Scientific results for Marseille

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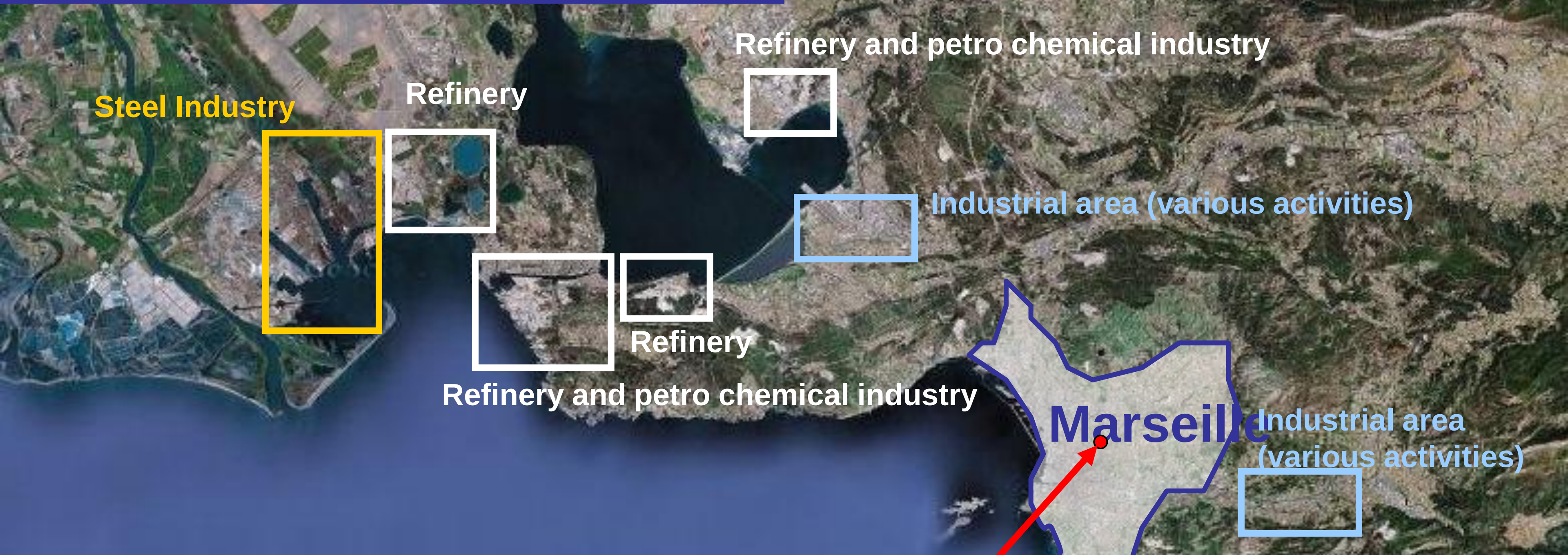
Marseille

2nde city in France ~ 1.6 million of inhabitants

- 1rst harbour in France
- 1rst harbour of the Mediterranean Sea
- 3rd harbour in the world for Crude oil and oil products



Sampling site :

« 5 avenues »

From the 25th of January to the 2nd of March 2011

Image Google Earth

Source apportionment methods :

- CMB analysis (Aix-Marseille Univ.)

- A complex method, developed in *ElHaddad et al., 2010*

Source profiles :	
Industrial sources :	**Non Industrial profiles :**
- Coke production *Weitkamp et al., 2005* - Steel facilities, mean of averall processes *Tsai et al., 2007* - Shipping main engines *Agrawal et al., 2008*	- Vehicular emissions *ElHaddad et al., 2009* - Diesel heavy duty trucks *Rogge et al., 1993* - Biomass burning *Fine et al., 2002* - Natural gas combustion *Rogge et al., 1993* - Vegetative detritus *Rogge et al., 1993*

Additional Sources :

Sea salt

[sea salt] = [Cl$^-$] + [Na$^+$] * 1.47 — *Putaud et al, 2004*

Crustal Dust

[Crustal Dust] = 2.20[Al] +2.49[Si] +1.63[Ca] +2.42[Fe] +1.94[Ti] — *Malm et al., 1994*

Selected markers :

Specific markers :

- Vehicular emissions : Elemental carbon + 3 hopanes (i.e.17α(H),21β(H)-norhopane, 17α(H),21β(H)-hopane, and 22S,17α(H),21βH)-homohopane
- Biomass burning : levoglucosan

Additional markers :

- Four PAH (i.e. benzo[b,k]fluoranthene, benzo[e]pyrene, indeno[1,2,3-c,d]pyrene and benzo[g,h,i]perylene) markers, for several kind of industrial processes
- C27, C32 n-alkanes
- Three metals (i.e. V, Ni and Pb)

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Source apportionment methods :

- PMF analysis

Partners involved	IDAEA-CSIC (Barcelona)	Univ Genoa and IDAEA-CSIC on behalf of ARPA veneto (Venezia)	UOWM (Thassaloniki)	Univ Genoa (Genova)
Species included	**22 Variables**	**21 variables**	**37 variables**	**15 Variables**
	Ca, K, Na, Mg, Fe, Mn, V, Ni, Cu, Zn, Sn, Sb, Pb, SO_4^{2-}, NO_3^-, NH_4^+, EC and Five Oc fractions (OC1, OC2, OC3, OC4 and Pyrolitic C)	Ca, Na, Mg, Fe, V, Ni, Cu, Zn, Sn, Sb, Pb, SO_4^{2-}, NO^{3-}, NH_4^+, EC, OC, E-Alk, O-Alk, PAH, HOPA, DHAA	8PAH, SO_4^{2-}, NH_4^+, NO_3^-, Al, Ca, K, Na, Mg, Fe, Mn, Ti, P, V, Cr, Ni, Cu, Zn, As, Rb, Sr, Sb, Cd, Sn, Pb, Li, Sb, La, OC and EC	Al, Si, P, K, Ca, V, Fe, Ni, Cu, Zn, SO_4^{2-}, NH_4^+, NO_3^-, OC and EC
	=> Metals, ions, EC and OC fractions	**=> Organic compounds, métals, ions, EC and OC**	**=> Organic compounds, métals, ions, EC and OC**	**=> Metals, ions, EC and OC**
Number of factor / sources	7	7	6	5

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Source apportionment methods :

- Intercomparaison : constitution of 5 source groups

Source group	Source and Source types derived from each source apportionment analysis				
	Aix Marseille Univ	IDAEA-CSIC	Univ Genoa and IDAEA-CSIC on behalf of ARPA veneto	UOWM	Univ Genoa
Road	Vehicular	Vehicular exhaust ; Road dust	Vehicular exhaust + sea spray ; Road dust	Road dust	Road
Residential	Biomass burning ; Vegetative detritus (incomplete combustion of wax alkanes) ; Natural gas combustion	Biomass burning	Residential	Residential combustion	-
Primary natural	Sea salt ; Crustal dust	Aged sea spray ; Mineral/industrial	Dust	Natural sea salt	Dust
Industrial and Shipping	Coke production ; HFO combustion/Shipping ; Steel manufacturing	Fuel Oil Combustion	Industrial / marine	Marine-Shipping emissions / Industry	Industrial / Marine
Secondary	Secondary ammonium, nitrate and sulfate ; Unexplained OM	Secondary aerosols	Secondary 1 ; Secondary 2	Secondary aerosols	Secondary 1 ; Secondary 2

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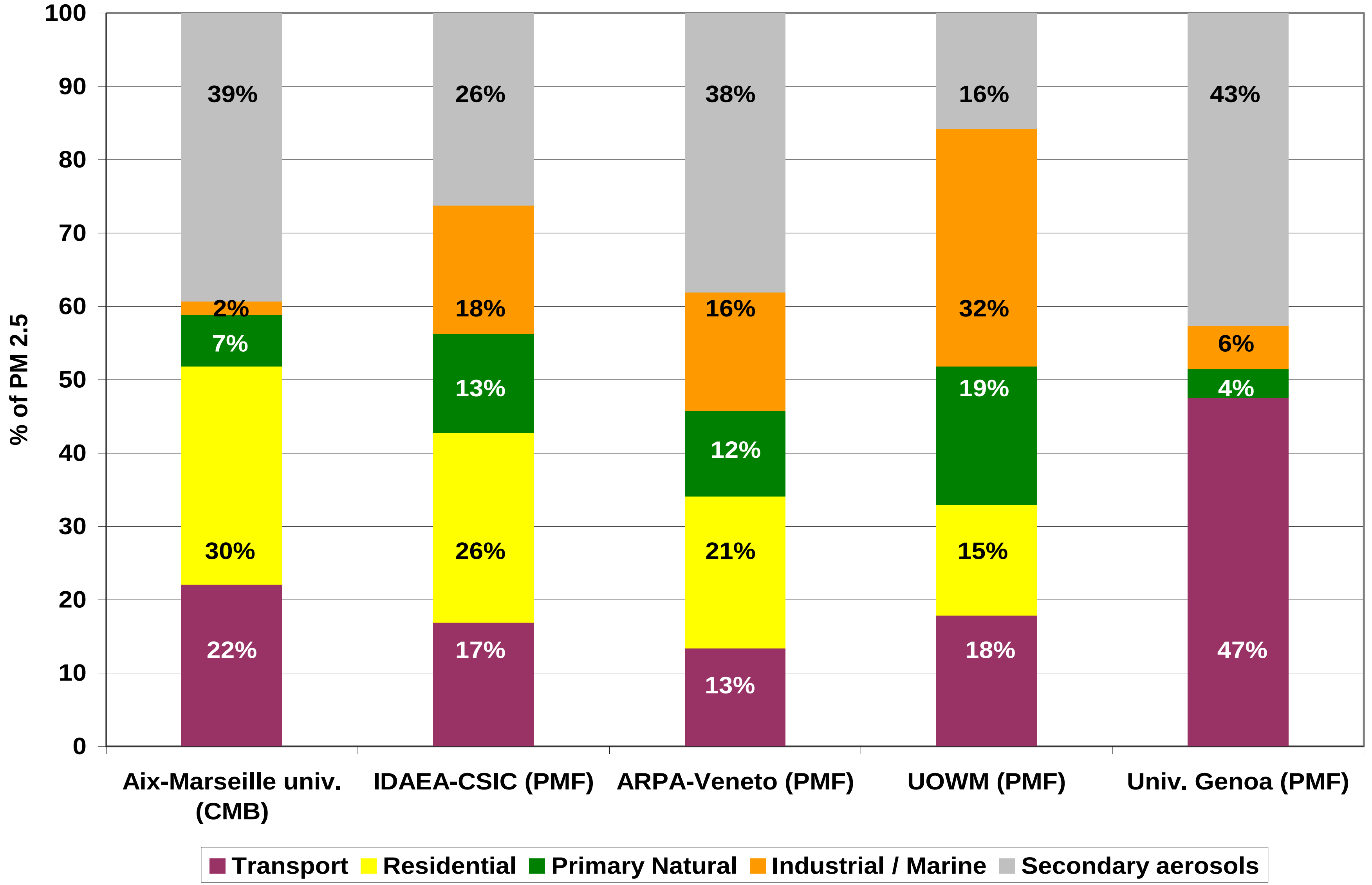
Intercomparaison results :



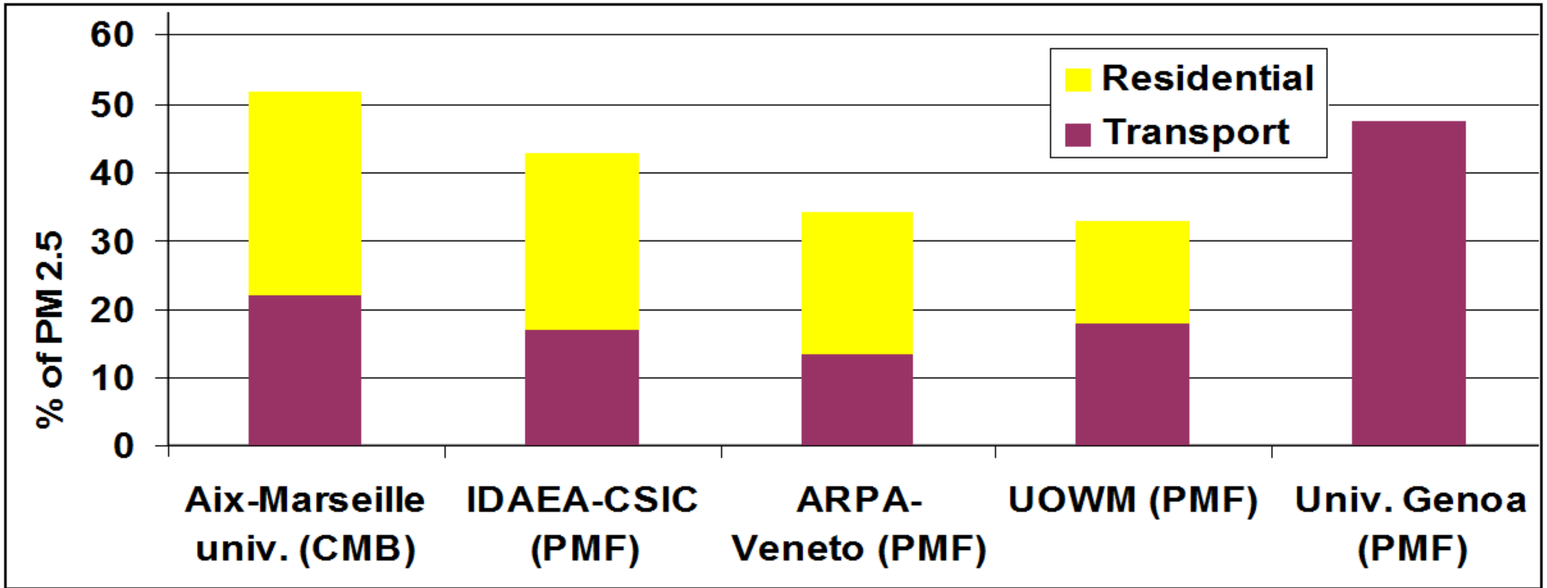
Intercomparaison results :

- Residential and transport emission

- **Residential sources :**
  - Mostly related to wood burning emissions, other negligible
    - ➢ Source mainly characterized by organic markers

- **Road emission sources**
  - Both exhaust emissions and road dusts
    - ➢ Factor driven by OC and EC (exhaust emission) and metals (road dust)

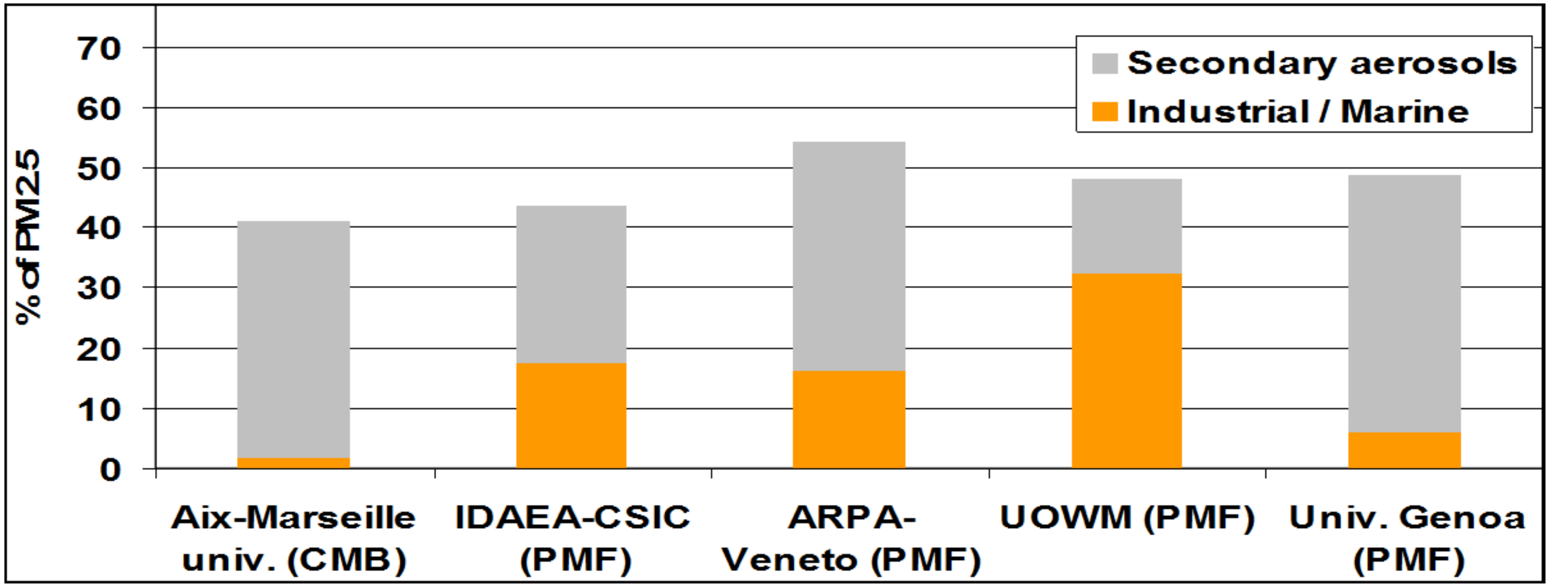
➡ The use of organic marker allows a better distinction between those two sources



Intercomparaison results :

- Industrial / marine and Secondary aerosols

- Important discrepancies observed about industrial factor
- Comparable results for these two factor sum
  - ➢ Difficulty to distinguish those two sources



➡ Necessity to work with a common database, to reduce uncertainties

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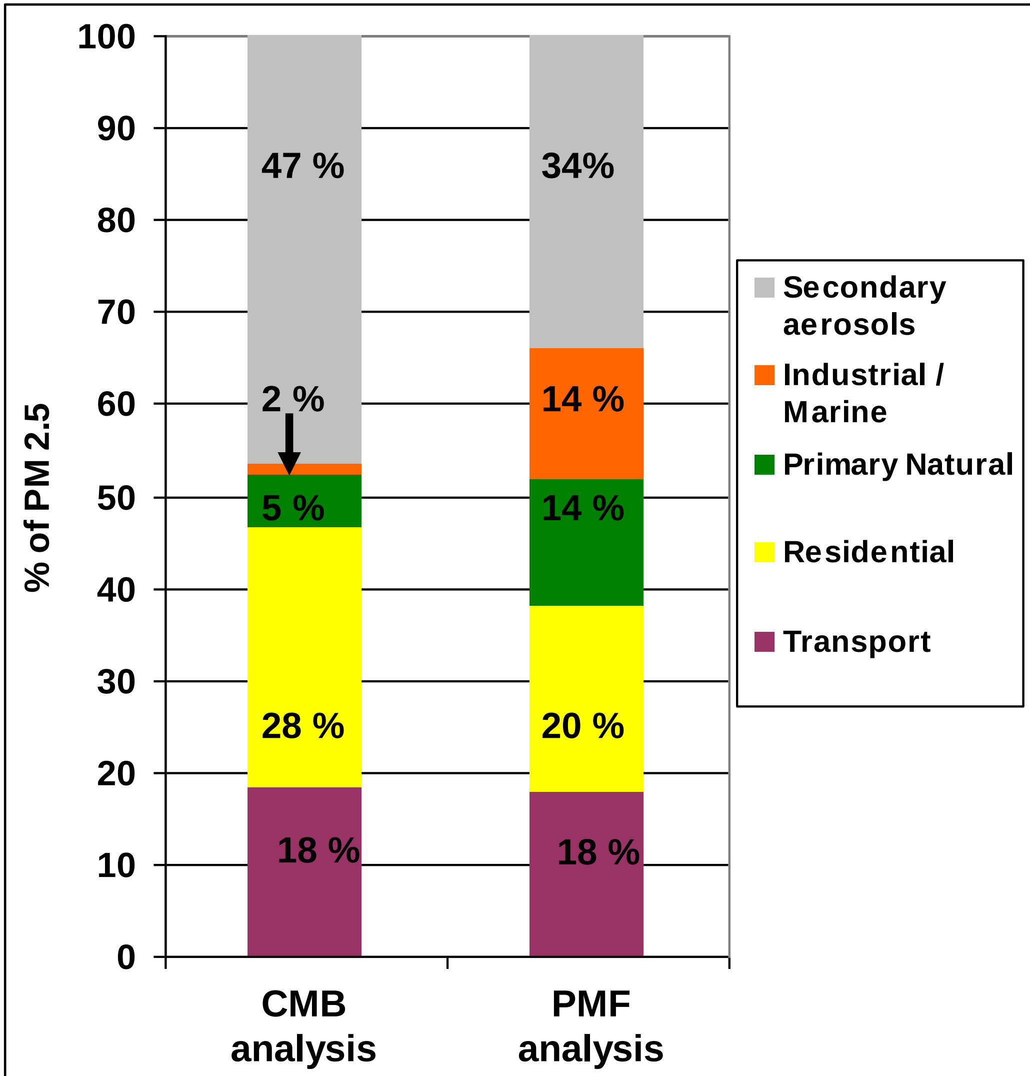
Intercomparaison results :

- Analysis of a same data base with PMF and CMB



Overall good accordance of results

Discrimination between secondary aerosols and industrial / marine source ?

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Marseille
Long monitoring campaign,
from July 20th 2011 to July the 20th 2012
Urban background
sampling site
« Cinq Avenues »
Eastern harbour
sampling site, « Gare de
la Major »
SNCM

Long term monitoring campaign
- Principle and methodology

- **Two measurement sites elected**
  - Urban background site « 5 avenues » :
    - ➢ Precise study of particulate matter in Marseille down town
  - Eastern harbor measurement site « Gare de la Major »
    - ➢ Characterization of incoming air masses, before their arrival in Marseille
    - ➢ Measure of ship emissions to characterize more precisely those emissions

- **Implementation :**
  - From July 2011 to July 2012 (one full year)
    - Seasonal evolution of sources
    - Constitution of a wide database, which would be analyzed trough both PMF and CMB
  - Collection of PM2.5 samples, analyzed according to their own interest

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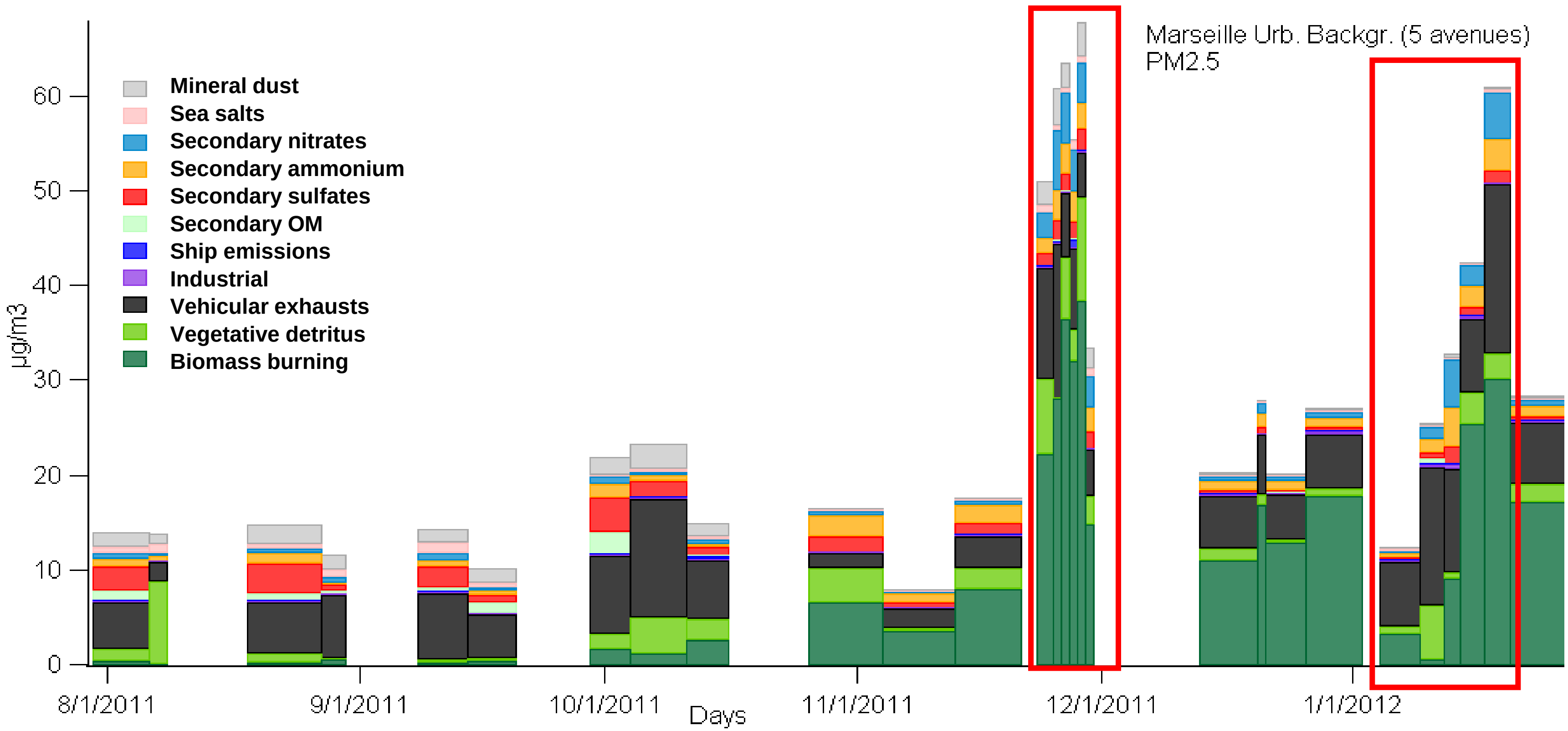
Long term monitoring campaign

- First results : CMB from 08/2011 to 02/2012 – 5 avenues site



Important seasonal evolution of sources

- ➢ **Importance of biomass burning source in winter**

Shallow impact of Industrial and marine sources

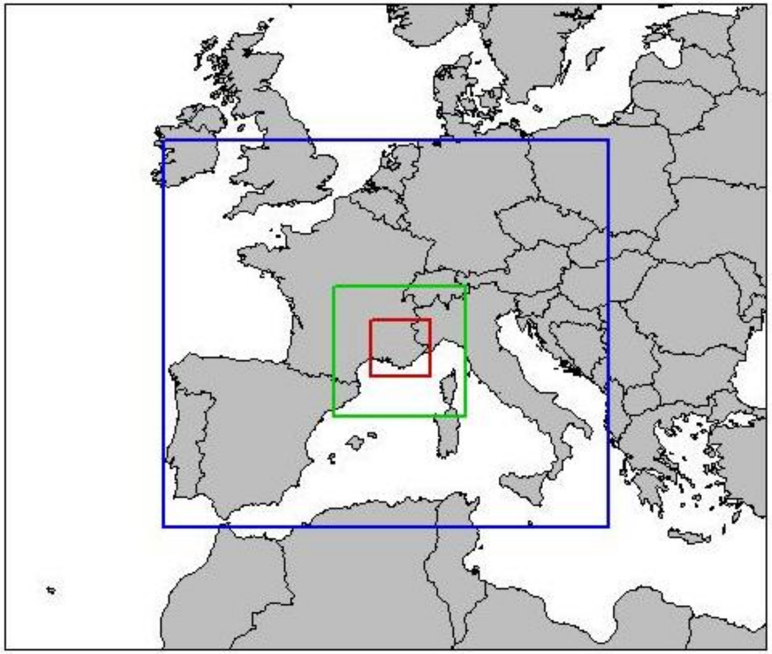
- ➢ **Good accordance with intercomparison campaign's results**

Several interesting events, that should be studied more thoroughly

Source apportionment by CTMs - Method

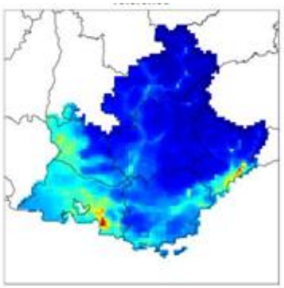
Modeling domain

From Europe to regional scale

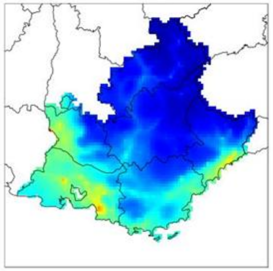


Source apportionment

- CHIMERE ⇨ zero-out modeling
  - ➢ Used since several years
  - ➢ Operational forecasting



- CAMx ⇨ tracer approach (PSAT)
  - ➢ Time saving
  - ➢ Mass consistency
  - ➢ Fully traceable



⇨ Good agreement between CTMs

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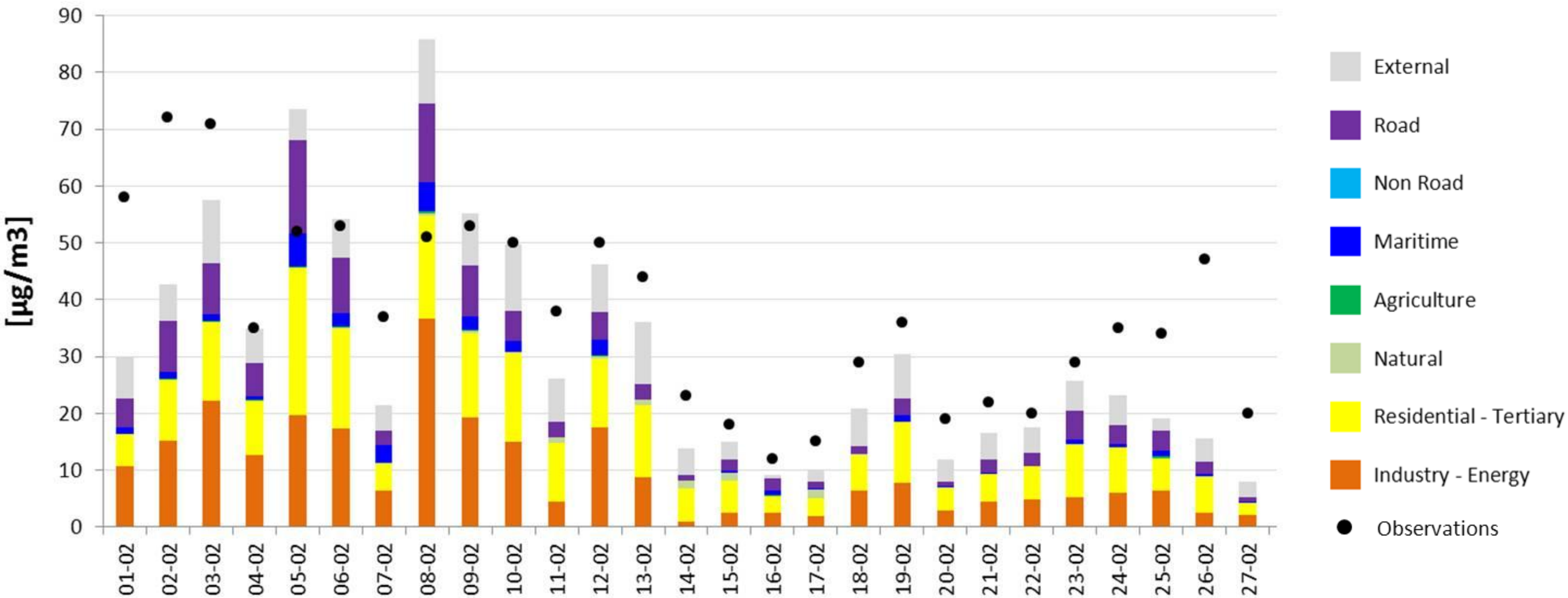
Source apportionment by CTMs - Results

Daily PM_{10} – Urban background site – Winter period



⇨ Temporal source apportionment

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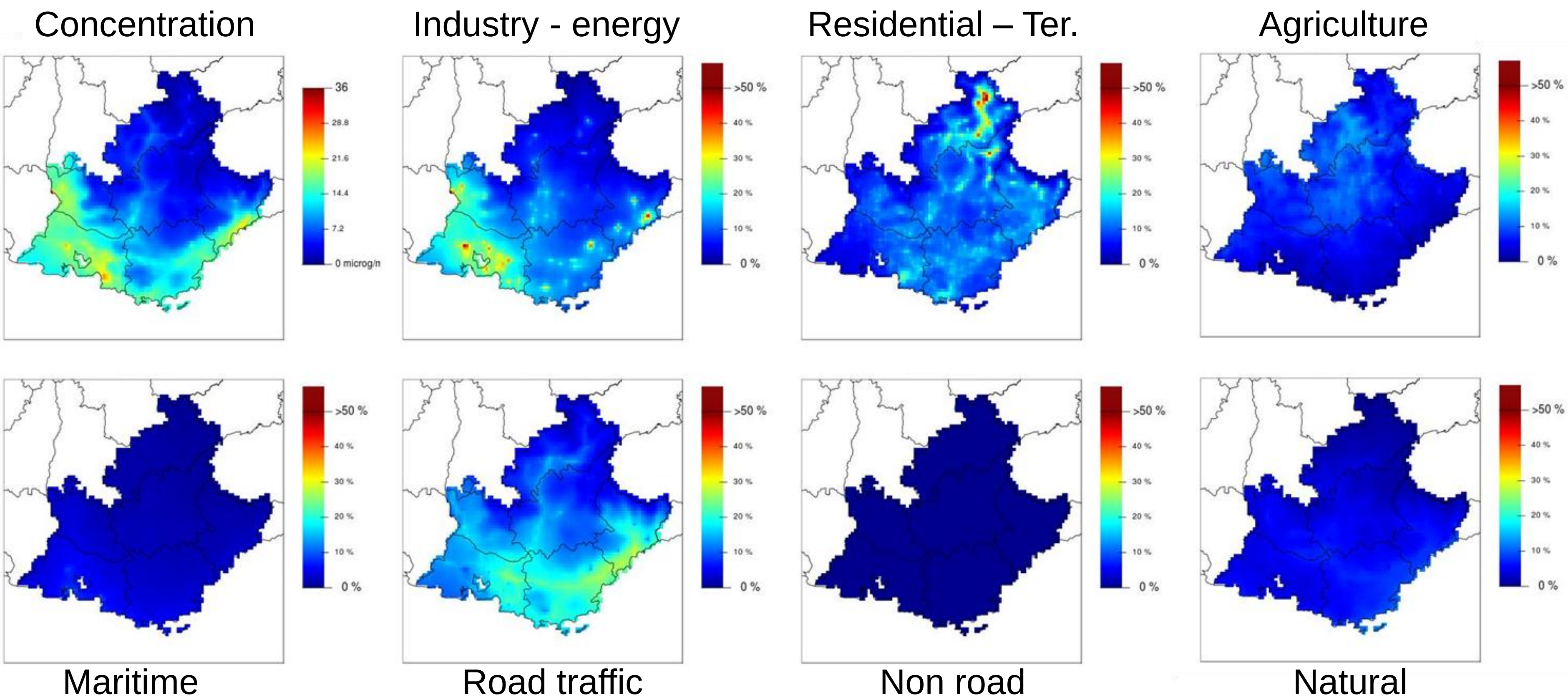
Source apportionment by CTMs - Results

Monthly PM_{10} – Winter period



⇨ Spatial source apportionment

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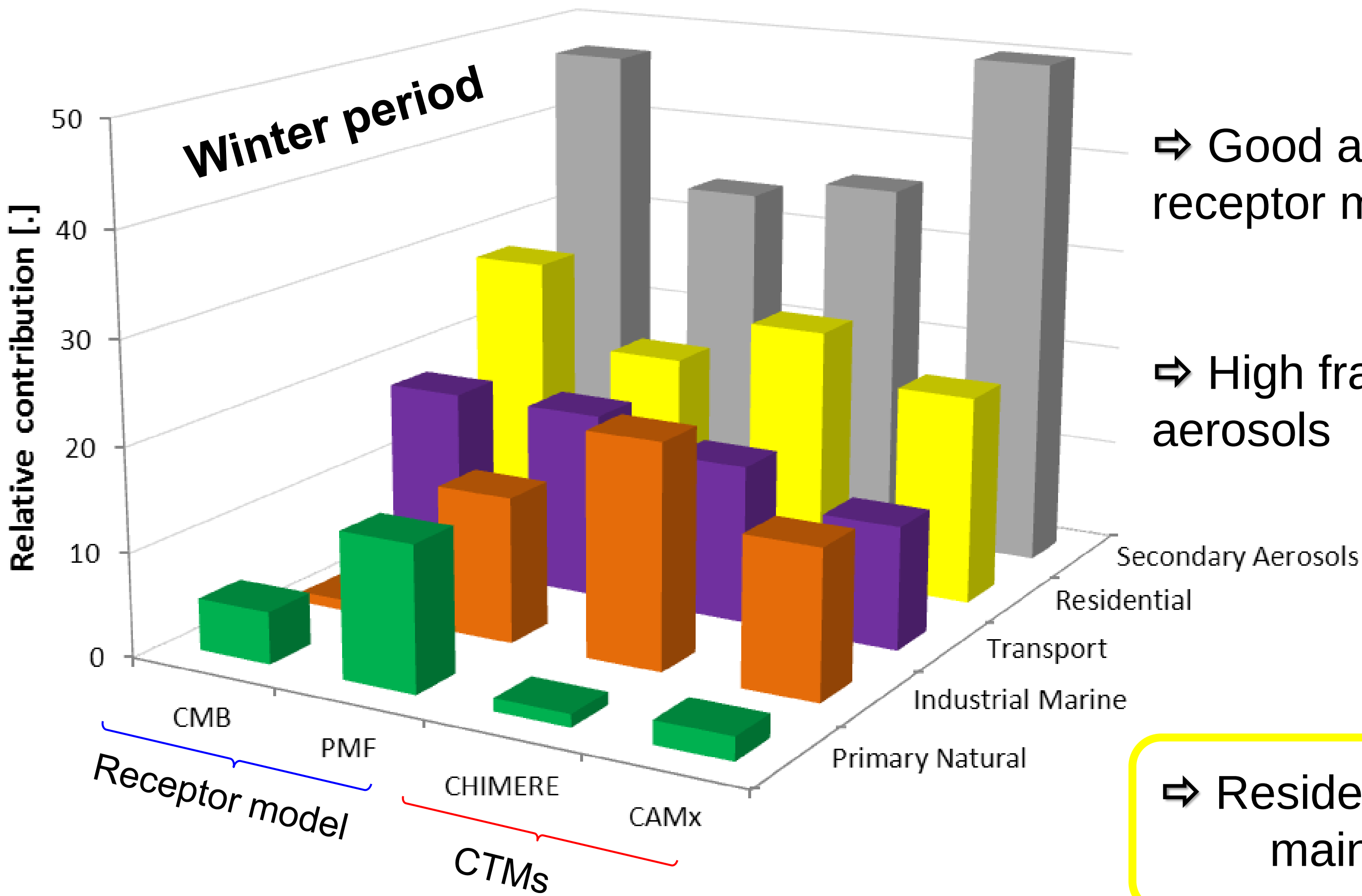
Source apportionment by CTMs - Validation



⇨ Good agreement between receptor models and CTMs

⇨ High fraction of secondary aerosols

⇨ Residential sector is the main contributor

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Future scenarios – List for Marseille

Scenario 0: Base case run

⇨ emission 2007

Scenario 1: Base case future run

⇨ emission 2025

Scenario 2: Common Future emission mitigation

⇨ emission 2025 + low fuel sulfur content

Scenario 3: Individual future emission mitigation

⇨ emission 2025 + OPS solution

Scenario 4: Individual future emission mitigation

⇨ emission 2025 + new cruise terminal

Scenario 5: Individual future emission mitigation (in progress)

⇨ emission 2025 + LNG for passenger ships

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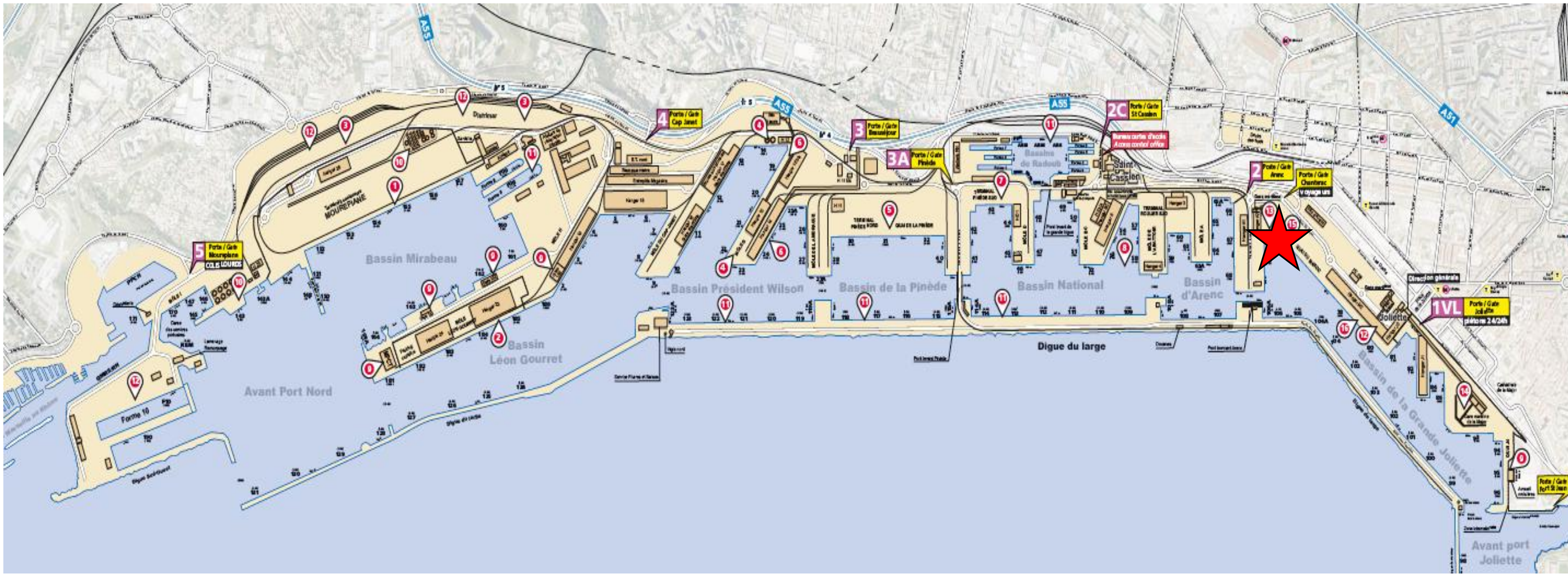
Future scenarios – Method

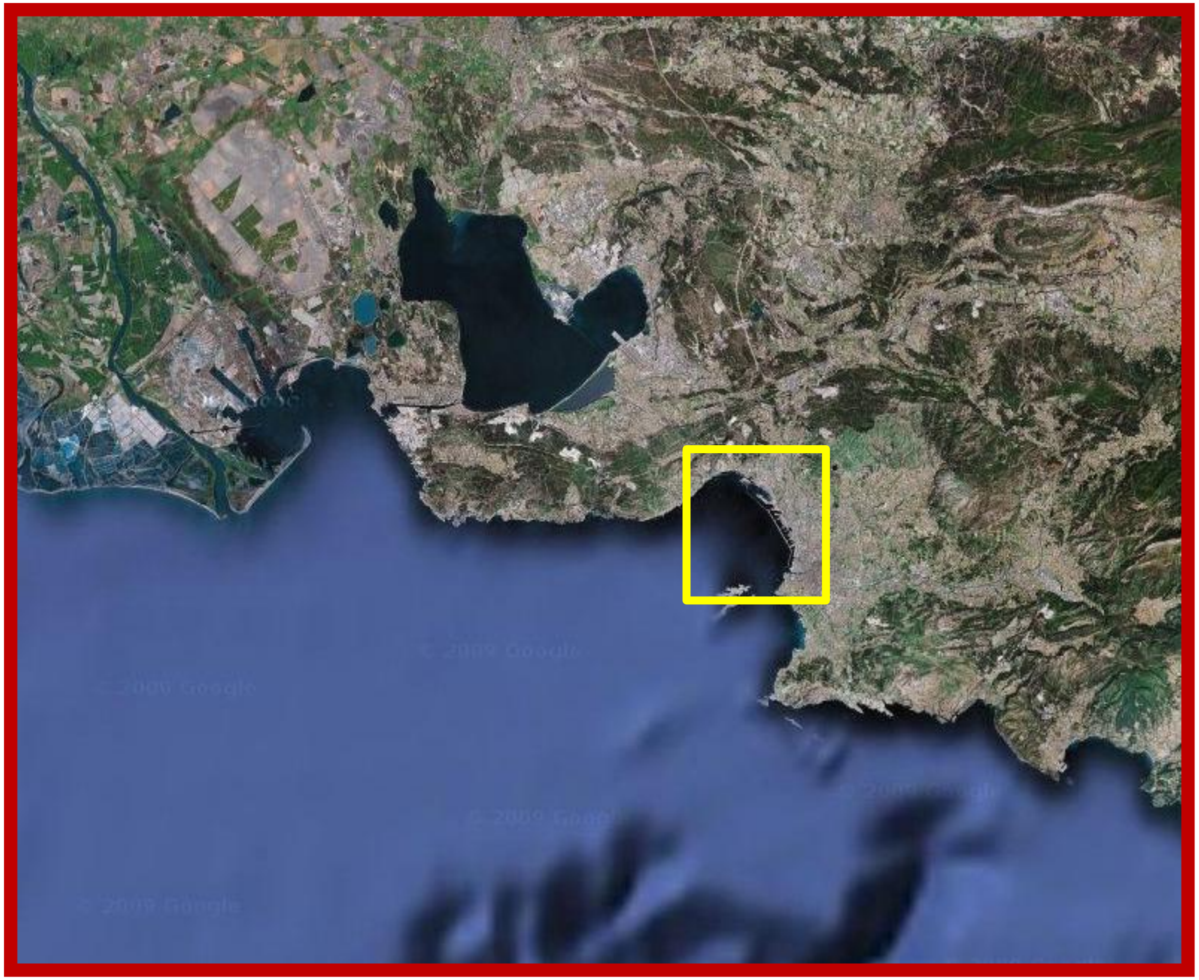
Scenario 3: Individual future emission mitigation ⇨ OPS solution



Future scenarios – Method

<u>Scenario 4</u>: Individual future emission mitigation ⇨ new cruise terminal

Future scenarios – Method



2 simulation tools:

➢ CHIMERE

- chemical model
- large scale
- 3x3km spatial resolution

⇨ Scenario 0, 1 and 2

➢ ADMS URBAN

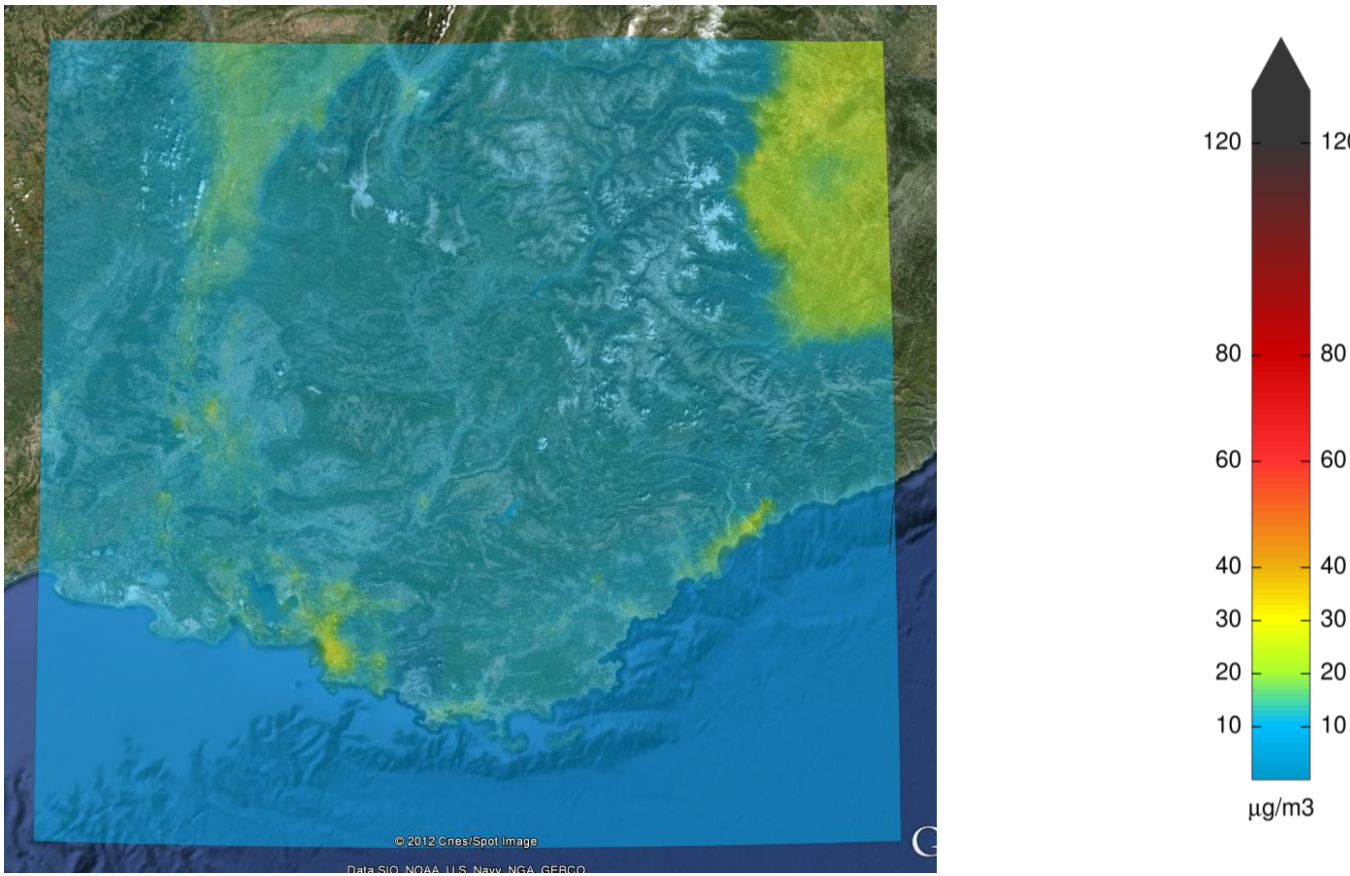
- no particles chemistry
- local scale
- spatial resolution ≈ 10m

⇨ Scenario 1, 3, 4, 5

Future scenarios – Results

Scenario 0: Base case run ⇨ emission 2007

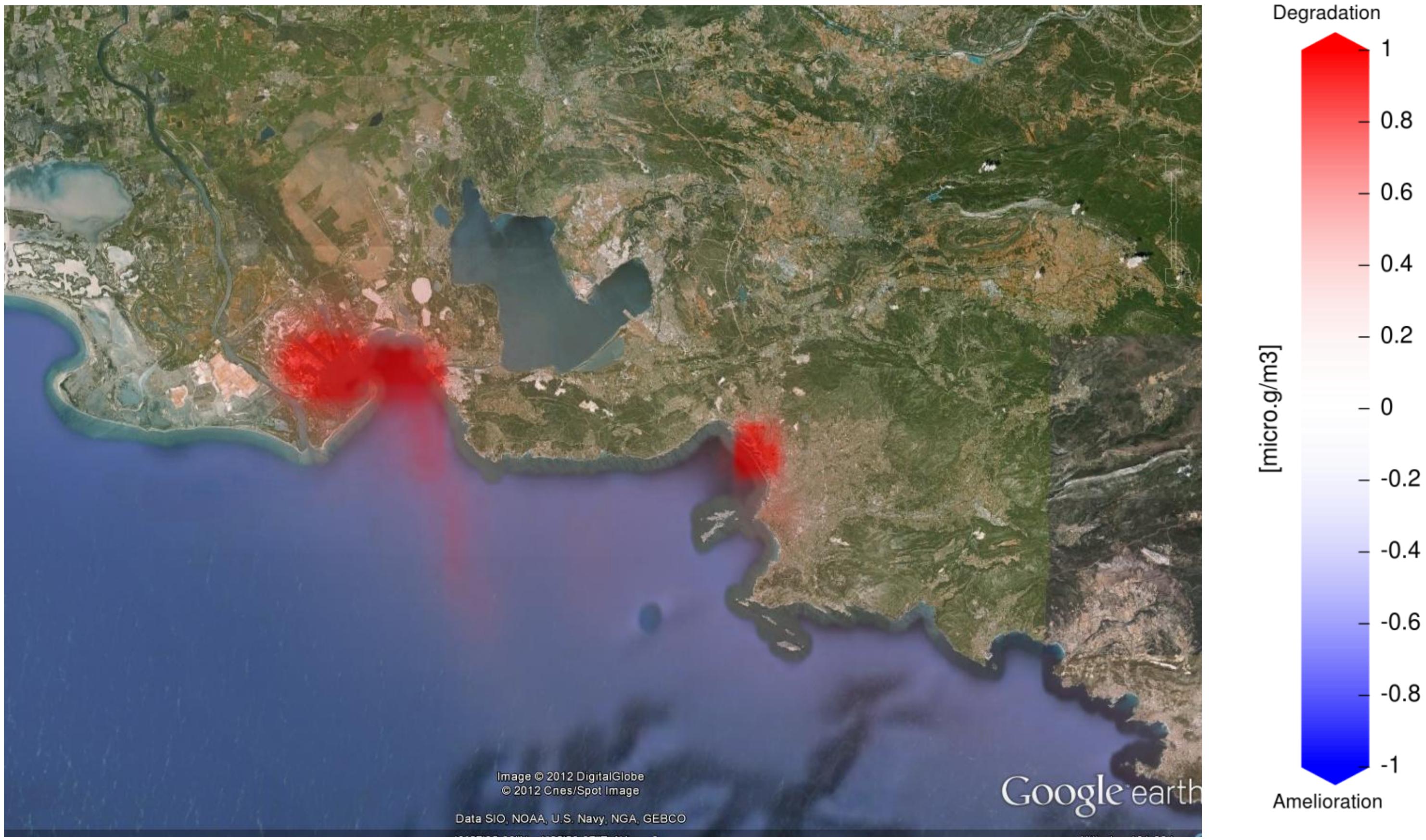
→ Regional PM_{10} concentration using CHIMERE



Future scenarios – Results

Scenario 1: Base case future run ⇨ emission 2025

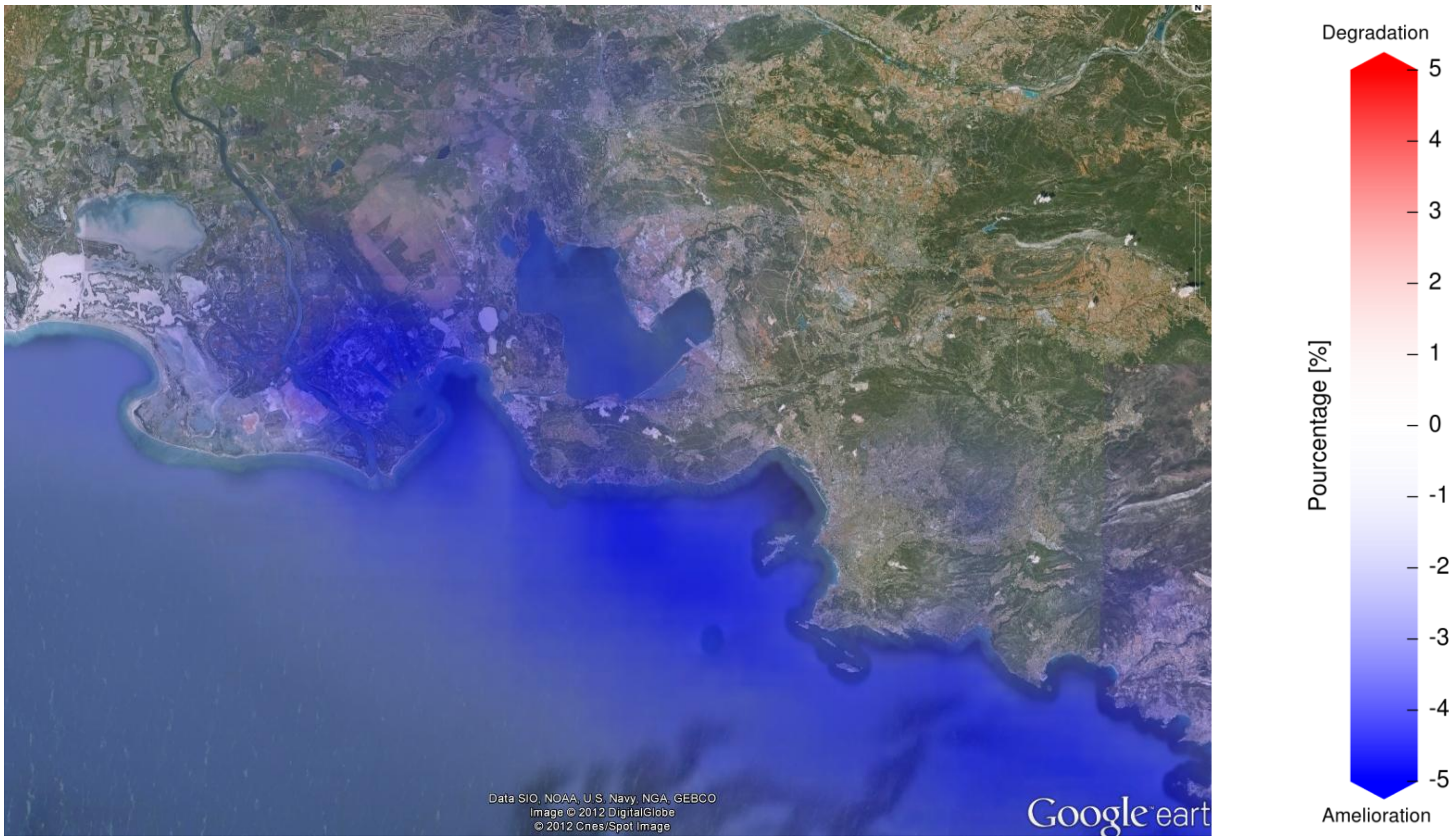
→ Difference between future and present for PM10 concentration



Future scenarios – Results

<u>Scenario 3</u>: Common Future emission mitigation ⇨ low fuel sulfur content

→ Difference between future and mitigation action for $PM_{2.5}$ concentration



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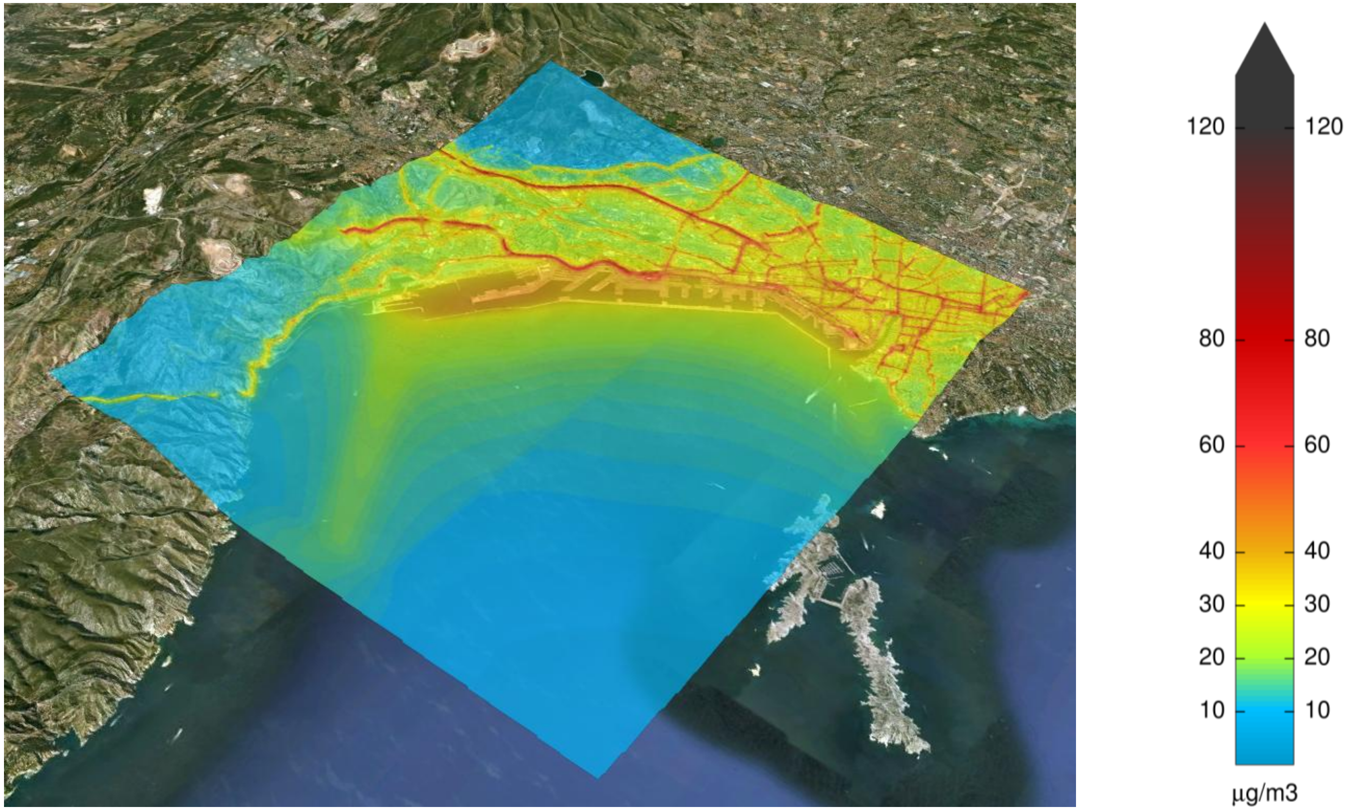
Future scenarios – Results

Scenario 1: Base case future run ⇨ emission 2025

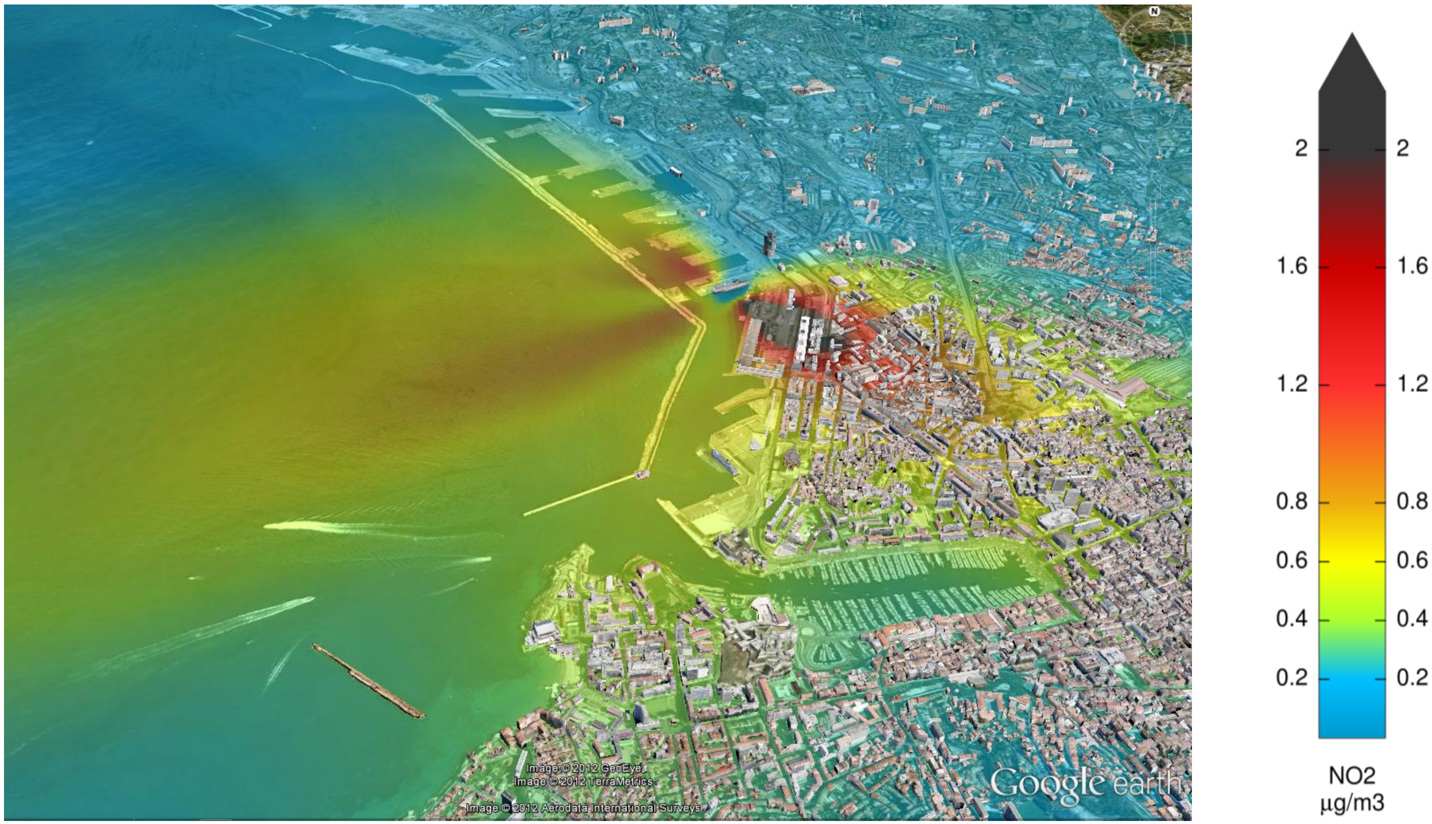
→ High resolution for NO2 concentration using ADMS Urban



Future scenarios – Results

<u>Scenario 3</u>: Individual future emission mitigation ⇨ OPS solution

→ Contribution for NO2 concentration of ships involved in the OPS scenario



Future scenarios – Results

<u>Scenario 3</u>: Individual future emission mitigation ➪ OPS solution

→ Difference between future and mitigation action for NO_2 concentration

Future scenarios – Results

Scenario 3: Individual future emission mitigation ⇨ OPS solution

→ Difference between future and mitigation action for PM10 concentration

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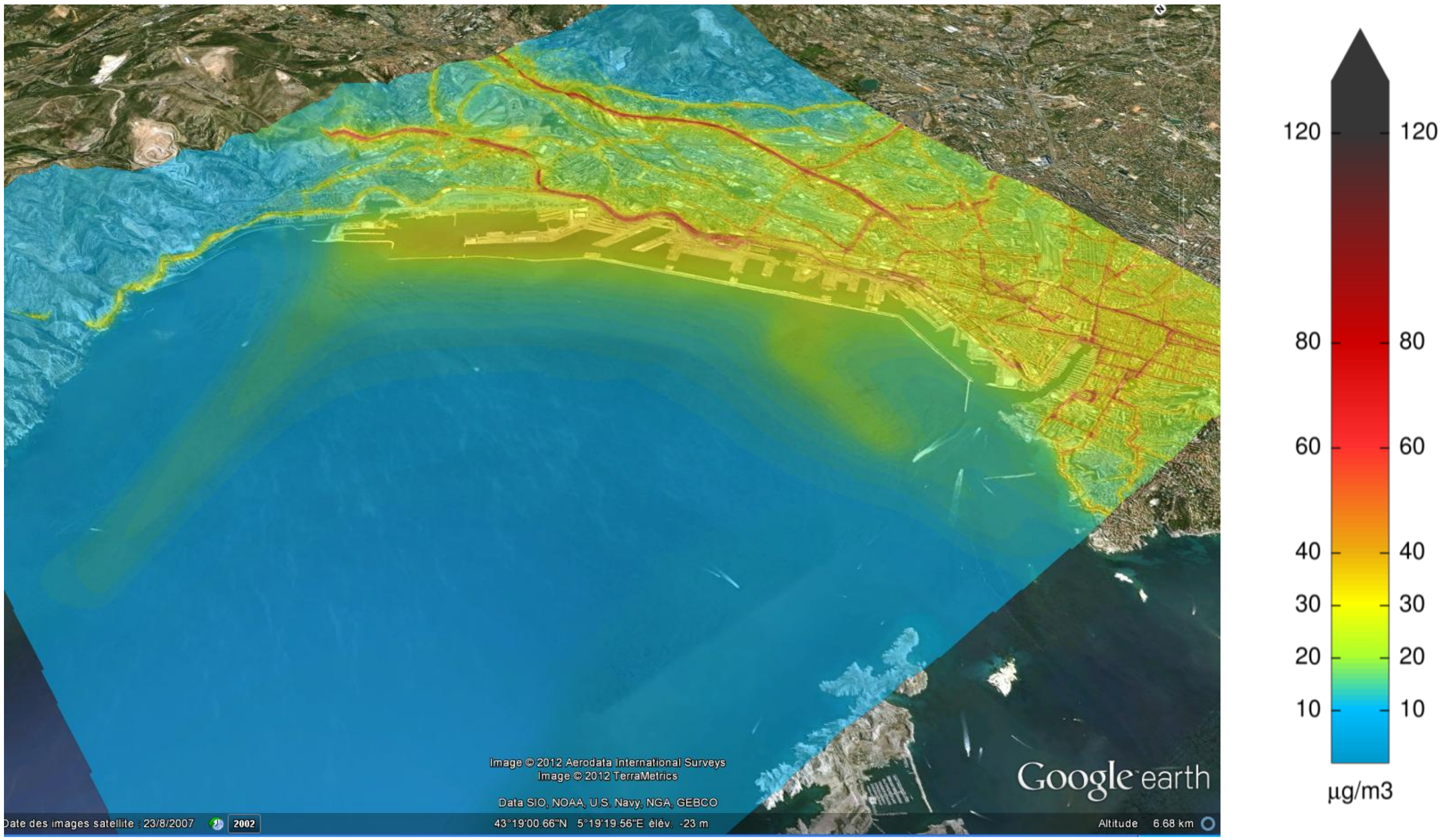
Future scenarios – Results

<u>Scenario 4</u>: Individual future emission mitigation ⇨ new cruise terminal

→ NO2 concentration using ADMS Urban for the new cruise terminal



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Future scenarios – Results

Scenario 4: Individual future emission mitigation ⇨ new cruise terminal

→ Difference between future and mitigation action for NO_2 concentration

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Future scenarios – Results

<u>Scenario 4</u>: Individual future emission mitigation ⇨ new cruise terminal

→ Difference between future and mitigation action for PM10 concentration

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Conclusion

- Source apportionment by receptor model
  - Sharing of methodologies
  - Improvement of source profiles
  - Analysis of the long term monitoring campaign in progress

- Source apportionment by chemical transport model
  - Development of a new tool to apportion local sources with CHIMERE
  - Set up of the new model CAMx
  - Validation of source apportionment results

⇨ **Significant contribution of biomass burning to PM concentration**

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Conclusion

- Future scenario and mitigation actions
  - Base case future run (2025) :
    - PM10 increase by 1µg/m3
  - Reduction of sulfur content
    - Maximal reduction for PM concentration by 5 %
  - OPS solution
    - Maximal reduction for NO_2 concentration by 5 µg/m3.
    - PM10 reduction below than 1 µg/m3
  - New cruise terminal
    - Significant improvement close to the port area for NO_2
    - PM10 decrease by 1µg/m3

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