2006 does not represent the volatile part. Since 2007, data have received this adjustment and are compared to the emit values.

PM10

BACKGROUND POLLUTION

As reported in the previous paragraph, PM_{10} adjustment has led to an increase of the yearly mean levels (from 12 to 37 %, according to the sampling site). The highest increase has been recorded at "Marignane" station. For the other stations close to Berre pond border, the increase was between 12 and 26 %. At the national scale, the increase was between 27 and 35 %. The yearly PM10 concentrations since 2006 are reported in figure 14 for MPM area. The traffic site of "Marseille Timone" exceeded the annual limit value of 40µg/m^3. In supplement to the traffic influence, excavation and building activities since 2009 have led to intense particles emission close to the station. In particular, a significant increase was noticed between 2008 (33 µg/m^3) and 2009 (41µg/m^3) levels. At the other sites, the recorded values were higher than the quality objective (30µg/m^3) except for one station, named "Marseille Cinq-Avenues" with annual mean value 29µg/m^3.

POLLUTION PEAK

Maximum daily PM10 concentrations recorded over MPM area since 2006 are reported in figure 15. For 2009, all stations recorded values higher the than the daily limit value (as for the three last years). For sampling site named "Marseille Timone", daily level reached 149µg/m^3 at the July 22nd, 2009, due to dust emissions by surrounding works, in addition to traffic emissions.

Figure 16 shows the number of days (since 2006) with a daily level equal or higher than 50µg/m^3, over MPM area. In 2009, the daily limit value (50 µg/m^3, and no more than 35 days

per year with an excess) was not reached nether at “Marseille Timone” nor at «Marseille Saint-Louis” sampling stations, during a period of 81 and 57 days respectively. Excavation and building works took place inside Saint-Louis district also.

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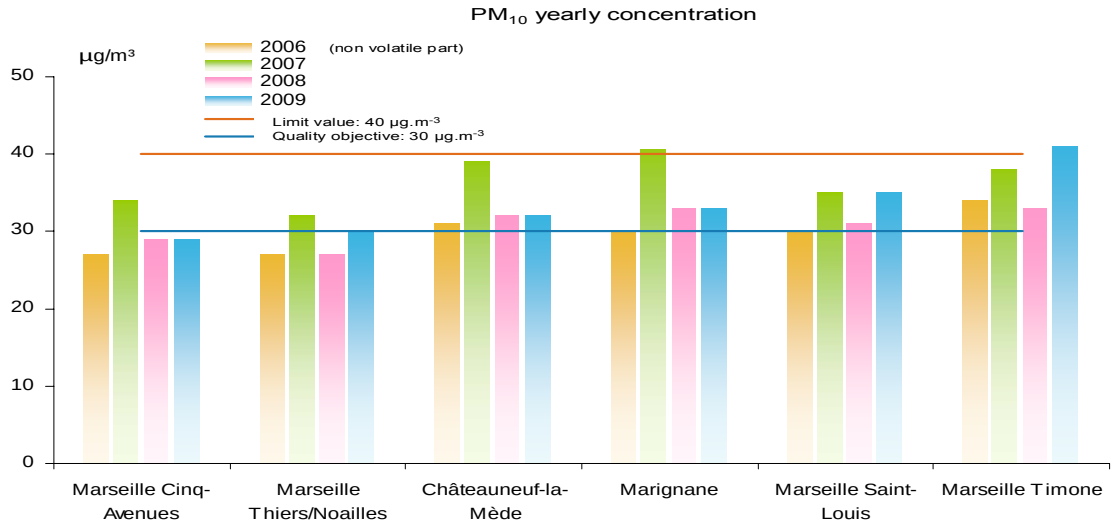

Figure 14: Yearly concentrations of PM10 over MPM area since 2006.

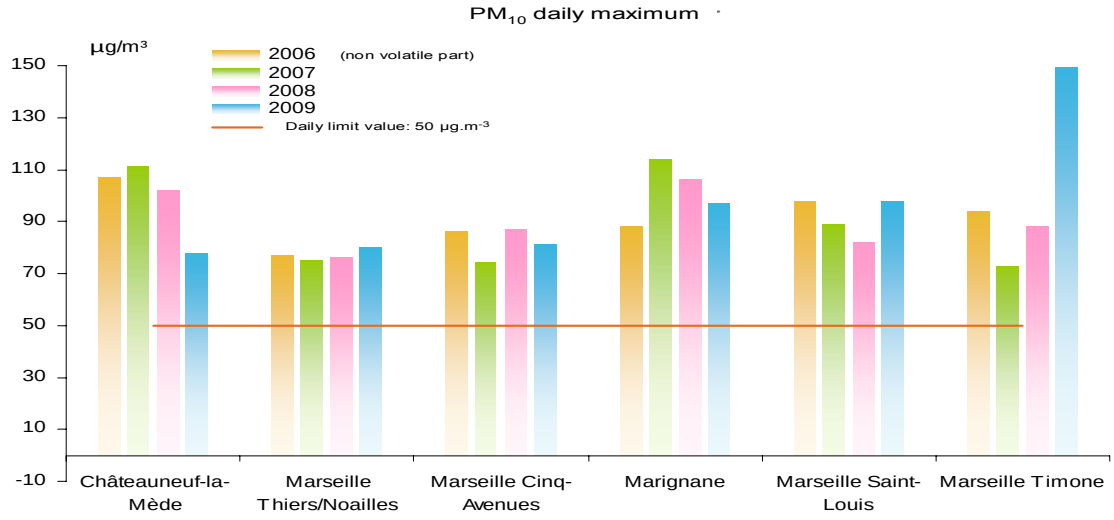

Figure 15: Maximum daily concentrations of PM10 over MPM area since 2006.

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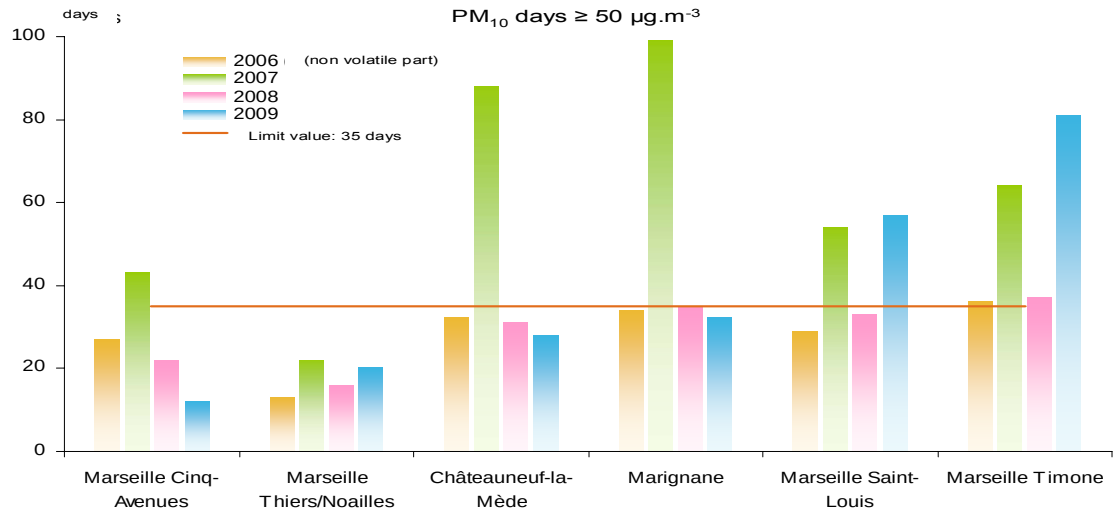

Figure 16: Day number with a daily PM10 equal or higher than 50µg.m^{-3} over MPM area since 2006.

PM2.5

PM2.5 sampling network is currently developed to consider the volatile part. The annual level recorded in 2009 at "Marseille Cinq -Avenue" sampling site, is lower than the objective value of 25µg/m^3 (20µg/m^3 in 2008 and 17µg/m^3 in 2009). The same objective is reached at "Rognac" sampling station (annual level 22 µg/m^3 in 2008 and 23µg/m^3 in 2009). However, at these stations the recorded levels were higher than both OMS recommended value (10µg/m^3) and value issue from French Environment Project (15µg/m^3).

HEAVY METALS

Heavy metals are found in ambient air as components of suspended particles. Some of them, as mercury, are also found as gases. Since the use of lead fuels stopped (2000), immobile sources are the main sources of metals in ambient air. They are emitted by manufacturing industries, iron and non iron industries (Cadmium, Arsenic), petrol combustion installations (Nickel, Arsenic) and incinerators (Nickel). Table 12 presents the reference and limit values to be applied for some heavy metals.

Table 202: Heavy metals reference and limit values

Threshold type			Calculation	Value (in ng/m^3)
Background	Limit value*	Lead (Pb)	Yearly mean	500
	Quality objective*			250
	Objective value**	Arsenic (As)		6
		Cadmium (Cd)		5
		Nickel (Ni)		20

**issue from Environmental Code and ** issue from 2004/107/CE European Directive*

HEAVY METALS LEVELS AT BERRE POND BORDER

Since 2007, AIRFOBEP manages two heavy metals sampling sites: Berre-l'Étang and Fos-sur-Mer. A third has been equipped in 2009 at Arles. As, Cd, Ni and Pb mean annual concentrations are lower than the limit values for these three sites (table 13).

Table 213: As, Cd, Ni and Pb yearly concentrations at 3 sites in 2009

2009 yearly means	Cd	Ni	Pb	As
Arles	0,11	1,93	4,84	0,49
Berre-l'Étang	0,18	4,28	5,12	0,36
Fos-sur-Mer	0,25	4,57	6,46	0,70

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HEAVY METALS LEVELS AT MARSEILLE "SAINT-LUIS" SAMPLING SITE

Pb, Cd, Ni and As measurements were conducted in the northern part of Marseille, in an urban environment, close to a catenaries industry. Measurements started at May 1999, in the framework of a national driver program, coordinated by ADEME and LCSQA in collaboration with CEREGE. Measurements of copper (Cu), chromium (Cr), barium (Ba) and manganese (Mn) have been added since 2007 for a more complete picture.

Just after the Cu/Cd industry closing in September 1999, Cd levels have significantly decreased at "Saint-Louis" sampling site (267ng/m^3 in 1999 and 10ng/m^3 in 2000). This decrease was continued during the next years. From 2001, the annual mean concentration (2.3ng/m^3) was lower than the European objective value (5ng/m^3). Since 2004, the Cd mean concentration is close to Marseille's background level where there is not an industrial influence (from 0.2 to 0.8ng/m^3). In 2009, the annual mean concentration was 0.2ng/m^3. For Pb, Ni (since 2000) and As, annual concentrations did not exceed the limit values.

Table 224: Heavy metals annual concentrations at Marseille Saint-Louis sampling site since 1999

Year	**Heavy metal concentration (ng/m^3)**							
	Cd	**Cu**	**Ni**	**Pb**	**As**	**Cr**	**Ba**	**Mn**
1999	267	46	23	29	/	/	/	/
2004 (April to October)	0,7	/	8,1	14	0,5	/	/	/
2005 (march to December)	0,4	/	6	11	0,5	/	/	/
2006 (except July and August)	0,4	/	4,7	12,8	0,5	/	/	/
2007	0,8	/	4,9	12,8	0,5	2,6	8,8	8,5
2008	0,2	/	3,2	7	0,3	2,2	5,4	5,1
2009	0,2	/	3,5	5,3	0,2	/	6,2	4,2

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POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

PAH emissions mainly originate from (2002 data):

Residential / tertiary sector (37 % of total emissions for metropolitan France),

Road transports (32 %, mainly diesel vehicular),

Manufacturing industries (22 %, mainly the metallurgy of iron metals).

Others sectors have a poor or no contribution for emission of these pollutants. The 96/62/CE European Directive (dated from September 27th, 1996) about *the evaluation and management of ambient air quality*, plans an obligation to measure PAH. Table 15 reports the reference and limit values to be applied for PAHs.

Three stations provide continuous measurements of PAHs over Bouches-du-Rhône department: “Martigues Lavéra” (industrial), “Marseille Cinq-Avenues” (urban), since January 2009 and “Arles Boulevard des Lices” (urban) since February 2009. PAHs levels at these stations are reported in table 16.

Finally, studies in a national scale have shown high concentrations close to roads, but finally note that some industries can also lead to increase PAHs concentrations

Table 15: PAH reference and limit values

Reference threshold for BaP		**Yearly concentrations (in ng/m^3)**
Objective value*		1
Exposition limit value**	**Daily measures**	0,7
Quality objective**		0,1

**issue from 2004/107/CE European Directive (listing a minimum of 7 compounds to measure) and **from the Upper Committee for Public Hygiene of France*

Table 16: PAH levels over three sampling sites.

	Martigues	**Marseille**	**Arles**
Phenantrene	0,11	/	0,13
Anthracene	0,02	/	0,01
Fluoranthene	0,25	/	0,16
Pyrene	0,24	/	0,18
Benzo(a)anthracene*	0,20	0,21	0,11
Chrysene	0,28	0,33	0,19
Benzo(b)fluoranthene* + Benzo(j)fluoranthene*	0,33	0,58	0,27
Benzo(k)fluoranthene*	0,17	0,16	0,10
Benzo(a)pyrene*	0,13	0,25	0,15
Dibenzo(a,h)anthracene* + Benzo(g,h,i)perylene	0,18	0,3	0,15
Indeno(1,2,3,cd)pyrene*	0,26	0,27	0,17

**7 minimum compounds to measure*

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BENZENE

Benzene is among the most important volatile organic compounds (VOCs), regarding its connection with adverse health effects. The main sources of benzene in ambient air are: combustion gases from vehicles, evaporation during storage and distribution of fuel and emissions from industries using benzene as synthesis intermediate product (plastic production, pesticide, solvent, etc). At the regional scale, more than 80% of the benzene emissions come from traffic emissions. At the scale of Berre pond border, about 50% of emissions come from refining and petrochemical activities. Table 17 presents the reference and limit values to be applied for benzene.

Figure 17 shows the yearly concentrations since 2006 over MPM area for benzene sampling sites, allowing an estimation of the background pollution of benzene in comparison with the yearly limit value (6µg/m^3 in 2009 and 5µg/m^3 in 2010) and the quality objective (2µg/m^3).

In 2009, all sampling stations over MPM area had an annual mean level lower than the limit value (6µg/m^3). Quality objective (2µg/m^3) was not reached at traffic stations located at the city centre. For a comparison, the maximum mean (4,4µg/m^3) for 2009 is recorded at sampling site "Vallée de l'Huveaune" due to the existence of an industrial source nearby. Benzene concentrations are higher close to heavy traffic roads and close to industrial sites.

Table 17: Benzene reference and limit values

Threshold type	**Calculation**	**Value [µg/m^3]**	**Application date**
Limit value for health protection* **Pollution peak**	Yearly mean	5	Since January 1st, 2010
Quality objective*		2	Since 2002

**issue from law 2002-213 dated February 15th, 2002 from Environmental Code.*

PRELIMINARY MONITORING CAMPAIGN IN FOS HARBOR AREA

During 2004-2005, a study conducted by AIRFOBEP, included measurements of different pollutants inside the harbor area. The levels of nitrogen dioxide, carbon monoxide, lead, arsenic, cadmium and nickel respected the limit values thanks to well-ventilated areas, decreasing pollutant accumulation in air. However, some excesses of values have been recorded for benzene, ozone and sulphur dioxide. The most significant excess has been recorded for the particulate matter issues from fossil fuel used by ships and industries. More details can be found on:

http://www.airfobep.org/docs/2004-2005%20rapport%20PAM_BR.pdf/

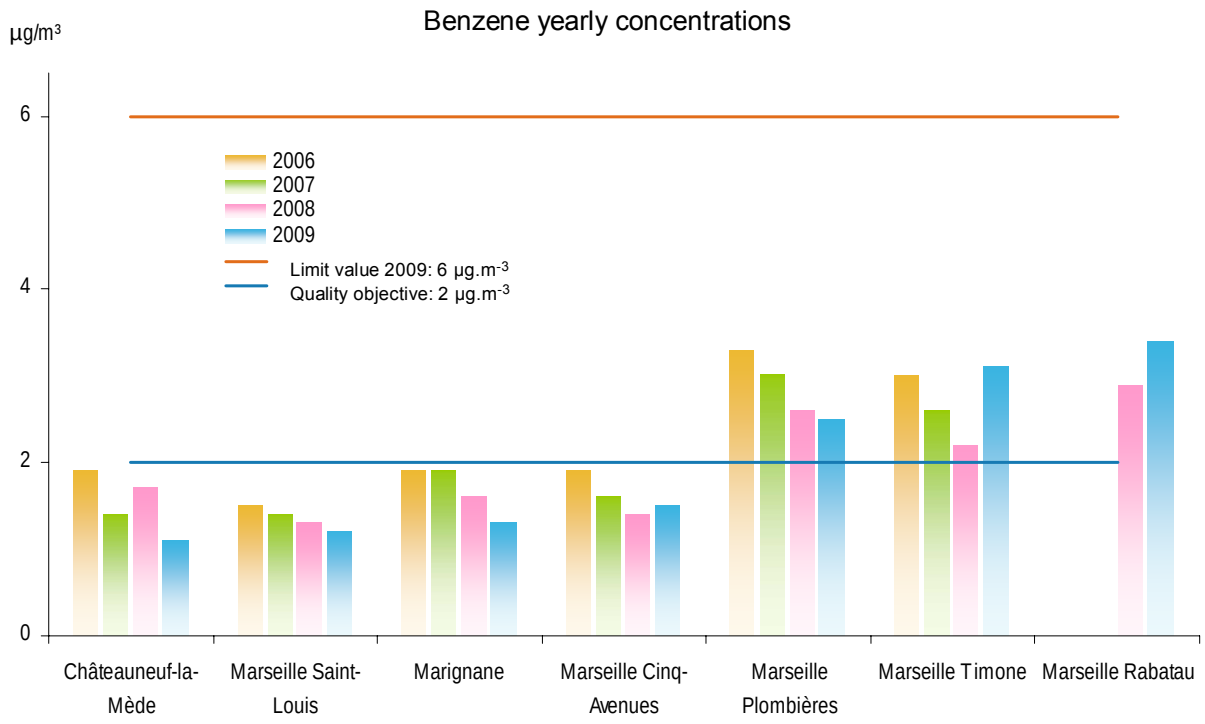

Figure 13 : Yearly concentrations of benzene over MPM area since 2006.

5.2 METEOROLOGICAL PARAMETERS

Wind roses (wind speed to wind direction) were created from data of three all meteorological stations close to the harbor for the year 2009 (figure 18). The wind pattern of the threse areas (Marseille, Martigues, and Marignane) presents similarities: the highest values of wind speed often correspond to north-western and south-eastern winds. At Marseille and Marignane stations, low wind speed values were also noticed, corresponding to wind of north-east and south-east direction respectively. Similar wind patterns are shown by the rose-diagrams created from Meteo-France database, for the years 2000-2007 (figures 19 and 20).

Temperature and relative humidity at Marseille during 2009 are reported in figure 21 and 22 respectively. Maximum temperature values were noticed during summer months, as expected while relative humidity presented a variation during all year. Figure 23 reports the monthly precipitation at Marseille, calculated for the period 1971-2000. As noticed, the

maximum value for precipitation corresponded to October. The minimum precipitation was noticed during summer period and especially July.

To have a view of specific pathways followed by air masses -arriving and departing from Marseille- figure 24 shows the probability distribution functions of back-trajectories and trajectories during summer 1998 and 1999.

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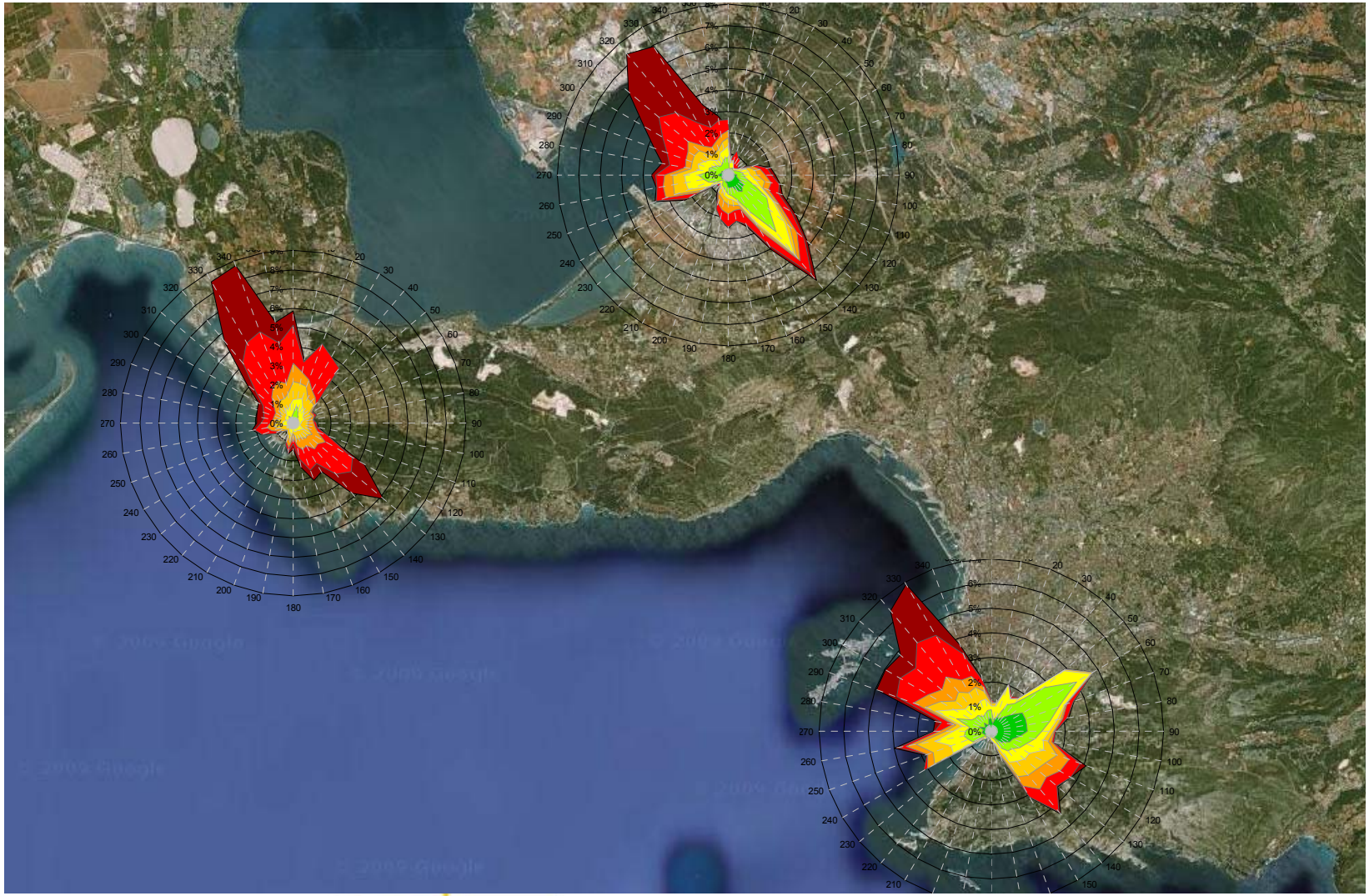

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Wind-roses at Marseille, Marignane and Martigues in 2009 from database of meteorological stations Figure 14 : Wind-rose at Marseille from Meteo-France database

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METEO FRANCE

ROSE DES VENTS

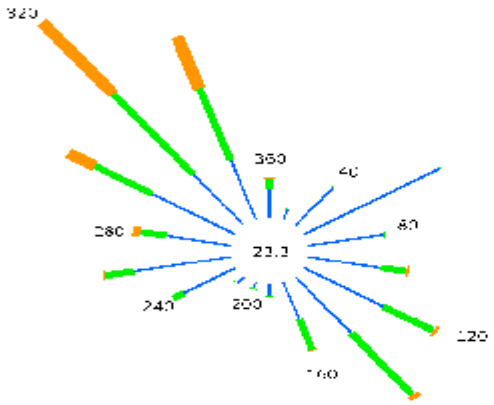
Vent horaire à 10 mètres, moyenné sur 10 mn

Du 01 JANVIER 2000 au 31 DÉCEMBRE 2007

MARSEILLE (13)

Indicatif : 13055025, alt : 5 m., lat : 43°15'18"N, lon : 05°22'48"E

Fréquence des vents en fonction de leur provenance en %



Valeurs trihoraires entre 0h00 et 21h00, heure UTC

Tableau de répartition
Nombre de cas étudiés : 22779
Manquants : 597

Dir.	[1.5;4.5 [	[4.5;8.0]	> 8.0 m/s	Total
20	0.5	+	0.0	0.5
40	2.3	+	0.0	2.3
60	6.1	+	+	6.2
80	3.0	0.1	+	3.1
100	2.8	1.0	0.1	4.0
120	3.6	2.2	0.2	6.0
140	3.4	3.7	0.2	7.3
160	1.8	1.5	+	3.4
180	0.5	+	0.0	0.6
200	0.2	+	+	0.3
220	0.4	+	+	0.4
240	2.3	0.5	0.0	2.8
260	3.8	1.2	+	5.1
280	2.6	1.0	0.3	3.9
300	3.8	2.6	1.2	7.5
320	3.1	4.9	4.4	12.3
340	2.9	3.5	2.6	9.0
360	1.3	0.5	+	1.9
Total	44.5	23.0	9.2	76.7
[0;1.5 [				23.3

Groupes de vitesses (m/s)

Pourcentage par direction

Dir. : Direction d'où vient le vent en rose de 360° : 90° = Est, 180° = Sud, 270° = Ouest, 360° = Nord
le signe + indique une fréquence non nulle mais inférieure à 0.1%

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2 Bd Château Double 13098 AIX EN PROVENCE CEDEX 02
Tél. : 04 42 95 90 00 – Fax : 04 42 95 90 29

Figure 15 : Wind-rose at Marseille from Meteo-France database.

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METEO FRANCE

ROSE DES VENTS

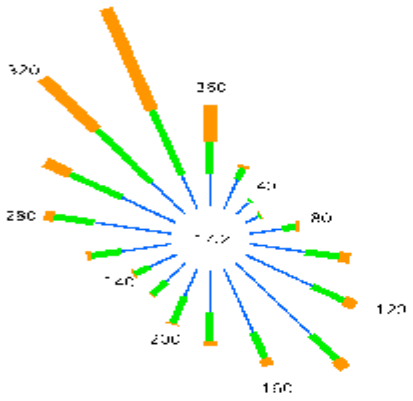
Vent horaire à 10 mètres, moyenné sur 10 mn

Du 01 JANVIER 1988 au 31 DÉCEMBRE 2007

MARIGNANE (13)

Indicatif : 13054001, alt : 5 m., lat : 43°26'30"N, lon : 05°13'36"E

Fréquence des vents en fonction de leur provenance en %



Valeurs trihoraires entre 0h00 et 21h00, heure UTC

Tableau de répartition
Nombre de cas étudiés : 58438
Manquants : 2

Dir.	[1.5;4.5 [	[4.5;8.0]	> 8.0 m/s	Total
20	1.7	0.6	0.2	2.5
40	0.8	0.1	+	1.0
60	0.7	+	+	0.8
80	1.4	0.6	0.2	2.2
100	2.4	1.5	0.5	4.4
120	3.3	1.6	0.5	5.5
140	5.0	1.7	0.6	7.3
160	3.6	1.5	0.4	5.5
180	2.2	1.6	0.3	4.1
200	1.6	1.5	+	3.2
220	1.3	0.9	+	2.2
240	1.3	0.7	+	2.1
260	2.2	1.3	0.2	3.7
280	3.4	1.8	0.4	5.5
300	2.7	2.5	1.2	6.5
320	2.2	3.7	3.6	9.5
340	1.9	3.7	5.8	11.4
360	1.7	1.7	2.0	5.5
Total	39.5	27.1	16.2	82.8
[0;1.5 [				17.2

Groupes de vitesses (m/s)

Pourcentage par direction

0% 5% 10%

Dir. : Direction d'où vient le vent en rose de 360° : 90° = Est, 180° = Sud, 270° = Ouest, 360° = Nord
le signe + indique une fréquence non nulle mais inférieure à 0.1%

Page 1/1

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Figure 16 : Wind-rose at Marignane from Meteo-France database.

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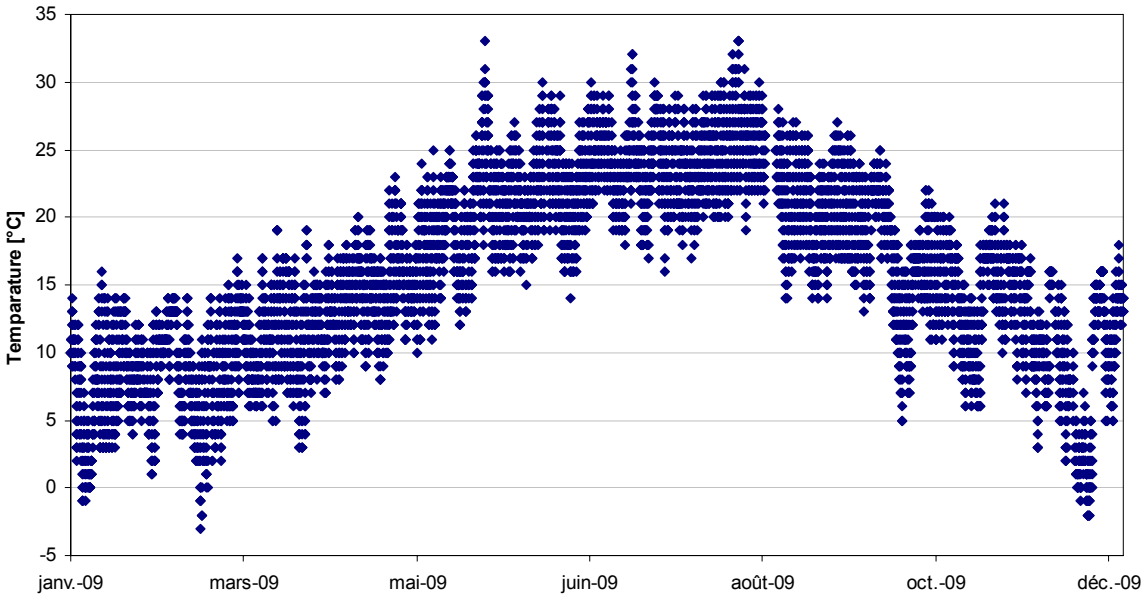


Figure 17 : Temperature at Marseille, year 2009

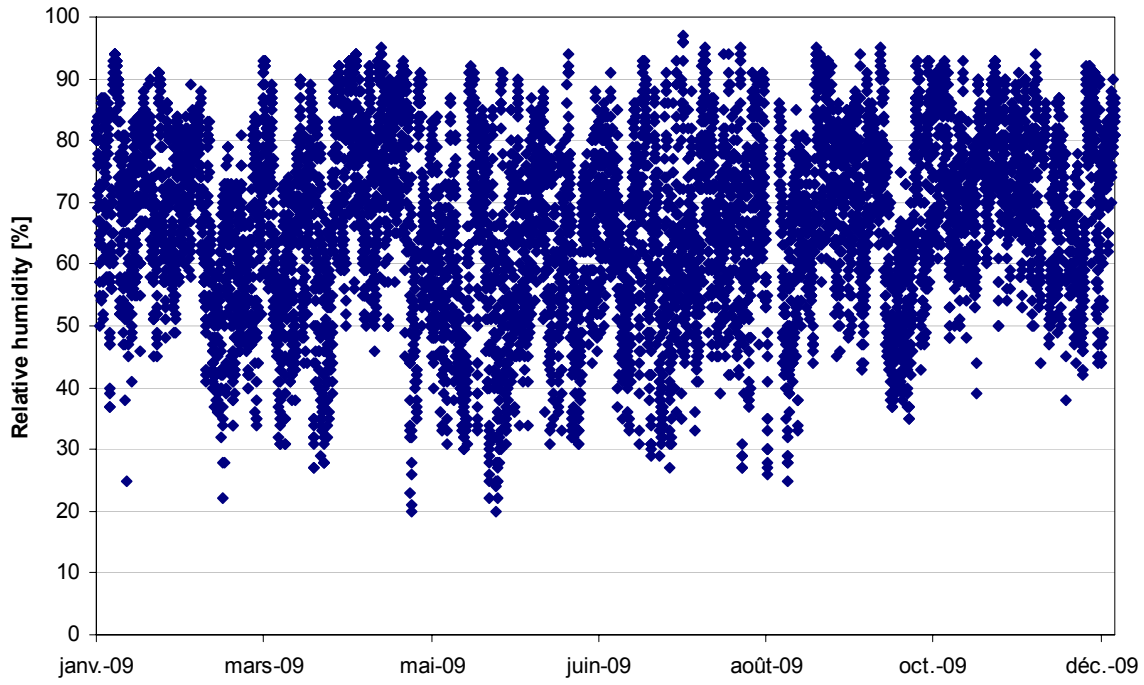


Figure 18 : Relative humidity at Marseille, year 2009

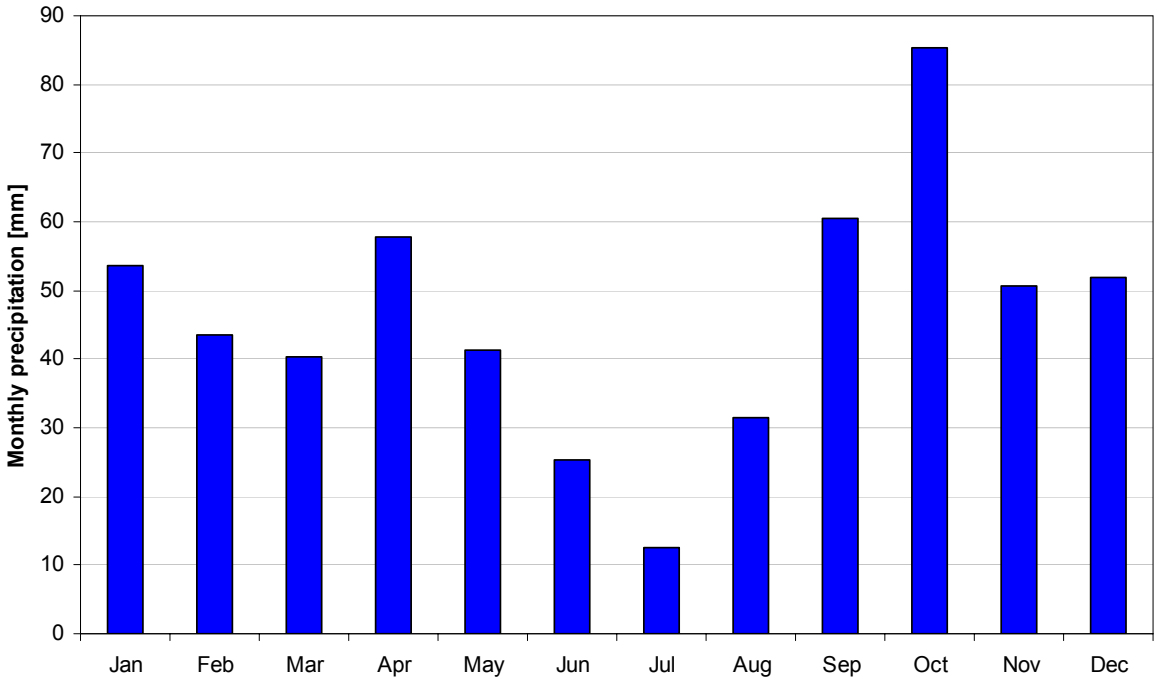


Figure 19 : Monthly precipitation at Marseille, mean 1971-2000 (annual mean: 554.6 mm)

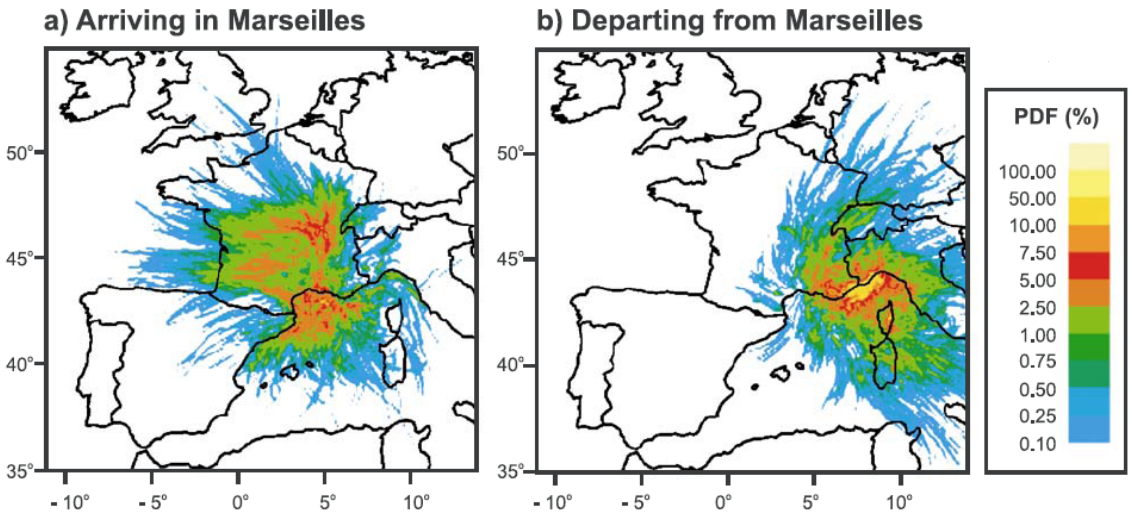


Figure 20 : Probability distribution function of air masses arriving at Marseille (back-trajectories) and departing from Marseille (trajectories) between June and July of 1998 and 1999, calculated by ALADIN model (Météo-France) (Cros et al., 2004).

6. ANALYSIS OF PM10 FOR YEAR 2009 FOR NEAR THE PORT STATION

In this section, an analysis of the air quality at "Marseille five Avenues" station is presented. This station was selected because of its closeness by the port and due to the immediate access to data. The location of **MARSEILLE FIVE AVENUES" station** is marked with an ''A'' red dot in the figure 25.

The available data from this station are shown in table1 in paragraph 4.1. The analysis is focused on PM10 particles which is one of the major pollutants that attract the scientific interest, as there is a proven connection with adverse health problems.

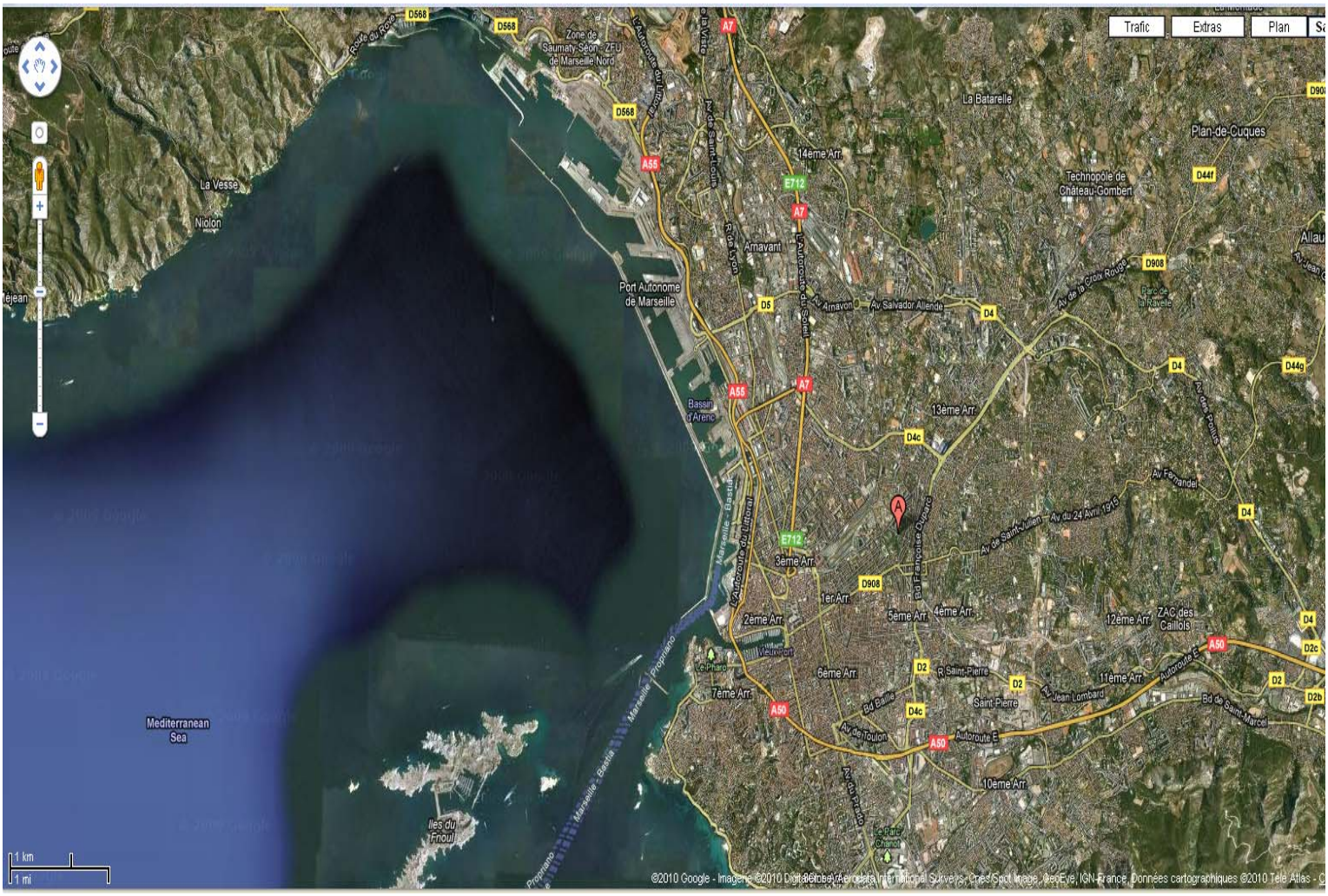


Figure 25: Location of MARSEILLE FIVE AVENUES" station marked with an ''A'' red dot

6.1 PM10 ANALYSIS

MONTHLY AVERAGES

A discussion for the monthly, daily, hourly variation of PM10 during 2009 follows. Furthermore, the correlation between meteorological conditions and PM10 levels is examined as well as the contribution of port activities to the air quality of Marseille.

The monthly variation of PM10 concentration for the year 2009 is presented in the figure 26. The maximum values correspond to January, July and August. During winter, the main sources that contribute to particles levels are the buildings' central heating and the bad operation of vehicle motors in starting because of the cold engine. During summer, chemical processes -connected with intense solar radiation- are responsible for secondary particles' formation. On the other side, the lowest values correspond to April, October and December. It is important to note that the factors that contribute to particles levels include permanent or seasonal sources. The meteorological pattern of each season plays a crucial role too; as a low dispersive atmosphere leads to particles levels increase while low pollution conditions can lead to significant levels' decrease.

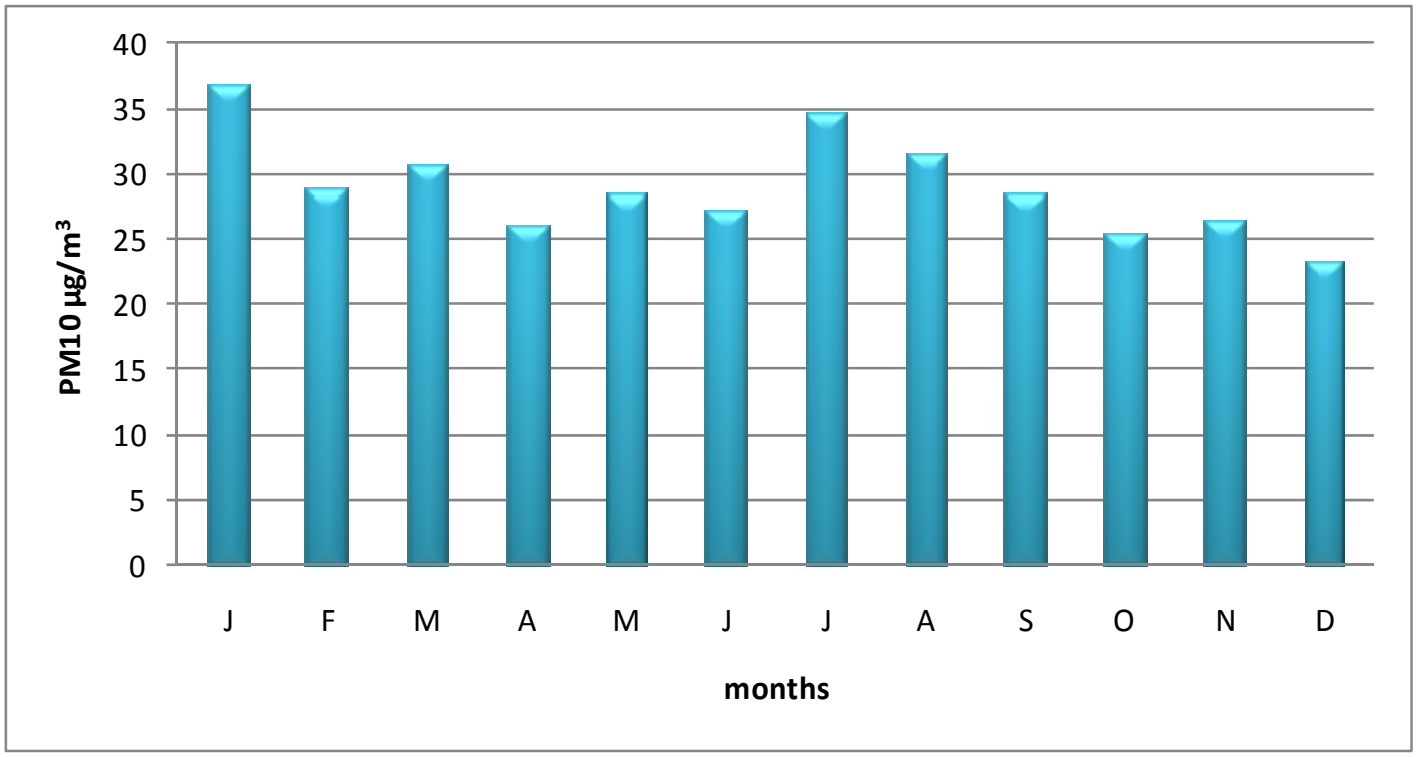


Figure 26: Monthly averages for year 2009 PM10 µg/m^3

EXCEEDED DAYS

The new Directive 2008/50/EC highlights that the limit of 50µg/m^3 should not be exceeded for more than 35 times per calendar year. From 01/01/2010, the limit is restricted to be 7 days per year. As noticed in the following figure, the measured concentration exceeded the limit in 14 days (three days in January, one day in February, five days in March, three days in July and two in November).

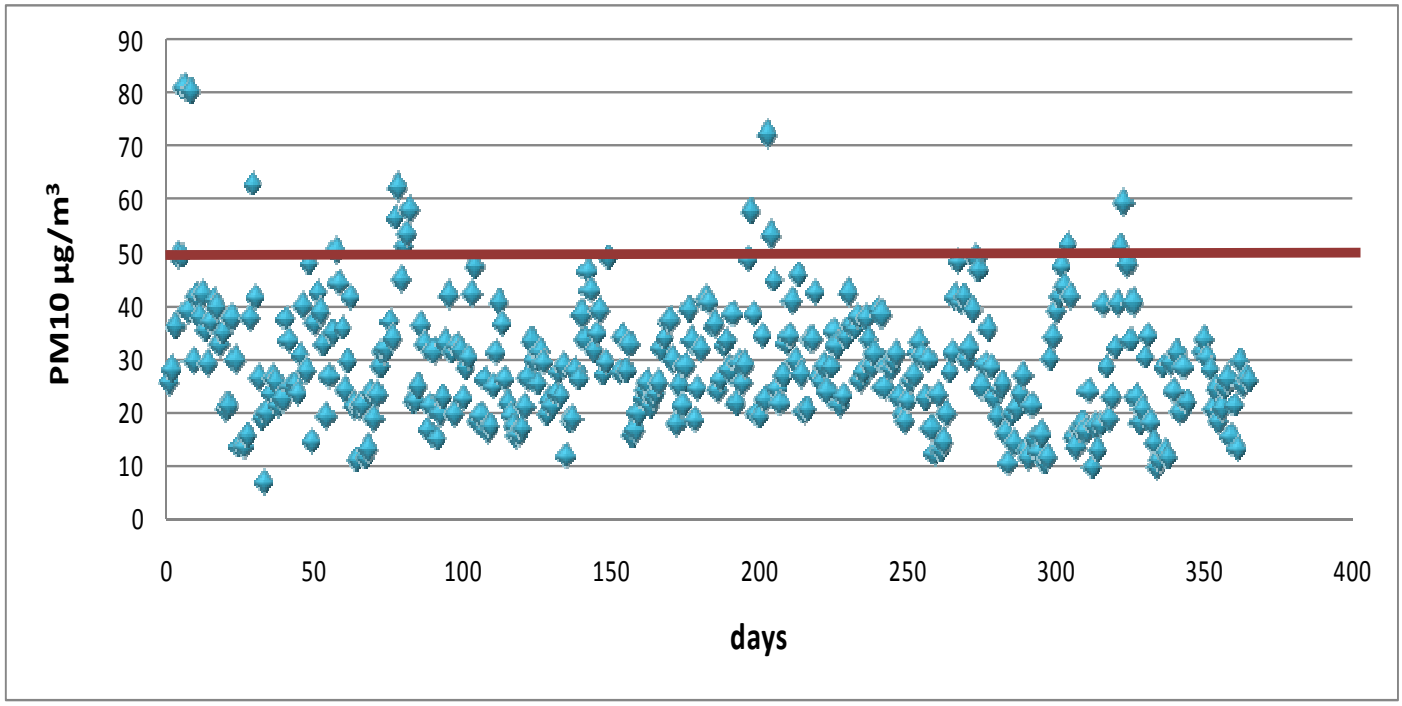


Figure 27: Exceeded days for year 2009 for PM10 µg/m^3

DAILY AVERAGES

The daily variation of PM10 concentration during 2009 is presented in the figure 28. The highest values are noticed during winter (January) and summer (July), as discussed in the previous paragraph.

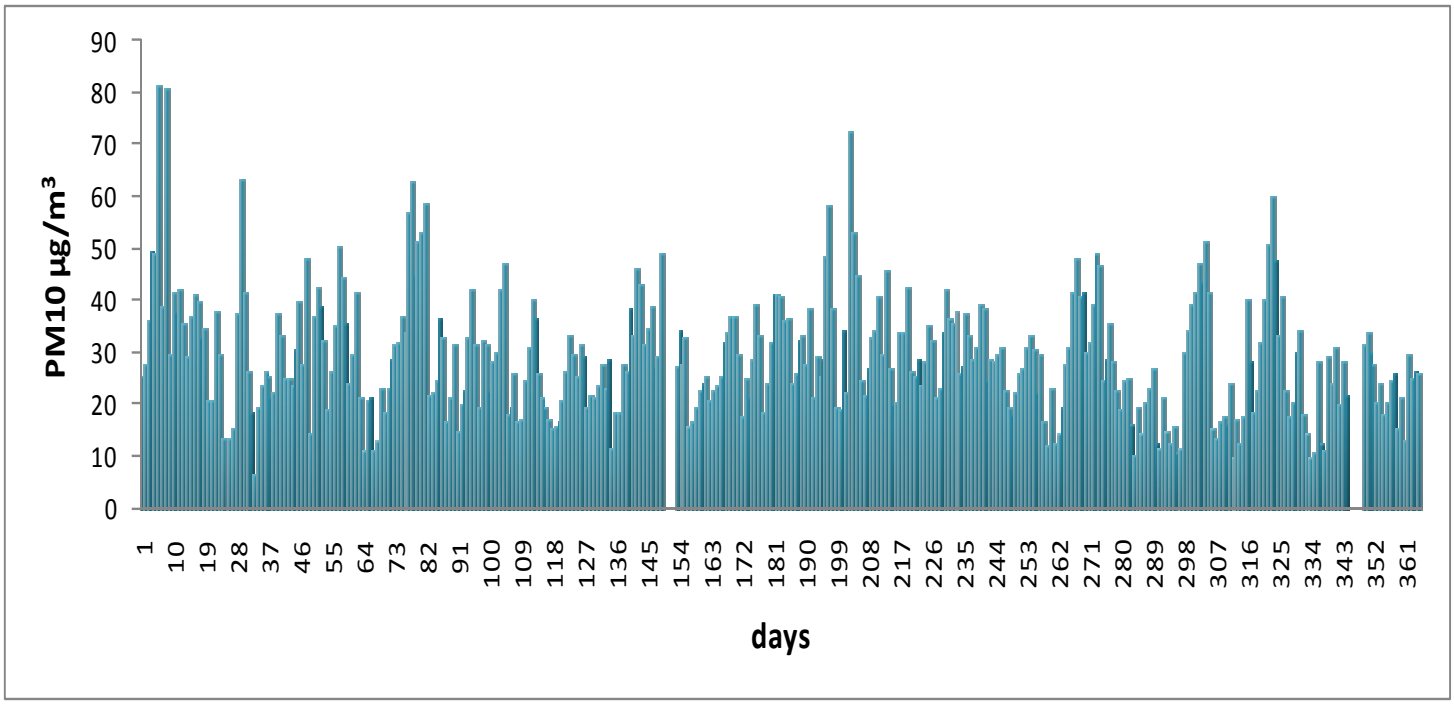


Figure 28: Daily averages for year 2009 PM10 µg/m³

AVERAGES PER DAY

The average PM10 concentration for each day of the week for the year 2009 is shown in figure 29. As it can be noticed, although there are not significant differences, concentration during weekends is lower, possibly because of the reduction of vehicles circulation and human activities.

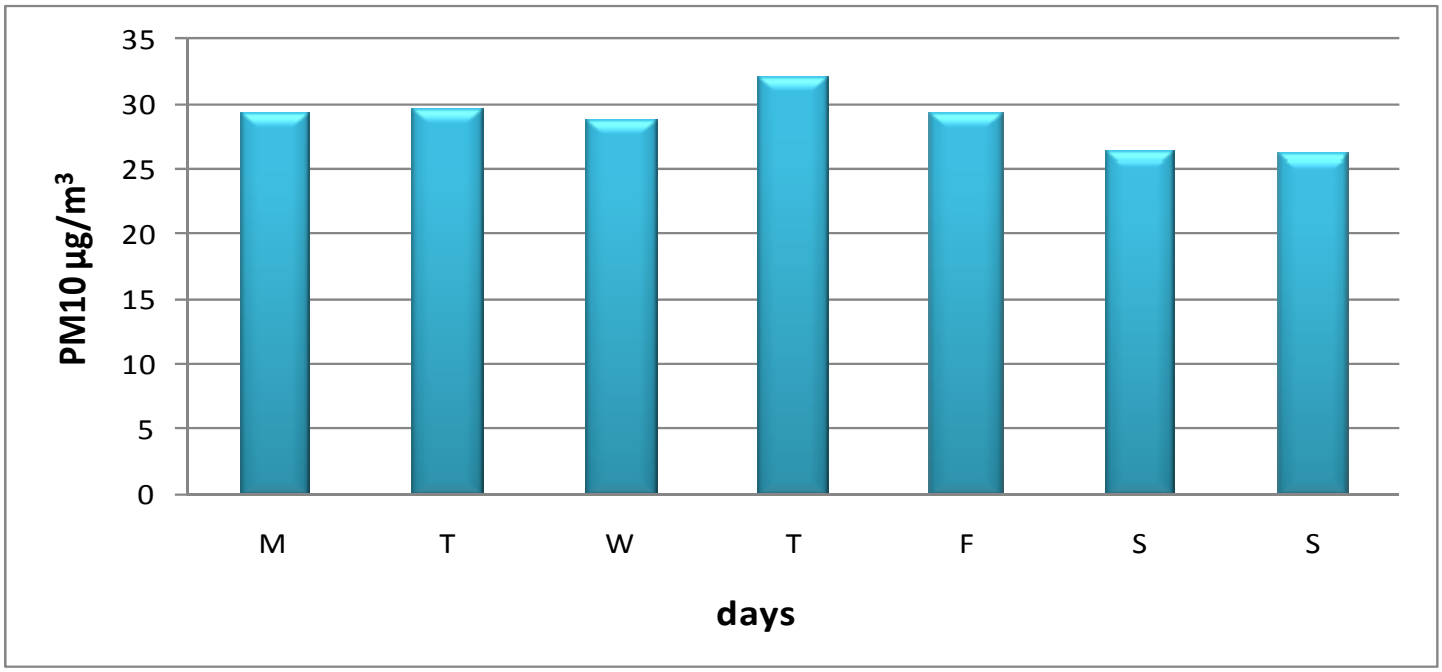


Figure 29: Averages per day for year 2009 PM10 µg/m³

HOURLY AVERAGES

Figure 30 presents the mean hourly (from 01:00 to 24:00) variation of PM10, for the year 2009. As it can be noticed, concentration levels increase during early morning hours, presenting a peak at 10-12am, possibly because of the intense vehicles circulation, central heating operation and human activities. Concentration levels during afternoon and night remain elevated as this time period is often characterized by prevailing favorable meteorological conditions for air pollutants accumulation.

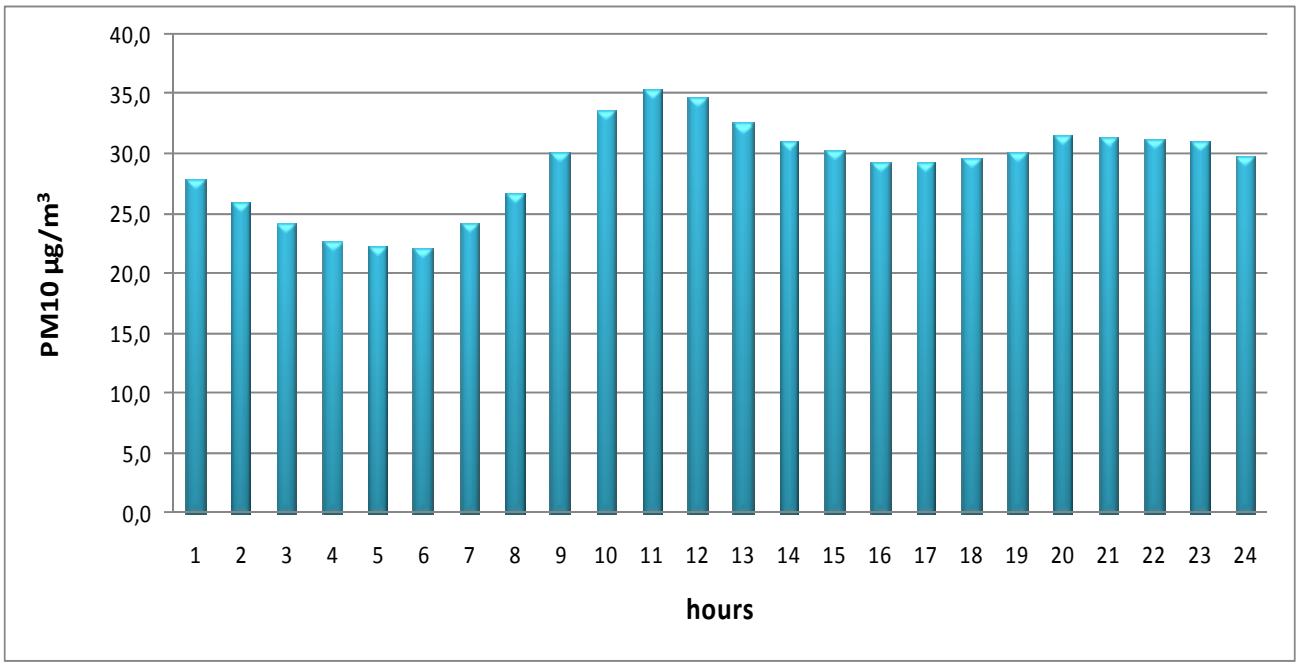


Figure 30: Hourly averages for year 2009 PM10 µg/m³

6.2 WIND ROSES

The meteorological parameters which can affect pollutants' levels in atmosphere are:

- Wind speed
- Wind direction
- Atmospheric stability
- Solar radiation
- Precipitation
- Humidity
- Temperature

WIND SPEED ROSE

Figure 31 presents the *wind speed-wind direction* rose-diagram for the year 2009. The diagram axis presents the frequency of the observed values of wind speed in % values.

Hourly data (in m/s and degrees respectively) were provided by ''Marseille'' meteorological station which is in the same region with ''Five Avenue'' station. As shown, maximum values (>8m/s) for wind speed were observed during periods with prevailing north-western wind and less often during periods with east-southeastern, eastern and east-northeastern winds. The lowest speed values (1-4 m/s) were observed with prevailing winds of all directions except for south-southwestern winds, which were rarely observed.

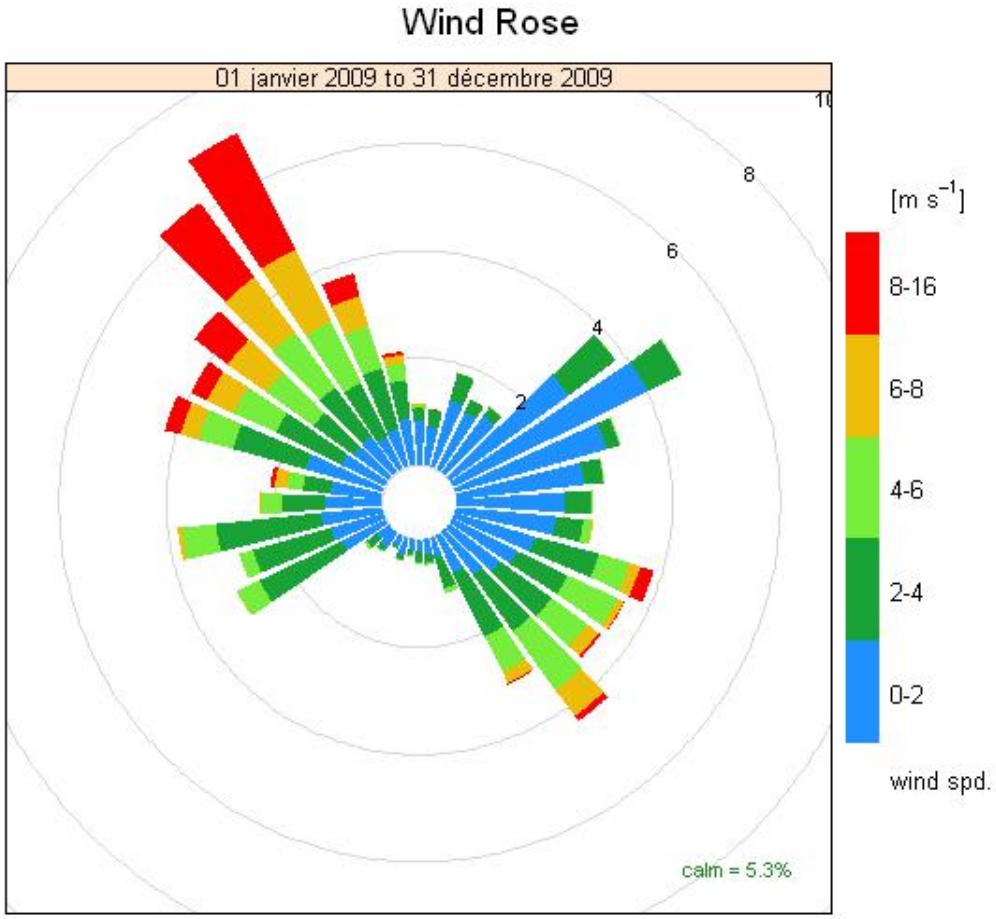


Figure 31: Wind speed rose for year 2009 (m/s, degrees)

Note: "calms" is wind speed lower than 1 m/s

PM10 ROSE

Figure 32 presents the PM10 hourly concentration (in μg/m^3)-*wind direction* (in degrees) rose-diagram for the year 2009. PM10 data were provided by "Five Avenues" station. The diagram axis presents the frequency of the observed values of PM10 concentration in %values.

As it can be noticed, maximum PM10 levels (> 50μg/m^3) were more often recorded during days with North-western, East-Northeast East and East-Southeast direction wind. The lowest PM10 values (< 1μg/m^3) were noticed during periods with prevailing north-western winds.

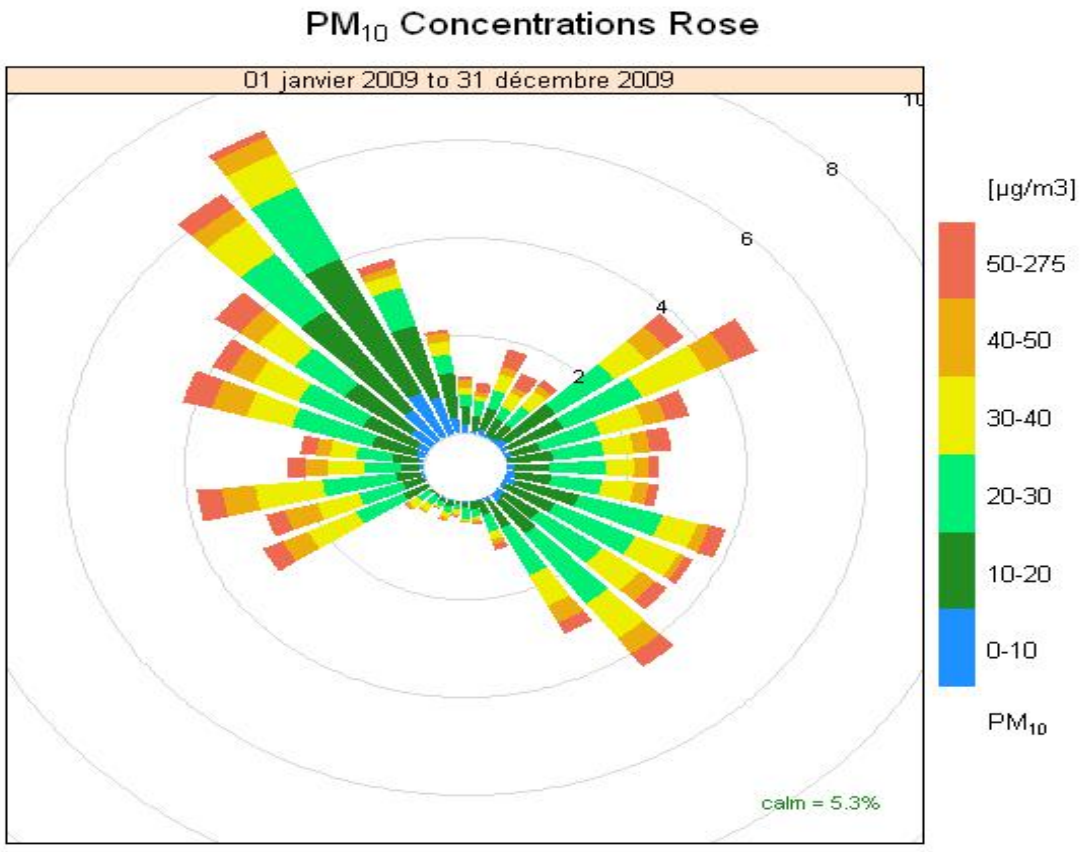
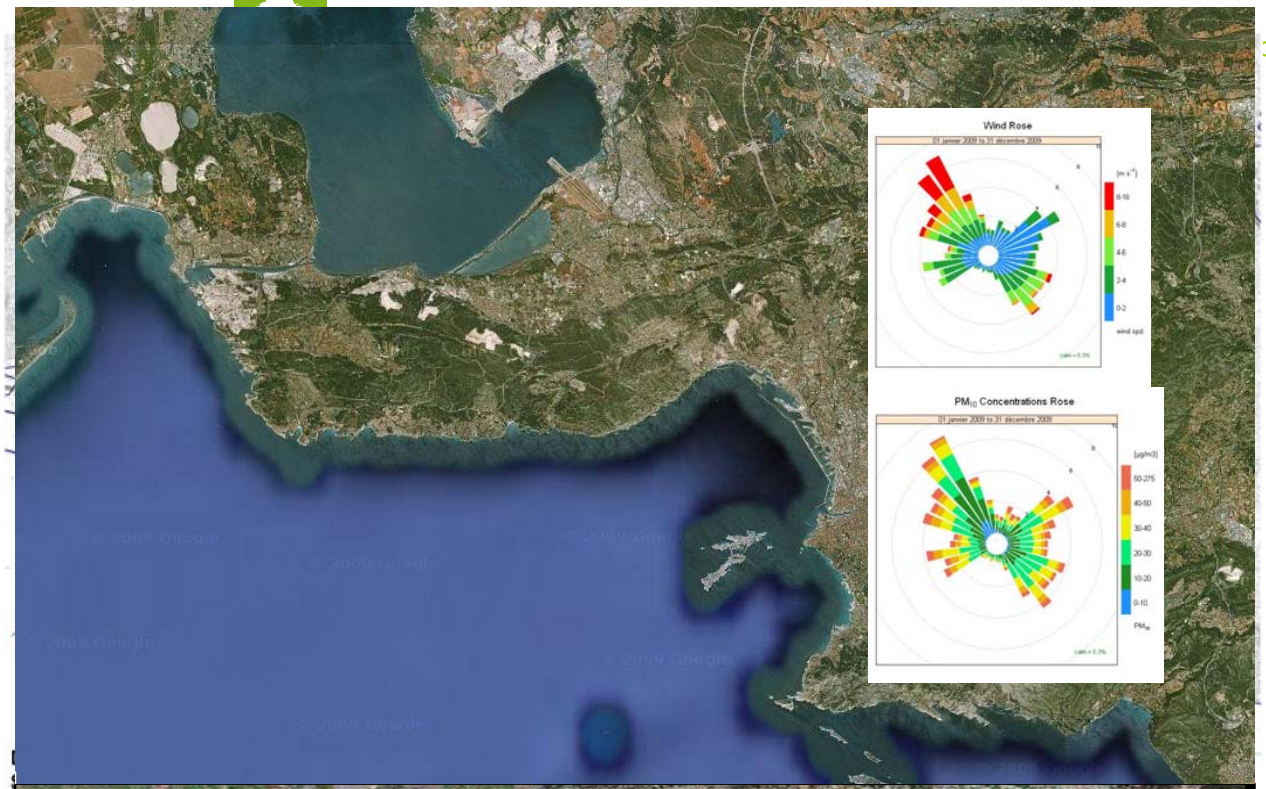


Figure 32: PM10 concentration rose for year 2009 (μg/m^3, degrees)



INTERCOMPARISON OF ROSES

By comparing the two rose-diagrams it is obvious that the highest wind speed values and the highest PM10 levels are mainly connected to winds from west-northwestern to north-northwestern, east-southeastern and southeastern winds. High PM10 levels are also connected to eastern and eastern-northeastern winds with lower wind speed values. In an effort to identify the sources contributing to PM10 concentration, primary trends can be drawn. To be more specific, the presence of west harbor (at a distance of 40km at a north-western direction) plays a crucial role to particles emissions and in combination with prevailing meteorological parameters, can significantly contribute to PM10 levels at Marseille's station. On the other side, the nocturnal urban breeze originating from south-east seems to have a significant impact on PM10 levels through particles transportation from another industrial area. ***Figure 33: PM10 concentration rose (μg/m^3, degrees) and wind speed rose (m/s, degrees) for year 2009 – Industrial activities in Marseille***

7. FRAMEWORK ANALYSIS

7.1 INTRODUCTION

By itself, technology is as likely to harm the environment as to help it. That's why laws and regulations have been such an important part of tackling the problem of pollution. Many once-polluted cities now have relatively clean air and water, largely thanks to anti-pollution laws introduced during the mid-20th century. In England, following the 1952 smog tragedy that killed thousands of people in the capital city of London, the government introduced its Clean Air Act of 1956, which restricted how and where coal could be burned and where furnaces could be sited and forced people to build smokestacks higher to disperse pollution. In the United States, a series of Clean Air Acts were passed between the 1960s and 1990s. The 1990 Pollution Prevention Act went even further, shifting the emphasis from cleaning up pollution to preventing it ever happening in the first place.

National laws are of little help in tackling trans-boundary pollution (when air pollution from one country affects neighboring countries or continents), but that doesn't mean the law is useless in such cases. The creation of the European Union (now comprising around 30 different countries) has led to many Europe-wide environmental acts, called directives. These force the member countries to introduce their own, broadly similar, national environmental laws that ultimately cover the entire European region. For example, the 1976 European Bathing Water Directive tried to enforce minimum standards of water quality for beaches and coastal areas across Europe to reduce pollution from sewage disposal, while the 1996 European Directive on Integrated Pollution Prevention and Control (IPPC) attempted to limit air and water pollution from industry. Other successful international laws include the Convention on Long-Range Trans-boundary Air Pollution (1979), which has helped to reduce sulfur dioxide emissions from power plants and, of course, the Montreal Protocol, which successfully brought 196 countries together to target ozone depletion. Unfortunately, attempts to control global warming through international laws and agreements have so far proved less successful.

Any effective program regulating maritime emissions will need to take account of the legal circumstances that govern maritime activity. Indeed, the international nature of shipping means that international regulations need to be accounted for in considering the legal context. To that end, the following section provides a very brief discussion of the existing international legal framework and its relevance for shipping.

7.2 INTERNATIONAL FRAMEWORK

INTRODUCTION

Exhaust emissions from ships are considered to be a significant source of air pollution, with 18-30% of all nitrogen oxide and 9% of sulphur oxide pollution. The 15 biggest ships emit about as much sulphur oxide pollution as all cars combined. Sulfur in the air creates acid rain which damages crops and buildings. When inhaled the sulfur is known to cause respiratory problems and even increase the risk of a heart attack. According to Irene Blooming, a spokeswoman for the European environmental coalition Seas at Risk, the fuel used in oil tankers and container ships is high in sulfur and cheaper to buy compared to the fuel used for domestic land use. "A ship lets out around 50 times more sulfur than a lorry per metric ton of cargo carried." Cities in the U.S. like Long Beach, Los Angeles, Houston, Galveston, and Pittsburgh see some of the heaviest shipping traffic in the nation and have left local officials desperately trying to clean up the air. The increasing trade between the U.S. and China is helping to increase the number of vessels navigating the Pacific and exacerbating many of the environmental problems. To maintain the level of growth China is currently experiencing, large amounts of grain are being shipped to China by the boat load. The number of voyages is expected to continue increasing. 3.5% to 4% of all climate change emissions are caused by shipping.

Although international regulation in other environmental areas is long standing, international efforts to reduce air emissions from ships are relatively new. The need for measures to reduce air pollutant emissions from international shipping has been on the agenda since the late 1980s. After years of negotiation, a first agreement – the Annex VI1 to the IMO's MARPOL Convention – was adopted in 1997. But even at the time of adoption it was widely recognized as being insufficient.

LEGISLATION AUTHORITIES

There are some common elements that an emissions policy for ships must include; one of them is an appropriate legal basis, which is also related to an effective monitoring and enforcement regime. Any new policy to control emissions would have to be in conformity with international and EU law. The United Nations Convention on the Law of the Sea ("UNCLOS") sets out the basic legal framework that governs international shipping. The Convention gives some support for the control of air emissions (Article 212), but this is balanced against the right of ships to innocent passage without being subject to any charges, except for services received. Relevant are also the current international environmental regulations, notably the International Maritime Organization's ("IMO's"), International Convention on the Prevention of Pollution from Ships ("MARPOL"), which sets a global limit on fuel sulphur content, and also designates Sulphur Oxide Emission Control Areas ("SECAs") in the North Sea and the Baltic Sea. MARPOL also sets NOx emissions standards via the IMO "NOx curve". (The 2005 EU Sulphur Directive imposes additional requirements to limit fuel sulphur content in SECAs, imposes restrictions on passenger vessels throughout the EU, and requires ships at berth to use 0.1 percent sulphur fuel or better from 2010 onward. The considered policies must be consistent with the existing legal framework for addressing emissions from shipping, although it is likely that certain details need to be worked out for each one.

The mentioned authorities are based on studies of emissions from ships. This is complicated by the fact that fuel consumption and emission factors are highly variable, depending on engine size, age, and load, on existing emission control technologies, on fuel composition, and on ambient conditions. In general, monitoring can be divided into periodic and continuous monitoring (periodic monitoring is cheaper but less accurate than continuous monitoring) and into monitoring of the fuel used or direct measurement of exhaust emissions (fuel-based is cheaper but less accurate than the monitoring of exhaust emissions). The appropriate trade-off between cost and accuracy is likely to depend on the instrument used, as requirements differ between different approaches. Additional considerations include the ability to keep track of emissions within a specific geographical area, which poses significant challenges without continuous monitoring.

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UNITED NATIONS CONVENTION ON THE LAW OF SEA (UNCLOS)

The United Nations Convention on the Law of the Sea ("UNCLOS"), formally codified in 1982, is the basic legal framework that governs international shipping. As noted in Davies et al. (BMT 2000), states operate in three capacities: as flag, port, and coastal states. UNCLOS gives flag states the primary authority to impose environmental regulations (including those related to air emissions) on marine sources through their responsibility to enforce international laws. The roles of other jurisdictions—i.e., port and coastal states— "have traditionally been more limited" (BMT 2000). However, the language in UNCLOS suggests that non-flag states do have some authority to regulate marine emissions.

UNCLOS guarantees port states the right to "establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports or internal waters" (Article 211, paragraph 2). In addition, UNCLOS gives each coastal state the authority to control in-port emissions through its right to "exclude vessels from its ports or place conditions upon their entry" (BMT 2000). Although coastal states have limited authority to regulate general pollution under UNCLOS, they appear to have greater power in the regulation of air emissions. Articles 212 and 222 of UNCLOS, which govern air emissions from marine vessels, are somewhat vague with respect to the jurisdictional limits of coastal states. Indeed, when it comes to air emissions, a state's jurisdiction is defined with respect to infringement upon its airspace. Article 212 allows states to "adopt laws and regulations to prevent, reduce and control pollution of the marine environment from or through the atmosphere, applicable to the air space under their sovereignty." While UNCLOS gives some jurisdiction to port and coastal states in the control of marine air emissions, the Convention professes a clear preference for international regulations wherever possible. IMO would manage any such international regulations. Though IMO is explicitly mentioned only once in UNCLOS (Article 2 of Annex VIII), UNCLOS frequently refers to the "competent international organization" in connection with the adoption of international shipping safety and pollution standards; in most cases, this phrasing (i.e., "the competent international organization") has been interpreted to refer exclusively to IMO. IMO is generally responsible for the oversight of international shipping activity. In particular, IMO's charter explicitly charges it with the oversight of safety and antipollution efforts in international shipping. Since its creation in 1948, IMO has established a variety of measures to enforce increased safety and reduced pollution from international shipping. A major limitation affecting any jurisdictional authority relates to the right of innocent passage, which is also codified in UNCLOS. UNCLOS Part 2, Section 3 guarantees innocent right of passage for foreign-flag vessels in the territorial sea without being subject to any charges, except for services received. This restriction is clearly relevant to the control of emissions from shipping, since under a strict reading of this requirement, payments or charges related to reducing emissions from foreign-flag vessels would have to be embodied in a framework of providing services to those vessels. In addition, one

aspect of the right of innocent passage, articulated in Article 21 of UNCLOS, precludes coastal states from enforcing any regulations that apply to the design, construction, manning or equipment of foreign vessels. This could be interpreted as restricting the ability of coastal states to require pollution abatement equipment or engine modifications on foreign vessels. A reason for considering market-based approaches to emissions regulations is that they offer a flexible means of complying with environmental regulations, and therefore may make it easier to promote the use of low-emissions technologies in certain sea areas, without impinging upon ships' right of innocent passage.

INTERNATIONAL MARITIME ORGANIZATION (IMO)

International Maritime Organization (IMO) is an agency of the United Nations which has been formed to promote maritime safety. It was formally established by an international conference in Geneva in 1948, and became active in 1958 when the IMO Convention entered into force (the original name was the Inter-Governmental Maritime Consultative Organization, or IMCO, but the name was changed in 1982 to IMO). IMO currently groups 167 Member States and 3 Associate Members.

IMO ship pollution rules are contained in the "International Convention on the Prevention of Pollution from Ships", known as MARPOL 73/78. On 27 September 1997, the MARPOL Convention has been amended by the "1997 Protocol", which includes Annex VI titled "Regulations for the Prevention of Air Pollution from Ships". MARPOL Annex VI sets limits on NOx and SOx emissions from ship exhausts, and prohibits deliberate emissions of ozone depleting substances.

The IMO emission standards are commonly referred to as Tier I...III standards. The Tier I standards were defined in the 1997 version of Annex VI, while the Tier II/III standards were introduced by Annex VI amendments adopted in 2008, as follows:

1997 Protocol (Tier I)—The "1997 Protocol" to MARPOL, which includes Annex VI, becomes effective 12 months after being accepted by 15 States with not less than 50% of world merchant shipping tonnage. On 18 May 2004, Samoa deposited its ratification as the 15th State (joining Bahamas, Bangladesh, Barbados, Denmark, Germany, Greece, Liberia, Marshal Islands, Norway, Panama, Singapore, Spain, Sweden, and Vanuatu). At that date, Annex VI was ratified by States with 54.57% of world merchant shipping tonnage.

Accordingly, Annex VI entered into force on 19 May 2005. It applies retroactively to new engines greater than 130 kW installed on vessels constructed on or after January 1, 2000, or which undergo a major conversion after that date. The regulation also applies to fixed and floating rigs and to drilling platforms (except for emissions associated directly with exploration and/or handling of sea-bed minerals). In anticipation of the Annex VI

ratification, most marine engine manufacturers have been building engines compliant with the above standards since 2000.

2008 Amendments (Tier II/III)—Annex VI amendments adopted in October 2008 introduced (1) new fuel quality requirements beginning from July 2010, (2) Tier II and III NOx emission standards for new engines, and (3) Tier I NOx requirements for existing pre-2000 engines.

The revised Annex VI enters into force on 1 July 2010. By October 2008, Annex VI was ratified by 53 countries (including the Unites States), representing 81.88% of tonnage.

EMISSION CONTROL AREAS

Two sets of emission and fuel quality requirements are defined by Annex VI: (1) global requirements, and (2) more stringent requirements applicable to ships in Emission Control Areas (ECA). An Emission Control Area can be designated for SOx and PM, or NOx, or all three types of emissions from ships, subject to a proposal from a Party to Annex VI.

Existing Emission Control Areas include:

- Baltic Sea (SOx, adopted: 1997 / entered into force: 2005)
- North Sea (SOx, 2005/2006)
- North American ECA, including most of US and Canadian coast (NOx & SOx, 2010/2012).

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EMISSION STANDARTS

NOx

NOx emission limits are set for diesel engines depending on the engine maximum operating speed (n, rpm), as shown in Table 18 and presented graphically in Figure 34. Tier I and Tier II limits are global, while the Tier III standards apply only in NOx Emission Control Areas.

Table 18. MARPOL Annex VI NOx Emission Limits

Tier	Date	NOx Limit, g/kWh		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier I	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
Tier III	2016†	3.4	$9 \cdot n^{-0.2}$	1.96

† In NOx Emission Control Areas (Tier II standards apply outside ECAs).

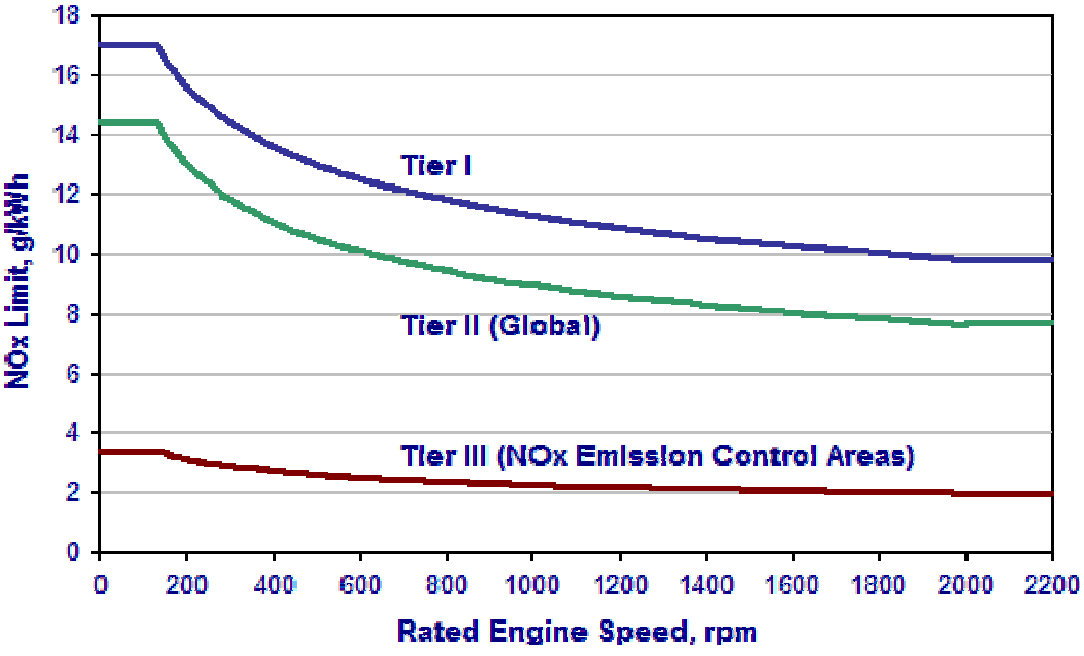

Figure 34: MARPOL Annex VI NOx Emission Limits

Tier II standards are expected to be met by combustion process optimization. The parameters examined by engine manufacturers include fuel injection timing, pressure, and rate (rate shaping), fuel nozzle flow area; exhaust valve timing, and cylinder compression volume.

Tier III standards are expected to require dedicated NOx emission control technologies such as various forms of water induction into the combustion process (with fuel, scavenging air, or in-cylinder), exhaust gas recirculation, or selective catalytic reduction.

Pre-2000 Engines. Under the 2008 Annex VI amendments, Tier I standards become applicable to existing engines installed on ships built from 1st January 1990 to 31st December 1999, with a displacement ≥ 90 liters per cylinder and rated output ≥ 5000 kW, subject to availability of approved engine upgrade kit.

Testing. Engine emissions are tested on various ISO 8178 cycles (E2, E3 cycles for various types of propulsion engines, D2 for constant speed auxiliary engines, C1 for variable speed and load auxiliary engines). Addition of not-to-exceed (NTE) testing requirements to the Tier III standards is being debated. NTE limits with a multiplier of 1.5 would be applicable to NOx emissions at any individual load point in the E2/E3 cycle. Engines are tested using distillate diesel fuels, even though residual fuels are usually used in real life operation.

Further technical details pertaining to NOx emissions, such as emission control methods, are included in the mandatory “NOx Technical Code”, which has been adopted under the cover of “Resolution 2”.

SULFUR

Annex VI regulations include caps on sulfur content of fuel oil as a measure to control SOx emissions and, indirectly, PM emissions (there are no explicit PM emission limits). Special fuel quality provisions exist for SOx Emission Control Areas (SOx ECA or SECA). The sulfur limits and implementation dates are listed in Table 19 and illustrated in Figure 35.

Table 19. MARPOL Annex VI Fuel Sulfur Limits

Date	Sulfur Limit in Fuel (% m/m)	
	SOx ECA	Global
2000	1.5%	4.5%
2010.07	1.0%	
2012		3.5%
2015	0.1%	
2020[a]		0.5%

a - alternative date is 2025, to be decided by a review in 2018

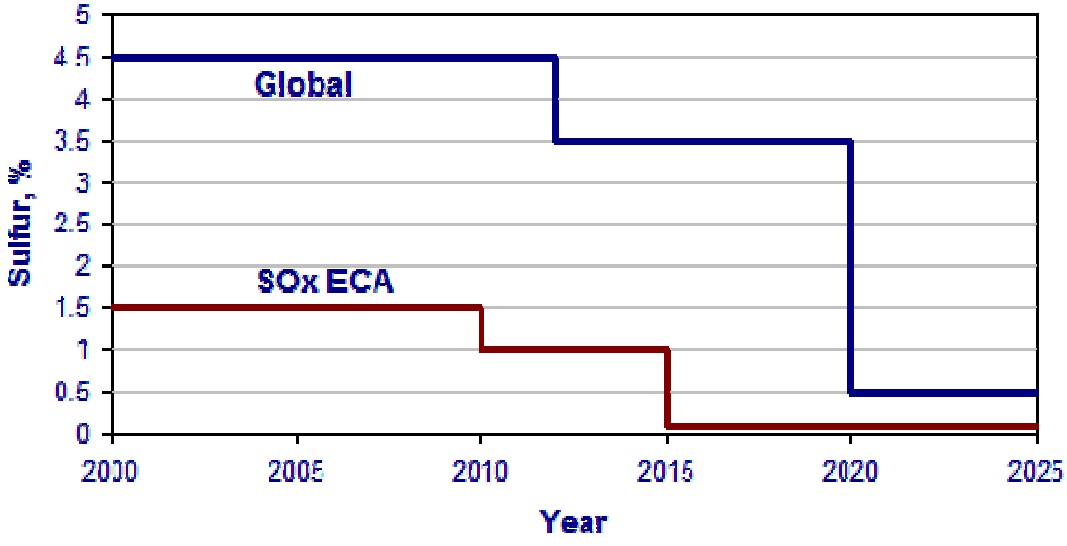

Figure 35: MARPOL Annex VI Fuel Sulfur Limits

Heavy fuel oil (HFO) is allowed provided that it meets the applicable sulfur limit (i.e., there is no mandate to use distillate fuels).

Alternative measures are also allowed (in the SOx ECAs and globally) to reduce sulfur emissions, such as through the use of scrubbers. For example, in lieu of using the 1.5% S fuel in SOx ECAs, ships can fit an exhaust gas cleaning system or use any other technological method to limit SOx emissions to ≤ 6 g/kWh (as SO_2).

OTHER PROVISIONS

Ozone Depleting Substances. Annex VI prohibits deliberate emissions of ozone depleting substances, which include halons and chlorofluorocarbons (CFCs). New installations containing ozone-depleting substances are prohibited on all ships. But new installations containing hydro-chlorofluorocarbons (HCFCs) are permitted until 1 January 2020.

Annex VI also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

Compliance. Compliance with the provisions of Annex VI is determined by periodic inspections and surveys. Upon passing the surveys, the ship is issued an “International Air Pollution Prevention Certificate”, which is valid for up to 5 years. Under the “NOx Technical Code”, the ship operator (not the engine manufacturer) is responsible for in-use compliance.

Greenhouse Gas Emissions. Annex VI does not cover the emission of greenhouse gases from ships. In November 2003, the IMO adopted resolution A.963(23) on IMO Policies and Practices related to the Reduction of Greenhouse Gas Emissions from Ships.

7.3 EUROPEAN

INTRODUCTION

Most European ports are free to determine their own dues and therefore also free to introduce dues differentiation. Indeed, dues are already commonly differentiated according to vessel class or particular vessel characteristics. The addition of environmental criteria is not likely to require new institutions, provided that ports can easily verify the status of ships with respect to the differentiation criteria it has in place. In the absence of existing institutions to carry out certification of ships according to the desired criteria, this may require that procedures be put in place.

AIR QUALITY STANDARTS

Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes health based standards and objectives for a number of pollutants in air. These standards and objectives are summarized in the table below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times.

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Table 20: Air quality standards per pollutant

Pollutant	Concentration	Averaging period	Legal nature	Permitted exceedences each year
Fine articles (PM2.5)	25 µg/m3***	1 year	Target value enters into force 1.1.2010 Limit value enters into force 1.1.2015	n/a
PM10	50 µg/m3	24 hours	Limit value enters into force 1.1.2005**	35
	40 µg/m3	1 year	Limit value enters into force 1.1.2005**	n/a
Sulphur dioxide (SO2)	350 µg/m3	1 hour	Limit value enters into force 1.1.2005	24
	125 µg/m3	24 hours	Limit value enters into force 1.1.2005	3
Nitrogen dioxide (NO2)	200 µg/m3	1 hour	Limit value enters into force 1.1.2010	18
	40 µg/m3	1 year	Limit value enters into force 1.1.2010*	n/a
Lead (Pb)	0.5 µg/m3	1 year	Limit value enters into force 1.1.2005 (or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applies from 1.1.2005 to 31.12.2009)	n/a
Carbon monoxide (CO)	10 mg/m3	Maximum daily 8 hour mean	Limit value enters into force 1.1.2005	n/a

Benzene	5 µg/m3	1 year	Limit value enters into force 1.1.2010**	n/a
Ozone	120 µg/m3	Maximum daily 8 hour mean	Target value enters into force 1.1.2010	25 days averaged over 3 years
Arsenic (As)	6 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Cadmium (Cd)	5 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Nickel (Ni)	20 ng/m3	1 year	Target value enters into force 1.1.2012	n/a
Polycyclic Aromatic Hydrocarbons	1 ng/m3 (expressed as concentration of Benzo(a)pyrene)	1 year	Target value enters into force 1.1.2012	n/a

**Under the new Directive the Member State can apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. Request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (48µg/m3 for annual NO2 limit value).*

***Under the new Directive the Member State can apply for an extension until three years after the date of entry into force of the new Directive (i.e. May 20011) in a specific zone. Request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (35 days at 75µg/m3 for daily PM10 limit value, 48µg/m3 for annual PM10 limit value).*

****Standard introduced by the new Directive 2008/50/EC*

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Under EU law a limit value is legally binding from the date it enters into force subject to any exceedences permitted by the legislation. A target value is to be attained as far as possible by the attainment date and so is less strict than a limit value.

The new Directive is introducing additional PM2.5 objectives targeting the **exposure** of the population to fine particles. These objectives are set at the national level and are based on the average exposure indicator (AEI).

AEI is determined as a 3-year running annual mean PM2.5 concentration averaged over the selected monitoring stations in agglomerations and larger urban areas, set in urban background locations to best assess the PM2.5 exposure to the general population.

Table 21: Air quality standards for PM2.5 in lines of AEI

Title	**Metric**	**Averaging period**	**Legal nature**	**Permitted exceedences each year**
PM2.5 Exposure concentration obligation	20 µg/m3 (AEI)	Based on 3 year average	Legally binding in 2015 (years 2013,2014,2015)	n/a
PM2.5 Exposure reduction target	Percentage reduction* + all measures to reach 18 µg/m3 (AEI)	Based on 3 year average	Reduction to be attained where possible in 2020, determined on the basis of the value of exposure indicator in 2010	n/a

** Depending on the value of AEI in 2010, a percentage reduction requirement (0, 10, 15, or 20%) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate measures need to be taken to achieve 18µg/m^3 by 2020.*

PRINCIPLES

European legislation on air quality is built on certain principles. The first of these is that the Member States divide their territory into a number of zones and agglomerations. In these zones and agglomerations, the Member States should undertake assessments of air pollution levels using measurements and modeling and other empirical techniques. When levels are elevated, the Member States should prepare an air quality plan or program to ensure compliance with the limit value before the date when the limit value formally enters into force. In addition, information on air quality should be disseminated to the public.

CLEAN AIR FOR EUROPE (CAFE)

In May 2001, the European Commission formally adopted the Clean Air For Europe (CAFE) program. The program is aimed at integrating the various strands of air pollution policy under the 6th Environmental Action Program and includes the preparation of a thematic strategy on air pollution – one of seven covering various areas of EU environmental policy. The CAFE process has therefore effectively become the focal point for the EU's air quality work, providing a framework within which air pollution measures, such as the Auto Oil program, national emissions ceilings Directive and the air quality Daughter Directives can be coordinated.

In September 2005, the Commission published its Thematic Strategy on Air Pollution; its aim being to cut the annual number of premature deaths caused by air pollution by 40% by 2020 from the 2000 level and to reduce the continuing damage to Europe's ecosystems. To do this the Strategy says that emissions of sulphur dioxide will need to be reduced by 82%, nitrogen oxides by 60%, volatile organic compounds by 51%, ammonia by 27% and fine particulate matter by 59% (compared to their 2000 levels).

The Strategy proposes streamlining European air quality legislation and to this end includes a proposal for a Directive on Ambient Air Quality and Cleaner Air for Europe (COM (2005) 447) which will replace the Air Quality Framework Directive and three of its Daughter Directives (on sulphur dioxide, oxides of nitrogen, particulate matter and lead; on carbon monoxide & benzene; and that on monitoring & information on ozone).

The Strategy also outlines proposals for reviewing the National Emission Ceilings Directive, and for consideration to be given to the feasibility of tighter (Euro 5) emission limits for cars and Euro VI for heavy goods vehicles. Consideration is also to be given to extending the Integrated Pollution Prevention Control Directive to cover small combustion plant, a new Directive reducing VOC emissions from fuel stations, setting NOx emission limit values for ships, and reducing nitrogen use for animal feedstuffs and fertilizers.

EUROPEAN QUALITY LIMIT VALUES

European Limit Values are legally binding, and exceedences can result in the European Commission taking legal action against the country at fault. In 1996, the European Union

adopted the Air Quality Framework Directive (96/62/EC), which in turn gave rise to a series of "Daughter" Directives containing Limit Values for seven pollutants. In June 2008, a new Air Quality Directive (2008/50/EC) came into force and must have been implemented by member states by 11 June 2010. This merges the former framework Directive and the first three Daughter Directives into a single Directive with no change to existing air quality objectives. It also introduces new air quality objectives for $PM_{2.5}$ (fine particles) including a limit value and exposure related objectives – exposure concentration obligation and exposure reduction target. The new Directive also introduced several new features that weaken the previous legislation, including the possibility to discount natural sources of particles (e.g. sea salt) when assessing compliance against limit values, and the possibility (with EU approval) of time extensions of three years (PM_{10}) or up to five years (NO_2, benzene) for complying with limit values.

EU MARINE SULPHUR DIRECTIVE

In 2002, the European Commission presented a proposal to amend Directive 1999/32 as regards the sulphur content of marine fuels (henceforth, the “marine fuel sulphur directive”) The European Parliament and Council finalized the marine fuel sulphur directive in April 2005 with a second reading agreement. At the time of writing, the directive had not yet been published in the EU Official Journal, but it had been formally signed and given the directive reference number 2005/33. The directive includes the following provisions: Ships in IMO Sulphur Emission Control Areas must use 1.5 percent sulphur fuel or better – starting with the Baltic Sea in May 2006, then extending to the North Sea and Channel in autumn 2007. All passenger vessels on regular services to or from Community ports must use 1.5 percent sulphur fuel or better from May 2006 onward. Ships at berth in ports must use 0.1 percent sulphur fuel or better from 2010 onward.

These provisions should apply to all marine fuels and replace the current regulations on marine gas oil, thereby establishing a similar regime for marine fuels as for heavy fuels and gas oils used by land-based sources, which are limited to 1.0 percent and 0.1 percent sulphur content, respectively. The Directive also allows ships to use other technical abatement technologies that achieve the same or greater levels of emission reductions, provided it can be demonstrated that these technologies do not adversely affect the marine environment. (The most often mentioned acceptable abatement technology is the desulphurization of exhaust gases via “seawater scrubbing.”)

EU CONTEXT- SUBSIDIES AND STATE AID RULES

The Commission has adopted the following three sets of state aid guidelines that define the context with regard to possible state subsidies for ship emissions reductions.

1. Community guidelines on state aid for environmental protection (2001/C37/03) allow aid where it serves as an incentive to firms to achieve levels of protection that are higher

than those required by Community standards, or where no Community standards exist—as is the case for NOX emissions from seagoing ships. Investment aid can be given for plant and equipment intended to reduce or eliminate pollution, but may not exceed 30 percent gross of the eligible investment costs.

2. Community guidelines on state aid to maritime transport (1997/C205/05) allow investment aid in certain circumstances to promote the use of clean ships, such as providing incentives to upgrade Community registered ships to standards which exceed mandatory environmental standards laid down in international conventions.

3. Finally, the most recent Commission framework on state aid to shipbuilding (2003/C317/O6) allows aid for research and development and allows aid up to 20 percent of gross expenditure for innovation, i.e. technologically new or substantially improved products and processes compared to the state of the art referring to industry. Thus, it appears to be legally possible for Member States to provide subsidies for emissions reductions generated through the development and use of emissions abatement technologies for ships, either for new vessels or for retrofits.

MARKET BASED APPROACHES TO AIR EMISSIONS POLICY

Once a primarily theoretical approach to environmental policy, economic instruments have gained wide acceptance over the last three decades. Indeed, virtually all environmental policy initiatives that have been developed recently in the US include a market-based component. Market-based approaches have recently gained wider acceptance in Europe as well. The EU Emissions Trading Scheme (the “EU ETS”) represents perhaps the most prominent example of Europe’s use of market-based approaches. Under the EU ETS, Member States are permitted to trade CO2 emissions reduction credits among one another, as part of an EU-wide initiative to meet anticipated obligations under the Kyoto Protocol. The Commission has recognized that market-based instruments might be used to deal with various environmental issues. Experience suggests that well-designed market based approaches can reduce the costs and increase the likelihood of achieving environmental targets (see, e.g., Ellerman, Joskow and Harrison 2003). This experience also indicates, however, that the market-based approaches need to be carefully thought out in order to achieve these and other objectives. Moreover, it is important to include all interested parties in this process, particularly since the approach is relatively new for shipping.

7.4 NATIONAL FRAMEWORK

The Environmental Code issue from the law n°96-1236 dated from December 30th, 1996 on *air quality and rational energy using*, acknowledges for each one to have a right to breathe a healthy air, aims to improve the air quality monitoring and to set up tools for regional plans (Regional Plan for Air Quality: PRQA) and local planning (Atmosphere Protection Plan: PPA, and Urban Transport Plan: PDU). These plans aim to assess air quality, to define and to evaluate with indicators the orientations/actions to reduce pollution levels. The National Plan for Health and Environment aims to define priority actions to reduce health effects in relation with environmental degradation. For air quality, the priority is for particles, pesticides, indoor environment, urban transport and the identification of overexposure areas. Several actions are interested by the reduction of emissions.

With the framework of this regulation, the State is in charge of the air quality monitoring and of health and environmental effects, with the collaboration of territorial authorities. The technical coordination of the air quality monitoring over the national area is performed by ADEME (Agency for the Environment and for Energy Control). In the regions, the set up of the air quality monitoring is given to approve organizations (French Approved Association of Air Quality Monitoring: AASQA).

FUTURE EVOLUTION ISSUE FROM THE "GRENELLE DE L'ENVIRONMENT"

Thanks to a global approach for air quality, the legislative background knows an evolution due to parliamentary works[ii] issue from the "Grenelle de l'environment".For example, future Regional Plans for Climate Air Energy integrate these three set of atmospheric problem as for Territorial Plans Climate Energy (PCET). So, the activities of AASQA should be involved in the evaluation of the contribution from regional to the global scale. Moreover, limit values have been decreed for the indoor air using as references for survey and action.

[1] the equivalent of a conference with the participation of representatives of government, of professional associations and of nongovernmental organization

MARSEILLE

AASQA monitoring strategy at the regional level has to be in agreement with the obligations and/or needs entrusted by their partners (State, local authorities, industrial companies, consumer or environmental protection associations and competent personalities), since their administrator board has acknowledged them with a global interest. For example:

State: besides commitments issue from national level, the specific needs linked with prefectural procedures for information and alert, with actions issue from different plans (PPA …).

Local authorities: specific needs and relative contributions for PRQA, PDU …

Industries: monitoring and environmental reports issue from prefectural order, global interest studies…

Associations: information and reply to preoccupations, information meetings …

PRQA (Regional Planning for Air Quality)

The development of the PRQA has been finished in 1999 and approved in 2000 without updating since. The following orientations are still topical: physical and chemical characterization of PM, sharing of tools and means between AASQA, monitoring of indoor and outdoor pollution and exposition of population.

PRSE2

(In progress) Examples of measures about «air»:

- Pesticide measures
- POP measures
- PM characterization, dispersion studies
- IAQ (indoor air quality) expert group, identification of IAQ priorities
- Evaluation of health impact of pollution
- Decision making tools

PPA (Atmosphere Protection Plan) by department

Bouches-du-Rhône: approved from 06/08/22, no specific orientation about air quality survey.

Alpes-Maritimes: approved from 07/05/23, plans different measures about air quality survey: set up of an olfactory pollution observatory, indoor air quality survey (also radon), and improvement of the monitoring in the hinterland.

Var: approved from 007/05/10, plans several measures about air quality survey: set up of an olfactory pollution observatory, measures of heavy metals and BTX for urban environment, indoor air quality survey, set up of a departmental emission inventory

Avignon: approved from 07/06/01, no specific orientation about air quality survey.

The whole PPA has to be review in 2011.

PREFECTURAL ORDERS

These orders define modes of public information for pollution peaks. Actually, these orders require a minimum of 2 sensors by activation area (expect for ozone in the Bouches-du-Rhône department where only one is sufficient).

02/08/02: prefectural order Bouches-du-Rhône NO_2 and SO_2

04/06/03: interprefectural order O_3

08/10/10: prefectural order Bouches-du-Rhône STERNES (Temporal system normative and regulation framework for sulphuric emissions). See part about sulphur dioxide for more details.

08/11/05: interprefectural order PM10

PDU (Urban Transport Plan)

Air pollution reduction is an objective for each PDU. However, these documents do not contain any measures about air quality monitoring and focuses their actions against nuisance.

- Sophia Antipolis: approved from 08/05/01
- Nice Côte d'Azur : approved from 08/01/28

Aix-Marseille:

- Marseille Provence Métropole: approved from 06/02/13
- Communauté du Pays d'Aix : approved from 05/06/24, cancelled by administrative court from 08/06/05
- Pays d'Aubagne et de l'Etoile: approved from 19/07/06

Toulon:

- Toulon Provence
- Méditerranée: project non approved actually

Agglomération d'Avignon

- Grand Avignon: project non approved actually

LOCAL REQUEST

A questionnaire has been subjected to Atmo PACA and AIRFOBEP members at the occasion of the redaction of the last PASQA, to know the point of view of local workers for action priority. Cartography is one of priority tools for the following years. Pollution maps are viewed as a tool of communication, awareness, explanation and decision making. Local authorities would like to develop modeling tools. These tools have to allow the set up of more precise maps, representing topical situation and also political development consequences for air quality (scenario).

8. EVALUATION OF AIR QUALITY IN REGION OF MARSEILLE

The current report has been redacted in lines of APICE program (Common Mediterranean strategy and local practical Actions for the mitigation of Port, Industries and Cities Emissions). The report includes a brief analysis of the air quality of the area during the last years. The interest is focused on the Port of Marseilles (the first harbor in France and the fourth in Europe) which has an ideal geographical position for north/south and east/west trade.

In total, 47 stations for AtmoPACA and 31 stations for AIRFOBEP equipped with 133 and 79 sensors respectively, measure the air quality in this area. The automated measurements transmitted to a Management Centre (in Marseille) are analysed, broadcast to the general public and can be used to alert the authorities in case of a pollution peak. The monitored pollutants are: PM10 and PM2.5 particles, polycyclic aromatic compounds, heavy metals, SO_2, NO_2, O_3, CO and benzene, toluene and xylenes. Data of meteorological parameters (wind speed, wind direction, temperature and relative humidity) are also available from the national meteorological network.

The main conclusions of the analysis of the air quality in Marseille's region are:

- **NO_2 is mainly associated with** *high traffic emissions.* As reported, since 2006, the annual concentration at three of seven sampling sites (sites of "Timone", "Rabatau" and "Plombières") exceeded the annual limit value for 2009 (42µg/m^3). The maximum annual mean was recorded at "Marseille Plombières" site while for middle size cities, as Marignane the limit value was not exceeded. It is characteristic that in 2009, the hourly limit value of 200µg/m^3 has been exceeded 20 times at "Marseille Plombières" station. *These excesses are mainly associated with stable meteorological conditions, frequently during winter, without wind and thermal inversion, leading to pollutants' accumulation.*

- ***SO_2 mean levels are stable and much lower than quality objective.*** (50 µg/m^3) for all stations. The highest yearly value was noticed at the "Sausset-les-Pins" site. *Due to petrochemical activities and industrial emissions*, the highest concentrations were recorded at sampling sites close to Berre pond border. Among 6 stations, only the "Châteauneuf-la-Mède" station recorded an hourly maximum higher than the limit value of 350µg/m^3. *These peaks of SO_2 are due to fallout of industrial pollutant plumes.*

- Regarding O_3, it is characteristic that for the year 2009, all sampling stations over MPM area, except for one, exceeded the limit value during more than 25 days. "Marseille Cinq-Avenues" sampling station reached the quality objective: *as the reactions between ozone and nitrogen oxides from traffic are very quick, ozone concentrations are lower at the city centre.*

- PM10 measurements since 2006 for MPM area showed that in supplement to *traffic influence, excavation and building activities* since 2009 have led to intense particles emission close to the "Marseille Timone" station. For 2009, all stations recorded values higher the than the daily limit value (as for the three last years). For "Marseille Timone" site, daily level reached a maximum value, *due to dust emissions by surrounding works, in addition to traffic emissions.* Since 2006, the most significant excess has been recorded for the particulate matter issues from *fossil fuel used by ships and industries*. *It is important to note that the factors that contribute to particles levels include permanent or seasonal sources. The meteorological pattern of each season plays a crucial role too; as a low dispersive atmosphere leads to particles levels increase while low pollution conditions can lead to significant levels' decrease*

- Regarding **heavy metals**, just after the *Cu/Cd industry closing* in September 1999, Cd levels have significantly decreased at "Saint-Louis" sampling site. From 2001, the annual mean concentration was lower than the European objective value (5ng/m^3). Since 2004, the Cd mean concentration was close to Marseille's background level where there was not any industrial influence. Pb, Ni (since 2000) and as, annual concentrations did not exceed the limit values.

- High levels of **PAHs** were connected to traffic and industries emissions, as recorded in regional scale.

- Regarding **benzene**, it is characteristic that in 2009, all sampling stations over MPM area had an annual mean level lower than the limit value (6µg/m^3). Quality objective (2µg/m^3) was not reached at traffic stations located at the city centre. For a comparison, the maximum mean (4,4 µg/m^3) for 2009 is recorded at sampling site "Vallée de l'Huveaune" *due to the existence of an industrial source nearby. Benzene concentrations are higher close to heavy traffic roads and close to industrial sites.*

- The present report has focused on the study of PM10 levels during 2009. Thus,

- The maximum monthly mean values correspond to January, July and August. During winter, the main sources that contribute to particles levels are the buildings' central heating and the bad operation of vehicle motors in starting

because of the cold engine. During summer, chemical processes -connected with intense solar radiation- are responsible for secondary particles' formation. Regarding daily variation, although there are not significant differences among the different weekdays, concentration during weekends is lower, possibly because of *the reduction of vehicles circulation and human activities.* Finally, regarding hourly PM10 variation during the day, concentration levels increase during early morning hours, presenting a peak at 10-12am, *possibly because of the intense vehicles circulation*, *central heating operation and human activities*. Concentration levels during afternoon and night remain elevated as this time period is often characterized *by prevailing favorable meteorological conditions for air pollutants accumulation.*

- As meteorological conditions are concerned, maximum temperature values for 2009 were noticed during summer months, as expected while relative humidity presented a variation during all year. The maximum value for precipitation corresponded to October. The minimum precipitation was noticed during summer period and especially July.

- The highest PM10 levels are mainly connected to winds from west-northwestern to north-northwestern, east-southeastern and southeastern winds. High PM10 levels are also connected to eastern and eastern-northeastern winds with lower wind speed values In an effort to identify the sources contributing to PM10 concentration, primary conclusions can be drawn. On the other side, the nocturnal urban breeze originating from south-east seems to have a significant impact on PM10 levels through particles transportation.

In conclusion, as mentioned previously, the aim of the present report was to briefly describe the air quality conditions in the region of Marseille, based on the data collected from the air quality and meteorological networks. A source apportionment study which will follow in the frame of APICE project will lead to focused conclusions on the main sources contributing to PM levels. The role of the ports emissions, in combination with the meteorological pattern of each area will be extensively examined.

SOURCES

- ***Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air.***
- ***Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe***
- ***Directive 2004/107/EC of the European Parliament and of the Council relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.***
- ***United Nations Convention on the Law of the Sea***
- ***World Shipping Council***
- ***International Shipping Federation***
- ***Port State Control***
- ***International Association of Ports and Harbors***
- ***International Marine time Organizations***
- ***International Convention on the prevention of Pollution from Ships***
- ***Sulphur Oxide Emission Control Areas***
- ***Protocol 1978 Relating Thereto***
- ***MEPC 176(58)***
- ***2008/50/EK Directive***
- ***MARPOL (ANNEX VI)***
- ***Directive 2005/35/EU***
- ***Marine Strategy Framework Directive 11/12/2007***
- ***ICZM***
- ***COM446/2005***
- ***Directive 1999/32/CE***
- ***DM60/2002***
- ***www.shippingandco2.org***

- ***www.cleanairatsea.com***
- ***www.dnv.com***
- ***www.aircm.org***
- ***www.maricopa.gov***
- ***http://eur-lex.europa.eu***

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ANNEX I

OLFACTORY POLLUTION

Over MPM area, olfactory pollution leads to frequent complaints for the quality of life. Olfactory survey is a regional mission given to AIRFOBEP (driver) and ATMOPACA. It is a part of the global approach, incited by the Permanent Secretary for Industrial Pollution, to decrease olfactory pollution. The objectives of the regional olfactory survey are:

- To manage and to develop olfactory pollution survey tools
- To determine areas with a high inconvenience and to help for olfactory source identification
- To inform public and partners about olfactory inconveniences

SURVEY TOOLS

VOLUNTARY NOSE INJURY

Composed of inhabitants, nose jury is involved in observation campaigns. During these campaigns, each “nose” notes, at a precise time, its olfactory observations: Is there an odor? Is it irritating? How to characterize it?

A permanent jury is located over Berre pond area since 2001. Over the eastern part of Bouches-du-Rhône department (Aix-en-Provence and Marseille), a jury has run from 2001 to 2004. Some juries of specific noses are frequently mobilized into carrying out these observation campaigns over areas where several complaints have been recorded.

COMPLAINT COLLECTION

Spontaneous observations or complaints are recorded during irritating odor events into a database. A free telephone number is available to signal all irritating olfactory.

2009 OSERVATIONS

More than 10 000 olfactory observations have been carried out by the permanent jury in 2009.

Between 600 and 1 100 observations are monthly recorded. The highest nose participation has been recorded during May, the lowest during July. Observations are carried out close to Berre pond border and over the North-western part of Bouches-du-Rhône department.

PERSEPTION RATE

Permanent jury observations show that the mean olfactory perception rate, over Berre pond area, stays stable in 2009 in comparison to the two last years (between 12% and 13%). The monthly perception rate is recorded during July with 20%.

In 2009, 1 observation for 10 has lead to an irritating olfactory perception over Berre pond area. The olfactory perception rate varies between and inside cities.

OLFACTORY COMPLAINTS

During 2009, about 2 070 complaints have been recorded for Provence-Alpes-Côte d'Azur (PACA) region. 86% of complaints come from Bouches-du-Rhône department. Complaint number has increased of 15% between 2008 and 2009.

ANNEX II

PROJECTS

1. FORMES: Organic Fraction of urban Aerosol: methods for source apportionment

The objectives of the program FORMES were to assess several source apportionment methods in urban environments and to define the requirements for these methods. A very large effort was put into 2 field campaigns for the physicochemical characterization of PM, one in Marseilles during summer, and another in Grenoble during winter. The concentrations of more than 120 chemical species in PM2.5 were measured in each campaign with a time resolution of 12hr for periods of 15 days. These also included measurements of EC, OC, 14C, HULIS, and functional groups of organic matter. These off line measurements were completed by on line investigations conducted with AMS, VHT-DMA, aethalometer, and SMPS.

Several methods were tested: CMB (« Chemical Mass Balance ») using concentrations of chemical tracers; deconvolution of the AMS signal with a PMF (Positive Matrix Factorization) approach; deconvolution of the aethalometer signal. Among the main results, one should note:

- A rather good agreement between the different methods, despite their very different bases,
- The evidence of the large impact of photochemical production in summer in Marseilles, together with the impact of industrial sources (particularly when particle number is concerned),
- The very dominant impact of biomass burning sources in winter in Grenoble,
- The application of the CMB method is possible with a limited set of tracers (about 15), that can be measured on the same sample; however, the extension of the method will require the development of a dedicated set of source profiles,
- The optical method using an aethalometer seems effective, providing further validation, in simple winter situations for the apportionment of biomass combustion,
- The efficient synergy between the CMB and AMS-PMF method for the apportionment of the secondary organic fraction, including the distinction between “actual AOS” and aging of a primary fraction,
- A real interest in the association of such studies in receptor sites with aerosol modeling.

Final Scientific report can be found here:

http://gsite.univ-provence.fr/gsite/Local/lcp-ira/dir/img%20FORMES/Rapport%20final%20FORMES%20Science.pdf

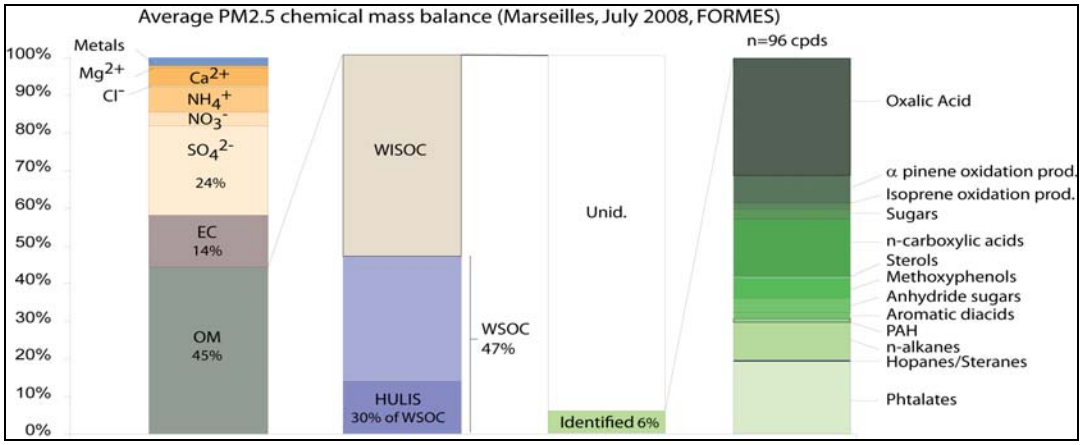

Figure 36: Average PM2.5 chemical mass balance over Marseille

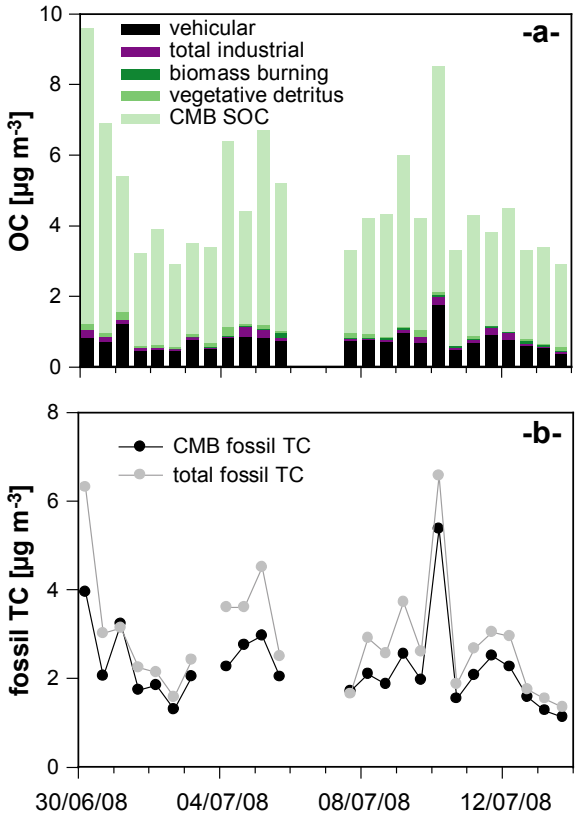

Figure 37: ***-a-*** *Source contributions to ambient organic carbon (OC) determined by the CMB modelling.* ***-b-*** *Comparison of TC fossil fractions resolved by* ^{14}C *and CMB modeling (sum of TC (OC+EC) emitted from mobile sources and industrial sources).*

Focus on Marseille: CMB source apportionment (July 2008)

The following text is extracted from El Haddad et al, 2010a.

Figure (37-a) represents the time series of source contribution estimates obtained by the CMB. Among the sources considered here, vehicular emission is the dominant source of primary OC during the whole sampling period, accounting on average for 17% of the total mass (Figure 37-a). Vegetative detritus and biomass burning are minor sources, contributing to 2.0% and 0.8% of the total OC, respectively.

Industrial emissions contribute on average for 2.3% of the total OC mass. Their relative contribution does not exceed 7% even on events ascribed to industrial emissions. However during industrial events, SMPS measurements show very sharp bursts of

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particles smaller than 80 nm associated with increases in SO2 concentrations (Figure 38). Even if the total concentration of submicron particles (11-1000nm) can reach up to 10^5 cm-3 over Marseille during industrial events, these particles do not contribute significantly to the total mass. In terms of total submicron particle number the influence of industrial emissions over Marseille can be roughly assessed by isolating these specific industrial events from urban background particle number concentrations. Industrial particle events were defined according to SO_2, PAH and metals concentration levels, and local wind direction associated with MM5 wind field's forecasts. The submicron particle number average concentration is 19300 cm^{-3} during the whole field campaign period. Excluding the industrial events periods, this average concentration decreases to 14100 cm^{-3}. Consequently the impact of industrial events on the total submicron particles number can be estimated to about 27%, more than 10 times higher that the impact on OC mass concentration. Moreover, industrial emissions dominate the ambient concentrations of heavy metal and PAH (Figure 37 in supporting information), which is a noteworthy result as in urban areas PAH are usually attributed by CMB to vehicular emissions, in absence of biomass burning or coal combustion.

Another key point highlighted in the figure 37 is that the aggregate contributions from primary sources represents on average only 22±5% of OC. As a result, the majority (~78%) of the OC remains un-apportioned (Figure 37-a). Under-apportionment of ambient OC by CMB modeling has often been reported for summertime measurements and the un-apportioned fraction is classically associated with SOA. This fraction will be subsequently referred to as "CMB SOC". The high contribution of the CMB SOC fraction observed here is consistent with the preliminary PCA analyses.

The source increments assessed by the CMB are compared with 14C results in the

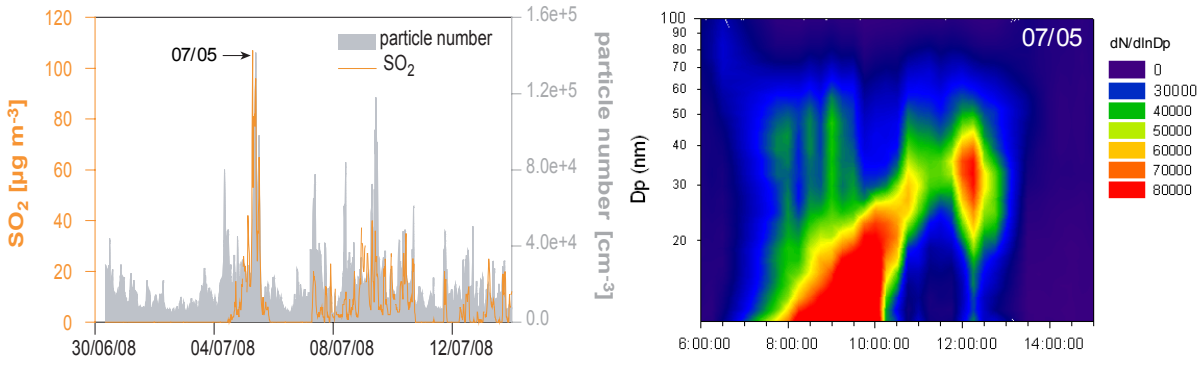

Figure 38: *Time series over the sampling period of SO_2 [µg m^{-3}] and particle total number [cm^{-3}] measured using a SMPS (11-1000nm). The evolution of particle distribution is also illustrated in the case of 05 July, when the sampling site was downwind of the industrial area*

Figure 37-b. The latter approach apportions the fossil and contemporary fractions of carbon that can be oxidized at 850°C under oxygen, thus denoting the total carbon (EC+OC). For comparison purposes, sources resolved by the CMB approach are further classified into two categories as having fossil or modern origins. Fossil sources consist of total carbon from vehicular emissions, industrial emissions and natural gas combustion whereas modern sources include wood combustion and vegetative detritus. For each source type, the CMB apportioned EC is added to the apportioned OC to get the total carbon. Figure 37-b illustrates the estimate of total fossil carbon obtained by the two independent methods (14C and CMB). A strong correlation exists between the two approaches (R2=0.87, n=23), underscoring the proper choices in the selected sources and profiles. The quasi systematic difference (~28%) between the two methods can most likely be related to SOA from fossil origins but also with the other sources of uncertainties in the CMB (like chemical degradation of organic markers or missing primary sources). However, the very good agreement between the two methods highlights that the uncertainties related to assumptions underlying the CMB approach does not significantly affect the different primary sources contributions.

Figure 39 shows the time series of the ambient PM2.5 mass apportioned by CMB. Primary sources considered by the CMB contribute only to a small fraction of the ambient PM2.5. For example, the average contributions to total PM mass from motor vehicles, industries, vegetative detritus, and biomass burning are 17, 7.1, 1.6 and 0.52%, respectively. Such estimates for the aggregate contributions of primary sources of PM2.5 (~26% on average) fall towards the low end of the range of previous CMB modeling studies performed in urban areas. Contribution of geological dust and sea salt are not represented in the Figure S3. However, considering Al as a marker of urban dust and a PM-to-Al ratio of 10, this contribution can be estimated to less than 2%. Likewise, based on Na+ concentrations, sea salt can be estimated to contribute between 0.08% and 6.4% (average 1.3%) of the total PM2.5 mass. The most important conclusion is that ambient

PM2.5 concentrations are governed by secondary species. Un-apportioned organic PM (CMB SOA), much of which is likely SOA, is the largest contributor (43%), followed by inorganic ions of secondary origins that account on average for 31% of the PM mass.

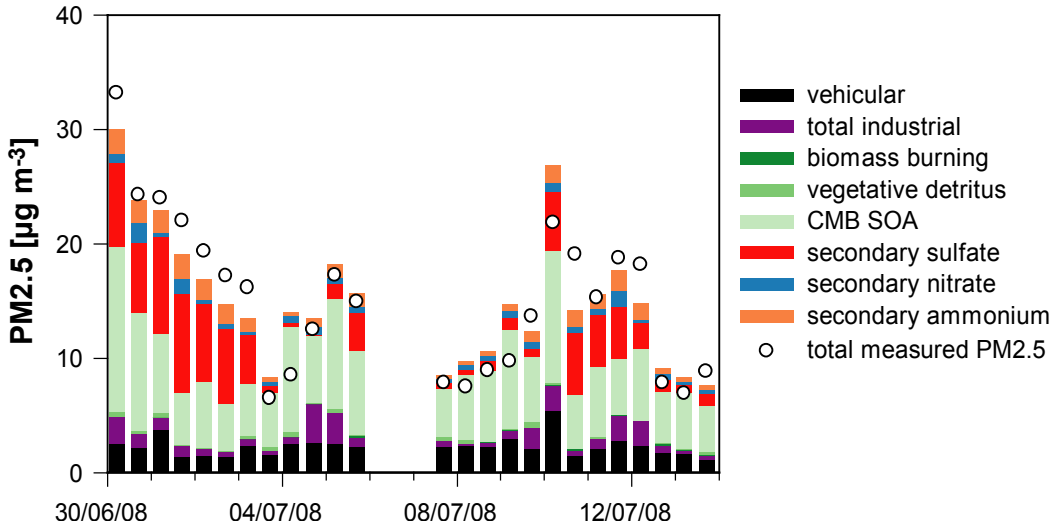

Figure 39: *Source contributions to fine particulate matter ($PM_{2.5}$) estimated by CMB modelling. Also shown are the concentrations of $PM_{2.5}$ measured by TEOM-FDMS (white circles).*

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2. BOND: BiOgenic Aerosols and Air Quality in the Mediterranean area.

The project focuses on two representative Mediterranean regions with important biogenic emissions and sufficient degree of diversity (Marseille, Athens). However, the overall methodology should be applicable to any other European region. Major milestones include:

- Establishment of mechanisms of Secondary Biogenic Organic Aerosol (SOA) formation based on targeted smog chamber experiments.
- Definition of relevant methodology and development/validation of anthropogenic and biogenic emissions inventories conforming to model requirements.
- Improvement and validation of a 3-D aerosol/photochemical/radiative modeling tool to assess the biogenic contribution to aerosols and account for the influence of secondary organic aerosol in global warming and consequently climate change

Further information: http://milos.ipta.demokritos.gr/bond/

3. SIMPYC project (Environmental impacts on ports upon their cities - Valencia, Spain; Livorno, Italy; Toulon, France)

The frontier between port and city has become a focal point for a wide range of tensons of an urban, environmental and social nature.

Cities and their ports need to look for solutions to the problems that arise from the relationship port-city, in order to find sustainable solutions that will contribute to a more harmonious coexistence, in functional and environmental terms, between ports and cities (http://www.simpyc.info/en/).

4. ESCOMPTE: A campaign to study atmospheric pollution at the regional scale: the Escompte program

The Escompte program was set up to improve and validate regional scale chemistry-transport numerical models enable to reproduce, as detailed as possible, atmospheric pollution situations.

During summer 2001, an ambitious field campaign (about 80 French and foreign teams, a huge quantity of instruments deployed like planes, boats, lidars, radars, sodars, mobile laboratories, radiosonde explorations...) collected plenty of data on the meteorological and chemical parameters of the atmosphere during some photo-oxidant pollution events.

Performed in the region of Marseille city and Berre Lake, this campaign constitutes one of the major operations in this field and a real opportunity for the region of Provence-Alpes – Côte d'Azur as regards of air quality control.

Because of his strong involvement in ESCOMPTE European campaign, Atmo PACA now has skills on emissions monitoring over the PACA region. The data sets are managed by a specialist engineer. The inventory consists of an hourly data set, on a 1 km^2 base. The reference year is 2004.

Further information: http://escompte.mediasfrance.org/

ANNEX III

PUBLICATIONS

- Albinet A, Suptil J, Combet E, Piot C, El Haddad I, Marchand N, and Besombes JL (2009) Development and evaluation of a high flow atmospheric denuder (HFAD) for the study of organic particulate matter. *Atmos. Envir.,* submitted.

- Baduel C, Voisin D, and Jaffrezo JL (2010) Seasonal variations of concentrations and optical properties of water soluble HULIS collected in urban environments. *Atmos. Chem. Phys.,* 10, 4085-4095.

- Dron J, El Haddad I, Temime-Roussel B, Jaffrezo JL, Wortham H, and Marchand N (2010) Functional group composition of ambient and source aerosols determined by tandem mass spectrometry. *Atmos. Chem. Phys.,* 10, 7041–7055, 2010. doi:10.5194/acp-10-7041-2010

- Favez O, El Haddad I, D'Anna B, Boréave X, Piot C, Themine B, Voisin D, Besombes JL, Sciare J, George C, Marchand N, and Jaffrezo JL (2010) Inter-comparison of source apportionment models for the estimation of wood burning aerosols at wintertime in a French Alpine city (Grenoble, France). *Atmos. Chem. Phys.,* 10, 5295-5314. doi:10.5194/acp-10-5295-2010.

- Lanz VA, Prévôt ASH, Alfarra MR, Mohr C, DeCarlo PF, Weimer S, Gianini MFD, Hueglin C, Schneider J, Favez O, D'Anna B, George C, and Baltensperger U. (2010) Characterization of aerosol chemical composition by aerosol mass spectrometry in Central Europe: an overview. ACPD, 9, 24985-25021. http://www.atmos-chem-phys-discuss.net/9/24985/2009/acpd-9-24985-2009.pdf

- Piot C, Jaffrezo JL Besombes JL, Pissot N, Cozic J, El Haddad I, and Marchand N (2010) Determination of levoglucosan and its isomers by High Performance Liquid Chromatography-Electrospray Ionization tandem Mass Spectrometry and its application to atmospheric and soils samples. In preparation.

- El Haddad I, Marchand N, Wortham H, Piot C, Besombes JL, Jaffrezo JL, Cozic J, and Robin D (2010a) Primary sources of PM2.5 particles in an industrial Mediterranean city, Marseille. *ACPD*, submitted.

- El Haddad I, Marchand N, Temime-Roussel B, Wortham H, Piot C, Besombes JL, Baduel C, Voisin D, and Jaffrezo JL (2010b) Insights into the secondary fraction of the organic aerosol in a Mediterranean urban area: Marseille. *ACPD*, submitted.

- El Haddad I, Marchand N, Dron J, Temime-Roussel B, Wortham H and Jaffrezo JL (2010) Influences of sources and chemical processes on the fictionalization of organic aerosol. In preparation.

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