QualeAria: NATIONAL SCALE AIR QUALITY FORECAST SYSTEM PERFORMANCE EVALUATION

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Arianet - Italy

18th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

QualeAria BACKGROUND

MINNI PROJECT

http://www.minni.org/

2002

QUALEARIA v.1

Domain:
20km 12 vertical levels top 4 km
FARM:
SAPRC90 aero3
EMISSIONI:
APAT 1999 - EMEP 1999 - Volcanoes (Etna, Stromboli, Vulcano)
BC:
EMEP 1999
Hardware/Software:
SO linux Cluster 4XOpteron QuadCore

2007

QUALEARIA v.3

FARM v. 4.x
saprc99-aero3
Dynamic emissions evaluation from vegetation MEGAN.
Dynamic soil dust and sea salt emissions
.....

2014

QualeAria on Cresco

ARIANET ed ENEA

In collaboration with the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, a copy of QualeAria has been migrated on the HPC infrastructure CRESCO.

2016

2005

FUMAPEX PROJECT

http://fumapex.dmi.dk/index.html

2010

QUALEARIA v.2

2 Nested domains:
Europe 45 km
Italy 12 km
16 vertical levels
top 10 km

Hardware/Software:
SO linux Cluster
4XOpteron 12-Core

2015

QUALEARIA v.4

dynamic BC are assigned from the ECMWF MACC-C-IFS-TM5 global model
Saharan dust contribute

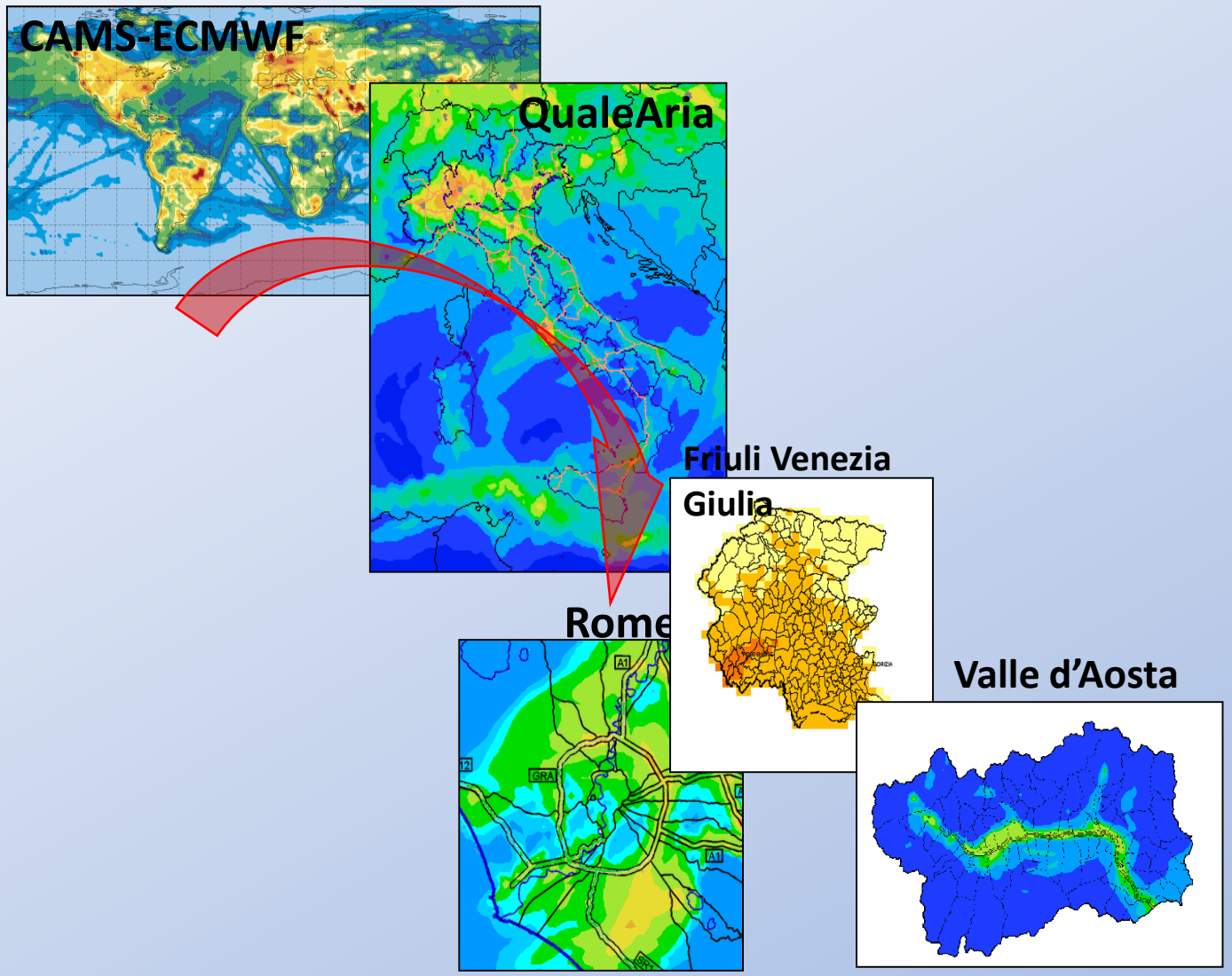
20xx

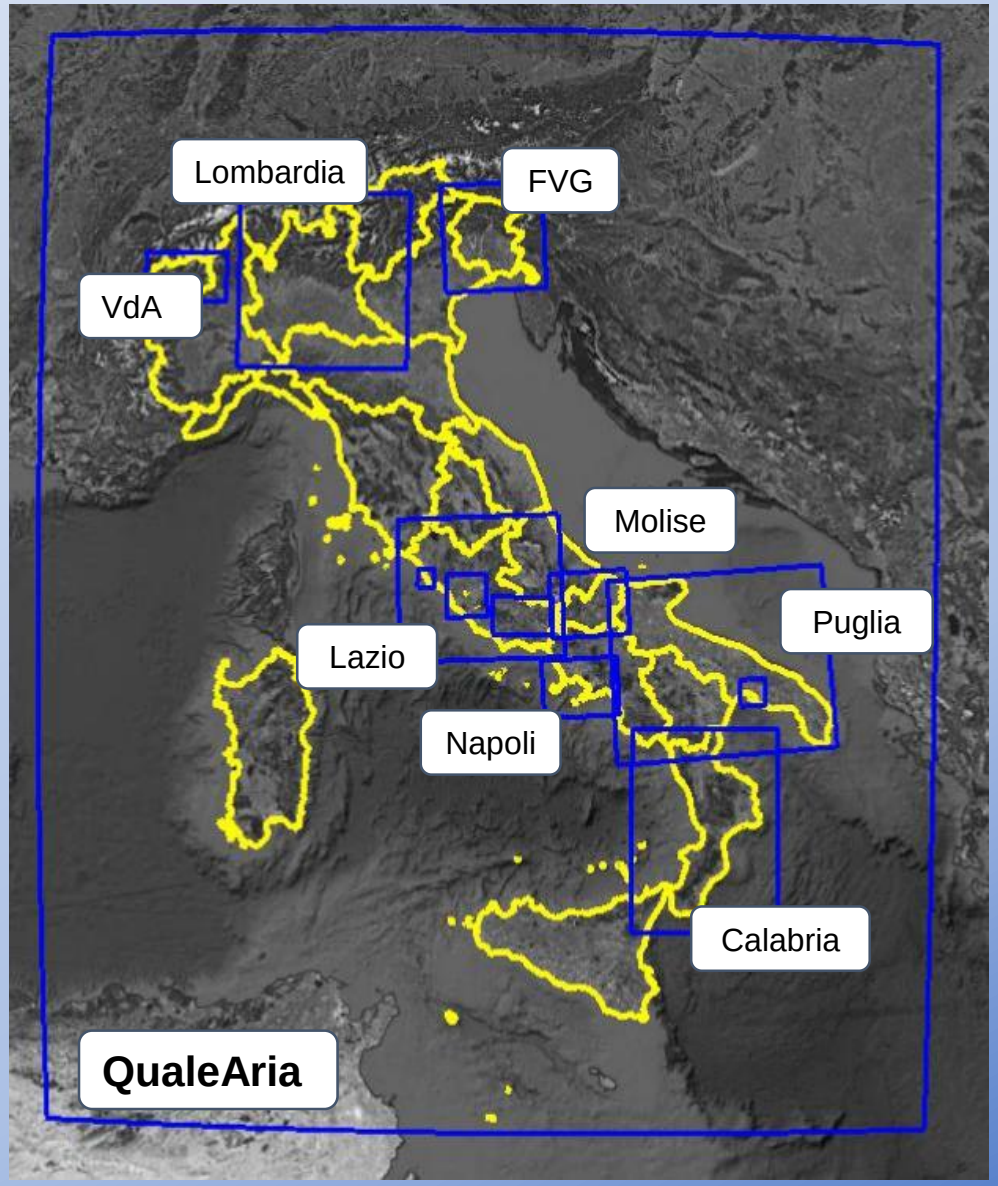
QUALEARIA v.5

WRF-ARW as the meteorological driver.
Introduction of dynamic elements in emissions modelling.
Further increase of the resolution.
Operational software shell improvement and migration to python programming language.
.....

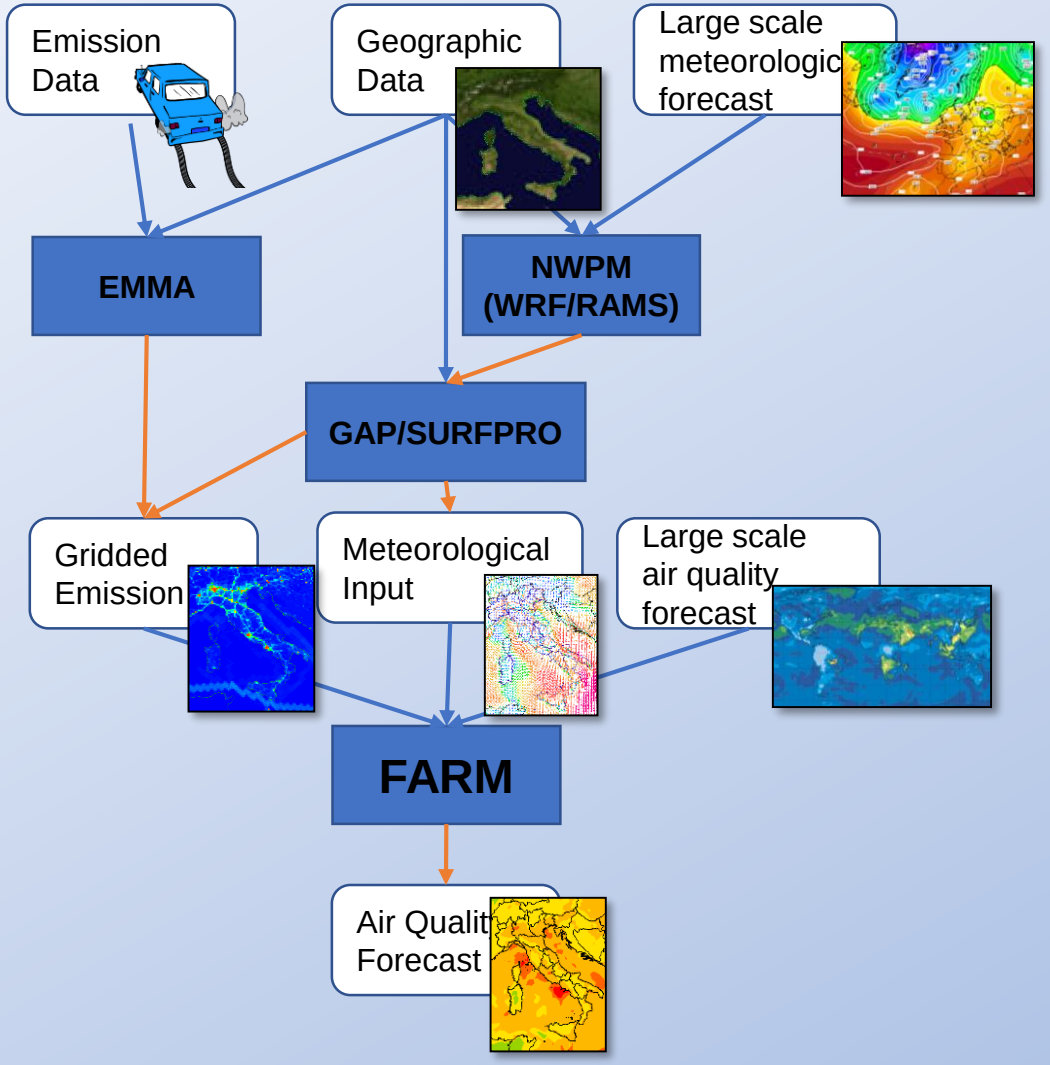
QualeAria products: TODAY FORECAST

QualeAria products:
Regional modelling system IC/BC





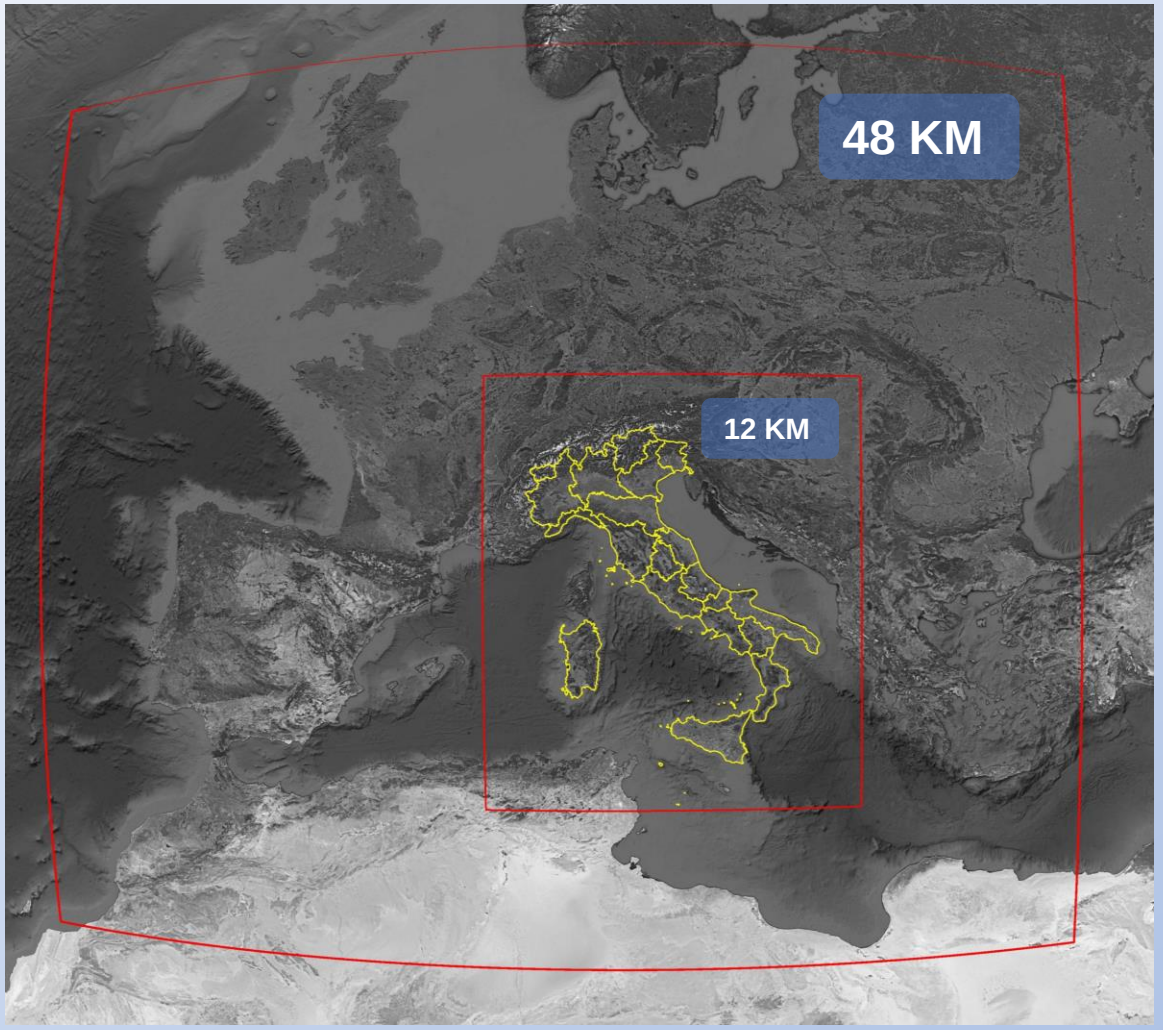
QualeAria
AIR QUALITY FORECAST SYSTEM FRAMEWORK



RAMS/WRF weather forecast downscaling;
Meteorological interface module **GAP/SURFPRO** describe atmospheric turbulence and define dispersion parameters;
Emission processor (**EMMA**) to provide gridded emissions of all the pollutants considered;
Eulerian chemical transport model **FARM**
F-Air (ARIANET Integrated Forecast System Manager)

(*Kukkonen, et al., 2012: A review of operational, regional-scale, chemical weather forecasting models in Europe, Atmos. Chem. Phys., 12, 1-87.*)

QualeAria
AIR QUALITY FORECAST SYSTEM FRAMEWORK



2 nested domains **48 km** and **12 km** horizontal resolution **16 vertical layers** up to 10000m.
Two-way nesting implemented.
Gas chemical mechanism: **SAPRC99**
Aerosol Module: **aero3** (US/EPA)
5 days forecast deployed at 5am UTC

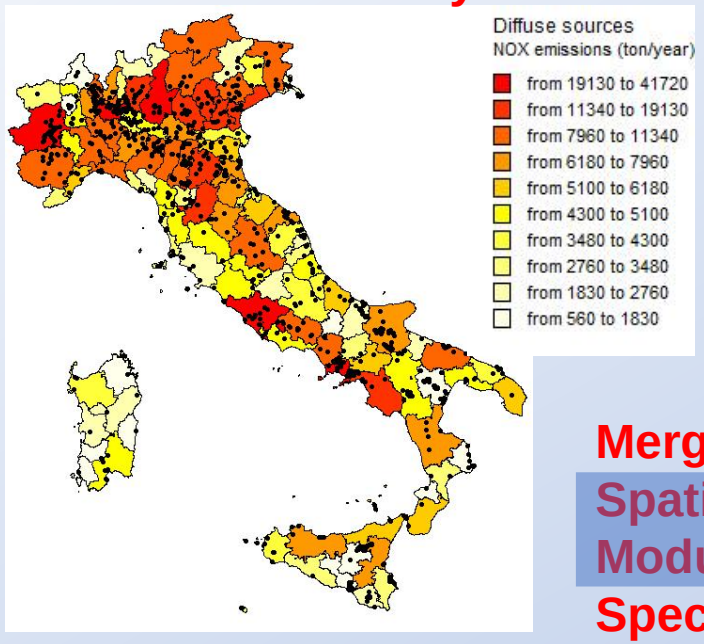
Boundary conditions:

Global weather forecast, **United States meteorological service**

Global Air Quality forecast, **CAMS ECMWF**
Composition Integrated Forecasting System (C-IFS): **gases, aerosols including dust**

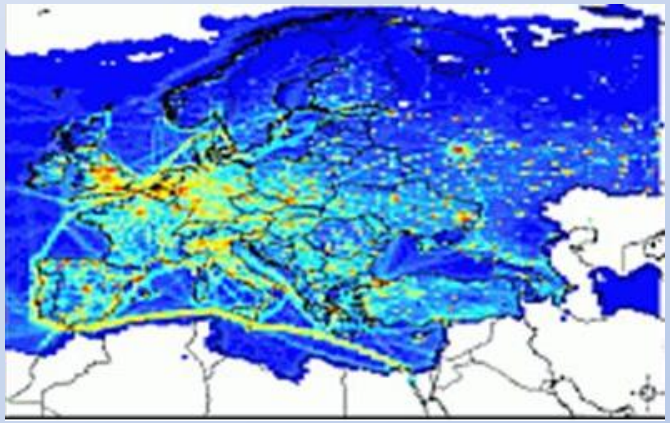
QualeAria Emissions treatment

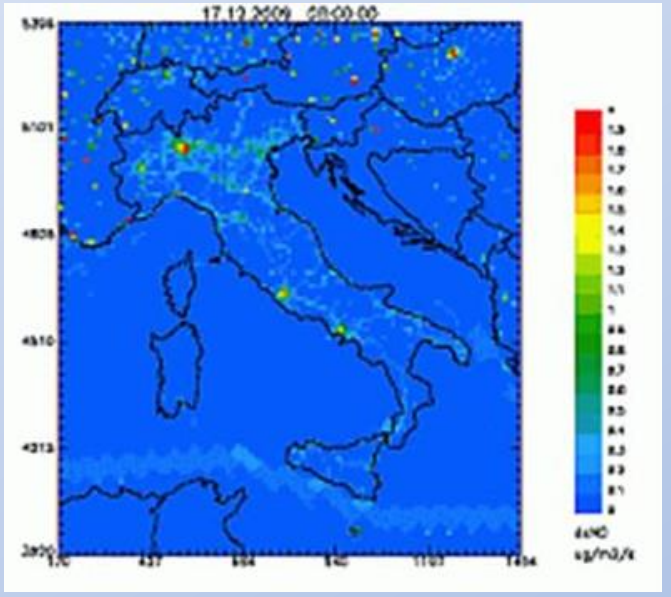
National inventory



Merge
Spatialization
Modulation
Speciation

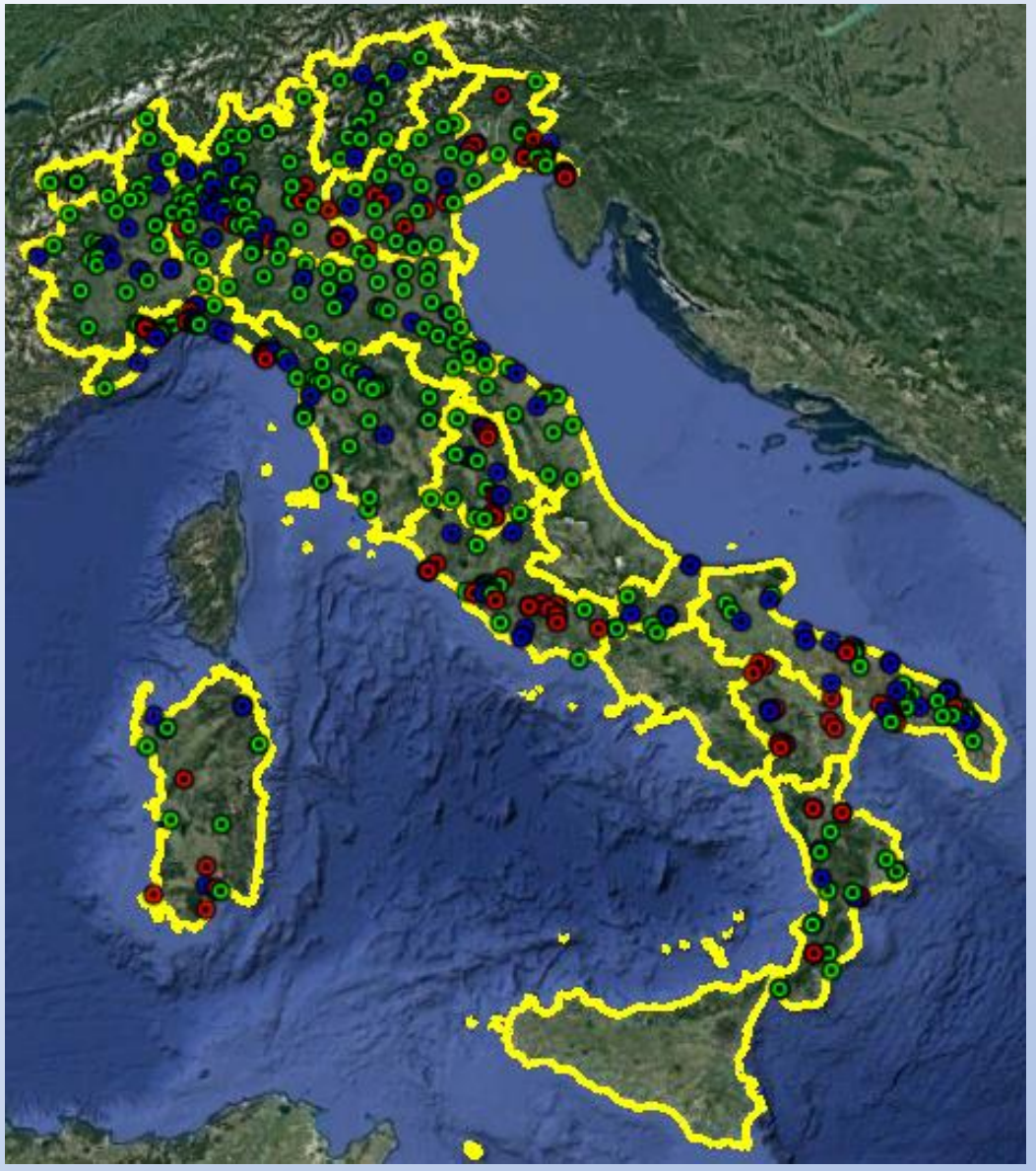
European inventory





Anthropogenic emissions are assigned starting from the reference national emission inventory distributed by ISPRA for Italy and the TNO/MEGAPOLI and EMEP inventory for Europe. Emissions from natural sources (biogenic emissions MEGAN model, soil dust and sea salt) are dynamically assigned through SURFPro.

QUALEARIA SCORES – REFERENCE YEAR 2015



EEA air pollution data center
primary validated assessment data.

More than **85% data availability**

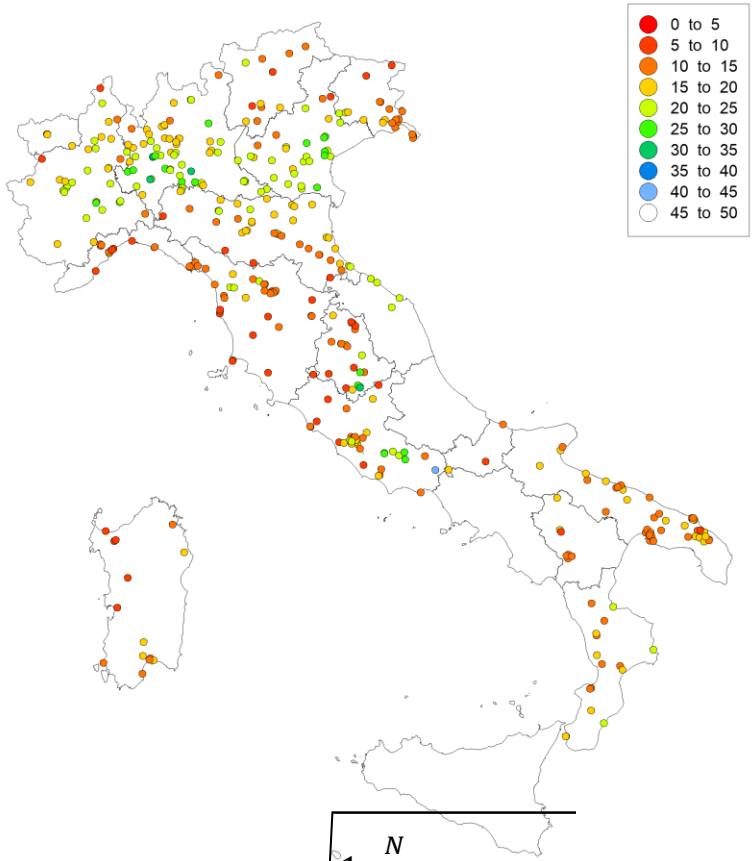
Station type:

BACKGROUND 267
INDUSTRIAL 105
TRAFFIC 150

Note: Abruzzo, Campania, Sicilia regions still missing from official data-base

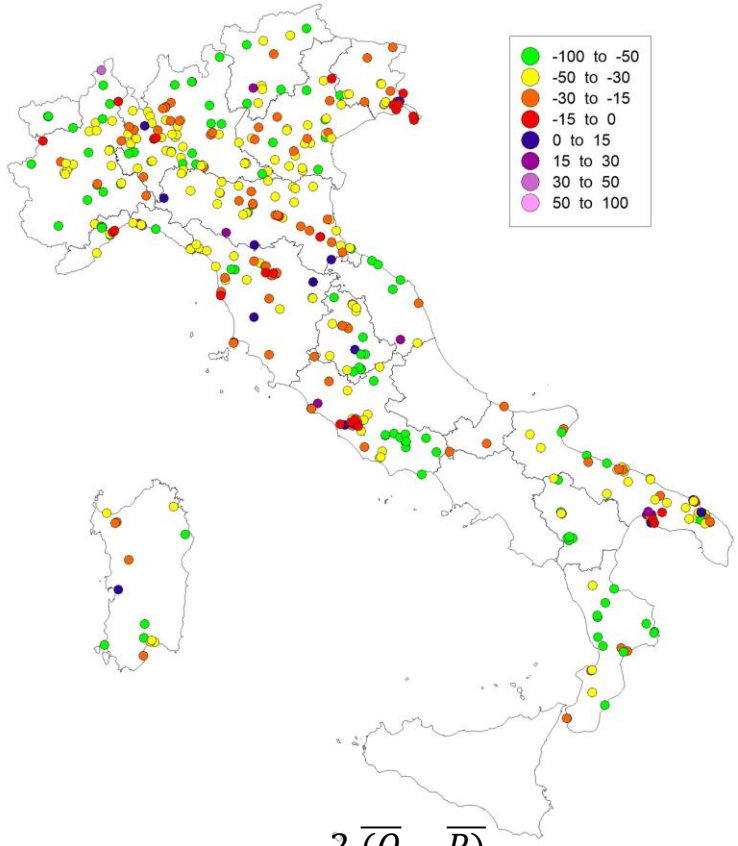
QUALEARIA SCORES – STATISTICAL METRICS

YEAR 2015 - PM10 RMSE



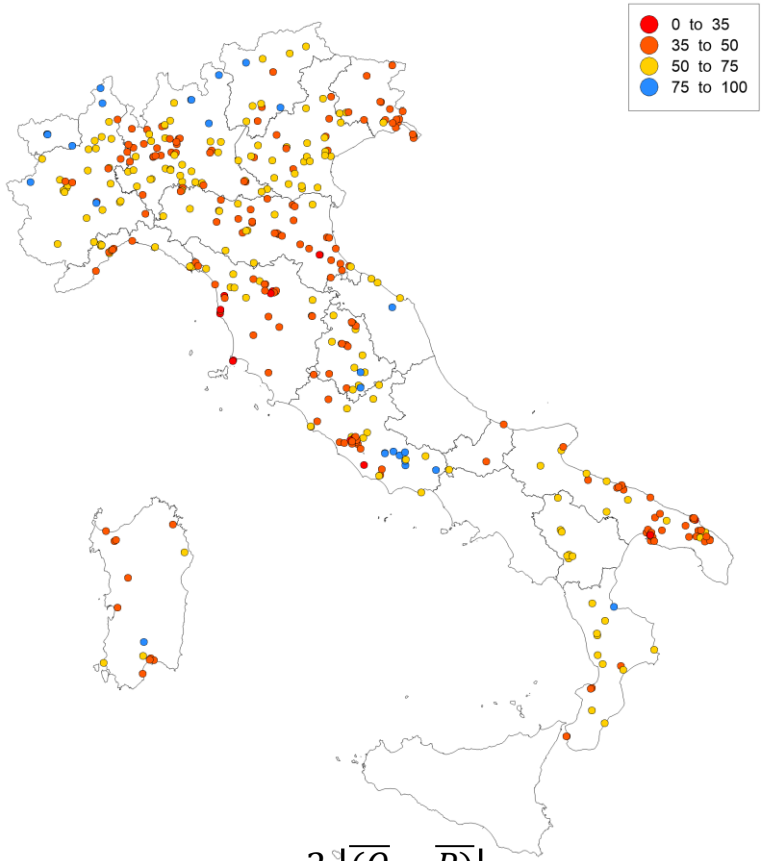
$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(O_i - P_i)^2}$$

YEAR 2015 - PM10 MFB



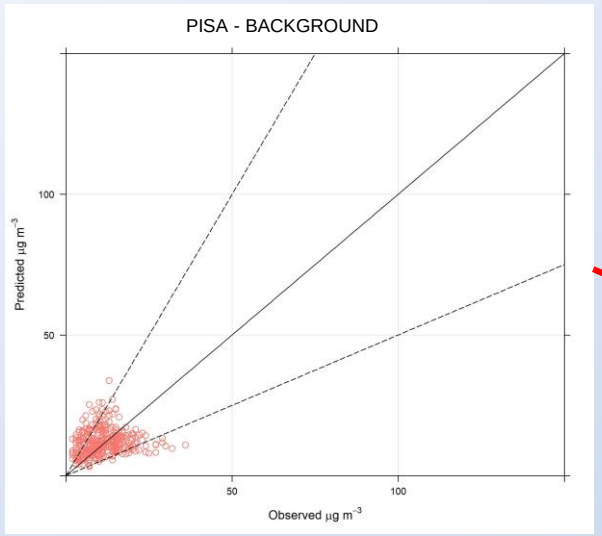
$$MFB = \frac{2}{N}\frac{\overline{(O - P)}}{\overline{(O + P)}} * 100$$

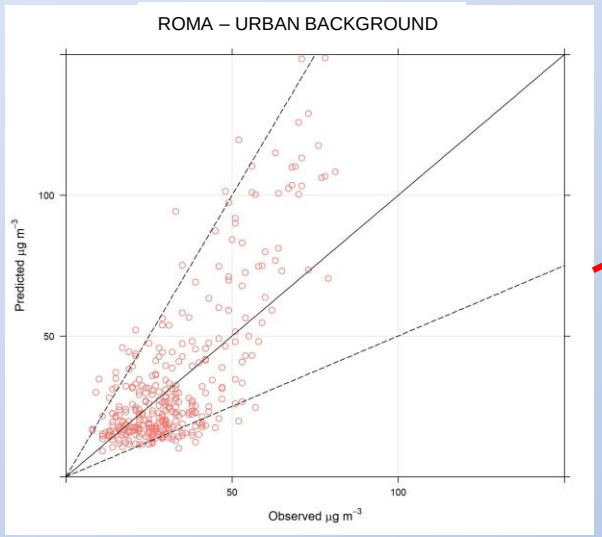
YEAR 2015 - PM10 MFE

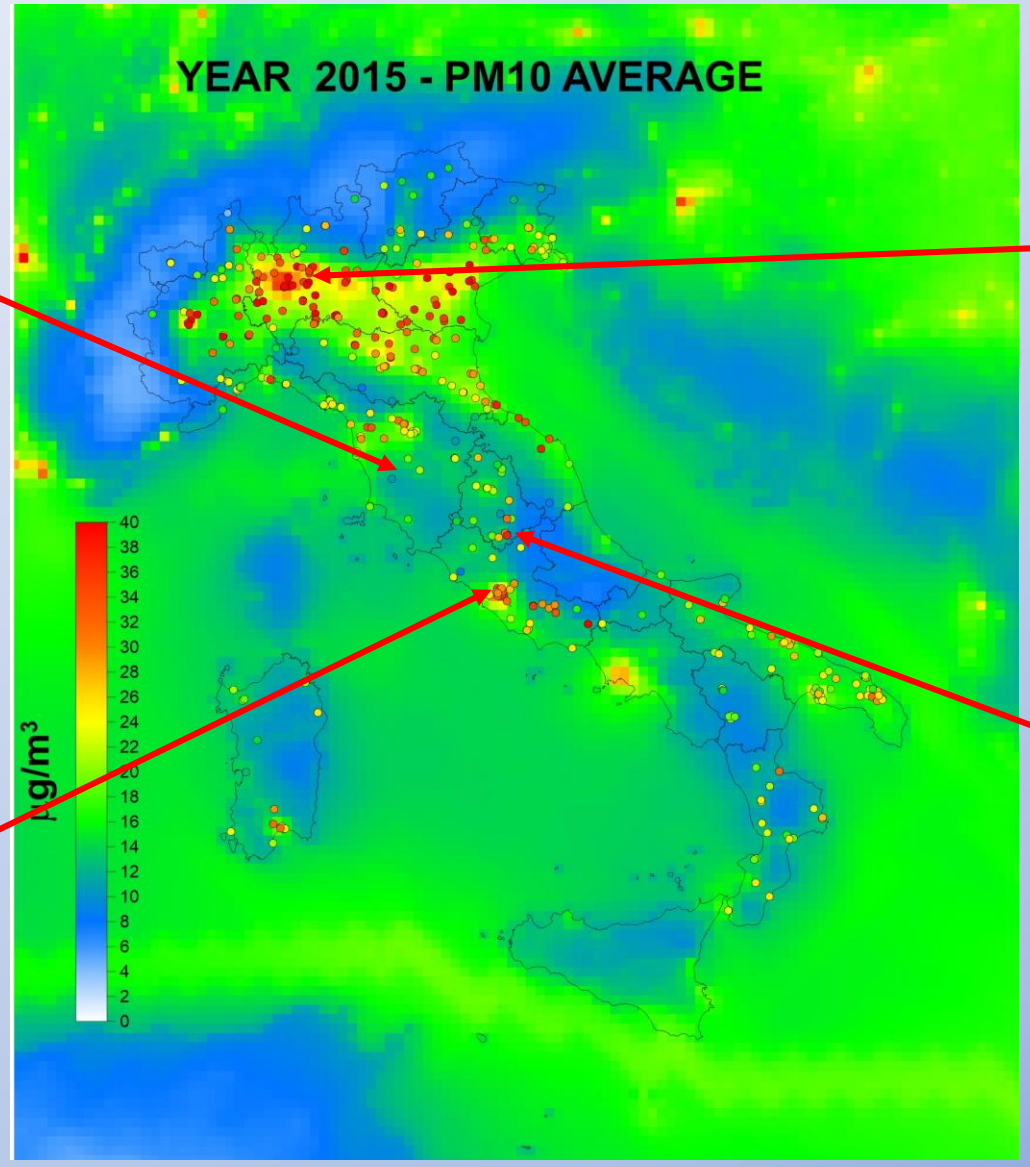


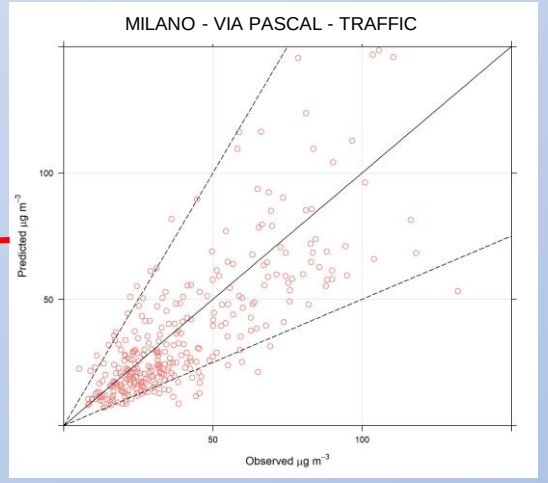
$$MFE = \frac{2}{N}\left|\frac{\overline{(O - P)}}{\overline{(O + P)}}\right| * 100$$

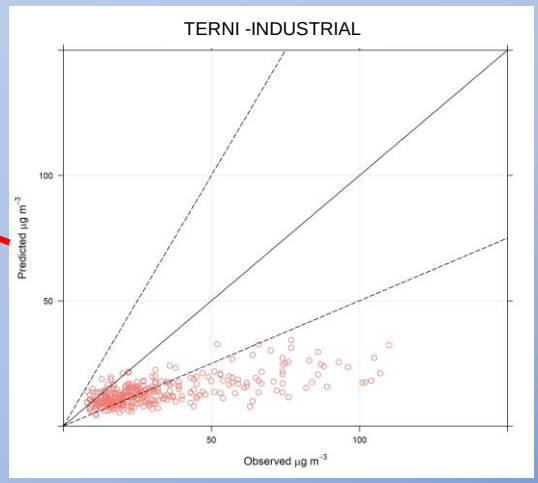
QUALEARIA SCORES – PM10



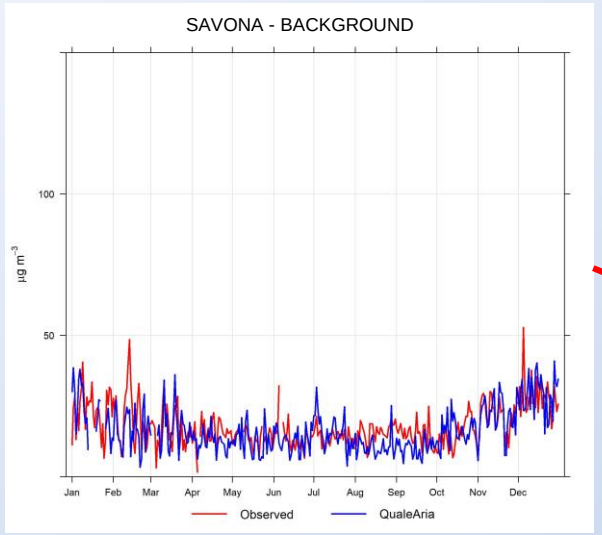


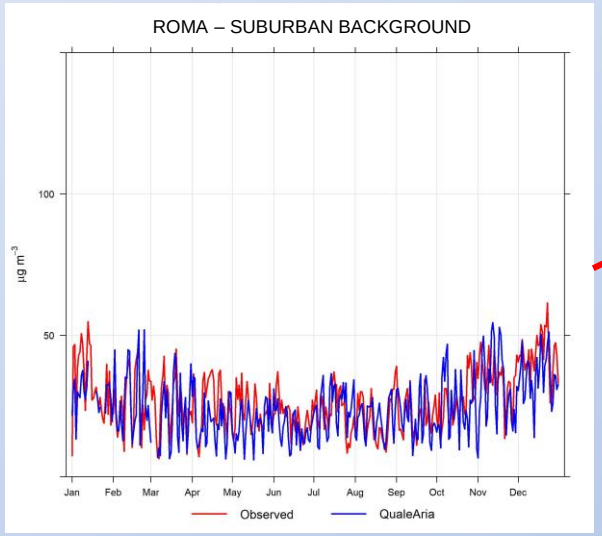


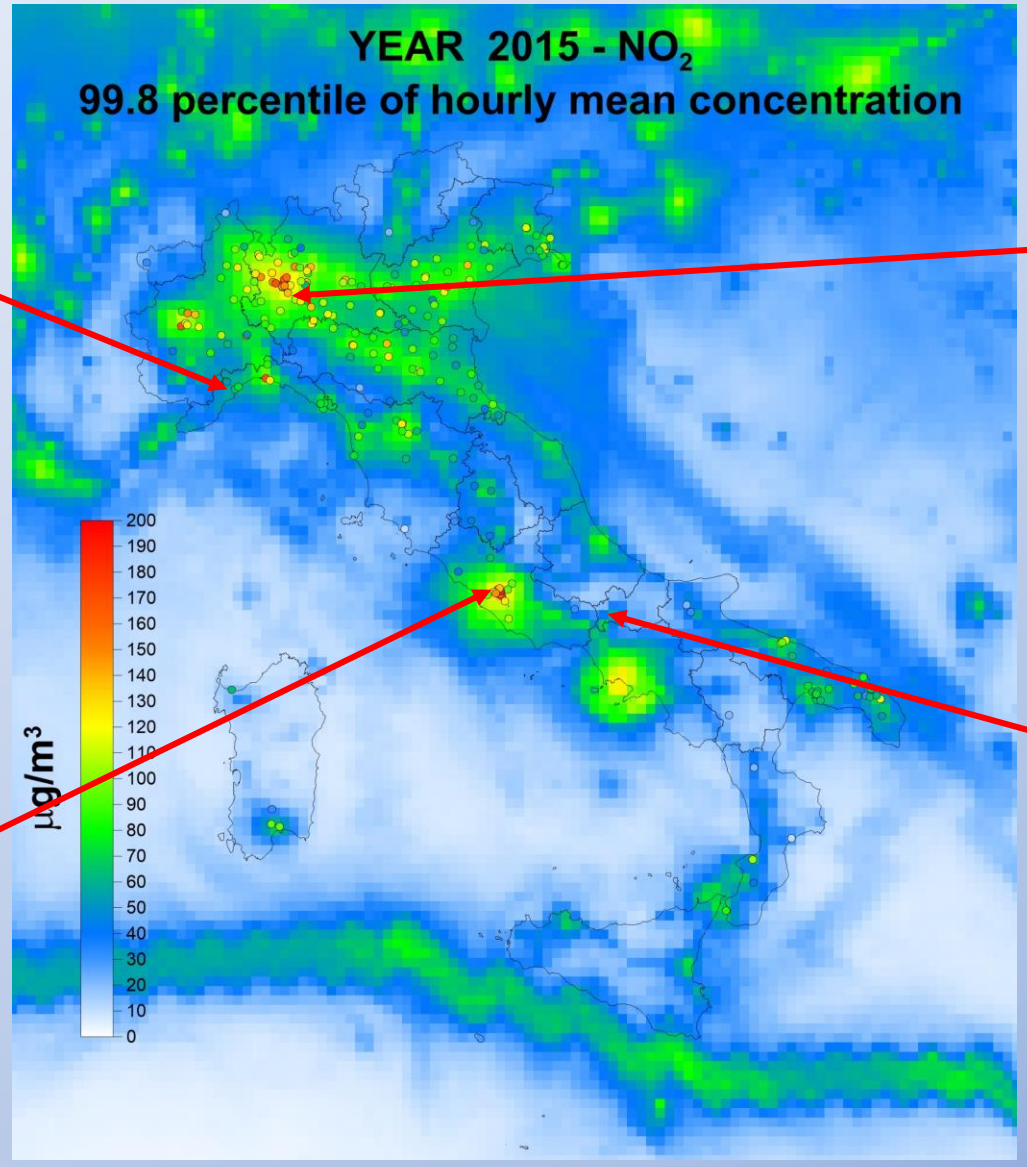


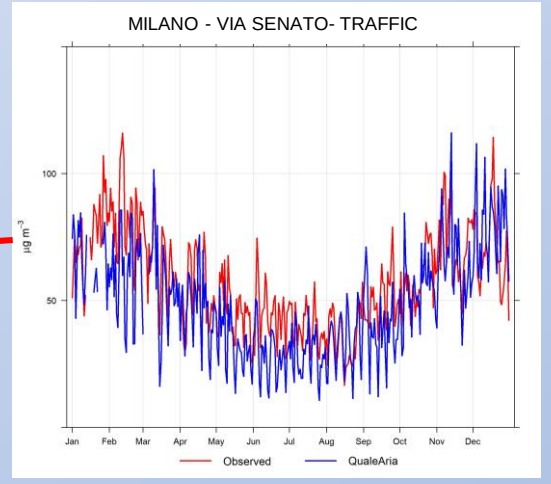


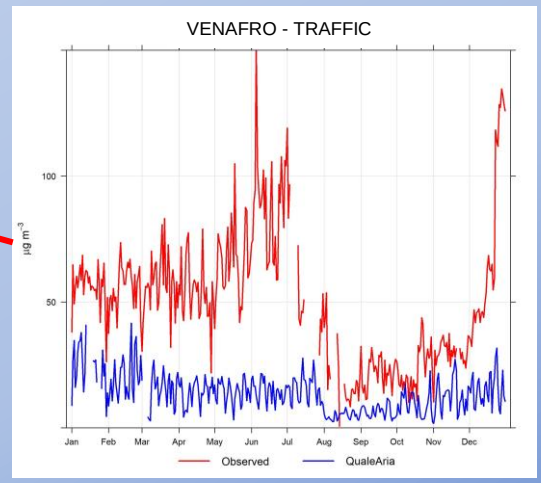
QUALEARIA SCORES – NO2











QUALEARIA SCORES – Contingency table

Index name	Formula	Range	Ideal value
Accuracy [ACC]	A=(a+d)/n*100	0 to 100	100
Bias [BIAS]	BIAS=(a+b)/(a+c)*100	0 to 100	100
Probability of Detection [POD]	POD=a/(a+c)*100	0 to 100	100
False Alarm Ratio [FAR]	FAR=b/(a+b)*100	0 to 100	0

	Observed yes	Observed no
Predicted yes	**a=9208**	**b=2310**
Predicted no	**c=24583**	**d=103197**

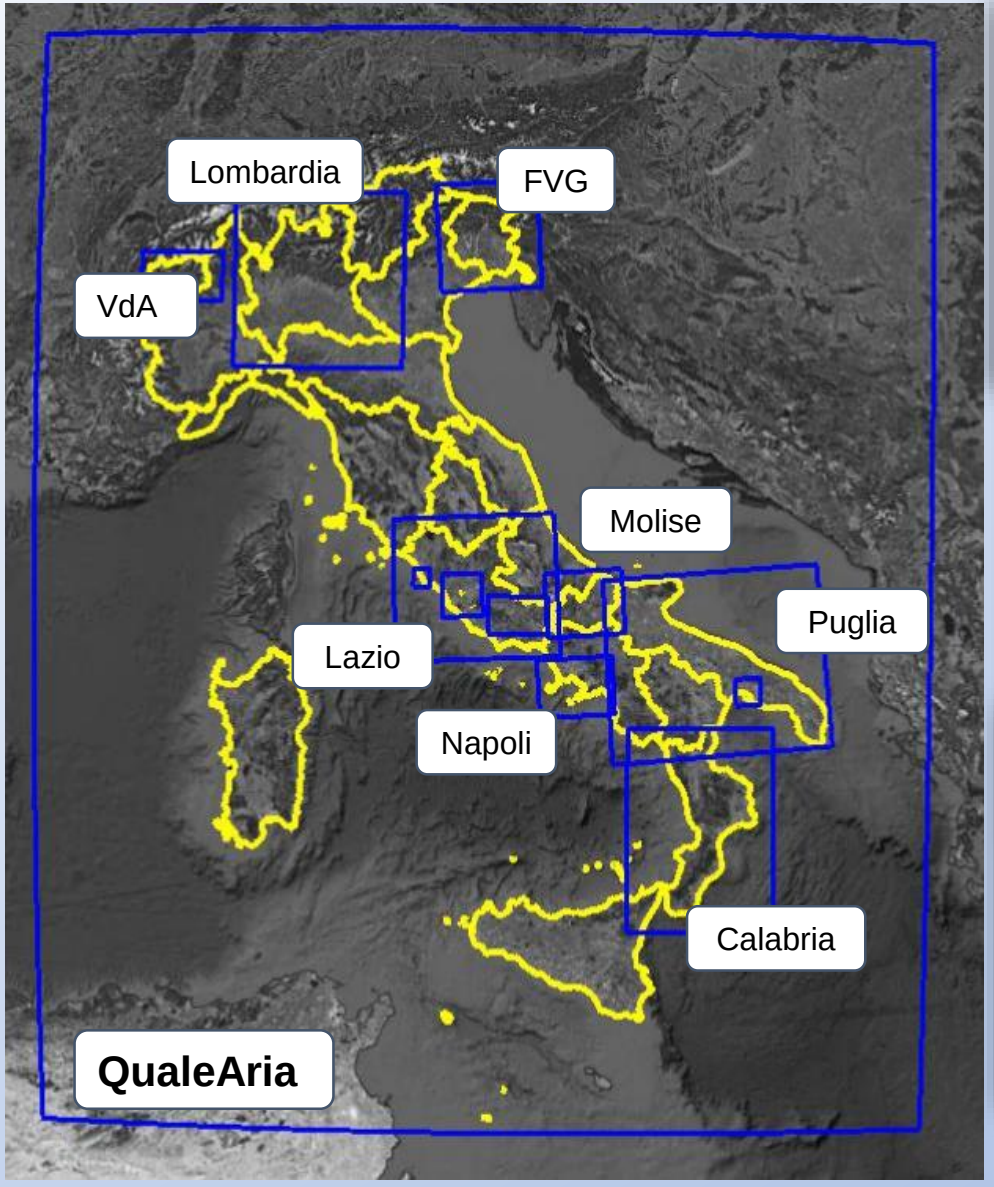
SPECIES	BIAS	POD	FAR	ACC	threshold (µg m^{-3})
PM10	34.09	27.25	20.06	80.69	33

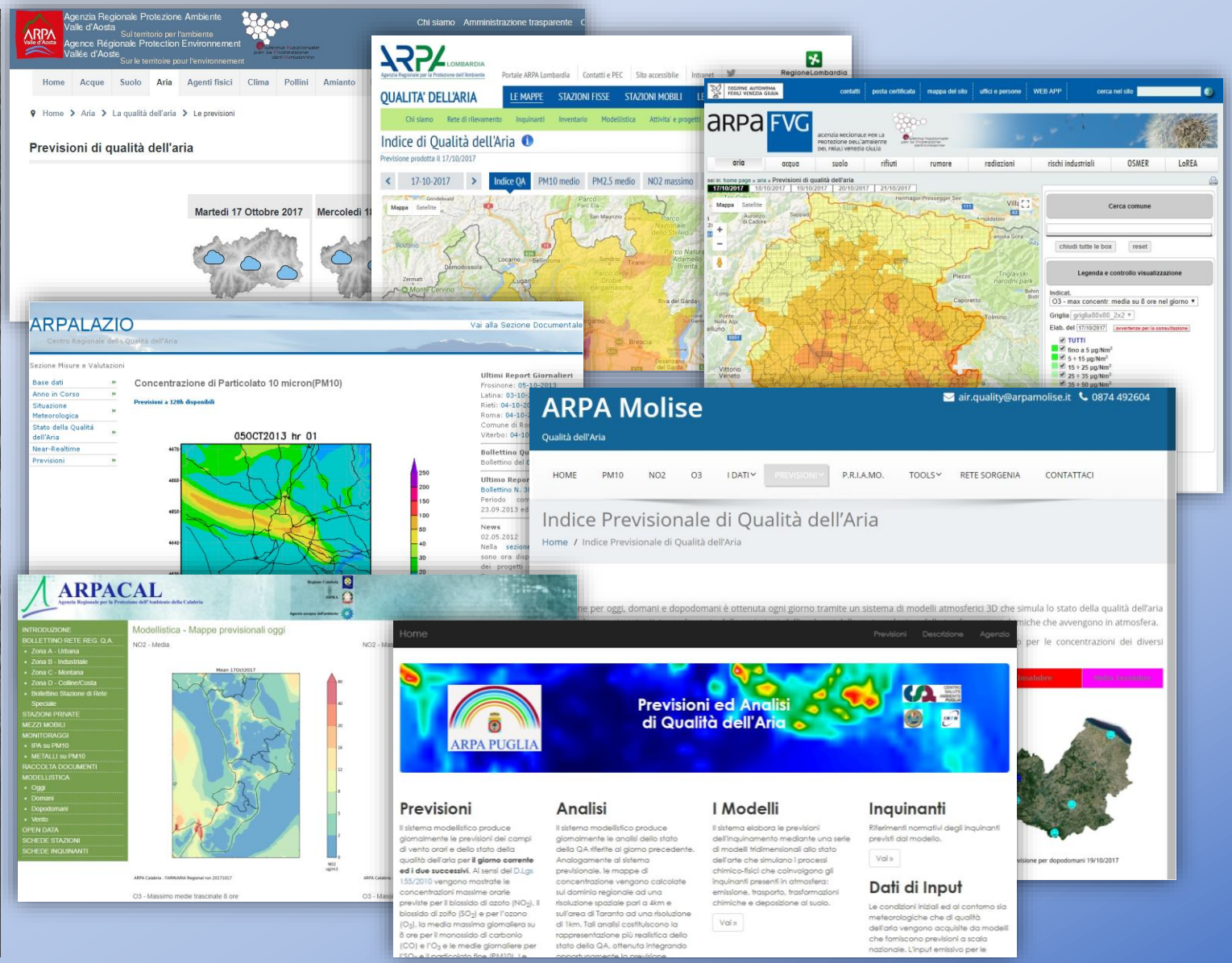
	Observed yes	Observed no
Predicted yes	**a=350552**	**b=198408**
Predicted no	**c=142037**	**d=1279373**

SPECIES	BIAS	POD	FAR	ACC	threshold (µg m^{-3})
O_3	111.44	71.16	36.14	82.7	83

QUALEARIA AND LOCAL SCALE FORECAST SYSTEMS

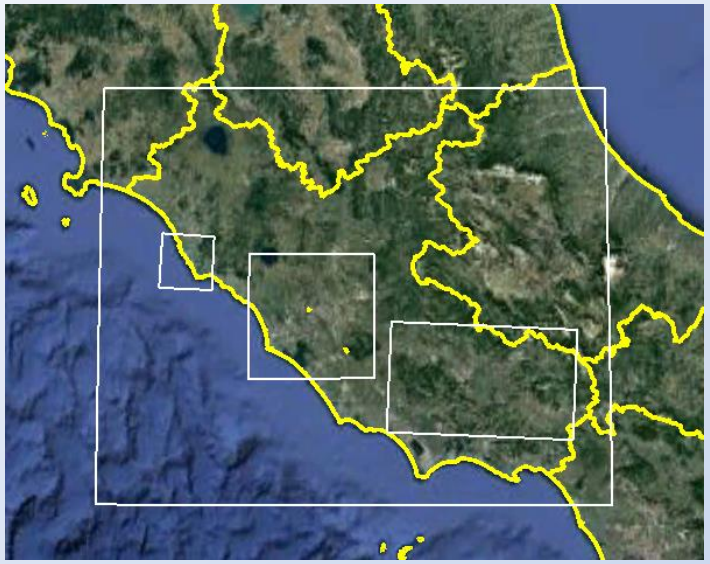
ARIANET

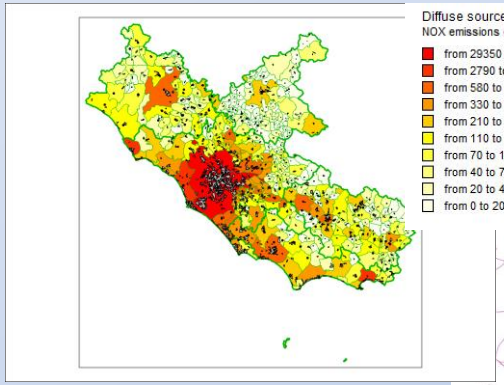


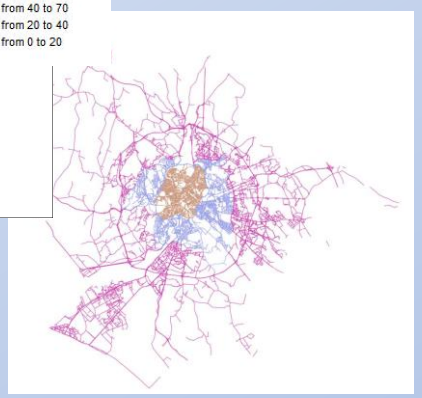


COMPARISONS – ARPA LAZIO

http://www.arpalazio.net/main/aria/sci/







- Same Modelling System as QualeAria
- Master domains 4 km and downscale at 1 km horizontal resolution for **ROMA**, **VALLE DEL SACCO** and **CIVITAVECCHIA**

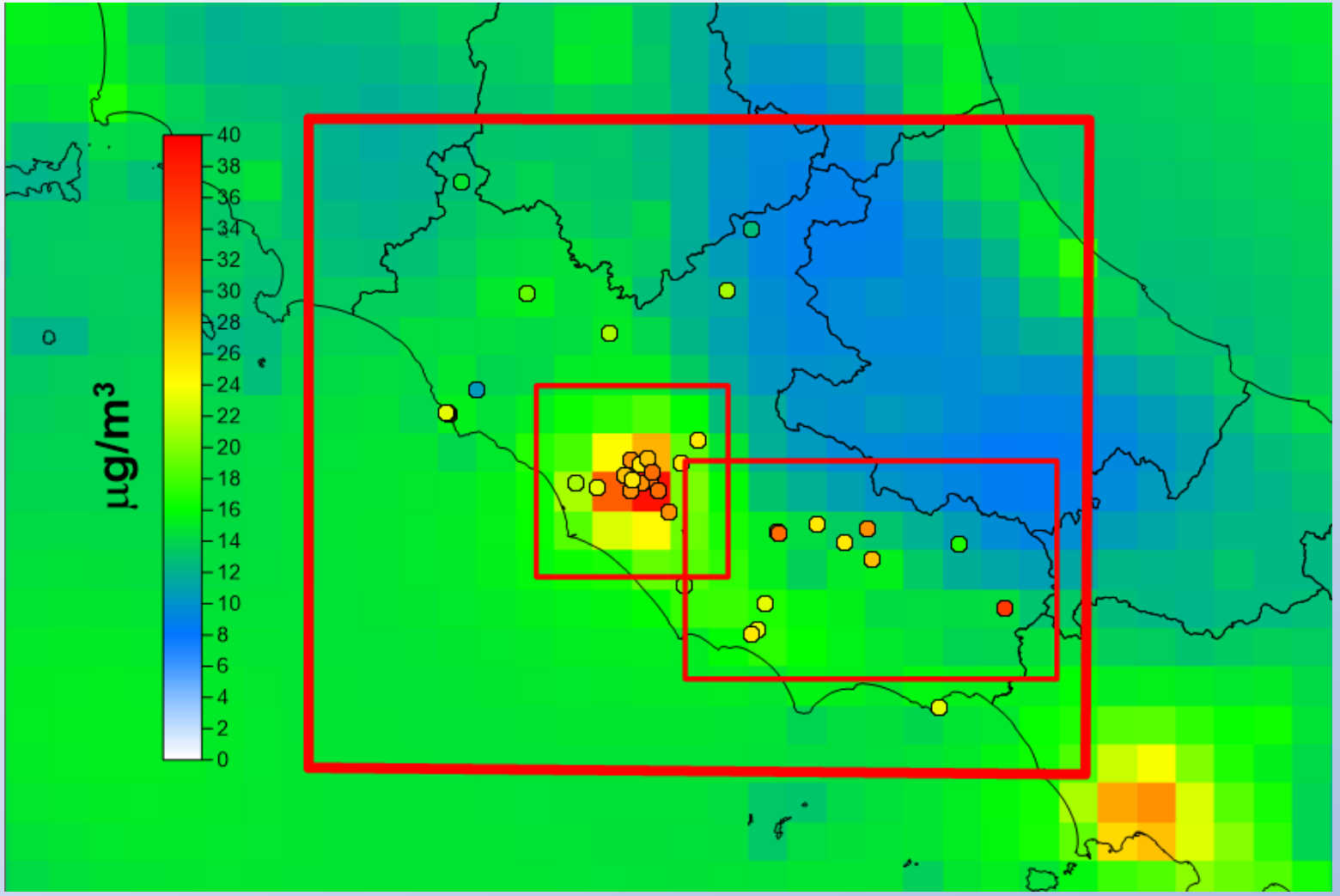
EMISSIONS

- Detailed emissions inventory with special regards to fuels for not industrial combustion
- Traffic emissions has been estimated with bottom-up approach and emission fluxes computed using the european methodology COPERT IV (TREFIC)

BOUNDARY CONDITIONS from QualeAria

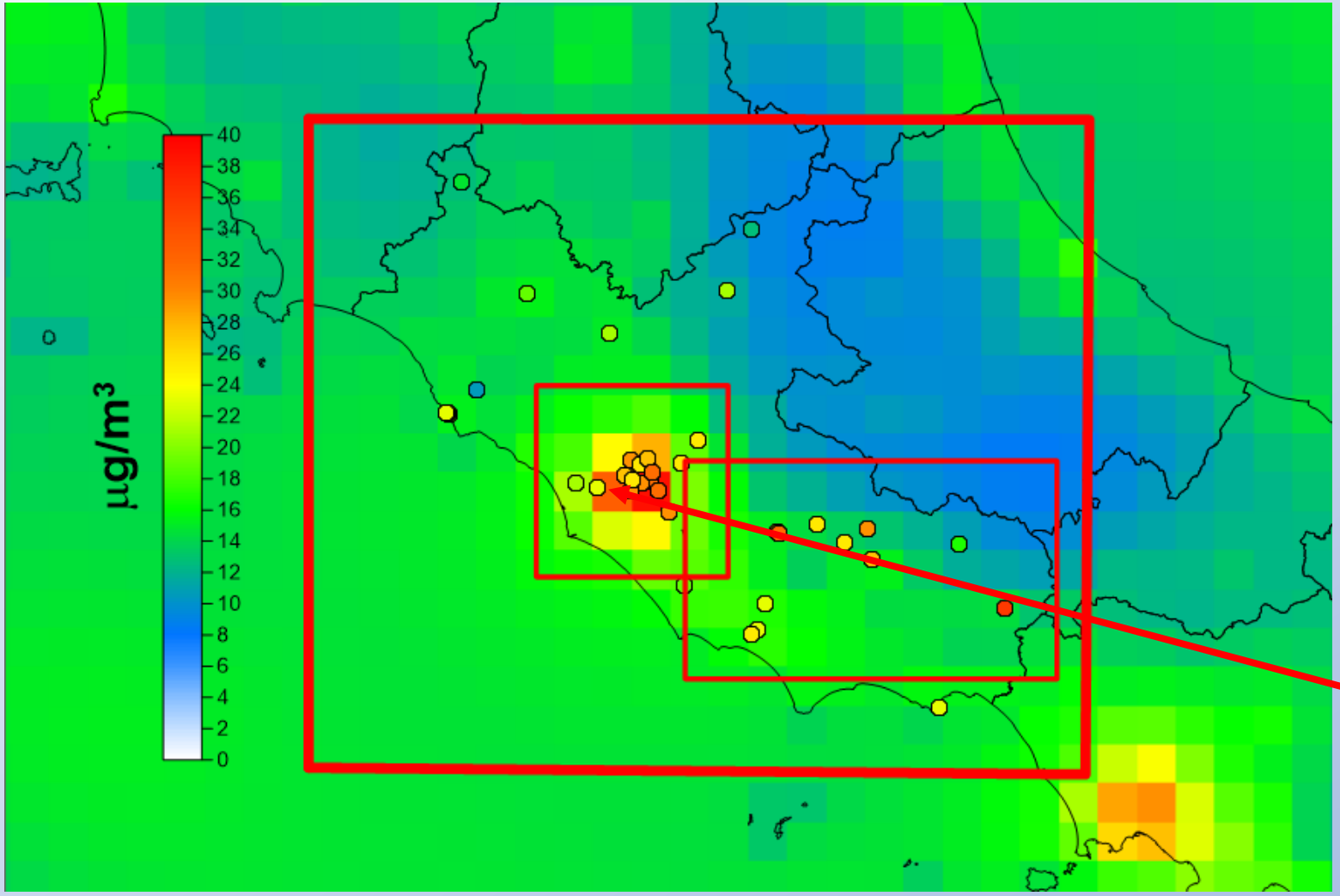
- positive effects: same AQ model, same chemical mechanism, influence of long lasting processes are taken into account.

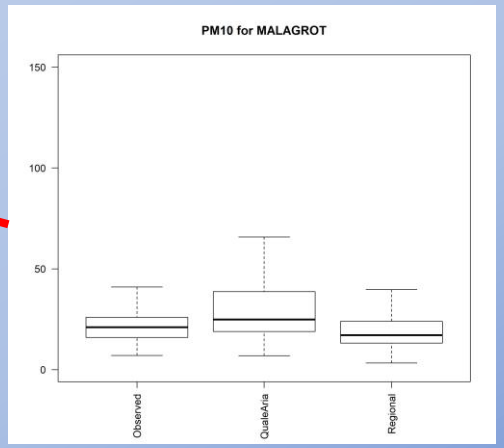
COMPARISONS – ARPA LAZIO



PM10 yearly average

COMPARISONS – ARPA LAZIO





PM10 yearly average

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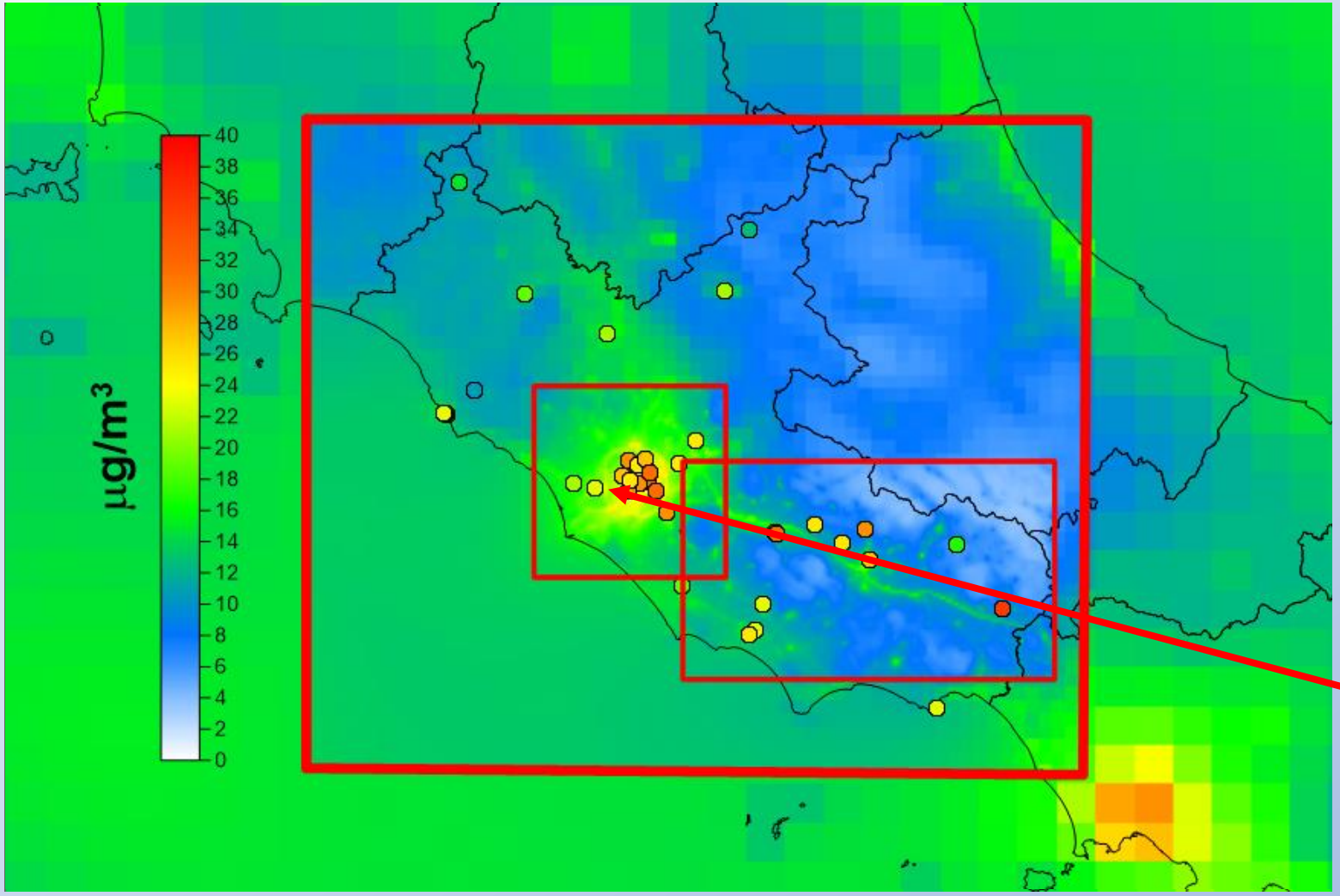

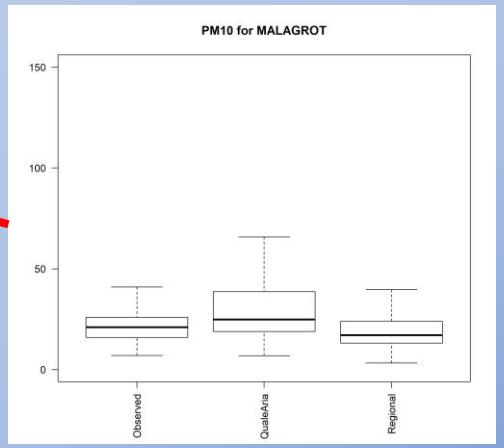

PM10 yearly average

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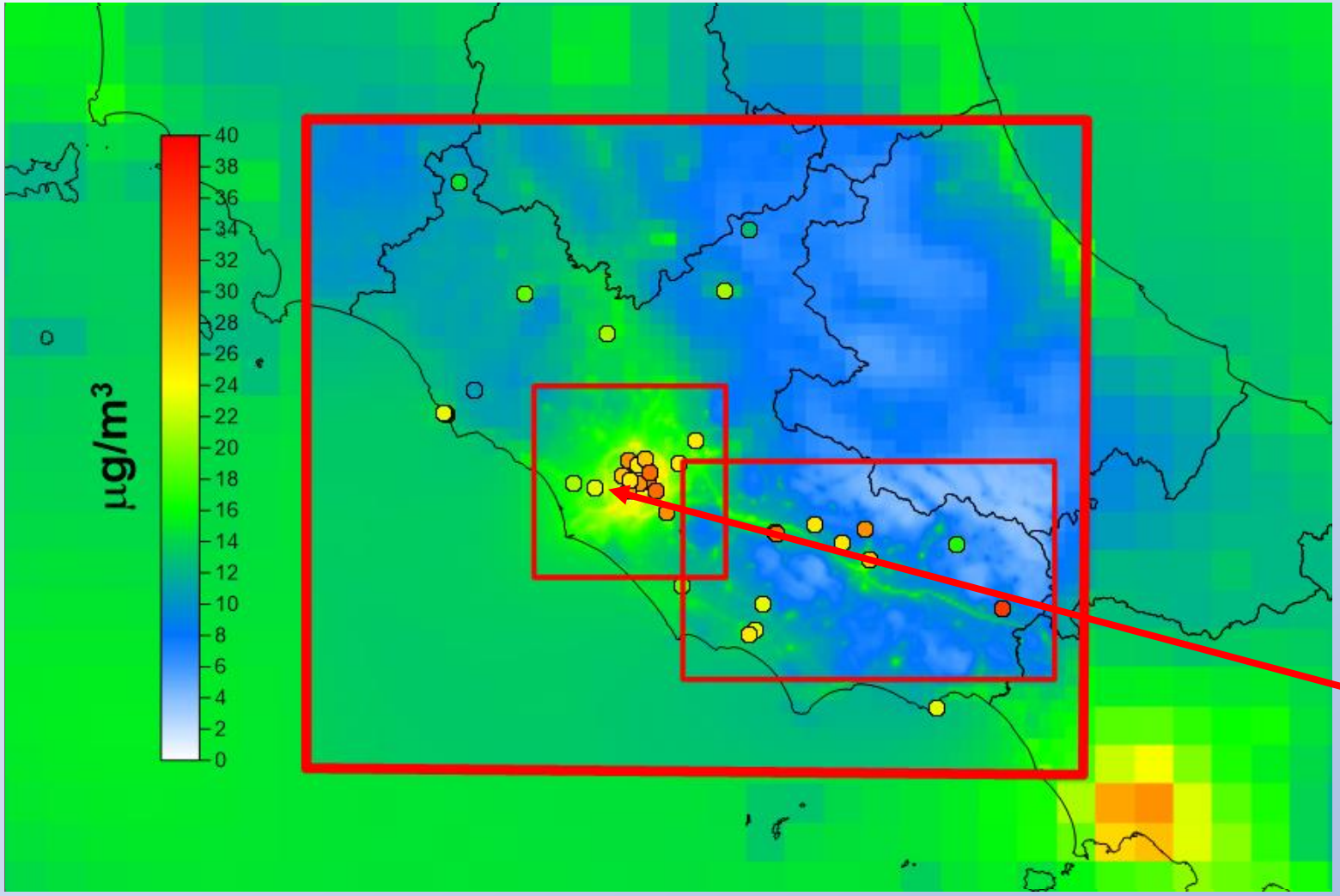
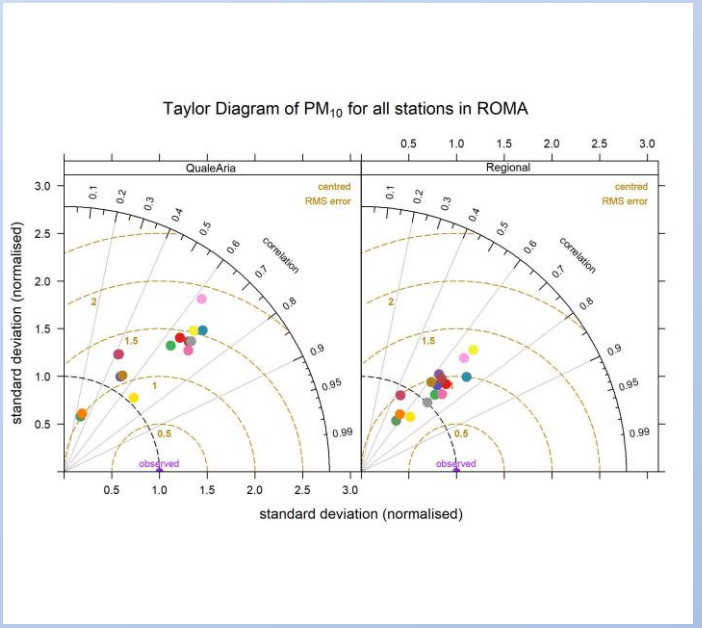
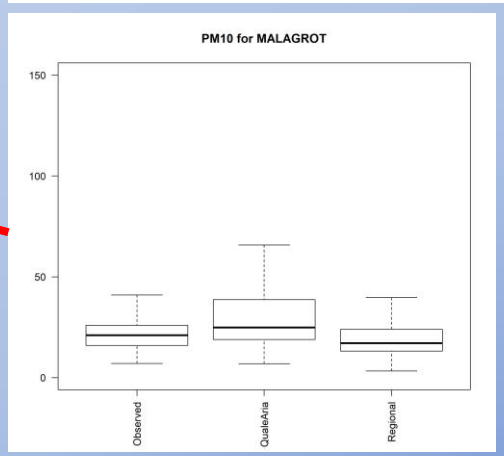
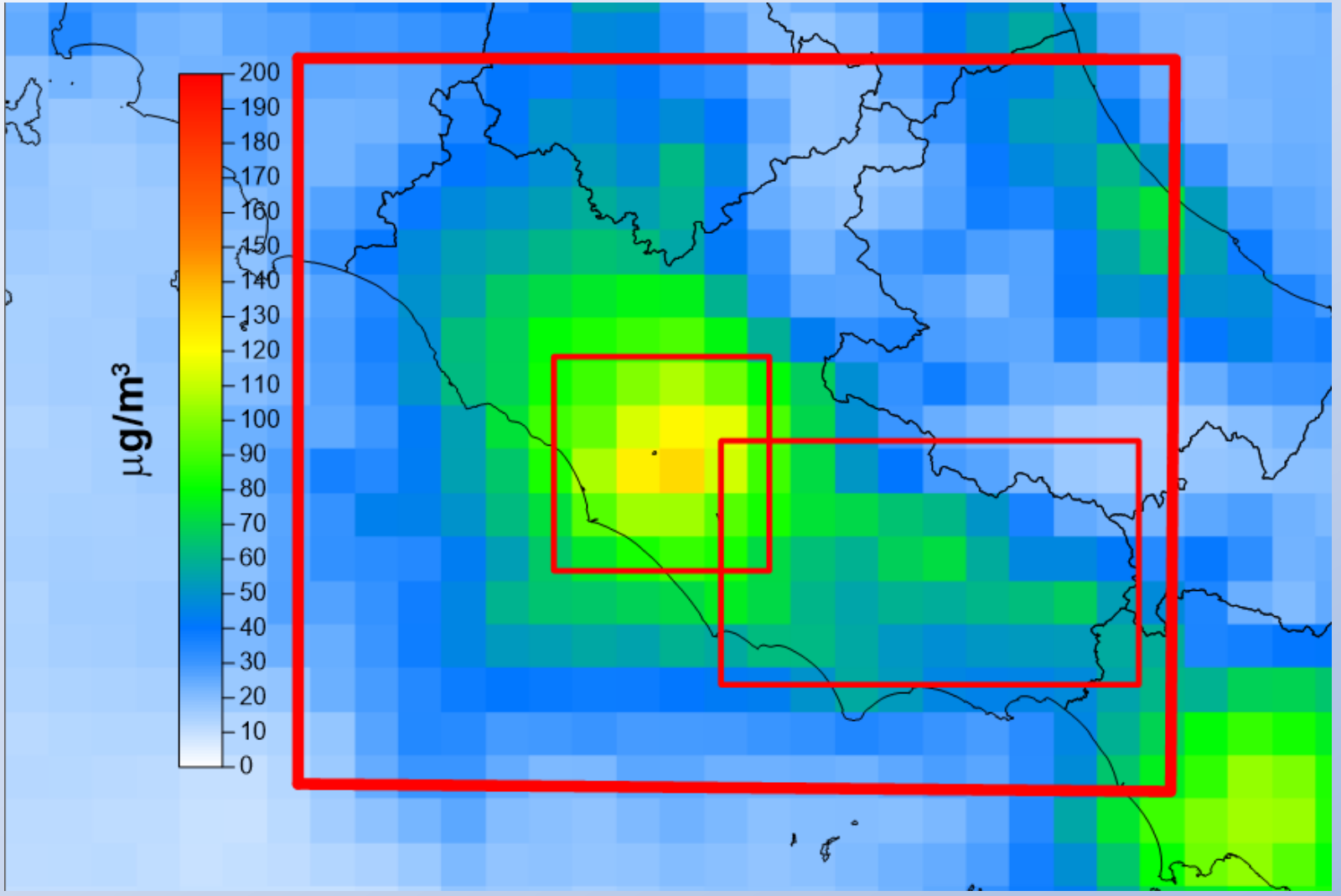






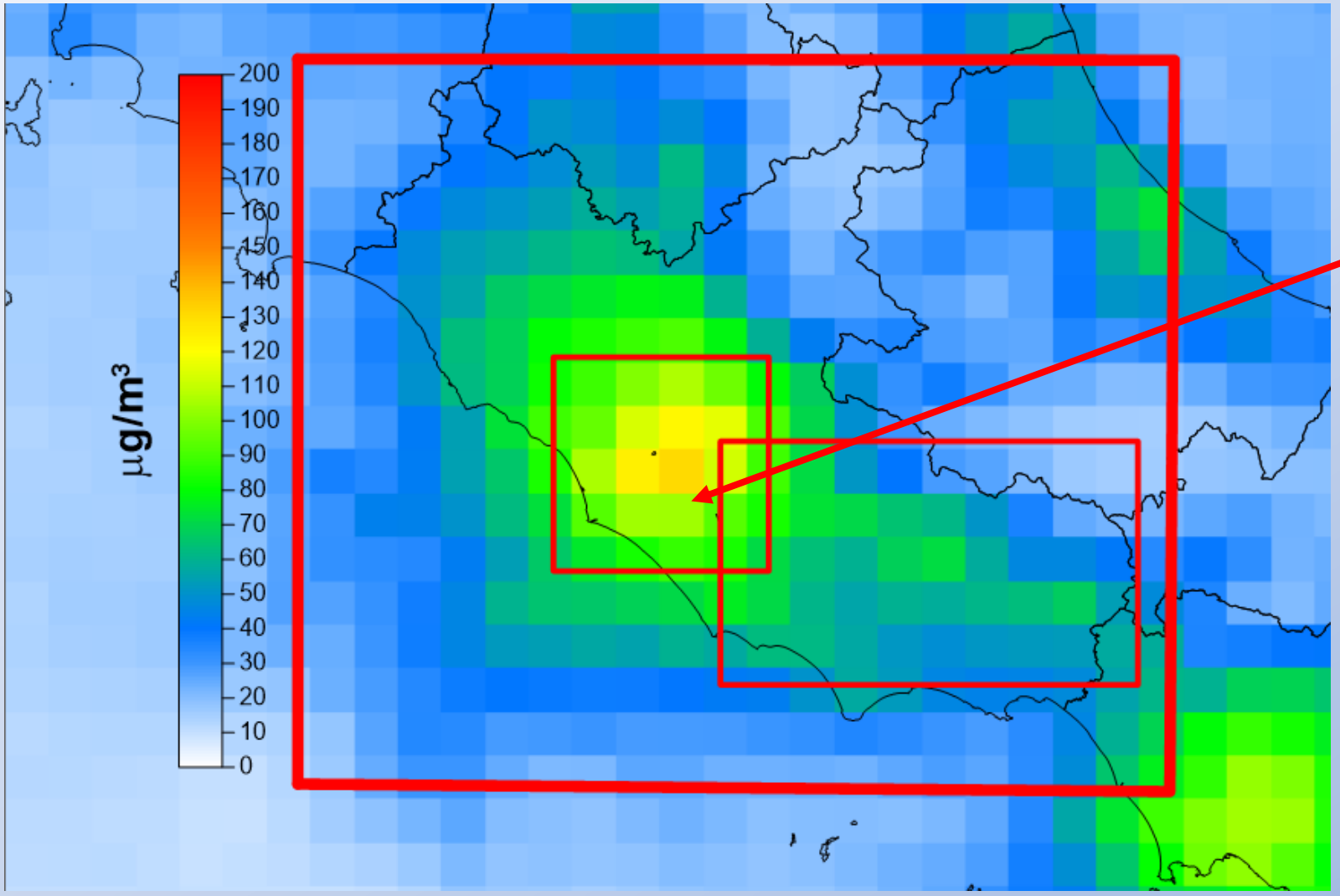
PM10 yearly average

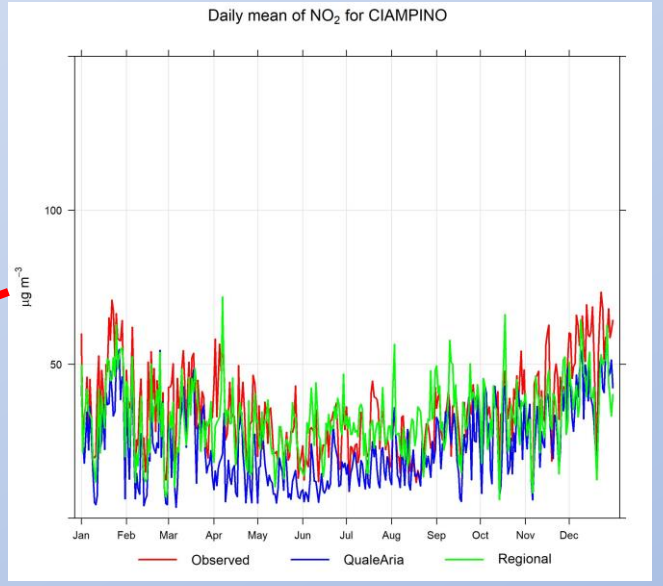
COMPARISONS – ARPA LAZIO



NO_2 99.8 percentile

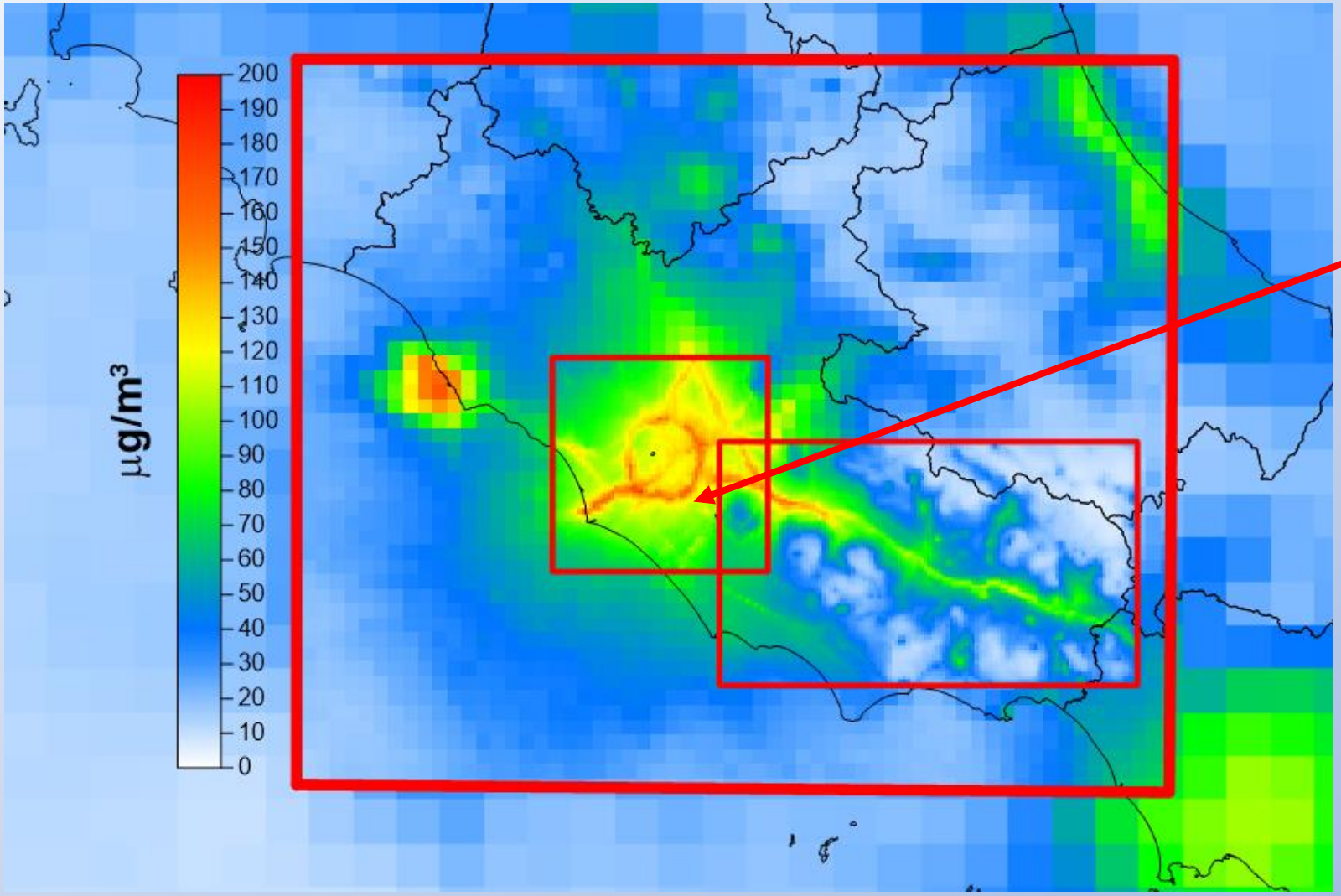
COMPARISONS – ARPA LAZIO

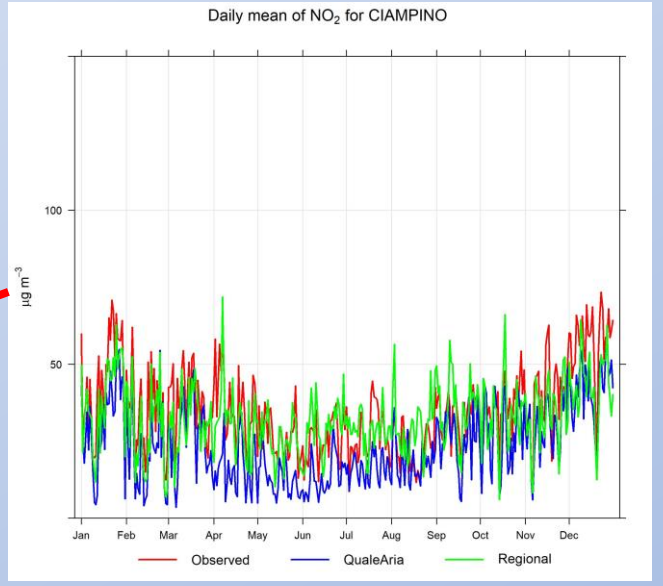




NO_2 99.8 percentile

COMPARISONS – ARPA LAZIO





NO_2 99.8 percentile

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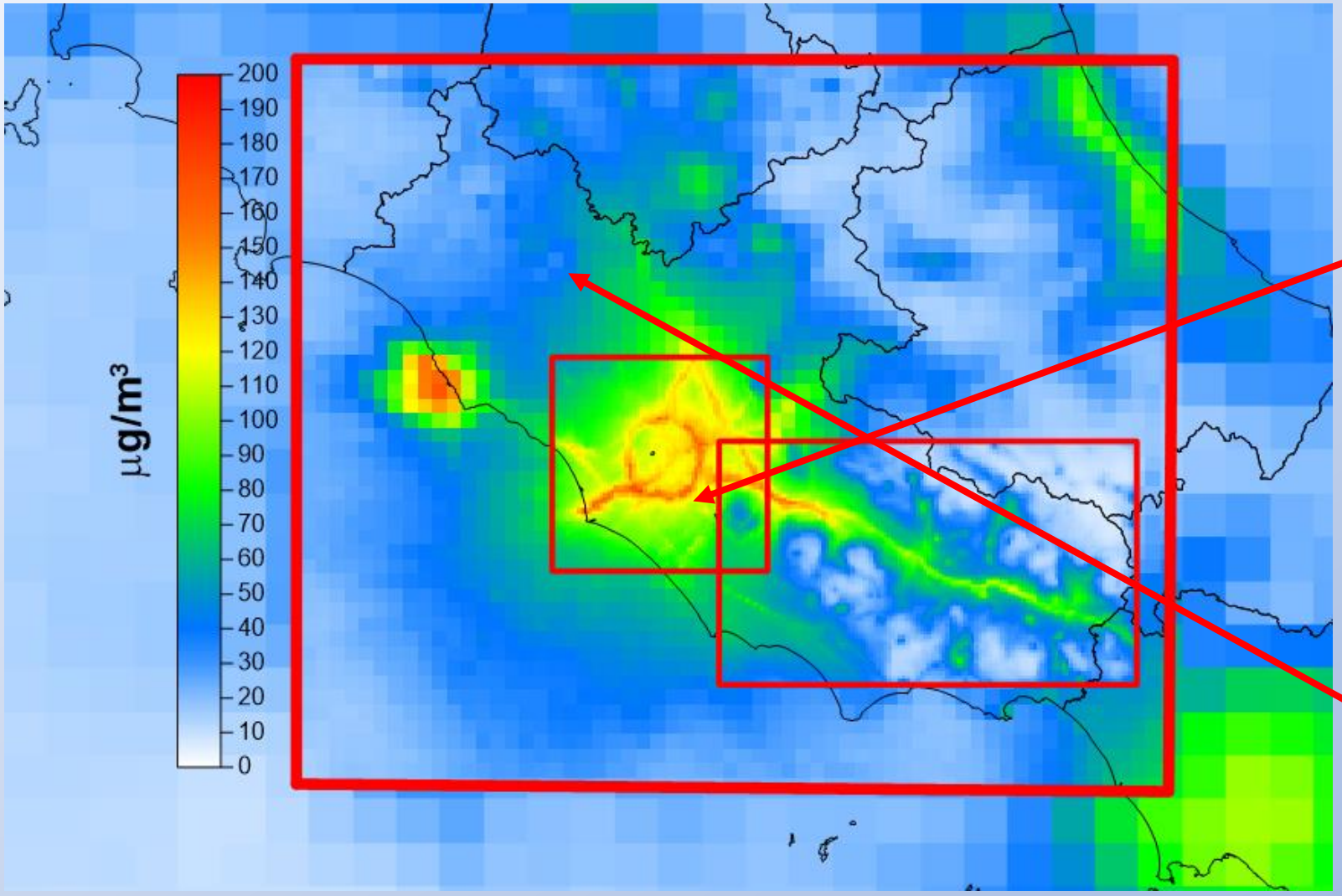
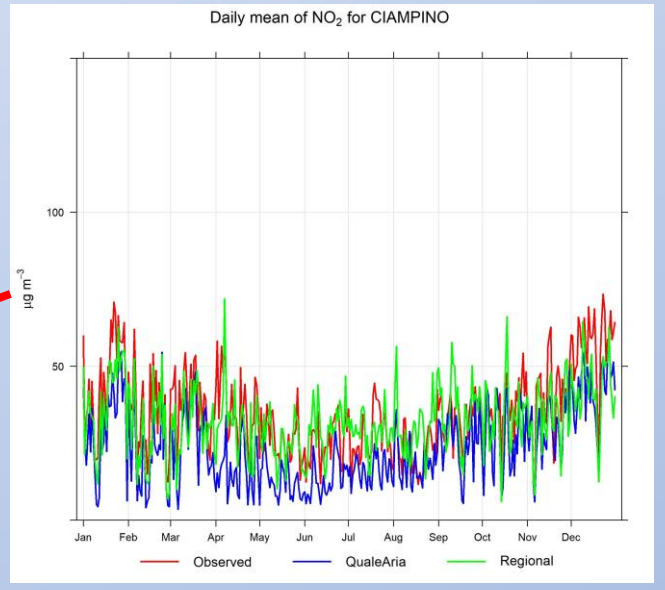
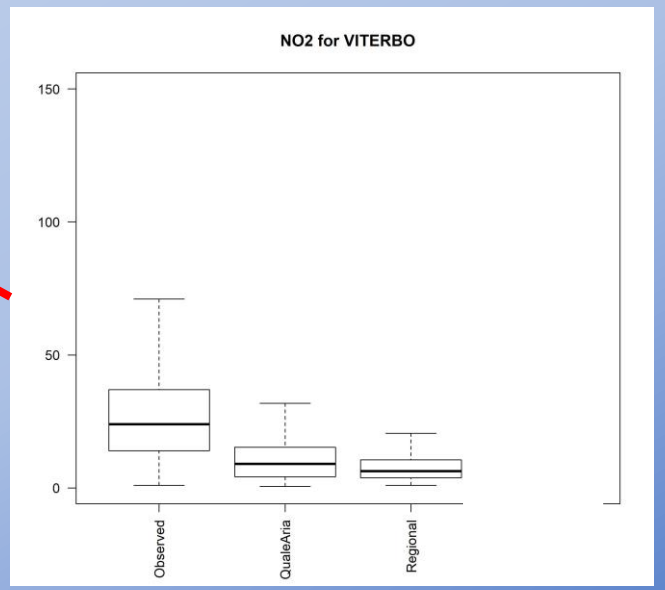






NO_2 99.8 percentile

ADJUSTED FORECAST – KALMAN FILTER

FORECAST

OBSERVATION

PREVIOUS DAYS FORECASTS

KALMAN FILTER

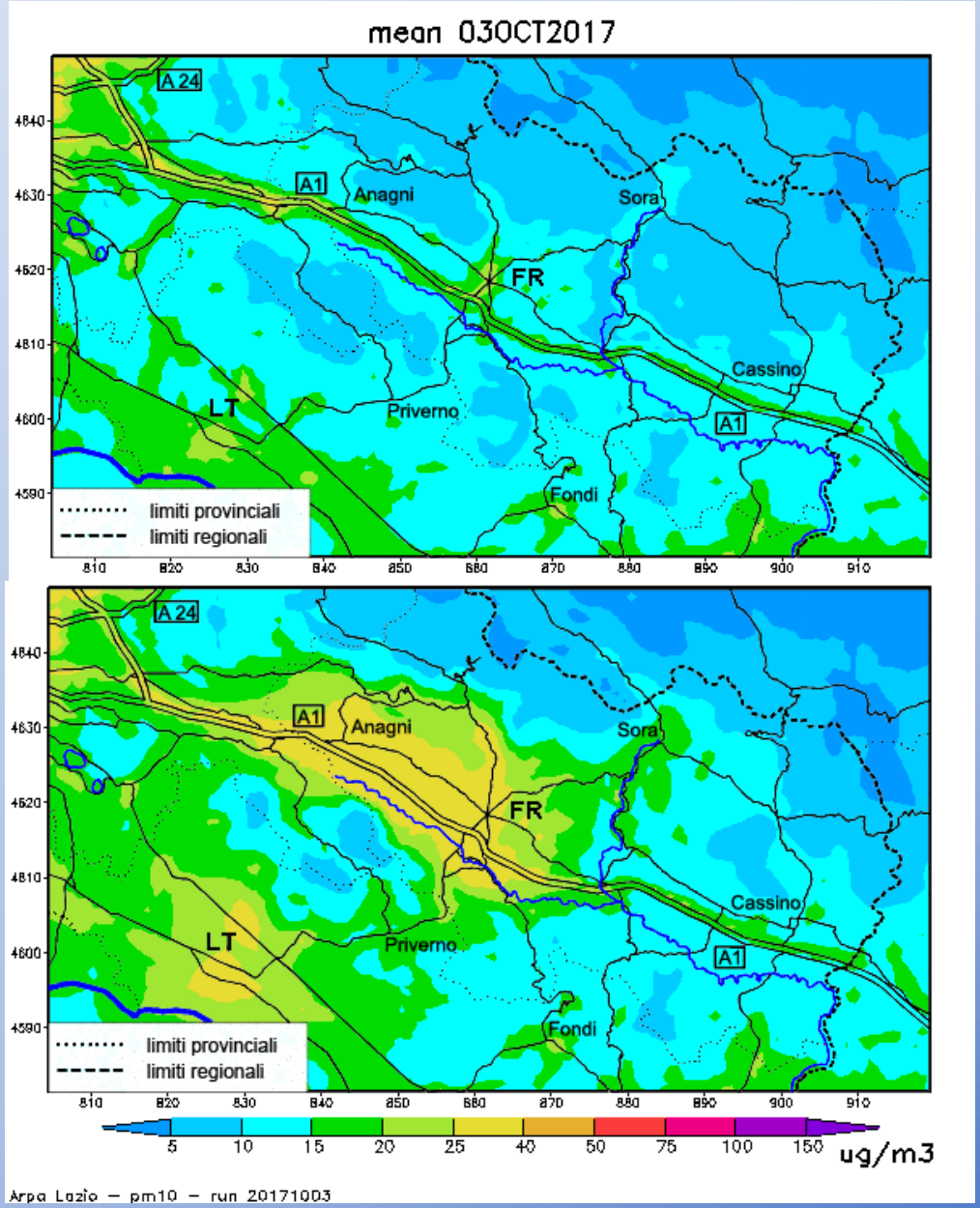
Delle Monache, 2008; Borrego et al., 2011

Adjusted time series

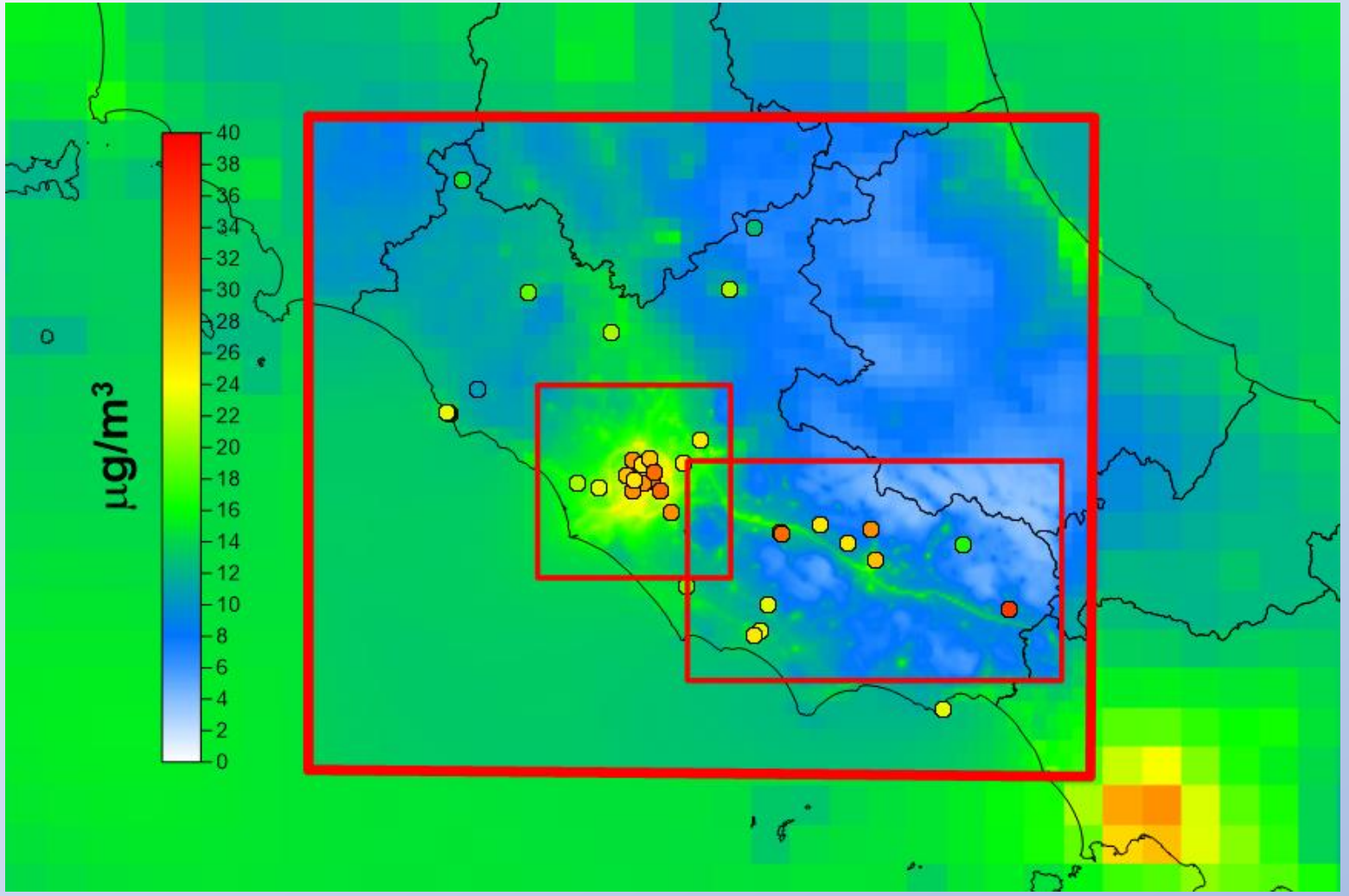
ARPMEAS

SCM FOR DATA ASSIMILATION *Bratseth, 1986*

Adjusted 2D fields

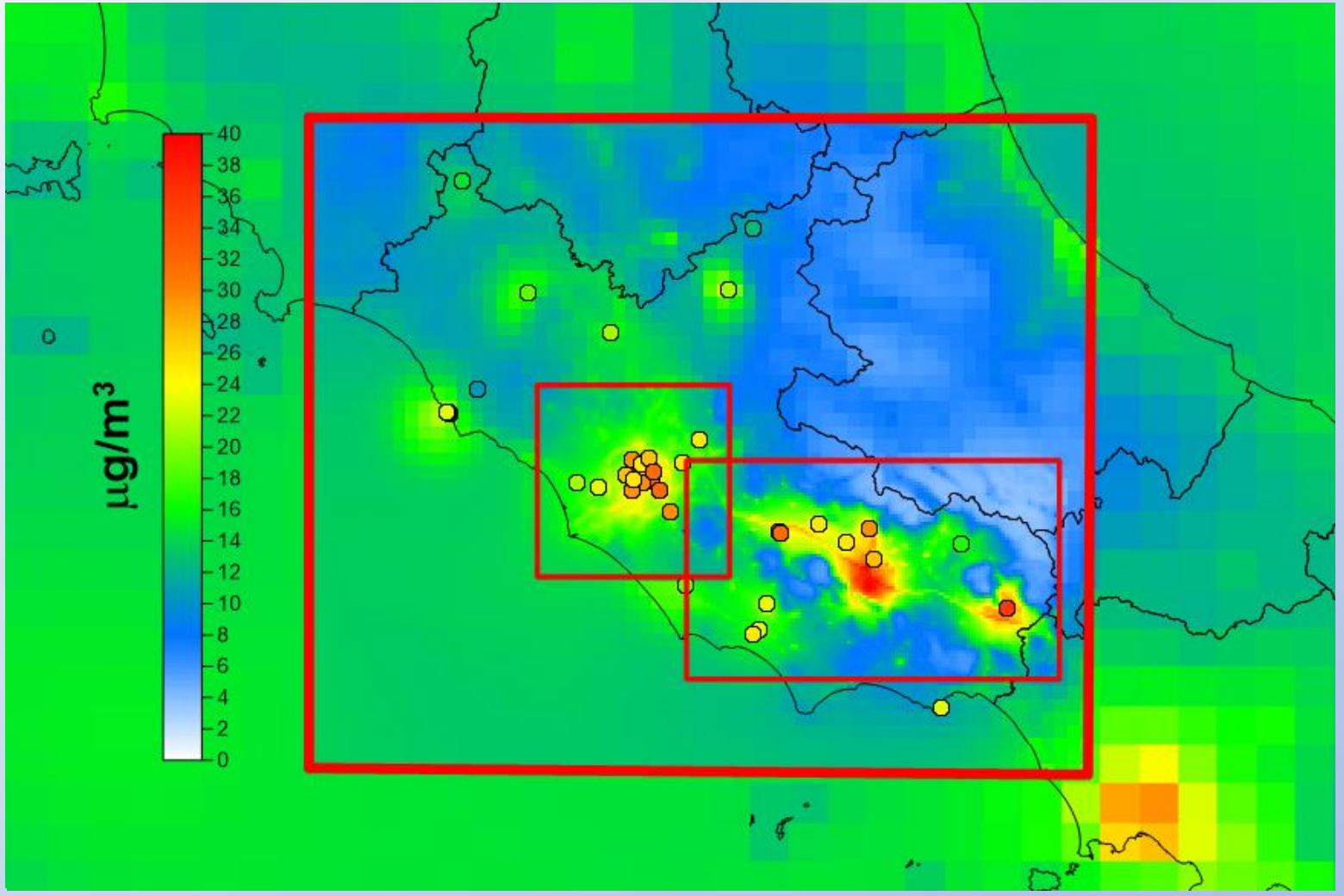


COMPARISONS – ARPA LAZIO



PM10 yearly average

COMPARISONS – ARPA LAZIO



PM10 yearly average

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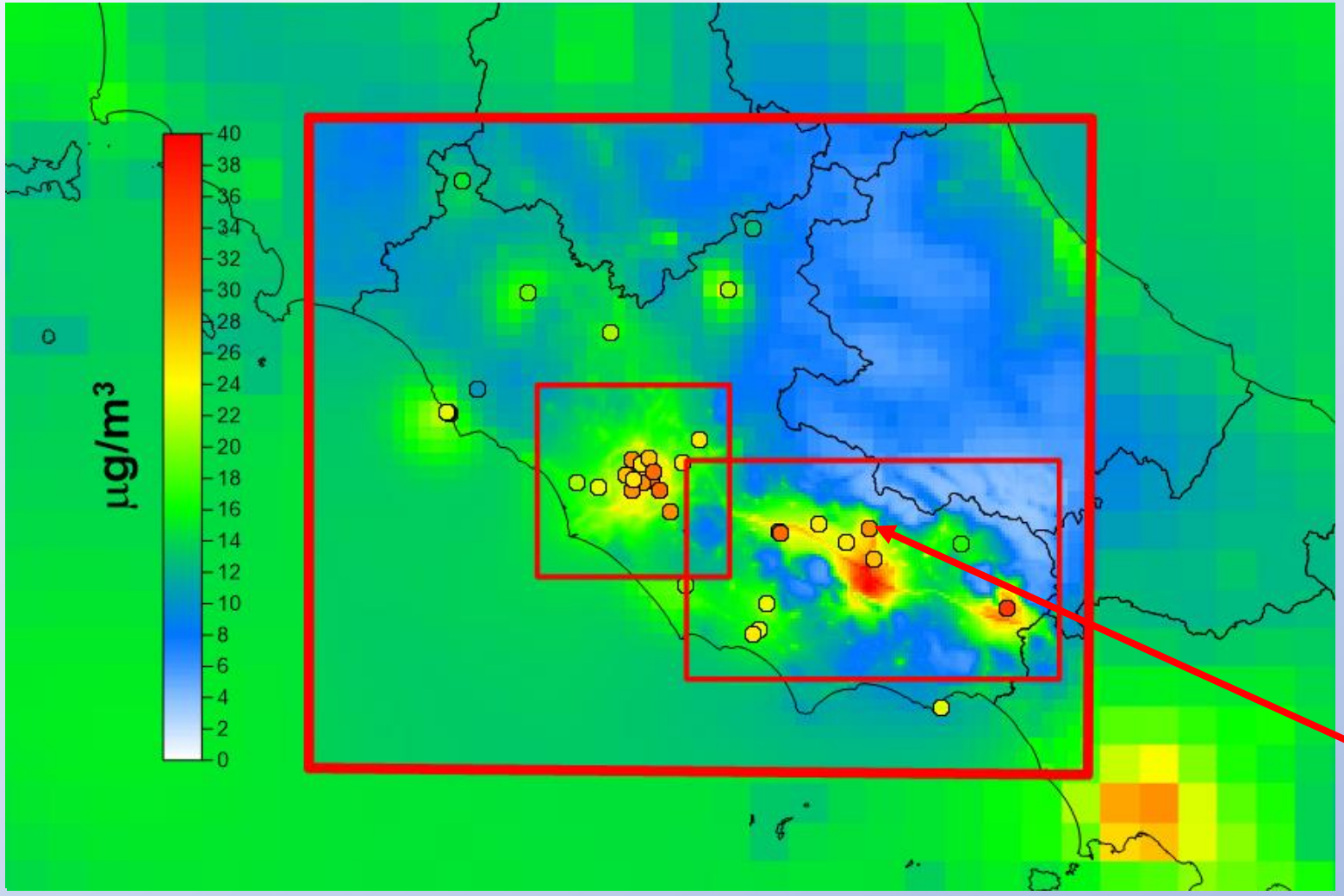
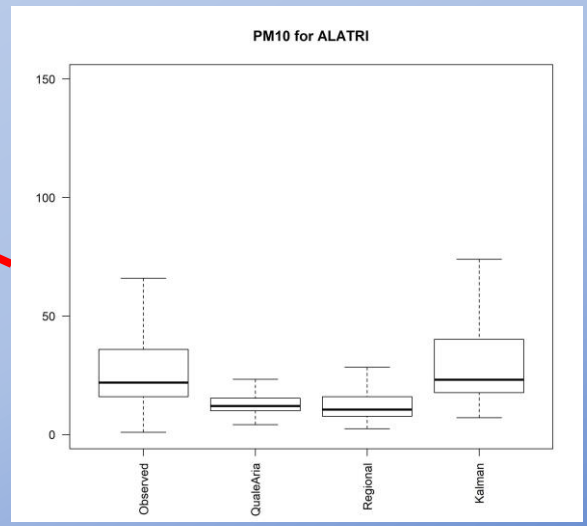
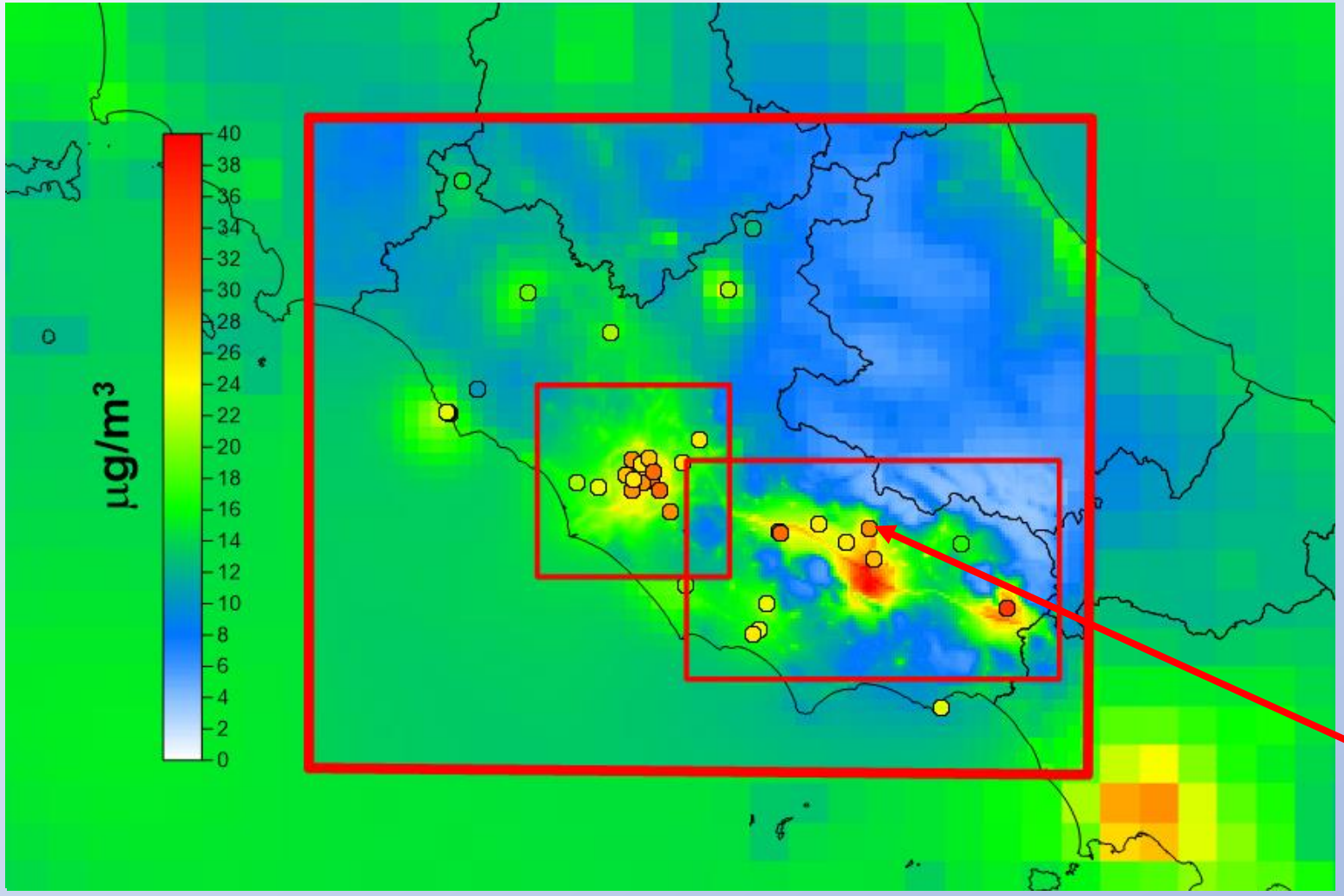


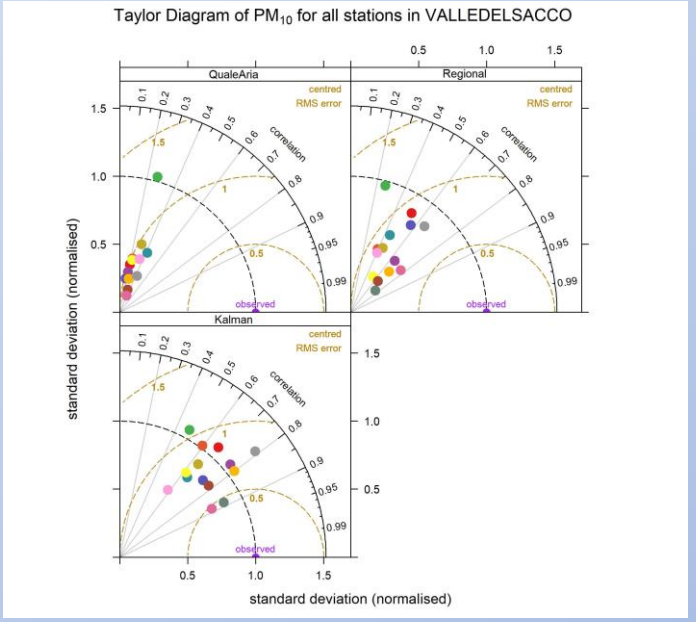


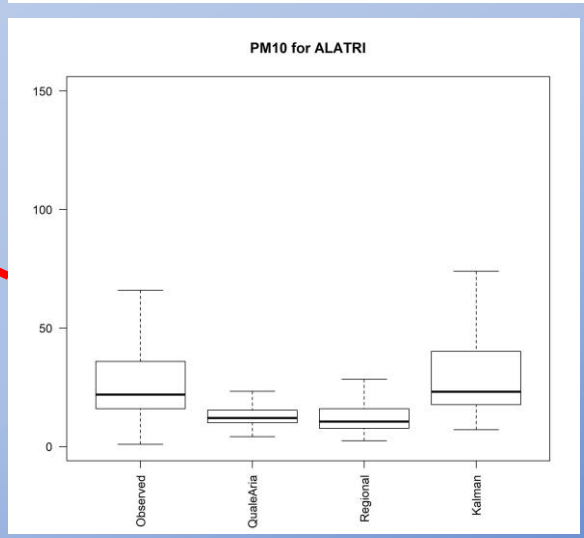
PM10 yearly average

COMPARISONS – ARPA LAZIO

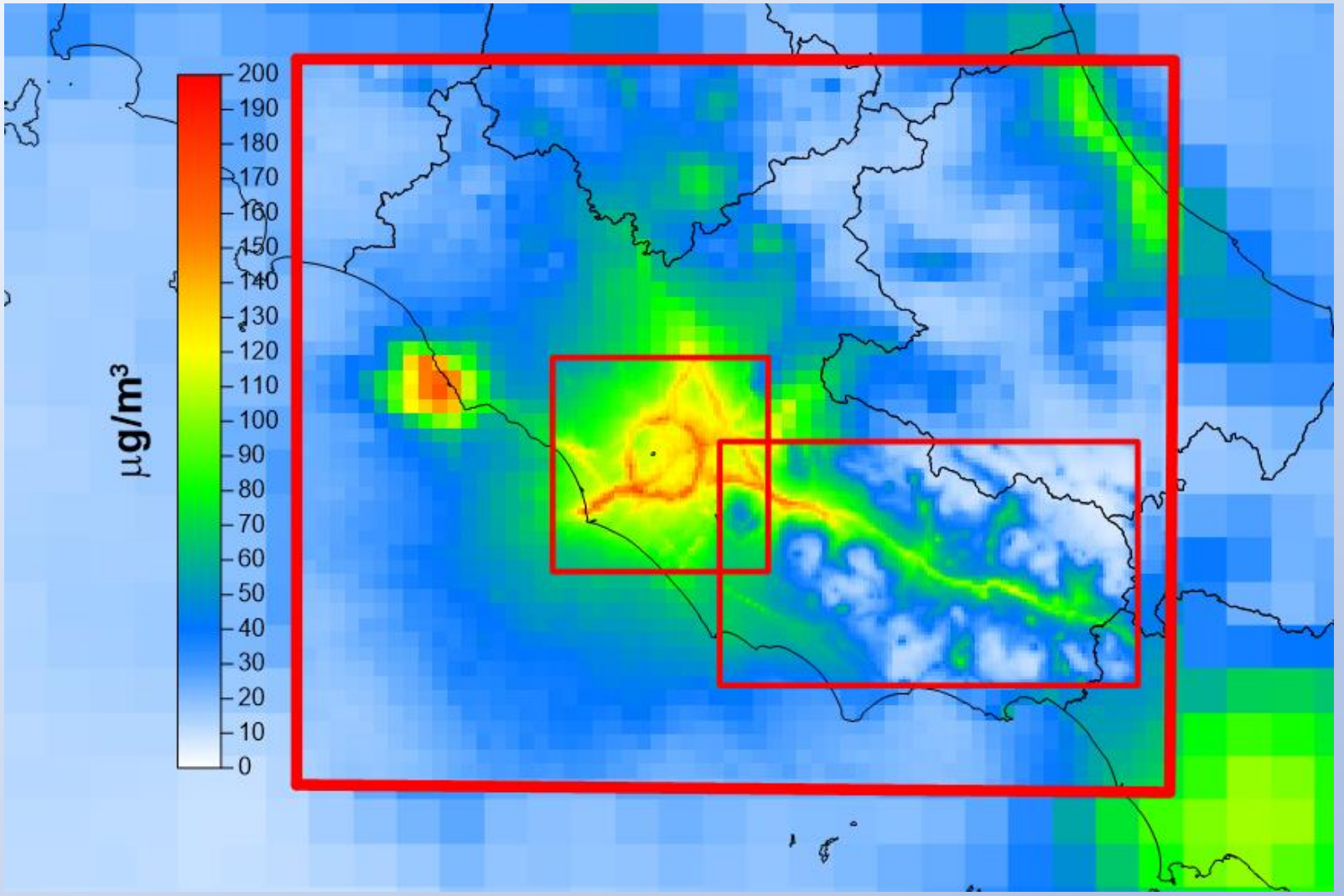


PM10 yearly average



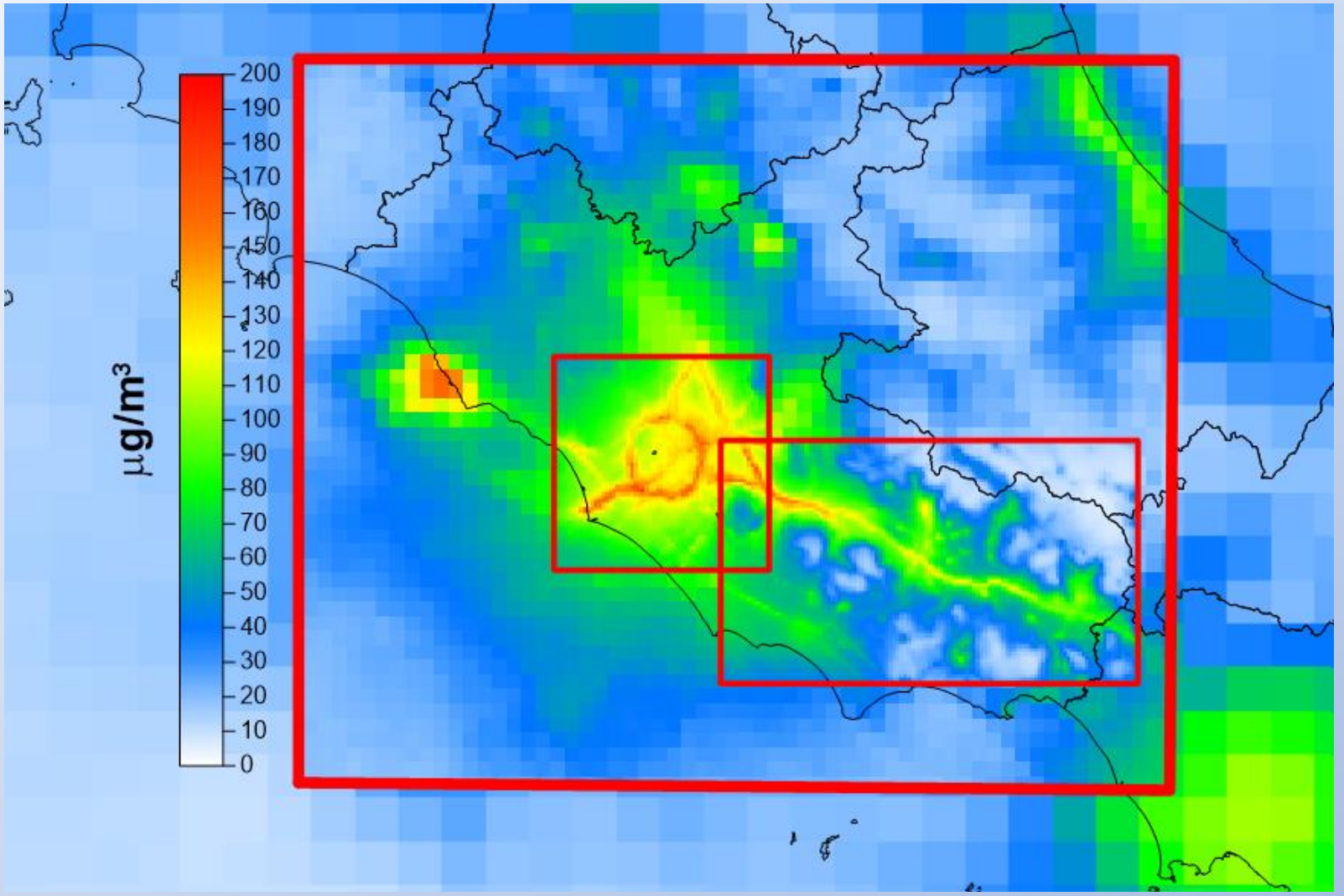


COMPARISONS – ARPA LAZIO



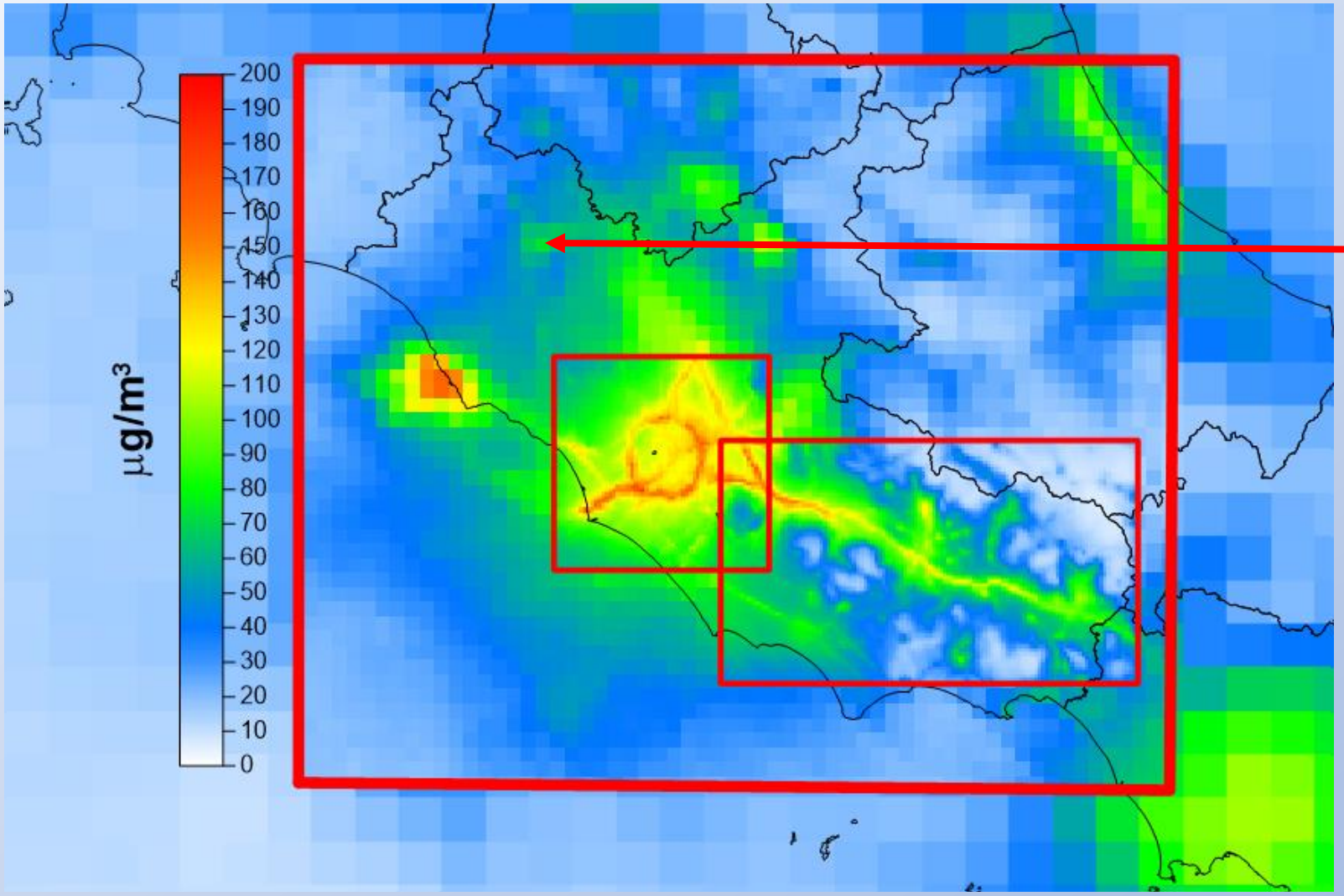
NO_2 99.8 percentile

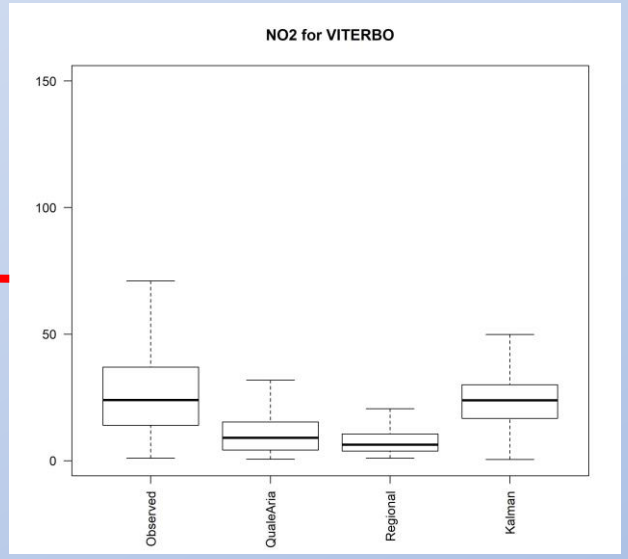
COMPARISONS – ARPA LAZIO



NO_2 99.8 percentile

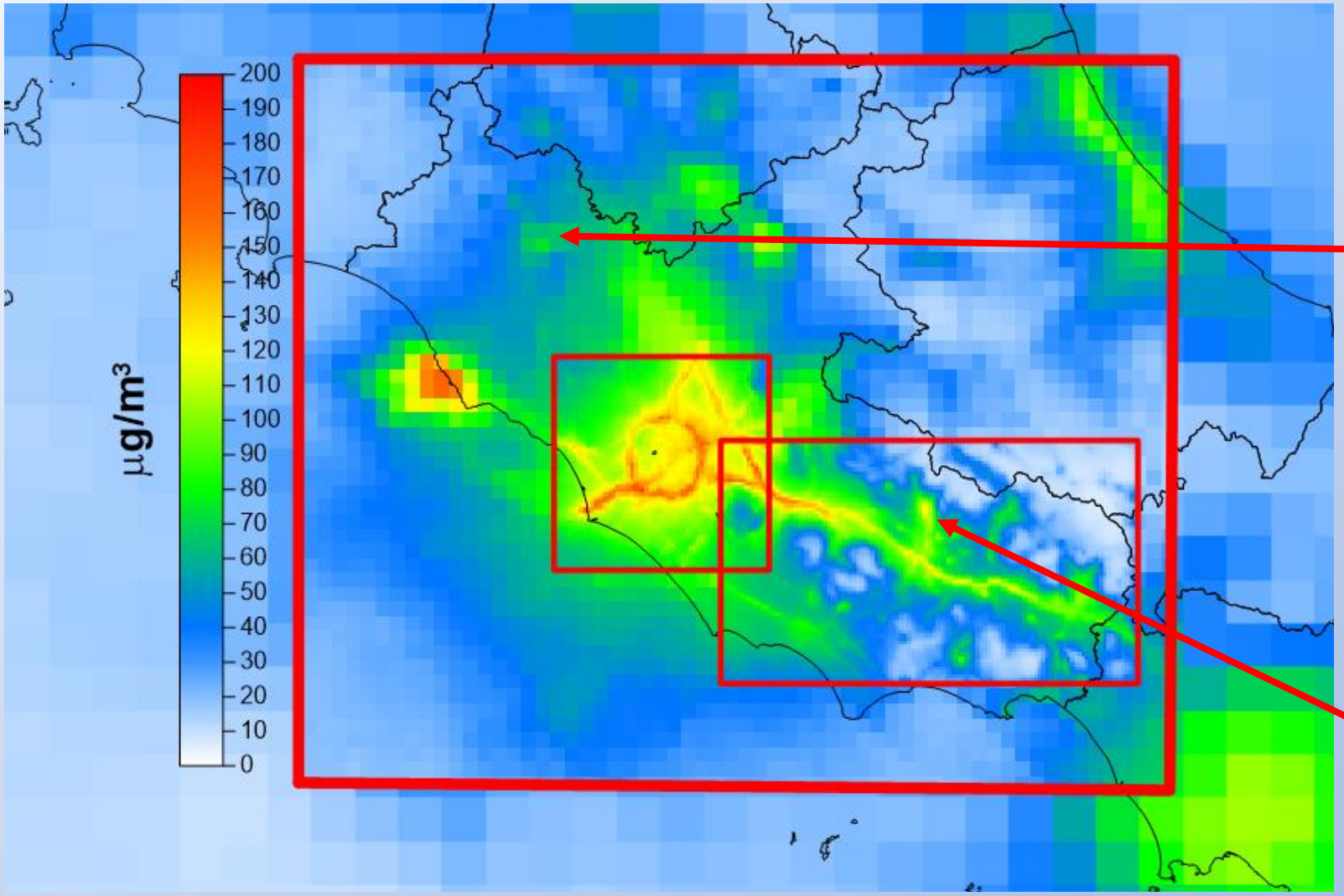
COMPARISONS – ARPA LAZIO

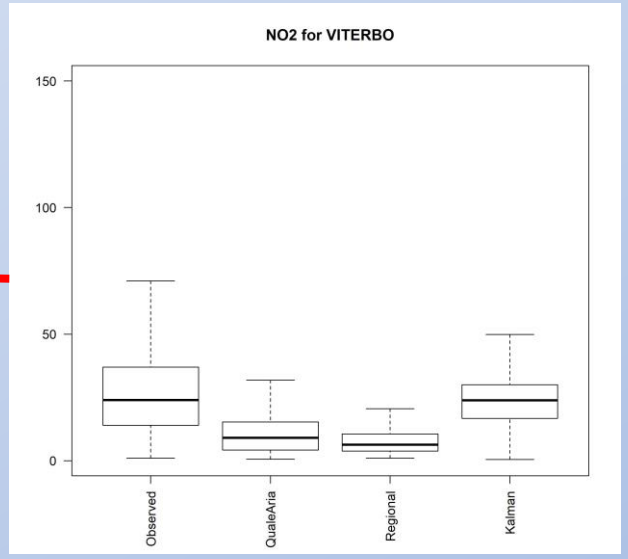


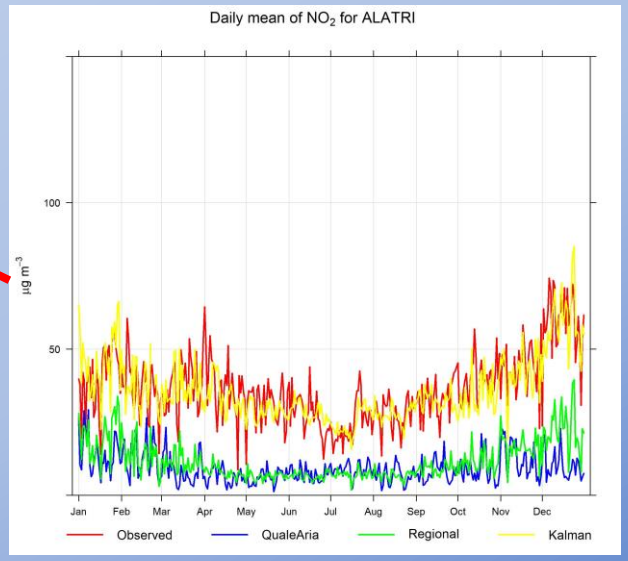


NO_2 99.8 percentile

COMPARISONS – ARPA LAZIO



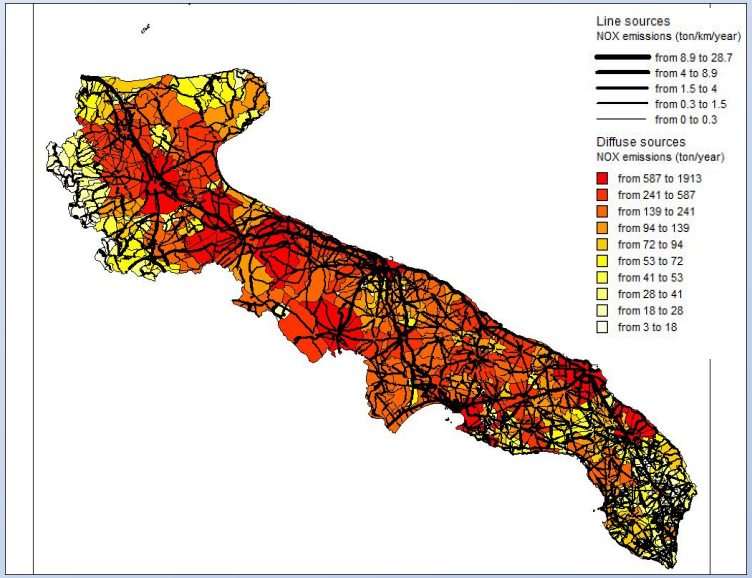




NO_2 99.8 percentile

COMPARISONS – ARPA PUGLIA

http://cloud.arpa.puglia.it/previsioniqualitadellaria/



- Same Modelling System as QualeAria
- Master domains 4 km and downscale at 1 km horizontal resolution for **Taranto**

EMISSIONS

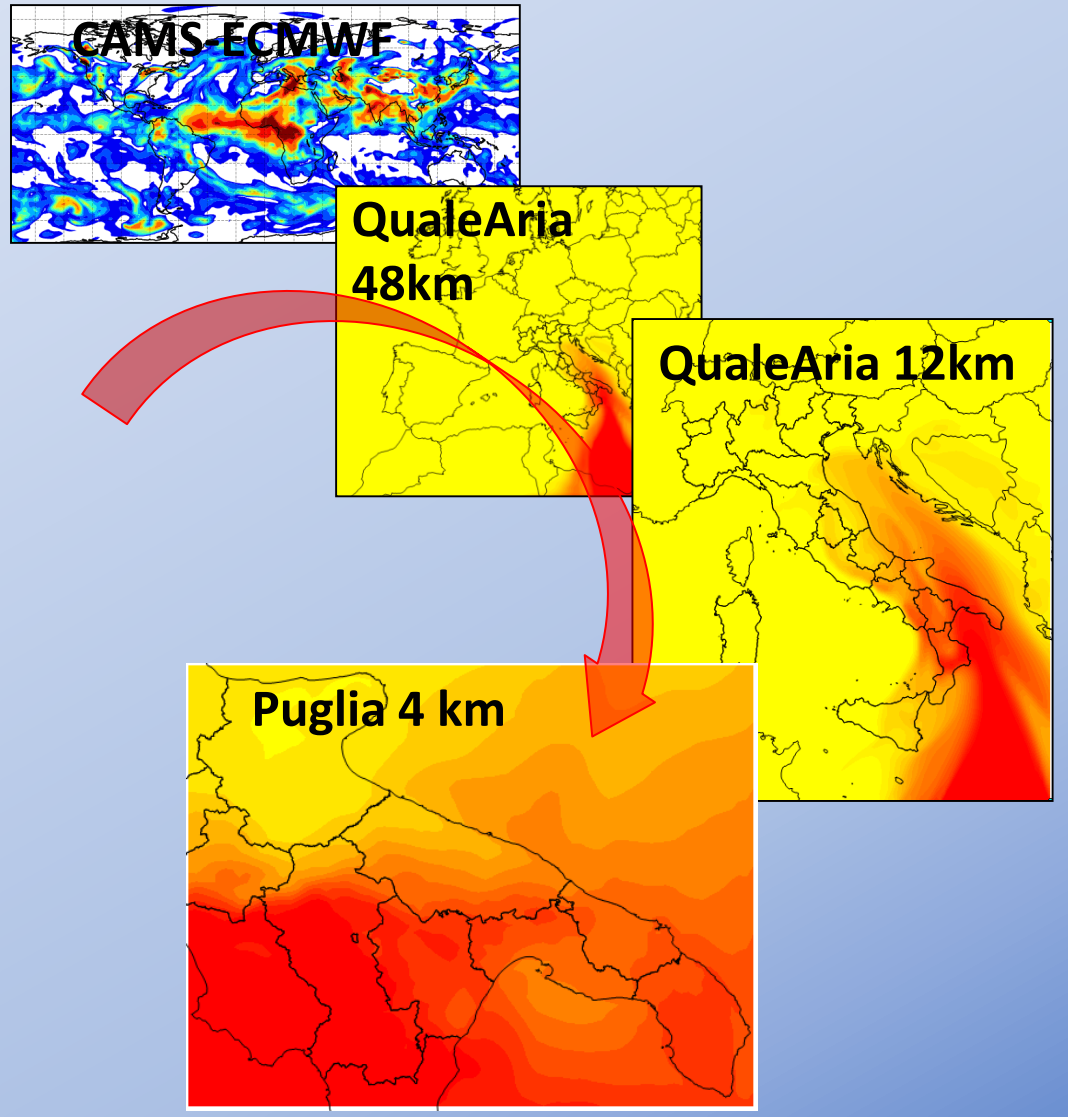
- Detailed emissions inventory with special regards to fuels for not industrial combustion **INEMAR**.
- Dynamic emissions evaluation for domestic heating based on atmospheric temperature.

BOUNDARY CONDITIONS from QualeAria

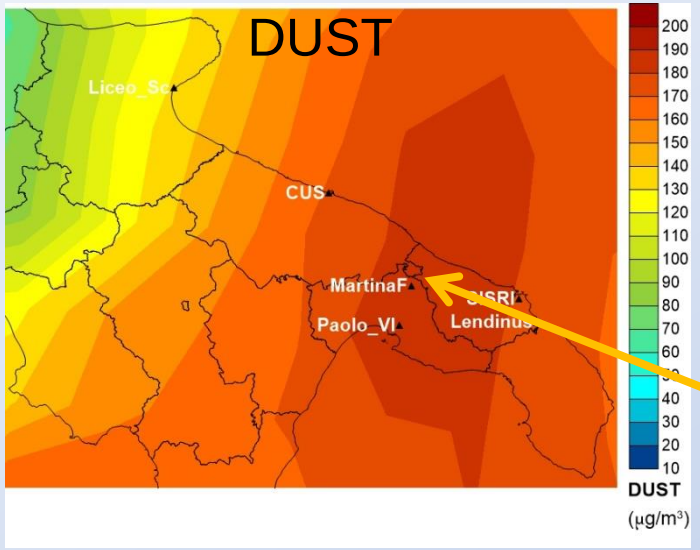
- positive effects: same AQ model, same chemical mechanism, influence of long lasting processes are taken into account.

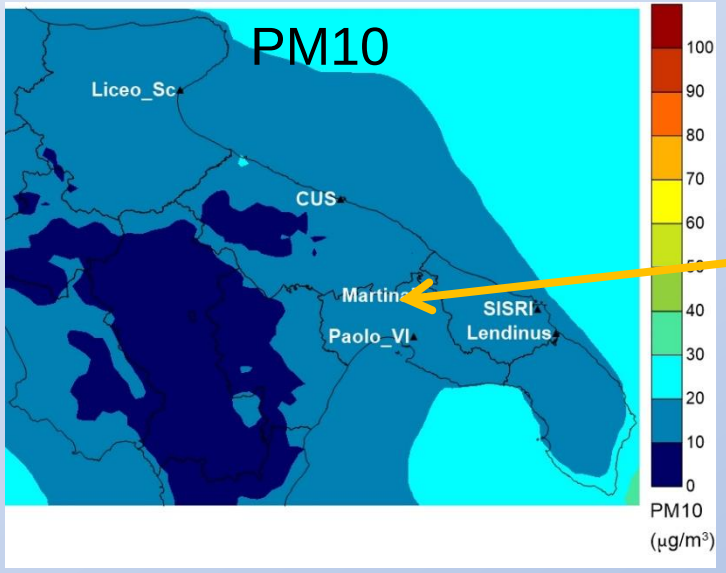
Saharan DUST from CAMS

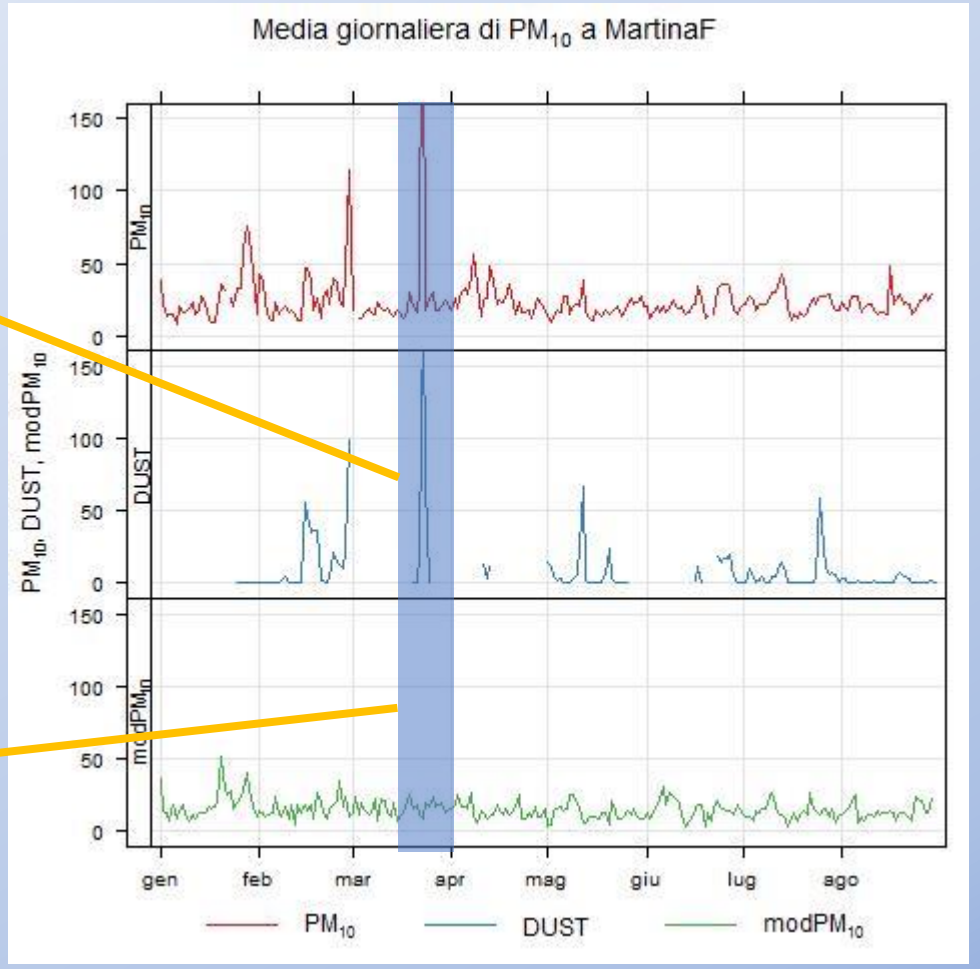
QualeAria is fed by boundary conditions from the global scale chemical weather forecast produced by the MACC/Copernicus service, allowing to account for contributions from distant anthropogenic and natural sources, including **Saharan dust** that may rise important intrusion episodes in the central/southern part of the Italian peninsula.

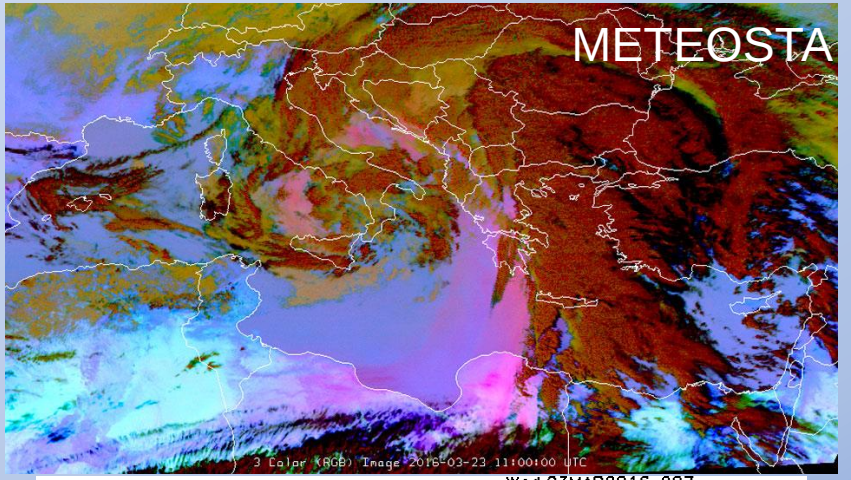


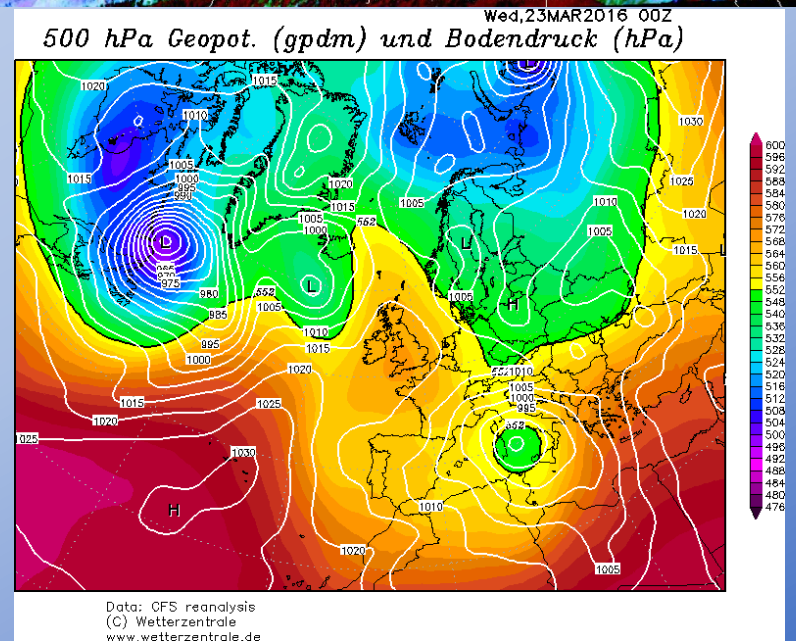
Saharan DUST Episodio 23/03/2016











UNKNOWLOGMENTS

Matteo Morelli, Andrea Bolignano, Roberto Sozzi – ARPA Lazio

http://www.arpalazio.net/main/aria/sci/

Angela Morabito, Ilenia Schipa, Annalisa Tanzarella, Francesca Intini – ARPA Puglia (!!visit the poster session!!)

http://cloud.arpa.puglia.it/previsioniqualitadellaria/

CONCLUSIONS

QualeAria a reliable operational prediction product over Italy.
The score analysis conducted for the reference year 2015 shows good results for both discrete and categorical verification methods. As expected, better agreement is targeted for sampling points representative of a background area on the other hand, underpredictions of PM and NO2 are more frequent for those locations affected by sub-grid phenomena. More detailed emissions inventories and higher horizontal resolutions resolve part of the uncertainty as shown by the comparison of QualeAria with the regional and local forecast systems. Nevertheless, the need to provide an operational prediction overcoming the modelling limitations is achieved by means of the Kalman filter bias adjustment technique as implemented for the Lazio and Puglia regional domains