UNCERTAINTY AND VALIDATION OF URBAN SCALE MODELLING SYSTEMS APPLIED TO SCENARIO ANALYSIS IN TUSCANY, ITALY

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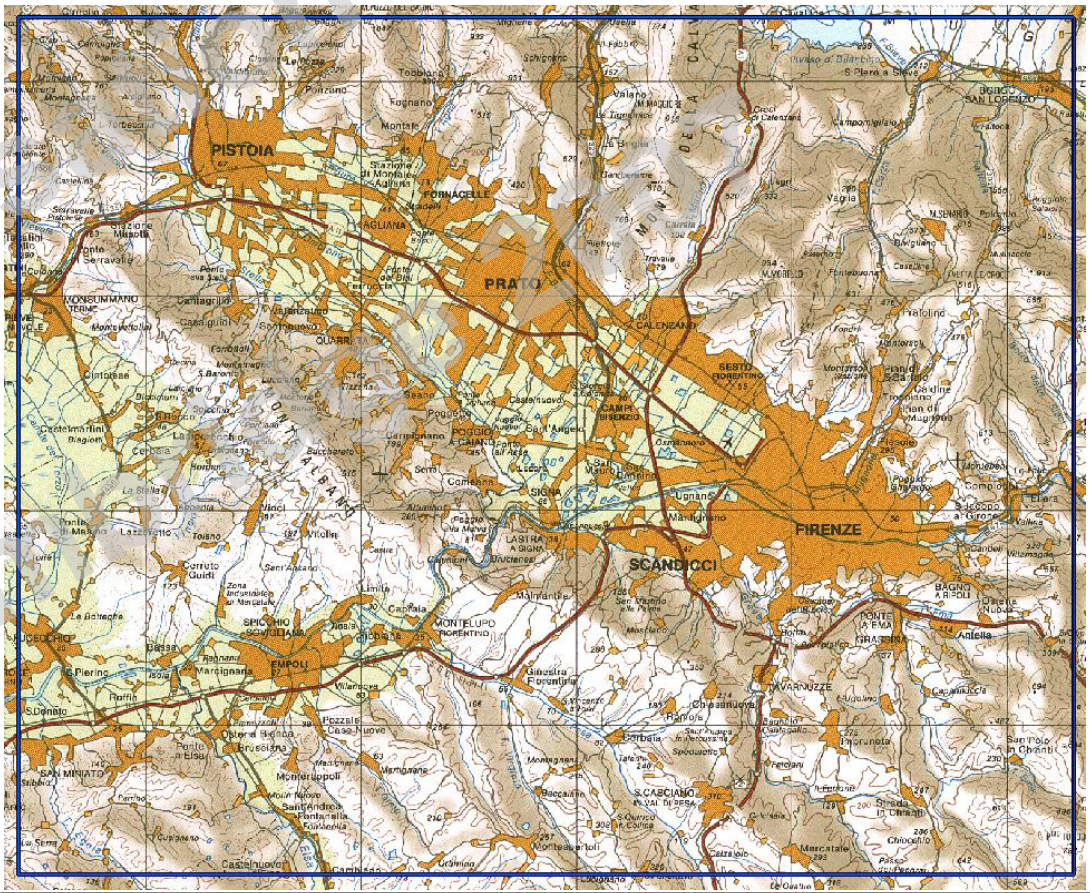
Introduction

The



Pistoia metropolitan area

Introduction

The MoDiVaSET project

Phase 1: *Preliminary study – concluded*

Year 2000 inventory – Analysis of critical factors – Preliminary sensitivity analysis, validation and uncertainty – Pollutants: PM_{10}, NO_X, SO_x

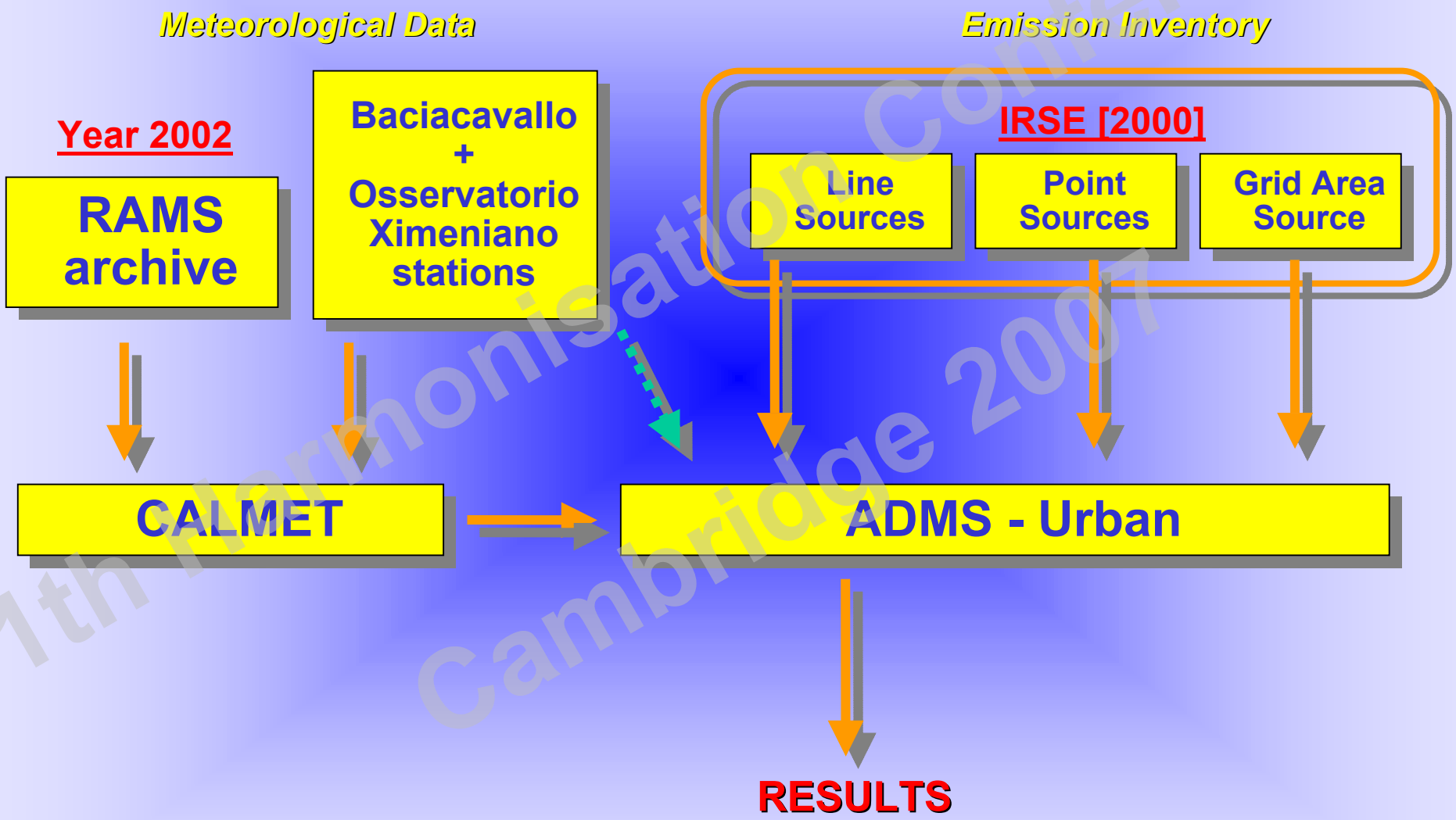
Phase 2: *Scenario analysis – in progress*

Year 2003 inventory – 2012 scenarios: BAU and modified – Pollutants: PM_{10}, NO_X

Phase 3: *Improvements - ???*

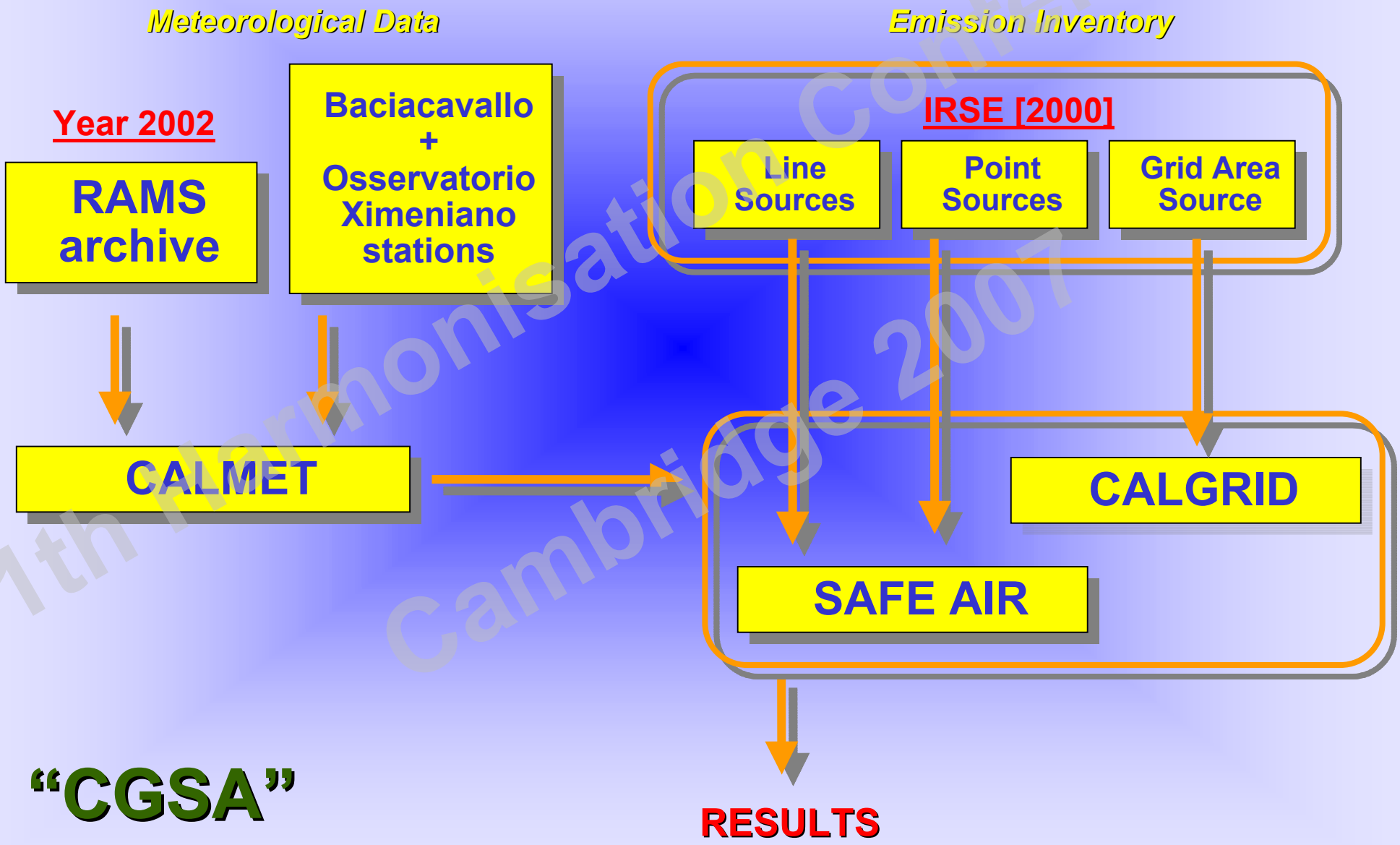
Year 2005 inventory – new scenarios – other pollutants – chemical mechanisms – multi-scale approach

Modelling Systems - 1



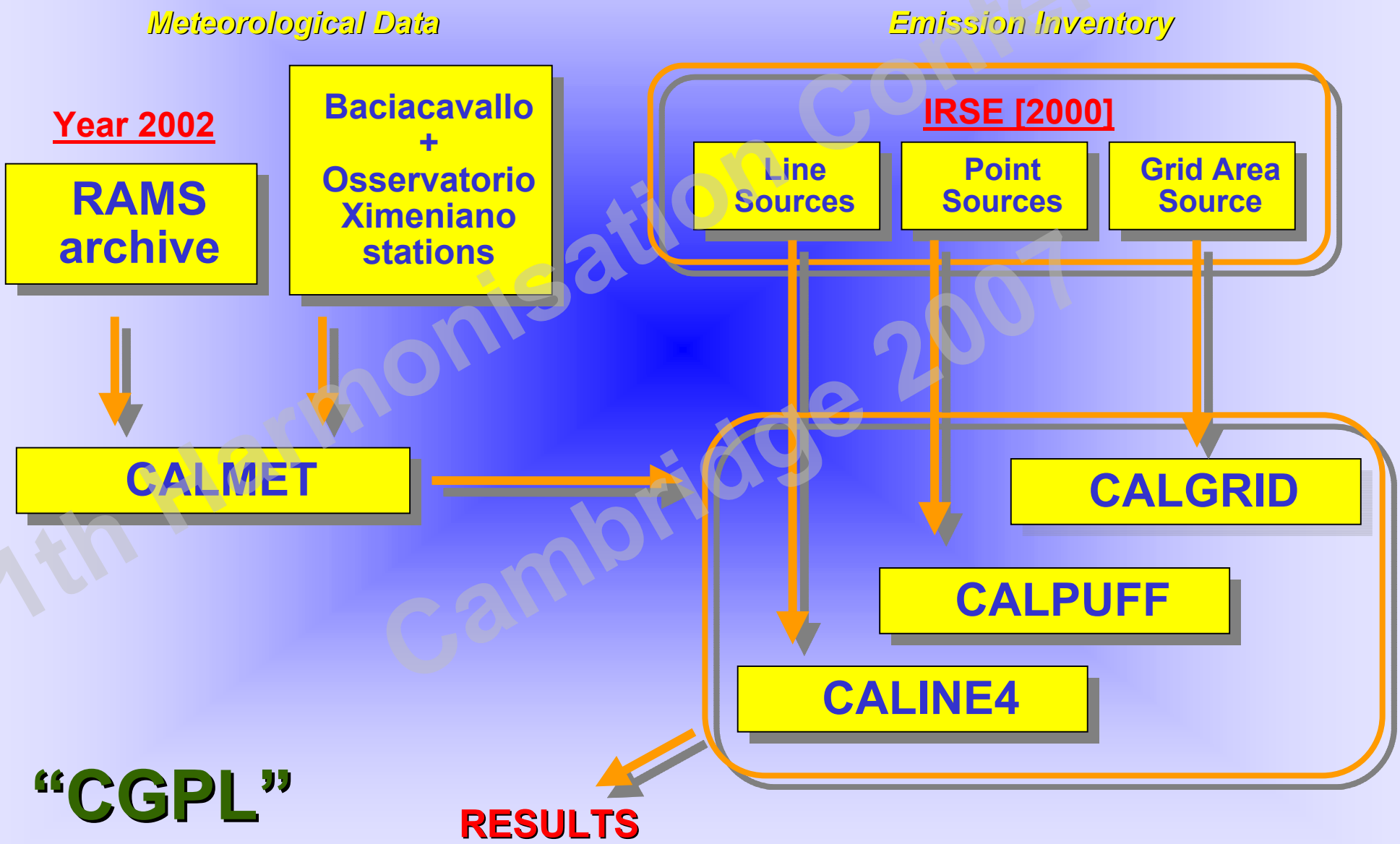
"ADMS"

Modelling Systems - 2

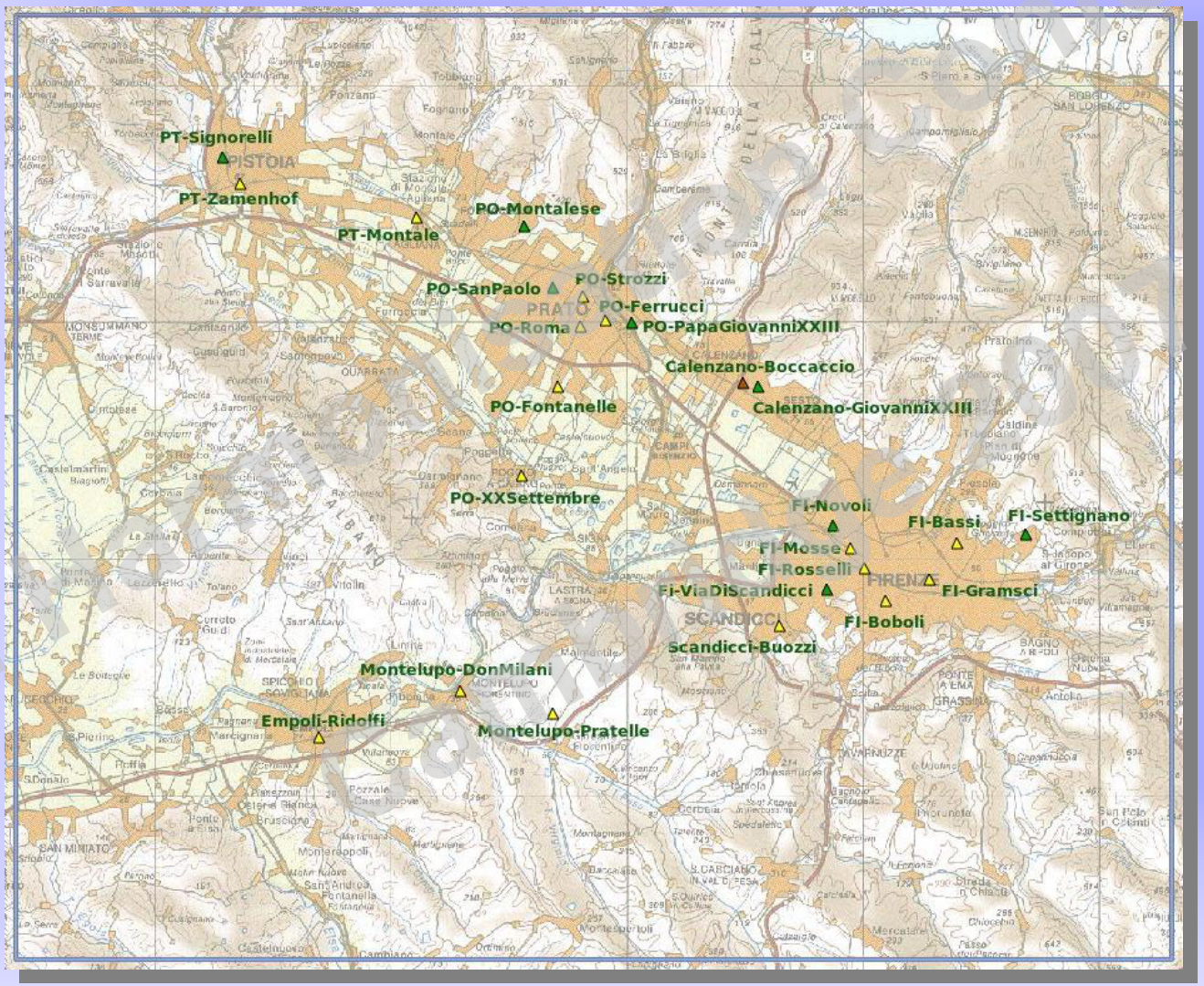


"CGSA"

Modelling Systems - 3



Validation and Uncertainty



Monitoring networks of Florence, Prato and Pistoia:

25 monitoring stations (24 NO_2, 17 PM_{10} and 9 SO_2)

Validation and Uncertainty

Models Evaluation and Validation

Validation: method based on the use of statistical indices derived from the BOOT (Hanna, 1989), the MVK(Olesen, 1995 & 2005) and the indices of Poli & Cirillo(1993) **- MEAN, BIAS, FB, SIGMA, FS, COR, FA2, NMSE, WNNR, NNR**

Quality objectives and acceptability criteria :

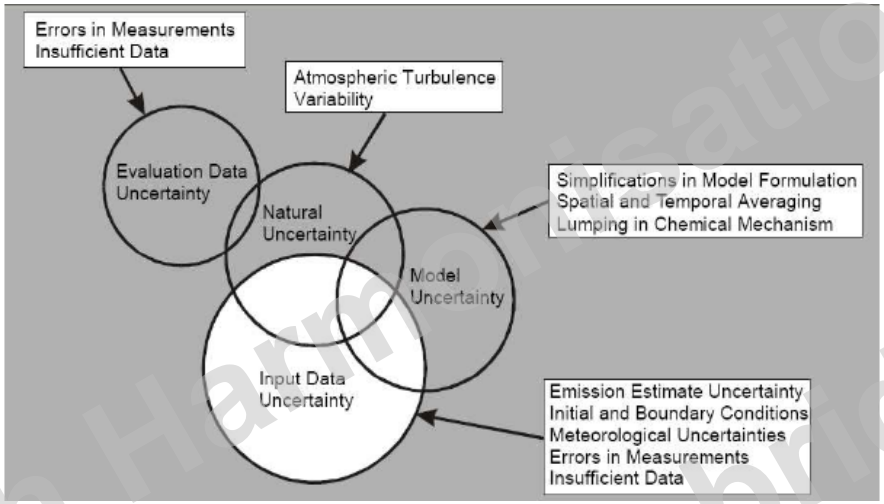
(1) Chang & Hanna criteria (2004):
FA2>0.5, -0.3<FB<0.3, NMSE<4

(2) Quality objectives of the EEC directives based on the results "accuracy"

Pollutant	Quality indicator	Quality objective	Directive
SO_2, NO_2, NO_x	Hourly mean	50–60%	1999/30/EC
	Daily mean	50%	
	Annual mean	30%	
PM, Pb	Annual mean	50%	
CO	8-h mean	50%	2000/69/EC
Benzene	Annual mean	50%	
Ozone	8-h daily maximum	50%	2002/3/EC
	Hourly mean	50%	

Validation and Uncertainty

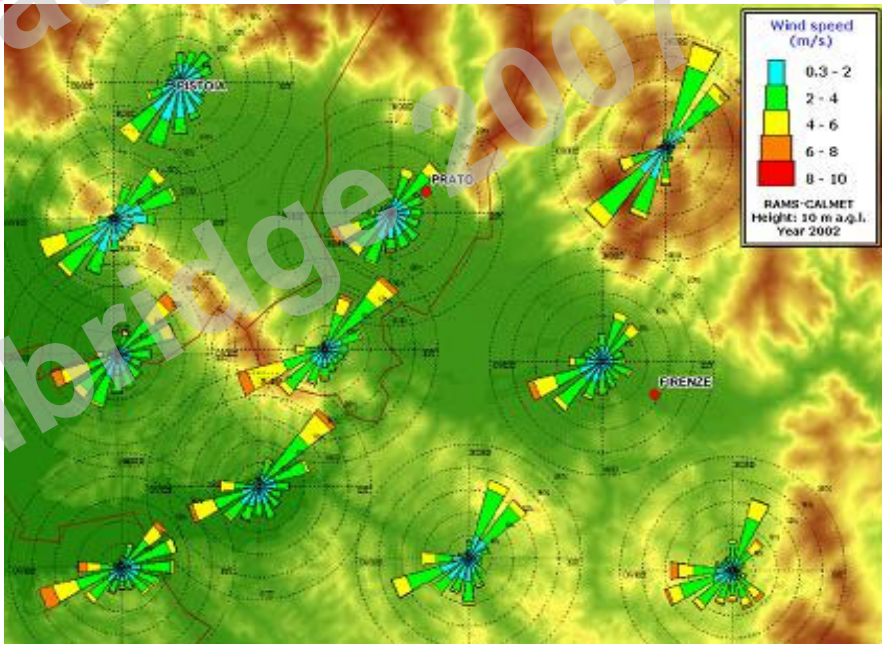
Models Evaluation and Validation



Uncertainty analysis: bottom-up method
Based on the estimation of the single error sources and, then, on the statistical calculation of the overall error.

Uncertainty analysis: top-down method (Colvile et al. 2002)
the single error sources are not considered, but the overall error is quantified by means of a high number of measures sufficiently representative of the phenomenon

Meteorological data



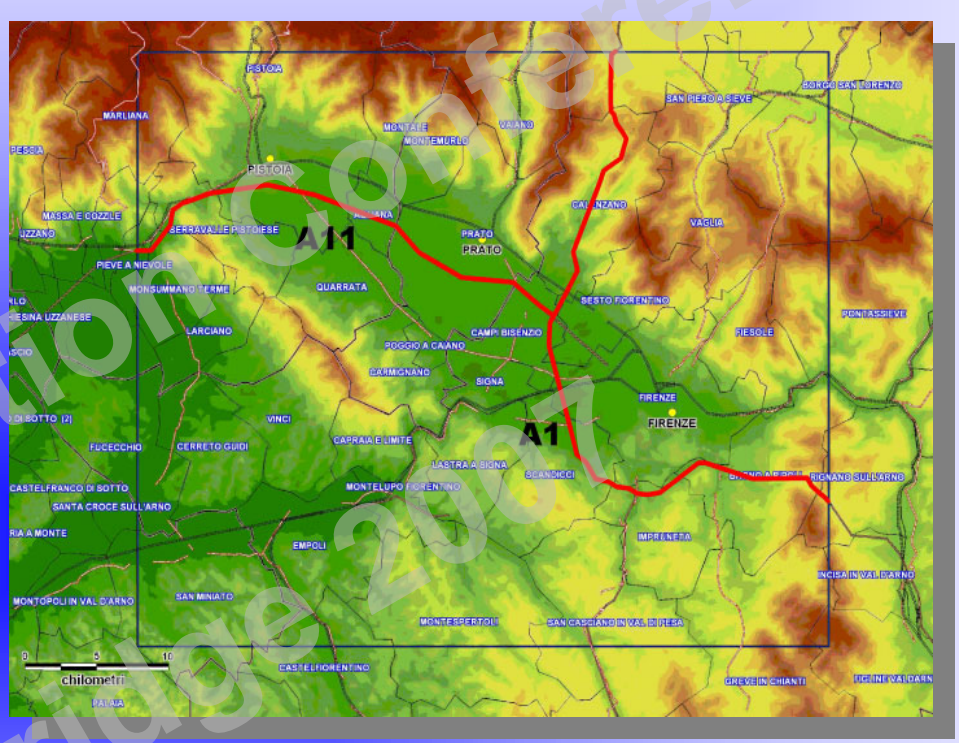
Concentration time series

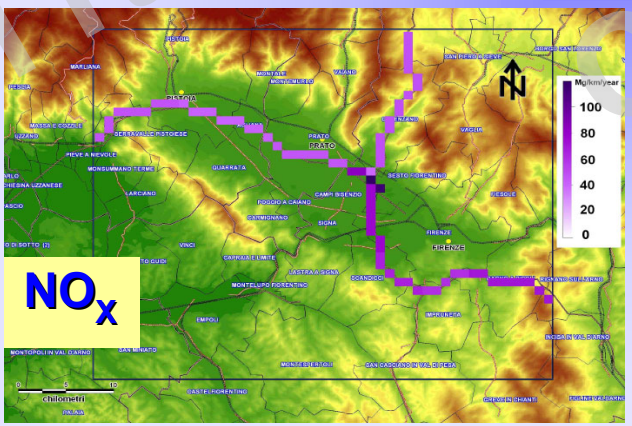
Emissions – Line Sources

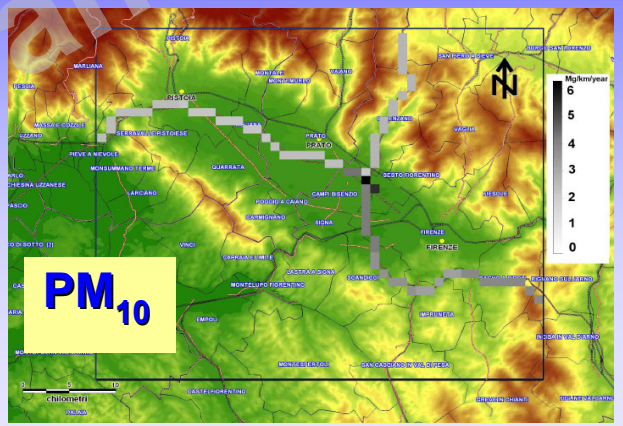
LINE SOURCES

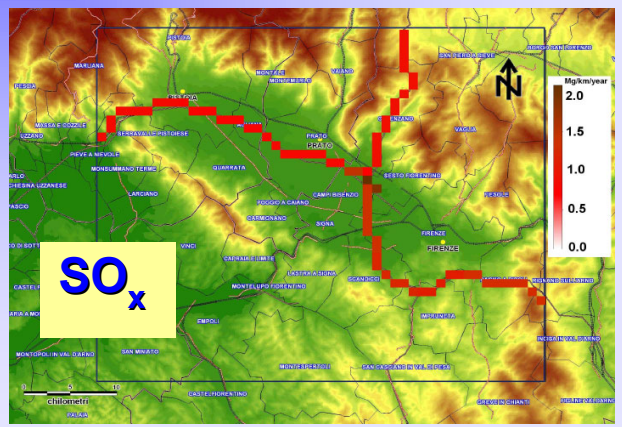
Schematization:
79 straight-line segments

Hour-by-hour EMISSIONS:
provided by IRSE regional inventory



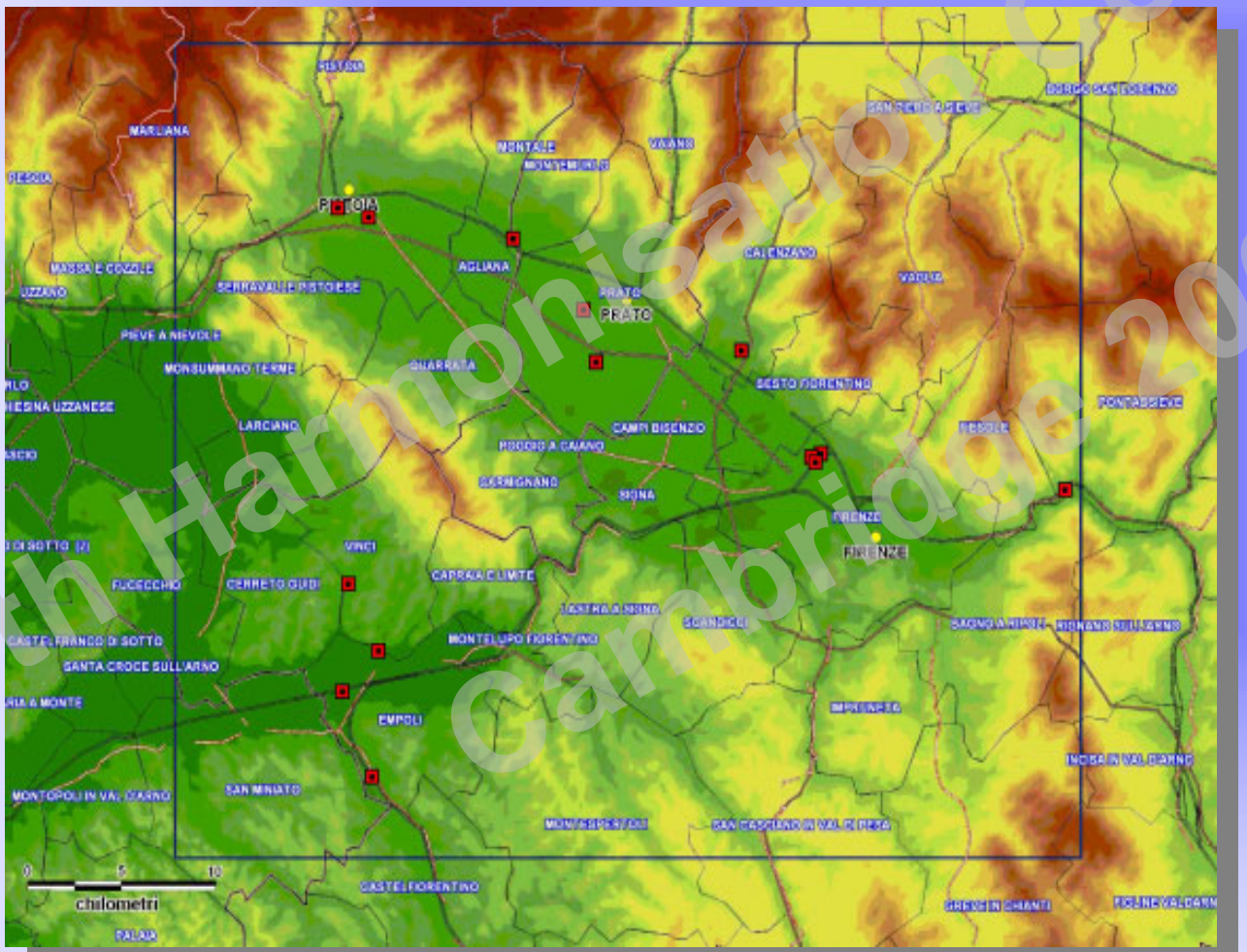






Emissions – Point sources

POINT SOURCES



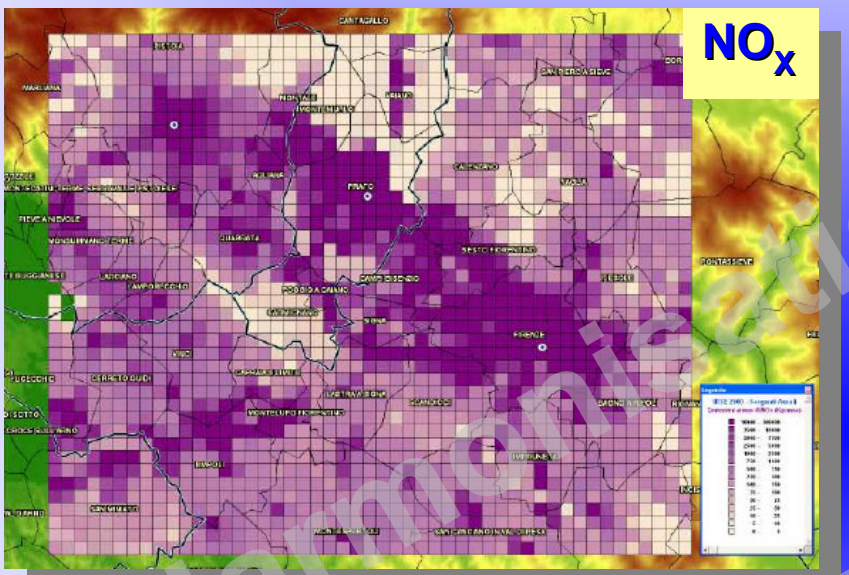
15 plants

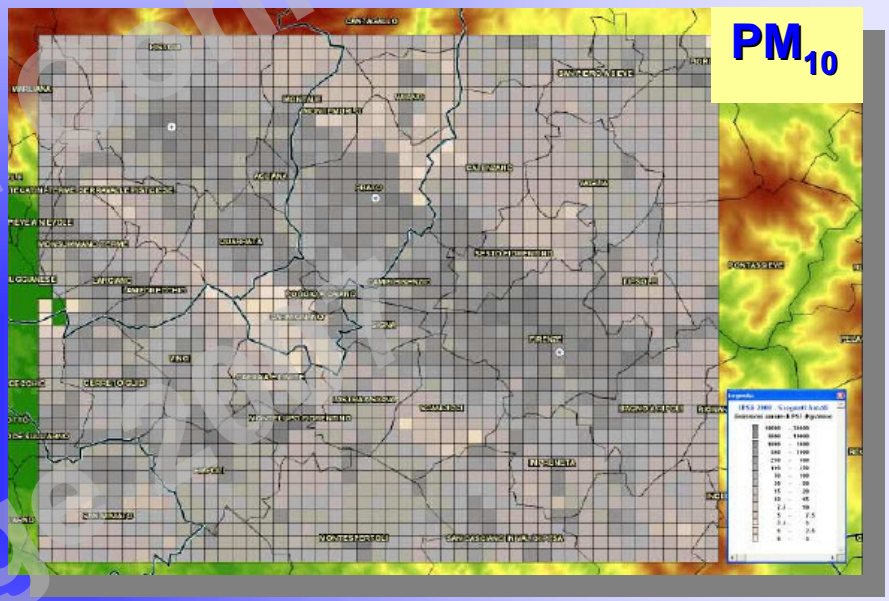
87 industrial stacks

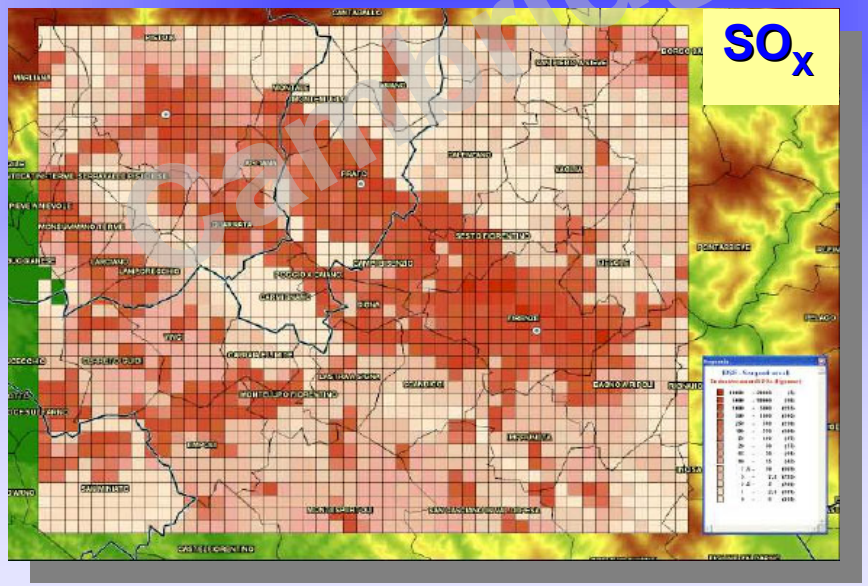
Emissions and geometrical parameters retrieved from IRSE regional inventory

Emissions – Area sources

GRID SOURCE



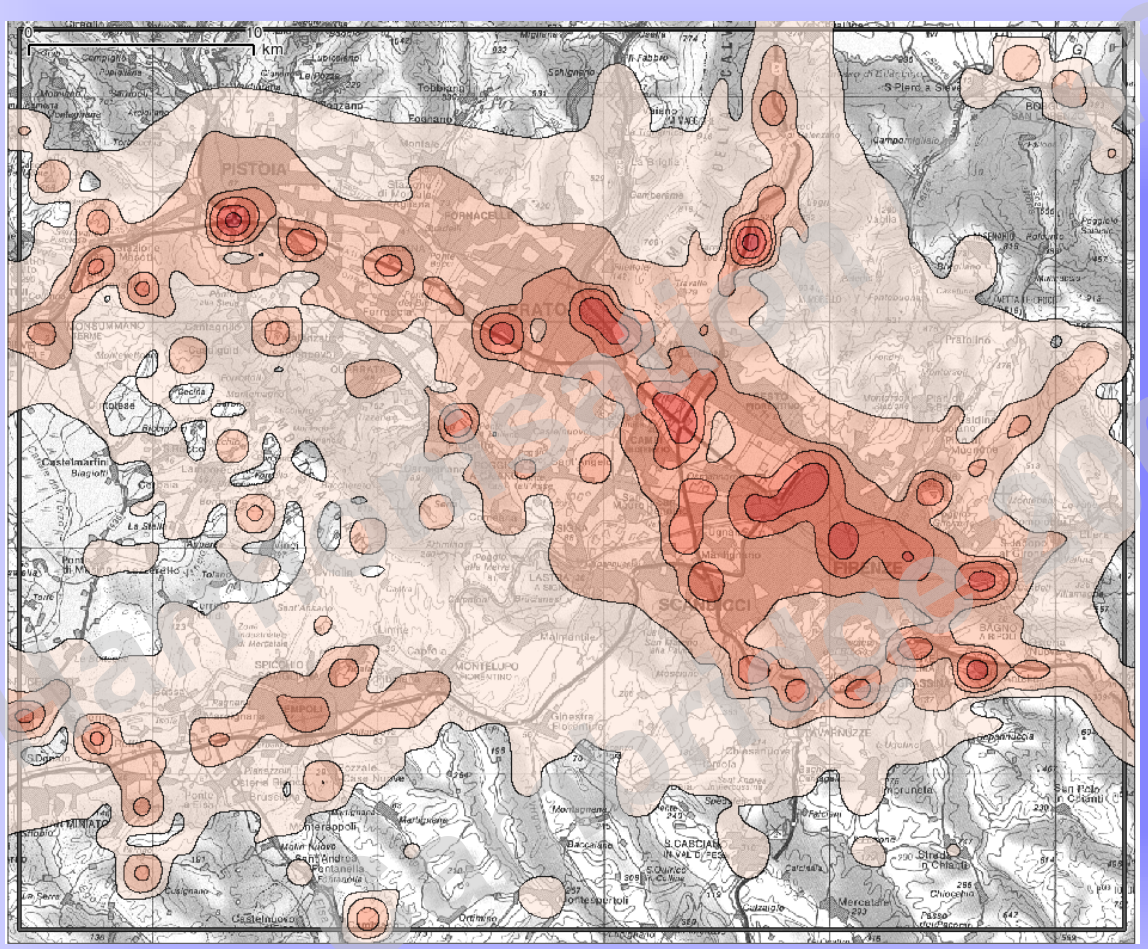




1x1 km2 cell

Hour-by hour emissions by IRSE

Model results

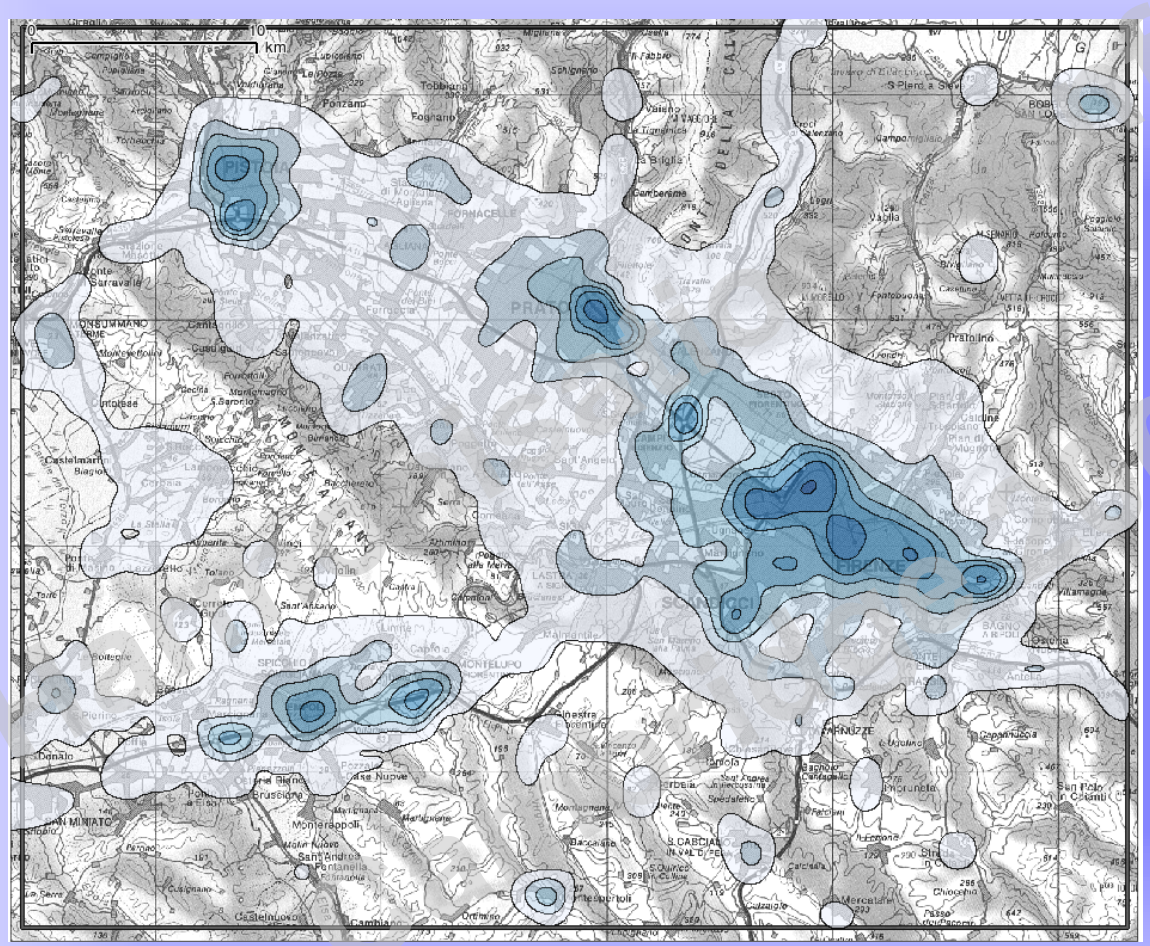


All the sources

100 µg/m³
75 µg/m³
50 µg/m³
30 µg/m³
20 µg/m³
10 µg/m³
5 µg/m³
0 µg/m³

NO_X

Model results

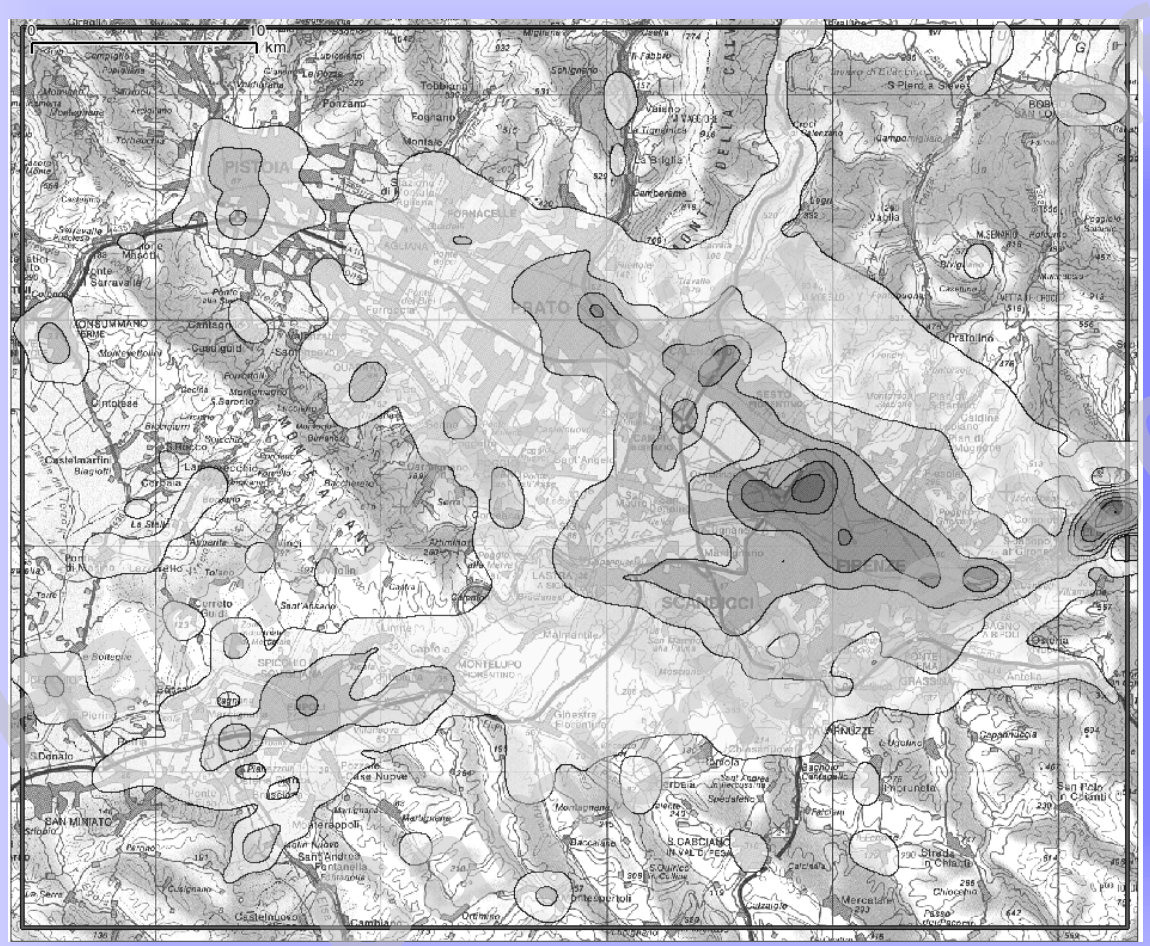


All the sources

5 µg/m³
3.5 µg/m³
2.5 µg/m³
2 µg/m³
1.5 µg/m³
1 µg/m³
0.5 µg/m³
0 µg/m³

PM_{10}

Model results



All the sources

5 µg/m³
3.5 µg/m³
2.5 µg/m³
1.5 µg/m³
1 µg/m³
0.5 µg/m³
0.25 µg/m³
0 µg/m³

SO_2

Validation exercise

Model Intercomparison

NO_2*

Background

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Montelupo Pratelle	28.6	4.2	11.1	8.2
FI – Montelupo Don Milani	31.8	8.4	9.7	7.8
FI – Scandicci Buozzi	47.5	18.7	29.0	20.4
FI – Bassi	37.8	18.8	30.3	26.1
FI – Boboli	30.7	20.3	26.6	20.9
PO – Fontanelle	36.9	11.9	23.9	15.0
PT – Montale	32.2	10.6	20.9	15.2

Table 1: NO_2 annual mean concentrations [µg/m³] – background monitoring stations

Traffic

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Empoli Ridolfi	58.2	25.0	11.5	11.1
FI – Mosse	66.7	23.9	32.1	27.7
FI – Rosselli	86.0	36.2	27.8	23.1
FI – Gramsci	69.1	23.9	26.4	21.2
PO – Ferrucci	48.6	50.1	30.9	21.2
PO – Strozzi	49.5	18.2	30.1	22.2
PT – Zamenhof	38.6	20.2	25.2	20.6

Table 2: NO_2 annual mean concentrations [µg/m³] – urban monitoring stations

FB: 0.84 (CGSA)
- 0.61 (CGPL)

COR: 0.25 (CGPL)
- 0.62 (ADMS)

FA2: 0.27 (CGSA)
- 0.60 (CGPL)

NMSE: 1.12 (CGSA)
- 0.65 (CGPL)

*** NO_X-NO_2 correlation: Derwent and Middleton (1996) formula**

Validation exercise

Model Intercomparison

SO_2

Background

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Scandicci Buozzi	2.80	1.44	2.22	1.53
FI – Bassi	3.78	1.33	2.44	1.85
FI – Boboli	2.93	1.52	2.09	1.46
PT – Montale	3.12	0.43	0.81	0.45

Table 3: SO_2 annual mean concentrations [µg/m³] – background monitoring stations

Traffic

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Empoli Ridolfi	3.05	1.26	1.04	0.79
FI – Mosse	2.72	2.21	3.31	2.39

Table 4: SO_2 annual mean concentrations [µg/m³] – urban monitoring stations

FB: 0.77 (ADMS) to 0.43 (CGPL)

FA2: 0.50 (CGSA) to 0.67 (CGPL)

NMSE: 0.82 (ADMS) to 0.35 (CGPL)

Validation exercise

Model Intercomparison

PM_{10}

Background

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Calenzano Boccaccio	38.1	1.2	2.9	2.1
FI – Montelupo Pratelle	46.7	0.5	1.7	1.4
FI – Montelupo Don Milani	31.1	1.6	1.6	1.4
FI – Bassi	42.6	2.4	3.6	3.2
FI – Boboli	37.6	2.7	2.9	2.4
PO – Fontanelle	39.5	1.2	2.1	1.5
PT – Montale	53.6	1.1	1.7	1.2

Table 5: PM_{10} annual mean concentrations [µg/m³] – background monitoring stations

Traffic

Monitoring Station	Measurements	ADMS	CGPL	CGSA
FI – Empoli Ridolfi	26.0	3.4	1.9	1.6
FI – Mosse	38.3	3.5	4.1	3.6
FI – Rosselli	47.3	4.9	3.3	2.9
FI – Gramsci	52.0	3.3	3.0	2.5
PO – Ferrucci	30.3	6.3	2.9	2.0
PO – Strozzi	55.4	2.3	2.9	2.2

Table 6: PM_{10} annual mean concentrations [µg/m³] – urban monitoring stations

FB: 1.80 (CGSA) to 1.76 (ADMS)

FA2: 0.00

NMSE: 18.0 (CGSA) to 14.1 (CGPL)

Validation exercise

Rural Background

Urban Traffic

Urban Background

Urban Background

Monitoring Station	FI – Boboli	FI - Settignano	FI – Mosse	FI – Scandicci Buozzi
FB	0.37	0.54	0.93	0.74
COR	0.19	0.14	0.16	0.35
FA2	0.45	0.33	0.28	0.40
NMSE	1.42	2.24	1.64	1.22

Table 7: Validation statistical indices for NO_2 hourly time series

NO_2

Validation exercise

Urban Background

Urban Traffic

Urban Background

Urban Background

Monitoring Station	FI – Boboli	FI – Scandicci Buozzi	FI – Mosse	FI – Via di Scandicci
FB	0.62	0.39	0.17	0.08
COR	0.02	0.12	0.19	0.22
FA2	0.26	0.38	0.39	0.34
NMSE	4.47	2.11	2.25	2.11

Table 8: Validation statistical indices for SO_2 hourly time series

SO_2

Validation exercise

Urban Traffic

Urban Traffic

Urban Traffic

Urban Background

Monitoring Station	FI – Boboli	PO - Ferrucci	FI – Rosselli	FI – Empoli Ridolfi
FB	1.76	1.30	1.66	1.52
COR	0.03	0.22	0.46	0.09
FA2	0.00	0.05	0.00	0.02
NMSE	17.23	4.17	11.51	7.19

Table 9: Validation statistical indices for PM_{10} daily time series

PM_{10}

Uncertainty analysis

Accuracy in accordance with the EC directive

	NO2			SO2			PM10		
	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
ADMS	149%	83%	3%	157%	87%	8%	196%	174%	131%
CGPL	134%	64%	14%	117%	56%	19%	188%	175%	161%
CGSA	136%	86%	37%	150%	79%	13%	191%	180%	165%

Table 10: Accuracy, calculated according to the EC directive: all the monitoring stations

Precision in accordance with Colvile et al. (2002) method

	NO2	SO2	PM10
ADMS	51 %	73 %	76 %
CGPL	41 %	54 %	34 %
CGSA	37 %	61 %	37 %

Table 11: Calculated precision

Conclusions

Summary

Annual mean concentrations: the order of magnitude of NO2 and SO2 concentrations is correctly reproduced by the models. PM10 result is underestimated.

Statistical validation indices confirm this analysis; Chang & Hanna (2004) criteria are generally satisfied for FA2 and NMSE, not for FB (NO2 and SO2).

The accuracy criteria of EC directive are not satisfied due to a sistematic underestimation of the concentrations.

Hourly time series: despite the uncertainties, results show good agreement between observed and calculated concentrations.

FB, FA2 and NMSE indices are rather close to the Chang & Hanna criteria (except for PM10)

Conclusions

Main limitations

1- Regional Background

The interaction with the bigger spatial scales (regional and continental scale) must be included in the simulations

2- Local scale effects

Main cause of the underestimation at the monitoring points placed inside complex urban geometry; it is appropriate to include the interaction with the smaller scales in order to improve efficiency of the validation study

3- Secondary pollution

It assumes fundamental significance, especially for PM10

Conclusions

Current and future work

New (updated) emission scenarios – year 2003 / 2005(?)

Inclusion of background concentrations

Smaller scale effects: main urban canyons

Chemistry module – secondary pollution
Other models (CAMx – CMAQ - .....)

Acknowledgements:

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THANK YOU FOR YOUR ATTENTION !