Using Air Quality Modelling to Improve Air Emission Inventories

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AGÊNCIA PORTUGUESA DO AMBIENTE

Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional

Objective

to evaluate the **available emission inventories** for Portugal through air quality modelling application/validation

to identify **weakness and strengthens** and the key sources of uncertainty that can be targeted for reduction via additional data collection and research.

How?

air quality modelling applications with **MM5-CHIMERE model system** using three emissions inventories for Portugal **INERPA, EMEP, LOTOS**

And also testing the…
different **values and resolution of the three inventories**
further **spatial disaggregation**
different **temporal profiles** used for time disaggregation.

Use of Air Emission Inventories

- **Verify compliance of national and international obligations.**
  - CLRTAP
  - UNFCCC and its subsidiary Kyoto Protocol;
  - Stockholm Convention on Persistent Organic Pollutants (POP);
  - UE's Directive of National Ceilings
- **Modelling of pollutant dispersal and deposition;**
- **Establishment of baseline scenarios for the identification and definition of policies and measures.**

Spatial Emission Inventories in Portugal

INERPA

- APA – Portuguese Agency for the Environment
- National Official Inventory (CLRTAP, UNFCCC)
- Gridded data for EMEP (50x50 km)
- Municipality + LPS disagregation for National (e.g. EIA)

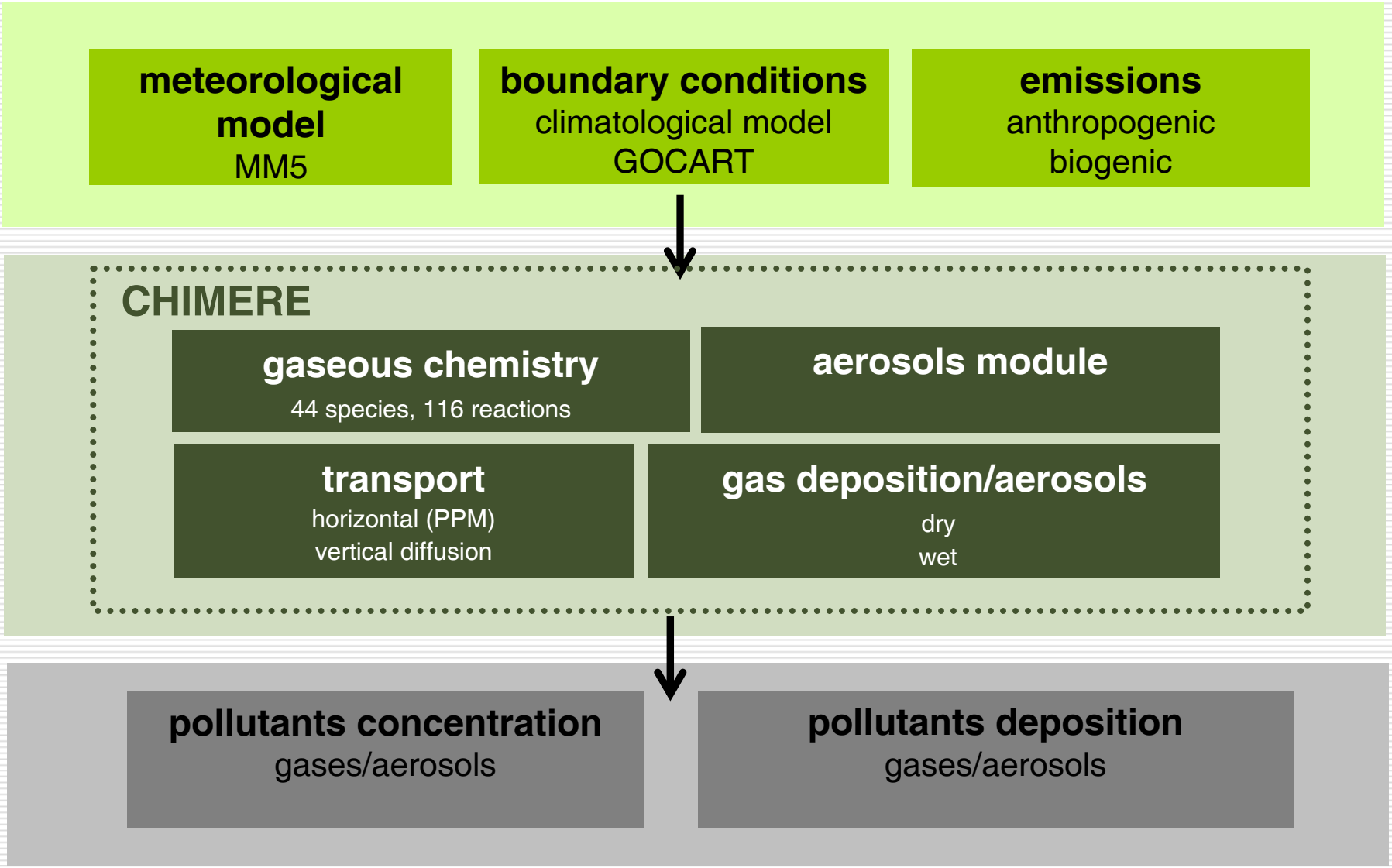
EMEP/EXPERT data

- National submission with some corrections
- EXPERT DB (Internet), June 2006. (MSC-W)
- Cover Europe (0.5º x 0.5º long-lat)

LOTOS

- TNO emission DB and baseline for 2000
- resolution: 0.25º x 0.125º long-lat (about 15 x 15 km2)
- EF PM from CEPMEIP

the modelling system



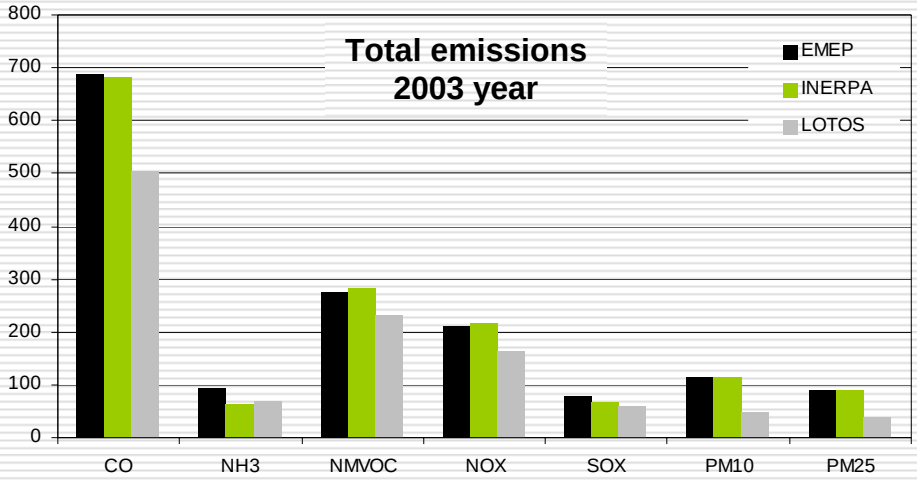
Motivation

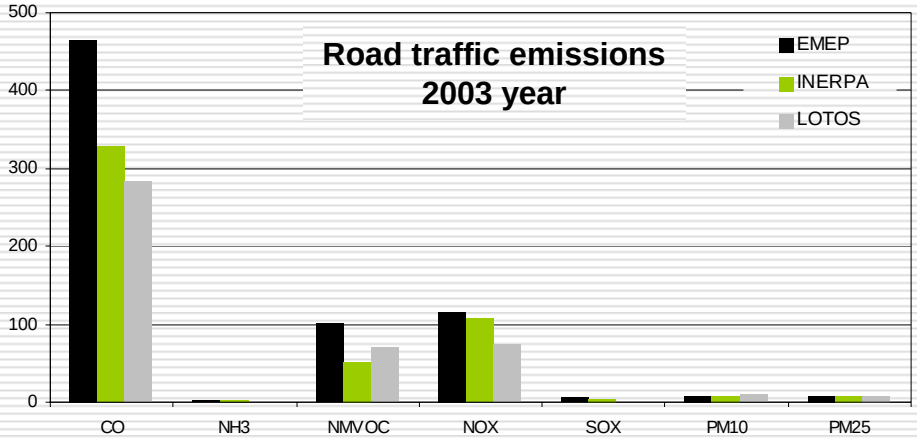
Model input category	Input variable	Uncertainty range
Initial conditions	O_3 concentration	Factor of 3
	NOx or VOC concentration	Factor of 5
Boundary conditions	O3 concentration aloft or at side	Factor of 1.5
	NOx or VOC concentration aloft or at side	Factor of 3
Meteorology	Wind speed	Factor of 1.5
	Wind direction	+/- 40 degrees
	Air temperature	+/- 3 K
	Relative humidity	30%
	Daytime vertical diffusivity below 1000 meters	Factor of 1.3
	Nightime vertical diffusivity	Factor of 3
	Rainfall amount	Factor of 2
	Cloud cover	30%
	Cloud liquid water content	Factor of 2
Emissions	Major point source NOx or VOC	Factor of 1.5
	All other emissions estimates	Factor of 2
Photolysis rates	Six reactions	Factor of 2
CBIV chemical mechanism	Chemical reactions	Factors from 1.17-2.5

Source: Hanna et al., 2001

Emission inventories

Totals





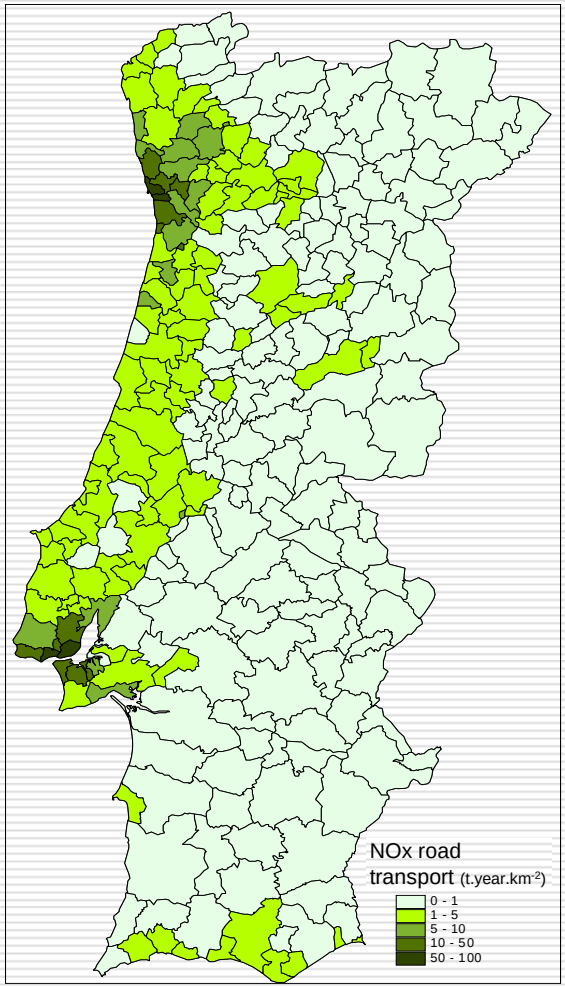
Major differences were obtained for
- LOTOS database: 20-30% lower than EMEP and INERPA
- PM emissions: 50%!

Similar EMEP and INERPA
- INERPA is the officially reported EMEP - correction/revision made by EMEP experts

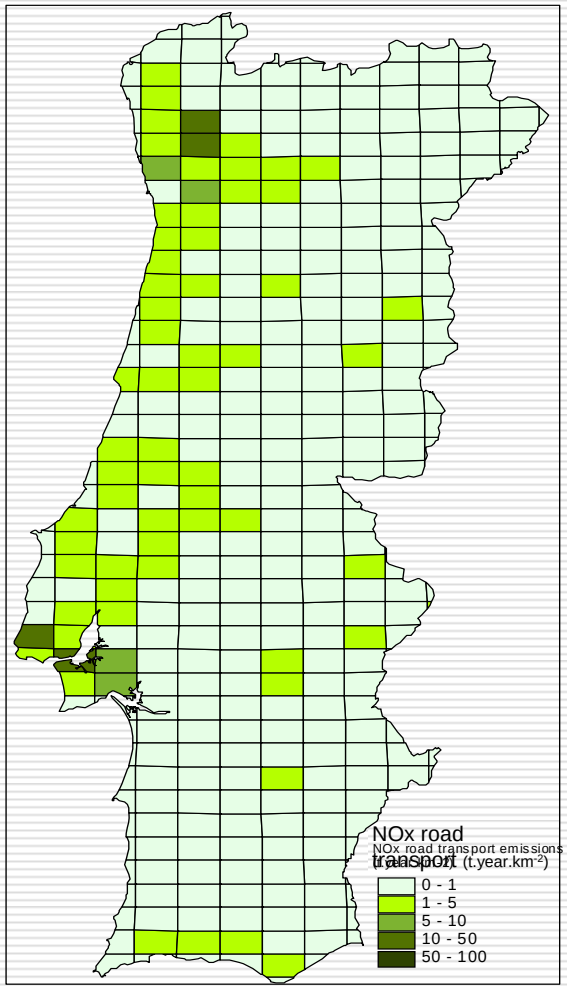
Analysis by pollutant activity shows
- That major discrepancies between inventories are registered for road transport (more than 30%)

Emissions inventory

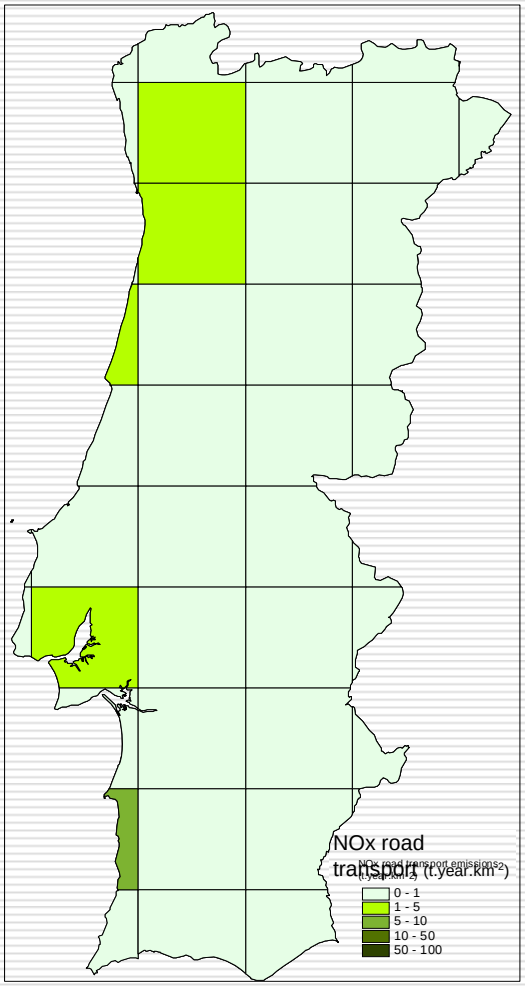
spatial distribution



INERPA



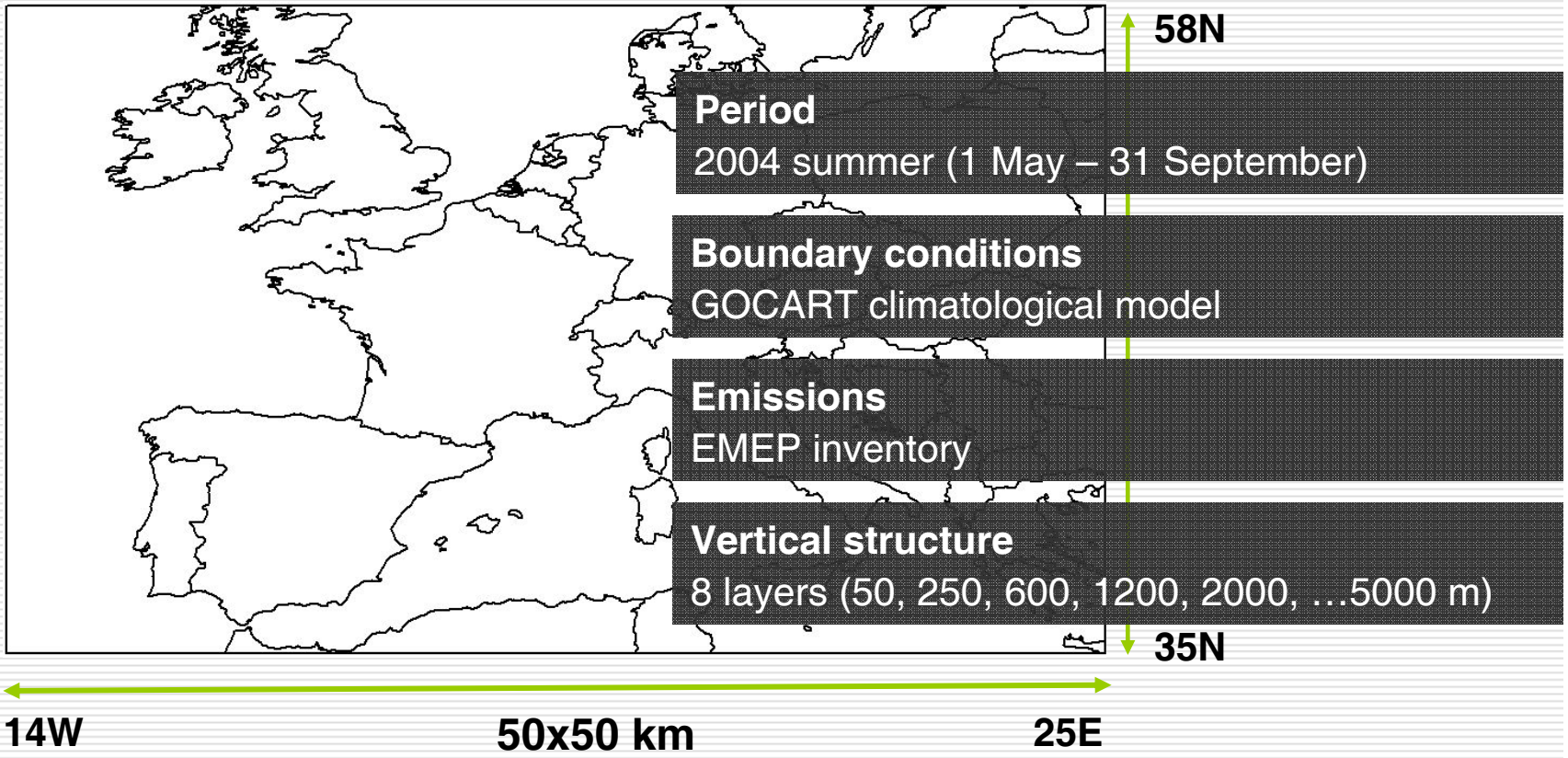
LOTOS



EMEP

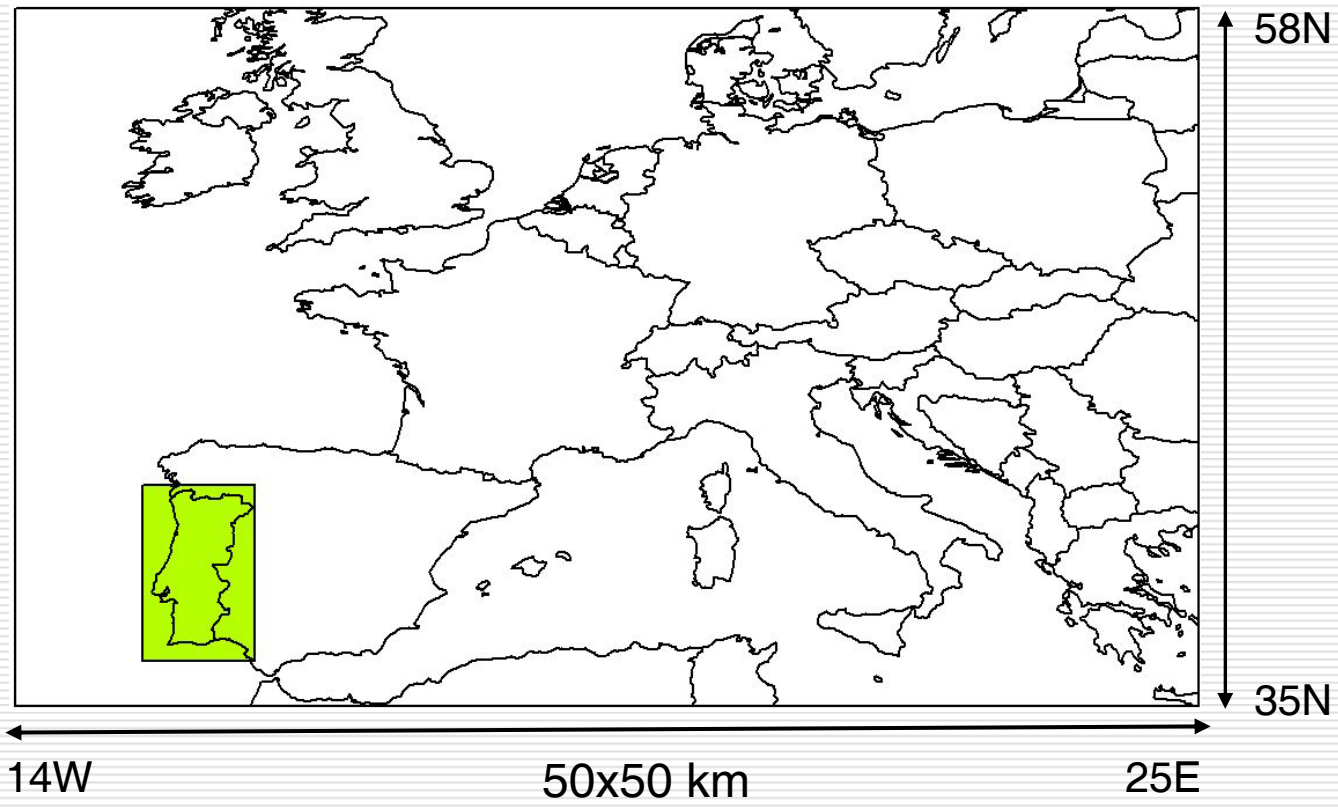
Model simulation

1st simulation **European domain**



Model simulation

2nd simulation **PORTUGAL domain**



Model simulation

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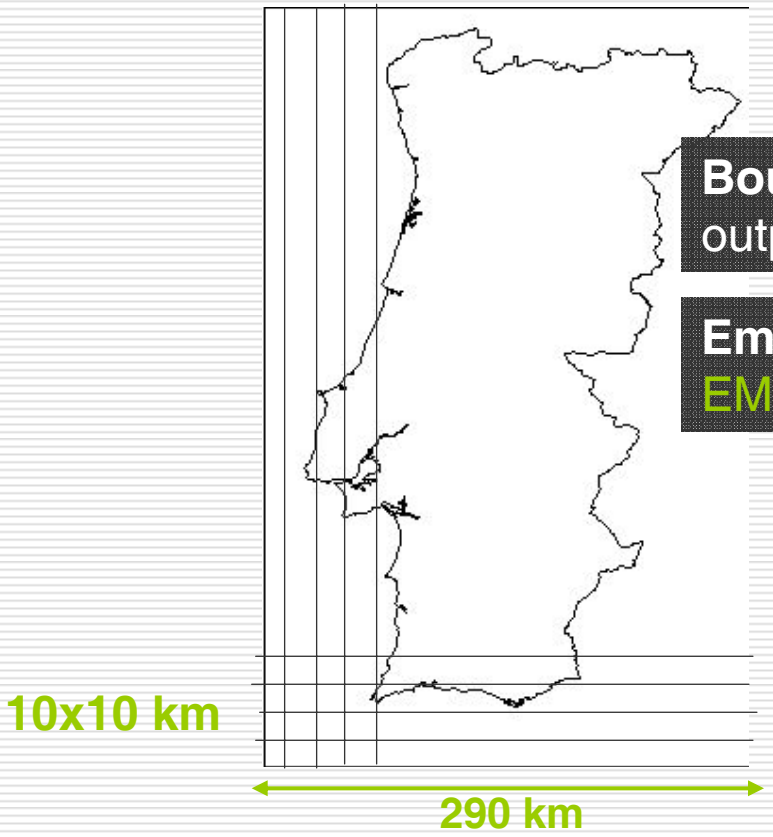


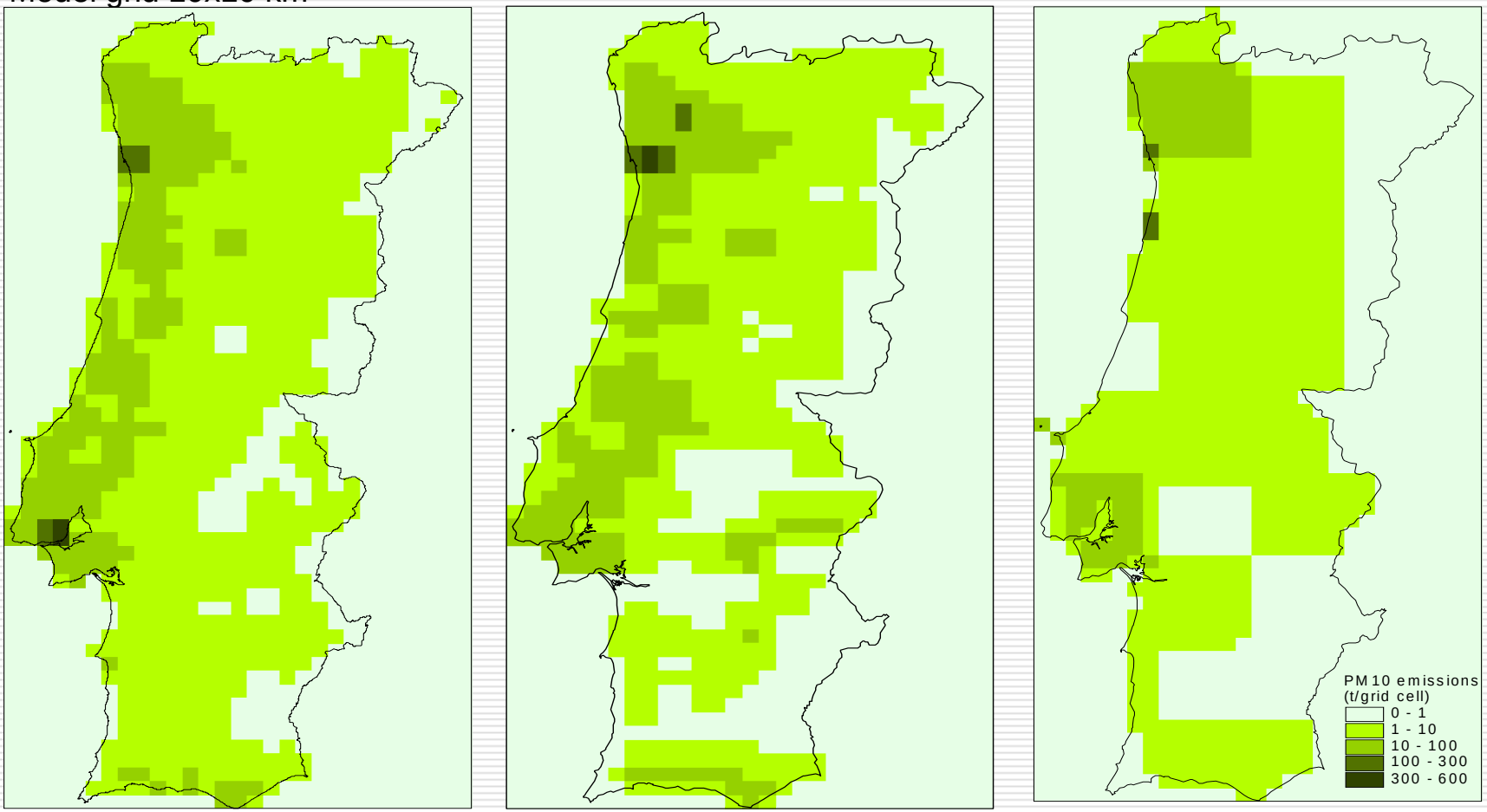
Boundary conditions
outputs 50x50 km

Emissions
EMEP, LOTOS, INERPA

Comparison of Emission Inventories

sensitivity tests

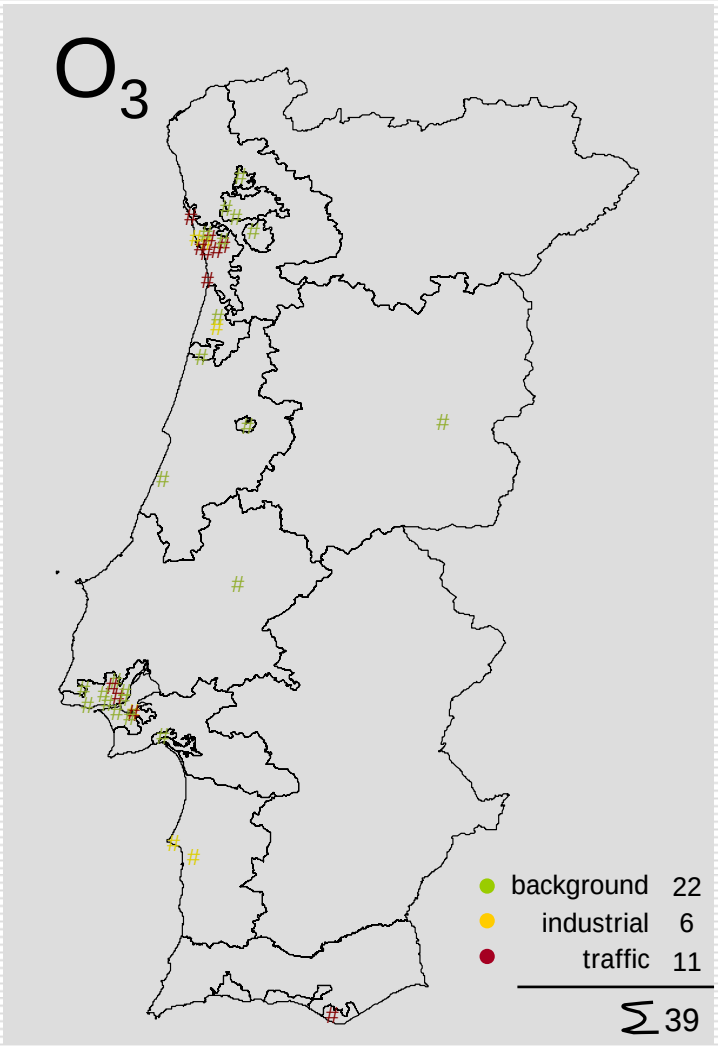
Road transport PM_{10} emissions
Model grid 10x10 km^2

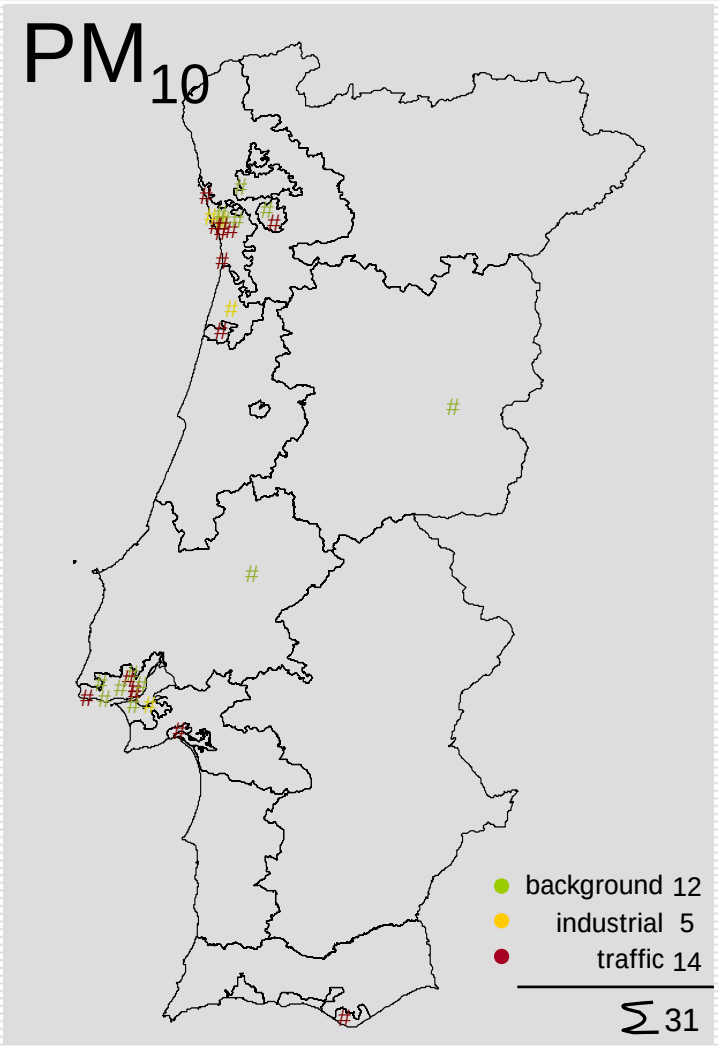


INERPA LOTOS EMEP

Air quality monitoring network

Model validation





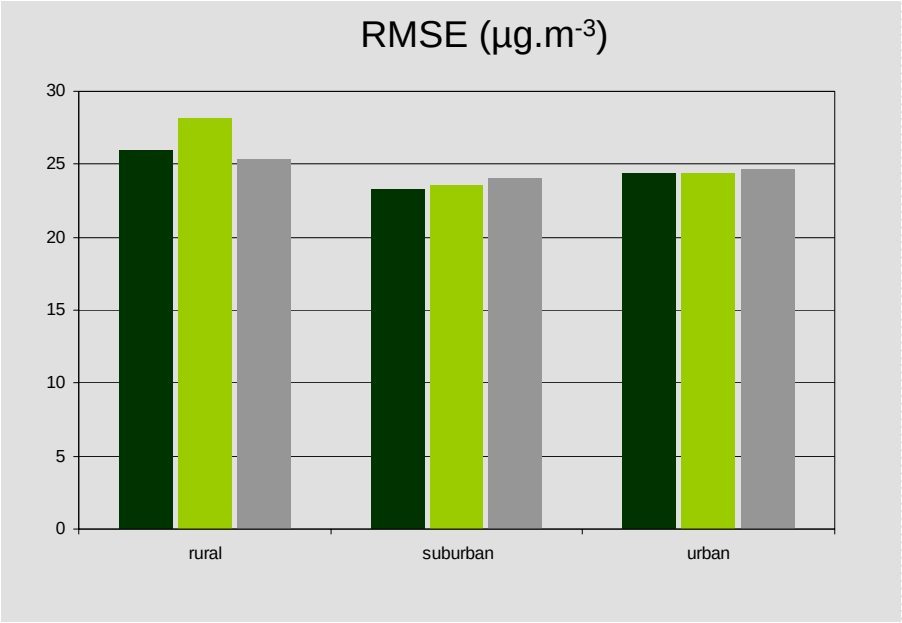
Indicators

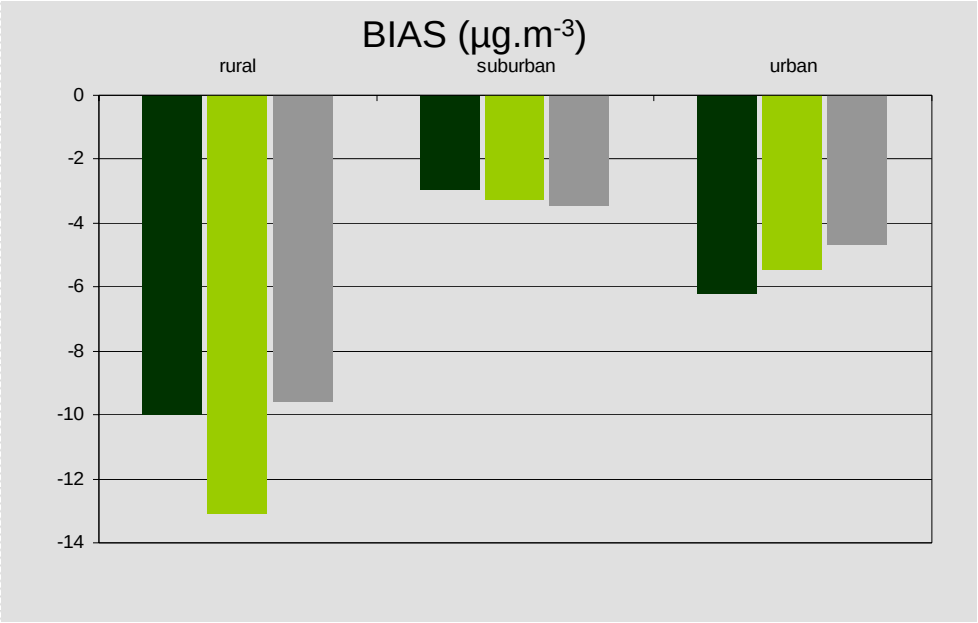
$$\mathrm{RMSE} = \frac{1}{N}\sum_{i}\left|(M_i - O_i)\right|$$

$$\mathrm{bias} = \frac{1}{N}\sum_{i}(M_i - O_i)$$

Comparison of Emission Inventories

O_3 model results





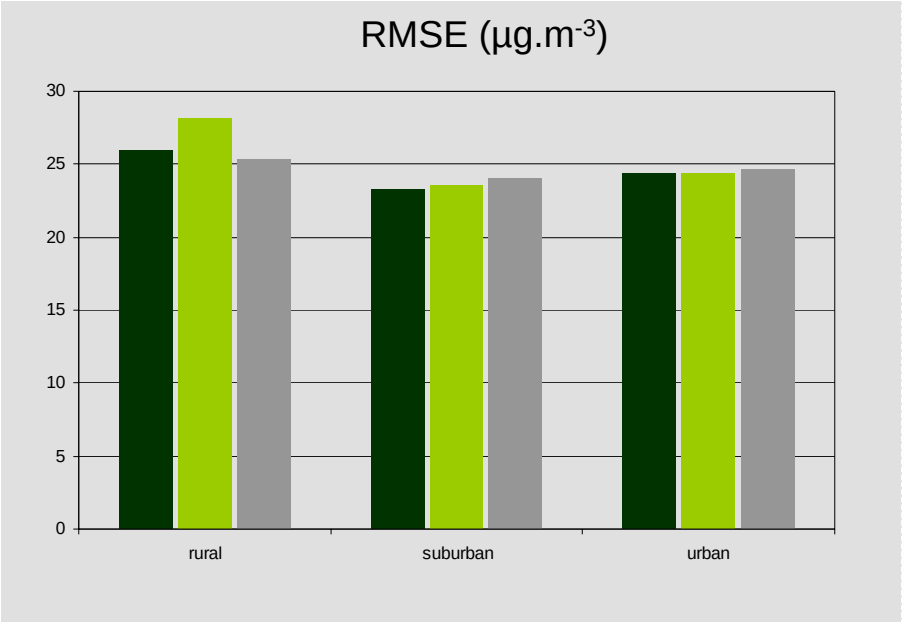
EMEP LOTOS INERPA

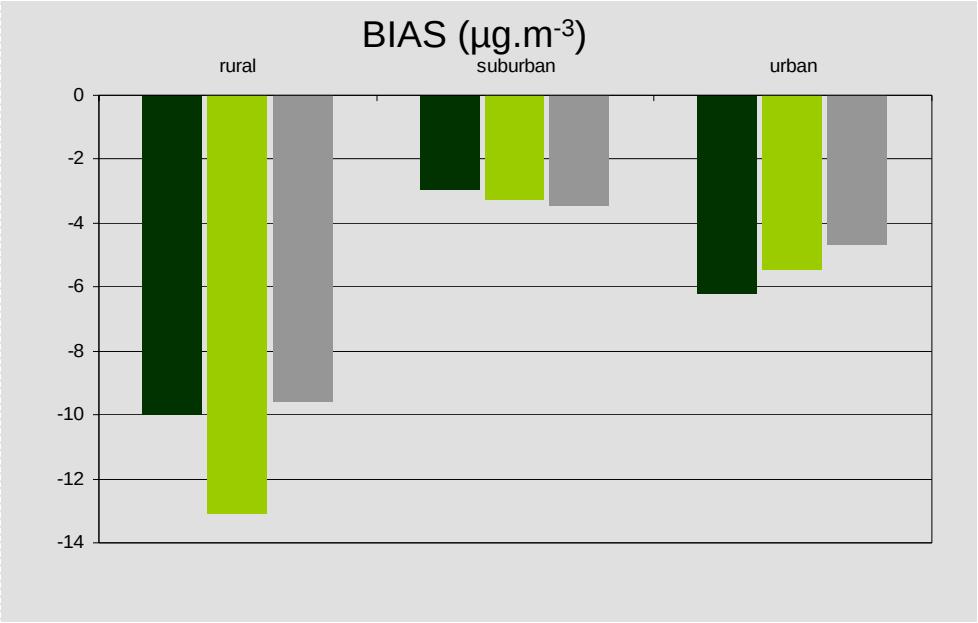
overall tendency for emissions underestimation
emphasised by the point sources omission

more notorious with the LOTOS inventory, and less with INERPA
on average, less systematic errors.

Comparison of Emission Inventories

O_3 model results





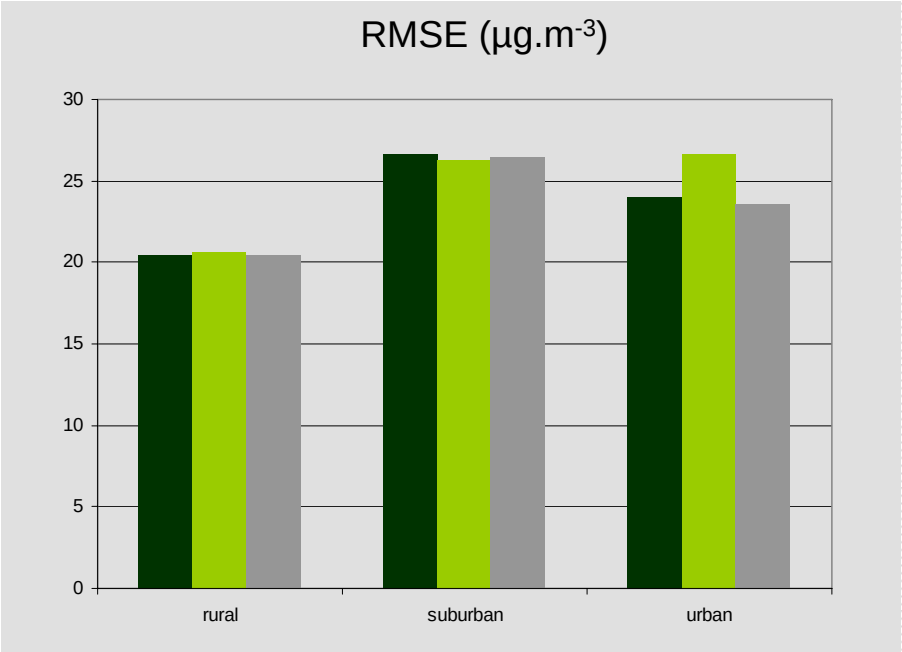
EMEP LOTOS INERPA

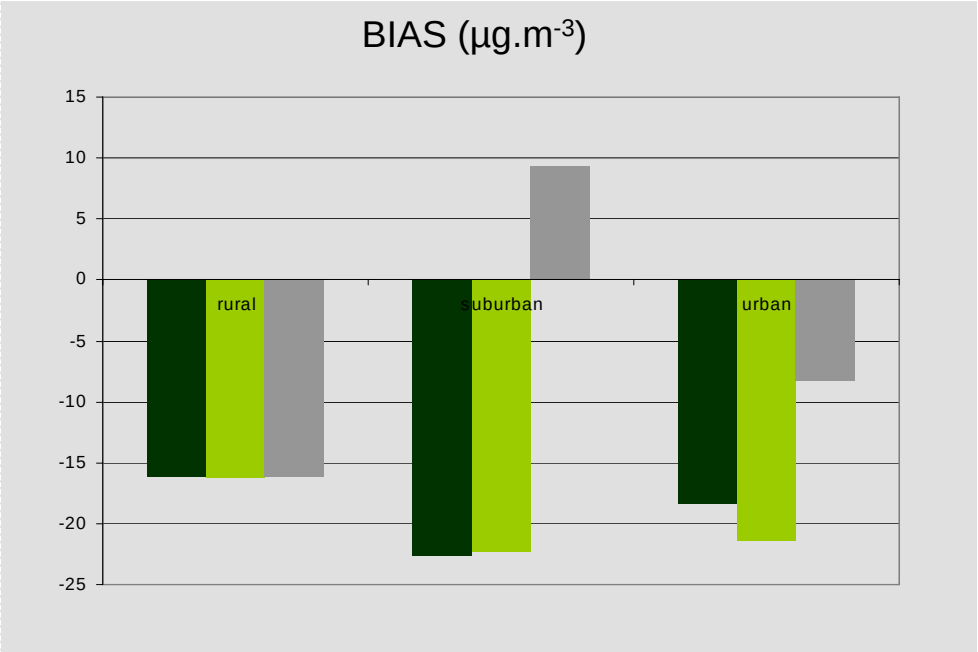
no significant discrepancies between the three emission inventories ->

higher resolution in the emission inventory do not mean necessarily better model performance

Comparison of Emission Inventories

PM_{10} model results





EMEP LOTOS INERPA

The range of uncertainty varies with locals and pollutants

There is probably a specific PM emissions overestimation by INERPA inventory...

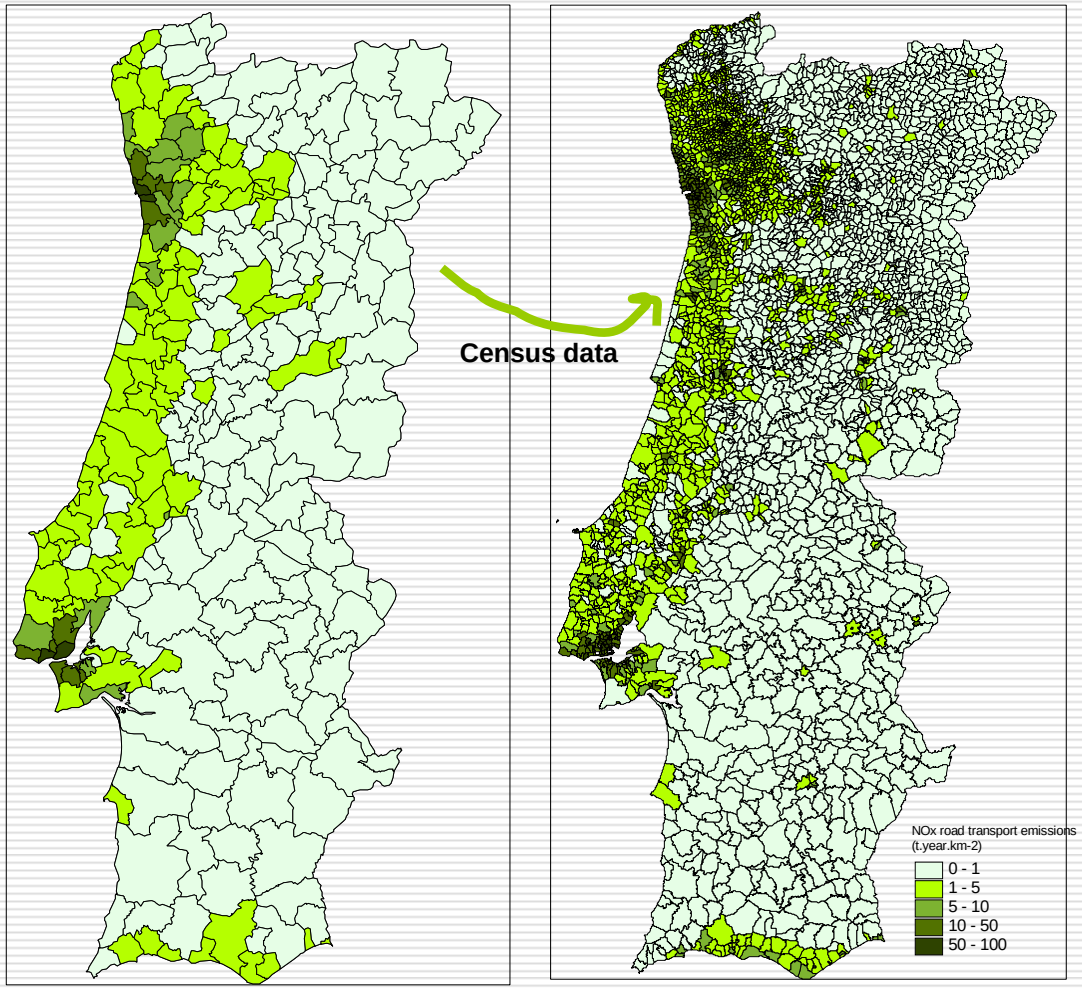
Spatial Disaggregation of Emissions

sensitivity test

Two different levels of spatial disaggregation were tested usingINERPA inventory:

- Original municipality estimates (APA)

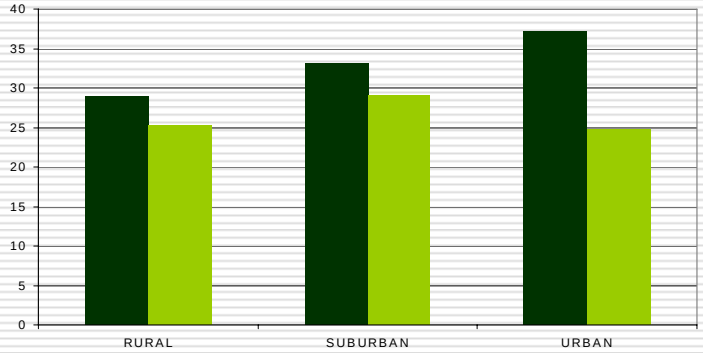
- further disaggregation to sub-municipality degree

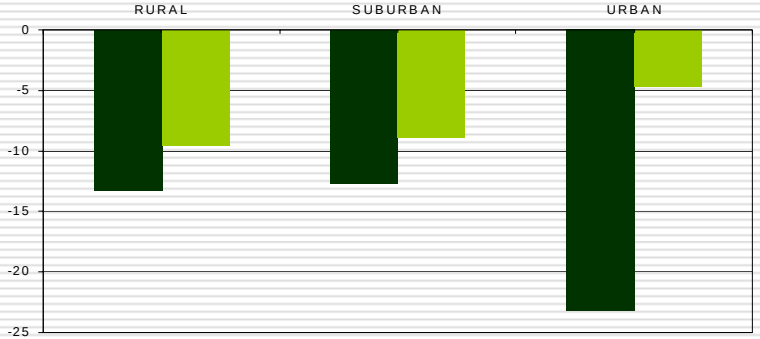


Spatial Disaggregation of Emissions

results

O_3

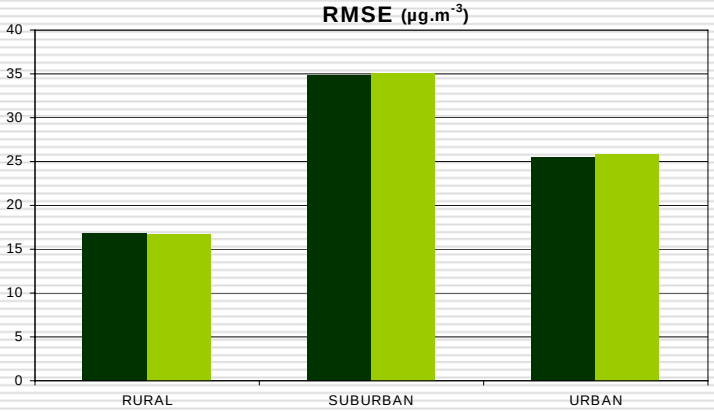


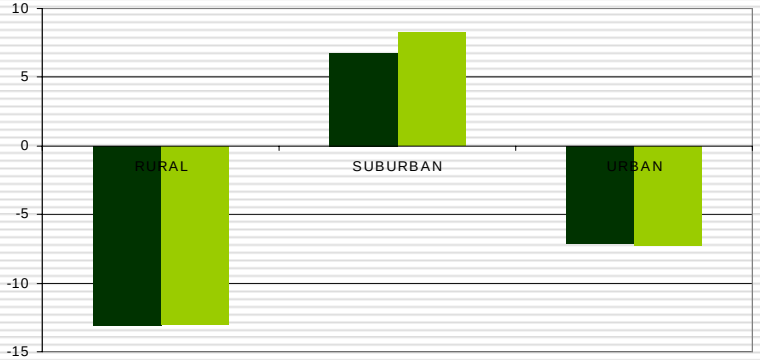


BIAS ($\mu g.m^{-3}$)

PM_{10}

RMSE ($\mu g.m^{-3}$)





Sub-municipality level Municipality level

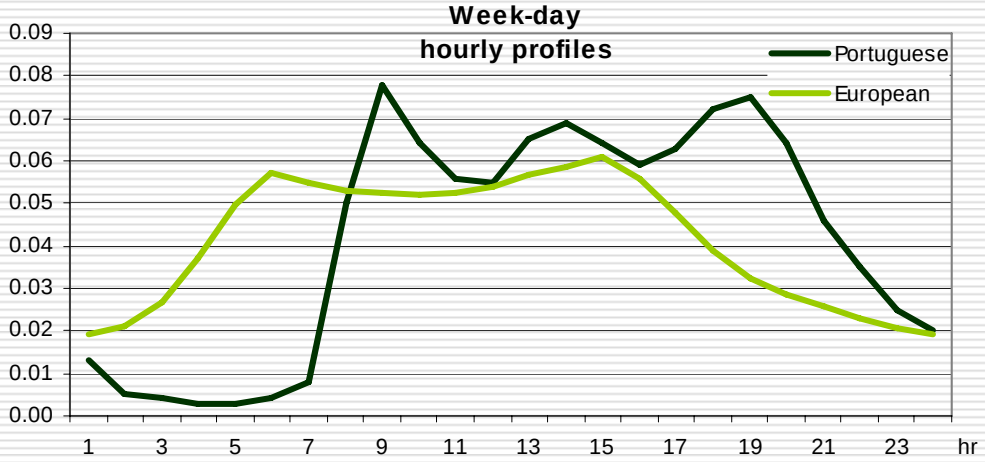
further spatial disaggregation performed introduced more errors to the emission inventory, specially for the urban area and O_3

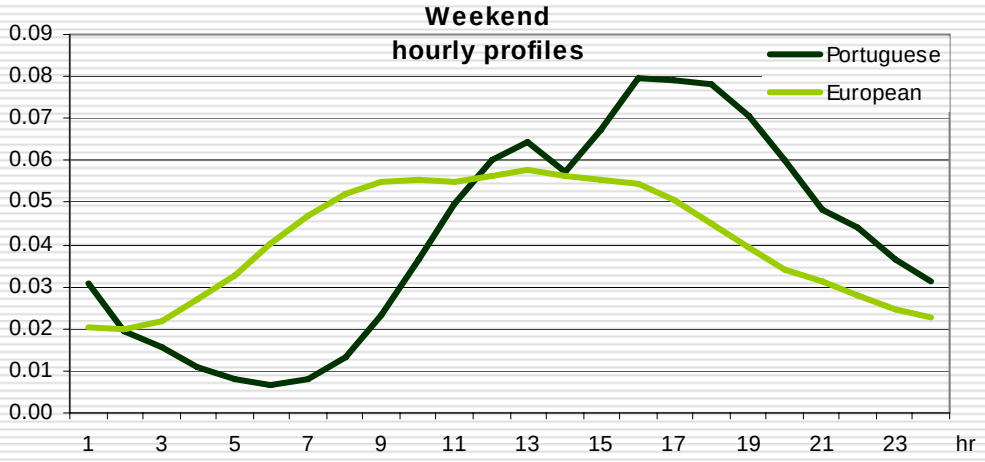
Temporal Disaggregation of Emissions

sensitivity test

2 Different Hourly Profiles were tested with the INERPA inventory

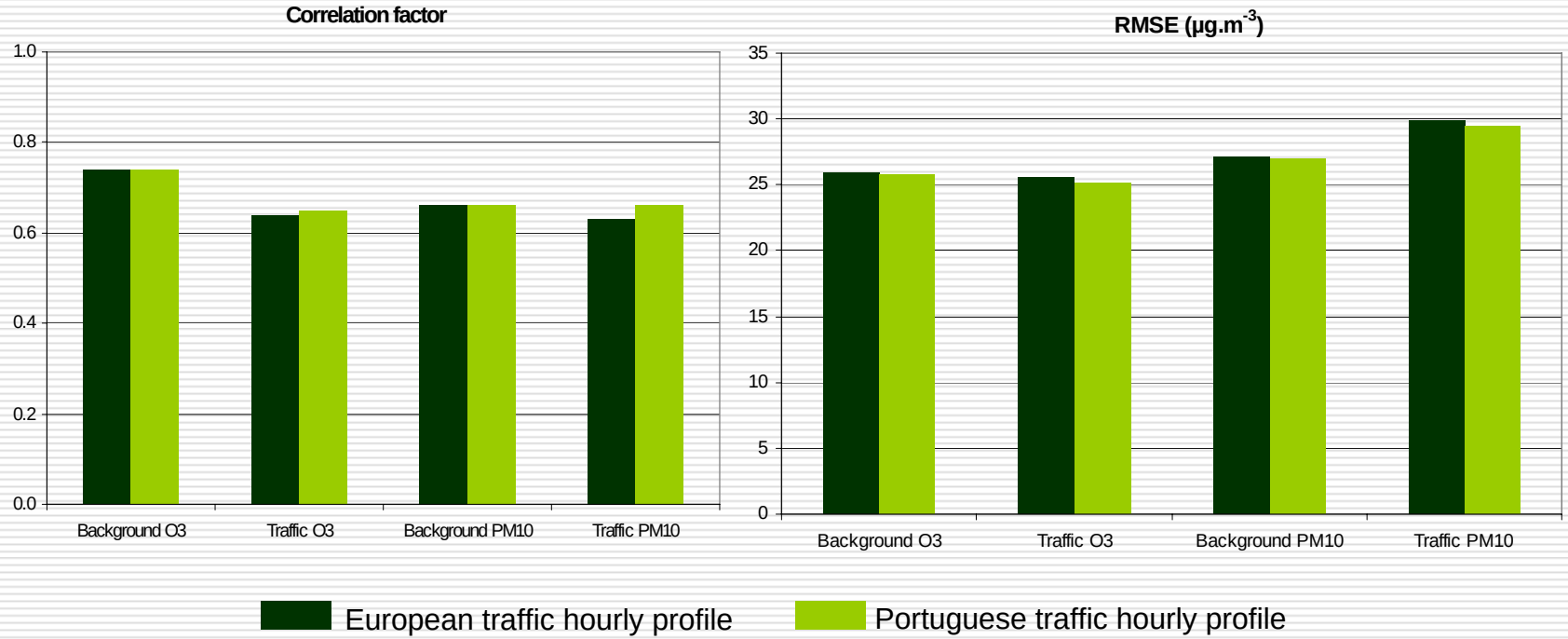
- Nacional profile measured by field campaigns
- European profile european average profile





Temporal Disaggregation of Emissions

results

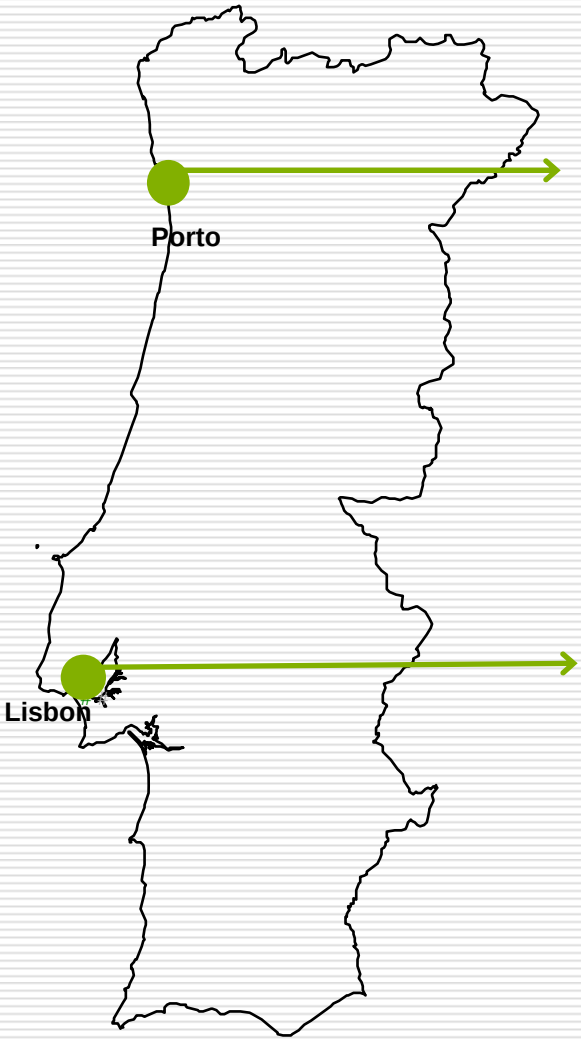


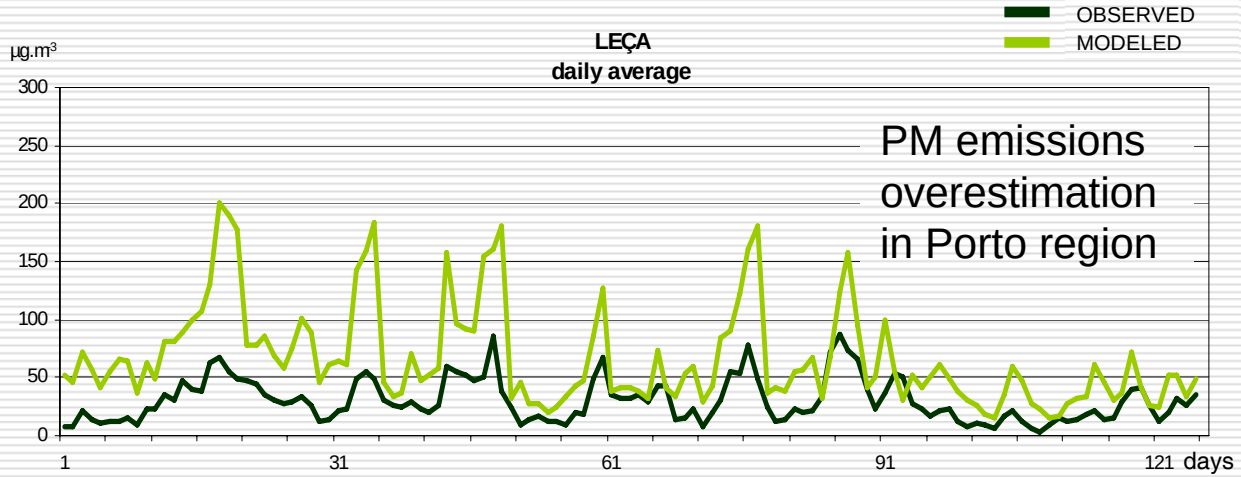
road traffic temporal profiles shows influence on the air quality results, in both traffic and urban stations

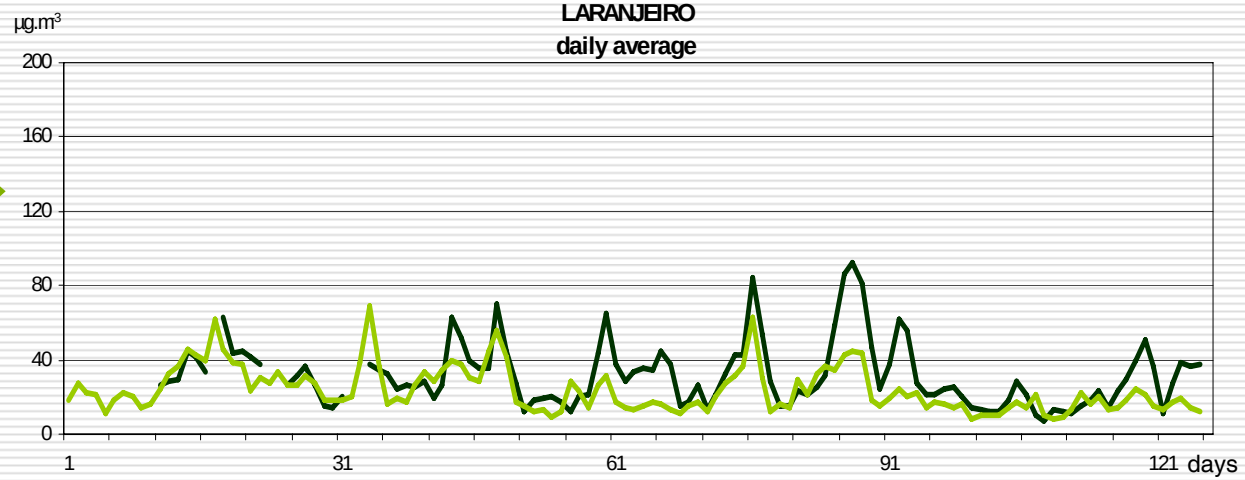
the Portuguese average profile is more adequate for these specific areas

Comparison of Emission Inventories

PM_{10} model results







Final comments

Analysis of model results **provided clues** for improving emission inventories!

- Spatial disaggregation of an emission inventory should be performed carefully, otherwise could be an additional source of uncertainty.
- There are no significant discrepancies between the direct applications of the three emission inventories, indicating that higher resolution in the emission inventory do not mean necessarily better model performance
- Road traffic temporal profiles have influence on the air quality results, mainly regarding traffic hot spots and urban areas.
- The range of uncertainty varies with locals and pollutants. It was found an overestimation of PM values for Porto agglomeration, which can be related to a less correct emission estimation and spatial disaggregation for this specific region of Portugal.
- Globally, is the national inventory (INERPA) application that implies the lowest bias.

Future work

Future work will involve testing this methodology with other air quality modelling systems and analysing each emission source category.

The development and assessment of an emission inventory ensemble will also be the focus of future work.

Thank You