The Italian National Topic Centre on Atmosphere Climate and Emissions in air

Modelling techniques for air quality evaluation and managing:
the work of the National Topic Center.

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The CTN-ACE:

☞ The Italian National Topic Centre on Atmosphere Climate and Emissions in air (CTN-ACE) was founded in 1999 by the Italian National Environmental Protection Agency (APAT, *formerly ANPA*).

☞ CTN-ACE is a network between the Italian Regional Environmental Agencies (ARPA) and several national research institutions.

☞ CTN-ACE, since its foundation, has been working to produce and review guidelines for several topics related to air quality. One of these topics is air quality modelling.

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Law and technical references:

- Modelling is one of the main tools to evaluate air quality and to prepare plans and programmes, as requested by the framework EU Directive on air quality evaluation and management (96/62/CE) and related "daughter" directives.
- Therefore the main task of the CTN-ACE WG on "air quality modelling" is to prepare the national **"guidelines for models application".**
- the Italian law (D.Lvo. 4 agosto 1999 n. 351, DM 2 aprile 2002 n. 60 and DM 1 ottobre 2002 n. 261) included the early guidelines prepared by the CTN-ACE as technical annex.

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Why environmental agencies and local authorities apply models ?

1. Preliminary assessment of ambient AQ, where no measurements are available, to design monitoring networks;
2. Annual A.Q. assessment throughout the territory (AQ analysis combining modelling and monitoring);
3. A.Q. daily forecast and analysis to inform population and take short term abatement measures;
4. Scenario analysis for AQ management (i.e. evaluate the effectiveness of practical measures, prepare plane and programs);
5. Environmental impact assessment (example: take decision about new plants authorisation)

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The status report on modelling in Italy:

A review on model applications in Italy, performed by the Italian WG during 1999-2000, put into evidence that modelling techniques were scarcely applied in the daily working routine by environmental agencies and local authorities;

- Modelling received poor funding and was scarcely supported;
- It was often difficult to prepare the input data, especially for the photochemical models;
- there is a gap between the needs and the true availability of models for practical purposes.

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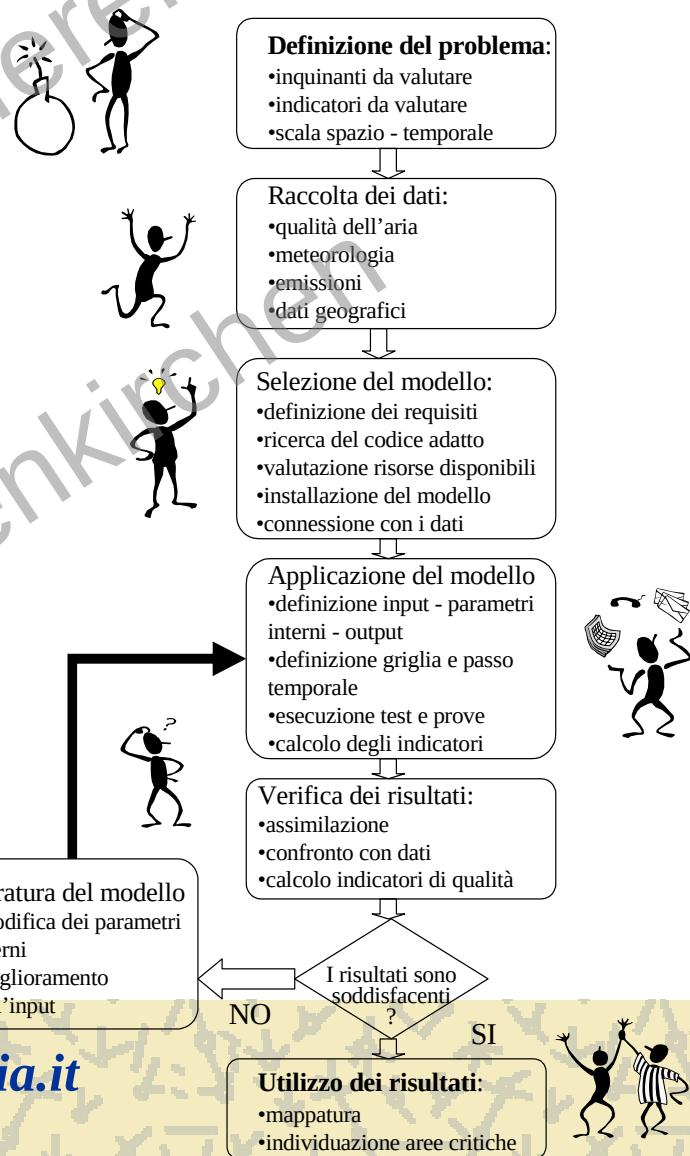
The first stage of the work:

Support the models users to:

- choose the models to apply
- prepare the input data
- correctly run the model
- Evaluate the results

The reports: RTI CTN_ACE 4/2001, RTI CTN_ACE 5/2001
The WEB



The website of the National Environmental Information System (SINA) and the hyper textual guide to air quality modelling: http://www.sinanet.anpa.it/aree/atmosfera/

CONTENTS:

- basic concepts,
- a list of air quality models and links;
- guide to meteorological input data (abstracts and links to the COST710 and 715);
- guide to emission input data;
- download the technical reports
- didactic documents.

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Models application typology and scales:

(1) urban areas	(2) industrial sources	(3) large scale models

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A list of air quality models, selected on the basis of main Italian experiences (example: list of large scale models)

name	type	reference	Open source YES/NO
CALGRID	Euleriano 3D	Atmospheric Studies Group Earth Tech., Concord MA 01742, USA (formerly Sigma Research Corporation)	Yes
CAMx	Euleriano 3D	ENVIRON	Yes
CHIMERE	Euleriano 3D	Institut Pierre-Simon Laplace CNRS FRANCE	Yes
STEM	Euleriano 3D	Centre for Global & Regional Environmental Research (CGRER)	No
FARM	Euleriano 3D	Arianet srl	No

For each model the guide provides some basic information, a link to the international databases (such as MDS and EPA-SCRAM) and/or to the web site containing more detailed information, and a description of the model availability (open source or commercial). Some examples describing the models application in Italy are included.

Needs for the new guidelines on modelling:

Guidelines on models applications should be better detailed to provide all the information on modelling techniques required by the EC directives:

- The reference techniques and the spatial resolution for modelling should be indicated (as requested by the 96/62/CE framework directive);
- the uncertainty of models should be evaluated (DM 2 aprile 2002 n. 60 – daughter directive 1999/30/CE annex VIII, "ozone Directive 2002/3/CE annex VII).
- the models should be evaluated on long term runs (season/year time periods).

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Data-quality objectives

Pollutant	Av. time	Data-quality objectives for Modelling (*)	Data-quality objectives for continuous measurement	Italian law	EC Directive
SO_2, NO, NO_2	1 h 1 d 1 y	50 – 60 % 50 % 30 %	15 %	DM 2 aprile 2002, N. 60	1999/30/EC
PM, lead	1 y	50 %	25 %		
CO	8 h	50 %	15 %		2000/69/EC
Benzene	1 y	50 %	25 %		
O_3, NO, NO_2	1 h day 8 h max	50 % 50 %	15 %	To be received	2002/3/EC

(*) the accuracy for modelling is defined as the maximum deviation of the measured and calculated concentration levels, over the period considered by the limit value, without taking into account the timing of events.

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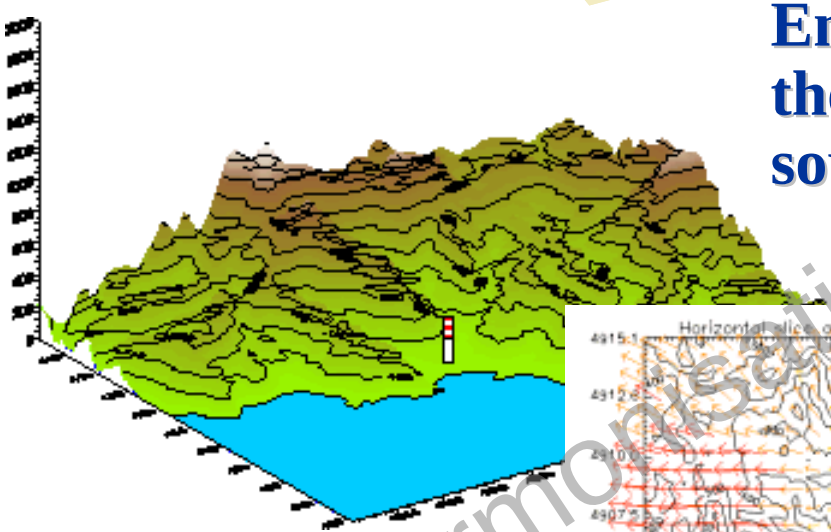
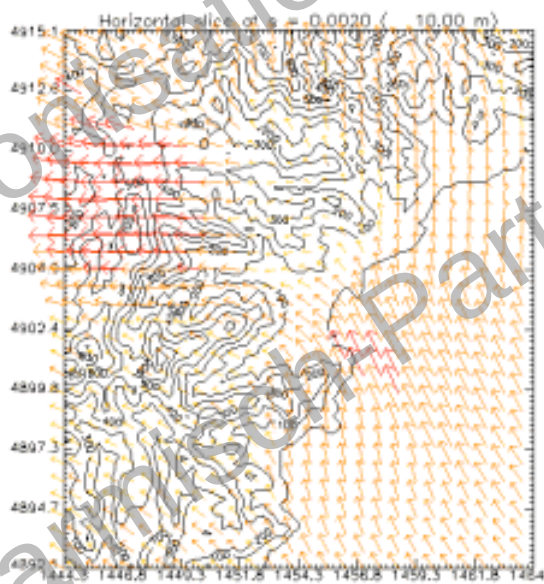
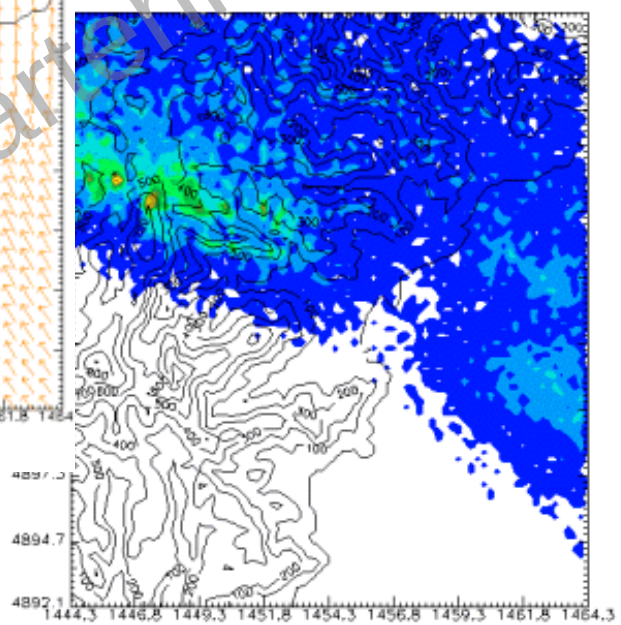
Environmental impact assessment at the local scale, single stack or arrays of sources.

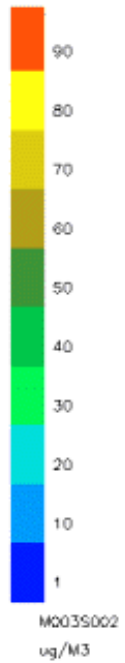


An industrial stack with complex orography



Wind and turbulence field





The pollution at the surface

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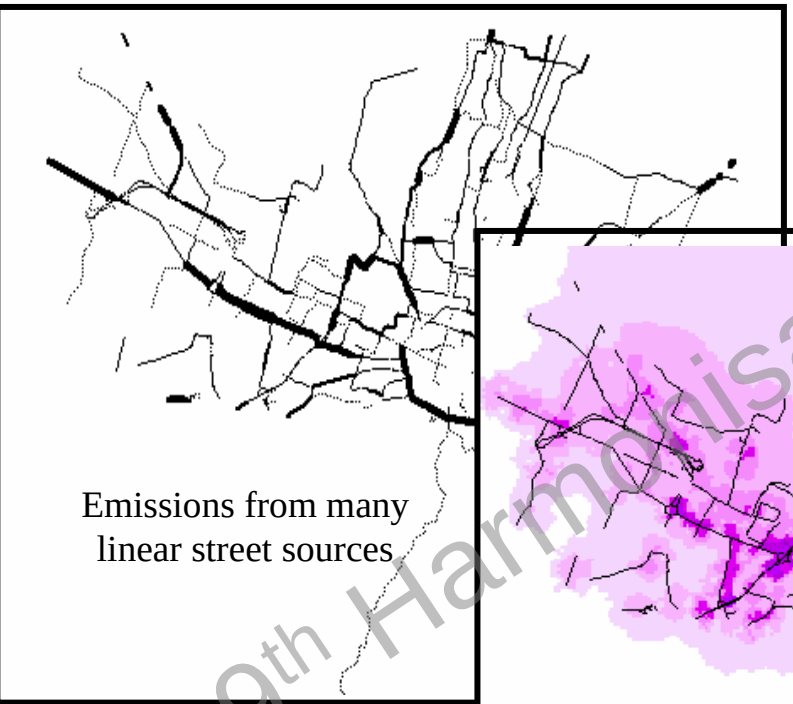
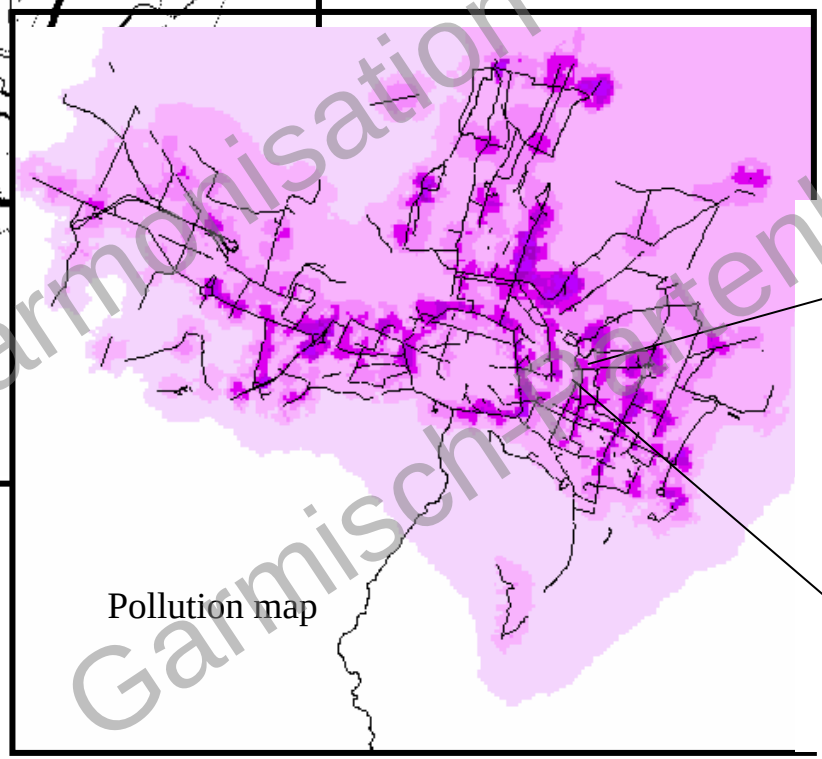
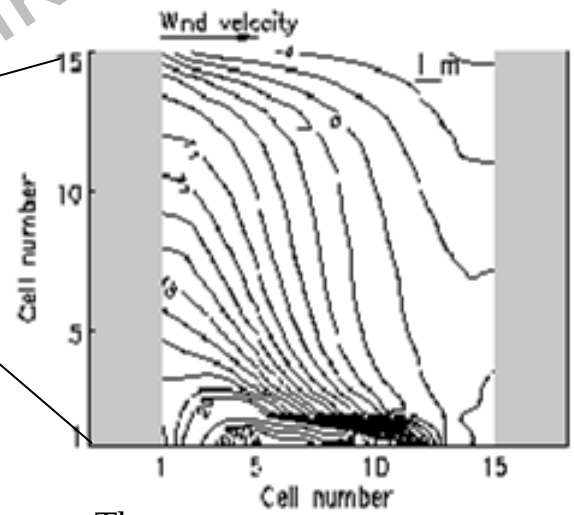
Air quality assessment and management in the urban areas and industrial agglomerates, generic passive pollutants, a large number of sources.



Emissions from many linear street sources



Pollution map



The street canyon

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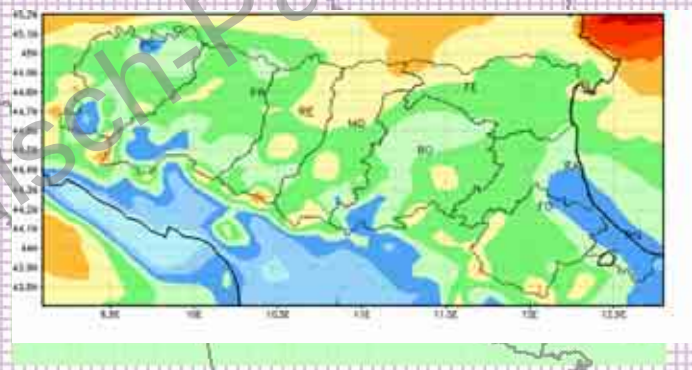
Large scale CTMs: air quality assessment and management in zones and agglomerates throughout the territory, chemically reactive pollutants (ozone and PM10).



Map of ozone exceedences

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Some practical features of the urban models

- Atmospheric processes: diffusion and transport, dry deposition (simplified chemistry), at least 1000-2000 emission sources;
- pollutants: generic passive (CO, NO2, Benzene, PM10);
- Application area: small/medium urban areas or part of an agglomerate;
- Typical domain: around 10x10 km 2;
- Simulation periods: 1 year/6months winter season;

Data-quality objectives:

- annex X DM 2 aprile 2002 n. 60 for sulphur dioxide, nitrogen dioxide, particulate matter and lead, benzene and carbon monoxide.

Models under evaluation by CTN-ACE WG:

- Large number of sources: ADMS-URBAN, IMPACT,
- Can be adapted for urban areas: CALPUFF, SPRAY,
- Only road links : CALINE-4,
- Only street canyon: CFX-TASCflow, MERCURE (now Aria Locale), OSPM, PROKAS-B, WINMISKAM

Input data format:

- Line sources (road links), point sources (stacks), area sources,
- Simple meteorology: data from one met. station + 1d pre-processor,
- Initial and boundary conditions: background concentration from monitoring stations or large scale models.

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some practical features of large scale models:

- Atmospheric processes: diffusion and transport, dry deposition, chemistry and particulate matter, dry/wet deposition,
- pollutants: ozone, nitrous dioxide, PM
- Application area: large urban agglomerates; throughout the country.
- Typical application domain: 300 x 300 Km^2 or larger, nested approach;
- Simulation periods: : 1 year/6 months summer

Data-quality objectives:

- annex VII 2002/3/EC for ozone.

Models under evaluation by CTN-ACE WG:

- Including PM10 modules: CAMx, CHIMERE, FARM
- Not including PM10: CALGRID, STEM

Input data format:

- hourly emissions on a regular grid at the same model resolution, all type of sources, all chemical species requested by the chemical mechanism.
- Meteorological fields from a 3D pre-processor or from a NWP meteorological model,
- Initial and boundary conditions: 3D concentration fields from a CTM.

Evaluating the uncertainty of models

The main method to quantify the uncertainty of modelling techniques is to realize a model inter comparison exercise.

In an inter comparison exercises, to insure the results comparability, all the models should be applied in the same conditions and evaluated on the same criteria.

method:

- ☞ prepare a common data set containing the input data needed to run the models and evaluate the results.
- ☞ the data set is distributed to the largest possible group of modellers and left open for a certain time, in order to increase the number of application that can be used to evaluate the range of results.

Because the results of a model application can differ depending from the set up and control parameters chosen, it is recommended that the same model is applied by different users.

Several exercises realized (example EUROTRAC, CityDelta..), but not focused on defining reference techniques and verify data-quality objectives

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The urban exercise:

Aim: verify if the listed models can comply with the EC quality objectives for modelling;

Domain: 12 x 12 Km^2, mainly flat land;

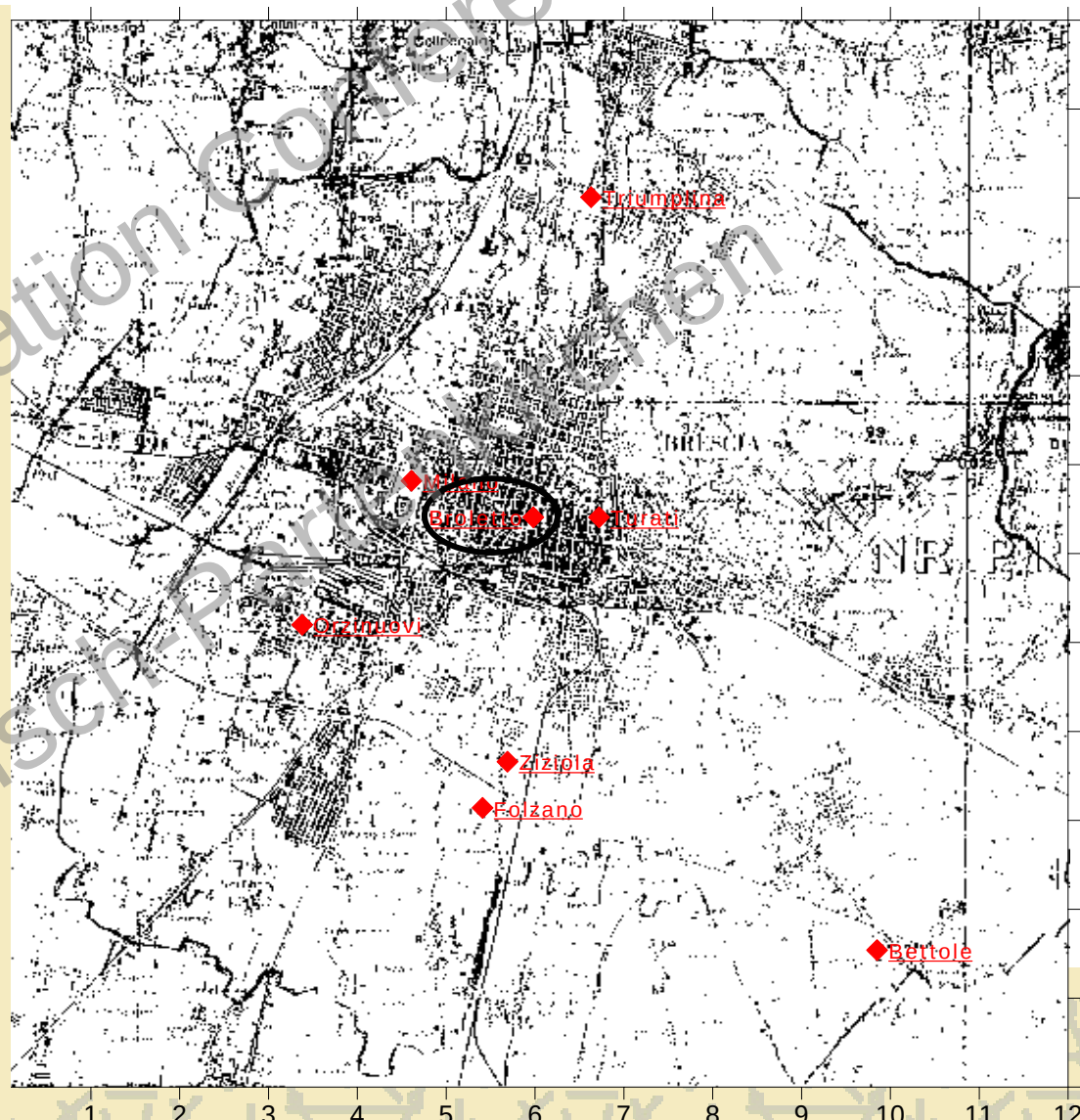
Middle sized urban area of 200.000 inhabitants;

Reference period: 1 year (1999 January – December);

Pollutants: CO, NO_x-NO_2

Input data: emissions and meteorology;

Verification data: concentrations at a monitoring station;



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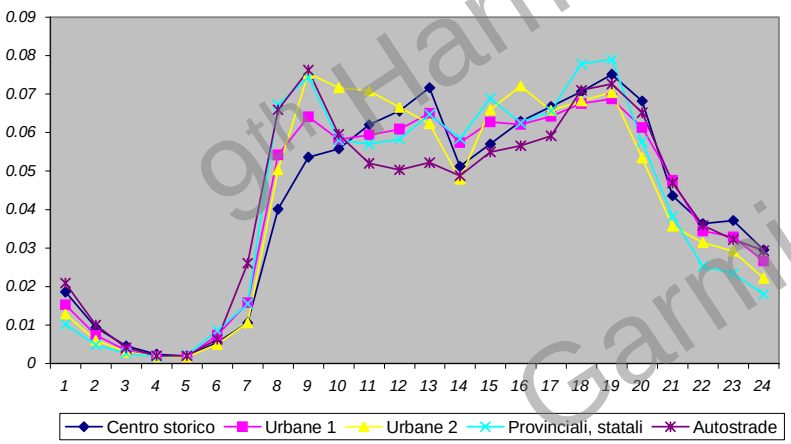
Emissions input data:

COPERTIII-CORINAIR methodology

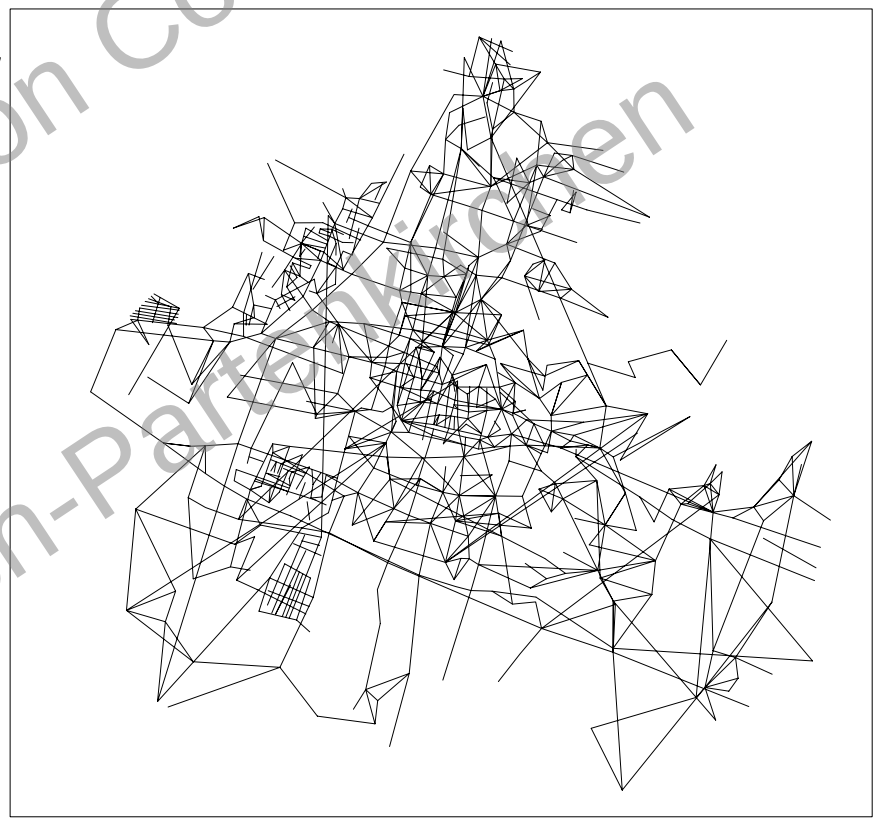
Line sources: road network extension ~ 650 km, 948 road links;

point sources: 6 NOx and 2 CO;

CO and NOx hourly emissions are provided for each source.



The road network



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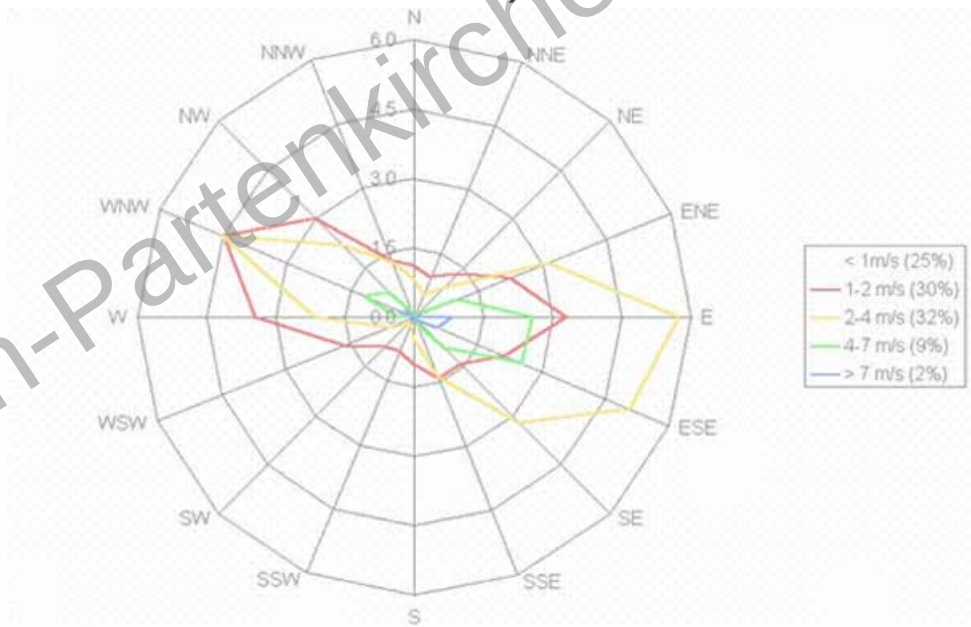
Meteorological and physiographic Input data:

CALMET-SMR: (300 x 300 km2), ECMWF+ Synop, local surface met. stations and upper air data.

Physiographic data estimated from "Corine" (land use, roughness, albedo, Soil heat flux constant, bowen ratio, leaf area index, terrain elevation).

Meteorological data	units
Temperature	°K
Wind Direction	Gradi *
Wind Module	m/s
Vertical Wind Velocity	m/s
Stability class	1-6 **
U*	m/s
Mixing Height	m
Monin-Ob-length	m
W*	m/s



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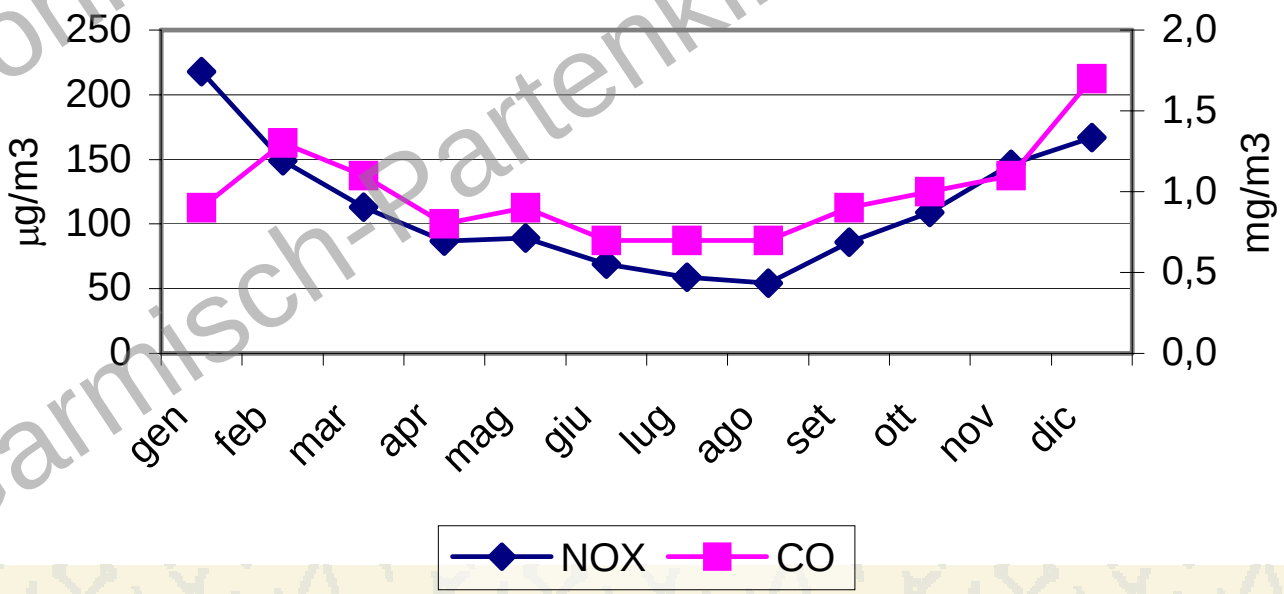
Verification data set:

NOx, NO, NO2, CO 1 h average data from an urban background monitoring station located in the core of the domain.

Annual mean, 50th and 98th percentile provided for comparison.

Background concentration is also provided.

Pollutant	Annual average (µg/m3)	50 th percentile (µg/m3)	98 th percentile (µg/m3)	Background conc. (µg/m3)
CO	1000	1200	3900	300
NO	48	15	292	-
NO2	65	61	145	36



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models evaluation:

- the computed CO and NO_x yearly average (expressed as NO_2) at the monitoring station location, compared with the measured concentration;
- the coordinates of the maximum CO and NOx calculated concentration;
- the matrix of the calculated yearly average concentrations values for the model domain.

Some preliminary results:

The data set was tested on two urban models used for routine applications among the Env. Agencies participating to CTN-ACE,

Both models underestimate the measured NO_X concentration (expressed as NO_2);

Both models satisfy the Data-Quality Objectives set by the EU directive.

Model	*NOx C.Y.A* ($\mu g/m^3$)	*NOx M.Y.A* ($\mu g/m^3$)	*Diff %*	*D.Q.O. 1999/30/EC %*
ADMS Urban	107	138	23	30
ARIA Impact	102	138	26	30

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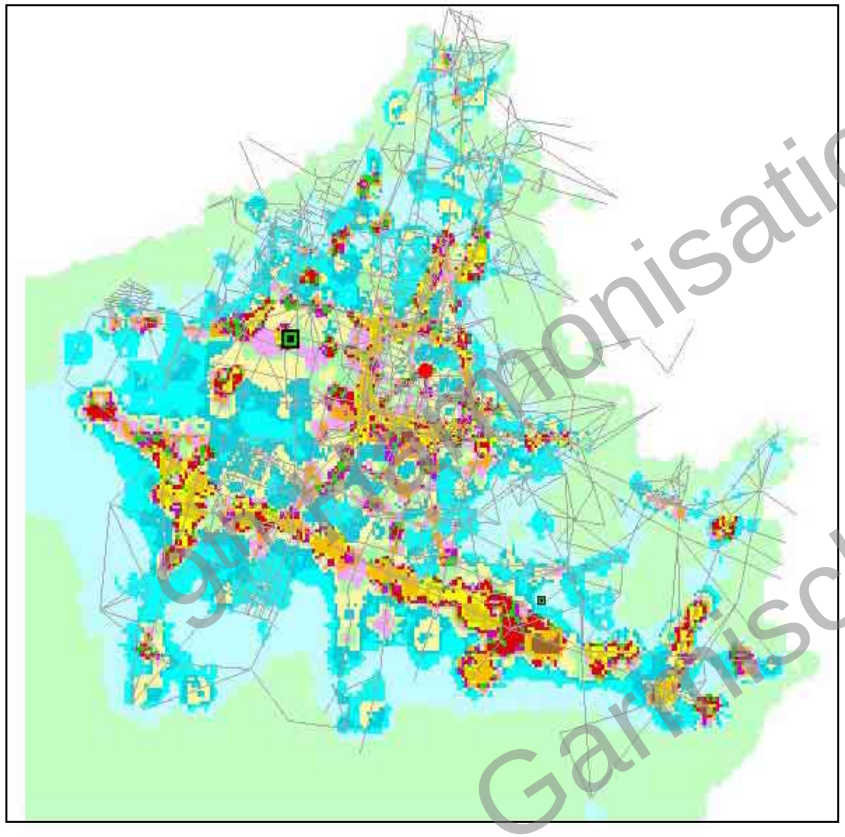
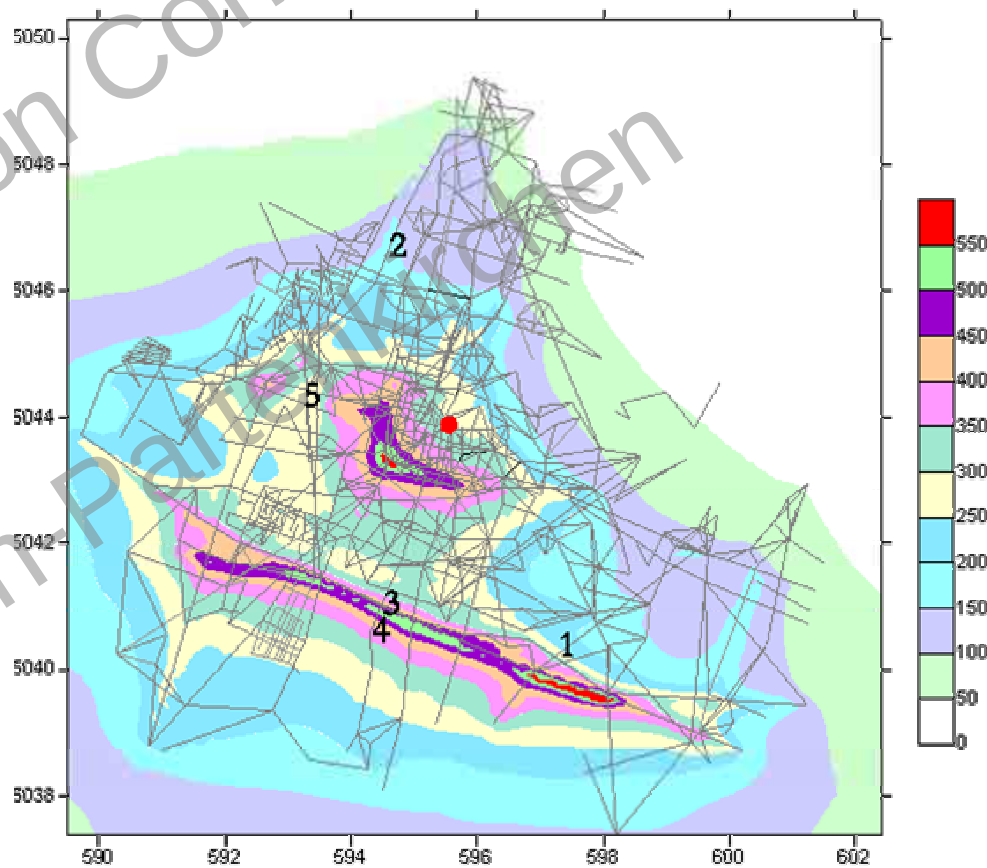
Conc. maps: there is a strong dependence from the grid resolution!

ADMS Urban, variable grid, CO



ARIA Impact, Regular grid 100 m hor. res., CO



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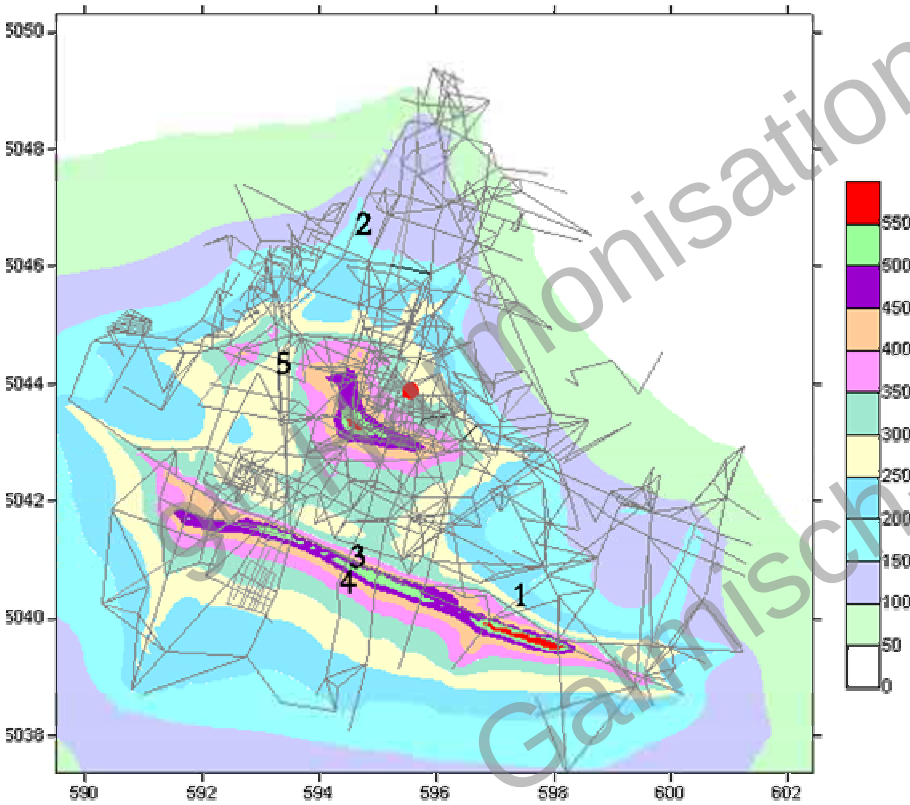
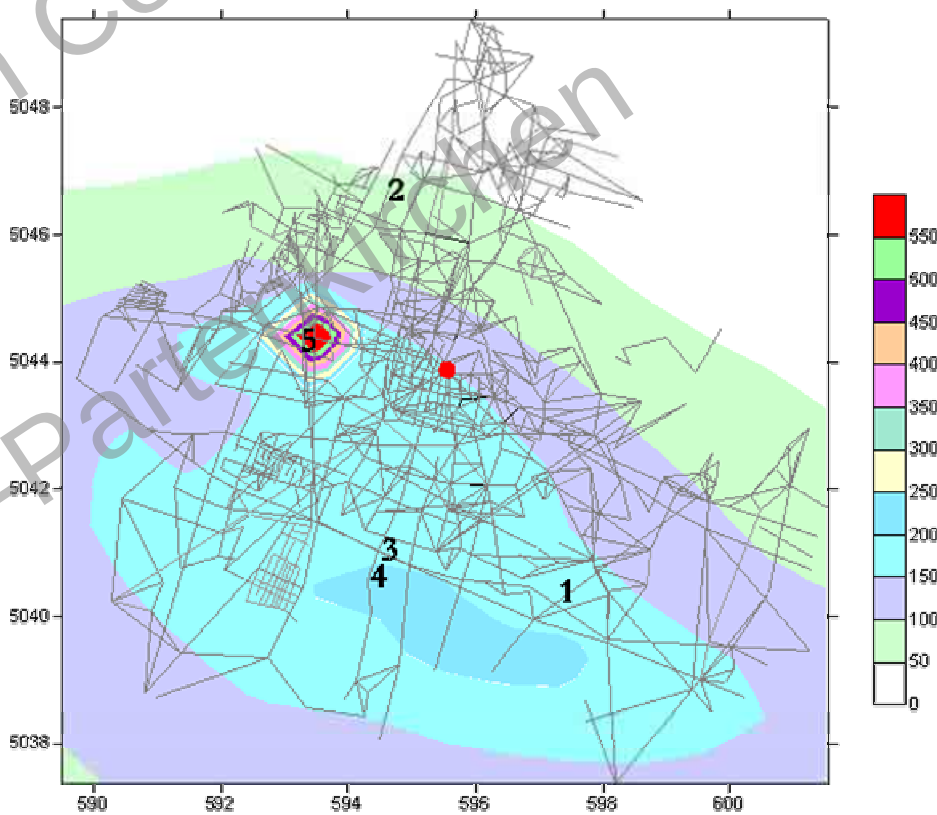
ARIA Impact, Regular grid 100 m hor. res., CO



ARIA Impact, Regular grid 1 Km hor. res., CO



Next work:

Test different urban models/different users of the same model;

The data set has been sent to several modellers and users in Italy that accepted to participate to the exercise;

The exercise is still open: modellers/users which are interested to participate, please send an E-mail. You will receive the instructions and the data set.

You will be asked to provide your results to the CTN-ACE workgroup, according to a common protocol. CTN-ACE workgroup will review all the results and prepare the guideline report.

Test CTMs models: an exercise will be prepared.

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A further data set to evaluate the large scale Chemical Transport Models (CTMs) will be prepared during 2004;

two Italian domains: BPA and MED

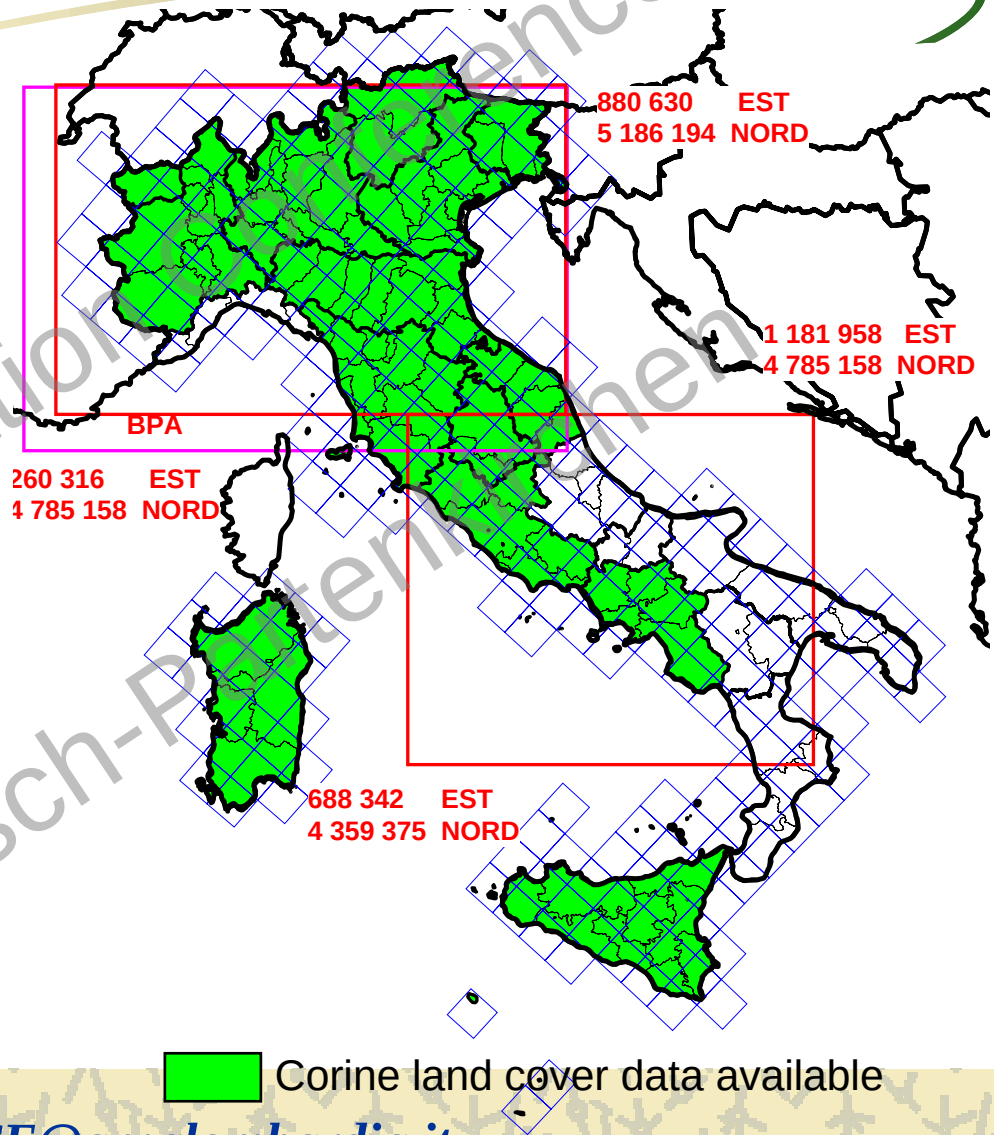
The data set will include:

Gridded emission data, 10 km horizontal resolution;

Meteorological data from the LAMI met. model;

Boundary conditions;

O_3, NO_2, Pm_{10} verification data from selected monitoring stations.



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