AQ modeling in northern Italy and future use of CAMS products

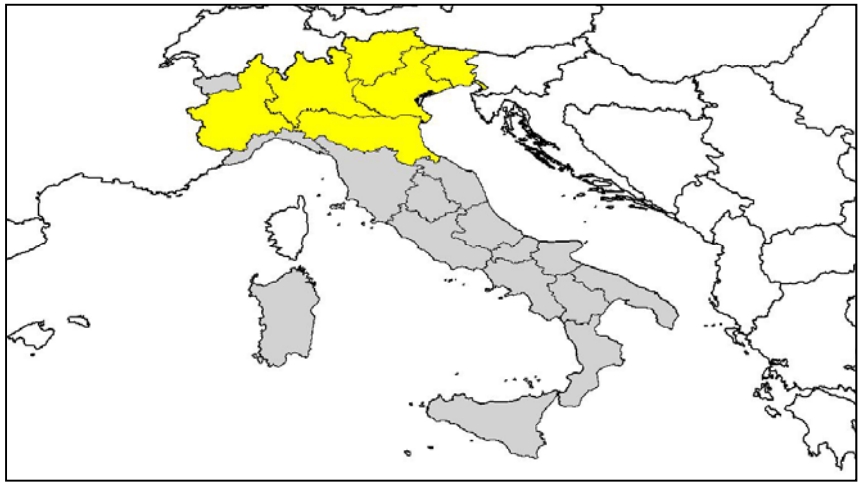
Marco Deserti, ARPA

Emilia Romagna, Lombardia, Piemonte, Veneto, Friuli V.G.

About the authors:

- The Italian National System for Environmental Protection includes the 21 ARPAs, the 2 agencies of the autonomous provinces (APPAs) and the National Institute for the Environmental Protection and Research (ISPRA);
- They have the responsibility to provide the technical support to the national and regional authorities about the air quality topics.

• The National and Regional governments of Po valley signed on 19/12/2013 an agreement aimed at developing and coordinating the short and long term actions to improve the air quality of the Po valley basin.
• Regions and ARPAs of Emilia-Romagna, Lombardia, Piemonte, Veneto are part of the LIFE-IP PREPAIR consortium *(LIFE14 IP)*



arpa agenzia regionale prevenzione e ambiente dell'emilia-romagna
ARPA LOMBARDIA Agenzia Regionale per la Protezione dell'Ambiente
PIEMONTE Arpa Agenzia Regionale per la Protezione Ambientale
arpav Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto
ARPA FVG Agenzia Regionale per la Protezione dell'Ambiente del Friuli Venezia Giulia

FACTS

- 6 June 2014, Paris: MACC-II Second User Workshop, “The Italian users perspective on Atmospheric services by MACC-II”
- 26 June 2014, Rome: the results were reported to the meeting about Copernicus Atm. Services at the Italian “Presidenza del consiglio dei ministri”.
- 7 January 2015, Paris: “special workshop on the use of MACC European data as boundary conditions for downstream modeling”
- 3 - 4 March 2015 in Wien, the “ second policy user workshop”,
- 11 May 2015, Rome, this meeting

The objectives of this meeting:

- Inform the potential community of Italian users about the services that are and will be available by CAMS;
- Encourage and promote the development of downstream service at various levels: institutional, research, commercial;
- Identify/suggest the needs of Italian institutional users;
- Define a common working program in order to satisfy the needs by a collaborative activity between the Italian users community and the group developing Copernicus services;

That goals can lead to the development of new enhanced tools for air quality assessing and forecasting in Italy starting from the current situation characterized by a wide set of operational models already run by Italians users.

contents

- Considerations about the usability of the MACCIII/CAMS services
- Results from some tests and suggestions for improvement
- Modeling tools for AQ management in Italy
- The Life-IP PREPAIR project
- Proposal for future cooperative works about Po Valley “Use cases”

CONSIDERATIONS ABOUT THE USABILITY OF THE MACCIII/CAMS SERVICES

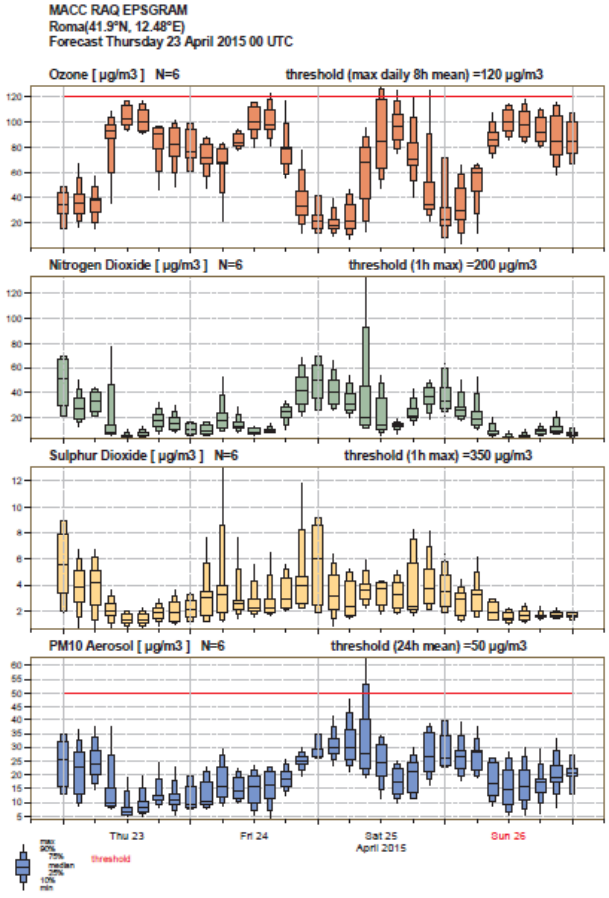
Modeling tools for AQ management in Italy and related CAMS products

- **Short term air quality forecasts:** most Italian regions have implemented an air quality forecast service, for communication purposes, and in some cases also for management of air pollution episodes **[Product: AQ Europe forecast]**
- **Assessment of air quality and population exposure** (on daily, seasonal and annual basis). Several applications: compliance with legislation, air quality plans, background concentration fields for the evaluation of specific emitting sources. This requires homogeneous spatial coverage and high resolution (often 1 km or less), and is by far the most pressing issue. This kind of product is presently available only in parts of Italy. **[Product: AQ Europe analysis and reanalysis]**
- **Evaluation of future scenarios**. Several applications: design and evaluation of air quality plans, future trends in emissions and AQ, evaluation of new emission policies (e.g. plans for energy production), effects of climate change on air quality, integrated evaluation of air quality and carbon footprint. **[Product: AQ Europe, Policy tools: assessment reports, scenarios, S-R models**]

Use of CAMS products in Italy:

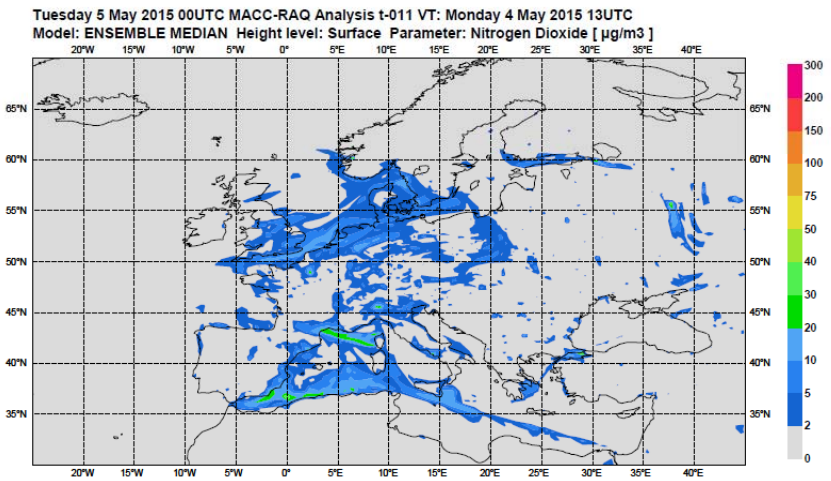
Forecast products

- Can satisfy most of the needs of Italian users (although a quantitative verification of ENS performance in Italy is required;
- it would be useful if the EPS-grams could be produced at every location requested by users



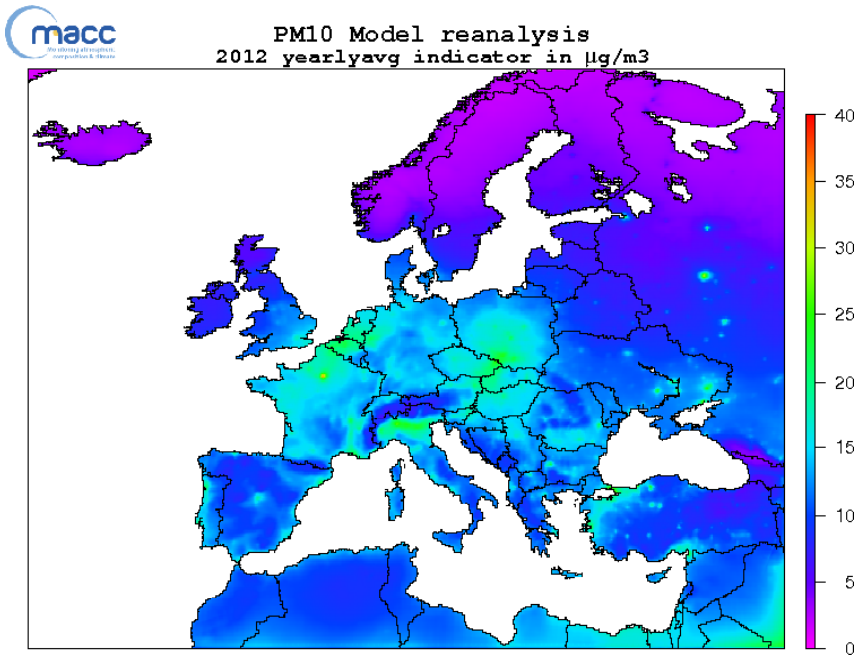
NRT analysis products

- To be improved:
  - ENS analysis of PM10 and PM2.5 are not yet produced;
  - horizontal resolution of 10 km is insufficient for most applications.



Re-analysis

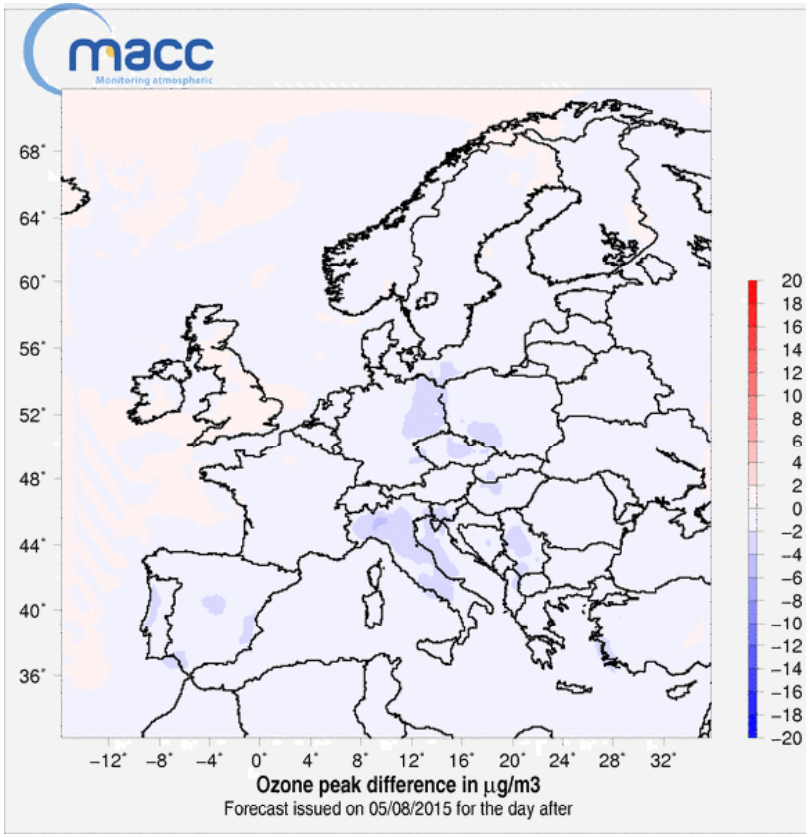
- would be useful, but they should be produced in the first months of the following year (presently available until 2012)
- We need clarifications about the use of the in-situ data for reanalisys.



Policy tools:

- **EU AQ assessment report:** can provide a general frame of reference for regional/local policies, no direct use;
- **Green scenarios:** would be useful but numerical data should be delivered for BCON to regional/local models in Italy;
- **Emissions inventory:** are used by some model suites in Italy, emissions scenarios corresponding to green scenarios can be helpful;
- **Country Source-receptor calculations (on-demand)**: we need some more details.

Ozone daily peak difference (stra-ref)



RESULTS FROM SOME TESTS AND SUGGESTIONS FOR IMPROVEMENT

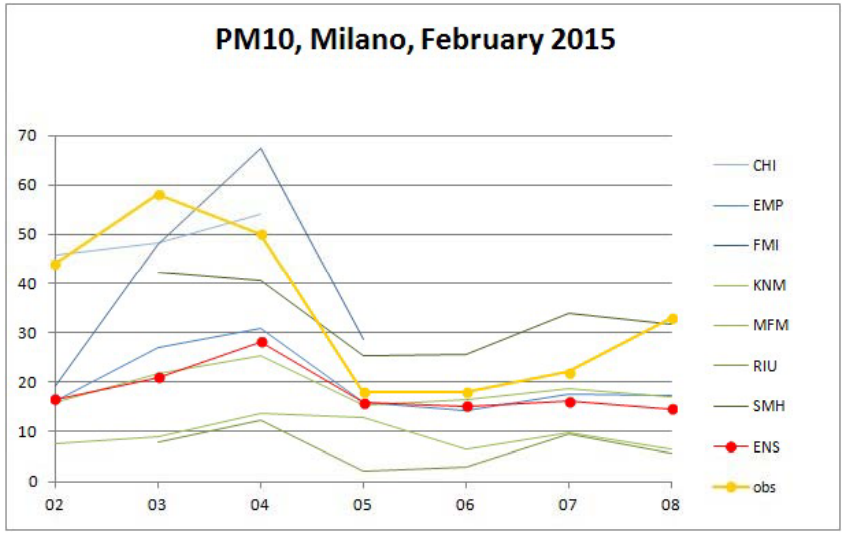
An example about CAMS performance in Italy (1)

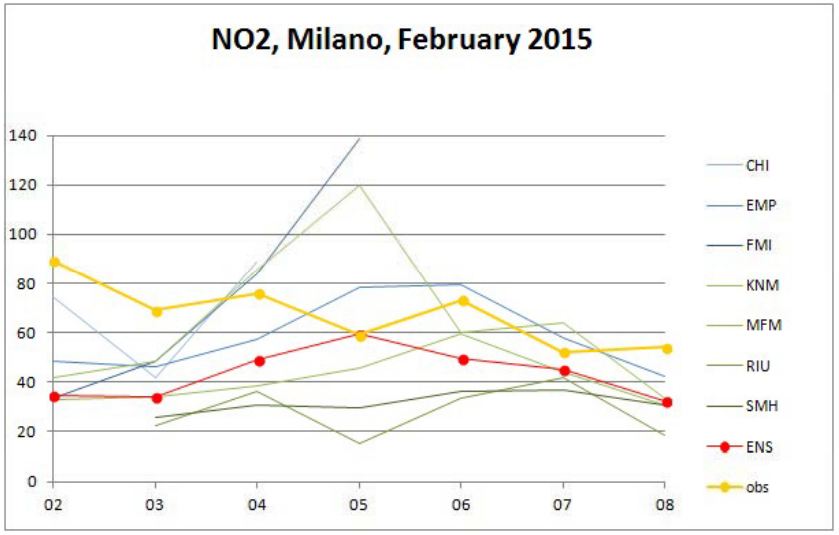
Italian data have so far not been included in CAMS verification: here follow some very preliminary indications.

Po Valley:

PM10: large spread between ensemble members. Differences seem mostly systematic, with some models almost always higher than others (MFM, RIU very low, CHI and FMI often very high)

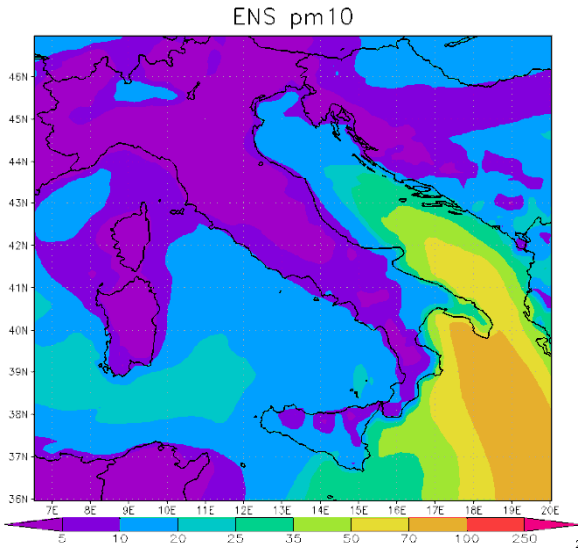
NO2: large spread, but differnces seem less systematic (*as it would be expected ni an ensemble*)

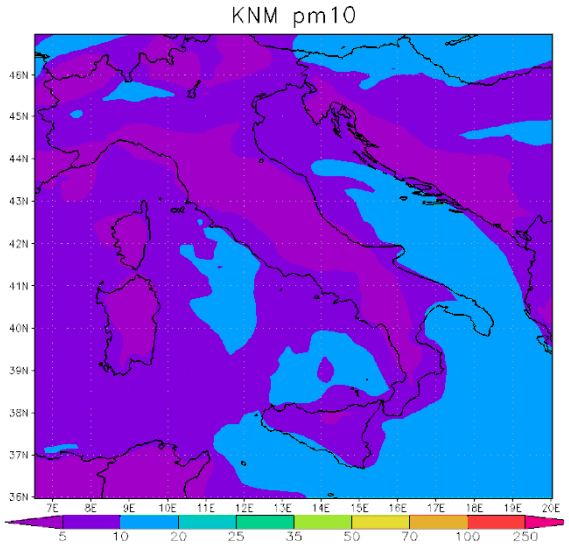


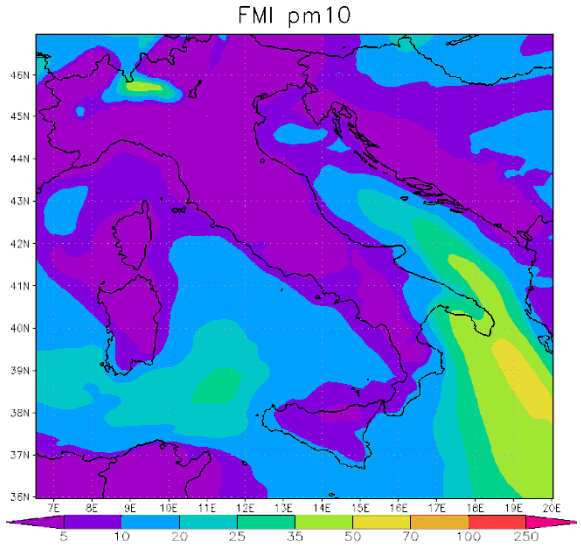


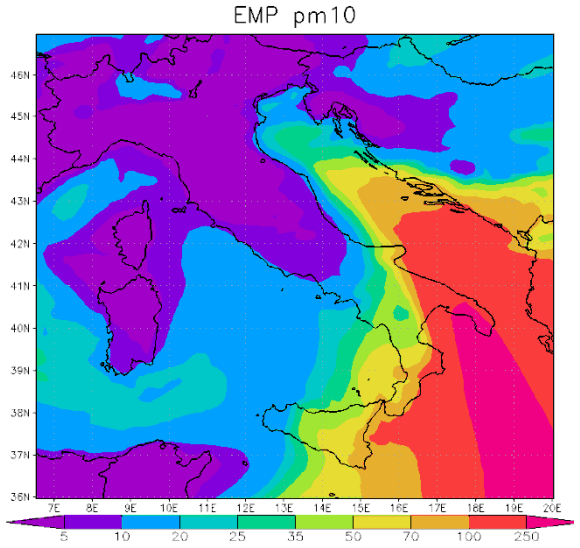
CAMS performance in Italy (example 2)

In some occasions ensemble members show drammatic differences in PM10.
These uncertainity probably happen only in specific conditions (desert dust transport or sea salt), but it can have a big impact on the assessment of air quality and of the natural contriubution to PM10.
Ensemble median may not be the best product for all applications (understimation of PM varibility and of the occurrence of this kind of episodes)





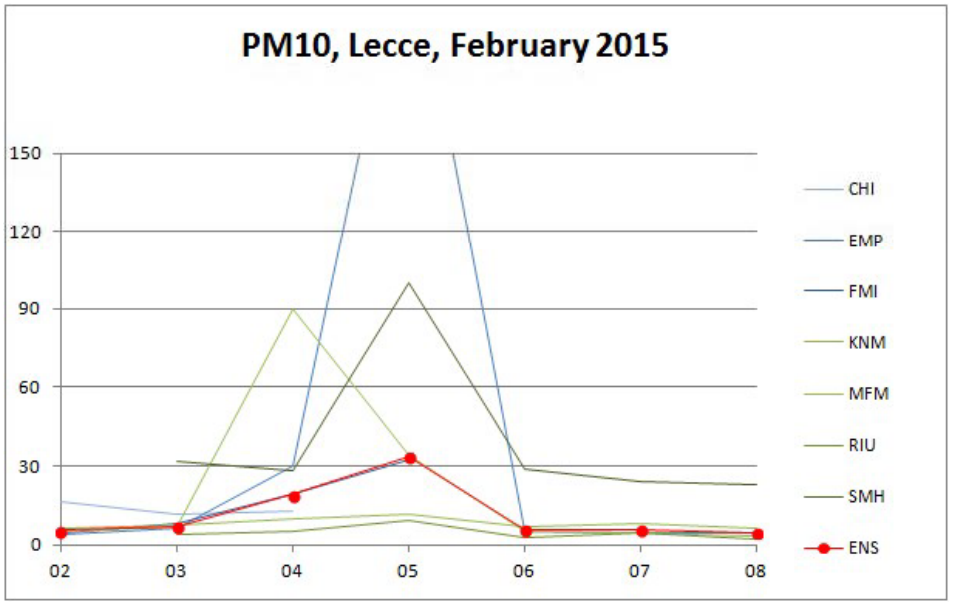




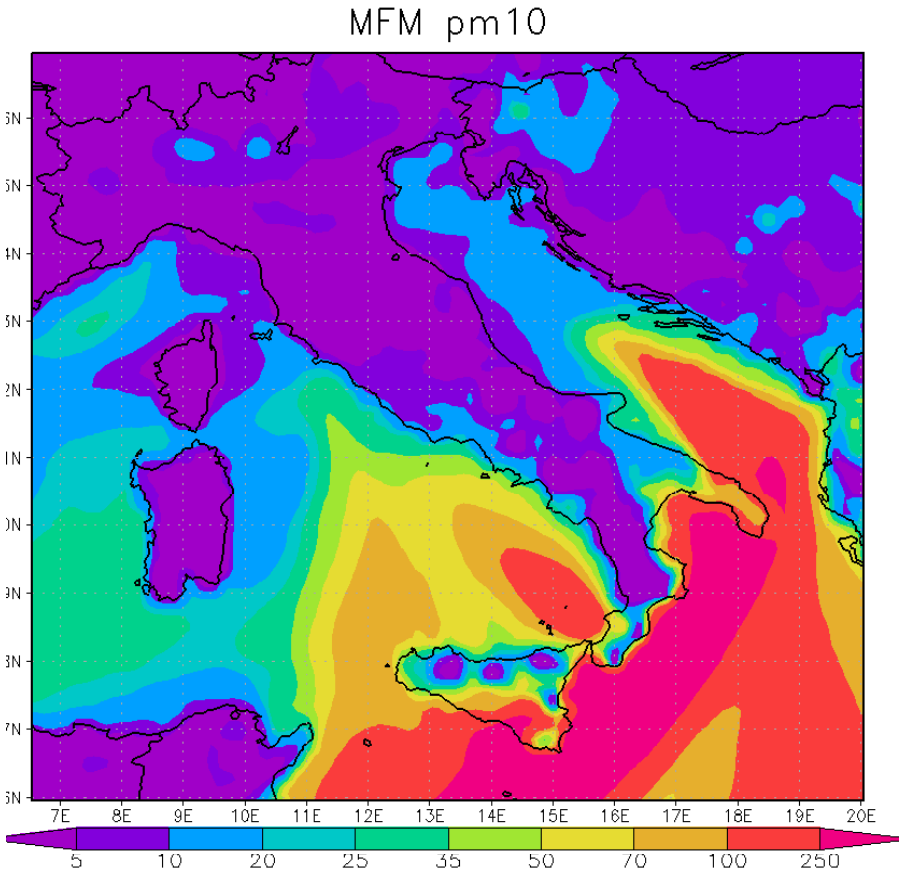
PM10 daily average for CAMS models, 5 feb 2015

CAMS performance in Italy (3)

Some special tuning may be needed for some of the ensemble members in the Mediterranean? (*dust, sea salt...*)



PM10 daily average for CAMS models, Lecce, feb 2015



MFM, PM10 daily average, 4 feb 2015

Remarks:

- Air quality in Italy is affected by a great variety of conditions:
  - topography, urbanization (large areas of diffuse urbanization) and meteorology (regions with Mediterranean, continental, alpine climate); air stagnation in northern Italy, dust transport in southern regions; air pollution hotspots, both diffuse (Po Valley) and localized (large cities and industrial areas, eg. Taranto).
- The peculiar characteristics of Italy may require a special verification, and possibly some tuning of CAMS models and Ensemble, especially if aerosols are considered

Suggestions for improvement of CAMS services

- CAMS data should be accessible through an online database (like MARS service at ECMWF: download of annual+ time series. Useful for AQ assessment, special verification, Nesting and develop new downstream applications, feedback with CAMS developers.
- For operational use of CAMS as BC, it should be possible to download data on sub-domains (presently one must download data on all Europe, 8 Gb per model run)
- The EPS-grams should be available for any requested location
- Re-analysis run should be available in the first months of the following year (otherwise their use is very limited)

Some details about the Po valley models

MODELING TOOLS FOR AQ MANAGEMENT IN ITALY

Operational CTMs in Italy

Italian regional environmental agencies (ARPA) have implemented 8 different CTMs:
- they cover different parts of Italy, with a resolution of 5 km or less
- they are used for daily (operational) forecasts, AQ assessment and scenario analysis
- they could be the basis for local-scale, high-resolution ensemble

Region	Model	Resolution	Domain	Boundary conditions	Meteorology
Piemonte	FARM	8 to 1 km	N. Italy + zoom	Chimere (INERIS)	Cosmo
Lombardia	FARM	4 km	Part of N. Italy	Chimere (INERIS)	ECMWF
Veneto [1]	CAMx	4 km	Part of N. Italy	Chimere (INERIS)	Cosmo
Friuli	FARM	4 km	Part of N. Italy	FARM (AriaNet)	WRF
Emilia Rom.	Chimere	5 km	Northern Italy	Chimere (INERIS)	Cosmo
Umbria [2]	Chimere	5 km	Central Italy	Chimere (INERIS)	Cosmo
Lazio [2]	FARM	4 to 1 km	C. Italy + zoom	FARM and Chimere	RAMS
Campania [2]	Chimere	5 km	Part of S. Italy	Chimere (INERIS)	Cosmo

(1) pre-operational model
(2) model not included in LIFE proposals

The operational models suite NINFA

Northern Italian Network to Forecast photochemical and Aerosol pollution

NINFA-E (daily forecast & analysis, scenarios):

- 5 km horizontal resolution, 8 vertical levels up to 500 hPa

http://www.arpa.emr.it/sim/?qualita_aria/previsioni_aria_nord
http://www.arpa.emr.it/aria/

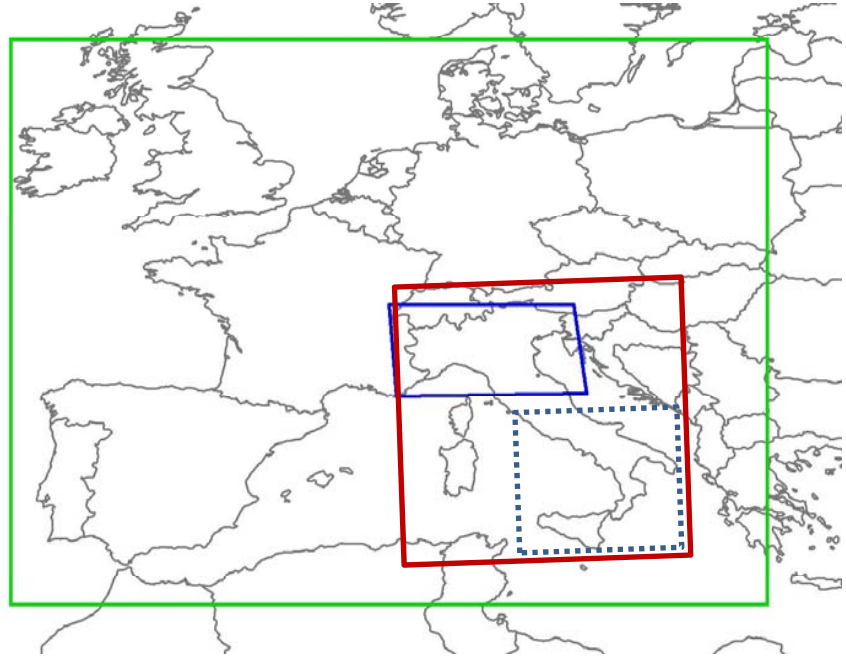
NINFA-national :

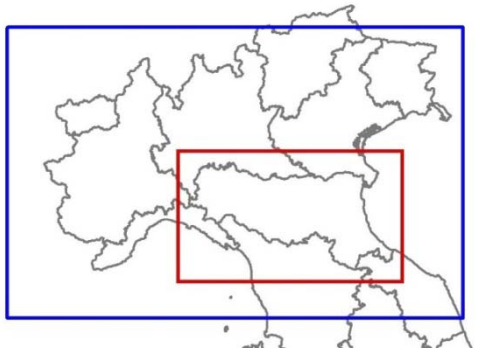
- run on demand, scenarios
- Italy:89*105, 10 km
- North:138*92, 5 km
- South: 110*100, 5 km

PESCO (geo statistical post processing):

- daily and annual compliance evaluation
- NRT data from E-R AQ stations, 1km

- CTM: Chimere
- Boundary conditions: Prev'air (0.5°~ 50 km)
- Meteorological input: COSMO-I7 (7 km)
- Emissions: adapted from INEMAR ER + Ispra Italy + MACCT-TNO

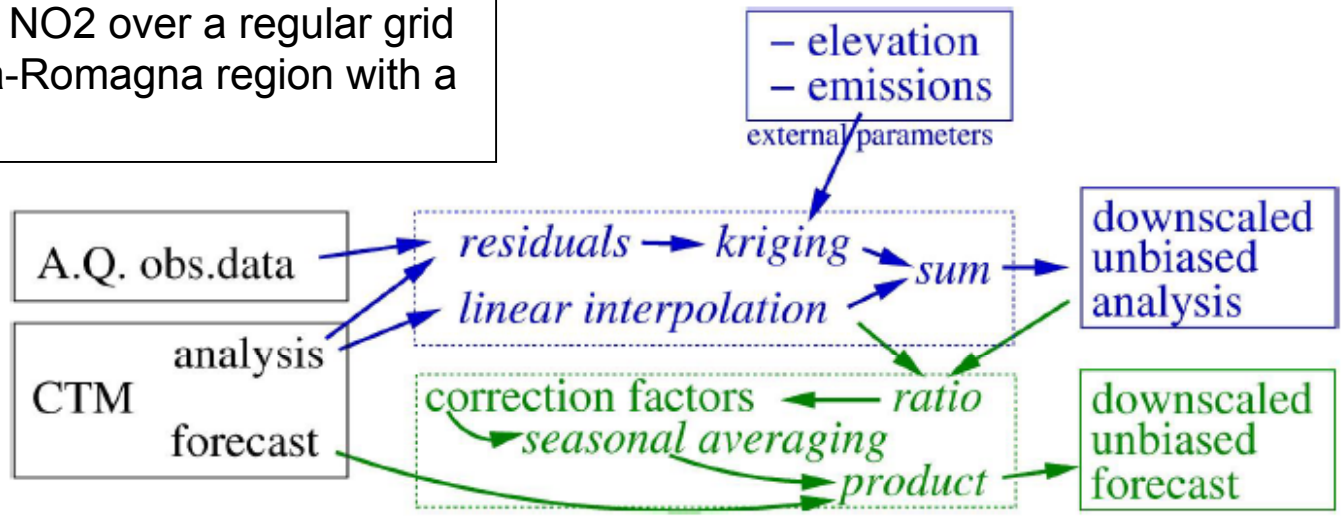




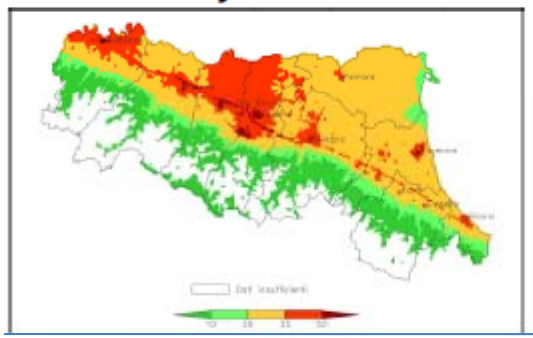
arpa
agenzia regionale prevenzione e ambiente dell'emilia-romagna

The PESCO-NINFA postprocessing for unbiasing and downscaling

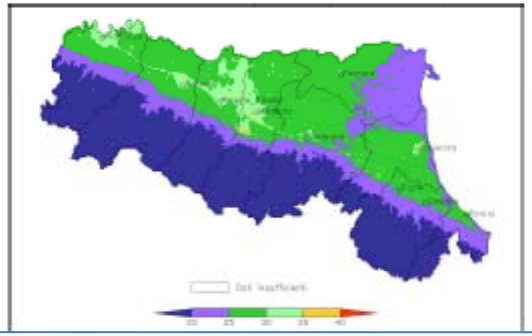
It produces surface concentrations fields of PM10, PM2.5, O3, NO2 over a regular grid covering the Emilia-Romagna region with a resolution of 1 km



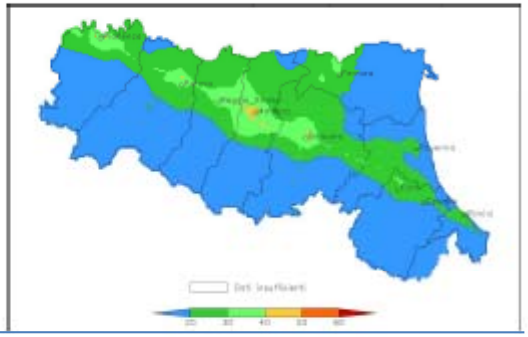
PM10 daily exceedances



PM10 annual mean



NO_2 annual mean



Evaluation of the compliance with EU legislation (year 2010)

ARPA Lombardia air quality modeling system

Based on ***three-dimensional Eulerian model FARM (Flexible Air Quality Regional Model,*** https://hpc-forge.cineca.it/files/Farm/public/)

Domain: covering the whole Lombardy Region (*horizontal resolution of 4 km*)

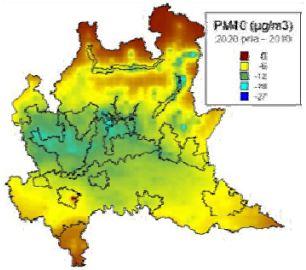
Meteo driver: *ECMWF*, mass consistent model minerve

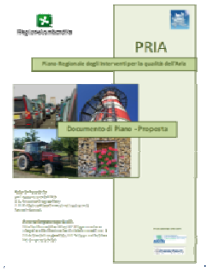
Boundary conditions CHIMERE continental fields provided by PrevAir service

Emission inventories: Detailed regional emission inventories, ISPRA national emission inventory, EMEP inventory

Services

Support to evaluation AQ plan



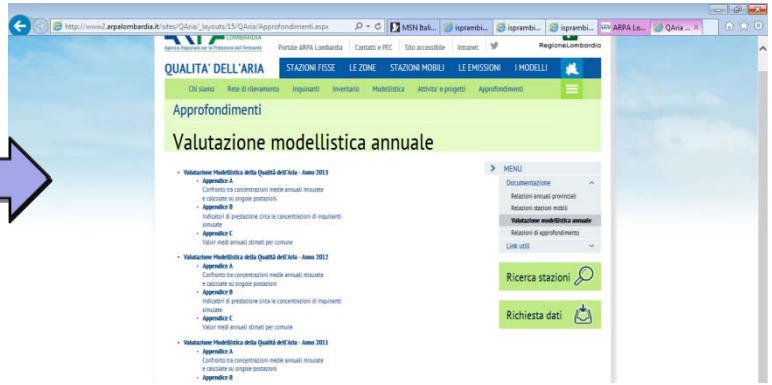


Results from scenarios AQ regional plan

Services

Yearly AQ modeling assessment AQMA

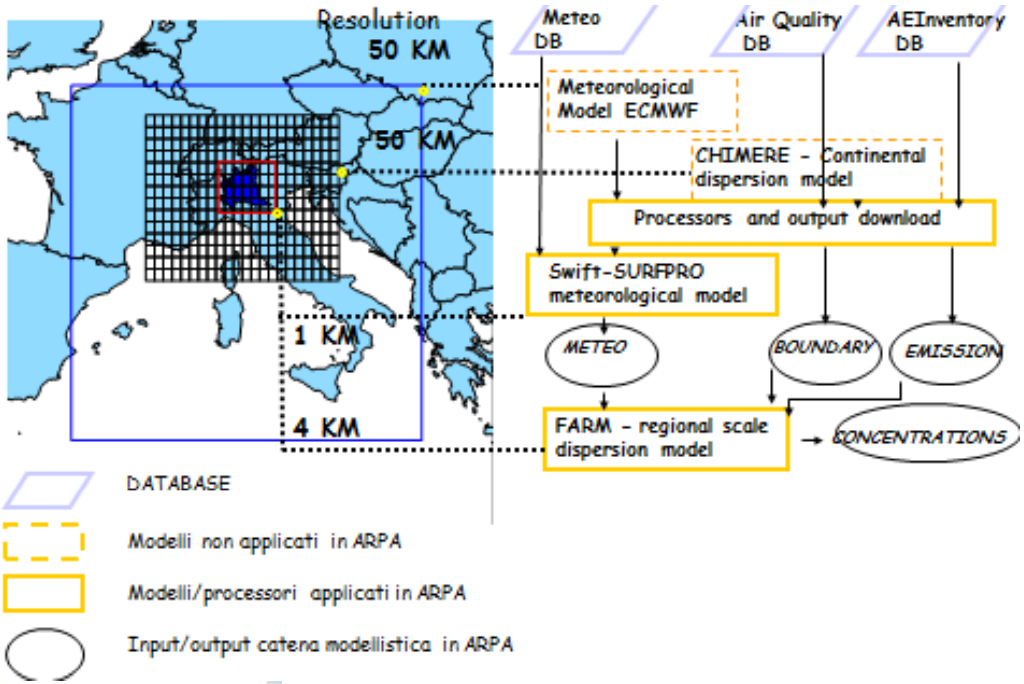
reports available on web site from AQMA 2009 year



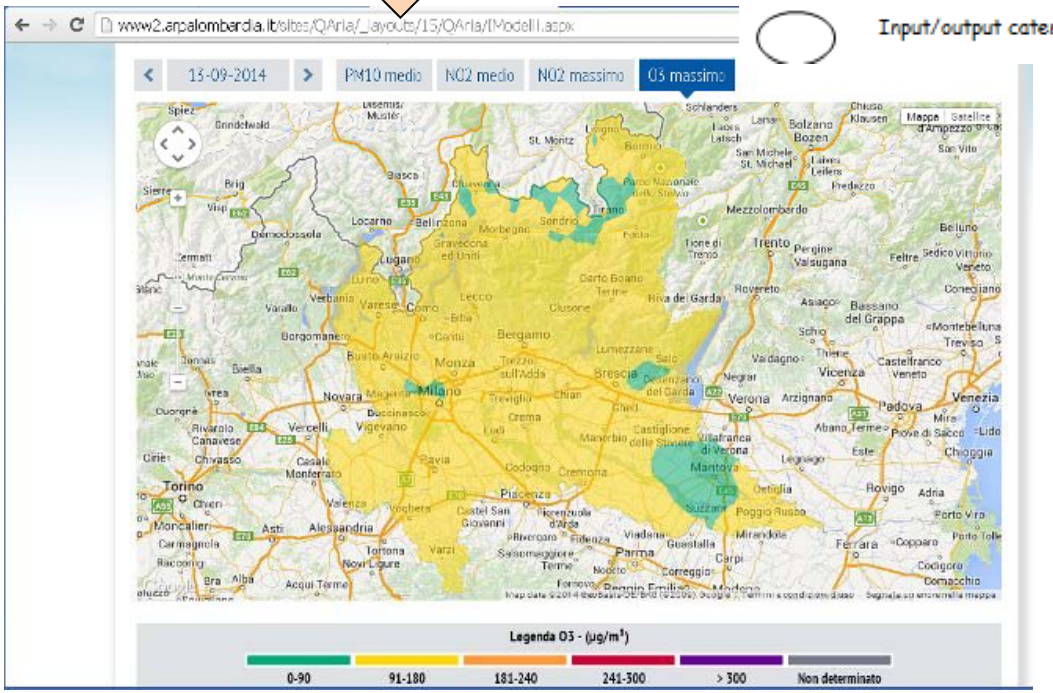
Services

Information

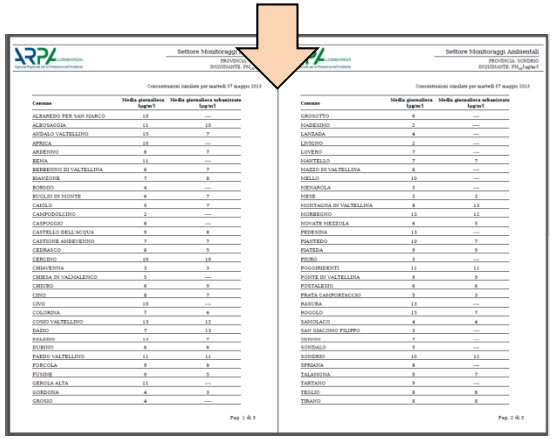
Modeling chain operationally used since 2008 for near-real-time analysis



Daily maps over Lombardy of NO2, PM10 and O3 concentrations referred to the previous day on the ARPA Lombardia web



NO2, PM10 and O3 daily average concentrations for the 1544 municipalites of the region



http://www2.arpalombardia.it/sites/QAria/_layouts/15/QAria/IModelli.aspx

ARPA Piemonte air quality modeling system

Based on ***three-dimensional Eulerian model FARM (Flexible Air Quality Regional Model,*** https://hpc-forge.cineca.it/files/Farm/public/)

Operationally used for:

- ***Daily air quality forecasts***: forecast time 72 hours (3 days from today 01:00 a.m);
- ***Daily near-real-time analysis;***
- ***Yearly assessment of air quality,***
- ***Evaluation of future scenarios.***

Domain: three nested domains:

- g1 covering Po valley basin and the Alps (*horizontal resolution of 8 km*);
- g2 covering the whole Piemonte Region (*horizontal resolution of 4 km*);
- 3 g3 domains, with *1 km horizontal resolution* (only in forecast mode)

Meteo driver:

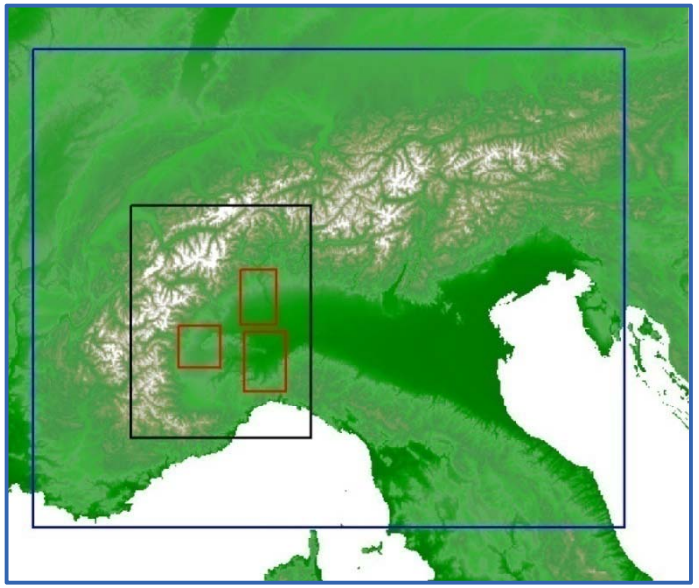
COSMO model (aq forecast); *ECMWF,* mass consistent model minerve, WRF (aq assessment and nrt);

Boundary conditions (only for the g1 domain):

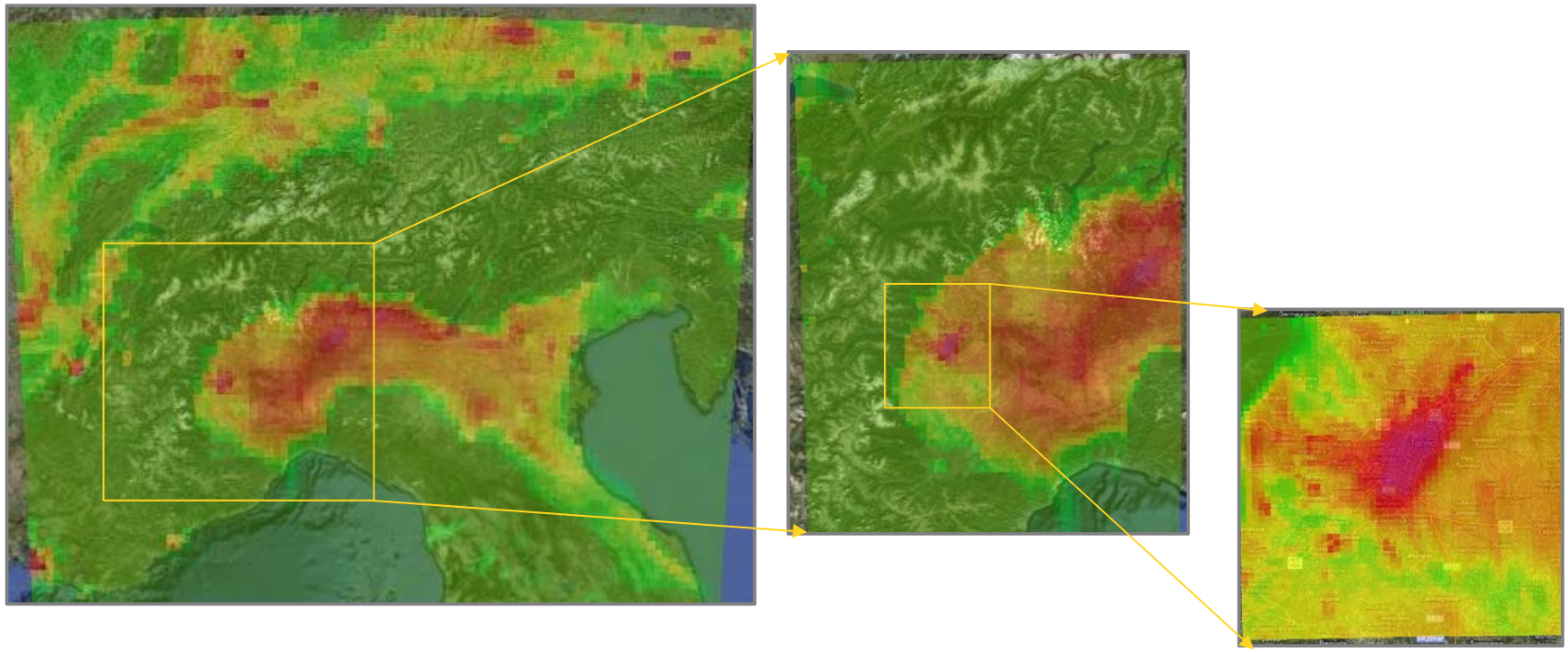
CHIMERE continental fields (analysis and forecast) provided by PrevAir service

Emission inventories:

Detailed regional emission inventories, ISPRA national emission inventory, EMEP inventory



ARPA Piemonte air quality modeling system



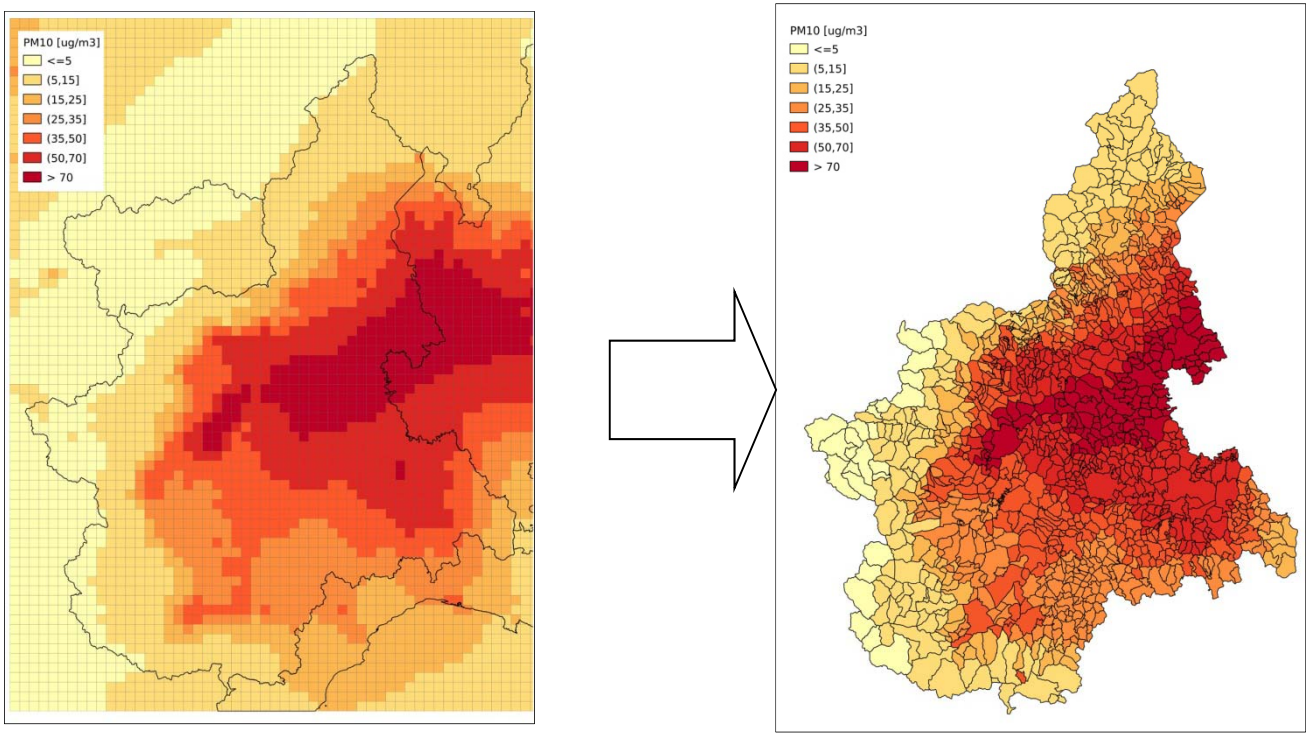
PM10, NO2 and O3 near-real-time analysis:
http://www.sistemapiemonte.it/ambiente/srqa/conoscidati.shtml

PM10 and O3 air quality forecasts:
http://www.arpa.piemonte.it/bollettini

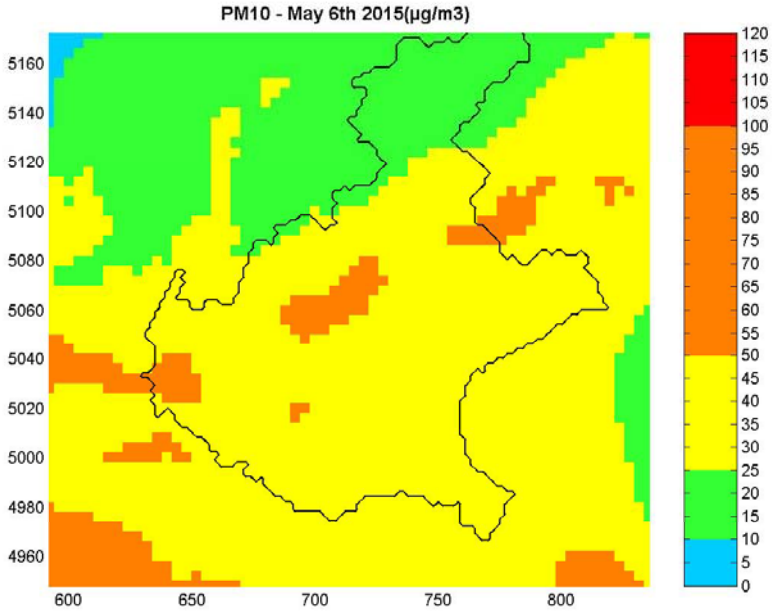
IPQA (forecasted Air Quality Index) over Turin metropolitan area:
http://www.provincia.torino.gov.it/ambiente/inquinamento/aria/qualita/ipqa
/

Postprocessing in ARPA Piemonte

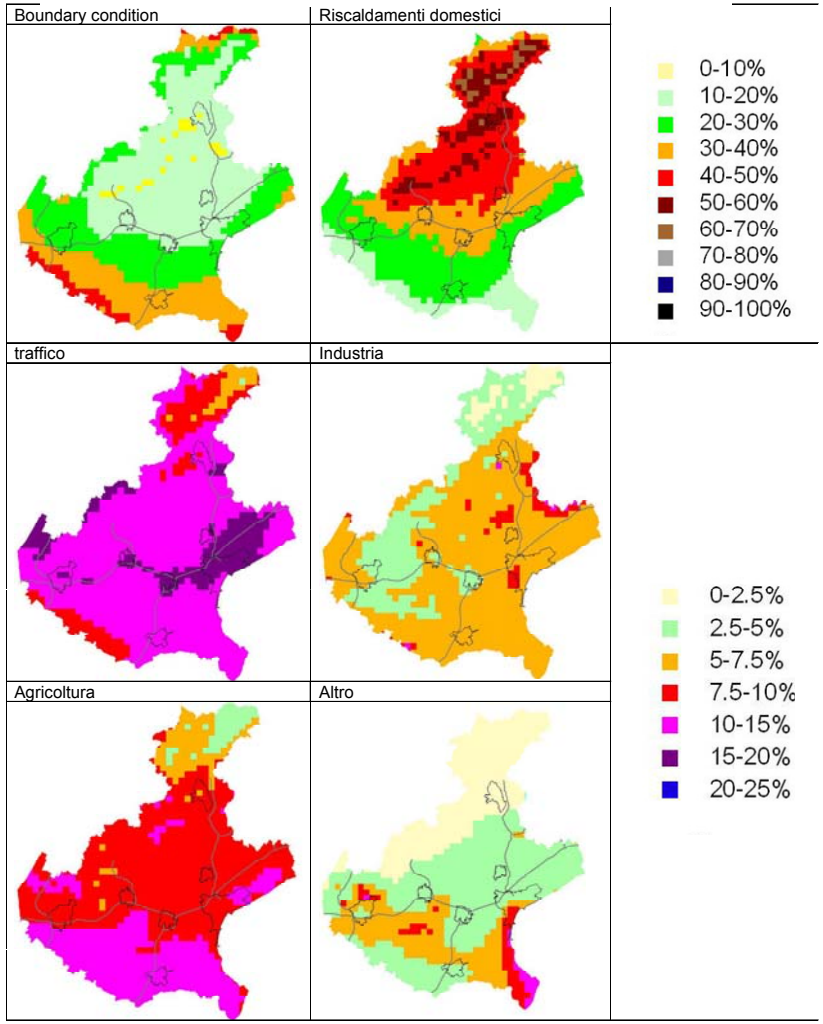
Kriging with external drift *i*s used to reduce bias between observed and simulated data produced by near real time and assement air quality modelling system.
The kriging is applied on the observed data and the external drift is the CTM output.
The kriged fields are up-scaled to the municipality level usinq a weighted-average on built-up areas algorithm.
Postprocessing procedure is applied only for PM10, NO2 and O3 over the regional domain (4kmx4km of horizontal resolution) using a background stations.



ARPA Veneto modelling chain



PM10 source apportionment
winter scenario



LAMI - CAMx 5.4

Domain: 250 x 230 km2

Resolution: 4 km2

Boundary conditions: CHIMERE – Prev'air service

Emissions: GAINS Italy, INEMAR Veneto 2010

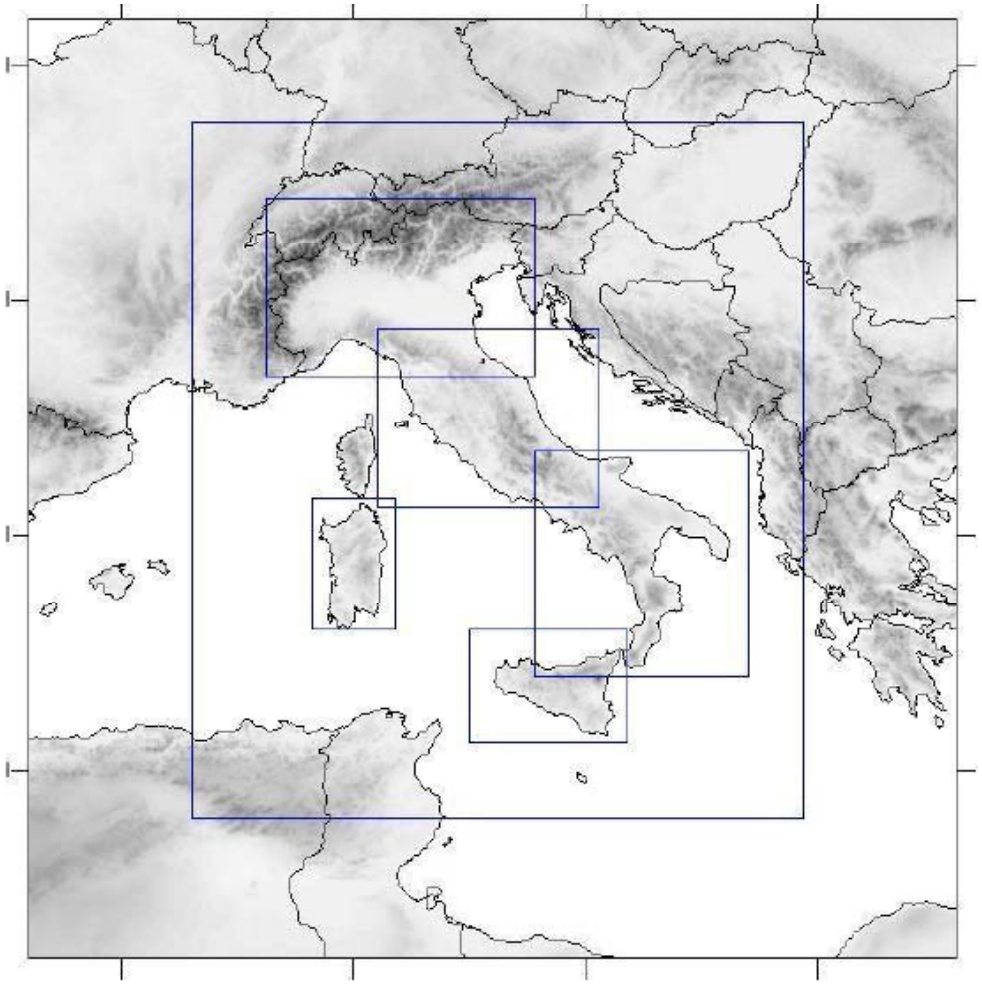
Frequency: daily runs

Product typology: annual periodic scenario for planning scope, PM source apportionment analysis

(http://bur.regione.veneto.it/BurvServices/Pubblica/Download.aspx?name=2872_AllegatoA_245142.pdf&type=9&storico=False)

operational daily runs (in testing phase)

MINNI – AMS NATIONAL DOMAINS

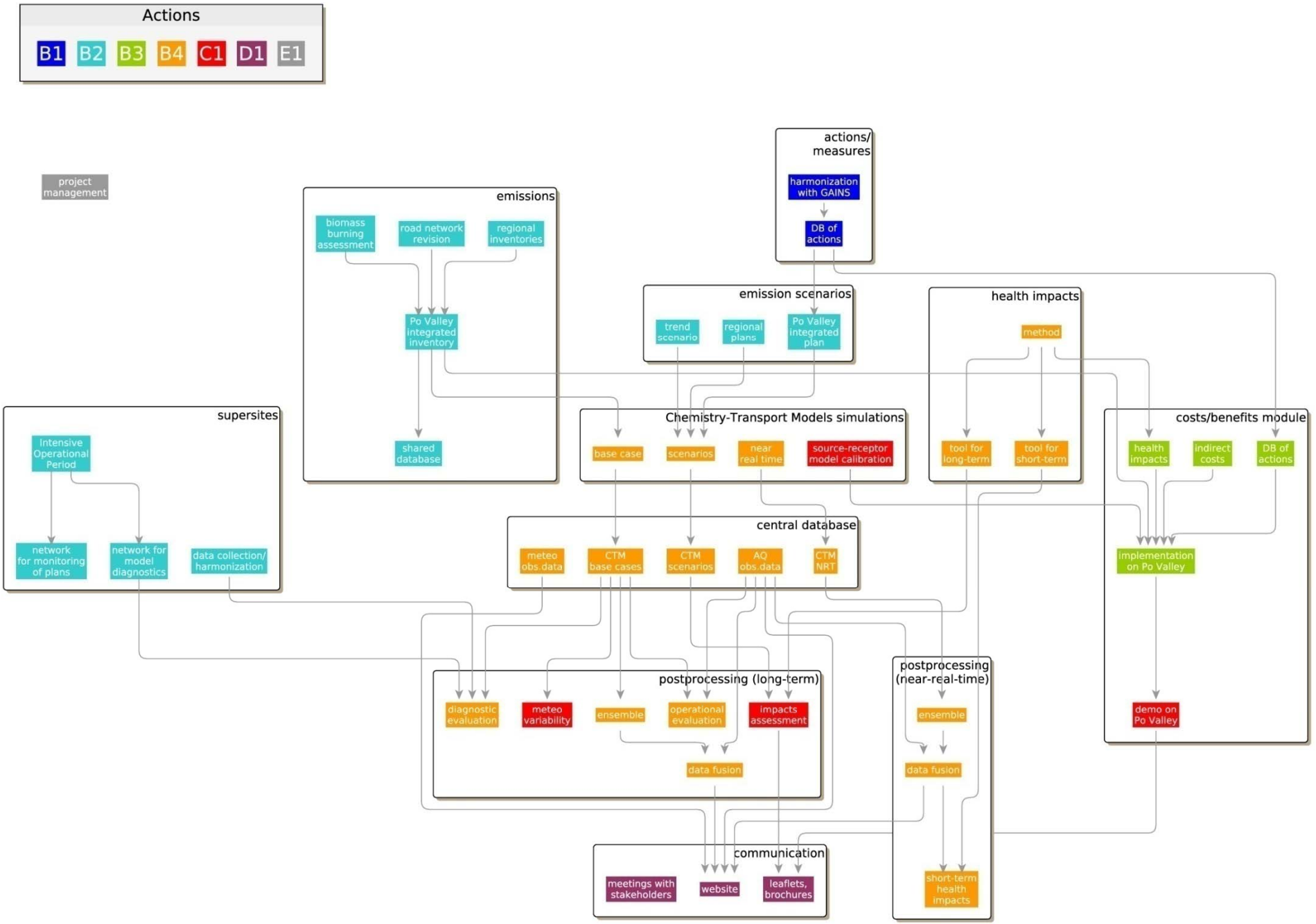


Ongoing projects by the Po valley regions:

THE LIFE-IP PREPAIR PROJECT

Ongoing projects by the Po valley regions:

- LIFE-IP PREPAIR: Implementing the AQ action plans and building the technical tools for monitoring the AQ action plans;
- Some core actions of the project are aimed at:
  - regular runs of an ensemble of 5 CTMs on the northern Italy domain;
  - realizing a permanent infrastructure for sharing air quality monitoring (NRT) and emissions data and CTMs outputs;
  - model outputs will be post-processed by monitoring data for bias correction and enhanced spatial resolution;
  - model outputs will be verified and tuned by data from special stations (supersites) and IO campaigns.


Actions
B1
B2
B3
B4
C1
D1
E1
project management
actions/ measures
harmonization with GAINS
DB of actions
emissions
biomass burning assessment
road network revision
regional inventories
Po Valley integrated inventory
shared database
emission scenarios
trend scenario
regional plans
Po Valley integrated plan
health impacts
method
tool for long-term
tool for short-term
supersites
Intensive Operational Period
network for monitoring of plans
network for model diagnostics
data collection/ harmonization
Chemistry-Transport Models simulations
base case
scenarios
near real time
source-receptor model calibration
costs/benefits module
health impacts
indirect costs
DB of actions
central database
meteo obs.data
CTM base cases
CTM scenarios
AQ obs.data
CTM NRT
implementation on Po Valley
postprocessing (long-term)
diagnostic evaluation
meteo variability
ensemble
operational evaluation
impacts assessment
data fusion
postprocessing (near-real-time)
ensemble
data fusion
short-term health impacts
demo on Po Valley
communication
meetings with stakeholders
website
leaflets, brochures

The ensemble of CTMs models on Po valley:

- Is based on models already implemented by each partner [2A-MINNI, 2B-NINFA-ER, 2C-FARM-PI, 2D-FARM-LO, 2E-FARM-FvG, 2F-CAMX-VE]
  - The application domains and emissions input data will be unified;
  - The numerical code, model set-up and meteorological driver will remain different;
  - Boundary conditions are different but: *"a special effort will be addressed to interfacing the new operational services to the atmospheric services of the European programme Copernicus"*

about Po Valley “Use cases”

PROPOSAL FOR FUTURE COOPERATIVE WORKS

1- Copernicus R&D activities that would be useful for Italian users

1. More efforts should be addressed to development of analysis products,
2. Verification and tuning of aerosol in individual models in Mediterranean areas
3. Use of CAMS as BC for CTM (increasing the number of species ;

- *Evaluation of ENS vs global model and single RAQ models for air quality assessment*

2- Possible cooperative work of Italian environmental agencies and copernicus: Use of CAMS as BC for CTMs - an use case for Italy ??

Presently, boundary conditions for Italian CTMs are provided by a single, continental-scale CTM (either Chimere or FARM)

CAMS products could improve these models in two ways:

A. By providing high-quality BC at **global** scale (including real-time assimilation of satellite data and global description of dust transports and biomass fires)
B. With the "**ensemble**" approach at continental scale (this would reduce model uncertainties, but nesting of local-scale models requires tricky assumptions)

Italian users (ARPAs) could test and implement the most affective solution for the different applications (forecast, assessment, scenarios)

3- development of a downstream service: NRT analysis

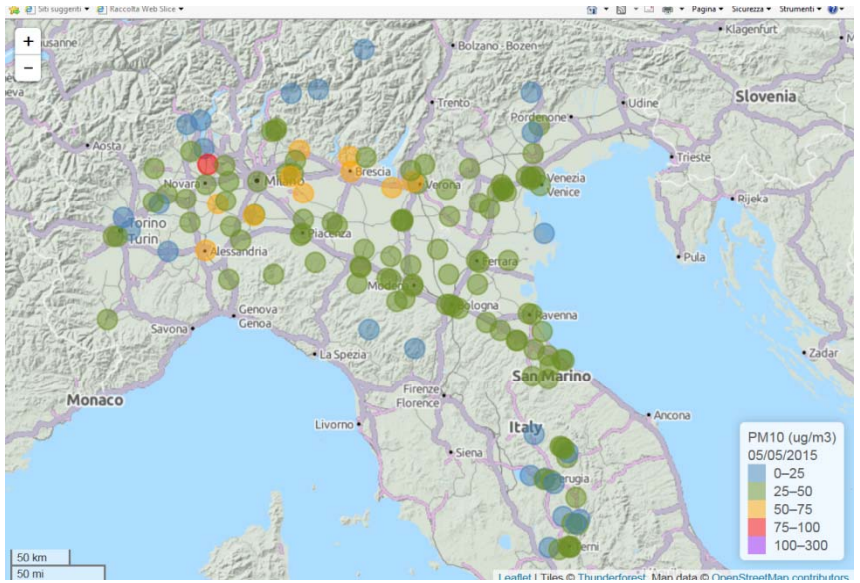
(an "use case" for Italy and/or Prepair project for Po Valley)

- A geo-statistical post-processing of CAMS-ENS or other CTM fields (data fusion) can be developed
- It would be an extension of services already available in some Italian regions;
- based on background observations and proxy variables (emissions, elevation), with a target resolution of 1 km;

NRT analysis:

a possible downstream service based on geo-statistical post-processing of CAMS-ENS:

- Italian monitoring networks are wide, but it has often been difficult to gather a sufficient amount of homogeneous data
- for northern Italy, this issue will be addressed in the near future in project Prepair (if funded).



Thank you for your attention

AKNOLEDGMENTS:

- Enrico Minguzzi, Michele Stortini, Giovanni Bonafè
- Elisabetta Angelino
- Strefano Bande
- Silvia Pillon
- Fulvio Stel, Dario Giaiotti