

FUTURE EMISSION SCENARIO ANALYSIS OVER ROME URBAN AREA USING COUPLED TRAFFIC ASSIGNMENT AND CHEMICAL TRANSPORT MODELS

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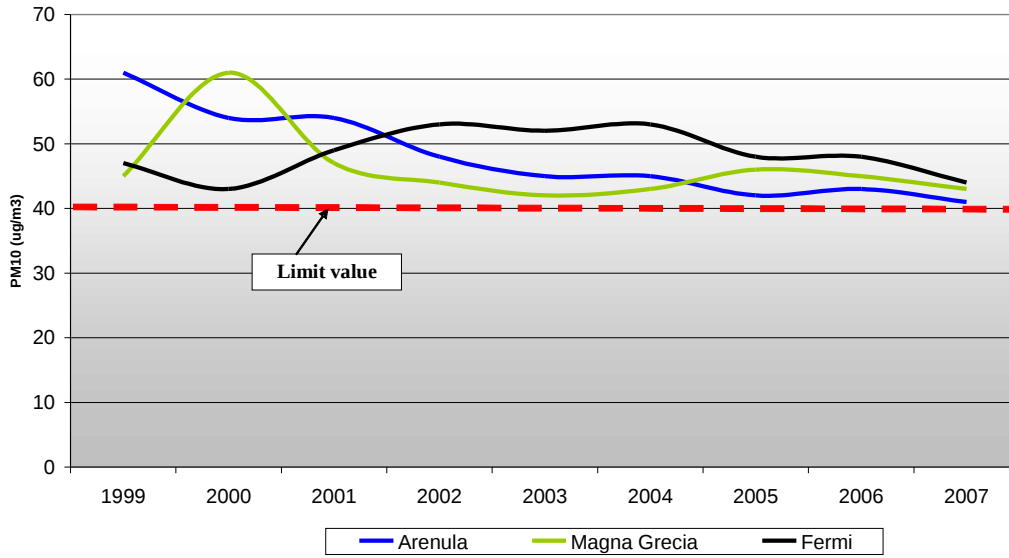
³ATAC, Roma, Italy

⁴Regione Lazio, Roma, Italy

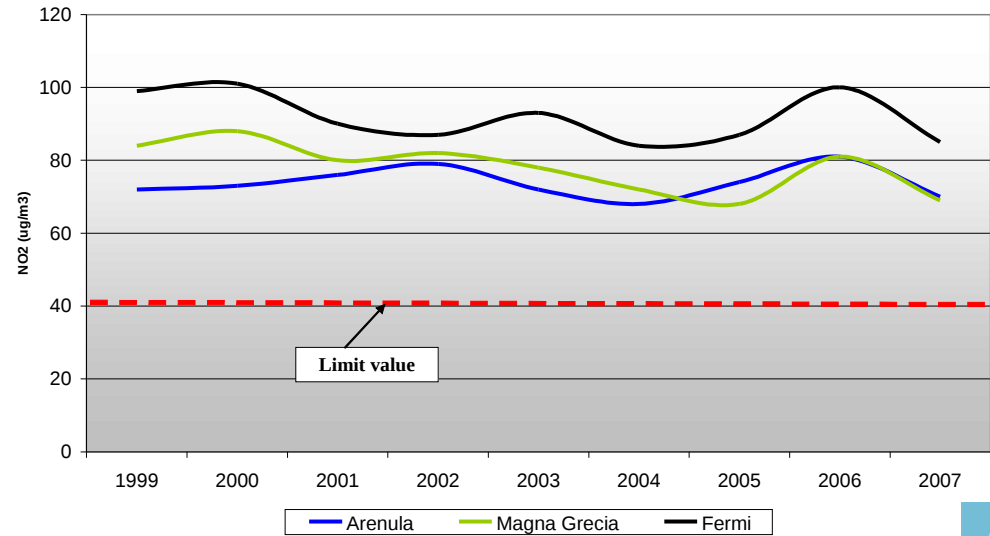
⁵ISPESL-DIPIA, Monteporzio Catone (RM) , Italy

Observations

PM10 - annual average



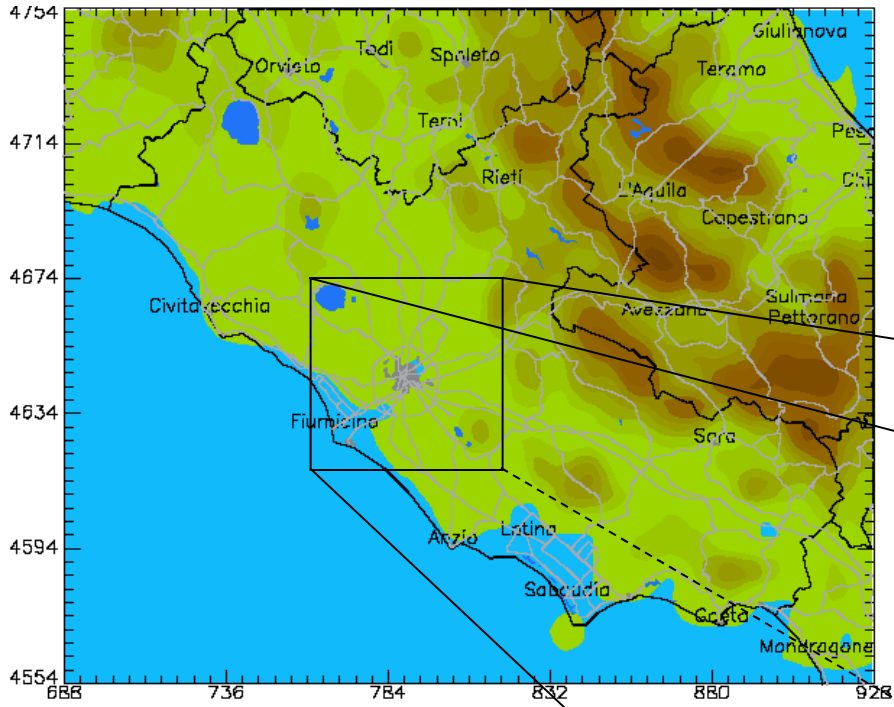
NO2 - annual average



OUTLINE

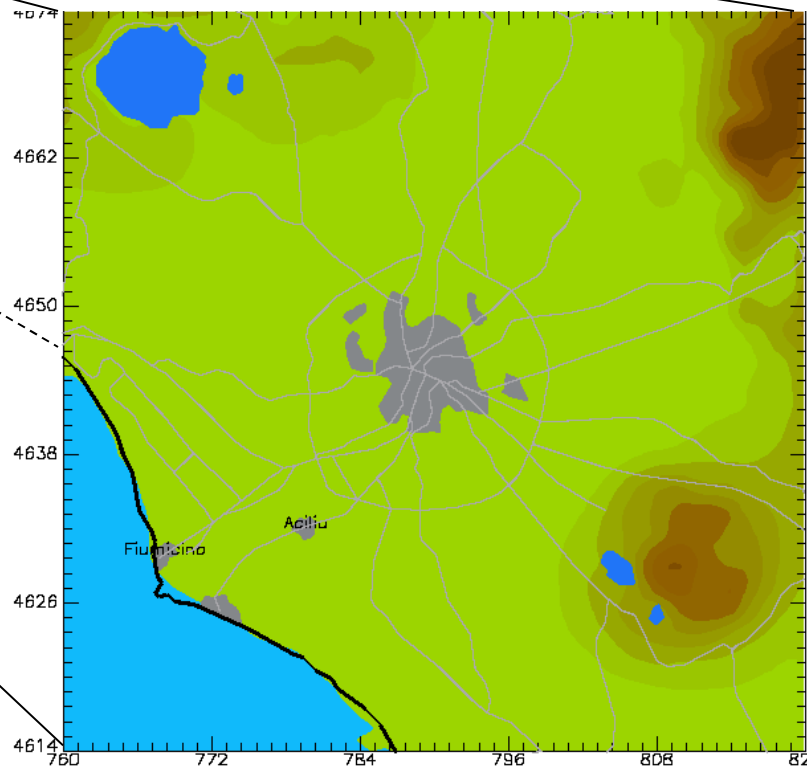
- *Atmospheric Modelling system (AMS) description (ARIA Regional)*
- *2005 scenario over Rome urban area*
- *Model performance*
- *2010 scenario and results over Rome urban area*

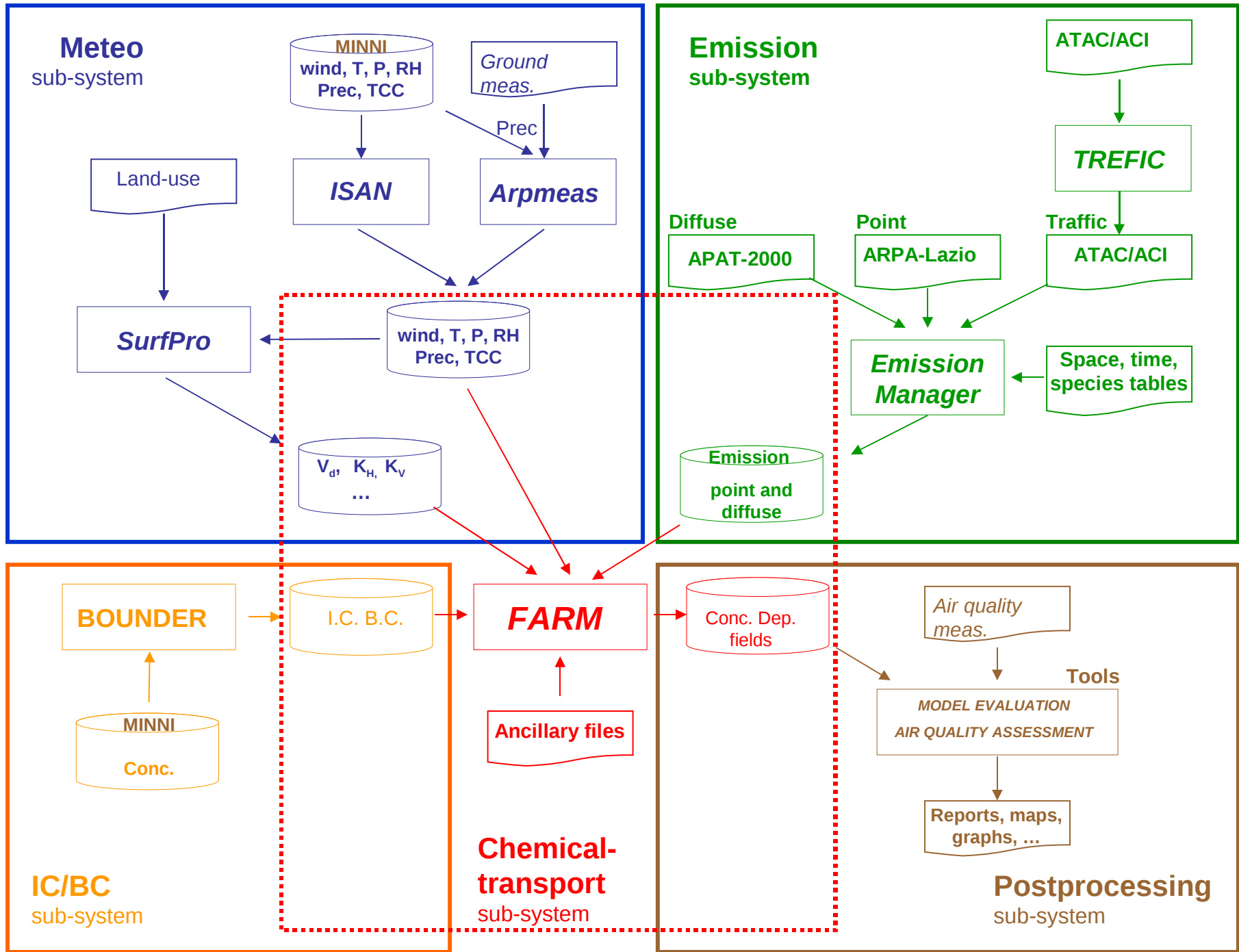
Modelling domains



Coarse Lazio Region domain
(4 x 4) km², 66 x 58 cells

Target Rome domain
(1 x 1) km², 61 x 61 cells

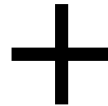
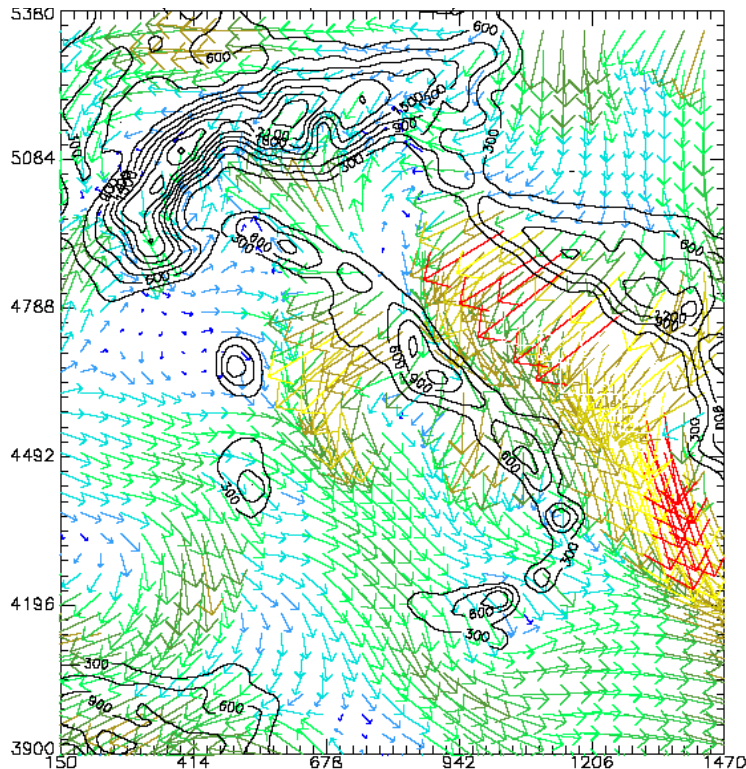




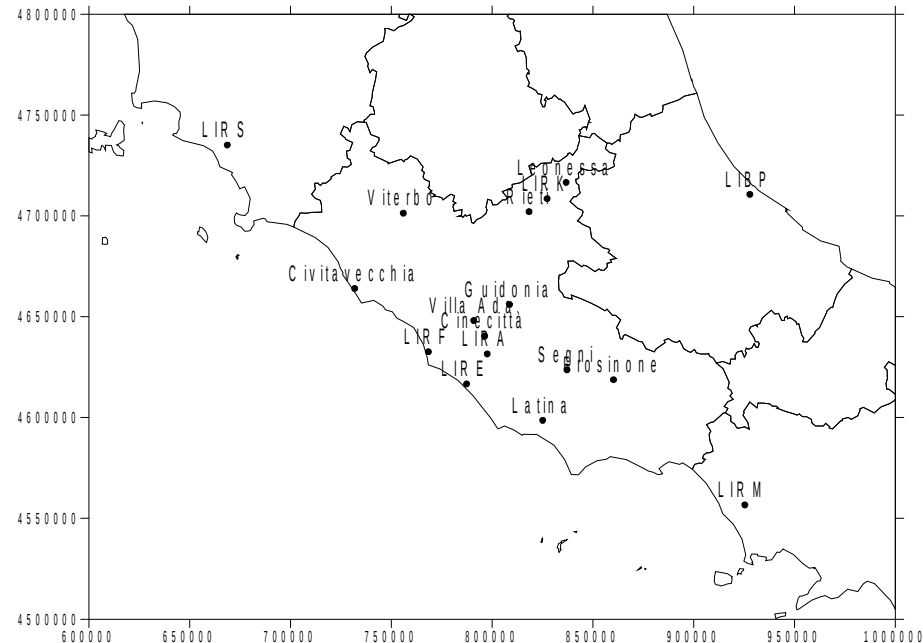
ARIA REGIONAL Meteorological sub-system

National scale meteorological fields produced within MINNI Project (Integrated National Model in support to the International Negotiation of air pollution) have been improved by applying the RAMS Isentropic Analysis (ISAN) package (Walko and Tremback, 1995) to perform high resolution meteorological analyses over Lazio and Rome target domains for the whole 2005 year. ISAN implements an optimal interpolation method based on Barnes algorithm to iteratively correct background fields with surface and upper air observations.

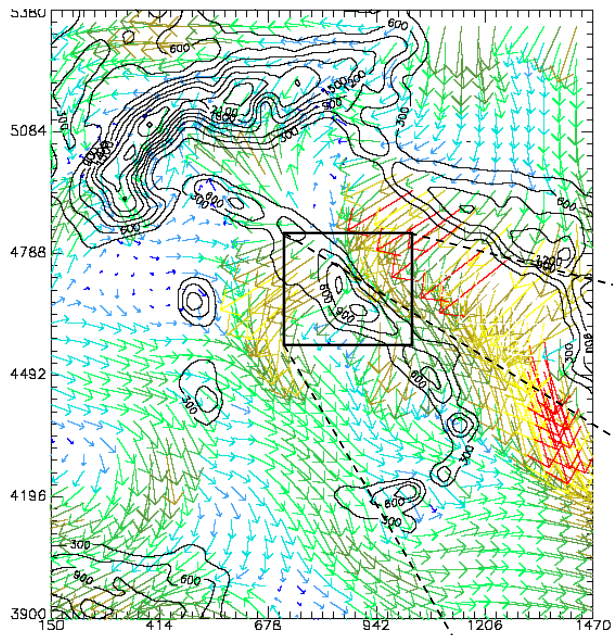
MINNI background field
(20 x 20) km² horiz. resolution



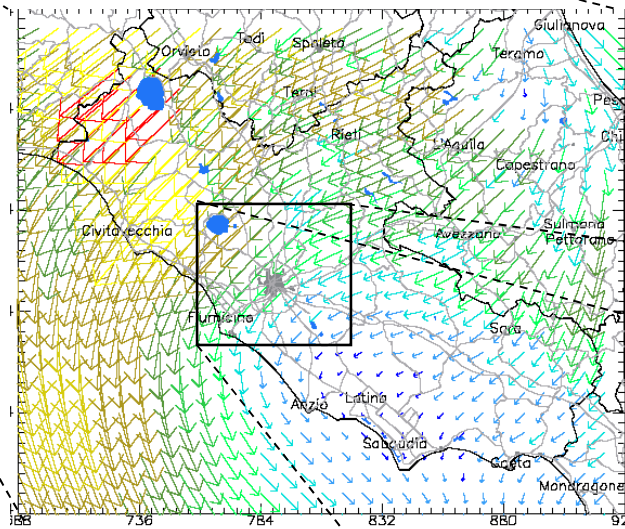
Surface observations



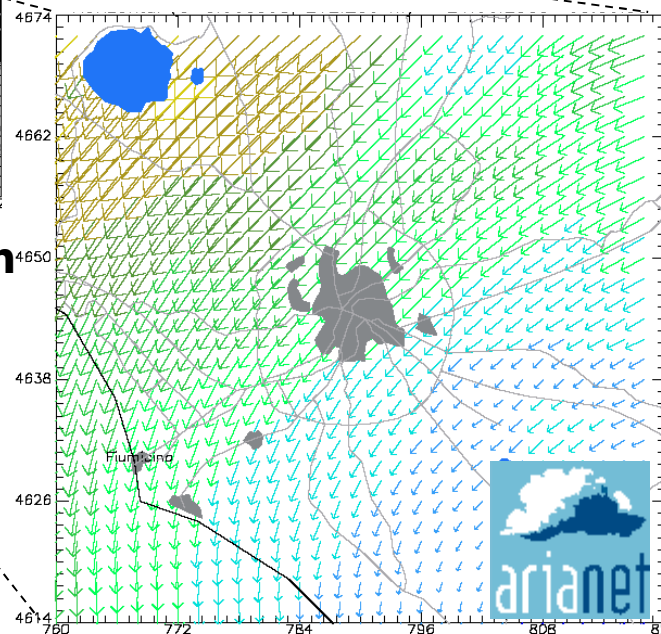
ARIA REGIONAL
Meteorological sub-system
From national to target local scale



MINNI Italian domain
(20 x 20) km²



Coarse Lazio Region domain
(4 x 4) km², 66 x 58 cells

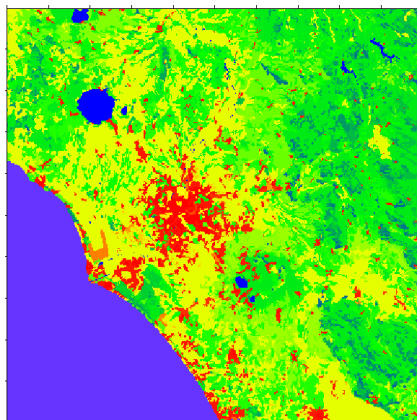


Target Rome domain
(1 x 1)-km², 61 x 61 cells

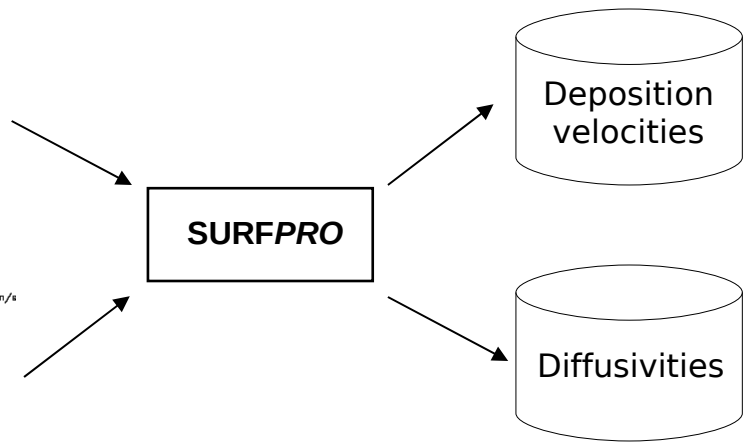
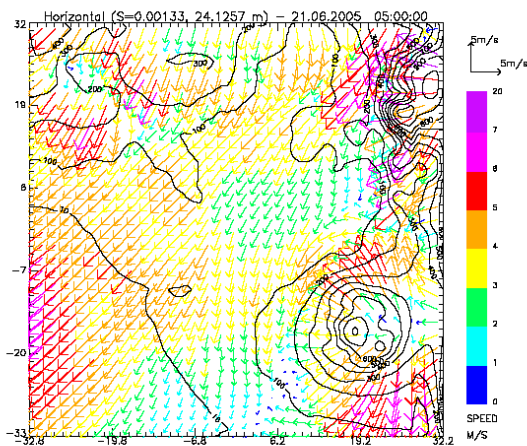
ARIA REGIONAL Meteorological sub-system *μ*eteorological parameters

Regional and urban scale meteorological fields together with land cover information (e.g. roughness length) and chemical species characteristics (gas reactivity), have been then used by interface module SURFPRO (FUMAPEX, 2006; Finardi et al., 2008;) to produce dry deposition velocities and turbulent diffusivity fields needed by FARM.

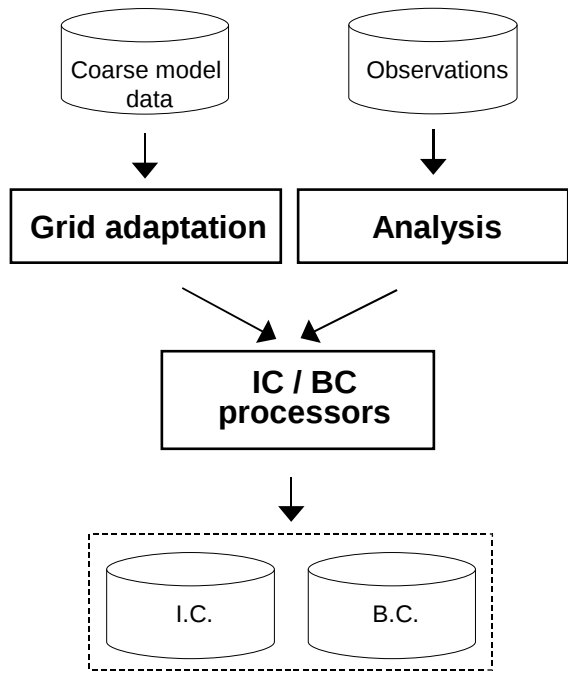
Topography
& land-use



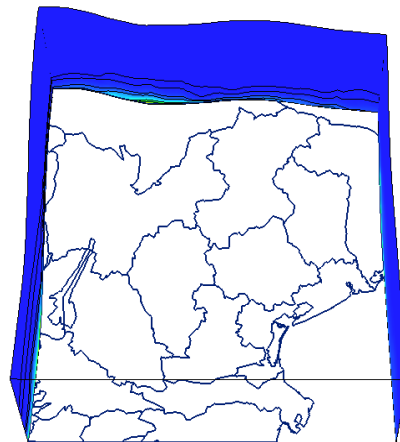
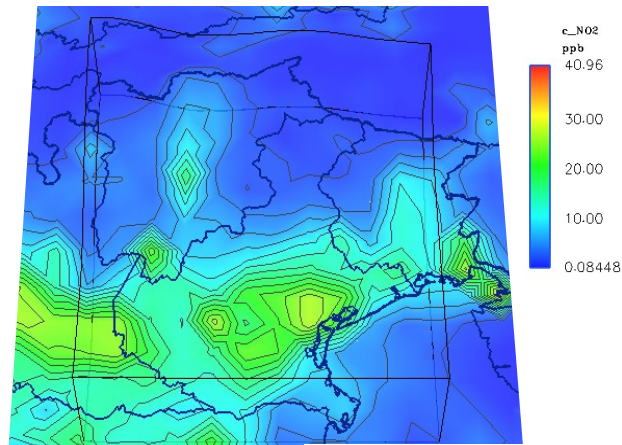
Meteorological
fields



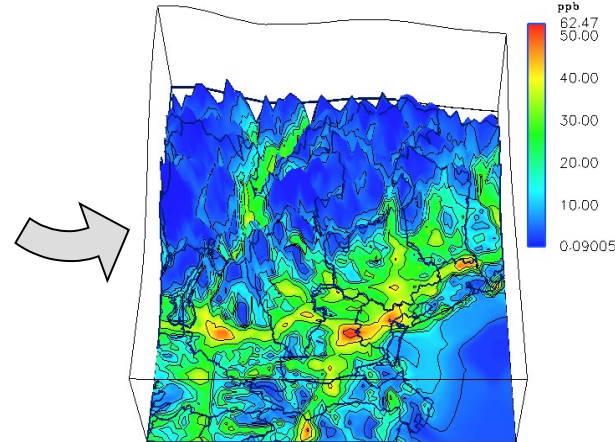
ARIA REGIONAL IC/BC sub-system



Coarse model concentrations

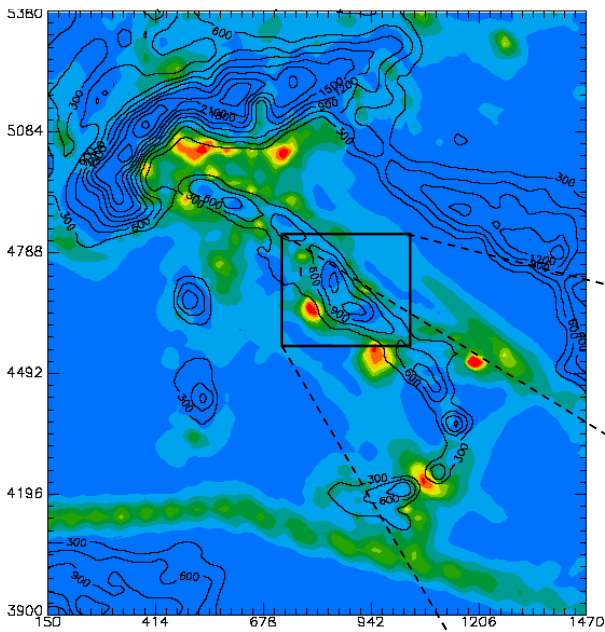


Boundary conditions

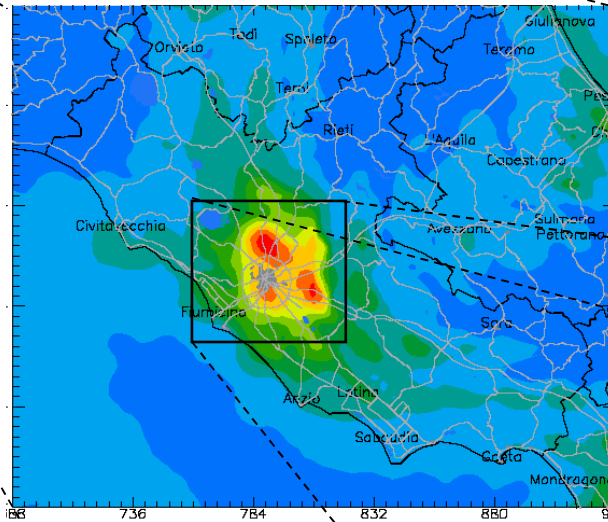


Initial conditions

ARIA REGIONAL
IC/BC sub-system
From national to target local scale (ICs)

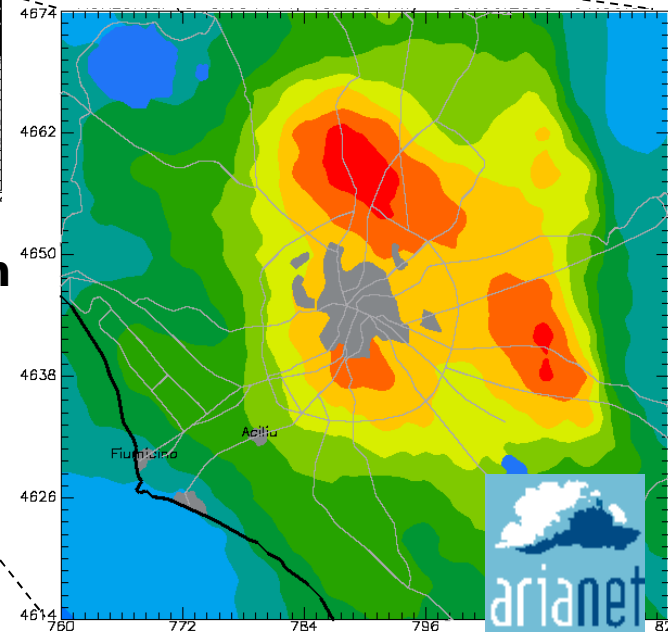


MINNI Italian domain
(20 x 20) km²



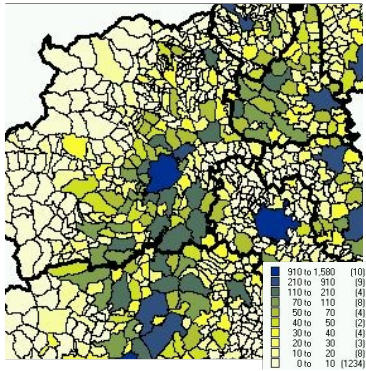
Coarse Lazio Region domain
(4 x 4) km², 66 x 58 cells

Target Rome domain
(1 x 1) km², 61 x 61 cells

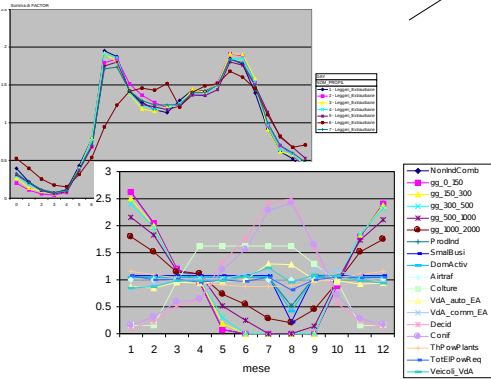


ARIA REGIONAL Emission sub-system

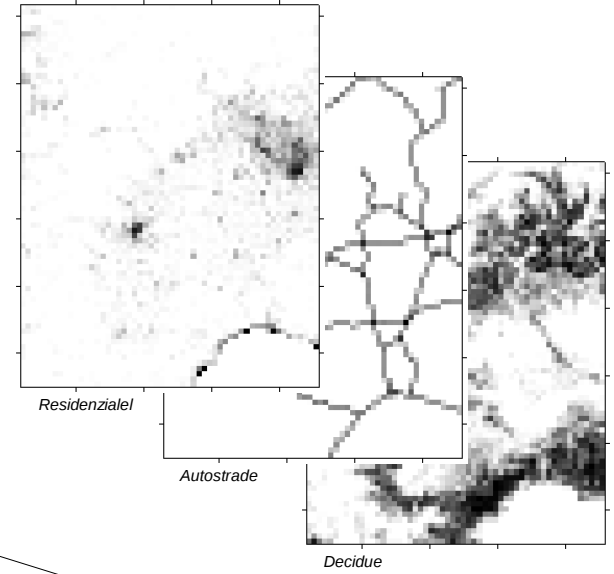
Inventories



Time profiles
(day, week, year)



GIS

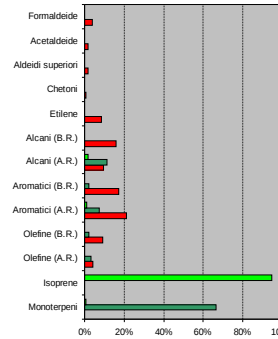
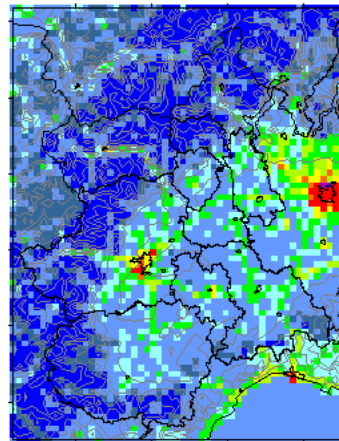


Spatial
disaggregation

Time variability

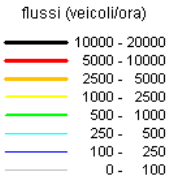
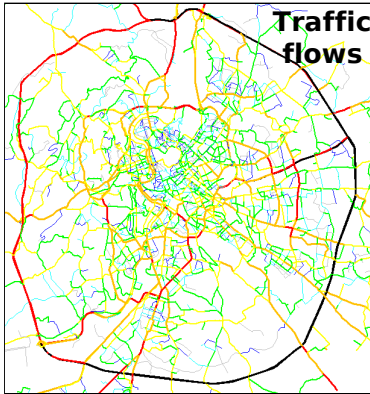
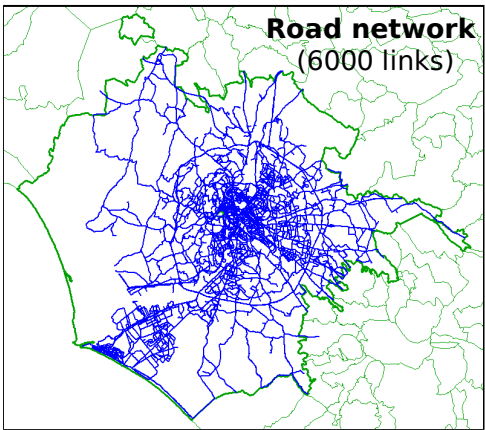
Speciation NMVOC
& PM size.

Gridded
hourly
emission

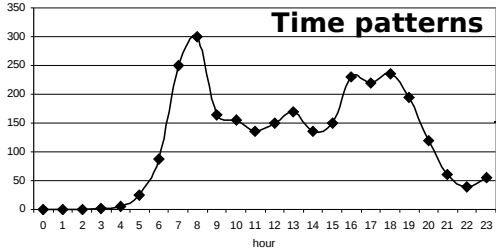


Speciation and
dimensional
profiles

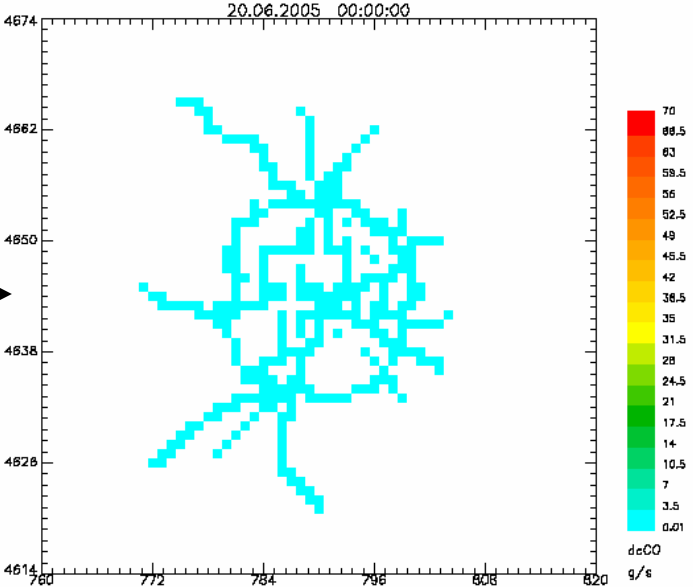
ARIA REGIONAL Emission sub-system *Traffic contribution*



trips (/1000)



TREFIC Module
(Copert III)



Fleet composition - EUROx classes
(cars, buses, trucks and motorbike)



ARIA REGIONAL Emission sub-system *Update to 2005*

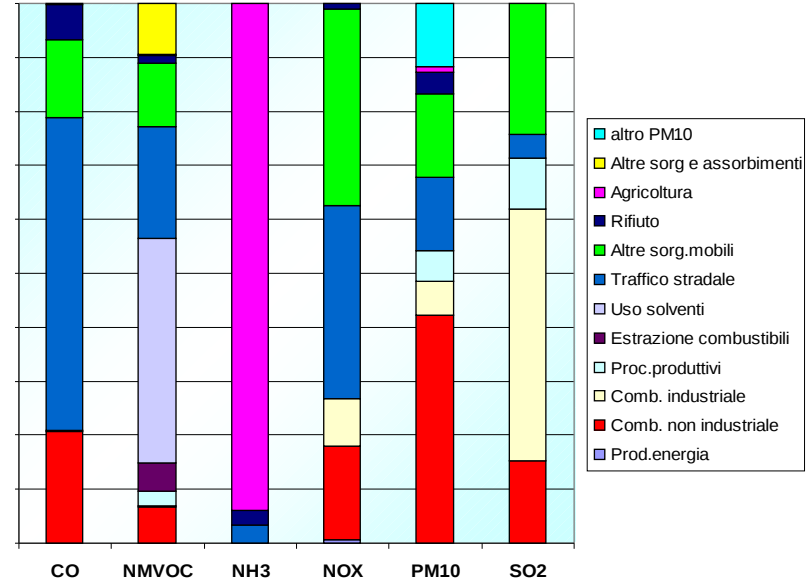
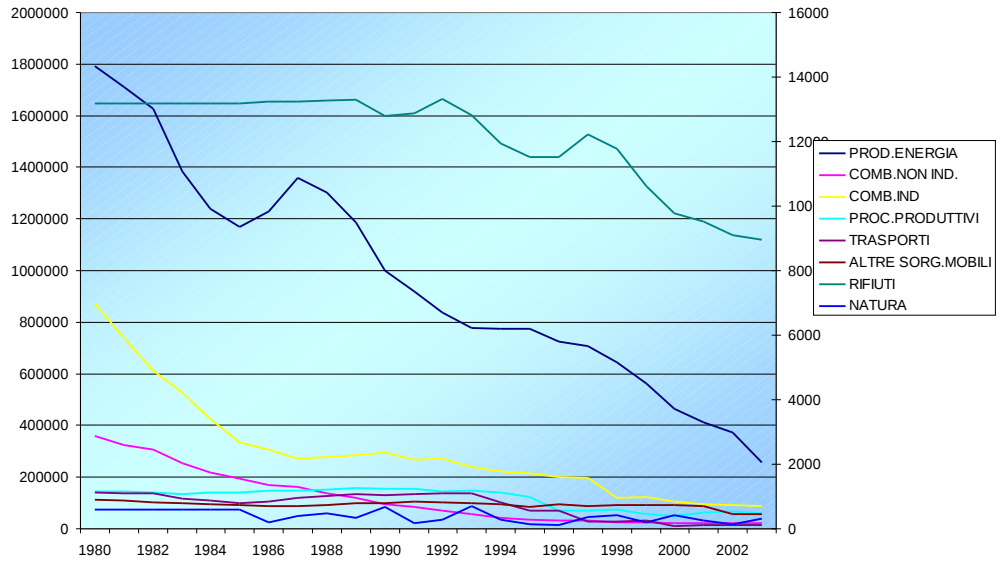
national inventory (2000)

national trends

update at 2005

each pollutant and activity

↑
TREND SOX

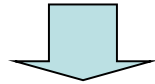


ARIA REGIONAL

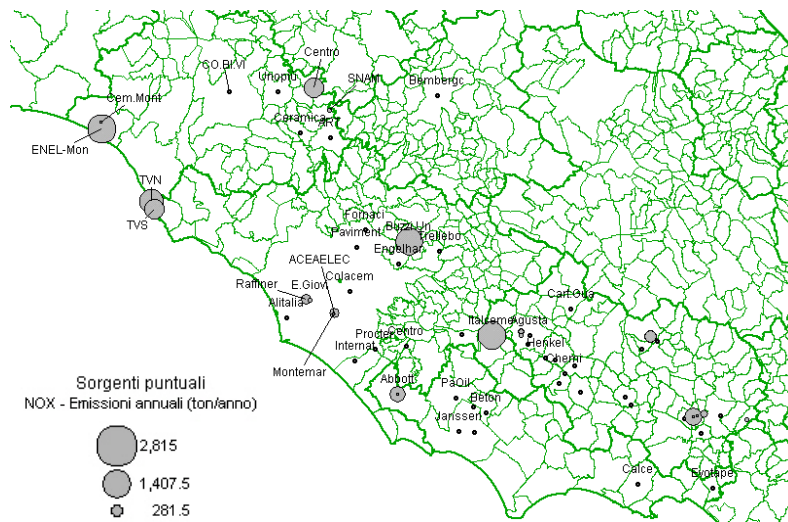
Emission sub-system

Point and area sources

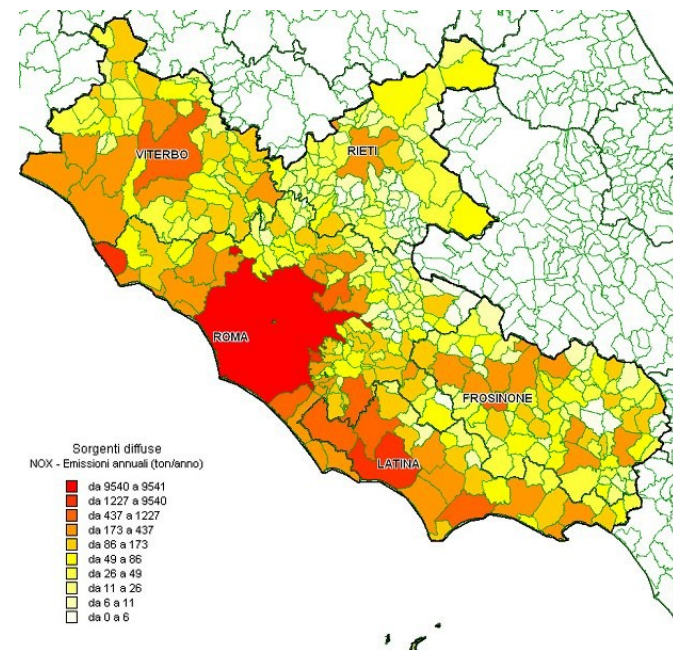
75 Major sources



- physical and geometric characteristics;
- # hours of annual emission;
- concentration (mg/Nm³);
- activity of every sources



Diffuse area sources



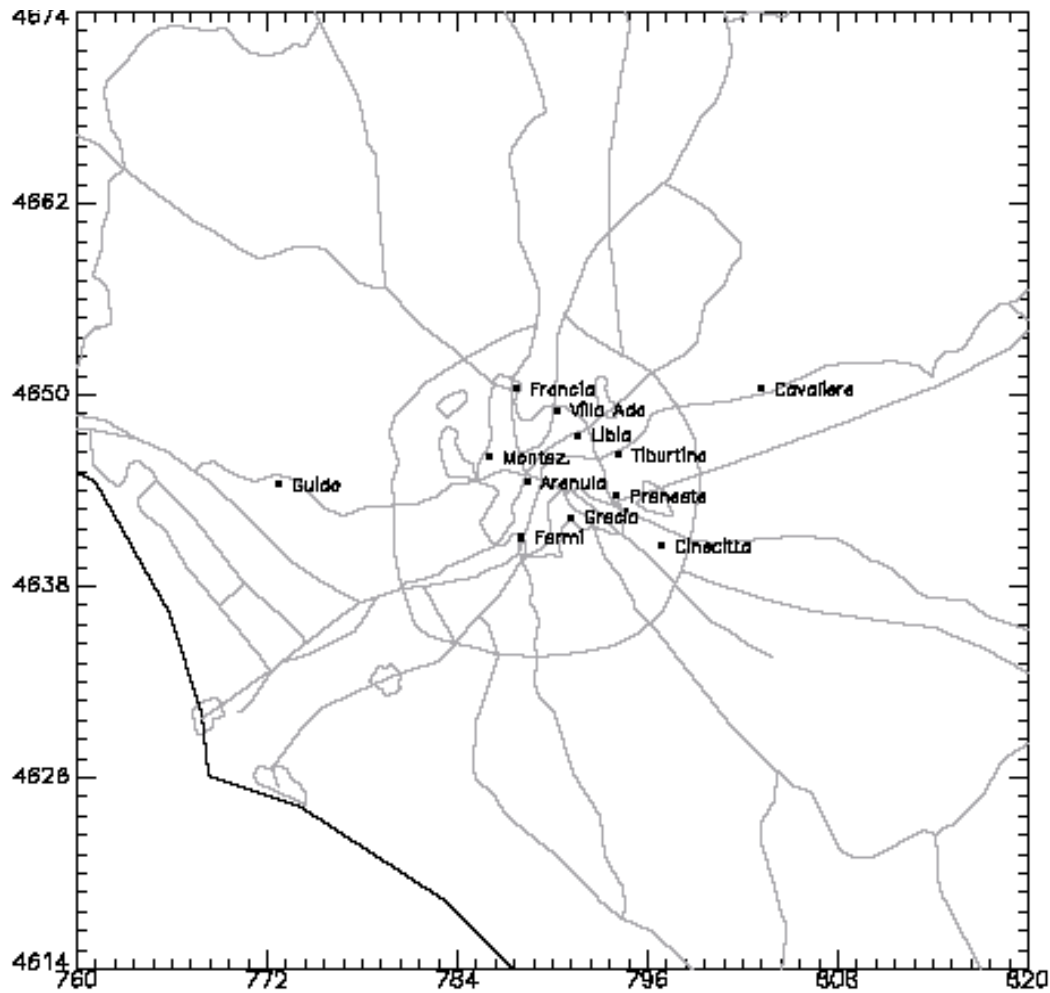
ARIA REGIONAL

Chemical-Transport sub-system
FARM (Flexible Air quality Regional Model)

Main features:

- **Emission** of pollutants from area and point sources, with plume rise calculation and mass assignment to vertical grid cells
- **3D dispersion** by advection and turbulent diffusion
- Transformation of chemical species by **gas-phase chemistry**, with flexible mechanism configuration (SAPRC-90, SAPRC-99, EMEP-acid - through FCM)
- Treatment of **PM₁₀** and **PM_{2.5}** (*aero0* inorganic equilibrium module, *aero3* modal aerosol module)
- **Dry removal** of pollutants dependent on local meteorology and land-use
- Removal through **precipitation scavenging** processes
- One- and two-way **nesting** on arbitrary number of grids
- Treatment of additional inert **tracers**
- **Parallel processing** using **OpenMP** paradigm
- Inclusion of **data assimilation** techniques
- Online calculation of photolysis rates using **TUV** model (Tropospheric Ultraviolet and Visible radiation model; Madronich *et al*, 1989)

GROUND MEASUREMENTS



Station	Type
Cavaliere Guido	<i>Natural Background</i>
Villa Ada	<i>Urban Background</i>
Cinacitta' Preneste	<i>Urban</i>
Arenula Fermi Francia Grecia Libia Montezemolo Tiburtina	<i>Urban Traffic</i>

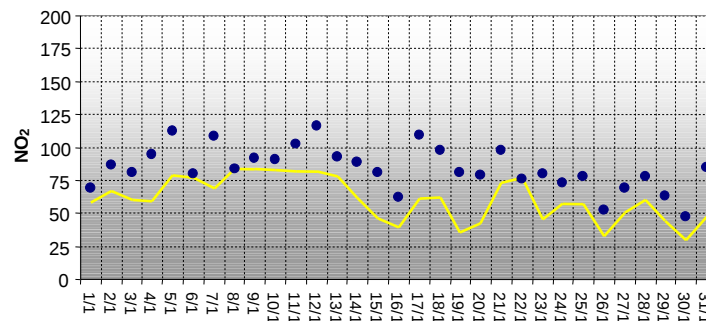
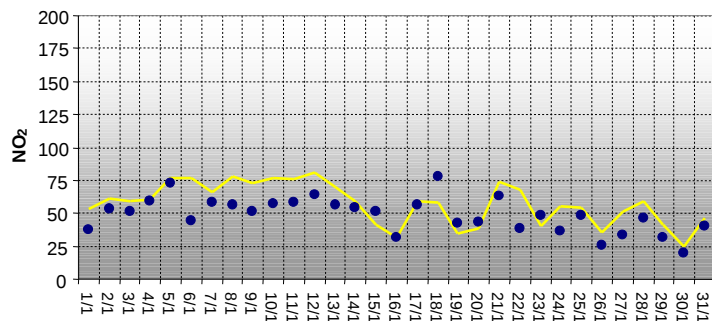
COMPARISON WITH MEASUREMENTS (2005)

NO₂

Ada (Urban Background)

Arenula (Urban-ZTL)

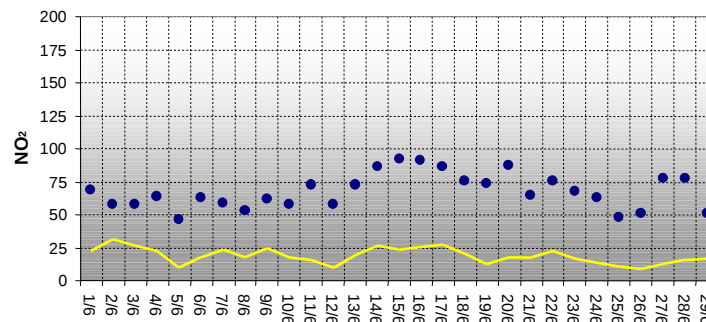
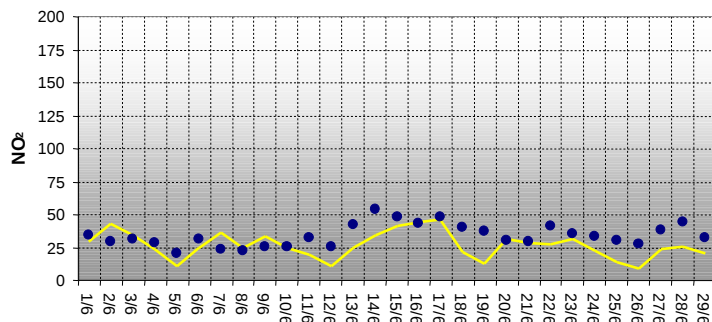
January



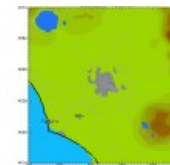
Ada (Urban Background)

Arenula (Urban-ZTL)

June



computed
measured



(1Km x 1Km)

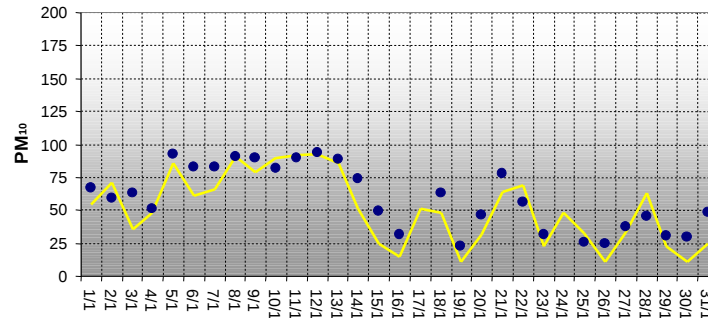
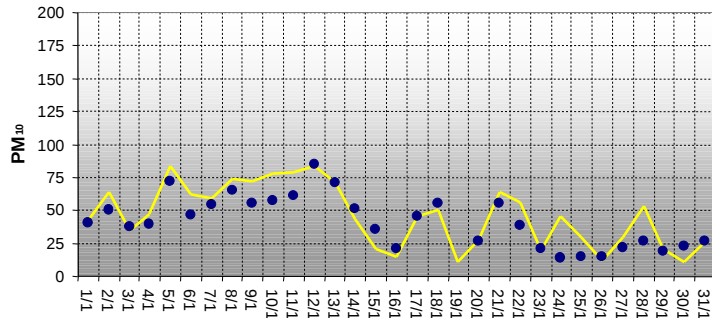
COMPARISON WITH MEASUREMENTS (2005)

PM₁₀

Ada (Urban Background)

Fermi (Urban Traffic)

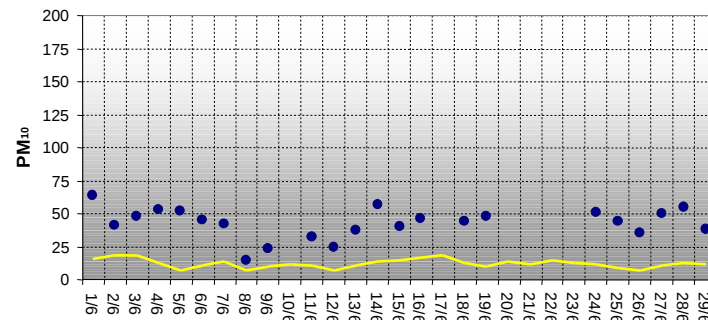
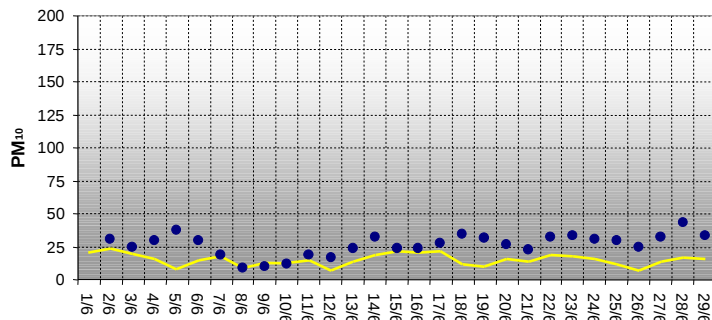
January



Ada (Urban Background)

Fermi (Urban Traffic)

June

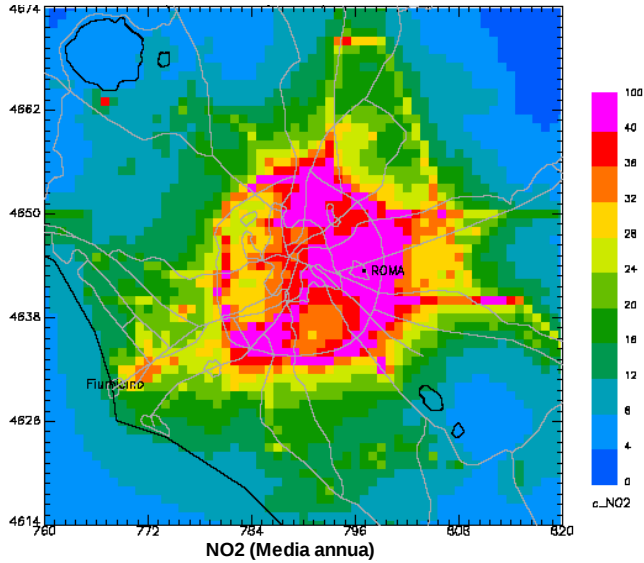


computed
measured

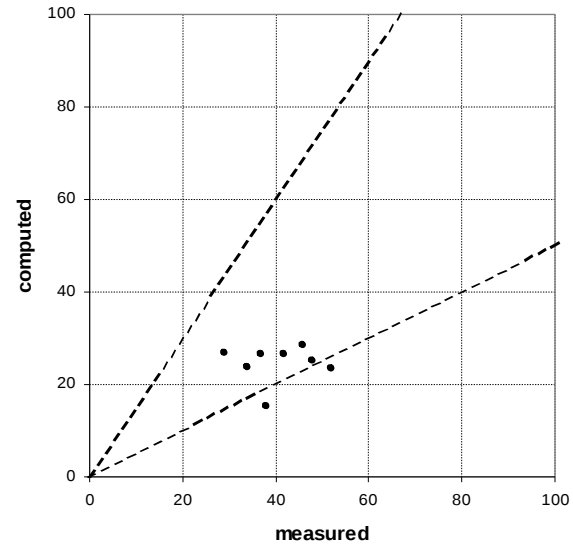
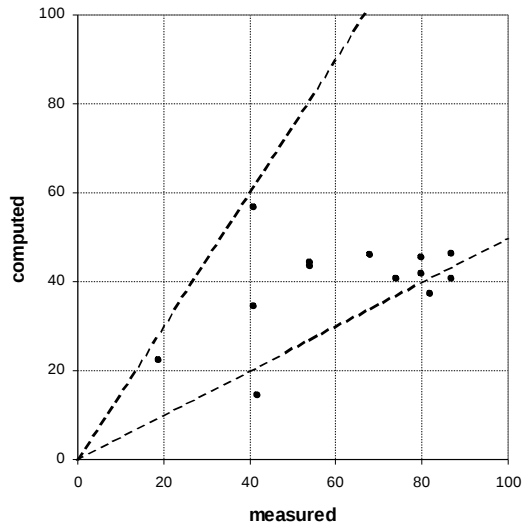
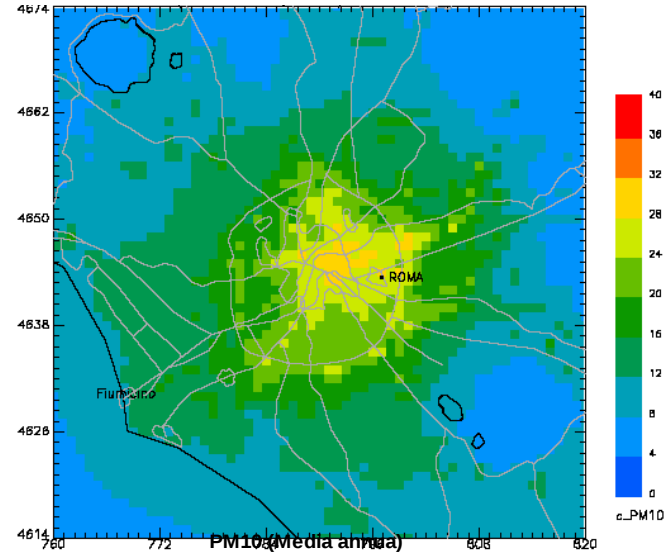
MODEL RESULTS and PERFORMANCE

2005 yearly concentrations

NO₂

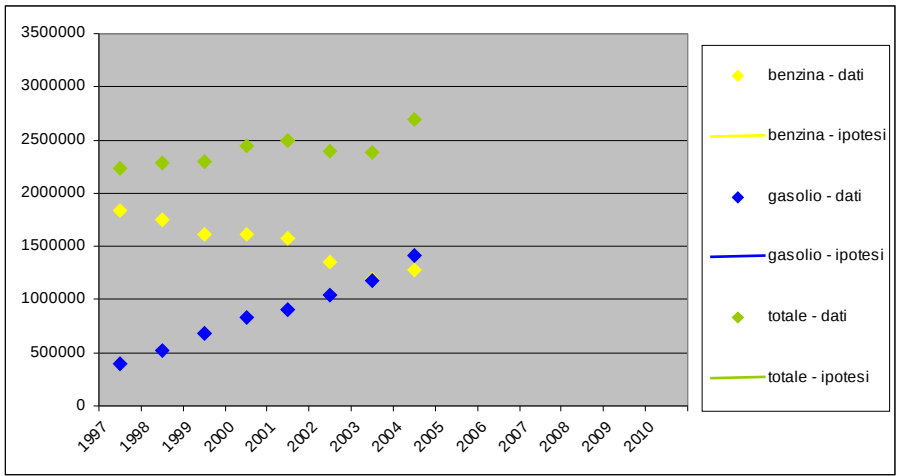
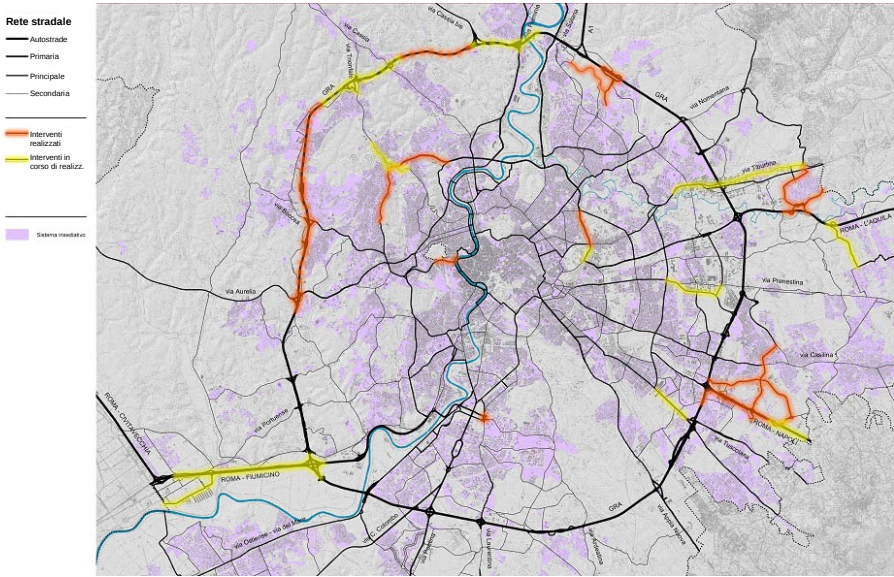


PM₁₀



Scenario 2005 → Scenario 2010

- RAINS-Italy model: future scenarios CLE (Current LEgislation);
- power plants;
- Traffic emission (mobility request and fuels);



Scenario 2005 → Scenario 2010

	CO	NMVOC	NH ₃	NO _x	SO _x	PM ₁₀
<i>Combustion in Energy and Transf. Industries</i>	28	975	0	924	81	89
<i>Non-Industrial Combustion Plants</i>	15933	2646	0	4501	2230	2231
<i>Combustion in Manufacturing Industry</i>	125	36	1	2144	133	134
<i>Production Processes</i>	3	699	0	0	126	178
<i>Extraction and distrib. of fossil fuels and geothermal Energy</i>	0	1578	0	0	2	2
<i>Solvent and other product use</i>	0	12078	0	0	0	0
<i>Road Transport</i>	76950	8070	693	15459	350	810
<i>Other Mobile Sources and Machinery</i>	3736	621	0	2678	174	184
<i>Waste Treatment and Disposal</i>	1615	135	44	68	49	74
<i>Agriculture</i>	41	15	1108	1	3	14
<i>Othes Sources and Sinks (+ PM-RAINS)</i>	0	213	0	0	726	995
Total	98432	27068	1846	25776	3873	4711

Base case
(2005)

	CO	NMVOC	NH ₃	NO _x	SO _x	PM ₁₀
<i>Combustion in Energy and Transf. Industries</i>	28	975	0	1317	95	105
<i>Non-Industrial Combustion Plants</i>	15496	2575	0	4635	1966	1967
<i>Combustion in Manufacturing Industry</i>	128	37	1	2349	146	148
<i>Production Processes</i>	3	714	0	0	138	196
<i>Extraction and distrib. of fossil fuels and geothermal Energy</i>	0	1604	0	0	2	2
<i>Solvent and other product use</i>	0	11847	0	0	0	0
<i>Road Transport</i>	55028	5863	647	10282	351	730
<i>Other Mobile Sources and Machinery</i>	3787	631	0	2610	170	180
<i>Waste Treatment and Disposal</i>	1620	135	27	68	49	74
<i>Agriculture</i>	41	15	1090	1	3	13
<i>Othes Sources and Sinks (+ PM-RAINS)</i>	0	213	0	0	364	505
Total	76132	24610	1764	21262	3285	3919

Scenario
(2010)



Predictor formula Rollback correction

$$C_A^{\text{Scenario}} = C_B + KE_A^{\text{Scenario}}$$

$$C_A^{\text{obs}} = C_B + KE_A^{\text{Present}}$$

$$C_A^{\text{Scenario}} = C_B + (C_A^{\text{obs}} - C_B) \cdot \frac{E_A^{\text{Scenario}}}{E_A^{\text{Present}}}$$

$$C_A^{\text{Scenario, modelled}} = C_A^{\text{Present, modelled}} \cdot \left(\frac{E_A^{\text{Scenario}}}{E_A^{\text{Present}}} \right)^\gamma$$

(Im. et al, 2005)

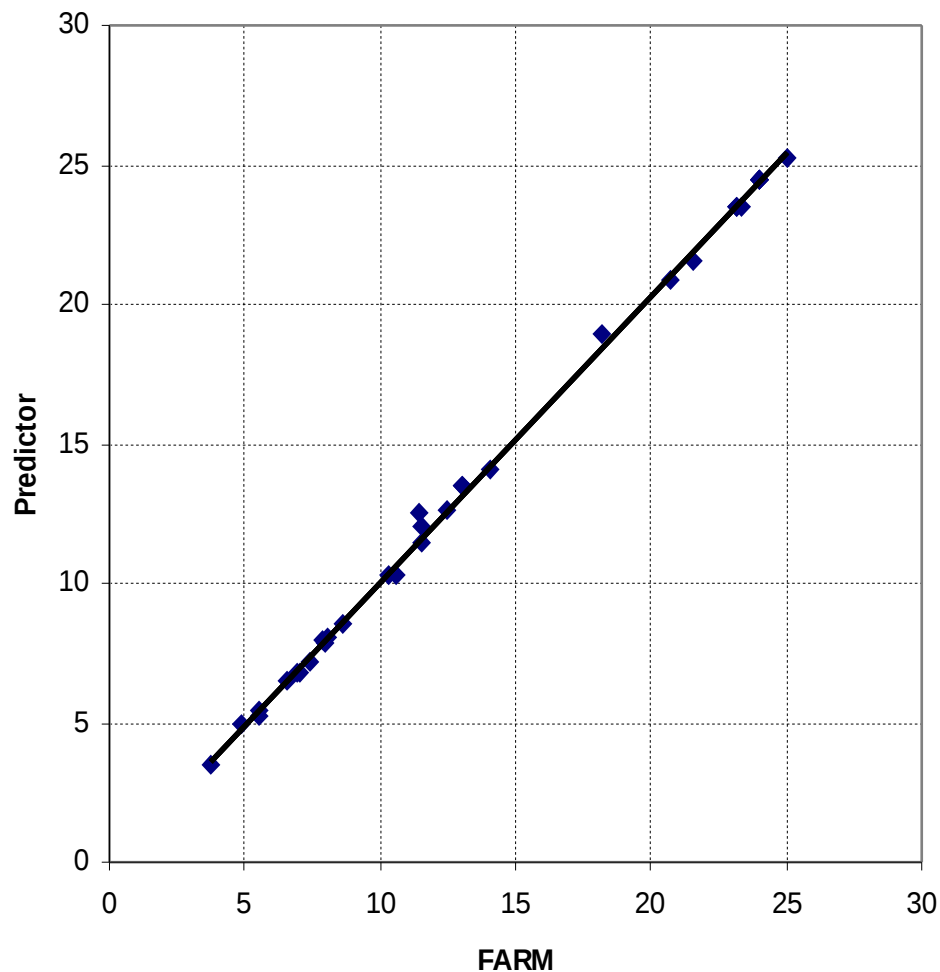
$$C_A^{\text{Scenario}} = C_B + (C_A^{\text{obs}} - C_B) \cdot \left(\frac{C_A^{\text{Scenario, modelled}}}{C_A^{\text{Present, modelled}}} \right)^{1/\gamma}$$

Predictor formula

Derivation of γ

(Scenario: lazio) - Scen1

Species	C_B [$\mu\text{g m}^{-3}$]	γ (R^2)
NO_2	5.0	0.72 (0.998)
PM_{10}	10.0	0.85 (0.999)

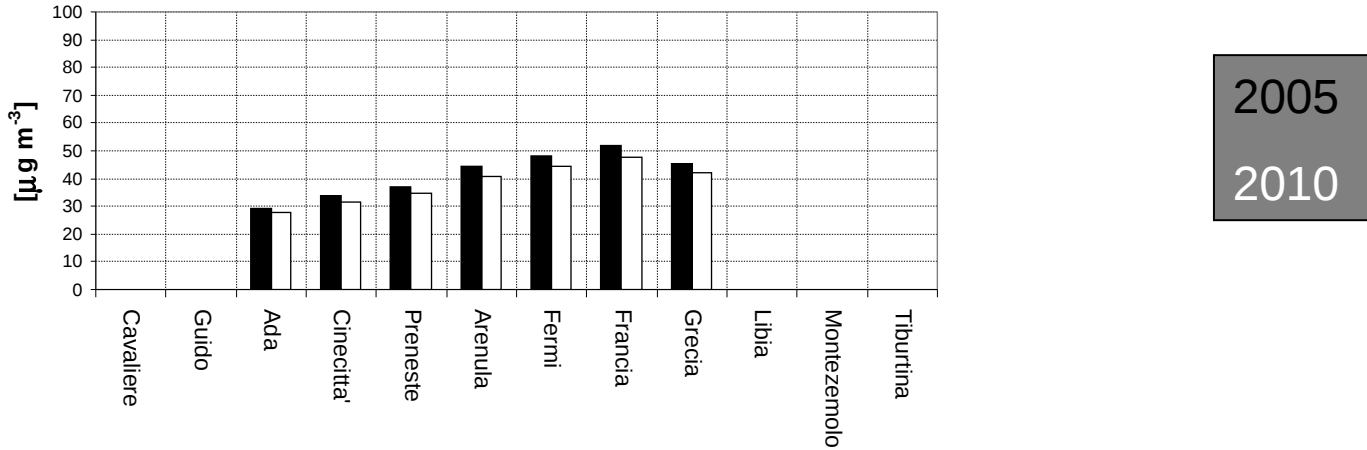


PM_{10} annual average for the 2010 scenario
comparison between FARM and predictor
formula ($\gamma=0.85$)

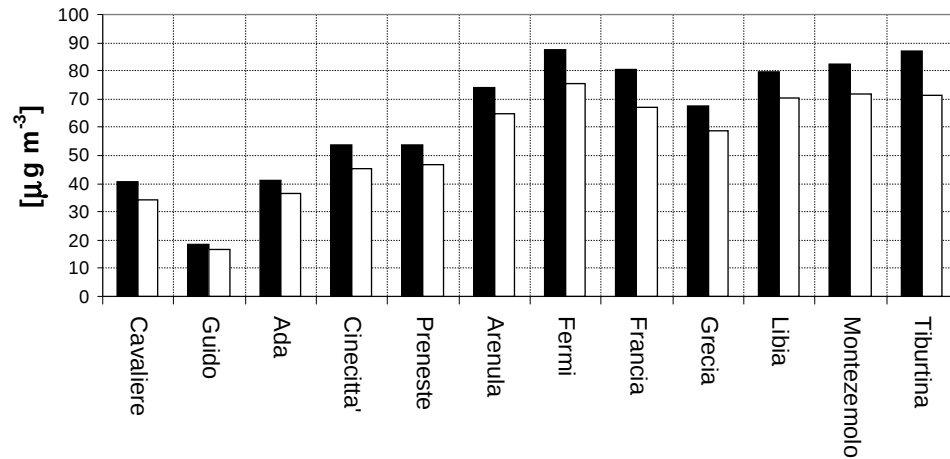
Scenarios analysis

Comparison at monitoring sites

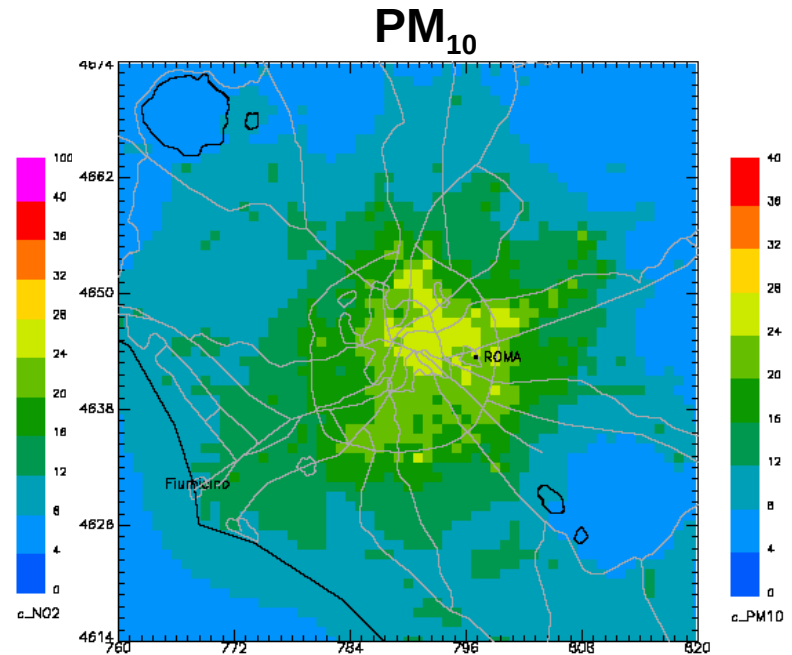
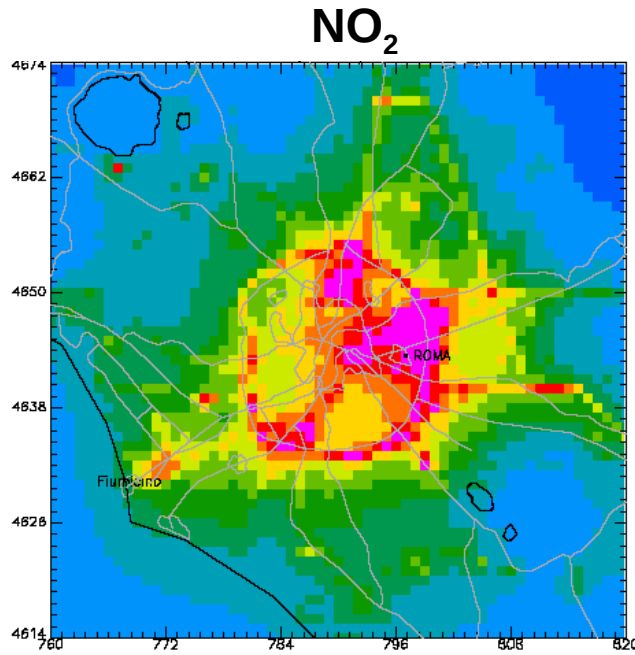
PM₁₀ – annual average



NO₂ – annual average

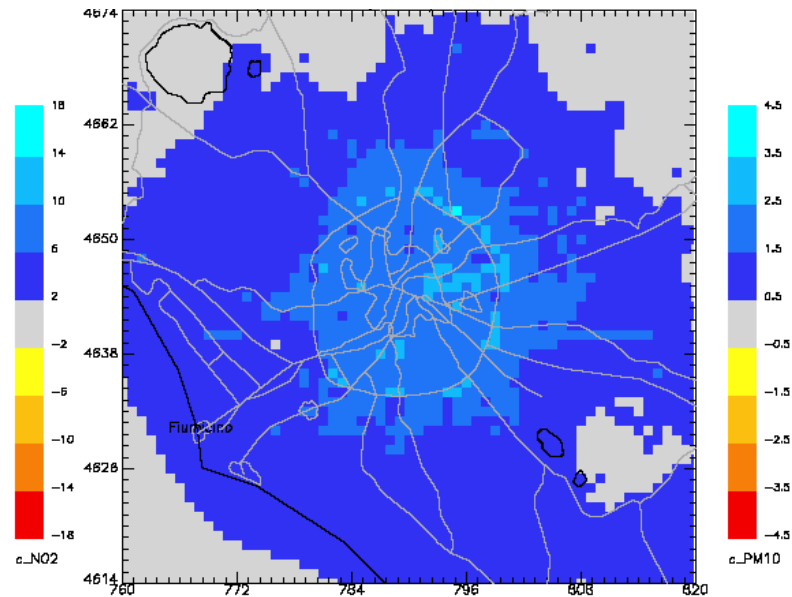
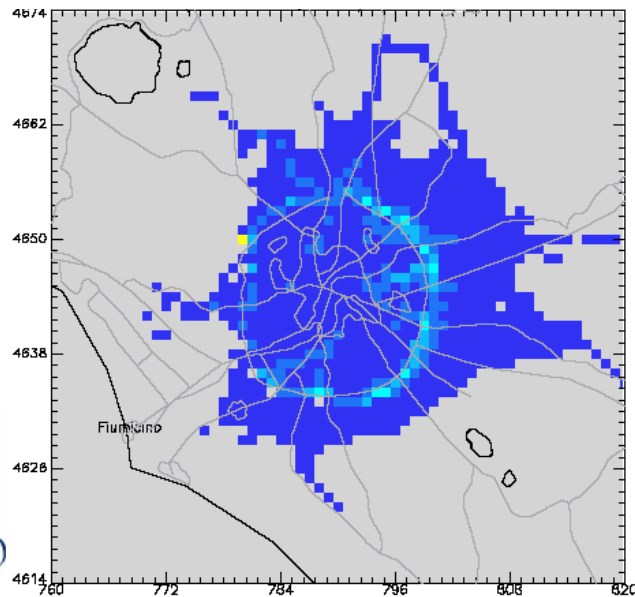


Scenario 2010 yearly averages Absolute reductions



Scenario
(2010)

2005 -
2010



CONCLUSIONS

- ✓ *capability of the modelling system to reproduce the observed pollutant concentrations and the air quality objective levels;*
- ✓ *model uncertainty of $\pm 50\%$ in urban domain;*
- ✓ *underestimations of pollutant levels in hot spot sites;*
- ✓ *realistic representation \rightarrow rollback model;*
- ✓ *significant decrease in urban stations respect to background stations;*
- ✓ *scenario 2010 \rightarrow not enough to reduce pollutant levels within air quality objectives;*

ACKNOWLEDGEMENTS

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Special thanks to :

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F. Troiano (ARPA Lazio) for providing air quality data used in this study.