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$PM_{2.5}$ dispersion in Venice area: a model validation

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OUTLINE

- $PM_{2.5}$ project presentation
- Model simulation
- Data comparison:
  - Statistical approach
  - Performance analysis
  - Multivariate analysis

Inorganic fraction

Dott.ssa S. Squizzato
Prof. G. Rampazzo

Organic fraction

Dott. M. Masiol
Dott. ssa E. Centanni
Prof. B. Pavoni

$PM_{2.5}$
(2009)

COLLABORATIONS

Arianet S.p.A.
Venice Water Authority
ARPAV
Port of Venice

Dispersion models

Ing. Eliana Pecorari
Prof. Rampazzo

PARTNERS

Ente Zona Industriale
Edison,
Enel SpA,
ENI SpA - Div R&M,
Polimeri Europa SpA

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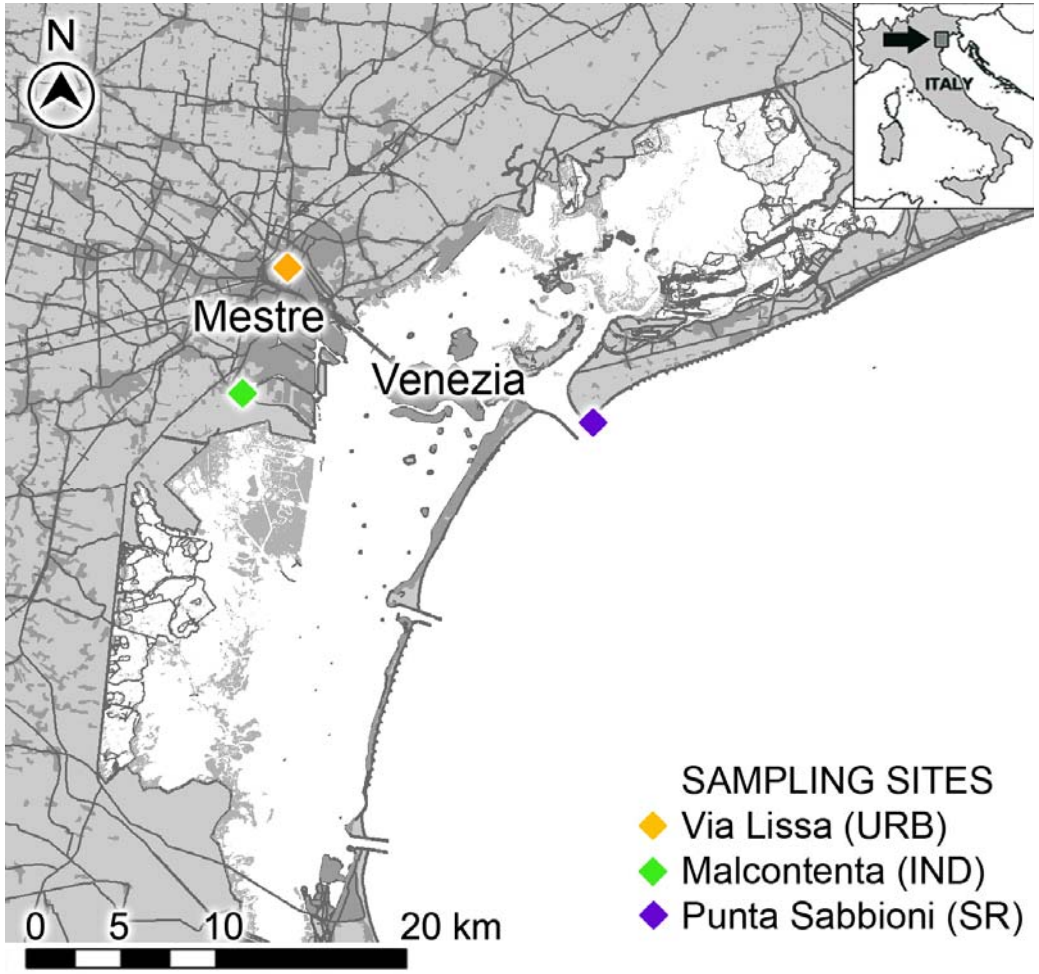

From January 1 2009 to January 31 2010, $PM_{2.5}$ samples were collected according to EN 14907:2005 with a low-volume sampler (2.3 m^3 h^{-1}) on quartz fiber filters (Whatman QMA).

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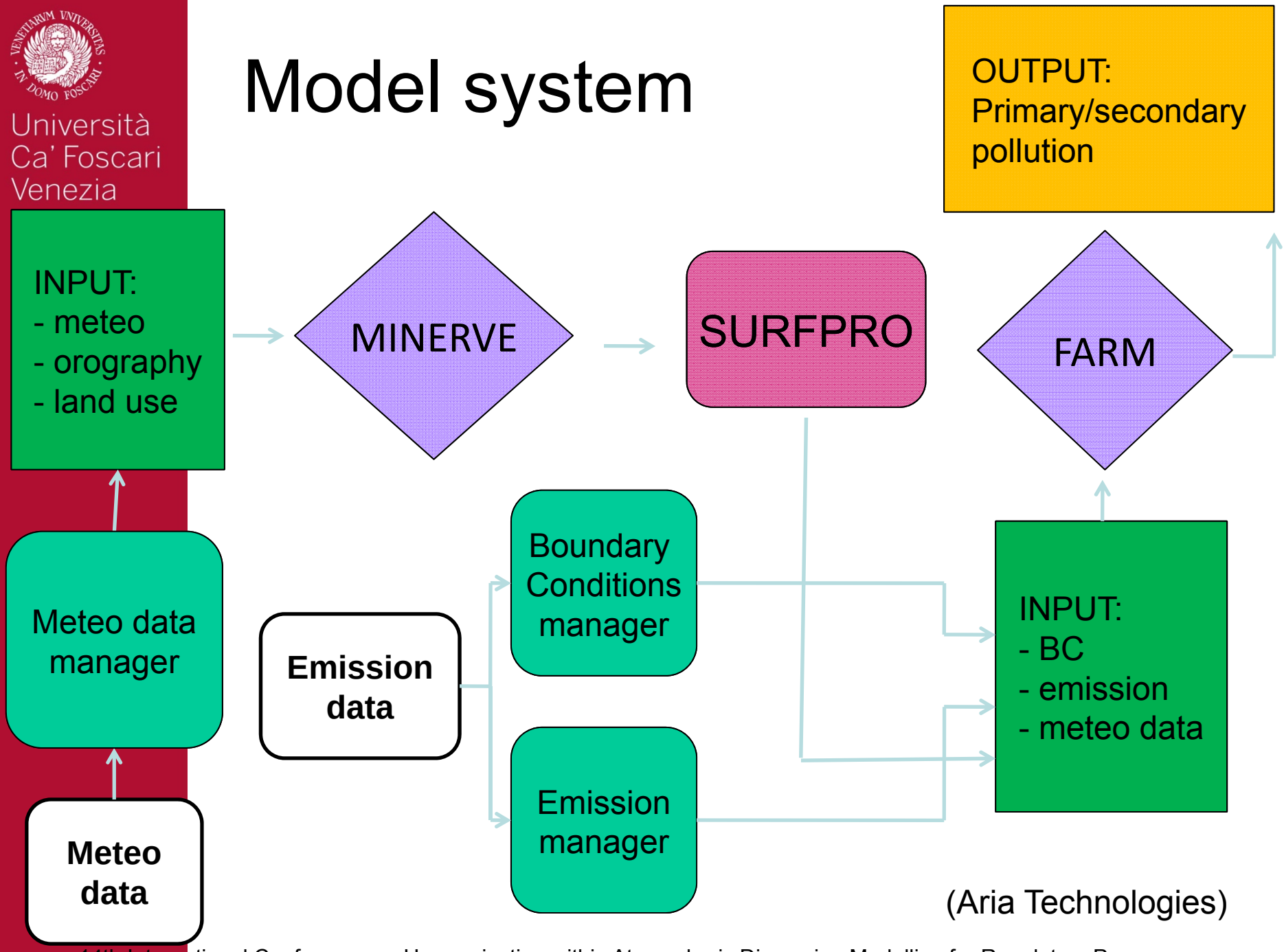
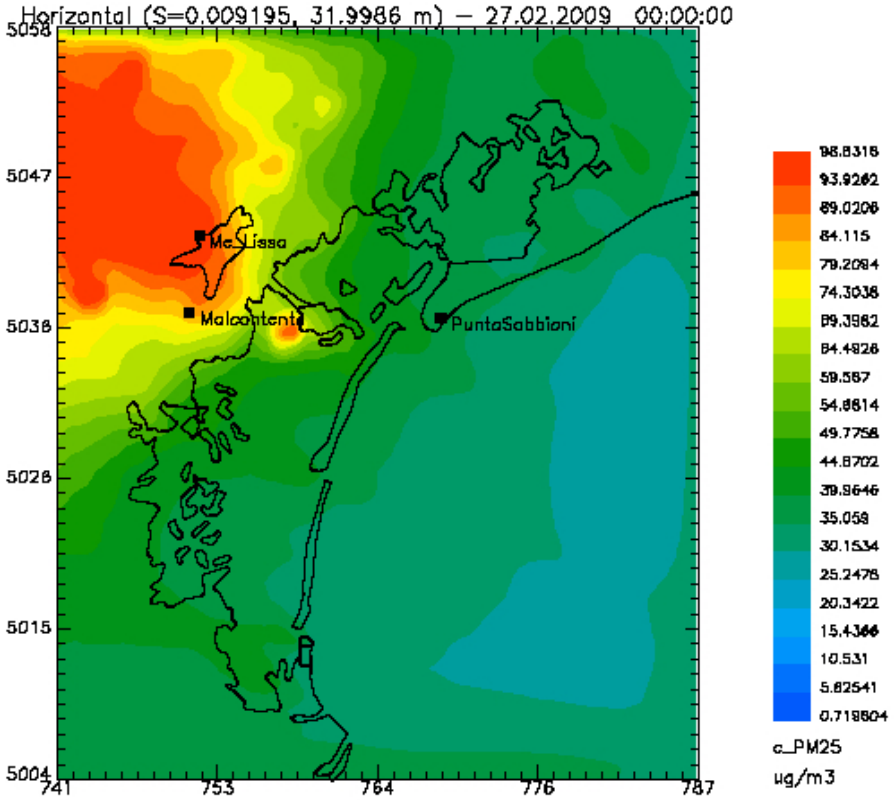
Model system





2009 Periods simulated:

Spring: 26/2 – 16/3

Summer: 11/6 – 16/7

Autumn: 5/10 – 31/10

Winter: 22/12 – 31/12

Spatial resolution: 47 x 55 cells at 1 km grid spacing

SAPRC-90 gas-phase chemical mechanism *Aero3* modal aerosol module

IC/BC: Air Quality Forecasting System *Quale Aria*

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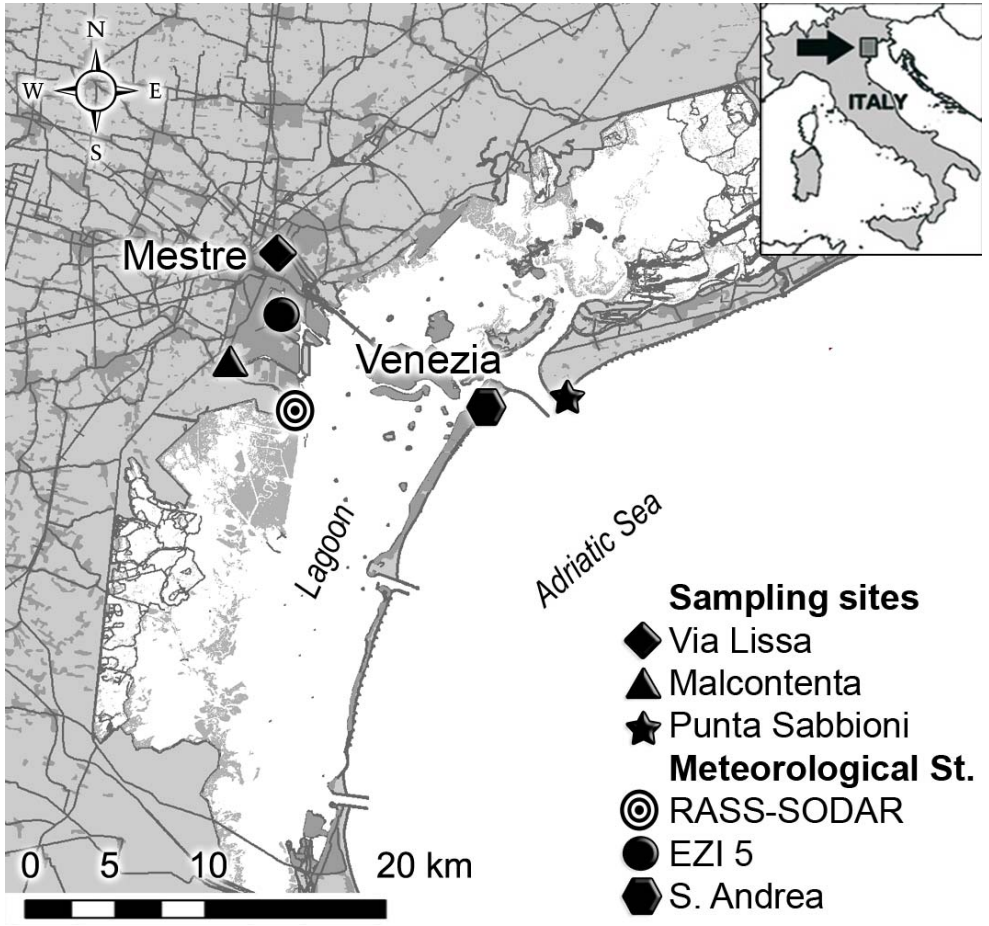
Meteorological data

- Surface stations
- Rass/Sodar data
- RAOB soundings



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Emission Treatment

- Two different approaches
  - Top-Down
  - Bottom-Up
- Veneto Region:

Local emission Inventory

Venice (ISPRA, 2005)

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Bottom-Up emission analysis

Industrial and
energy plants

Murano

glass factory

Ships and boat

Traffic

Airport

Bottom-Up emission analysis

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2009

Industrial and energy plants

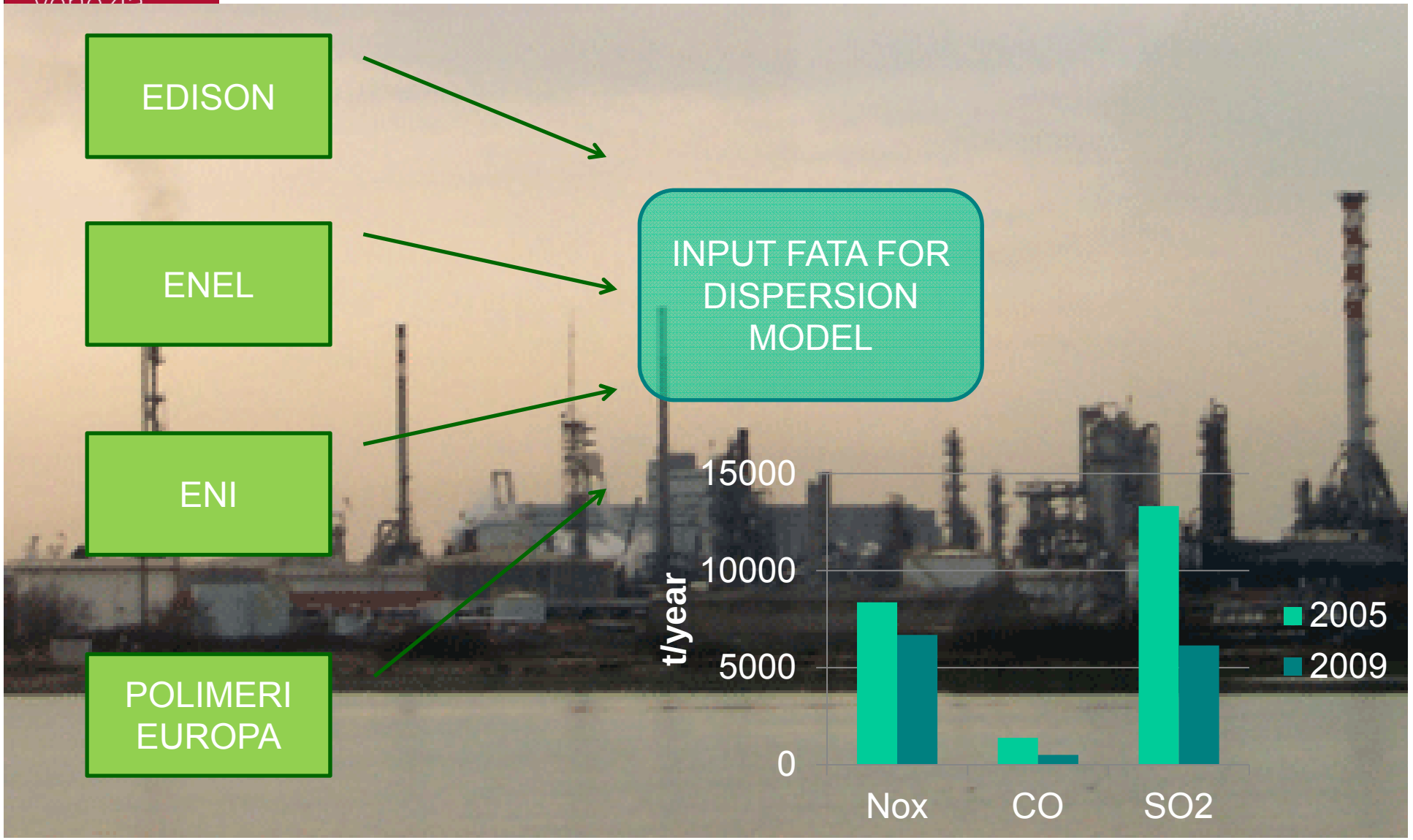
Murano glass factory

Ships and boat

Traffic

Airport

Industrial and energy plants
- Porto Marghera, Venice -



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Data Comparison

- $PM_{2.5}$
- Water soluble ions (NH_4^+, NO_3^- and SO_4^{2-})

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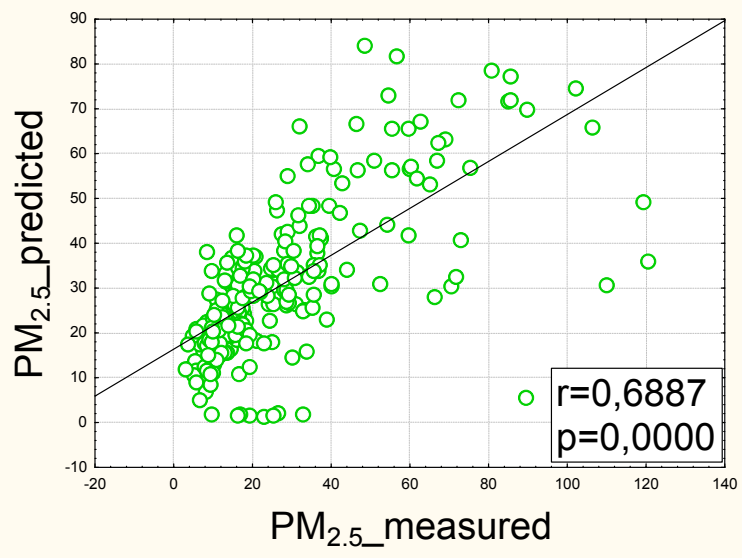
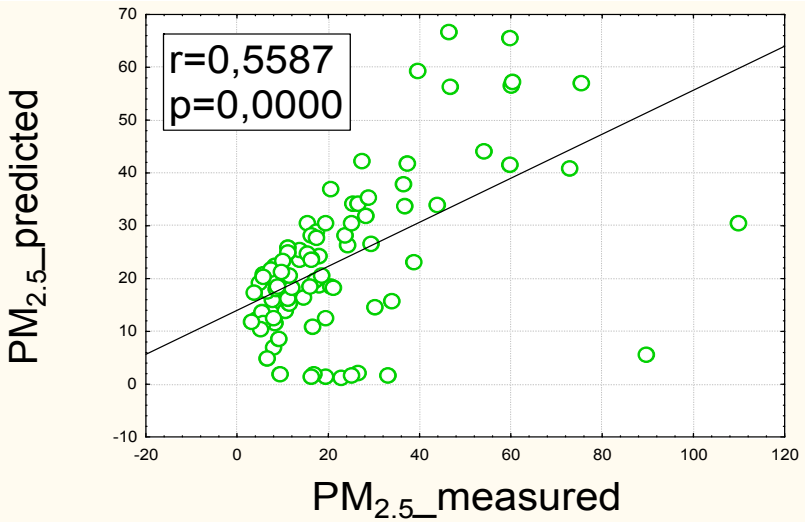
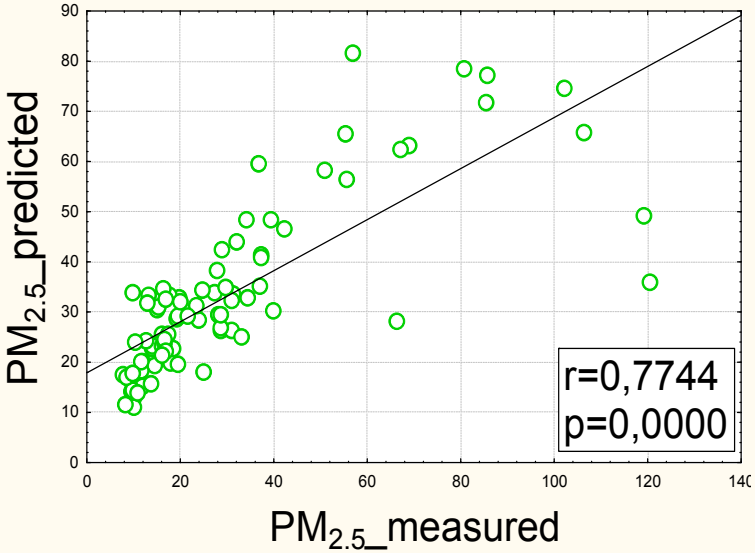
TOTAL



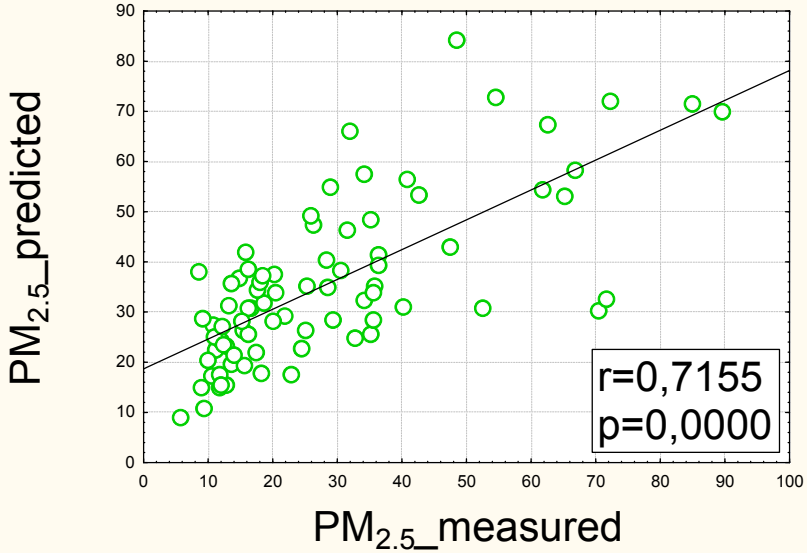
SEMI RURAL



URBAN



INDUSTRIAL



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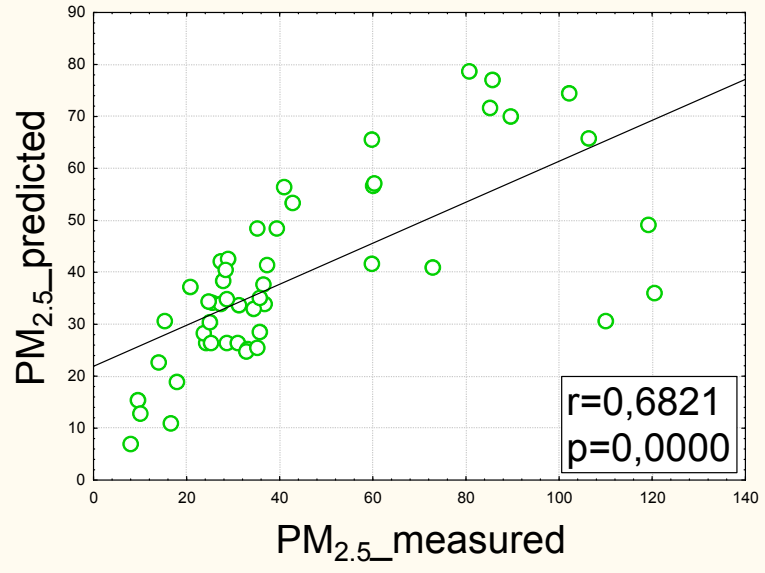
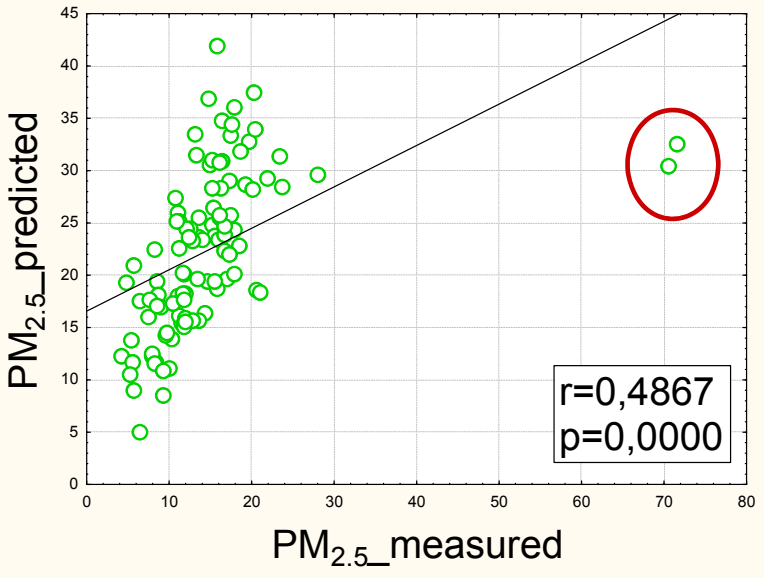
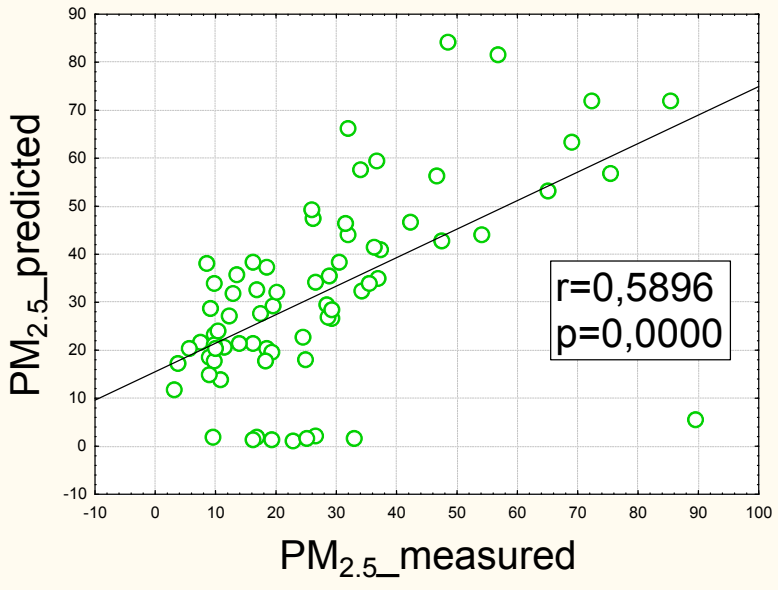
SPRING



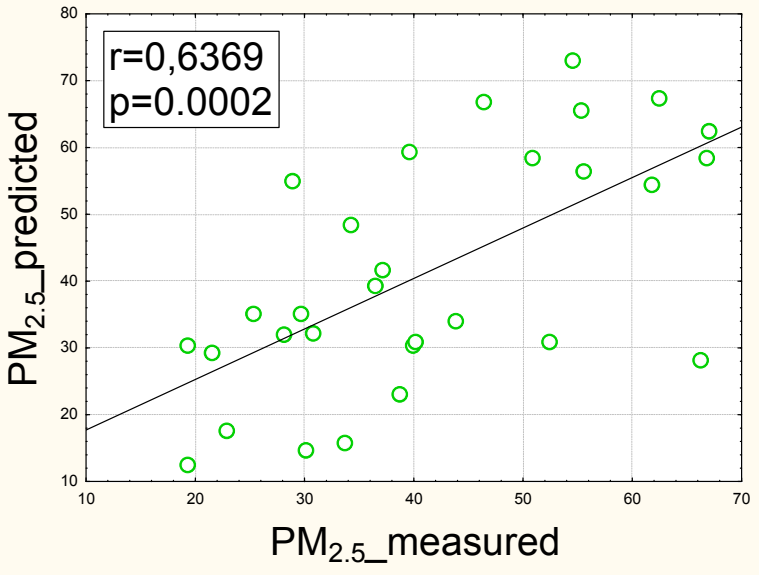
SUMMER



AUTUMN



WINTER



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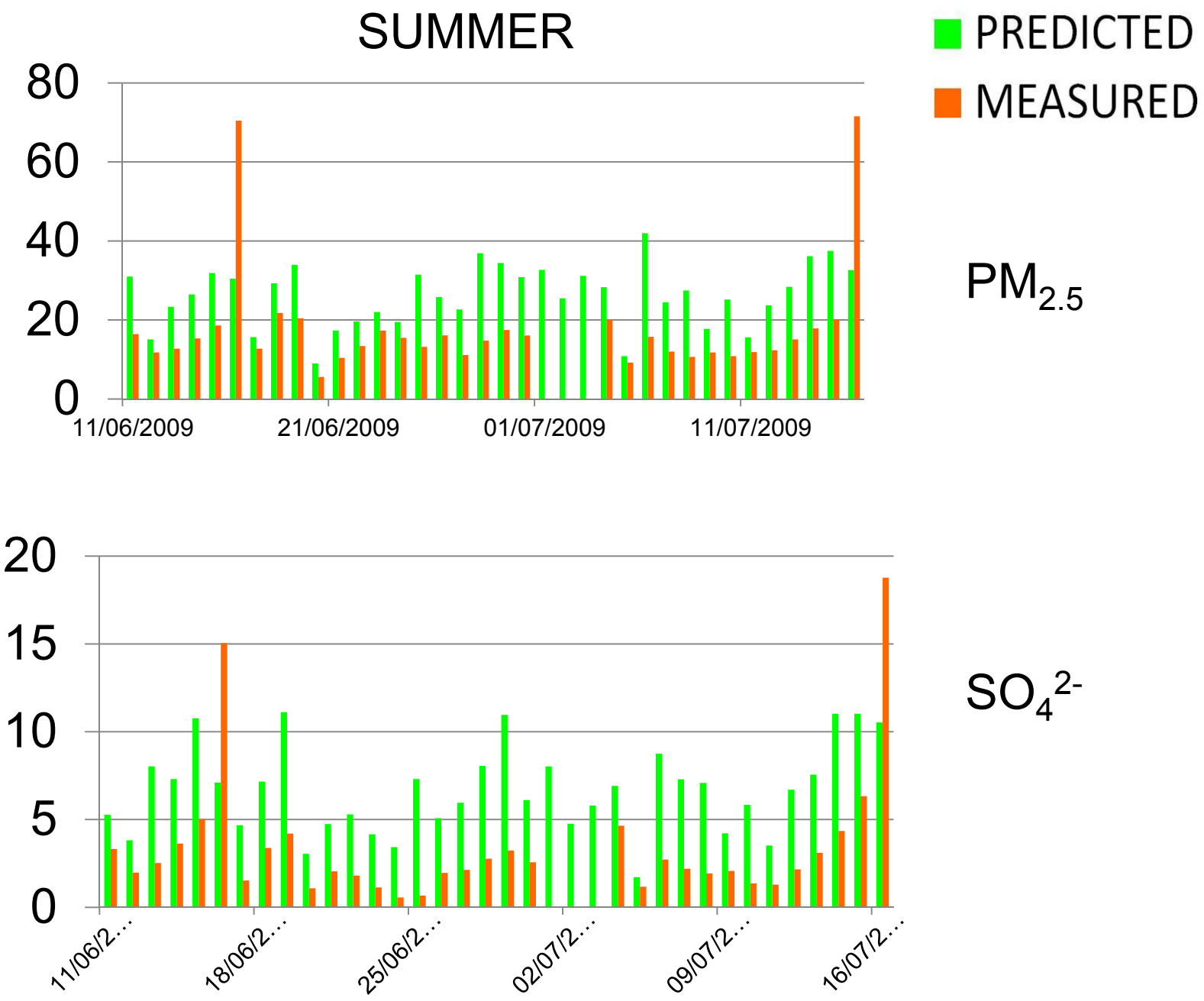

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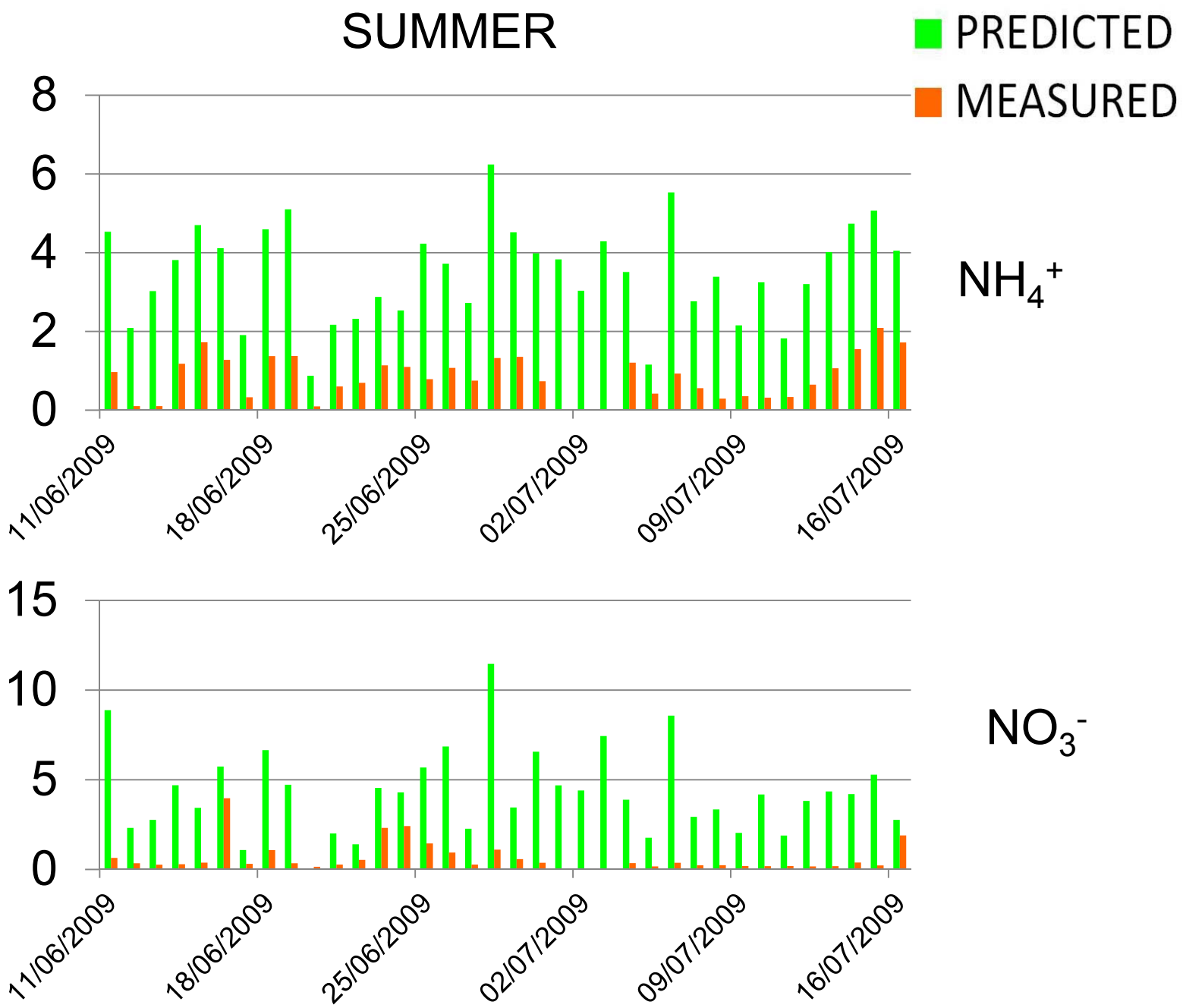

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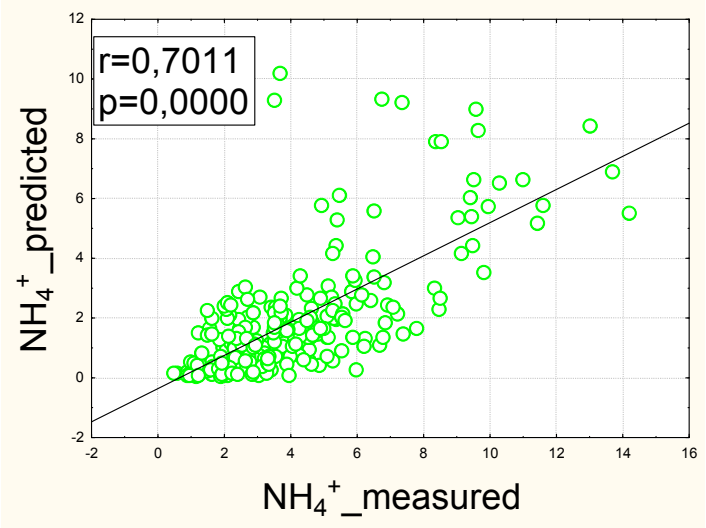
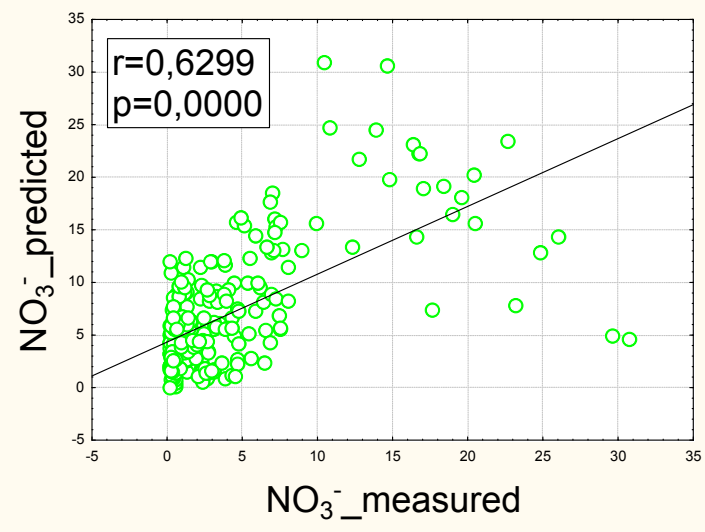
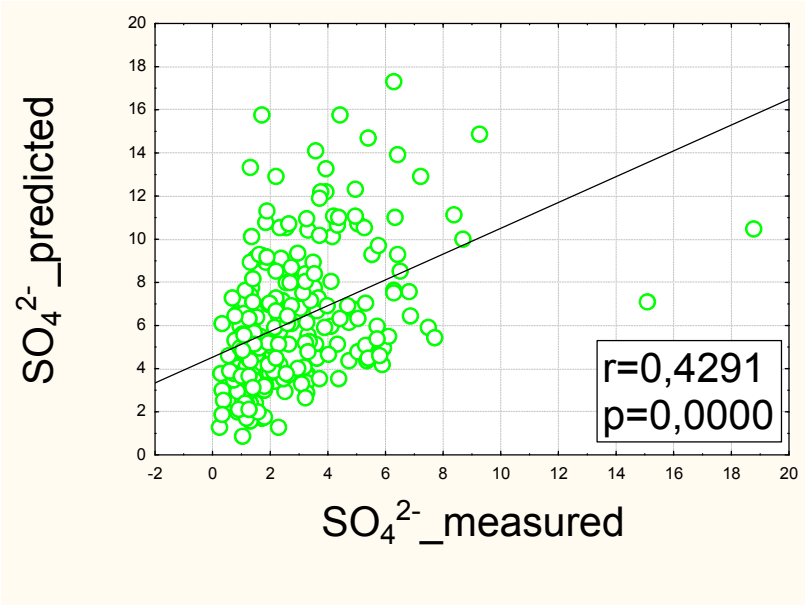
NH_4^+



NO_3^-



SO_4^{2-}



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PERFORMANCE ANALYSIS

(Weil et al., 1992; Hanna et al., 1993; ASTM, 2000)

	SRC	URB	IND	Spring	Summer	Autumn	Winter
$PM_{2.5}$							
FB	-0.1	-0.1	-0.2	0.1	-0.4	-0.3	0.0
MG	0.7	0.8	0.7	1.0	0.6	0.7	1.0
NMSE	0.3	0.3	0.2	0.3	0.4	0.2	0.1
VG	1.4	1.2	1.3	1.2	1.4	1.4	1.2
FAC2	0.8	0.9	0.8	0.9	0.8	0.8	1.0

- Overestimation tendency
- Worse performance for water soluble ions
  - problem of model chemical representation?
  - emission problem (2005 → 2009)?

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Multivariate Analysis

to investigate this relation:

$PM_{2.5}$ ↔ Water soluble ions

-Discriminant

- Factorial

- Variables: $PM_{2.5}$, Water soluble ions (NH_4^+, NO_3^- and SO_4^{2-}), T., W. dir. and speed, pressure, RH%

- Different matrices considered (sites/seasons) for both measured and predicted data

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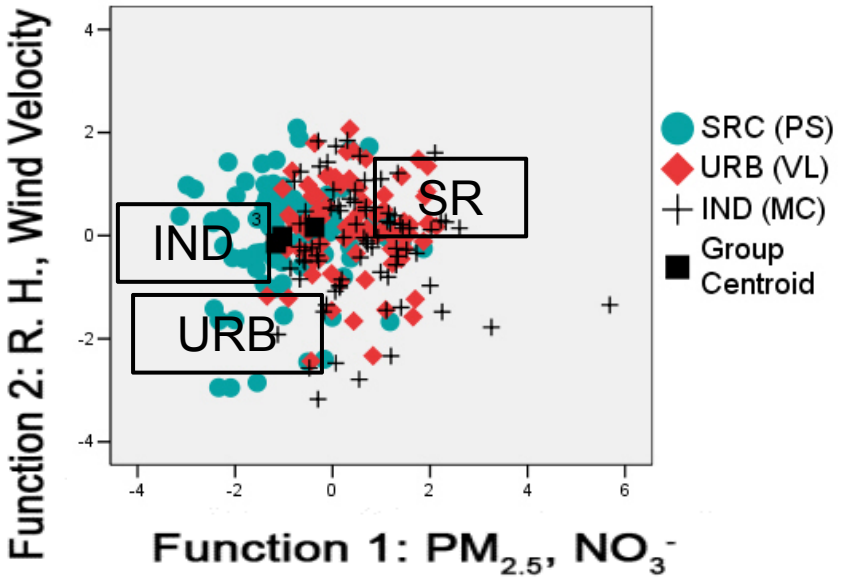
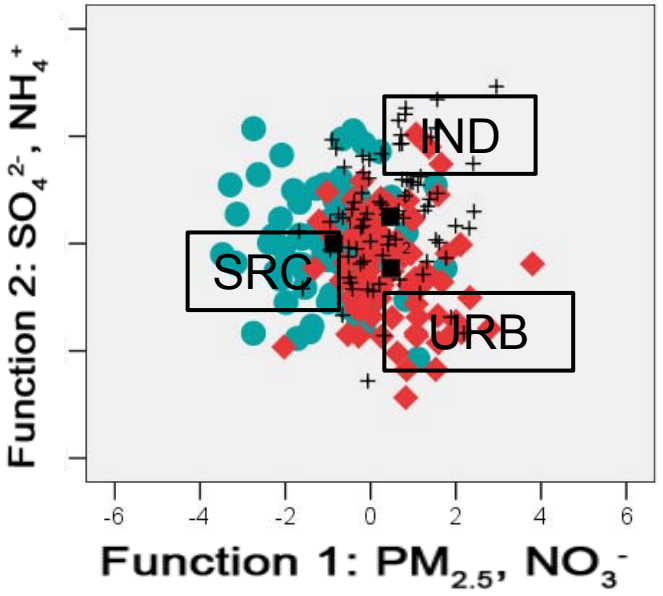
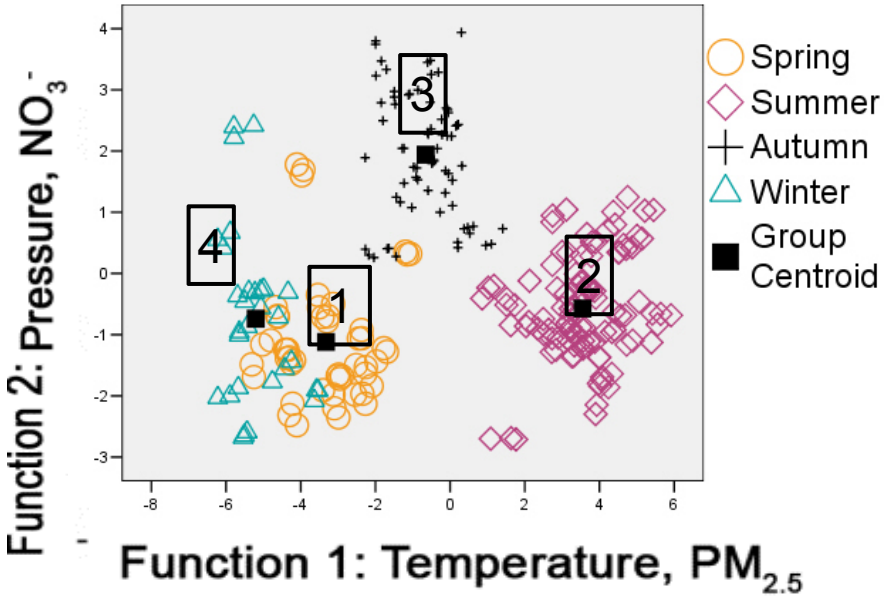
Discriminant Analysis

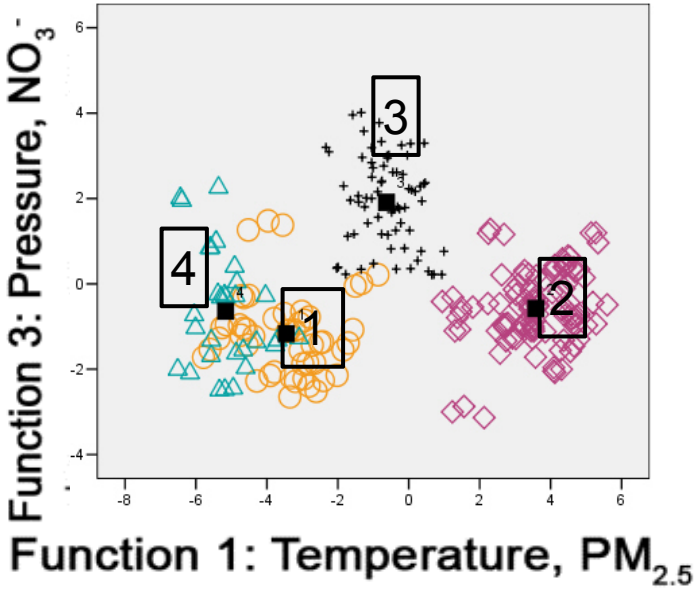
MEASURED

PREDICTED









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FACTORIAL ANALYSIS

It analyses the *variability* of a matrix elements and synthesize the information in new factors that represent a *real* situation to which we give an *interpretation* and a *relevance* respect to the variables included and to the variance explained.

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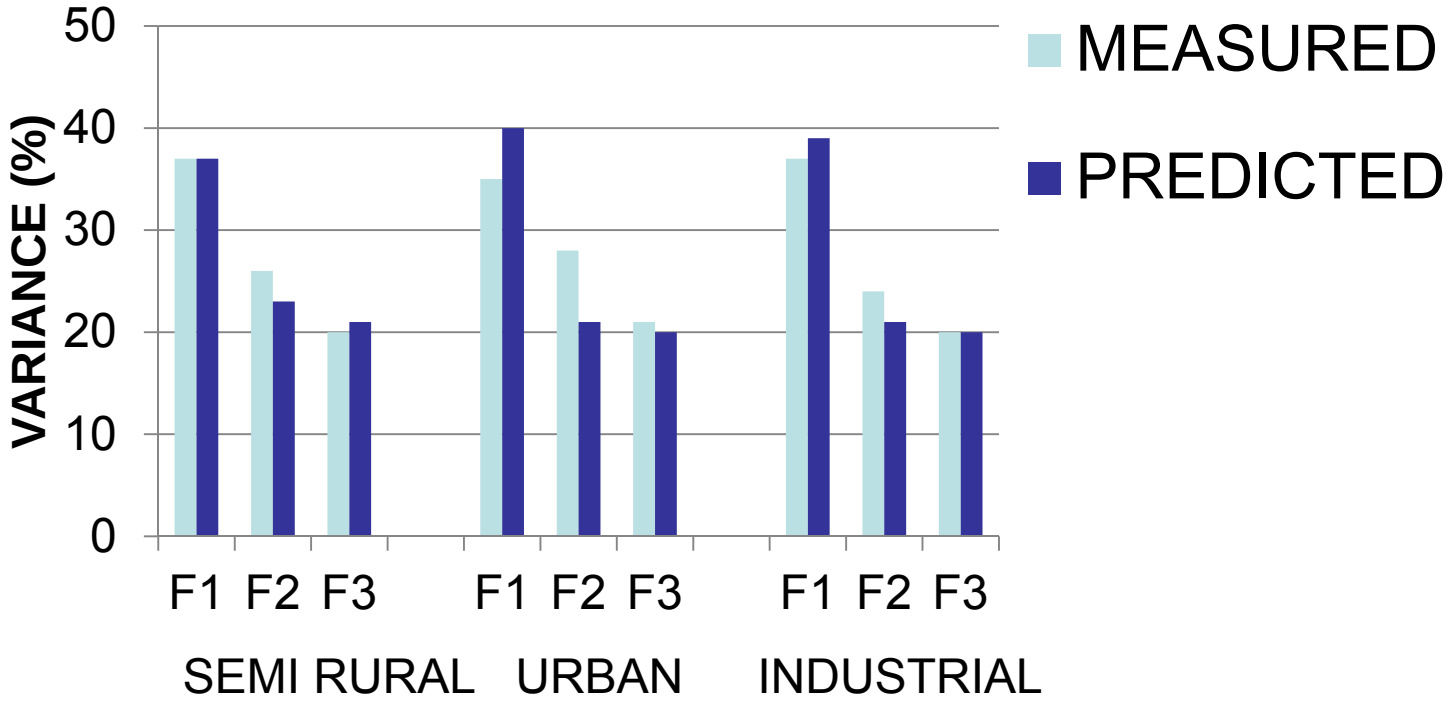
Factorial Analysis: spatial distribution



F1	F2	F3
Pollutants concentrations + wind speed (- no differences m/p; - RH% for urban and industrialized sites for measures)	Water soluble ions + temperature (not good performance)	Meteorology (no differences between m/p)

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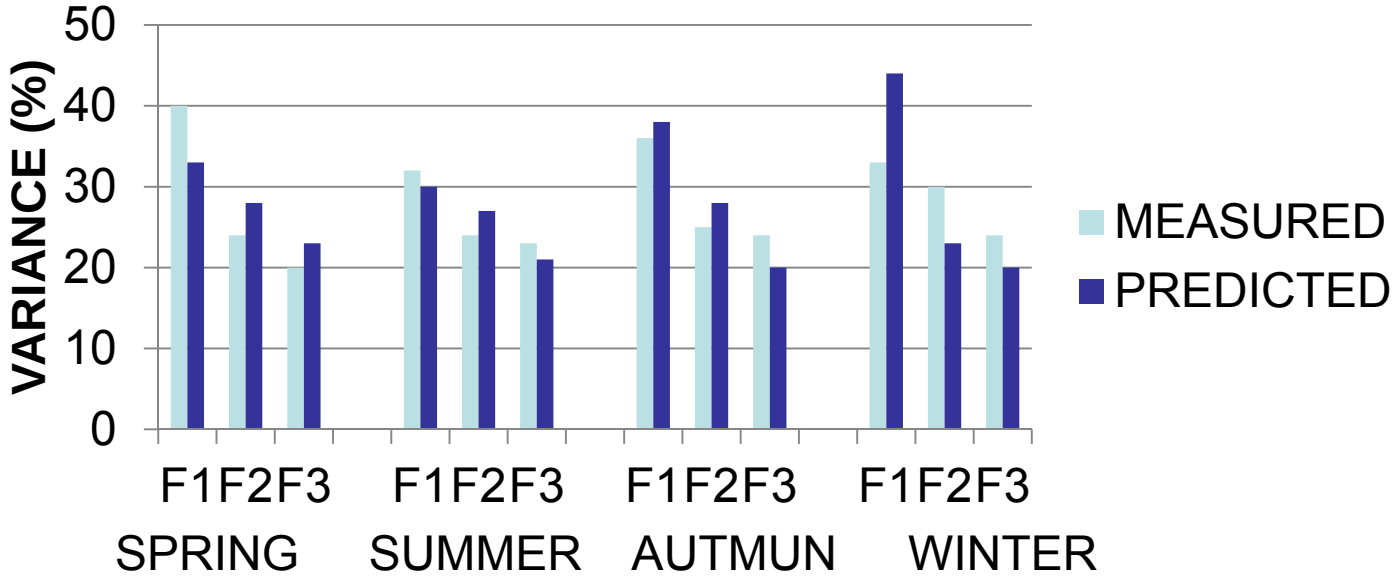
Factorial Analysis: temporal distribution



F1	F2	F3
•Spring: more importance to T then to Wind respect to pollutant concentrations •Autumn: well represented (pollutants concentrations and wind speed) •Summer: NO_3^- and SO_4^{2-} for measures •Winter : few data	• Spring ions and T not well performed •Meteorological aspects for autumn • no relation for summer and winter	•Meteorological aspects for autumn and spring (good) • no relation for summer and winter

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Conclusions

- Good performance for $PM_{2.5}$
- Difficulties in representing secondary ions or specific chemical processes especially for summer season
- Multivariate analysis help to investigate model performance in relation to spatial and temporal distribution
- Model performance can be improved by upgrading the emission inventory (2005 → 2009)
- Improvement of meteorological description (upper air data) and of lagoon characterization
- Addition of organic data to the analysis

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Thank you for your attention!

...

Any question?

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Spring	N = 50	F1	F2	F3	F1	F2	F3
$PM_{2.5}$		0.88	0.31	0.19	0.72	0.44	0.45
NH_4^+		0.79	0.52	0.08	0.68	0.57	0.40
NO_3^-		0.77	0.53	0.10	0.58	0.62	0.31
SO_4^{2-}		0.72	0.49	-0.08	0.63	0.22	0.48
WIND SPEED (S. Andrea)		-0.85	-0.11	-0.14	-0.22	-0.11	-0.91
WIND SPEED (Station n°5)		-0.92	-0.07	-0.05	-0.22	-0.07	-0.94
TEMPERATURE(S. Andrea)		-0.21	-0.92	-0.02	-0.92	0.05	-0.14
TEMPERATURE (Station n°5)		-0.27	-0.94	0.03	-0.93	0.08	-0.14
PRESSURE(S. Andrea)		0.28	0.09	0.92	0.14	0.94	0.18
PRESSURE(Station n°5)		0.28	0.09	0.92	0.14	0.94	0.18
RH (S. Andrea)		0.36	0.24	-0.73	0.32	-0.64	0.23

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Summer	N = 104	F1	F2	F3	F1	F2	F3
$PM_{2.5}$		0.43	0.56	0.42	0.93	0.30	-0.01
NH_4^+		0.55	0.68	0.30	0.97	0.19	0.08
NO_3^-		-0.26	0.81	-0.09	0.81	0.12	0.01
SO_4^{2-}		0.74	0.32	0.45	0.75	0.32	0.13
WIND SPEED (S. Andrea)		-0.44	-0.75	0.08	-0.34	-0.77	0.15
WIND SPEED (Station n°5)		-0.46	-0.72	0.21	-0.25	-0.81	0.27
TEMPERATURE(S. Andrea)		0.88	0.11	0.24	0.12	0.82	0.40
TEMPERATURE (Station n°5)		0.88	0.11	0.29	0.16	0.79	0.45
PRESSURE(S. Andrea)		0.12	-0.07	0.97	0.05	0.01	0.97
PRESSURE(Station n°5)		0.11	-0.07	0.97	0.05	0.01	0.97
RH (S. Andrea)		0.70	0.14	-0.18	0.38	0.47	-0.07

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Autumn	N = 72	F1	F2	F3	F1	F2	F3
$PM_{2.5}$		0.94	0.17	0.18	0.83	0.17	0.13
NH_4^+		0.95	0.13	0.21	0.95	0.14	0.22
NO_3^-		0.87	0.18	0.27	0.86	0.18	0.28
SO_4^{2-}		0.86	0.10	0.15	0.86	0.11	0.15
WIND SPEED (S. Andrea)		-0.52	-0.60	-0.36	-0.49	-0.61	-0.38
WIND SPEED (Station n°5)		-0.61	-0.58	-0.26	-0.58	-0.58	-0.28
TEMPERATURE(S. Andrea)		0.04	0.96	0.08	0.04	0.95	0.08
TEMPERATURE (Station n°5)		0.05	0.95	0.14	0.06	0.95	0.14
PRESSURE(S. Andrea)		0.30	0.08	0.94	0.29	0.07	0.94
PRESSURE(Station n°5)		0.24	0.08	0.95	0.24	0.07	0.96
RH (S. Andrea)		0.38	0.72	-0.23	0.37	0.73	-0.22

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Winter	N = 30	F1	F2	F3	F1	F2	F3
$PM_{2.5}$		0.25	-0.68	-0.57	0.94	0.09	-0.13
NH_4^+		0.83	-0.46	-0.14	0.93	0.25	-0.17
NO_3^-		0.52	-0.73	-0.35	0.75	0.52	-0.05
SO_4^{2-}		0.93	0.11	-0.11	0.93	-0.03	-0.22
WIND SPEED (S. Andrea)		0.27	0.94	-0.01	-0.84	-0.42	-0.09
WIND SPEED (Station n°5)		0.22	0.92	0.03	-0.89	-0.33	-0.03
TEMPERATURE(S. Andrea)		0.19	0.01	0.96	-0.02	-0.24	0.95
TEMPERATURE (Station n°5)		0.00	0.10	0.98	-0.14	-0.07	0.96
PRESSURE(S. Andrea)		-0.89	-0.20	-0.31	0.11	0.86	-0.29
PRESSURE(Station n°5)		-0.75	-0.27	-0.52	0.25	0.74	-0.50
RH (S. Andrea)		0.58	0.52	0.06	-0.31	-0.81	-0.05