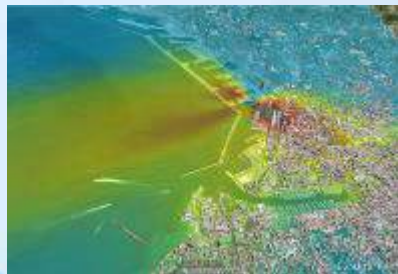


Maritime Emissions & Impact on Air Quality

Air PACA

Claicity & ClimAERA – Alcotra projects, Genova Smart week, 22 Nov. 2017



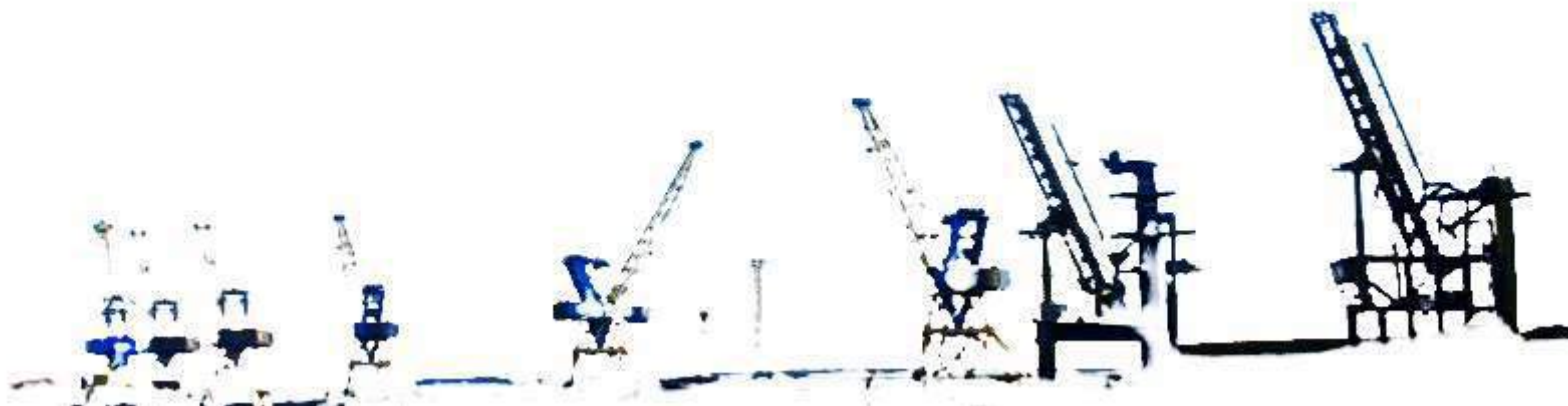
surveillance de la qualité de l'air
PROVENCE - ALPES - CÔTE D'AZUR

www.airpaca.org

► Air & Ports : context

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2017 Genova 20-24 Novembre

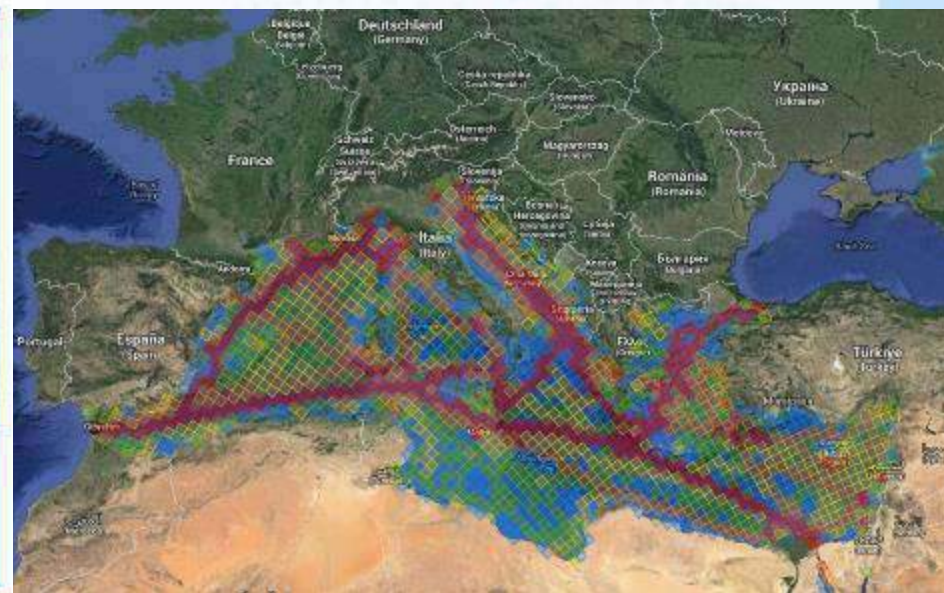
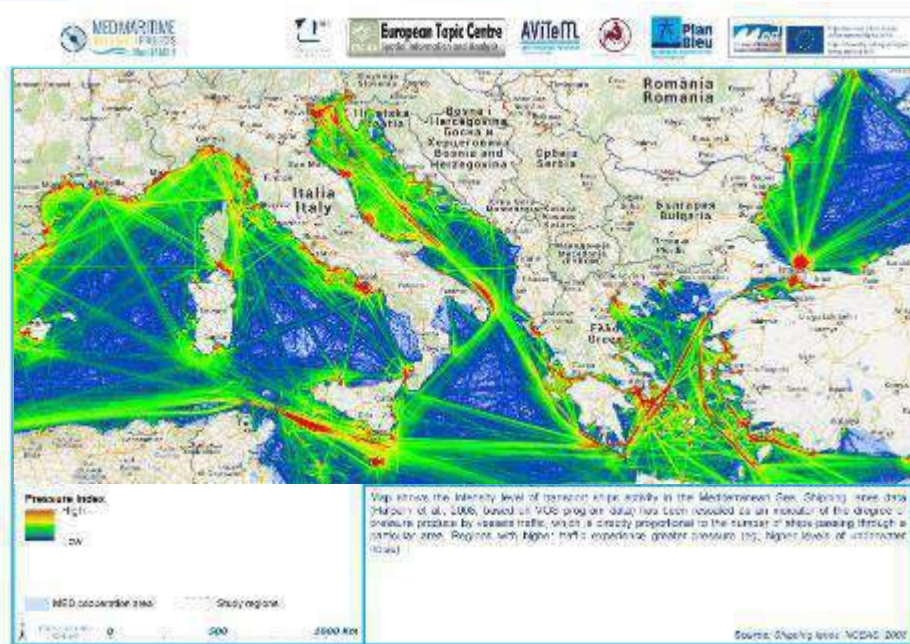
Air PACA



PORTS

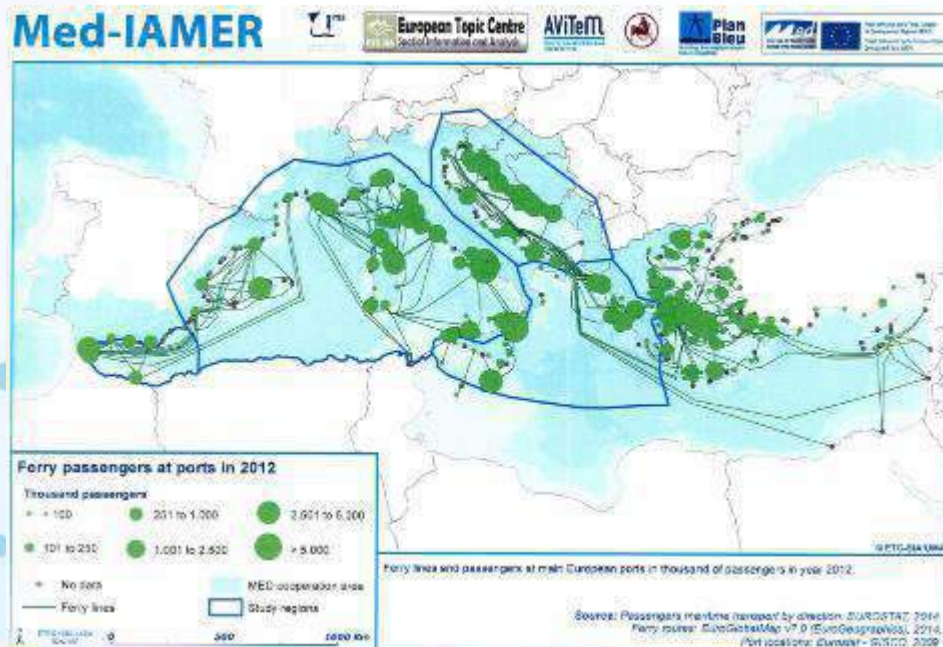
SUSTAINABLE DEVELOPMENT
CLIMAT ENVIRONMENT STUDIES HEALTH PROTECTION
GROWTH ECONOMY NORTH TOURISM ACCESS
INNOVATION FRET QUESTIONS EMISSIONS
INDUSTRIES TRANSPORT FERRIES SMARTS PORTS
ACCESSIBILITE HERITAGE INDICATORS
CRUISE INTEGRATED PROJECTS
AIR QUALITY
PROSPECT PASSENGERS
CONTROL CAPITALISATION
ELECTRIC CONNECTIONS
SOLUTIONS
MED PROGRAM
MED ZONE
SOUTH

Maritime Axis - Emissions

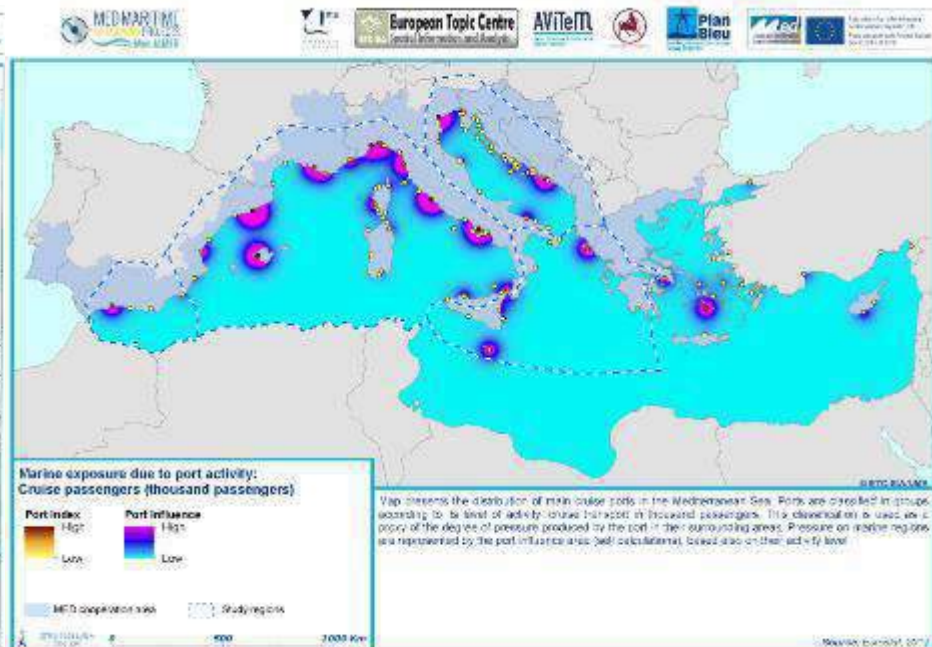


NOx emissions in 2012 from SNAP 08 - Source EMEP

Ferry



Cruise



Air & Ports : Pax Evolution

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2013 : 1 700 000

+ 41 %



2007 : 1 000 000

2013 : 2 400 000

+ 33 %



2007 : 1 600 000

2013 : 1 165 000

+ 65 %



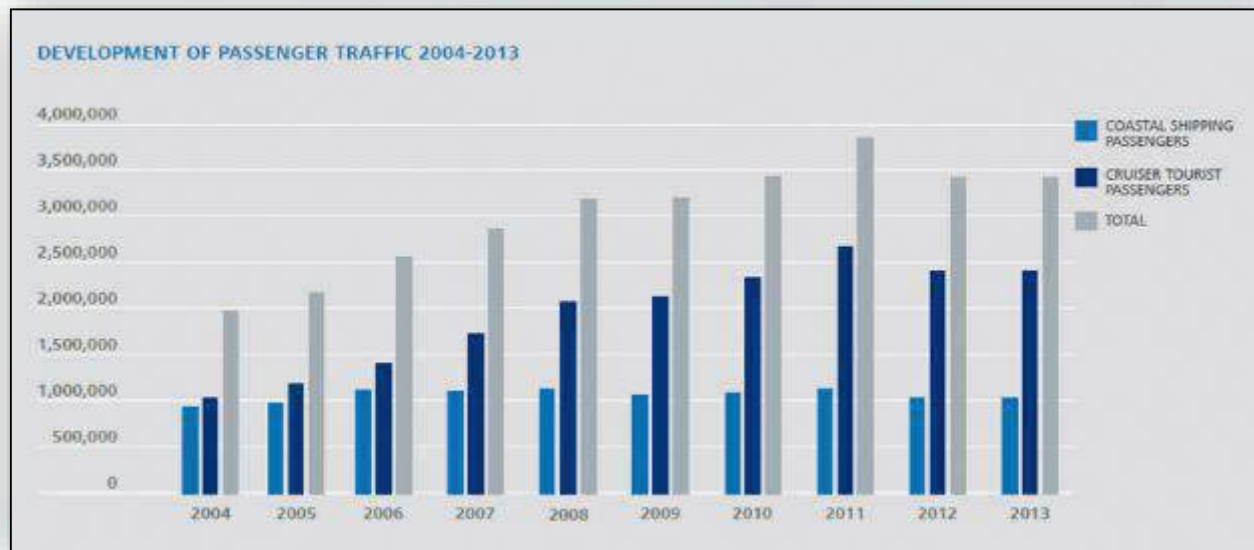
2007 : 400 000



Air & Ports : PAX last 10 years

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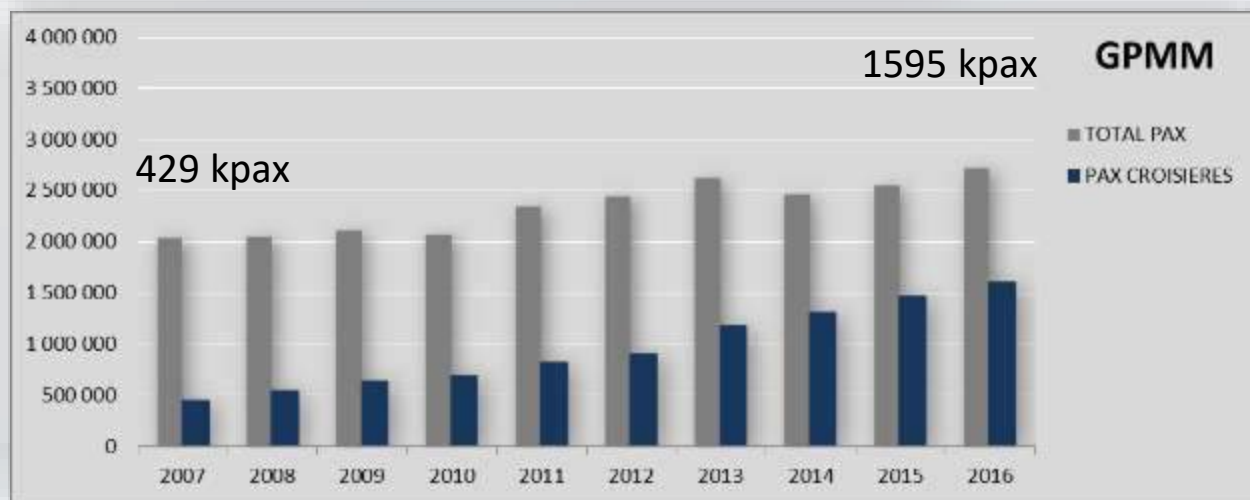
Barcelona

Marseilles

2007-2016

+ 73 %

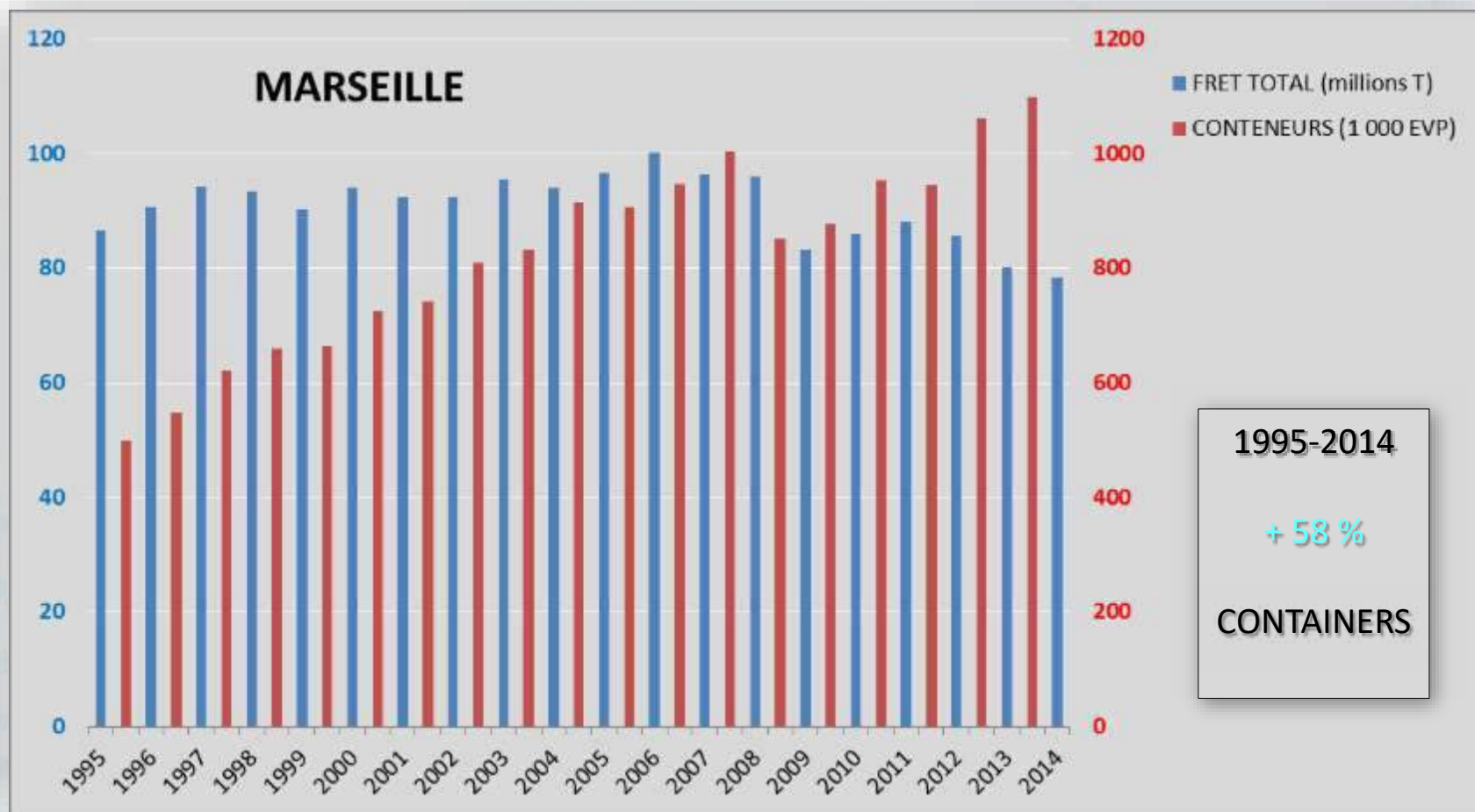
PAX cruise



► Contexte Air & Ports : FREIGHT

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$$Marseilles = \sum_{1995}^{2014} \overline{FREIGHT} = 90 \text{ Mt}$$

$$Toulon = \sum_{1995}^{2014} \overline{FREIGHT} = 0,9 \text{ Mt}$$

$$Nice = \sum_{1995}^{2014} \overline{FREIGHT} = 0,27 \text{ Mt}$$

Air & Ports

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Genova 20-24
Novembre

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APICE: *Common Mediterranean strategy and local practical Actions for the mitigation of Port, Industries and Cities Emissions* (www.apice-project.eu) *EU MED*

- ⇒ **Main objectives** :
- ⇒ **to define local adaptation plan and common strategy to improve air quality**
- ⇒ **Maritime Tourism impact on Air Quality**



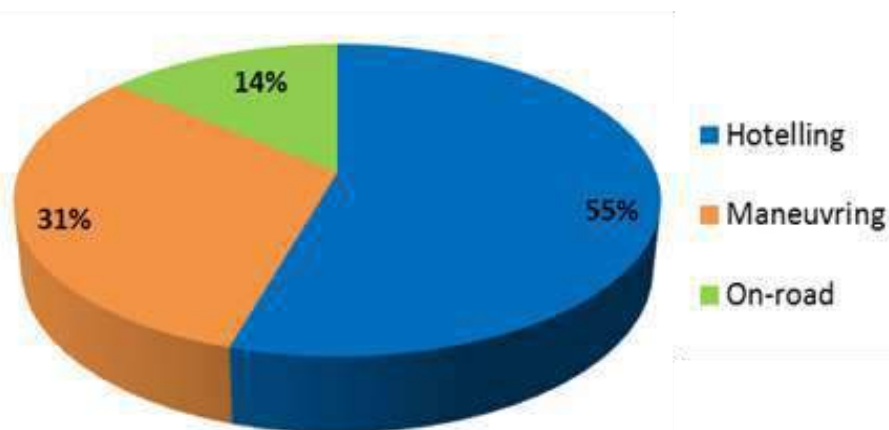
Air & Ports : emissions

Emissions of pollutants from maritime activities are derived from the **combustion** of fuel necessary for propulsion as well as for the **supply of energy** for activities **on board**.

Pollutants : Nitrogen Oxides (NO_x), sulfur dioxide (SO_2), particles (**PM10, PM2,5, Black Carbon**, ...), heavy metals (**Nickel, Vanadium**, ...), carbone dioxide (CO_2), volatils organic compounds (**VOCs**), ...

Many pollutants can be transformed in the atmosphere in secondary pollutants (emissions of precursors)

Maritime activity emissions phases :



% Maritime activity emissions of PM2.5 = fn (hoteling, Maneuvring, on road) over the total of maritime emissions
APICE MARSEILLE AERA (100 x 100 km) around Marseille

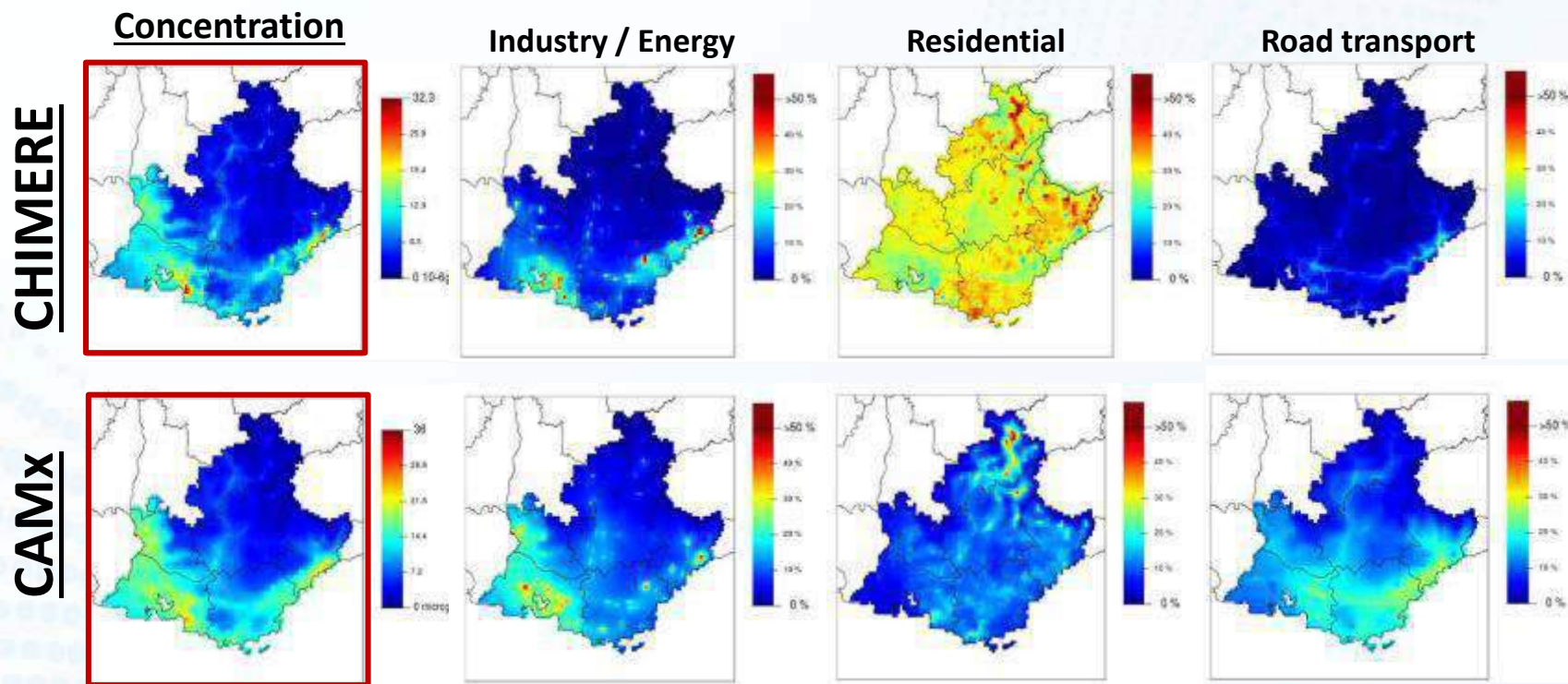
► From global scale to « micro-scale »

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2 novembre

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Comparison between numerical models at the regional scale

Monthly PM_{10} output during the winter period at the regional scale



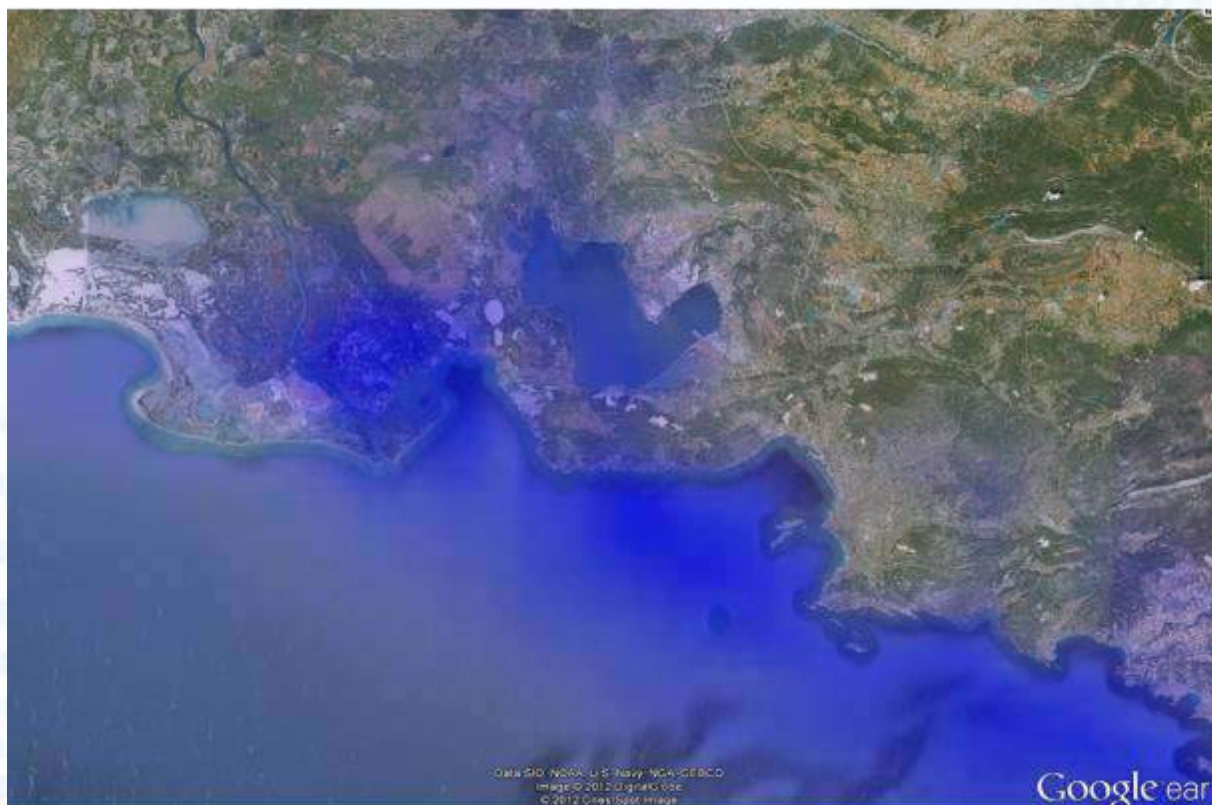
► From global scale to « micro-scale »

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20-24 novembre 2017

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Study example at regional scale

Impact scenario : use of (fuel TBTS) (very lower % of sulfur) on PM2.5 concentrations

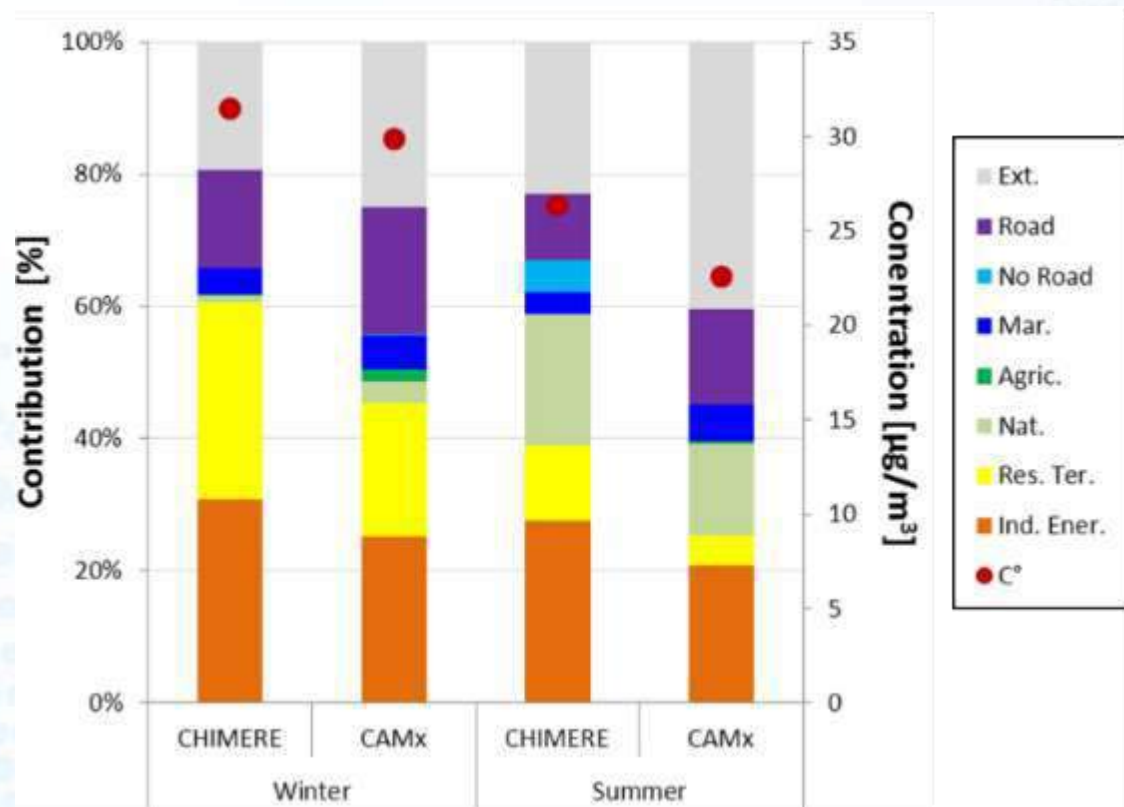


► From global scale to « micro-scale »

Example in Marseilles urban center

Relative Contribution of sources on monthly PM10 concentrations in the center of Marseilles with 2 Chemical Transport Model CHIMERE et CAMx.

Red dot = total concentration PM10



► From global scale to « micro-scale »

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Genova 20-24 Novembre 2017

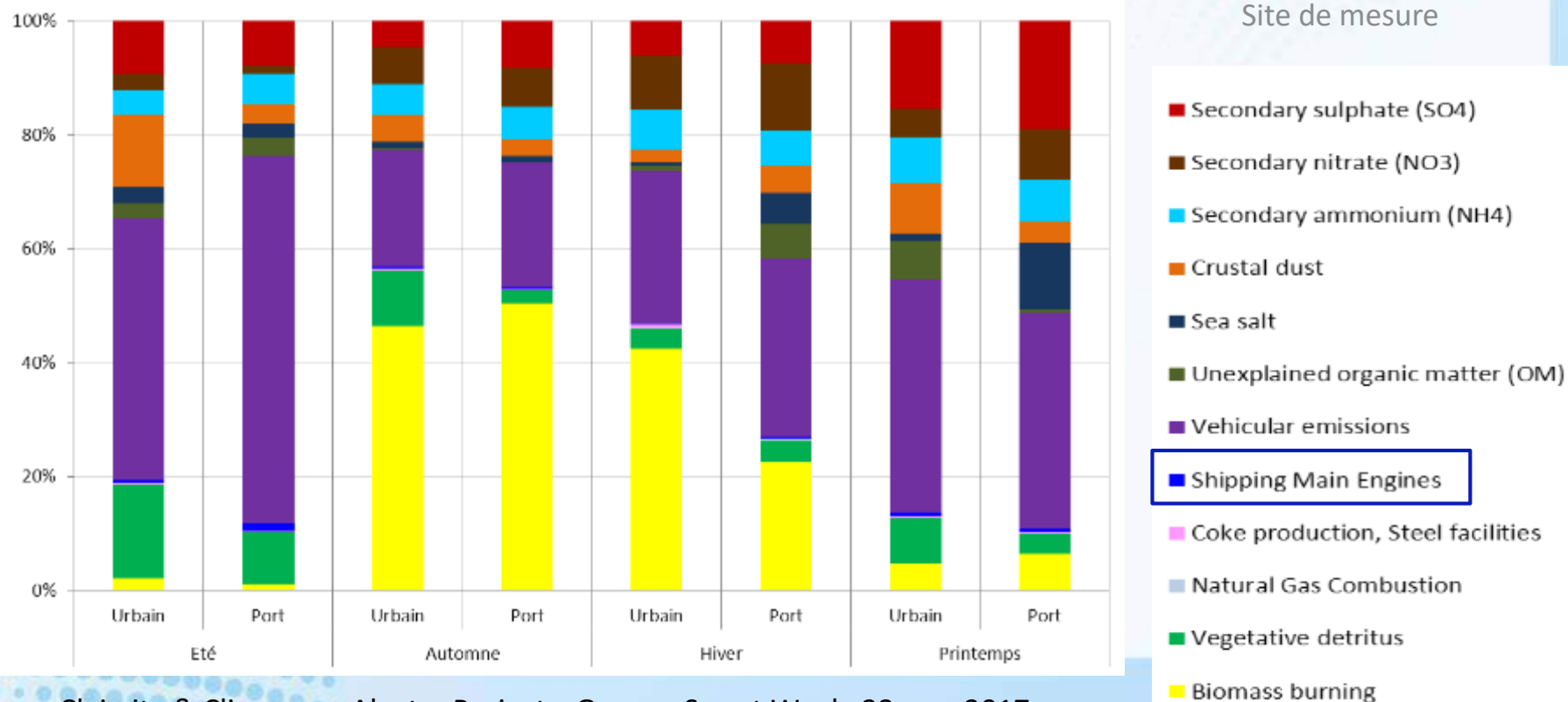
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Example in Marseilles urban center

Relative Contribution of sources on PM2.5 concentrations in the center of Marseilles with Receptors models (observations from filters laboratory Analysis (LCE, Marseilles University))



Site de mesure



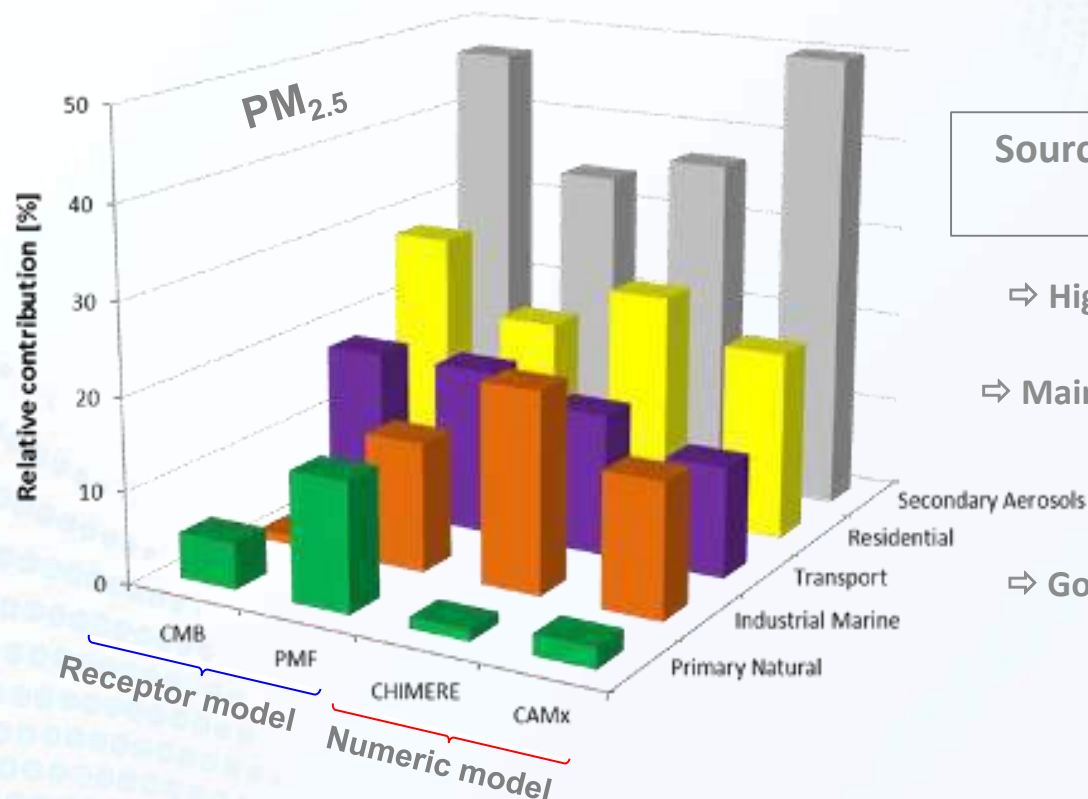
► From global scale to « micro-scale »

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Comparison between numerical models and receptor models

Results at the downtown station during the winter period



Source apportionment for primary particles only

⇒ High fraction of secondary aerosols

⇒ Main contribution from the residential sector

⇒ Good agreement between receptor models and CTMs

► From global scale to « micro-scale »

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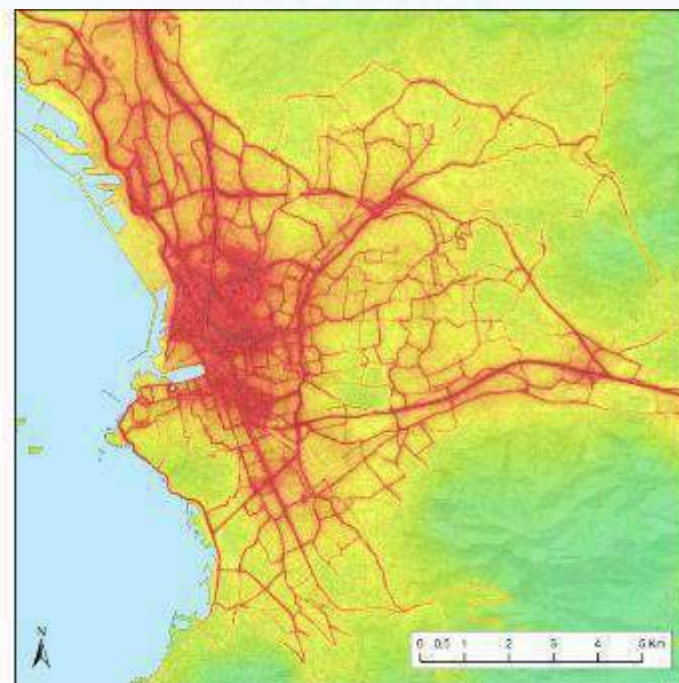
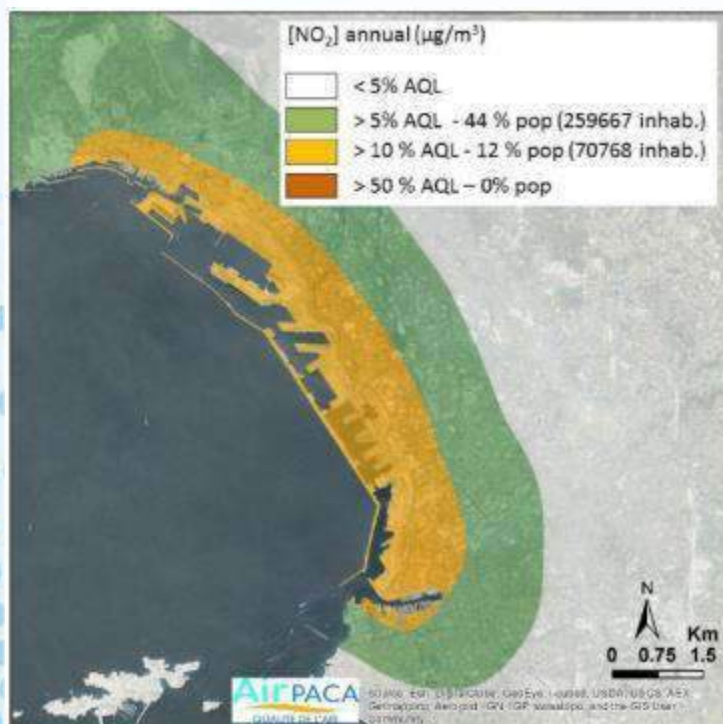
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Analysis at urban scale



(Left) : **Maritime activity contribution** on annual NO_2 concentrations

(right) : **Reference** (right) : Annual mean NO_2 concentrations in Marseille s in 2015



What did we learn ?

Instructions on emissions diagnostic

Stop over Emissions in function of average boat dimensions for 1h landing

		Tanker	Liner	Container Carrier	RoRo	Ferry
Combustible	>2h	Heavy fuel	Marine Diesel	Heavy fuel	Heavy fuel	Marine Diesel
Consommation	kg fuel	300	750	650	350	340
Emissions NO _x	kg	25	56	52	28	25
Emissions PM10	g	1 750	3 150	3 700	1 950	1 400
Emissions PM2.5	g	1 650	3 000	3 500	1 850	1 300
Emissions SO ₂	kg	17	1	36	19	0,6
Emissions CO ₂	t	1	2,3	2	1	1

► What did we learn ?

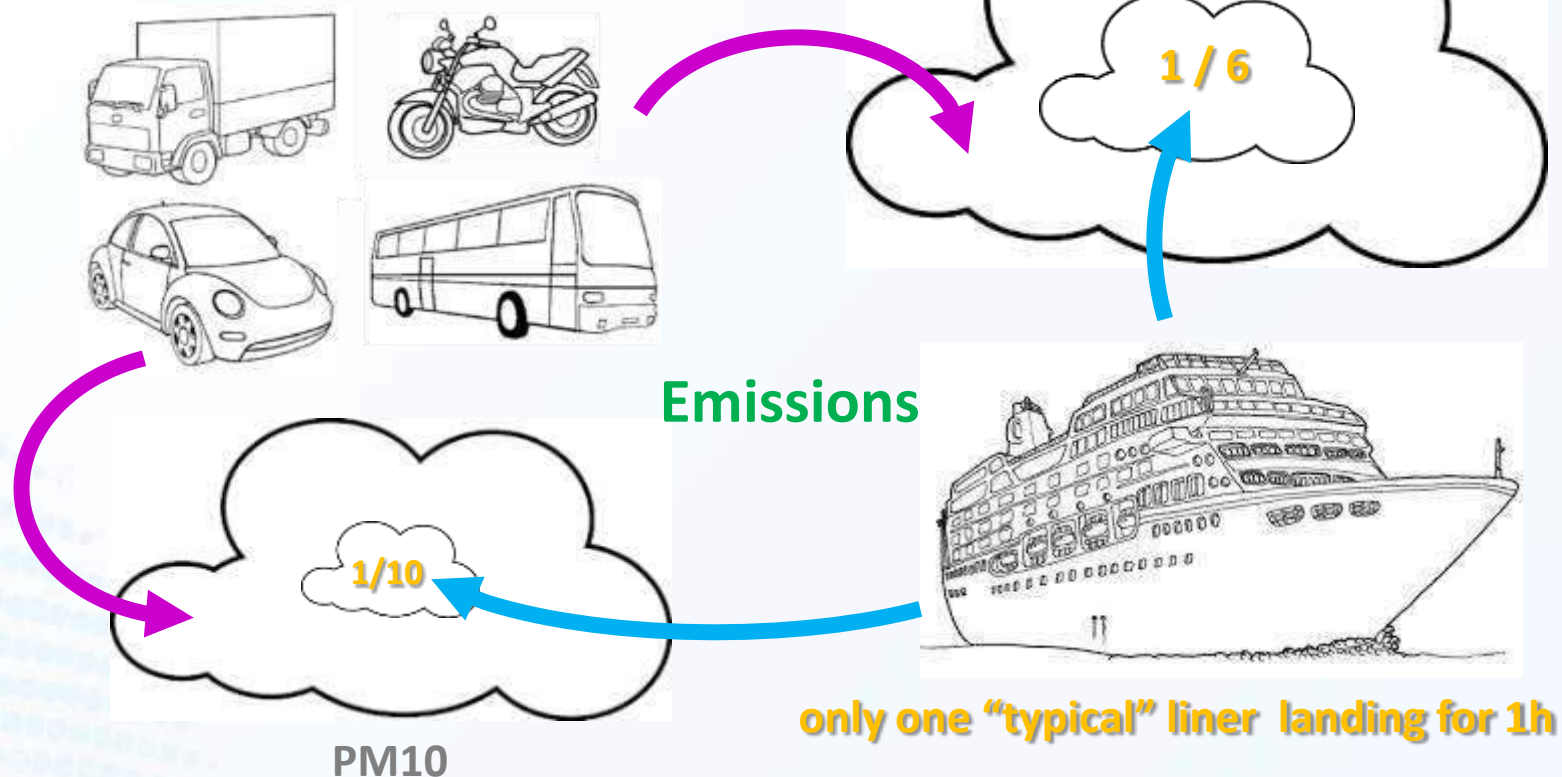
*Emissions factors (g/Gj)
OMINEA (CITEPA 2015)*



	GAZ			PARTICLES		
	SO ₂	NO _x	CO	TSP	PM10	PM2,5
Heavy fuel	1360	1983	185	146	139	131
Marine Diesel 0,1% sulfur	48	1869	176	110	105	99
Marine Diesel 0,5% sulfur (2020)	250	?	?	?	?	?
Diesel road traffic	<1	334	78	14	14	14
LNG	8	200	85	nd	nd	nd

► What did we learn ?

Hourly average Emissions of traffic road transport over City of Marseilles

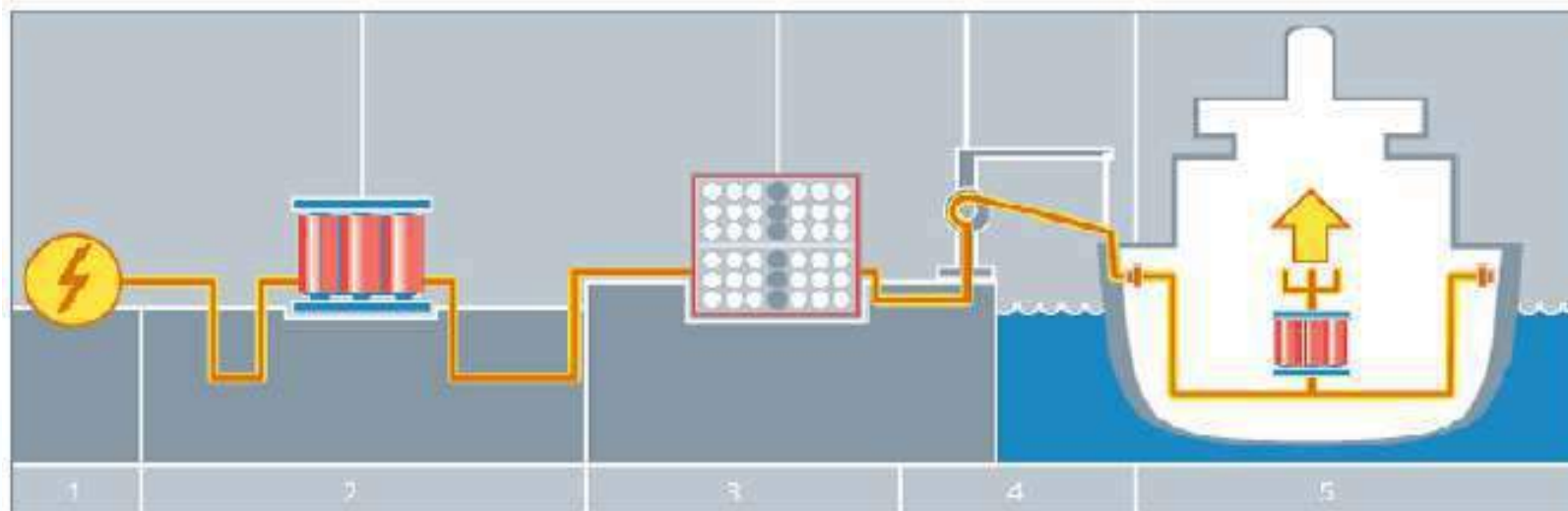


► What did we learn ?

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One possible technical solution : (OPS) : On Power Supply - Electric connection



► What did we learn ?

A technical solution: the electrical connection of ships to the dock

	GPM Marseilles port	CMN
Perimeter	Terminal Arenc 2 dockside	3 mixed cargos connected Piana, Girolata, Kalliste
Investment (M€ HT)	1,5	2
Number of stops / year	494 Equivalent to de 8 000 hours at ock	
Environmental gains	50 t / yr NOx 4,5 t / yr SOx	



► What did we learn ?

Air PACA

A technical solution: LNG carburation



The port of Marseille - Fos has the largest capacity of LNG in the Mediterranean

► What did we learn ?

A technical solution: the "scrubbers"



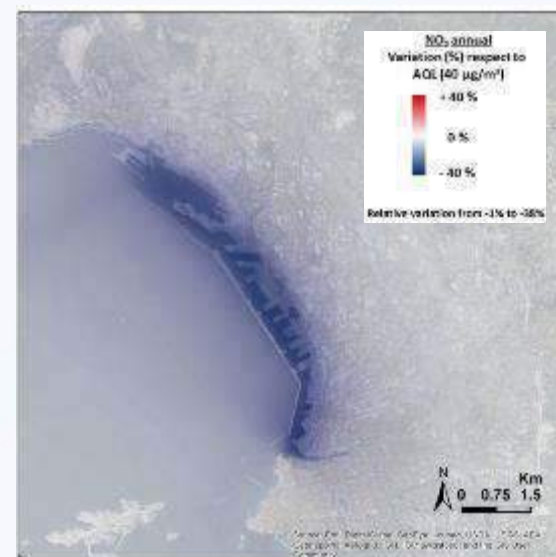
Originally designed for household waste incinerators, **scrubbers filter the smokes using a shower of water and chemicals**. For the maritime sector, this operation has the consequence, as it stands, of increasing the fuel consumption and therefore the amount of carbon dioxide (CO₂) and particulate matter. There are two models of scrubbers: open loop with discharge of washing residues, and closed loop with a storage tank to receive these same residues. **"For new ships, the installation of scrubbers poses no technical problems**. On existing ones, the closed loop models with storage tank placed at the top of the chimneys alter the stability of the vessels. Also, one of the main lines of research could be the development of scrubbers adapted to the maritime industry including fuel consumption ". Systems exist for both NO_x and SO_x filtering, but they are very expensive and technically complex to install, not suitable for all types of vessels and would pose a problem on many ferries because their bulk would limit capacity of ships. Their use can therefore only be made on a case-by-case basis, after examination by the shipowners of the feasibility of such installations on existing vessels and their installation cost in relation to the book value of vessels . This suggests fleet exits of the oldest vessels when the new standards come into force ...

► What did we learn ?

Lessons on improvement actions

Example of Scenarios for Local Improvement Actions :

- Electrification of a dock
- Development of new terminals
- Modification of fuels



► What did we learn ?



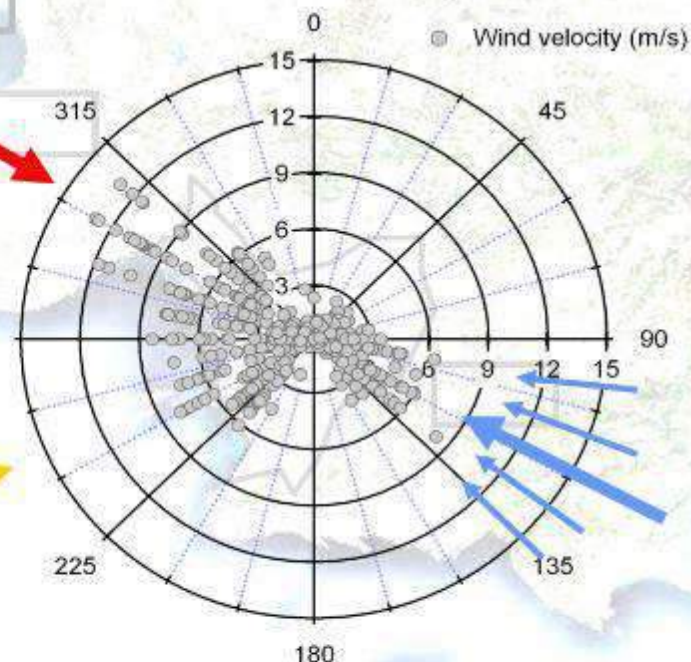
Marseille : 3 characteristic meteorological conditions

- Mistral
- « Land » and sea breezes
- Nocturnal Urban breeze

Composition of land/sea breezes and mistral

Transit time of the air masses above the mediterranean sea increases during the day

Evolution during the day



Marseille is most of the time downwind industrial areas and harbours

Urban breeze occuring most of the nights
(hot spot of Marseille)

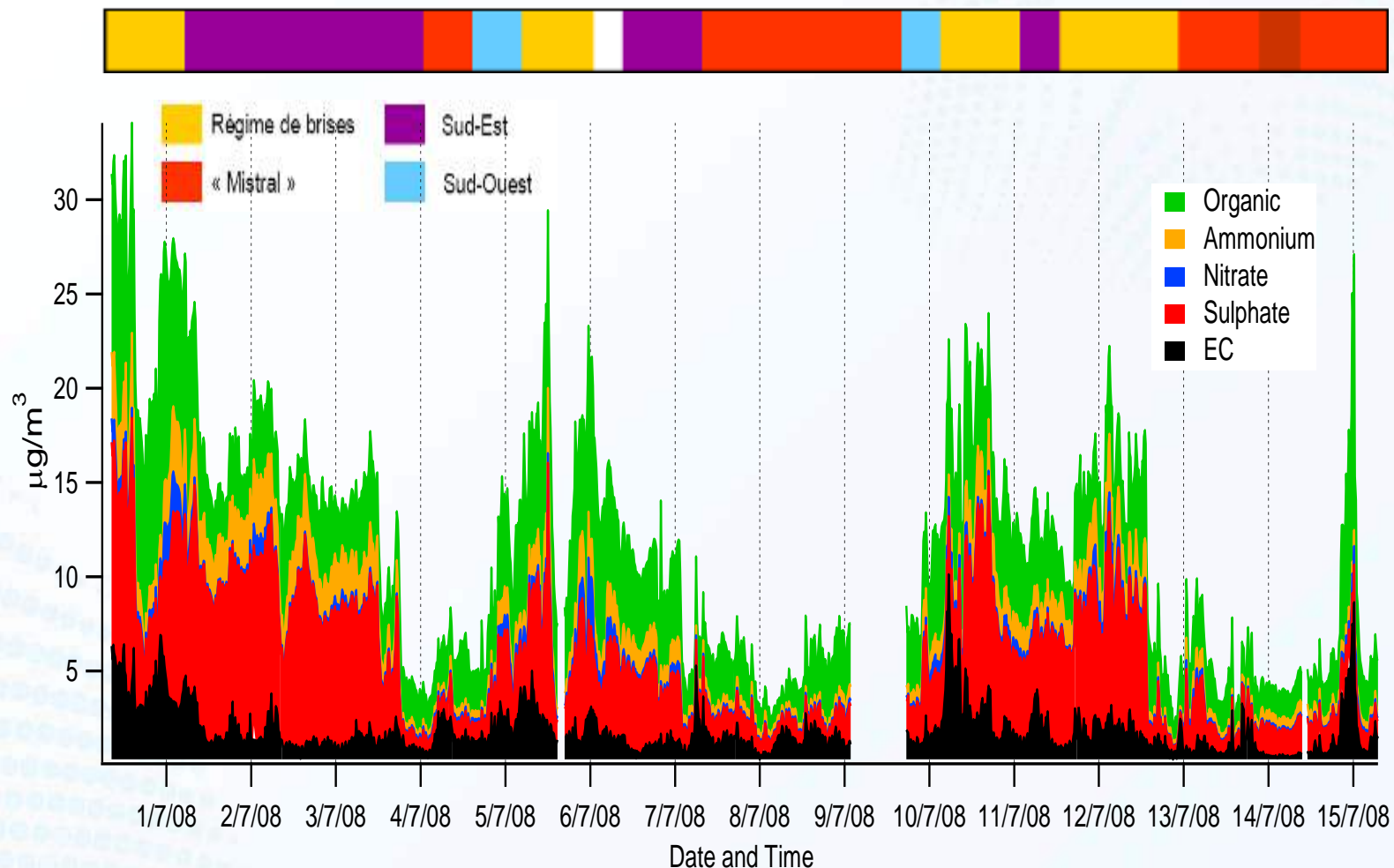
► What did we learn ?

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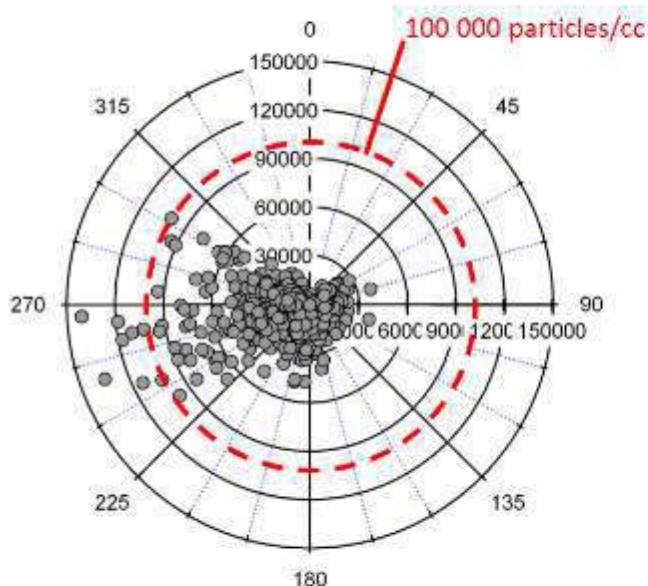
Time series of the main PM1 components in Marseille



► What did we learn ?

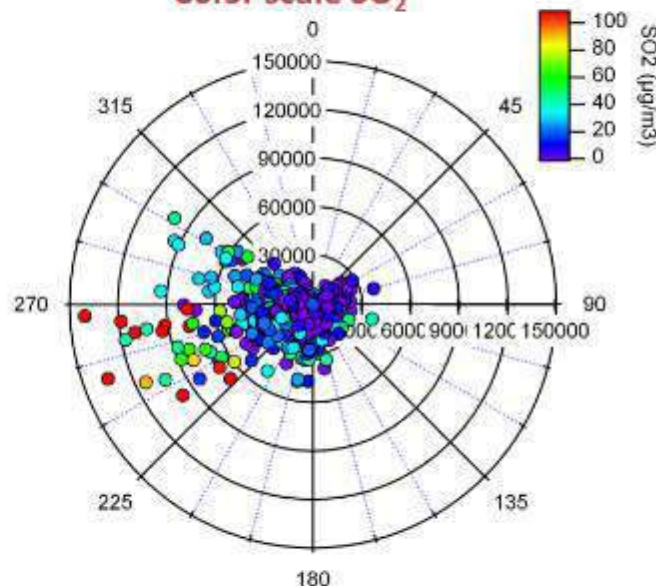


Total number of particles (cm^{-3})
(10-1000 nm)



Total number of particles (cm^{-3})
(10-1000 nm)

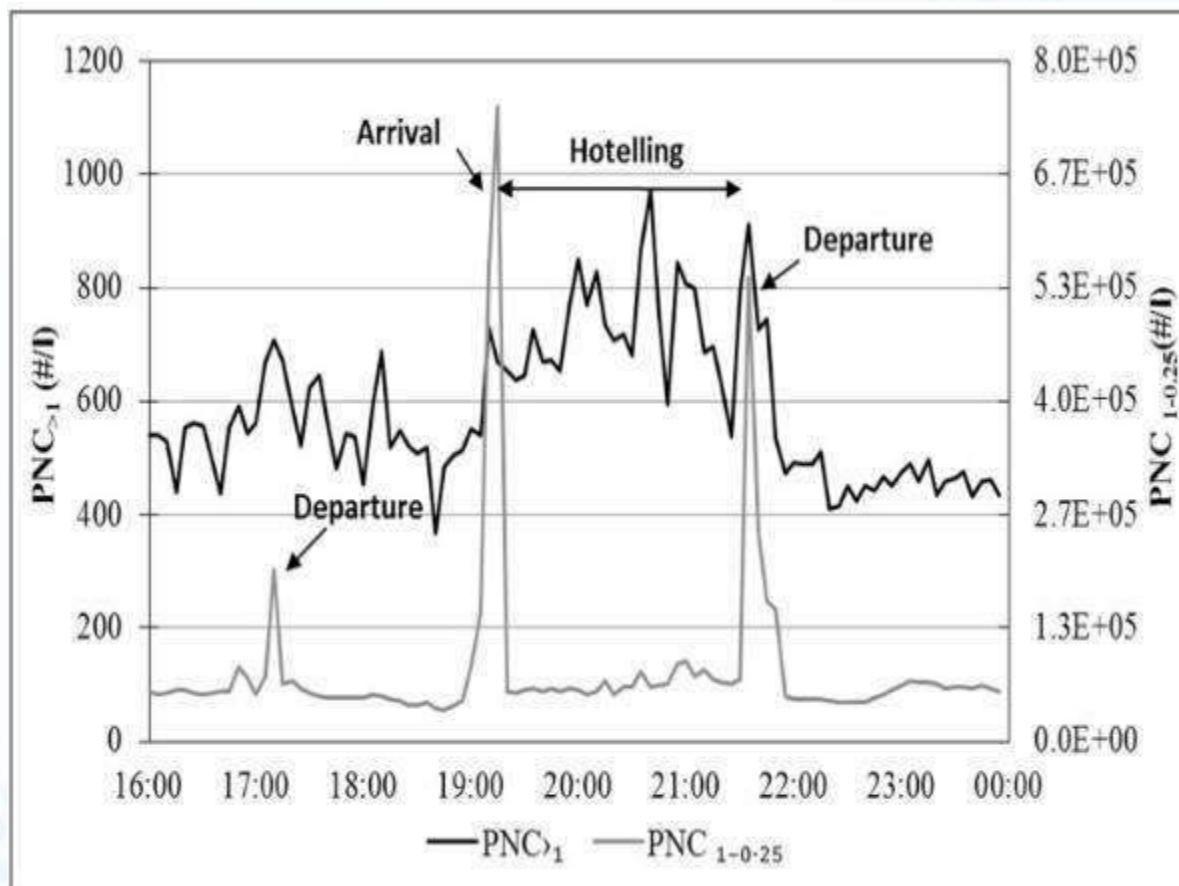
Color scale SO_2



- In sea breeze and moderate mistral conditions very intense particles events are observed (**total number concentrations higher than $100\,000\ \text{\#}/\text{cm}^3$**)
- These particle events are highly correlated with SO_2 and thus most probably linked to petrochemical/steel industrial activities (or maybe shipping emissions)

► What did we learn ?

Limits of regulatory thresholds, limit of mass measurement



Evolution PM1 versus PM2.5, Proximity of Port, Merico et al. 2016

CONCLUSIONS for better understanding and actions

Emissions :

Emissions computations are based on many hypothesis : we need to **consolidate** them

- Estimation power of ship vessels motorizations
- Estimation of ship vessels consumption of fuel or gas
- Other port activities (traffic, works, reparations,

Impacts and contribution :

Exploration and identification of new chemical signature from ship emissions in order to identify impacts

Modeling and Scenario:

Development of modeling tools at micro-scale

Development of validation tools at micro-scale

MESUREMENTS in Buildings fronts & in the plume of ship vessels

=> **We need to work with citizens, collectivities, ports, maritime companies**

Perspectives for better understanding and action

NEEDS :

- OBSERVATIONS NEAR SHIP EMISSION : 0 - 500m max
- OBSERVATIONS 3D

INHABITANTS

Chemical
Signature

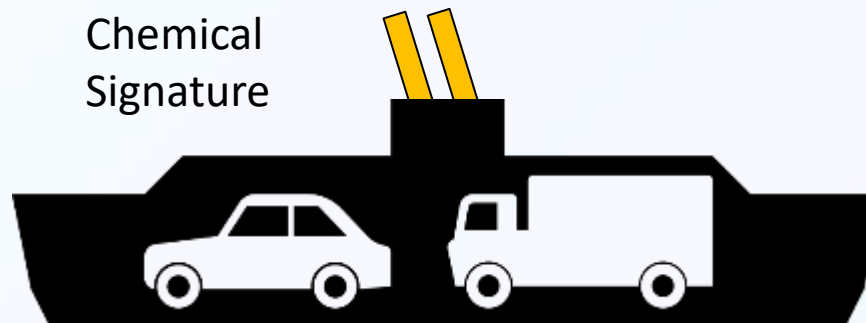
Granulo-
metry



SEA BREEZE



Chemical
Signature



LAND BREEZE

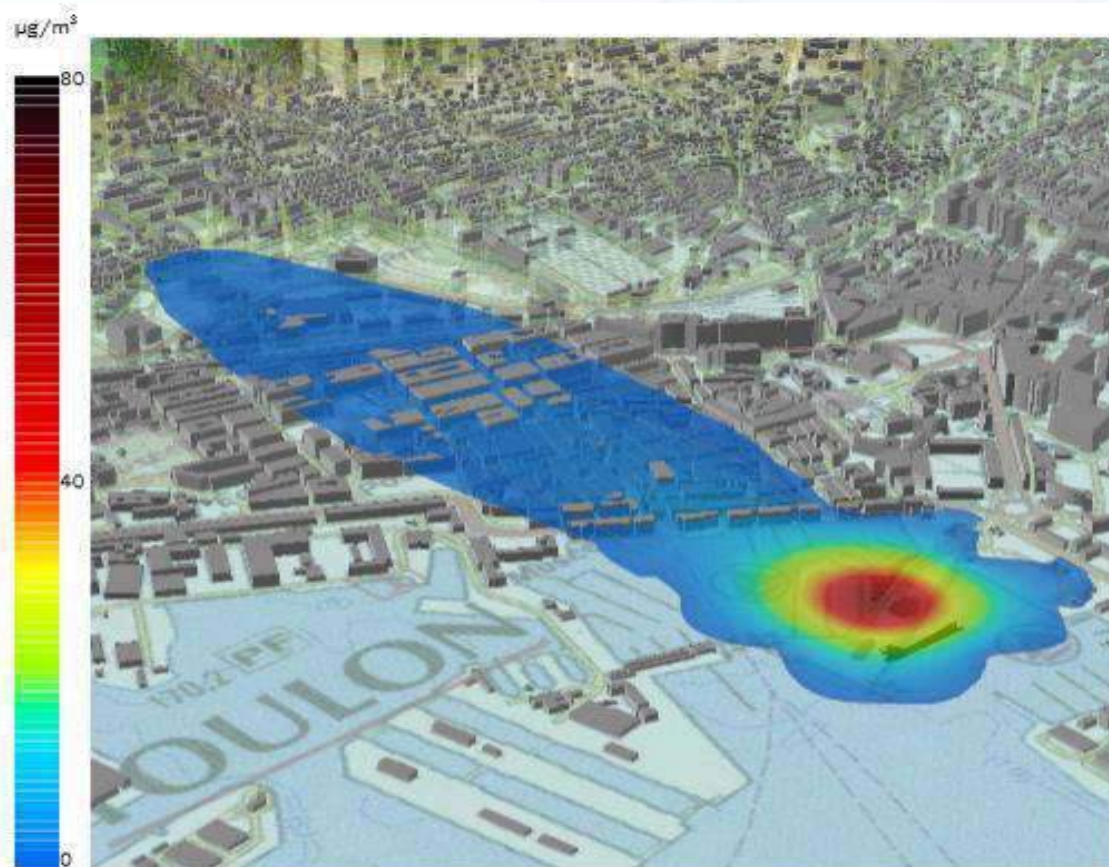


► Perspectives for better understanding and action

- Air PACA wishes to set up monitoring projects to best meet the expectations and needs of each on the port thematic (near field)

At the scale of an impacted neighborhood:

- Simulate the plumes of ships by taking buildings into account with recirculation effects and bypasses,
- Measuring pollutants in proximity situations,
- Identify nuisances: light bulbs, noises, odors



SIMPYC PROJECT (EU/LIFE)

► Perspectives for better understanding and action Air PACA

COMPLAINTS

ODOURS

AIR POLLUTION

NOISE

HEALTH CITIZENS

MODELING PLUME SHIP
3D TRANSPORT HR
0-500m

MEASUREMENTS PLUME SHIP CONTENT
CHEMICAL SIGNATURE

Lack of
knowledge

SOURCE OPPORTIONNEMENT

SCENARIOS - SOLUTIONS

- Alternative fuels impacts
- LNG, scrubbers, OPS



STAKEHOLDERS

PORTS AUTHORITIES

MARITIME COMPANIES

COLLECTIVITIES

STATE

ACTIONS PLANS

SHIP EMISSIONS REDUCTION

INTERMODALITY

Perspectives : ready for European cooperation





Thank you for your attention

Learn more

Publications & Video :

www.airpaca.org : research with keywords : « activité maritime, APICE, CAIMANS »

Project APICE: www.apice-project.eu

Project CAIMANS: www.medmaritimeprojects.eu/section/caimans

14th November - Marseilles

PORTS and AIR QUALITY conference - World Trade Center –

<http://imaports-airpaca.blogspot.it/p/programme.html>

Contacts :

- **Damien Piga (Air PACA) :** damien.piga@airpaca.org
- **Alexandre Armengaud (Air PACA) :** alexandre.armengaud@airpaca.org

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