

# SIMPYC PROJECT

**AIR QUALITY OF THE CITIES OF TOULON AND LA SEYNE-SUR-MER:  
COMPARISON BETWEEN DOWNTOWN AND PORTS**



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# 1. PRESENTATION

## 1.1. PRESENTATION OF ATMO PACA

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Atmo PACA is a French Approved Association of Air Quality Monitoring (AASQA). It covers the east of Bouches-du-Rhône, Var, Alpes-Maritimes, Vaucluse, Alpes-de-Haute-Provence and Hautes-Alpes departments. Atmo PACA is born from the fusion of Airmaraix and Qualitair (20<sup>th</sup> October 2006).

The monitoring of air quality on the Var department is ensured since 1996, by Airmaraix then by Atmo PACA.

## 1.2. OBJECTIVES

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This monitoring campaign is carried out at the request of the Var Chamber of Commerce and Industry (CCI Var), within the framework of the SIMPYC LIFE ENVIRONMENT program. Its goals are the study of the influence of the harbour area on the urban area which surrounds it on air quality.

The study concerns the commercial ports of the Toulon urban area and the urban zones which surround them, excluding the naval port. The considered areas are mainly the sector of the Toulon harbour, on the "Darse Vieille", the dock of Mourillon and the area in the vicinity of the commercial port of Brégaillon (see Figure 2, page 5).

This work is integrated in a broader study of the port and city air quality, within the framework of the project SIMPYC, which contains three phases:

- An analysis of the studied area (weather, relief, pollutant emissions, exposed population, significant establishments...)
- An air quality monitoring campaign on the area (object of this report)
- The cartography and analysis of the results of this study
- Proposal of an operational air quality monitoring of the port.

The objectives of this campaign, targeted on the port, are mainly:

- Determination of the air quality on the harbour area and in its close environment,
- Comparison to the applying standards (limit values, quality objectives).
- Level of potential exposure of the residents to the air pollution.
- Evaluation of the representativeness of the permanent monitoring sites on the harbour zone.

The measurements carried out during this campaign are made at ground level. The possible effects of plumes resulting from the boats chimneys on high buildings cannot be observed by this method.

## 1.3. SYNERGY

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The monitoring campaign, centered on the harbour area, complete the information available to Atmo PACA on the Toulon urban area (6 permanent monitoring sites and preceding studies undertaken on this territory) (AIRMARAIX 2002, 2003).

Two other monitoring campaigns carried out by Atmo PACA were held on Toulon at the same time as SIMPYC study:

- A study complementary to the AirProche program on the downtown area of Toulon, in collaboration with the French Agency of Medical Safety of the Environment and Work (AFSSET). It aims at establishing high resolution cartography of air pollution (AFSSET 2007 and Atmo PACA, 2007).

- A monitoring campaign on the pilot of mud treatment on the harbour area of Brégaillon, in collaboration with Toulon Provence Méditerranée (TPM).

These two campaigns make it possible to bring a higher degree of accuracy on estimating the annual means with the data of the SIMPYC campaign, and thus to facilitate the exploitation of the results.

## 1.4. RESOURCES FOR THE MONITORING CAMPAIGN

The evaluation of air quality focus mainly on the indicators of pollution related to transport and harbour activities (nitrogen dioxide, sulfur dioxide and volatile organic compounds). Measurements are carried out by passive samplers, supplemented by 24h/24 measurements resulting from automated analyzers. The analyzers are those of Atmo PACA's permanent monitoring network, as well as Atmo PACA's mobile laboratory. These were mobilized at the same time for another campaign on the perimeter of the port of Brégaillon (on the site of the pilot of harbour mud treatment).

*Figure 1: Passive sampler for BTX measurement, in its shelter*



The sampling plan aims at covering two types of environment:

- Urban site - situation out of direct influence of the roads with heavy traffic (background site).
- Harbour observation site - covering the zones representative of the maximum level to which the bordering population of a fixed source is likely to be exposed, by phenomena of plume (at ground level) or accumulation.

Measurements are taken on the level of the ground, which do not make it possible to take into account the possible effects of plume in height related to the boats chimneys.

Measurements (about fifteen points of measurement) are carry out by couple (according to the reality of ground) : a measurement on the dock; a measurement on the inhabited part nearest of the port. The other data around this perimeter (outside the perimeter defined by the CCI) are provided by Atmo PACA from the existing modeling. The two data sources are necessary to carry out the cartography of the ports (pollution spatialization).

The means of measurement deployed during the program are supplemented by the numerical tools for processing data, making it possible to chart and model pollution.



Figure 2: Sampling during the SIMPYC monitoring campaign

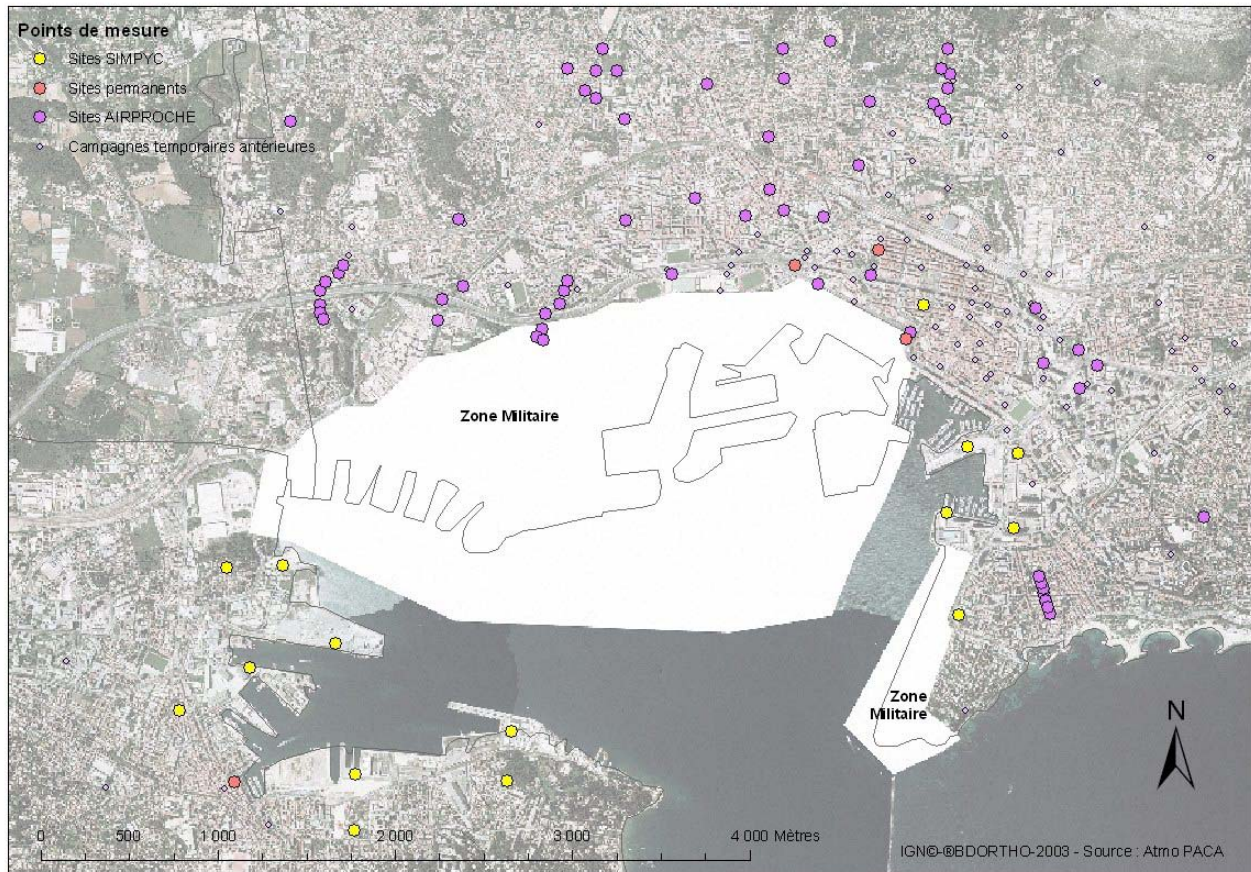
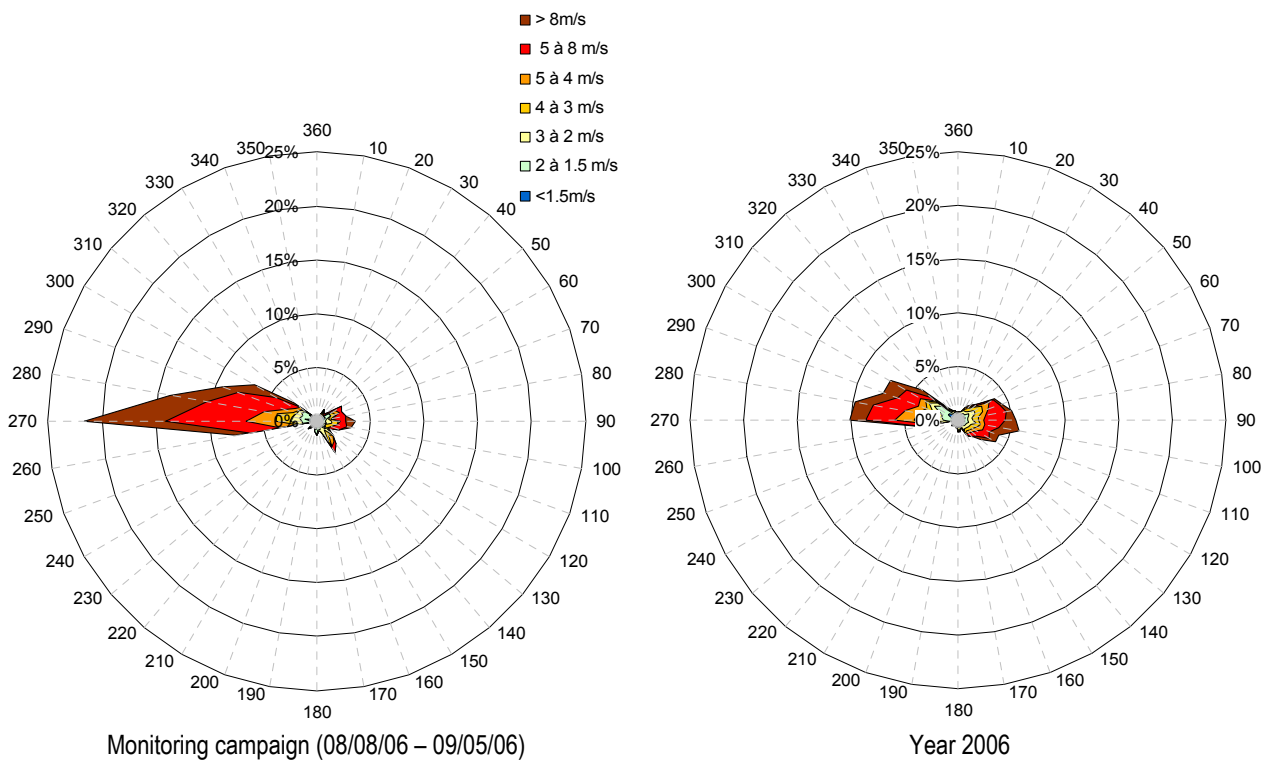


Figure 3: Wind roses during the SIMPYC monitoring campaign and the year 2006 (Toulon La Mitre monitoring site, from Météo-France)



## 2. RESULTS – DISCUSSION

### 2.1. RESULTS

#### 2.1.1. OBSERVED CONCENTRATIONS DURING THE CAMPAIGN MEASUREMENT

The period of the monitoring campaign (August the 8<sup>th</sup> to September the 5<sup>th</sup> 2006) is characterized by a dispersive windy period (cf. Figure 3, page 5). The observed concentrations during this interval are thus relatively low compared to the usual levels observed over a one year average with the permanent sites (cf. Table 1 below, Figure 4 page 7 and Figure 5 page 8).

*Table 1: Pollution levels recorded on the Toulon ports during the SIMPYC campaign*

N°	Monitoring sites	NO <sub>2</sub>	Benzene	Toluene	Xylenes*	PM <sub>10</sub>	SO <sub>2</sub>
81	Mud treatment pilot	19	0.7	2.6	3.4	30	2
82	Chemin de la colline (la Seyne)	18	0.6	2.6	3.7	/	1
83	Brégaillon loading zone	19	0.5	2.3	3.3	/	2
84	Brégaillon activity zone	19	0.6	3.3	4.6	/	4
85	Jules Verne school	19	0.8	3.9	5.3	/	1
86	La Seyne port	18	0.6	2.7	3.4	/	1
87	Chemin des Mouissèques	18	0.7	3.7	4.7	/	1
88	Boat selling	18	0.5	2.6	3.1	/	2
89	Rue Charles Tournier	17	0.7	3.1	4.1	/	5
90	Rue de Langeron	20	0.8	3.7	4.4	/	3
91	Toulon marina	19	0.6	3.6	4.4	/	2
92	"Port Marchand" Gymnasium	22	1.0	6.1	7.3	/	4
93	Minerve quay	24	0.7	3.7	4.8	/	3
94	Rue Marc Baron (SPA)	26	1.1	6.5	7.4	/	7
95	Rue de la Paix	28	1.0	5.2	6.4	/	1
96	Permanent site Toulon Chalucet	25	0.8	3.7	4.2	26	2
97	Permanent site Toulon Foch	47	1.3	6.8	8.7	31	1
98	Permanent site La Seyne	24	1.0	4.8	6.3	/	1
99	Permanent site Toulon Arsenal	19	/	/	/	/	/

\* Xylenes: sum of Ethylbenzene and ortho, meta and para-xylenes

Values in µg/m<sup>3</sup>

In order to compare these results with the standards in force, it is necessary to bring back the values measured during the campaign to an **annual mean**. The annual average concentrations can be estimated from the study of the permanent monitoring sites (cf. chapter 2.1.2. Estimation of annual means, page 9).

#### **THE CASE OF H<sub>2</sub>S**

H<sub>2</sub>S is measured on 6 sites of the campaign within the framework of the evaluation of the impact of the harbour mud treatment station (5 sites around Brégaillon and 1 on the permanent site Toulon Chalucet as a reference). The measured concentrations are systematically lower or equal to the limit of detection (0.2µg/m<sup>3</sup>). Levels of H<sub>2</sub>S are thus insignificant on this area.



Figure 4: Map of NO<sub>2</sub> means measured during the SIMPYC campaign

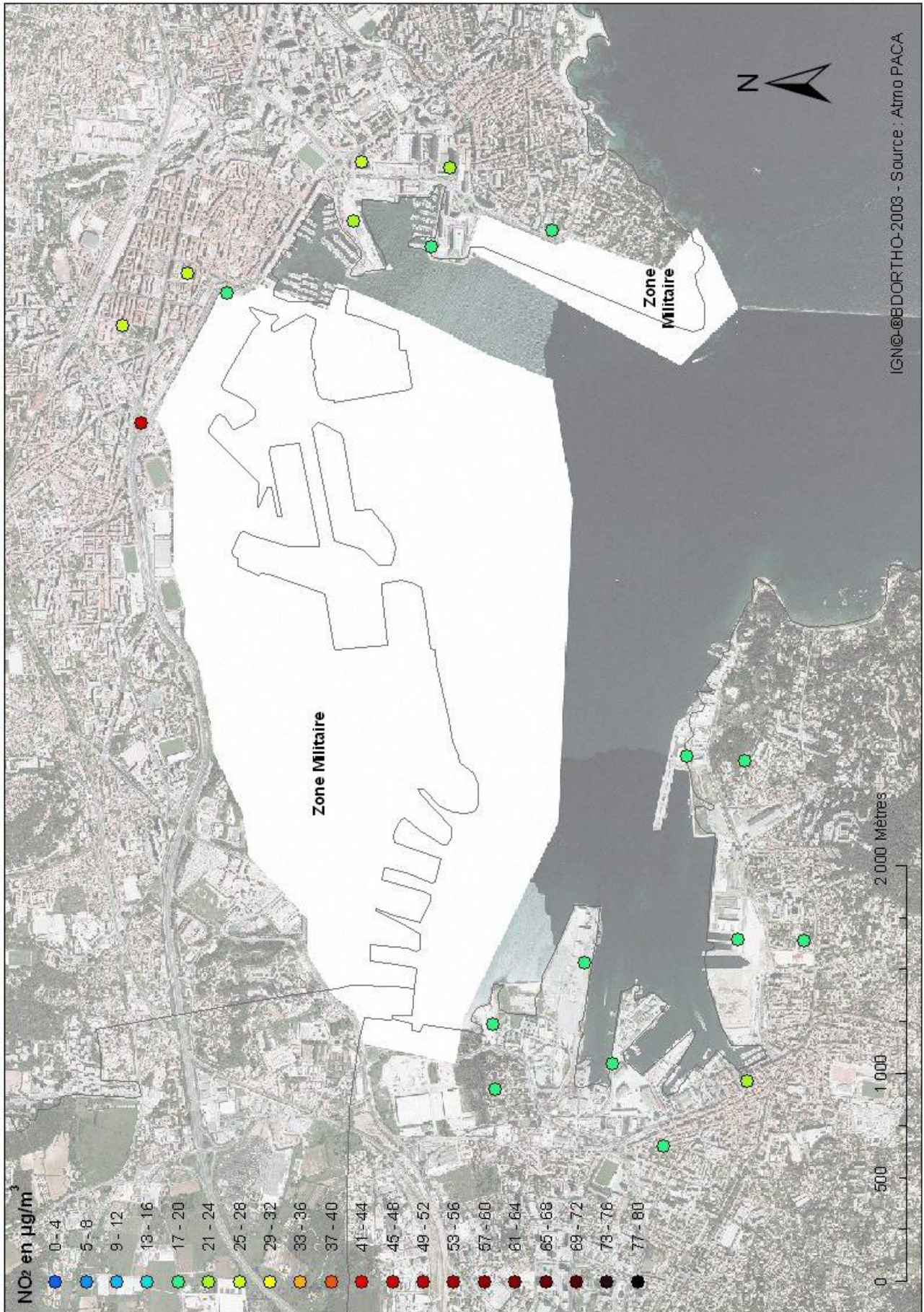
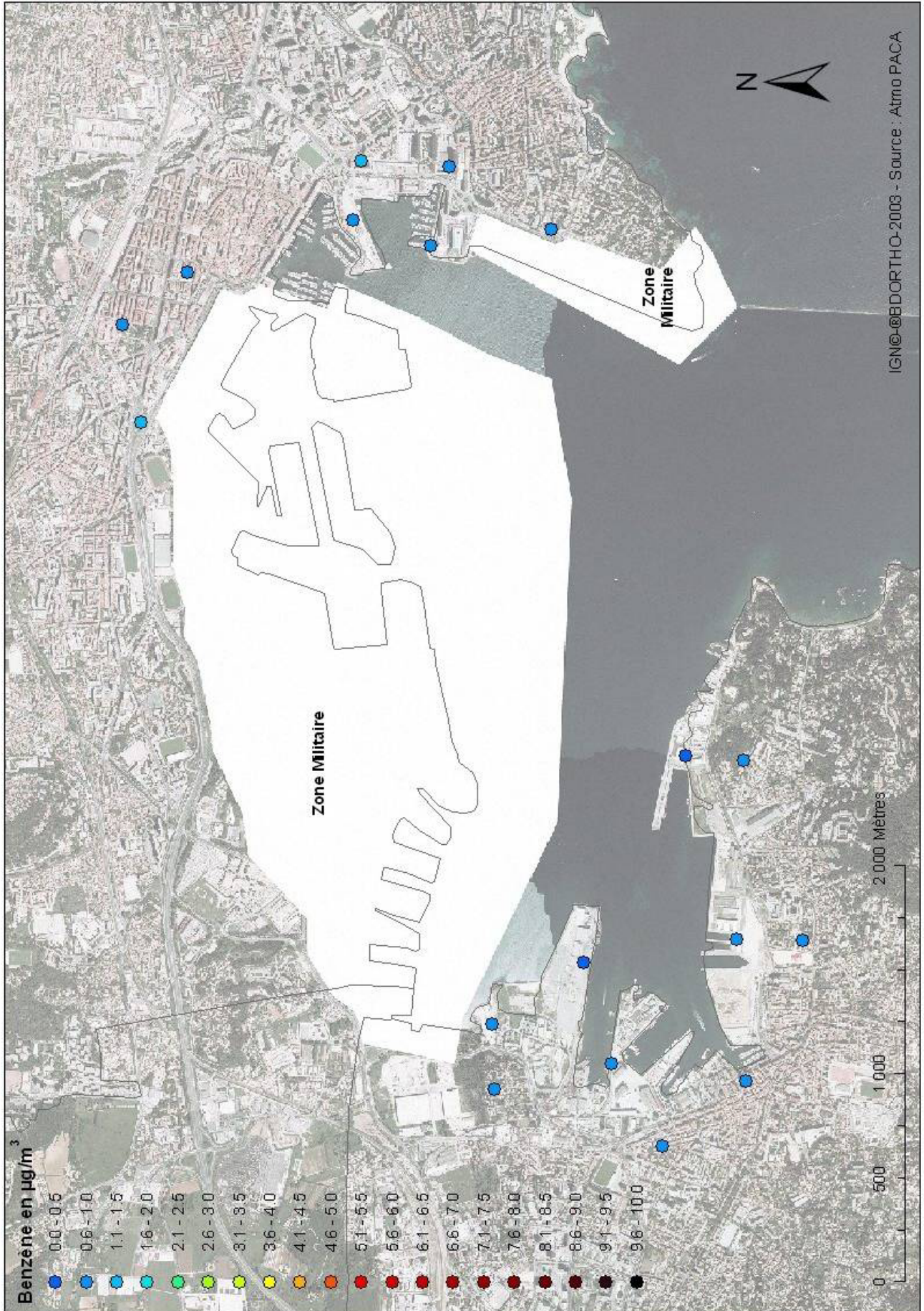




Figure 5: Map of benzene means measured during the SIMPYC campaign





## 2.1.2. ESTIMATION OF ANNUAL MEANS

In order to estimate the annual mean for a given pollutant, the pair of data (campaign mean; Annual mean) of each **permanent** site of the zone is collected. The linear relation between all these pairs is then calculated. The following equations are then deducted, along with the coefficient of correlation between annual means and campaign means:

- NO<sub>2</sub> : [Ann. mean] = 0.98 x [Campaign mean] + 12.1 (Coefficient of correlation R=0.97)
- Benzene : [Ann. mean] = 2.20 x [Campaign mean] + 0.09 (Coefficient of correlation R=0.98)
- Toluene : [Ann. mean] = 1.36 x [Campaign mean] + 2.32 (Coefficient of correlation R=0.96)
- Xylene : [Ann. mean] = 1.12 x [Campaign mean] + 3.05 (Coefficient of correlation R=0.96)
- PM<sub>10</sub> : [Ann. mean] = 1.23 x [Campaign mean] - 4.07 (Coefficient of correlation R=0.77)
- SO<sub>2</sub> : Not enough permanent sites to estimate the annual mean

These equations are applied to the results of the campaign, for each pollutant. The same technique is applied on the results of the complement of the AirProche campaign which was held at the same time. The obtained results appear in Table 2 below, on Figure 6 and on Figure 7, page 10.

In the case of the SO<sub>2</sub>, the annual mean cannot be estimated. However, the concentrations measured during the campaign are very low, far from the standards and under the lower assessment threshold for this pollutant (8 µg/m<sup>3</sup>). The precise evaluation of the annual concentrations of this pollutant is thus less necessary.

**Table 2: Annual estimated 2005 means on the SIMPYC campaign sites**

N°	Monitoring sites	NO <sub>2</sub>	Benzene	Toluene	Xylenes*	PM <sub>10</sub>	SO <sub>2</sub> (campaign)
81	Mud treatment pilot	28	1.5	6.3	6.9	<b>33</b>	2
82	Chemin de la colline (la Seyne)	30	1.4	6.3	7.2	/	1
83	Brégaillon loading zone	31	1.1	6.0	6.7	/	2
84	Brégaillon activity zone	31	1.5	7.0	8.3	/	4
85	Jules Verne school	31	1.8	7.6	9.0	/	1
86	La Seyne port	29	1.4	6.4	6.9	/	1
87	Chemin des Mouissèques	30	1.7	7.3	8.3	/	1
88	Boat selling	29	1.3	6.3	6.6	/	2
89	Rue Charles Tournier	29	1.6	6.7	7.6	/	5
90	Rue de Langeron	32	1.9	7.4	8.0	/	3
91	Toulon marina	31	1.4	7.3	8.0	/	2
92	"Port Marchand" Gymnasium	34	<b>2.2</b>	9.8	11.2	/	4
93	Minerve quay	36	1.7	7.4	8.4	/	3
94	Rue Marc Baron (SPA)	38	<b>2.4</b>	10.2	11.4	/	7
95	Rue de la Paix	39	<b>2.2</b>	8.9	10.3	/	1
96	Permanent site Toulon Chalucet	<b>43</b>	1.9	8.7	9.4	<b>30</b>	2
97	Permanent site Toulon Foch	<b>56</b>	<b>2.8</b>	12.9	15.6	<b>40</b>	1
98	Permanent site La Seyne	36	<b>2.2</b>	8.7	10.9	/	1
99	Permanent site Toulon Arsenal	39	/	/	/	/	/
	<b>Guidelines</b>	<b>40</b>	<b>2</b>			<b>30</b>	<b>50</b>
	<b>Limit values**</b>	<b>40</b>	<b>5</b>			<b>40</b>	

\* Xylenes: sum of Ethylbenzene and ortho, meta and para-xylenes

Values in µg/m<sup>3</sup>

\*\* Limit Values for NO<sub>2</sub> and benzene enter into force in 2010

Figure 6: Map of NO<sub>2</sub> estimated annual means–SIMPYC and AirProche campaigns

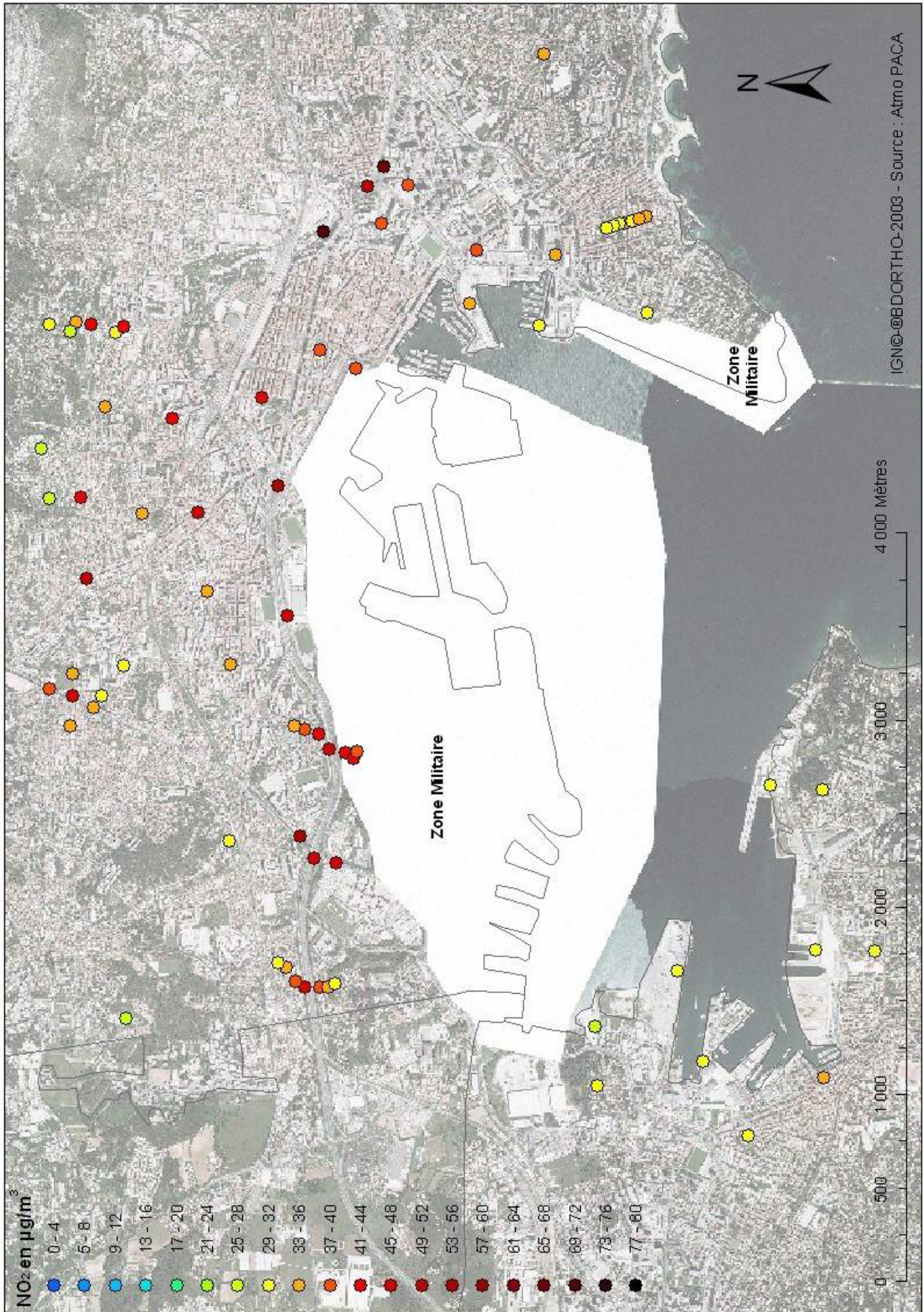
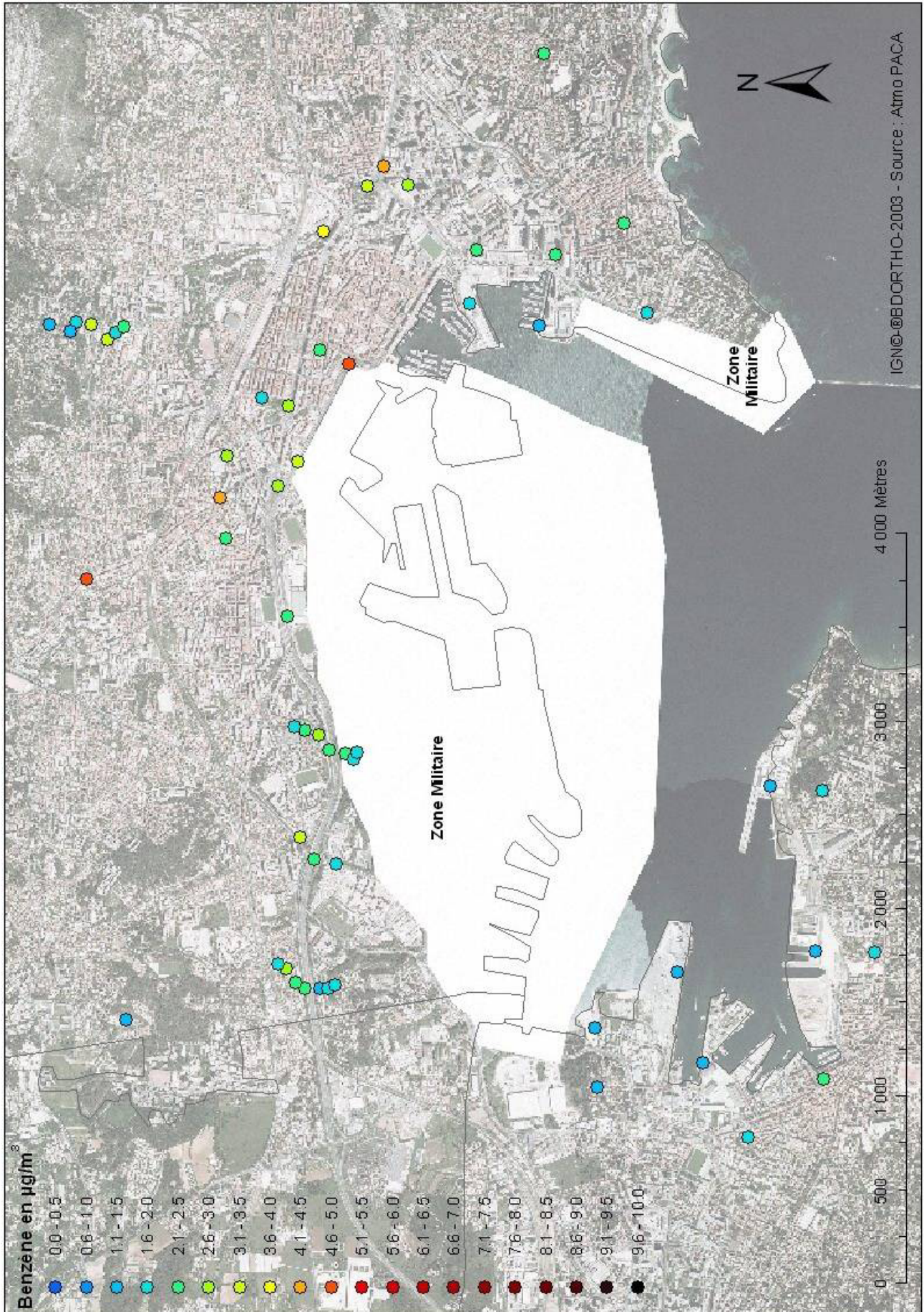




Figure 7: Map of benzene estimated annual means–SIMPYC and AirProche campaigns



## 2.2. DATA ANALYSIS

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### 2.2.1. DIFFERENCES BETWEEN THE ZONES

Resulting data from the campaign on the two studied ports are analyzed. They show few differences in concentration between the area located directly on the coast line (harbour zone of activity) and the area located just behind the first (bordering residential zone).

The levels observed on the residential area are generally slightly higher than those observed on the harbour area. This difference can be explained by an influence of the port, to which is added:

- Important traffic in the urban residential zones, involving local pollutant emissions.
- Denser buildings on the residential zone than on the harbour zone, conditions less favorable to the dispersion of the pollutants.

In addition, the whole harbour zone is subjected to pollution levels lower than those of the downtown area of Toulon, for the same reasons: the downtown area is at the same time a zone of intense pollutant emissions and a zone of high building density, reducing the dispersion of this pollution.

Generally, the mean levels of pollutants seem more influenced by the distance to the downtown area than by the distance to the ports.

The benzene/toluene ratio (B/T close to 0.2 to 0.25) is characteristic of pollutant emissions by transport on all the monitoring sites. The other sources of these compounds (industrial for example) thus seem negligible on this area.

Levels of sulfur compounds (SO<sub>2</sub> and H<sub>2</sub>S) are low or very low on the whole zone.

These observations are representative of the concentrations present at ground level. Taken measurements do not make it possible to evaluate the possible effects of high plumes from the boats chimneys.

### 2.2.2. COMPARISON WITH THE STANDARDS

The concentrations estimated over the year are lower than the 2010 limit values for NO<sub>2</sub> (40 µg/m<sup>3</sup>) and for benzene (5 µg/m<sup>3</sup>) on all the points close to the studied ports within the SIMPYC campaign.

#### Nitrogen dioxide

Estimated levels of NO<sub>2</sub> on these sites are in general moderate (around 30 µg/m<sup>3</sup>), characteristic of an urban zone. Concentrations on some points are more elevated (higher than 34 µg/m<sup>3</sup>), when the sites are located in zones of high building density and surrounded by a more important road traffic.

The case of the Minerve Quay is noticeable, as its estimated annual concentration is 36 µg/m<sup>3</sup>. The quay, with very few buildings, is in a favorable situation for pollution dispersion. In spite of that, the estimated levels are close to the limit value (for 2010), probably because of important local emissions and an influence of the close downtown area. The nearest urban point has a higher level (Street Marc Baron - SPA, 38 µg/m<sup>3</sup>).

#### Benzene

The estimated average concentrations for benzene are relatively moderate, in general lower than the guideline (2 µg/m<sup>3</sup>). Here too, the highest levels are met in the zones of denser building, with more important motor vehicle traffic.

#### Particulate matter

The concentrations were measured only on one point of the port. On this site, the guideline (30 µg/m<sup>3</sup>) is exceeded. The level of this pollutant being generally rather homogeneous, it is probable that this threshold is exceeded on most of the port.



## 3. CONCLUSIONS AND PROSPECTS

### CONCLUSION

The levels observed on the area are characteristic of pollution by transport: the principal pollutants observed are NO<sub>2</sub> and VOC, while the sulfur compounds are in small quantities. In addition, the toluene/benzene ratio is characteristic of pollution by transport (B/T close to 0.2 to 0.25).

The air pollution levels observed during the campaign are in general lower on the harbour zones than on the urban zones. The highest concentrations are observed in the vicinity of the downtown area of Toulon. The concentrations estimated over one year near the harbour zones are recalled in the table below.

*Table 3: Summary of the annual estimated concentrations on the campaign sites*

Pollutant	Concentrations	Guideline	Limit Value
NO <sub>2</sub>	28 à 39 µg/m <sup>3</sup>	40 µg/m <sup>3</sup>	40 µg/m <sup>3</sup> (2010)
Benzene	1.1 à 2.4 µg/m <sup>3</sup>	2 µg/m <sup>3</sup>	5 µg/m <sup>3</sup> (2010)
Toluene	6.0 à 10.2 µg/m <sup>3</sup>		
Xylene	6.6 à 11.2 µg/m <sup>3</sup>		
SO <sub>2</sub>	1 à 7 µg/m <sup>3</sup>	50 µg/m <sup>3</sup>	
PM <sub>10</sub>	30 à 33 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	40 µg/m <sup>3</sup>

In addition, the Toulon urban area, including the harbour zone, is subjected to important ozone concentrations in summer: each year the target value for human health protection (120 µg/m<sup>3</sup> on an 8 hour mean, not to be exceeded more than 25 days per year) is exceeded approximately 40 days on the agglomeration. Moreover, the information threshold (180 µg/m<sup>3</sup>/h) is exceeded approximately ten days each year. The emissions of the port take part locally in the ozone formation, and thus in summer pollution.

The high building density and pollutant emissions by transport in the center of Toulon constitute an unfavorable factor for the air quality of the urban zone. The harbor zones, lightly built, are more favorable to pollutants dispersion.

However, the pollutant emissions related to boats traffic could potentially have escape the measuring instruments deployed during the program, as these are emitted in height, by the ships chimney. These emissions have a behavior similar to that of a factory chimney plume. In this case, the repercussions can be observed at a certain distance, possibly directly on the urban zones or frontages of high buildings bordering the port.

### PROSPECTS

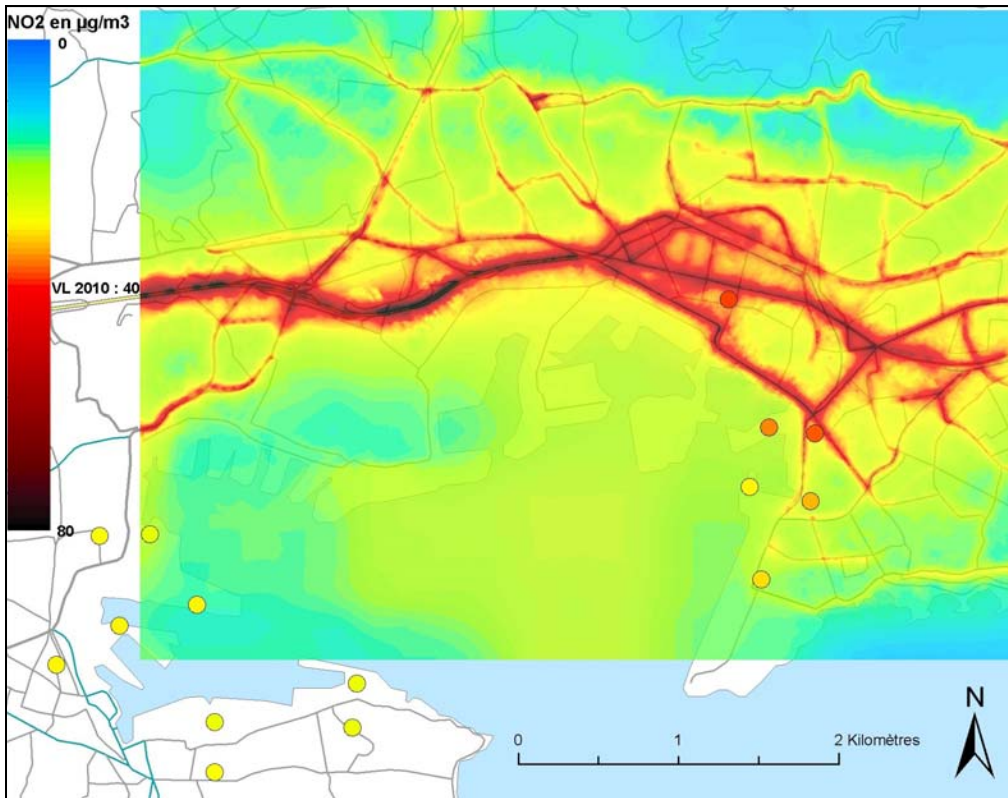
Finer analyses of the weather and pollutant emissions of the zone are necessary to evaluate the possible repercussions of the boats plumes, with a modeling of the chimneys plumes and high buildings which they possibly meet.

The campaign could also be supplemented by a finer analysis of the distribution of particles PM<sub>10</sub>, as well as by measurements of the PM<sub>2,5</sub> on the port in order to better know the composition of the aerosol on this zone.

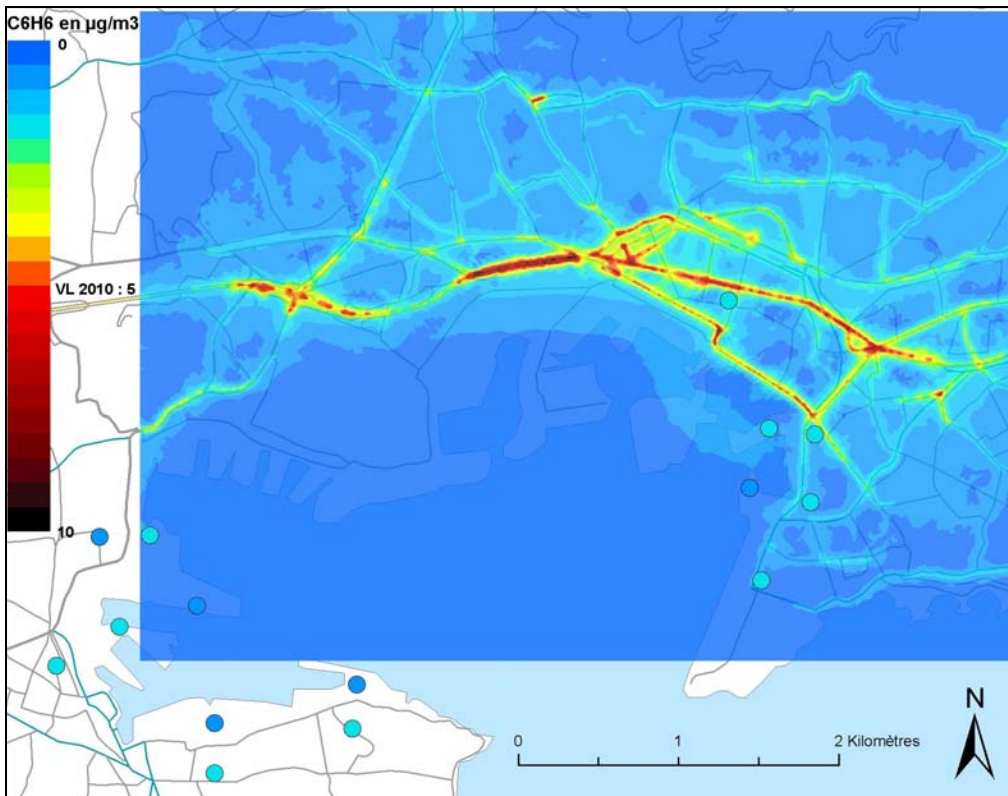
Data resulting from SIMPYC project (measurements, emissions of pollutants on the port...) could be used to refine the knowledge of the air quality of the Toulon urban area, on the harbour zone.

The current state of knowledge on this zone is synthesized in the maps resulting from the AirProche program (cf. Figure 8 and Figure 9). Moreover, the zone covered by thinner precision could be extended to the south to include all the harbours.

*Figure 8: Comparison map of NO<sub>2</sub> levels on Toulon between data from AirProche program and points from SIMPYC campaign*



*Figure 9: Comparison map of benzene levels on Toulon between data from AirProche program and points from SIMPYC campaign*





## 4. REFERENCES

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