

Model based yearly air quality evaluation on Piemonte region

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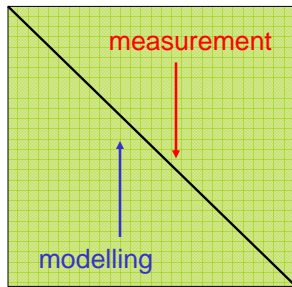
10th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
Sissi (Malia), Crete, Greece 17-20 October, 2005

*The Framework Directive (1996/62/EC) and the first Daughter Directive (1999/30/EC) introduce, for the first time in European air quality directives, the combined use of **monitoring data, emission inventories and modelling techniques** in assessment and management of air quality.*



Assessment under EU Air Quality Directives

*Combining models with
measurement*



100% measurement

- Measurement, no interpretation
- Measurement+interpretation
- Measurement+interpolation
- Measurement+model fitted to measurement
- Data assimilation

Model validated by measurement in the same zone

- Model validated elsewhere
- Unvalidated model

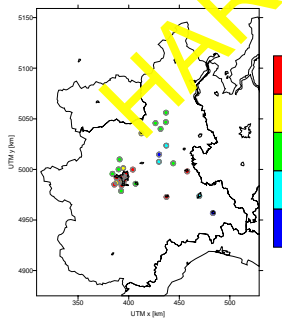
100% modelling

...there is an almost continuous spectrum of combination of measurements and other assessment methods (mathematical techniques and models)
From: Guidance on Assessment under the EU Air Quality Directives, EEA 2002

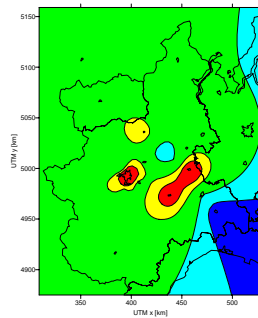


Combining models with measurement

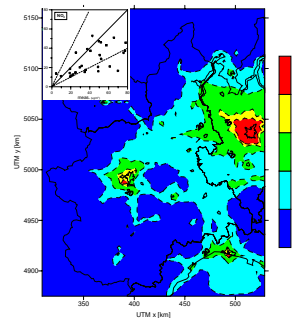
Example: NO₂ yearly averages



Measurement, no interpretation



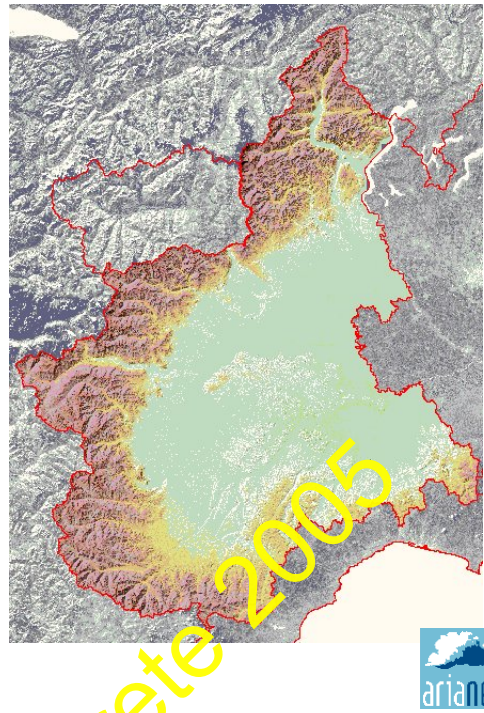
Measurement+interpolation



Model validation using
measurement in the same zone

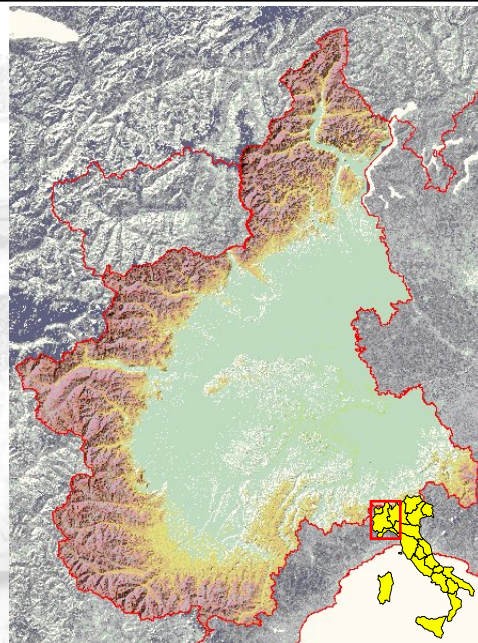
MAIN GOAL

To give an example of air quality assessment over Piemonte Region using an atmospheric modelling system validated by measurements in the same zone.



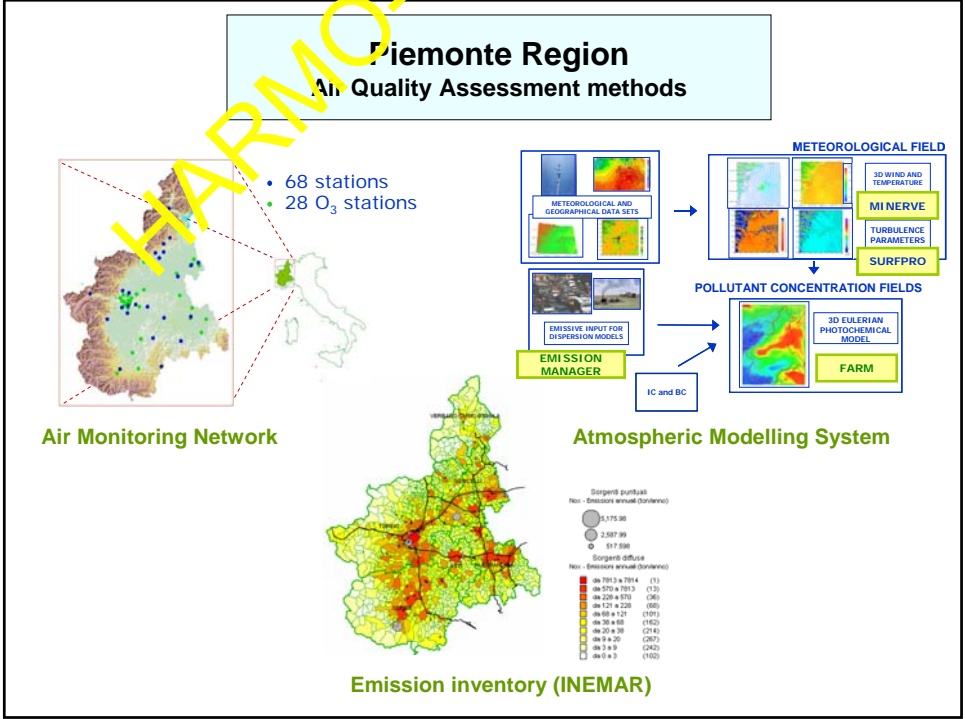
CONTENTS

- Piemonte Region Air Quality Assessment methods;
- The Italian national-scale MINNI Project;
- Air Quality Assessment for 1999 (Downscaling of MINNI data);
- Related works:
 - Air Quality Management (two examples);
 - Air Quality Assessment for 2004 (highlights);
 - Smaller scale study;
- Conclusions



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**Piemonte Region
Air Quality Assessment methods**



FARM
(Flexible Air quality Regional Model)

3D Eulerian model, derived from STEM-II (Carmichael *et al.*)

- Diffuse sources & LPS with plume rise
- Horizontal adv.-diff.: Blackman cubic polynomials (Yamartino, 1993)
- Vertical adv.-diff.: hybrid semi-implicit Crank-Nicolson / fully implicit scheme (Yamartino *et al.*, 1992)

- Actinic flux reduction effect from clouds

- SO_x-NO_x-NH₃ simplified scheme (EMEP)
- Photochemistry: SAPRC-90 chemical scheme
- PM: Models-3/CMAQ aero-3 module (Binkowski, 1999); aero-3 simplified bulk module

- One- or two-way nesting



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**The Italian national-scale
MINNI Project**



National-scale MINNI Project

GOAL

Development of an Integrated Assessment Modelling System, supporting the international negotiation concerning the air pollution and the development of environmental policies at national level.

AMS Italia

Dealing with the air pollution dynamics (transport and dispersion) and multiphase chemical transformations, able to quantify concentrations and deposition flux of air pollutants (SO_x, NO_x, NH₃, PM and O₃), with a spatial resolution of 20 x 20 km²

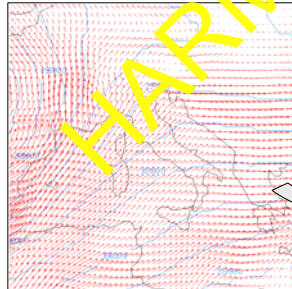
RAINS Italia

Inheriting the valuable features of RAINS-Europe model, but fed by the coefficients of the Atmospheric Transfer Matrix (ATM) calculated with the AMS-Italia at a higher spatial resolution.

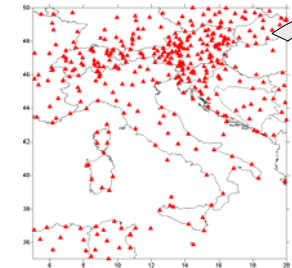


MINNI Project Meteorological sub-system

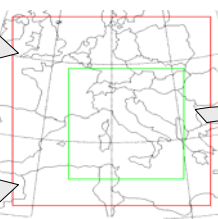
ECMWF field



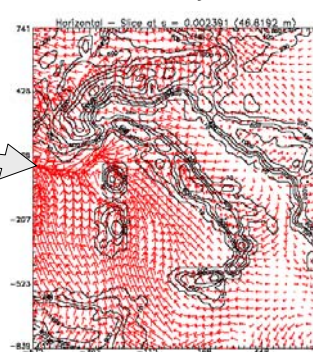
SYNOPS

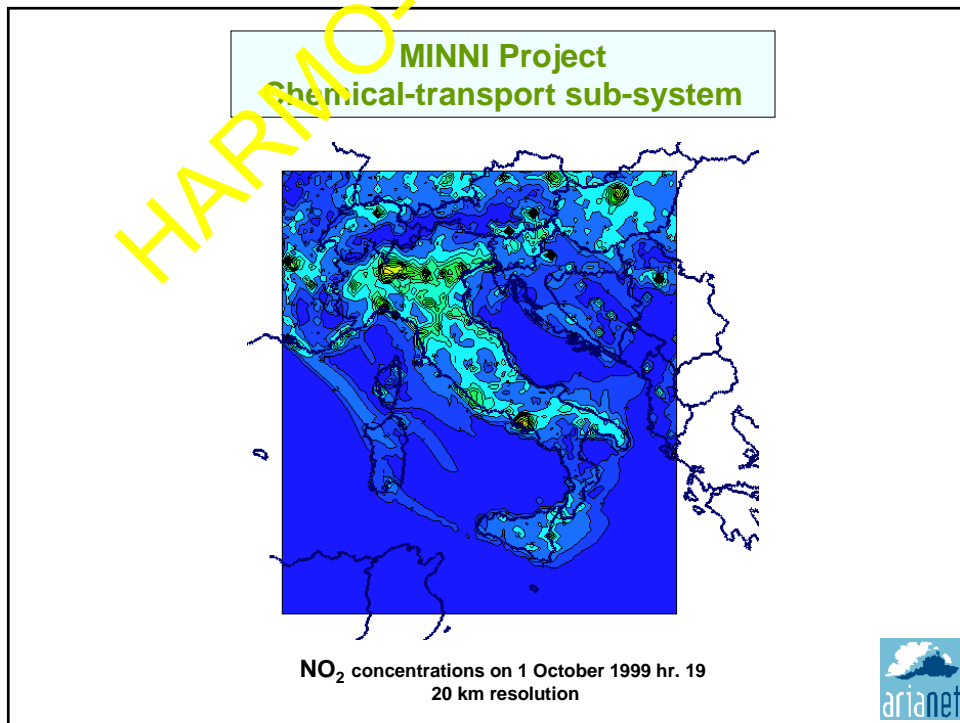
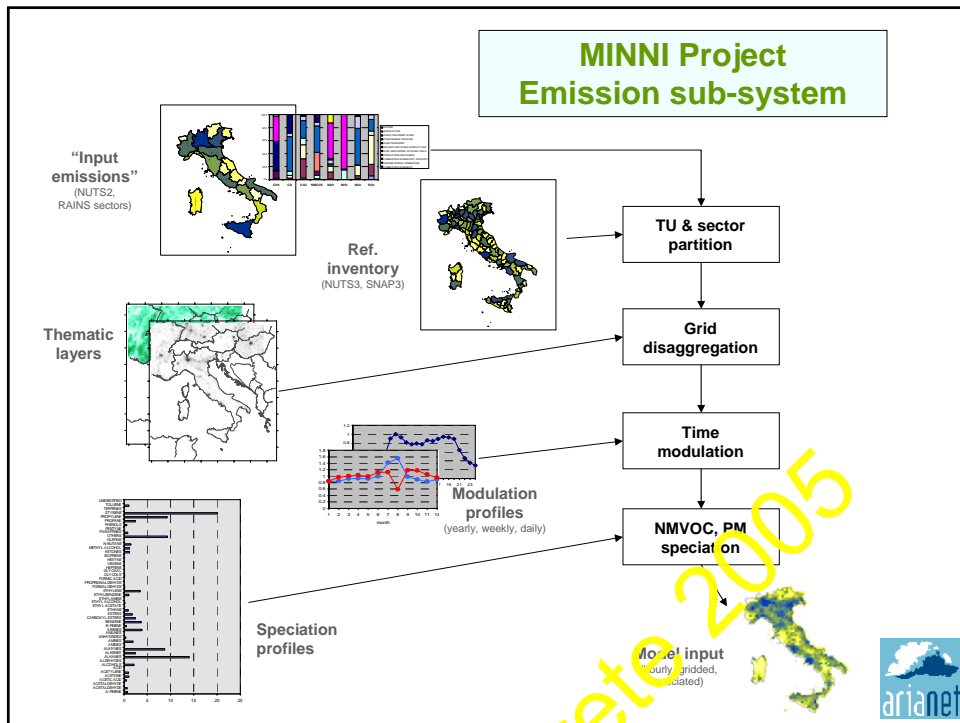


RAMS 1 | 2 grids, 4DDA



Re-analysis

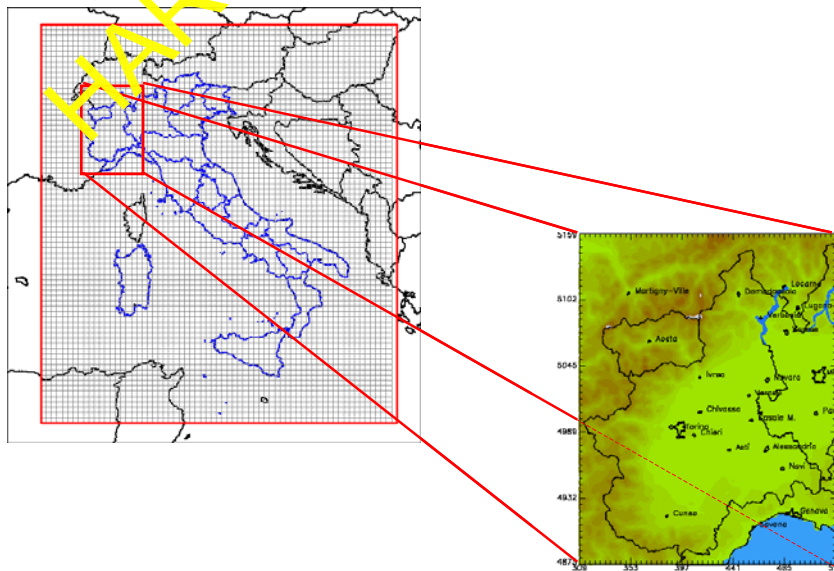




**Air Quality Assessment for 1999
(Downscaling of MINNI data)**



Downscaling of MINNI national data



Temporal and spatial aspects of limit values under EU Air Quality Directives

Temporal aspects of limit values			
Limit value SO ₂	Coverage	Resolution	Statistical parameter
Health: 350 µg/m ³	Calendar year	1 hour	99.7 percentile (24 exceedences)
Ecosystems: 20 µg/m ³	(1) Calendar year; (2) winter mean	1 year	n.a.

Spatial aspects of limit values			
Limit value SO ₂	Coverage	Resolution	Statistical parameter
Health: 350 µg/m ³	Entire zone, but not < 25 m from road junction and ...	About 200 m ²	Maximum ¹⁾
Ecosystems: 20 µg/m ³	Areas >20 km from agglomerations or >5 km from ...	1000 km ²	

from 1 hr to 1 year

from 15 m to 30 km

¹⁾ The directives encourage also the calculation of the area in exceedence and population in exceedence.

From: K.D. van den Hout, *Air Quality Assessment Requirements Under The New EU Air Quality Directives*

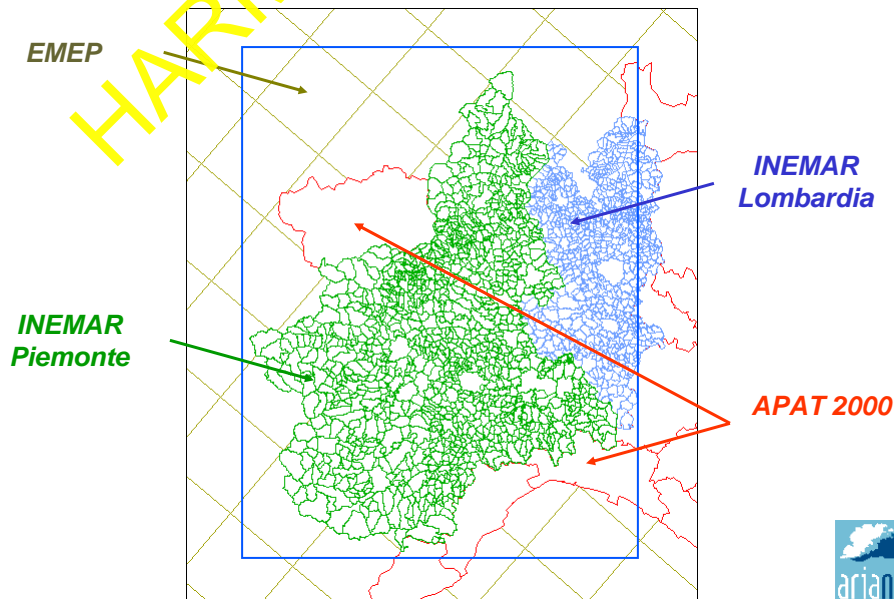
State-of-the-art models (as FARM) require so much calculation time that a high spatial resolution and a full coverage of calendar year is impossible!

FARM has been applied to whole 1999, on hourly base, over Piemonte region with:

- > a spatial resolution of 4 km (56x72x12) cells;
- > simplified aerosol module (*aero0*).

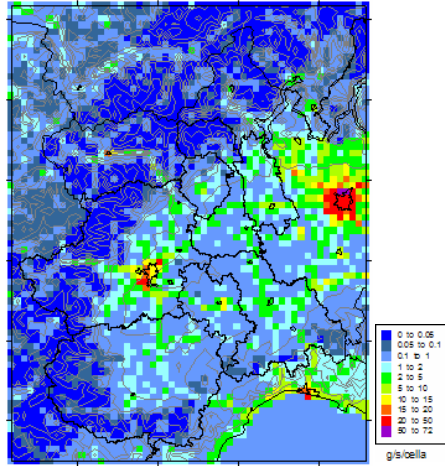


EMISSION SUB-SYSTEM Integration of local inventories

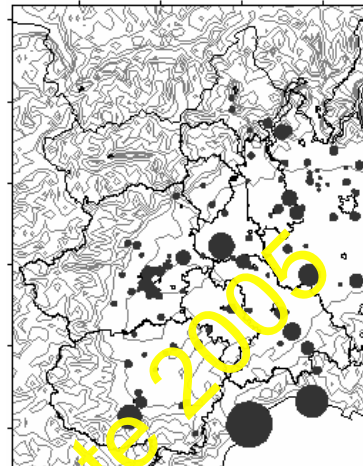


EMISSION SUB-SYSTEM
Spatial disaggregation (NOx)

Gridded area sources

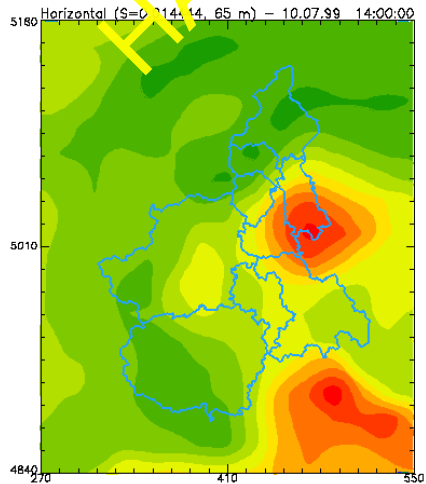


Point sources

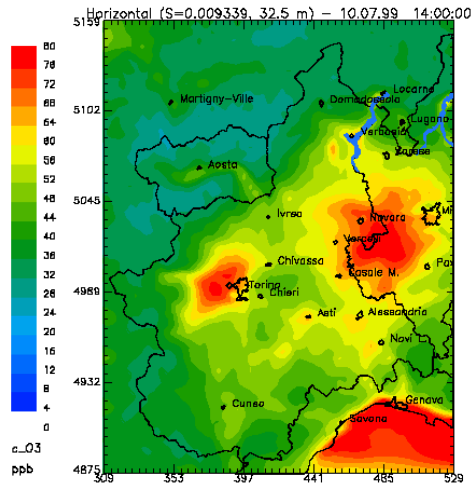


SPATIAL RESOLUTION EFFECTS
Ozone at ground

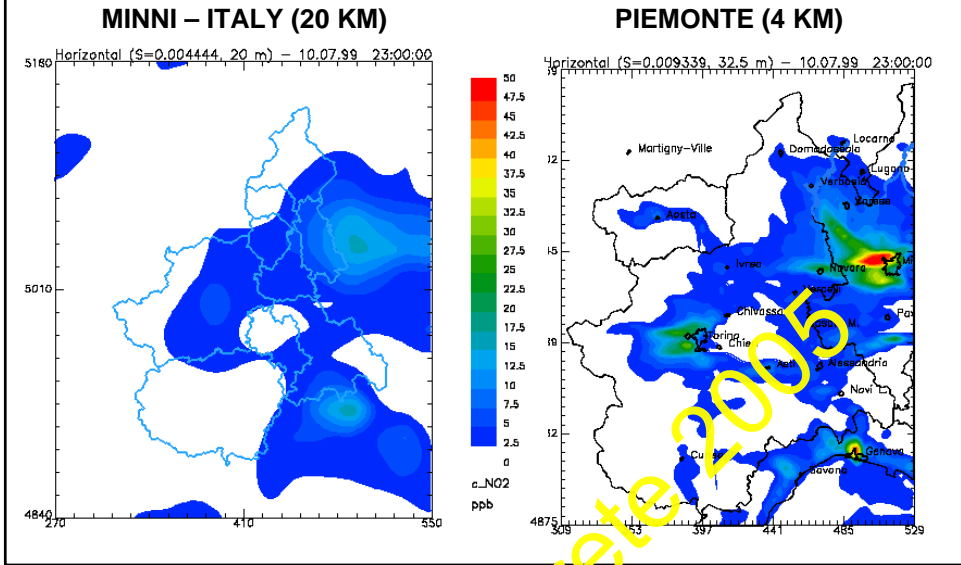
MINNIO - ITALY (20 KM)



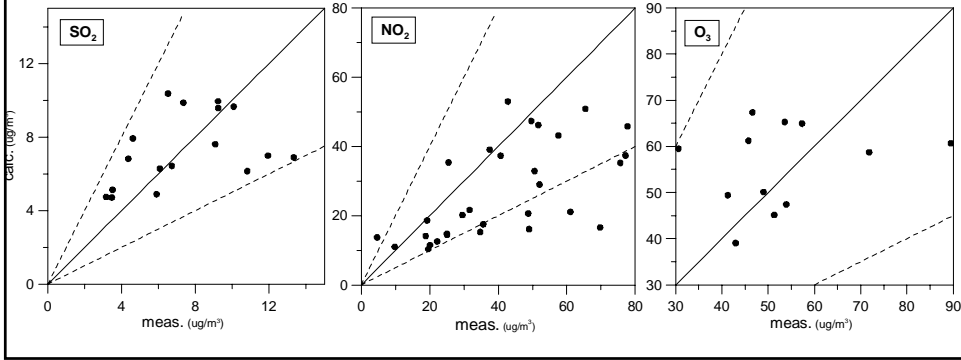
PIEMONTE (4 KM)



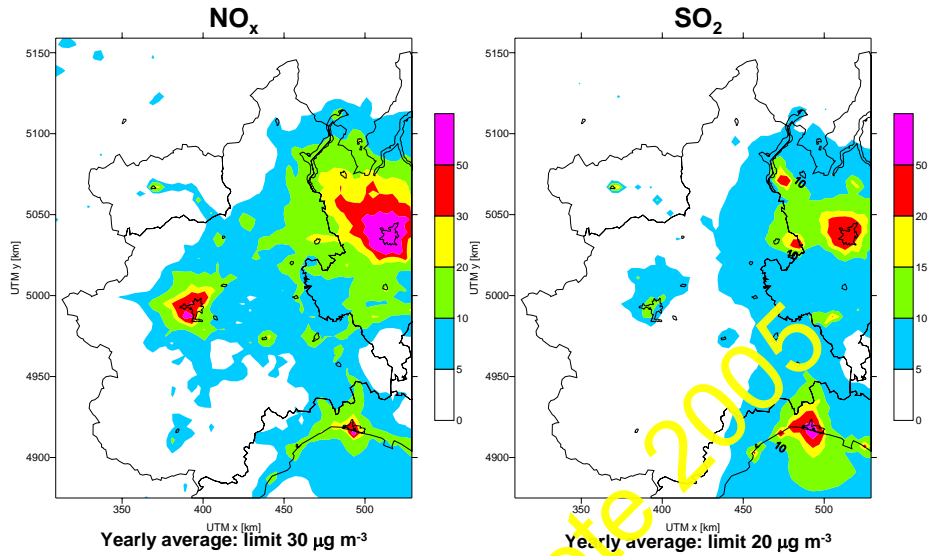
SPATIAL RESOLUTION EFFECTS
Nitrogen dioxide at ground



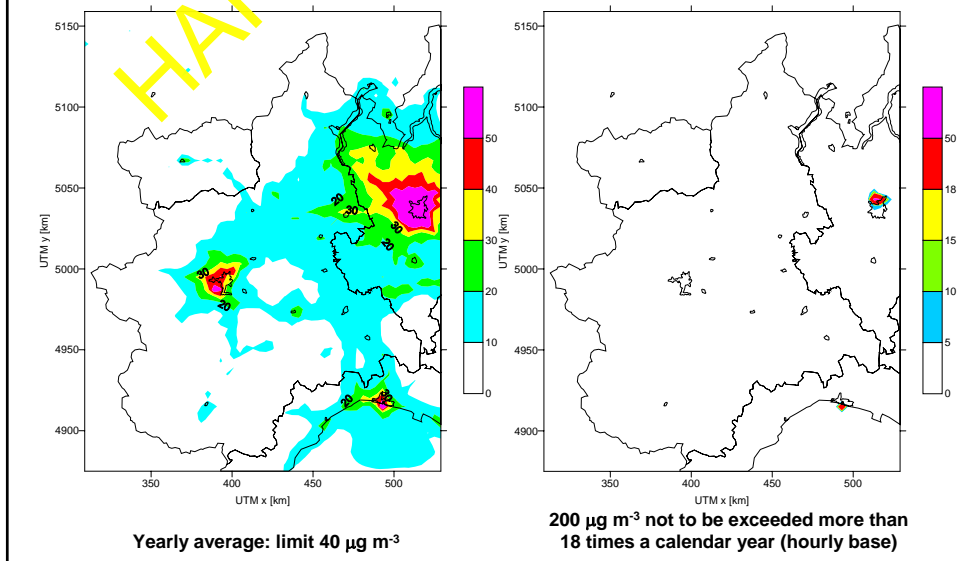
Assessment under EU Air Quality Directives
Model validation by measurement in the same zone (yearly averages)



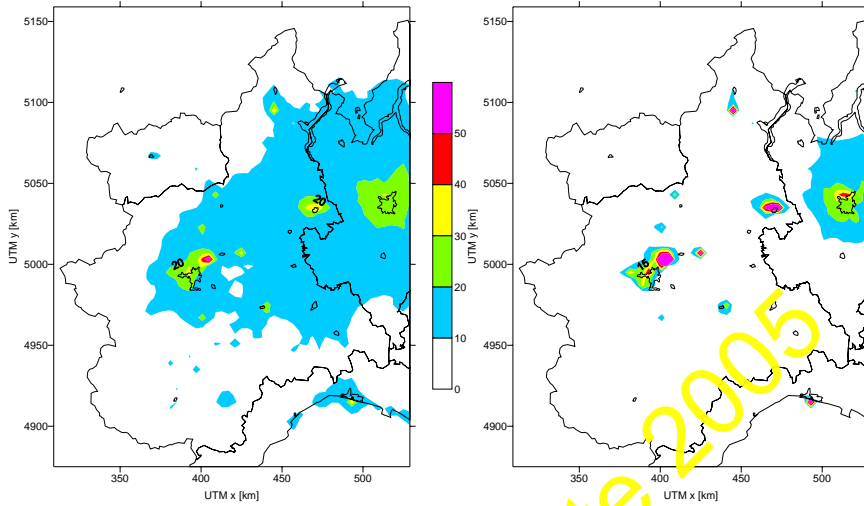
Assessment of the Limit Values for the protection of ecosystems



Assessment of the Limit Values for the protection of human health (NO₂)



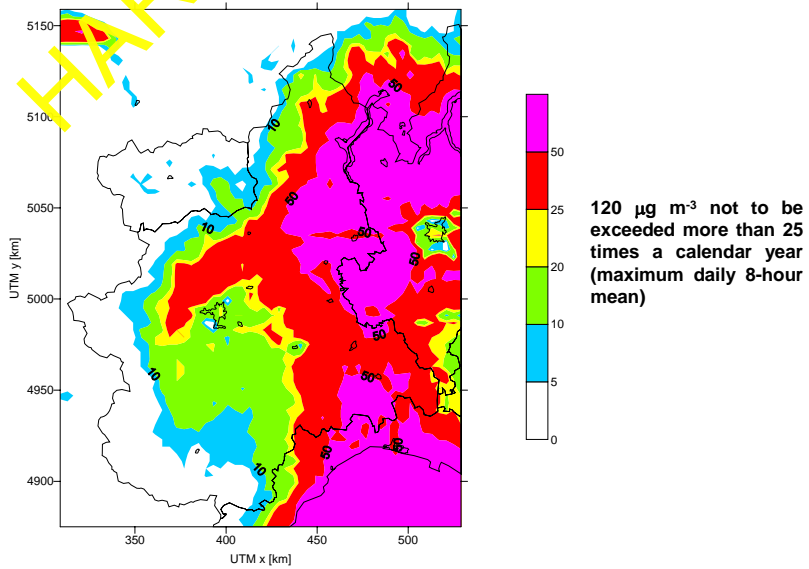
Assessment of the Limit Values for the protection of human health (PM₁₀)



Yearly average: limit 40 µg m⁻³

50 µg m⁻³ not to be exceeded more than 35 times a calendar year (daily base)

Assessment of the Limit Values for the protection of human health (O₃)



120 µg m⁻³ not to be exceeded more than 25 times a calendar year (maximum daily 8-hour mean)

Air Quality Management

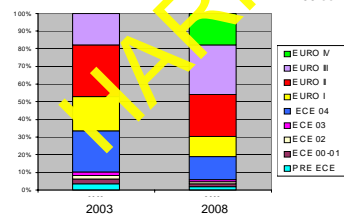
...air quality models have an important place in air quality management. They are essential tools in the development of action plans for improving air quality, which is the ultimate goal of the Member States and local authorities in order to fulfil their obligations under the directives.

From: *Guidance on Assessment under the EU Air Quality Directives*, EEA 2002

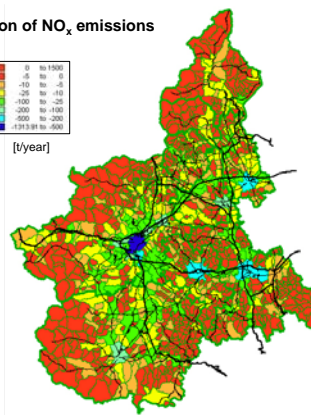
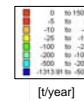


Impact of year 2008 vehicles fleet

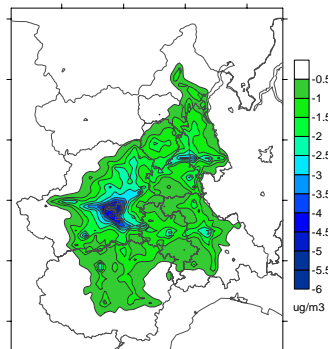
Fleet projection
Example: COPERT classes of gasoline cars > 1400 cc



Variation of NO_x emissions



Variation of NO₂ yearly avg. concentrations



Impact of future buildings heating sector

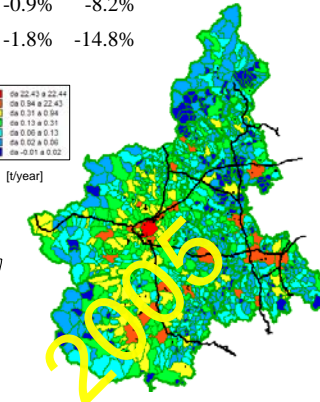
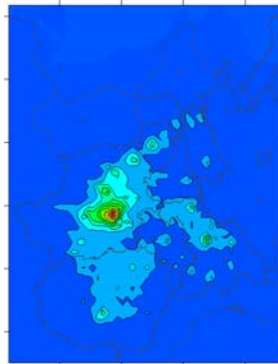
- Changes of:
- fuels
 - boilers
 - buildings
 - district heating over 10 years



Changes in regional emissions

	NO _x	PM ₁₀	SO ₂
Macrosector 2	-39%	-21%	-73%
Yearly totals	-2.2%	-0.9%	-8.2%
Winter totals	-4.2%	-1.8%	-14.8%

Decrement of PM₁₀ avg. concentrations in cold season



Example: decrease of PM₁₀ emissions



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Air Quality Assessment update at 2004

Most significant changes from 1999 assessment:

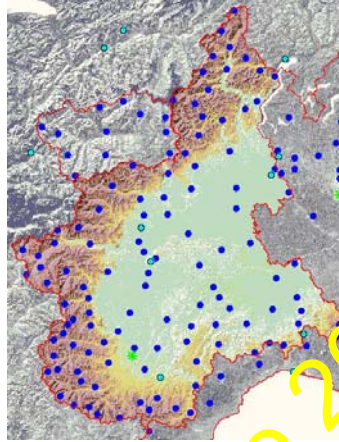
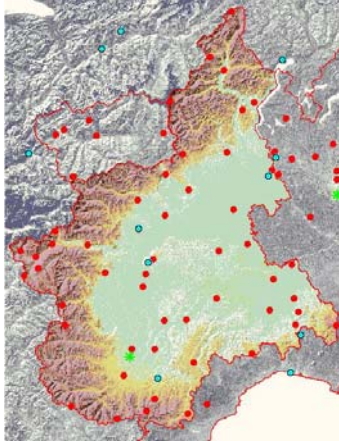
- use of local meteorological data;
- nesting on CHIMERE continental-scale model.



METEOROLOGICAL NETWORK Ground level stations

• wind ground stations

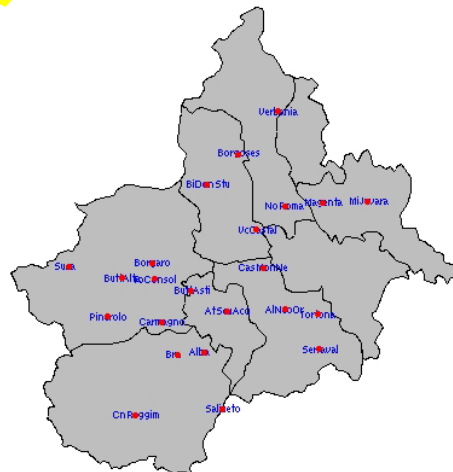
• temperature ground stations



+ radiosoundings
• synop stations

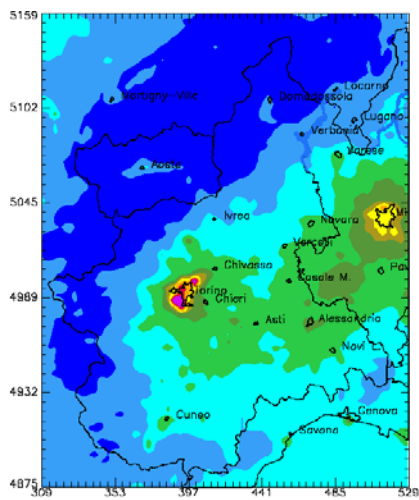


AIR QUALITY MONITORING NETWORK PM10 stations (with almost 90% of valid data)

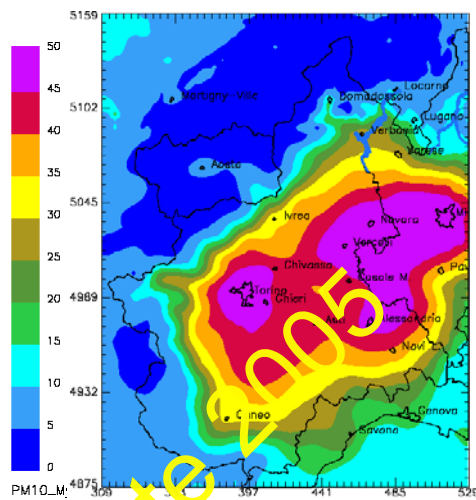


PM10 Yearly average (2004)

Model



Data assimilation
Successive correction scheme (ADAS)



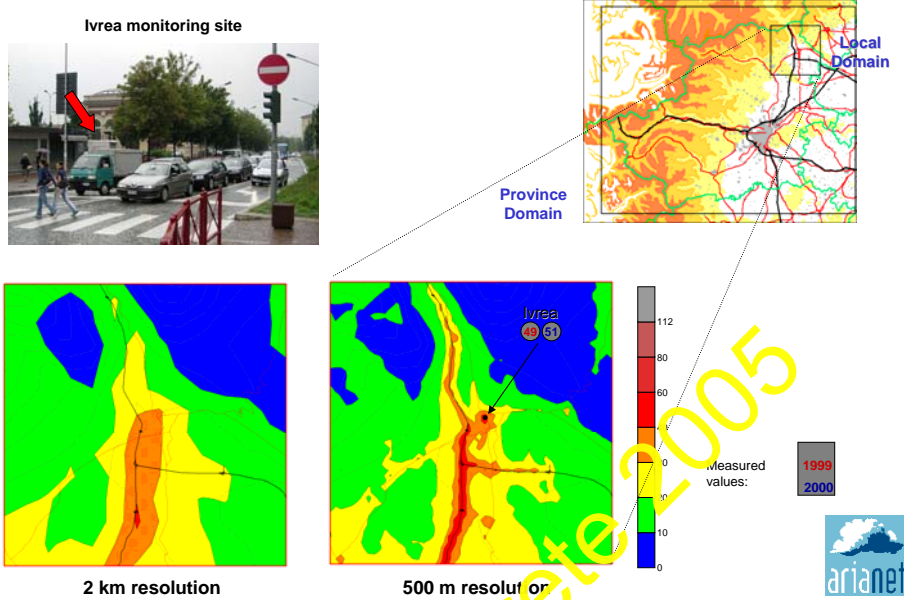
Yearly average: limit 40 $\mu\text{g}/\text{m}^3$

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Smaller scale study
(500 m resolution)



SPATIAL RESOLUTION EFFECTS
Ivrea, NO₂ yearly average



CONCLUSIONS

- Piemonte Region has implemented the Framework directive and daughter legislations using measurements (regional air quality network), emission inventories (INEMAR) and modelling techniques;
- the Air Quality Assessment for 1999 (downscaling of MINNI data) shows exceedances for ozone in large portions of the regional basin and for NO_x and PM₁₀ within Turin urban area;
- The use of the modelling system has permitted to estimate the impact of future emission scenarios (Air Quality Management);
- The Air Quality Assessment for 2004 year is terminated and 2005 is in progress;
- Simulation results claim for the use of a more complete aerosol module (aero3) and a better representation of PM₁₀ phenomenology

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- Gianluigi Truffo for his contribution to the preparation of the regional emission inventory
- ENEA for providing MINNI data used in this work (contact person: Dr. Gabriele Zanini: zanini@bologna.enea.it);
- EMEP for providing data (emission, concentrations) used in this work .

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