AirPACA
QUALITÉ DE L'AIR

Particulate source apportionment using two chemical transport models over French South Eastern coastal area

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Introduction

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The APICE project

<u>APICE</u>: *Common Mediterranean strategy and local practical <u>A</u>ctions for the mitigation of <u>P</u>ort, <u>I</u>ndustries and <u>C</u>ities <u>E</u>missions (<u>www.apice-project.eu</u>)*

Project financed by MED 2007/2013 (from July 2010 to February 2013)

⇨ **<u>Main objective</u>: to define local adaptation plan and common strategy to improve air quality**

Introduction

The APICE project

To design efficiency actions ⇨ knowledge about source contributions

<u>Source apportionment studies</u>

- using monitoring campaigns (PMF, CMB)
- using numerical models (CAMx, CHIMERE)

⇨ Intercomparison and evaluation

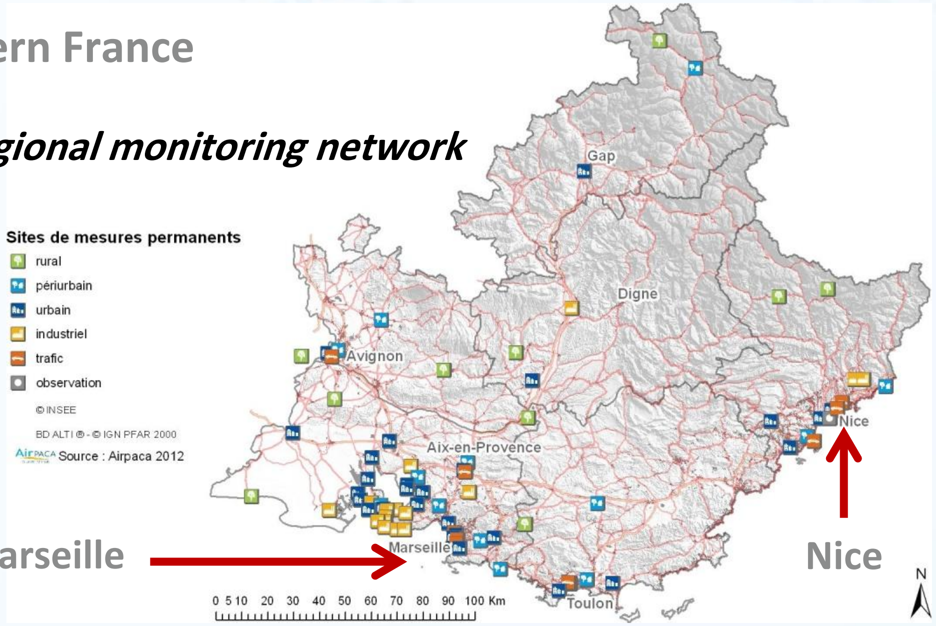
Introduction

Presentation of AirPACA

AirPACA: regional air quality survey in south-eastern France

- Air quality monitoring
- Air quality forecast
- Air quality information

Regional monitoring network



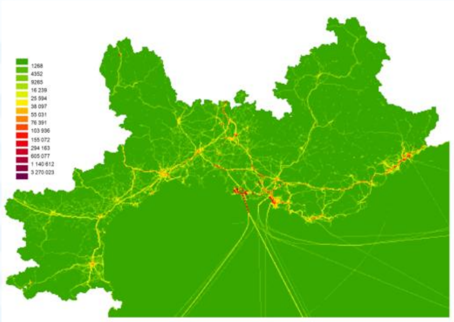
Marseille

Nice

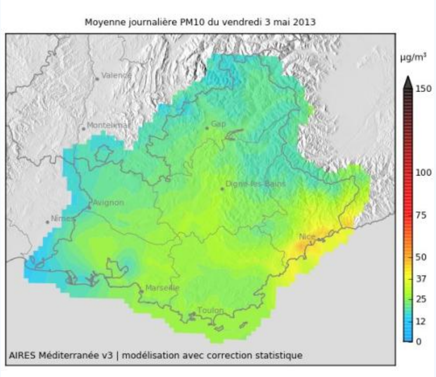
Modeling activities:

- Emission inventory
- Daily forecast
- Scenario evaluation

Inventory



Forecast



Scenario

Introduction

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Source apportionment study

Two approaches to assess contribution of emission sources

- **Receptor models** → Positive Matrix Factorization (PMF), Chemical Mass Balance (CMB)

  First step: intercomparison campaign in Marseille with all partners participation (winter period)

  Second step : long monitoring campaign in Marseille

- **Chemical Transport models** → CHIMERE, CAMx

  First step: simulation of the intercomparison campaign over Marseille area using CHIMERE

  Second step: set-up of CAMx model over the regional area thanks to the participation of Guido Pirovano

  Third step: intercomparison of different source apportionment approaches

Data and method

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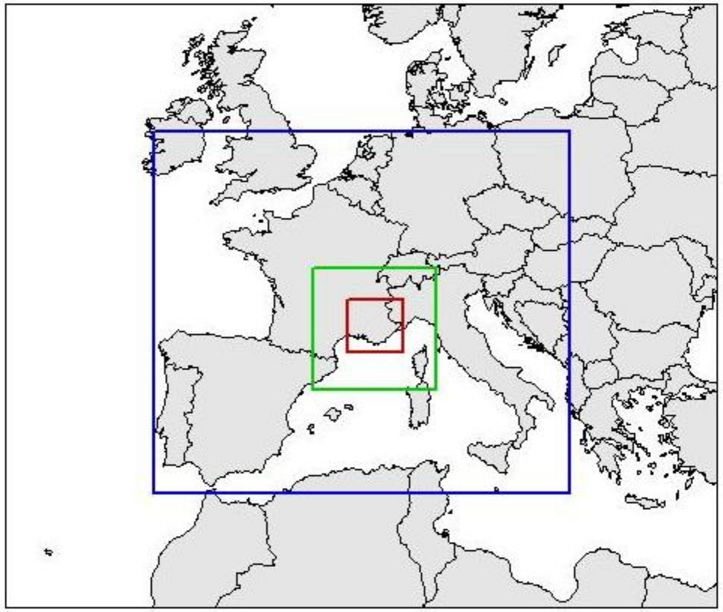
The modeling system



Simulation area: 3 nested domains

- European domain (27 km) - GFR27
- Large South France domain (9 km) - FRSE9
- Regional domain (3 km) - PACA3

Meteorology

- WRF (GFR27 – FRSE9 – PACA3)

Anthropogenic emission data

- EMEP data (GFR27 & FRSE9)
- Local emission inventory (PACA3)

Natural emission data

- MEGAN (GFR27 – FRESE9 – PACA3)

Boundary and initial conditions

- Meteorological fields
  - GDAS - NCEP (GFR27)
  - WRF output (FRSE9 & PACA3)
- Chemical fields
  - LMDz-INCA2 (GFR27)
  - CHIMERE output (FRSE9 & PACA3)

⇨ **Common input for CHIMERE and CAMx over PACA3 domain**

Data and method

Air PACA

The modeling system

Emission sectors involved in the source apportionment approaches

Name	Description	Color
Industry – Energy	Public power, heating plants, industry, waste, …	(orange)
Residential – Tertiary	Biomass combustion, residential plants, commercial plants, …	(yellow)
Natural	Windblown dust, sea salts, biogenic, …	(light green)
Agriculture	Agriculture, forest, …	(green)
Maritime transport	Shipping, loading and unloading processes, maritime activities…	(blue)
Non-road transport	Inland waterways, railways, air traffic, …	(light blue)
Road transport	Cars, trucks, motorcycles, road abrasion, …	(purple)
External	Long-range transport from outside of the domain	(grey)

Simulation period

- Winter period: February 2011
- Summer period: August 2011

Pollutants studied

- Focus on particles concentrations : PM_{10} and $PM_{2.5}$

Data and method

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CHIMERE model and zero-out approach

Starting equation

C°total = a.energy-industry + b.residential + c.natural + d.agriculture + e.maritime + f.non road + g.road + h.boundary conditions

Removing each emission sector, we have the following matrix system: **A.X = B** where X is a concentration

$$A = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix} \quad X = \begin{bmatrix} a \\ b \\ c \\ d \\ e \\ f \\ g \\ h \end{bmatrix} \quad B = \begin{bmatrix} C° \, (0 \, industry - energy) \\ C° \, (0 \, résidential) \\ C° \, (0 \, natural) \\ C° \, (0 \, agriculture) \\ C° \, (0 \, maritime) \\ C° \, (0 \, non \, road \\ C° \, (0 \, road) \\ C° \, (0 \, boundary \, conditions) \end{bmatrix}$$

Contributions are given by:

→ contribution for industry/energy : A = a / ∑ (a, b, c, …, h)

→ contribution for residential : B = b / ∑ (a, b, c, …, h)

Reference run is used to estimate the methodology error:

→ Error = [C° ref. - ∑ (X)] / C° ref.

Data and method

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CAMx model and tracer approach

Using Particulate Source Apportionment Technology (PSAT)

- Same starting equation

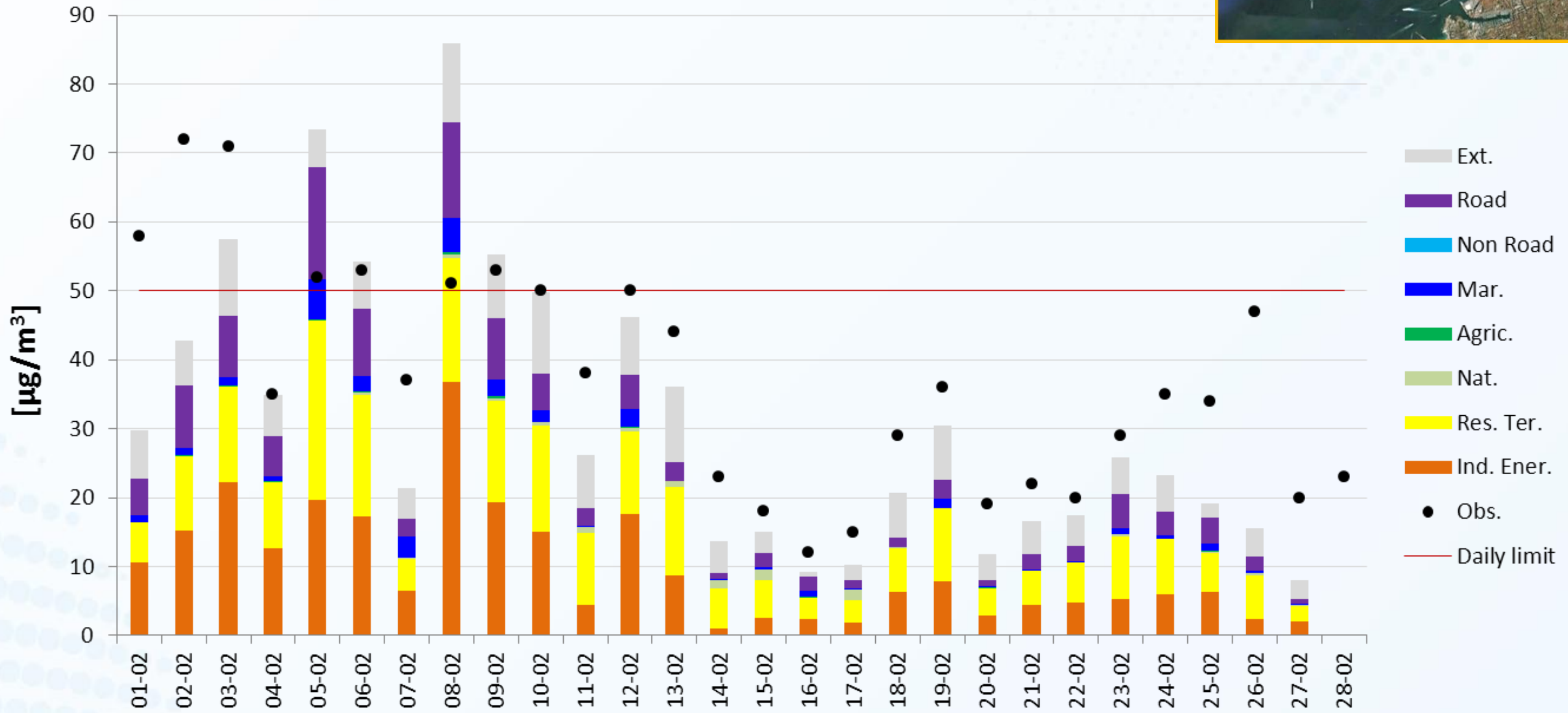
C°total = a.energy-industry + b.residential + c.natural + d.agriculture + e.maritime + f.non road + g.road + h.boundary conditions

- Reactive tracer methods
  - Time saving (one simulation)
  - Mass consistency
  - Fully traceable
- Direct source apportionment PMx
  - Primary particle
  - Gaseous precursors
  - Secondary particle

Results

CHIMERE model and zero-out approach

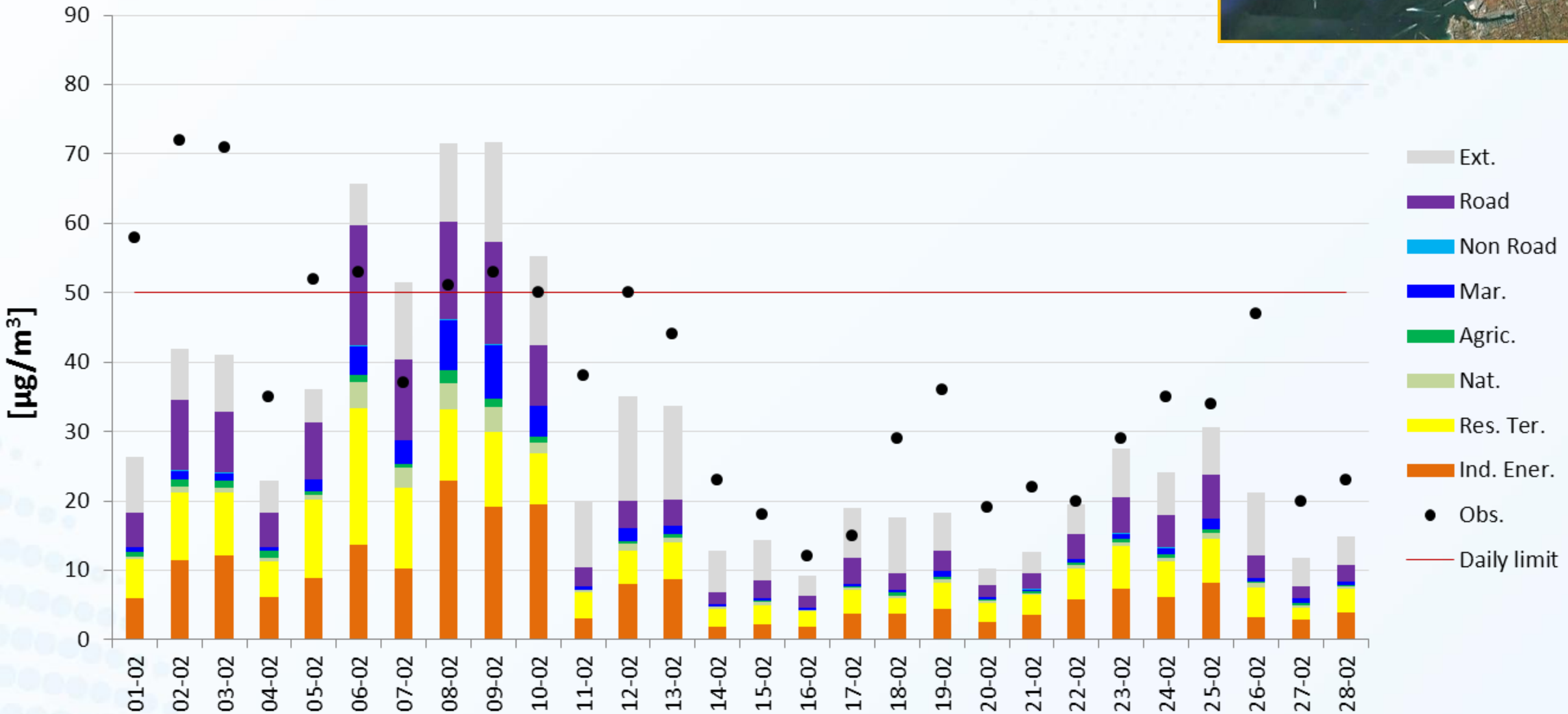
Daily PM_{10} output for the winter period at the urban background station (Marseille)



Results

CAMx model and tracer approach

Daily PM_{10} output for the winter period at the urban background station (Marseille)



Results

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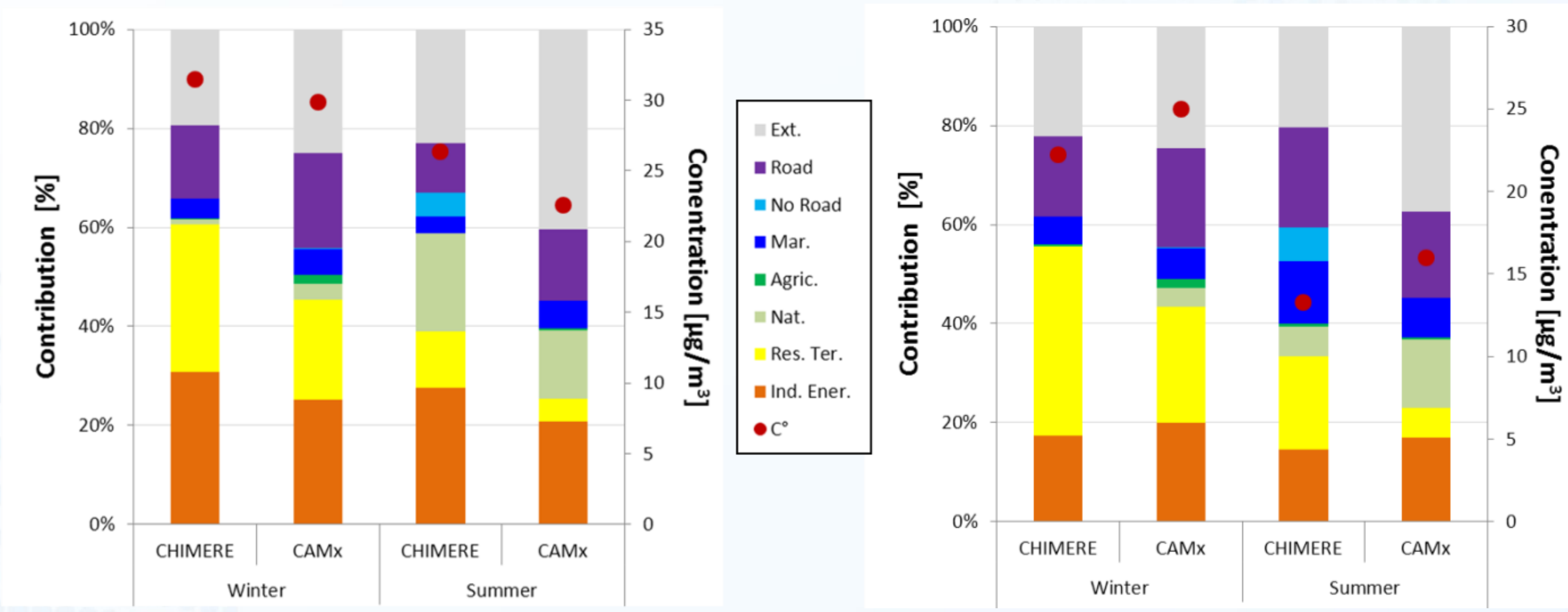
Comparison between CHIMERE and CAMx

Results at the downtown station during both winter and summer period



PM_{10} $PM_{2.5}$

Results

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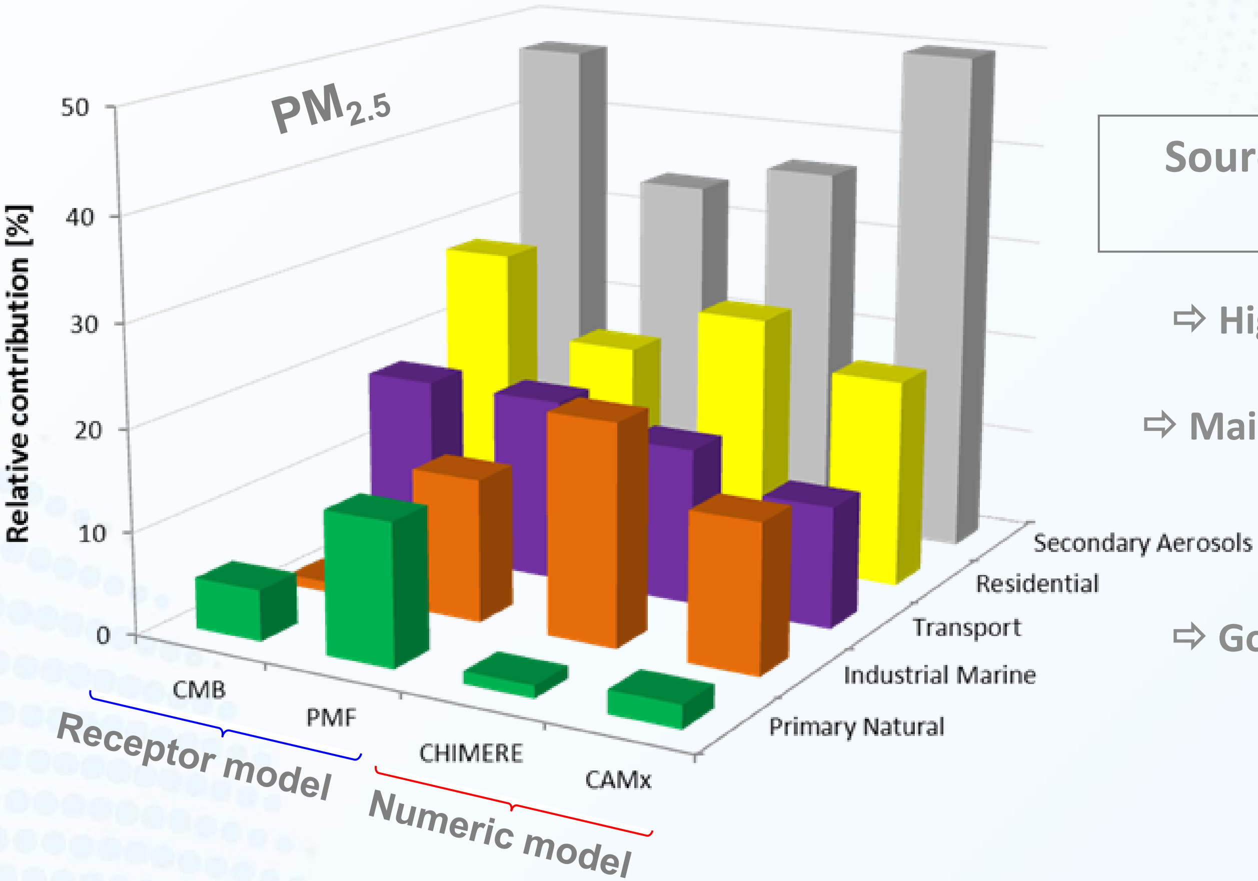
Comparison between numerical models and receptor models

Results at the downtown station during the winter period



Source apportionment for primary particles only

⇨ High fraction of secondary aerosols

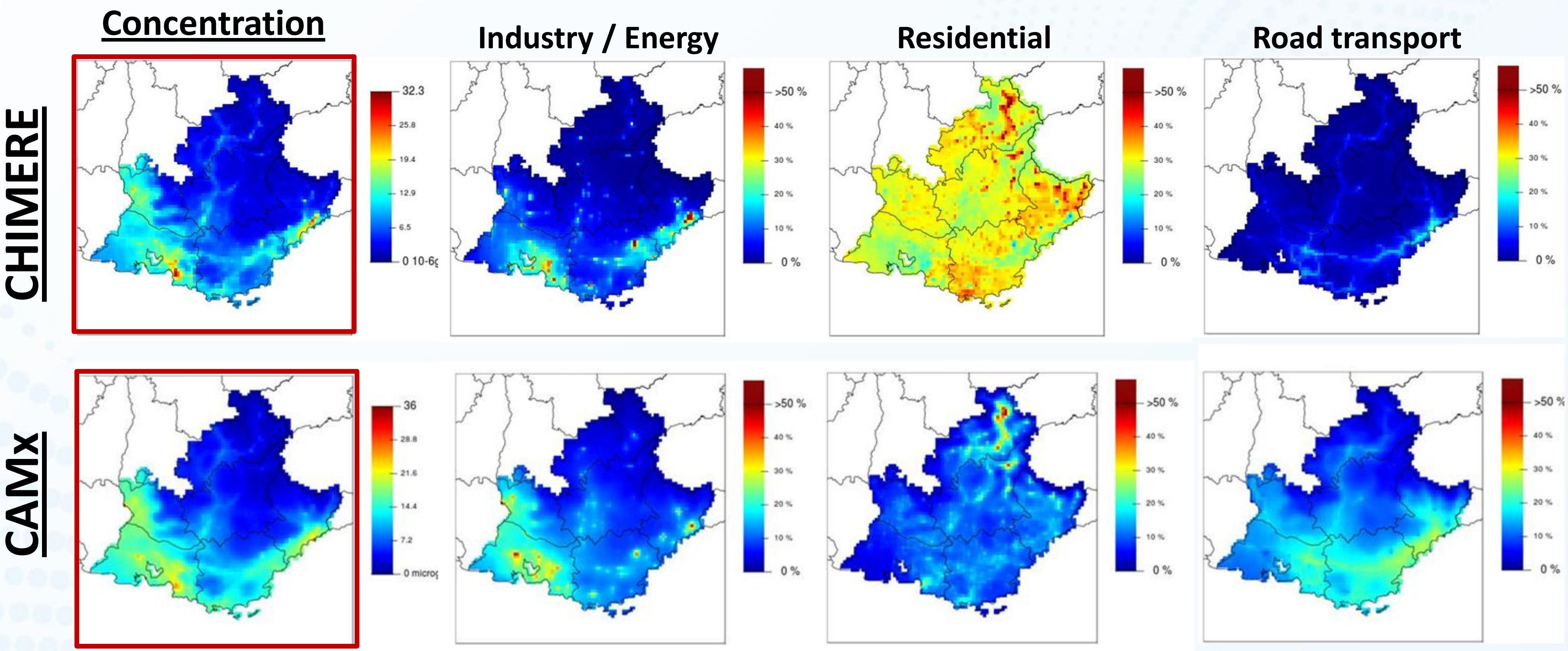
⇨ Main contribution from the residential sector

⇨ Good agreement between receptor models and CTMs

Results

Comparison between numerical models at the regional scale

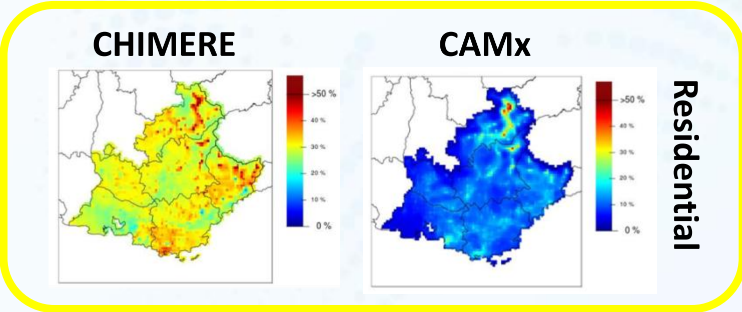
Monthly PM_{10} output during the winter period at the regional scale



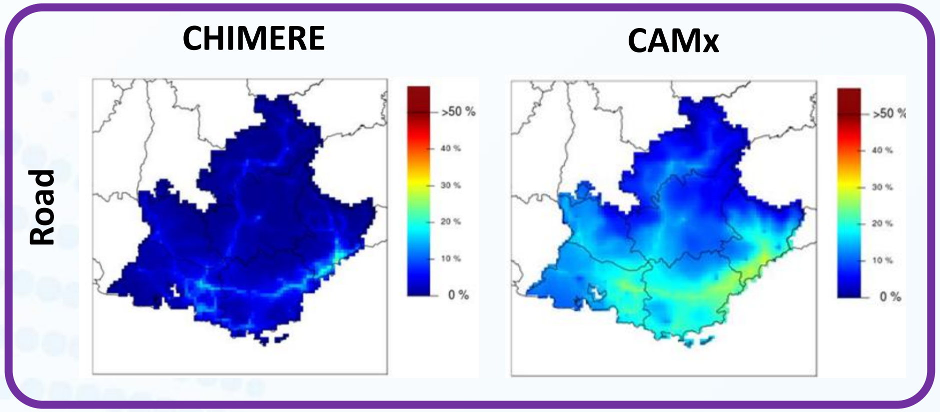
Discussion

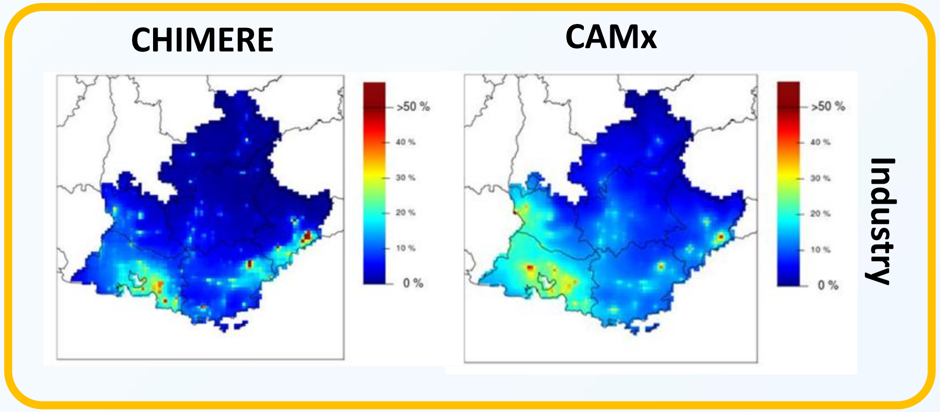
Comparison between numerical models

Significant difference observed at the regional scale



- From CHIMERE with zero-out approach
  - higher contribution from the residential sector
- From CAMx with PSAT approach
  - more important spatial extent for road transport and industry-energy sectors





⇨Due to secondary particles source apportionment

Discussion

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Comparison between numerical models

For the zero-out approach

- Removing a source contributing to the emissions of a gas phase precursor could have no effect on the corresponding secondary aerosol species if the removed precursor is not limiting for the conversion reaction
    - Underestimation of contribution for the secondary species (as industry, road transport, …)
    - Overestimation for the primary species (as biomass burning)

For the reactive tracer approach

- All sources contribute, proportionally to their weight, to secondary species, although they are in excess
    - More realistic representation of contribution for the secondary species
    - Higher dispersion extent for the contribution for the secondary species

⇨ **Important contribution from gas phase precursor and chemistry reactions at the regional scale**

Conclusion

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Comparison between different approaches

- **Source apportionment over French south eastern Mediterranean coast using:**
  - zero-out approach with CHIMERE
  - reactive tracer with CAMx

- **At the large scale, significant differences between approaches due to non-linear system**
  - overestimation of local sources with zero-out method
  - overestimation of contribution for primary emissions with zero-out method

- **At the monitoring station, downtown in Marseille**
  - comparison between receptor models and numeric models for the primary fractions
  - global good agreement during the winter period (study for the summer period in progress)
  - some differences between receptor models, mainly for the industry sector
  - underestimation of the natural contributions with the numerical models due to a lack for the emissions

Conclusion

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Source apportionment study outcomes

- **During the winter period:**
  - significant contributions from industry-energy, road transport and residential sectors

- **During the summer period:**
  - significant contributions from natural emissions in a large part of the region
  - inside large cities, road transport and industry-energy remain important

- **During the both periods:**
  - significant contributions of the long range transport from areas outside of the region area

Perspectives

- **Using these outcomes to design efficiency actions to reduce PM concentrations**

- **Using CAMx with PSAT to apportion PM and precursors among different area**

Thanks for your attention

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