# A Methodology for Seasonal Photochemical Model Simulation Assessment

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# Outline

- **Seasonal photochemical model assessment**
  - Critical issues
  - The proposed methodology

- **Application cases**
  - Northern Italy domains
  - GAMES Modelling System
  - 1996 Summer Season
  - The CityDelta Modelling Exercise

- **Conclusions**

# Seasonal Simulation Assessment

## Critical issues:

- no standard performance procedure exists
- each run of the models results in a large amount of output data
- Comparison between punctual and average values

- to focus the analysis for a **restricted number of typical concentration patterns**
- to summarize the simulation results over long time period by means of **proper performance indexes**.
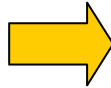
# The Model Evaluation Methodology

**(1) Clustering process** ➡️
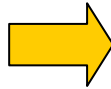
Used for classifying patterns
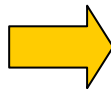- –Ozone concentrations
- –Daily shape, peak distribution

**(2) Sites Identification** ➡️

Each cluster can be represented by a single station
- –Representative station
- –*Virtual* station

**(3) Performance indicators** ➡️

- Statistical indicators (EPA, EC)
- Other Statistical indexes
- O3 exposure values
- Percentile values
- Model inter-comparison
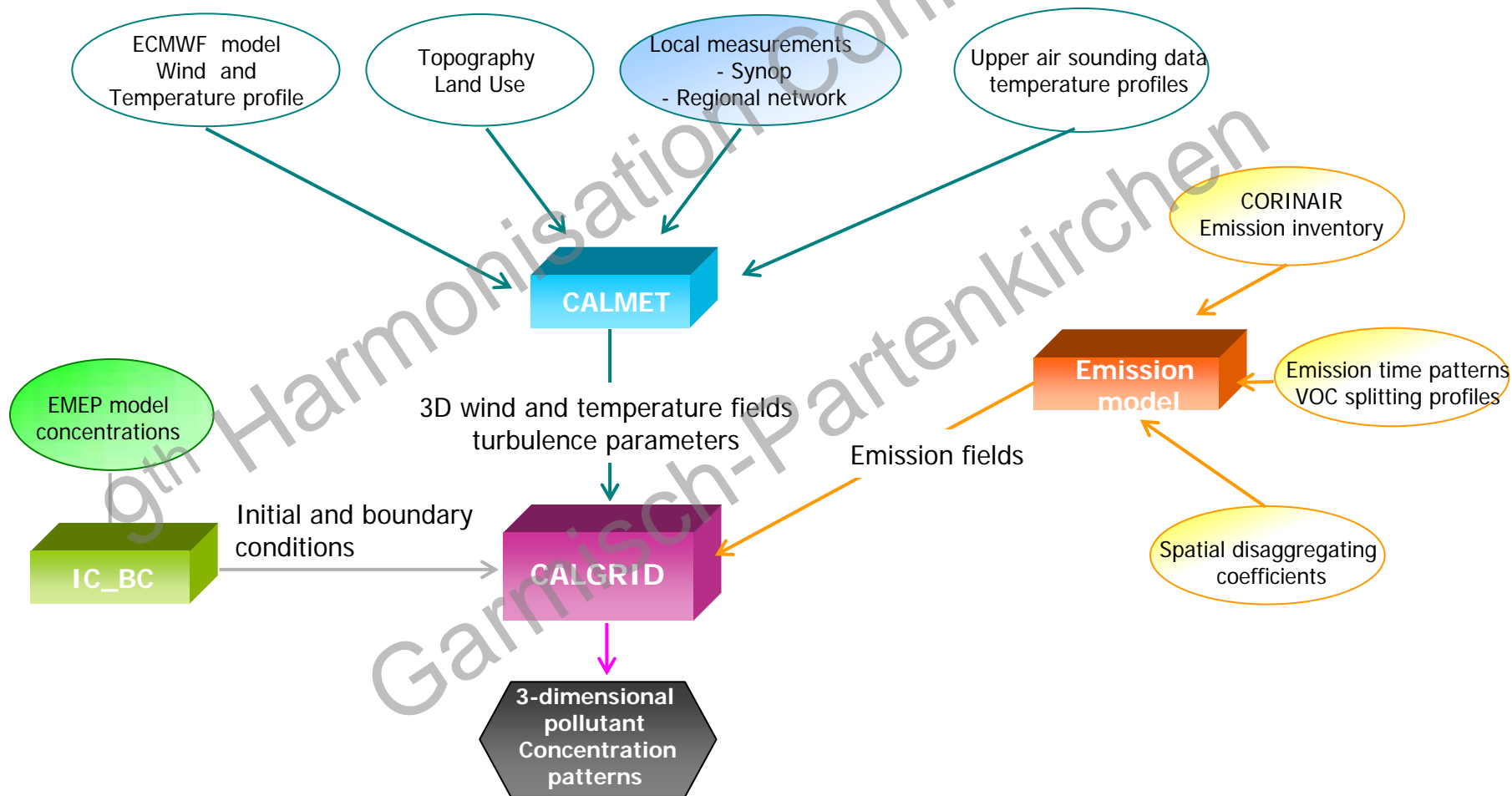
# Seasonal Application Cases

- Simulation performed with GAMES system over Northern Italy domains

- Preliminary Application: 1996 Summer Season - Contribution to EUROTRAC2/SATURN Project
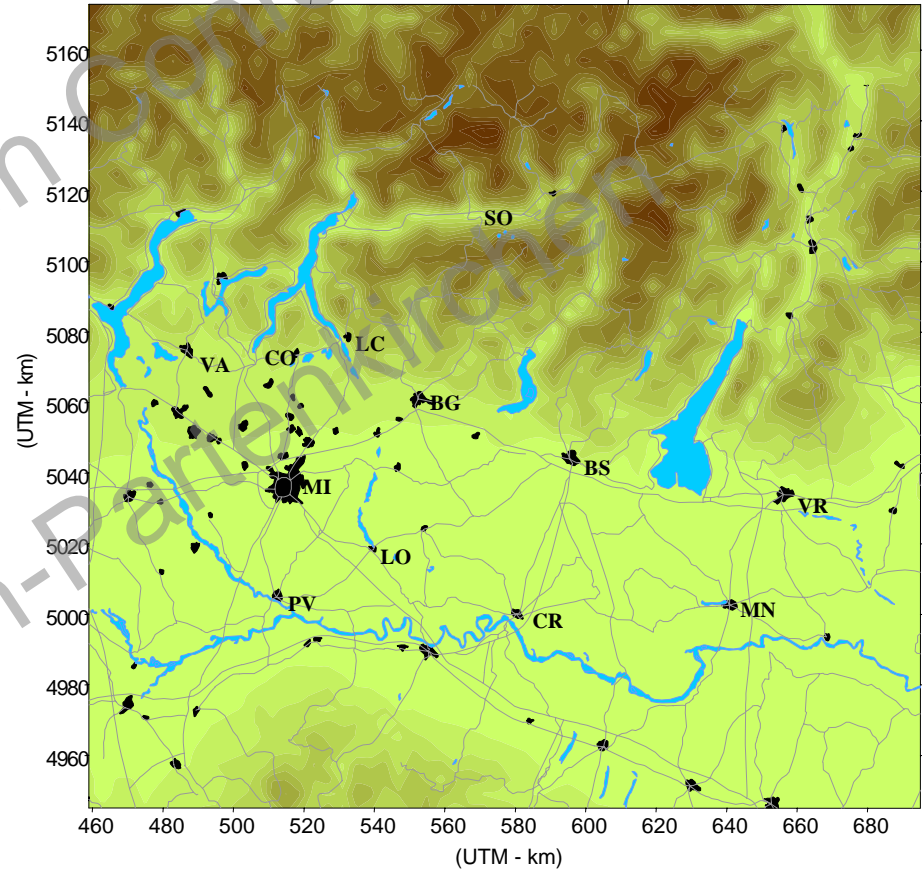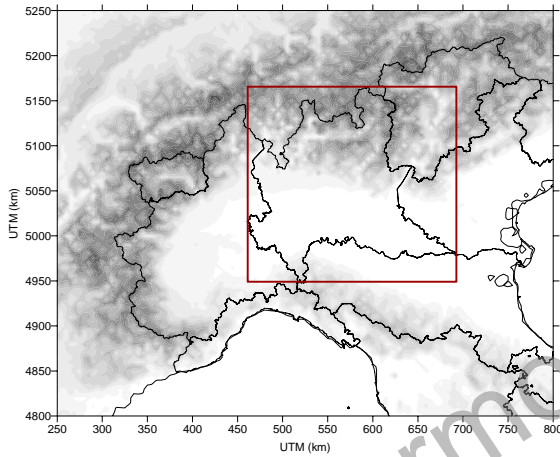
- CityDelta Modelling Exercise

# The GAMES system

## Gas Aerosol Modelling Evaluation System



ECMWF model
Wind and
Temperature profile

Topography
Land Use

Local measurements
- Synop
- Regional network

Upper air sounding data
temperature profiles

CORINAIR
Emission inventory

**CALMET**

Emission time patterns
VOC splitting profiles

**Emission model**

EMEP model
concentrations

3D wind and temperature fields
turbulence parameters

Emission fields

Initial and boundary
conditions

**IC_BC**

**CALGRID**

Spatial disaggregating
coefficients

**3-dimensional
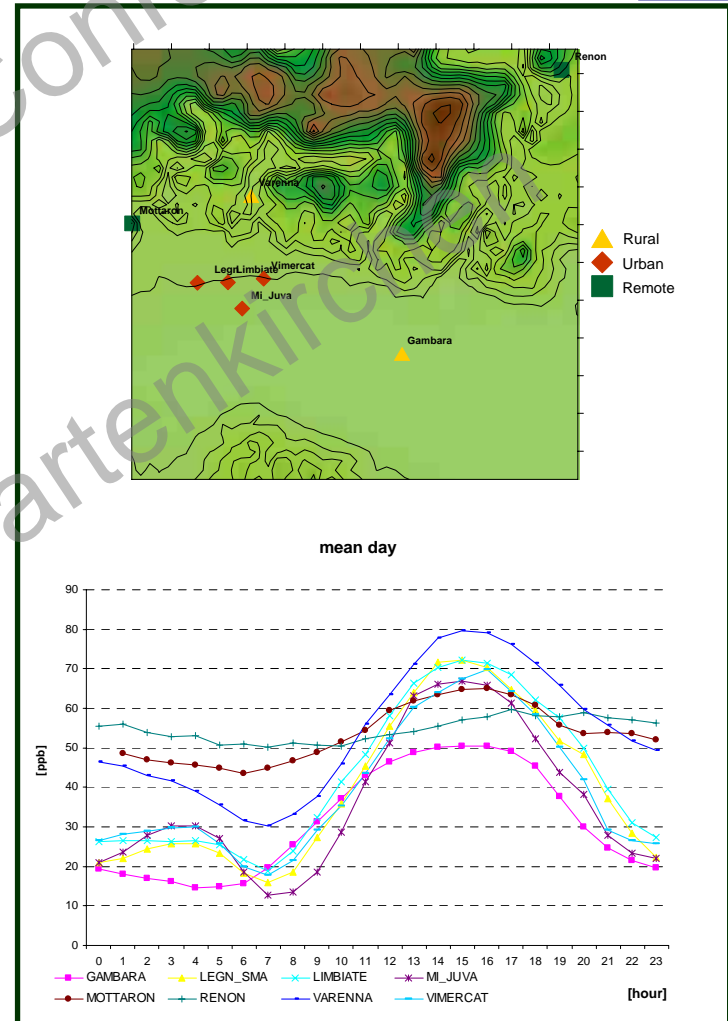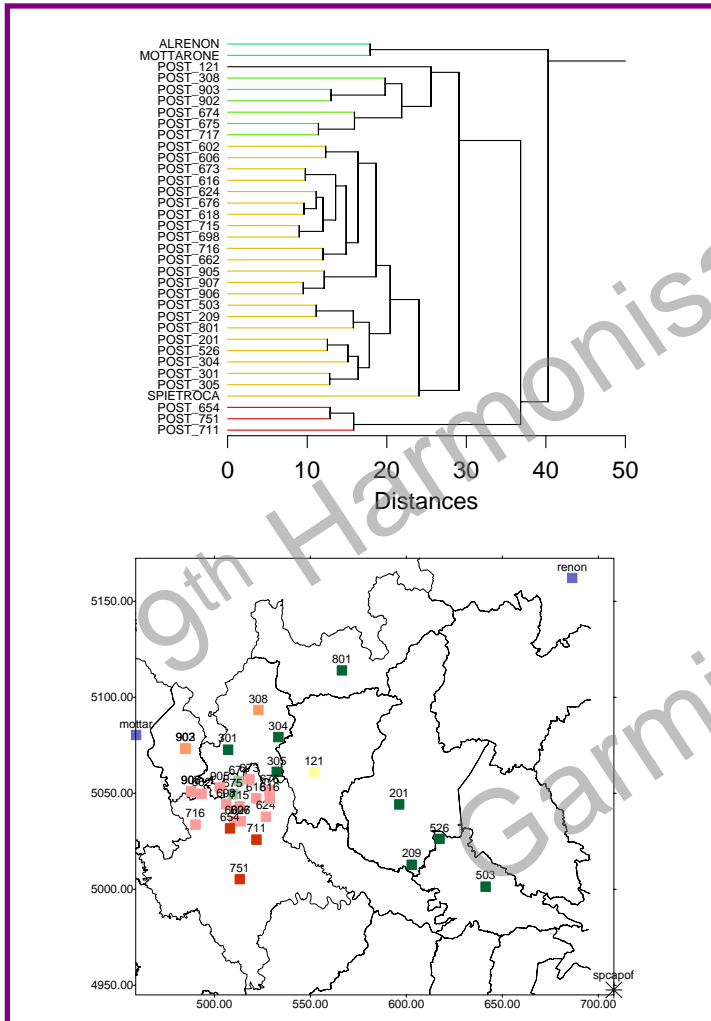pollutant
Concentration
patterns**

# Case I:
# the selected domain



- 240km x 232km

- complex terrain

- industrialised and populated area

- close road network

- critical anthropic emissions

- the simulated period:
  - April-September 1996

# Clustering process and sites identification

mean day

# Statistical Indexes

- US EPA guidelines:
  - Mean Normalized Bias Error (MNBE), $\pm 5 \div 15\%$

    $$\frac{1}{n}\sum_{1=1}^{n}\frac{C_{\text{mod}}(x,t)-C_{obs}(x,t)}{C_{obs}(x,t)}$$

  - Mean Normalized Gross Error (MNGE), $\pm 30 \div 35\%$

- EC Directive:

    $$\frac{1}{n}\sum_{1=1}^{n}\frac{\left|C_{\text{mod}}(x,t)-C_{obs}(x,t)\right|}{C_{obs}(x,t)}$$

  - the 1 hour averages (daytime), $\pm$ 50%
  - the 8 hours daily maximum, $\pm$ 50%

- Model intercomparison:
  - CALGRID
  - STEM

| | O3 - 1-h daily max | | O3 - 8-h daily max | | NO2 - mean conc. | |
|---|---|---|---|---|---|---|
| | mnbe [%] | mnge [%] | mnbe [%] | mnge [%] | mnbe [%] | mnge [%] |
| Legnano | 4.4 | 27.6 | 14 | 32.6 | -29.8 | 29.4 |
| Limbiate | -15.4 | 27.5 | -11.2 | 26.2 | 2.5 | 32.0 |
| Juvara | 1.4 | 31.2 | 14.3 | 36.6 | -20.1 | 25.9 |
| Vimercate | -5.6 | 28.3 | 1.8 | 28.5 | -17.5 | 33.3 |
| Ispra | 13.3 | 25.6 | 19.7 | 29.6 | - | - |
| Parma | 21.6 | 30.4 | 25.5 | 32.2 | - | - |
| Varenna | -1.3 | 25.2 | 0.6 | 23.1 | - | - |

# Model inter-comparison
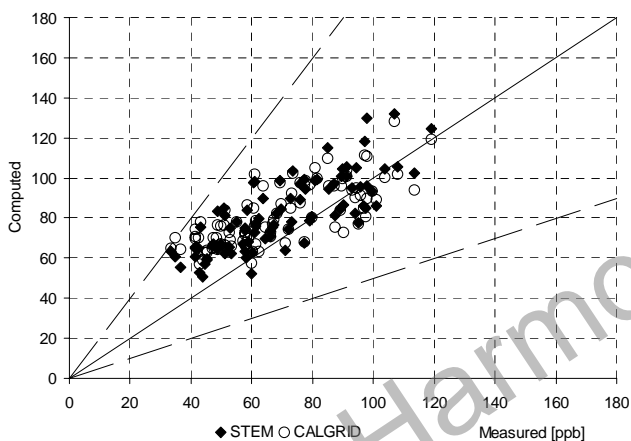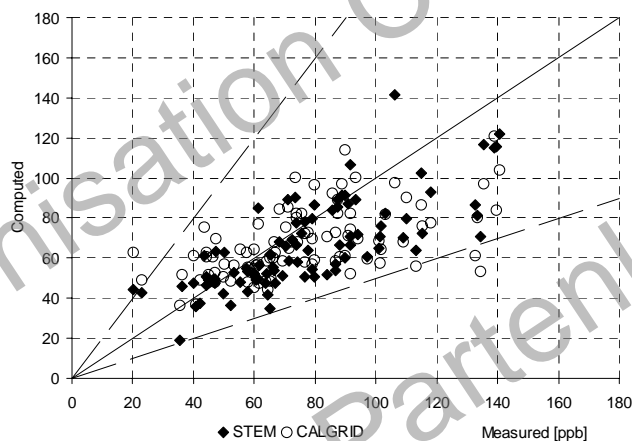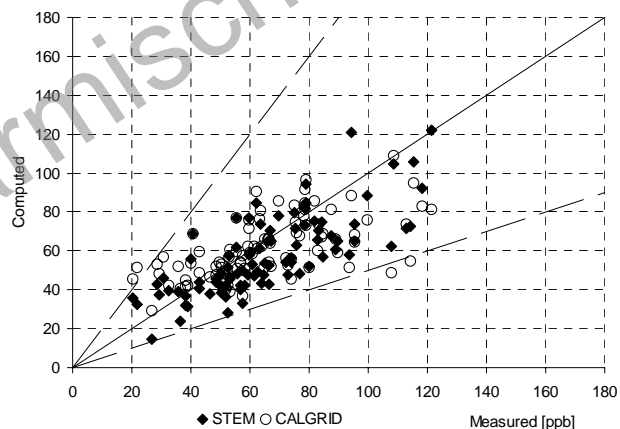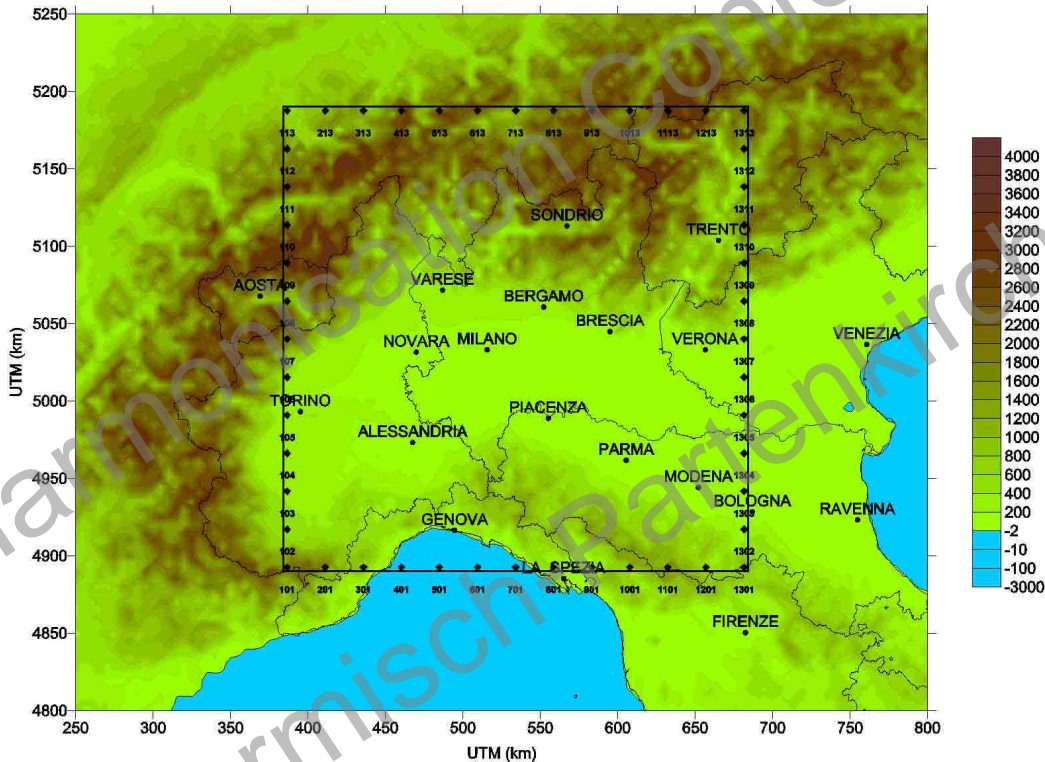
LEDA: low emission density area

HEDA: high emission density area
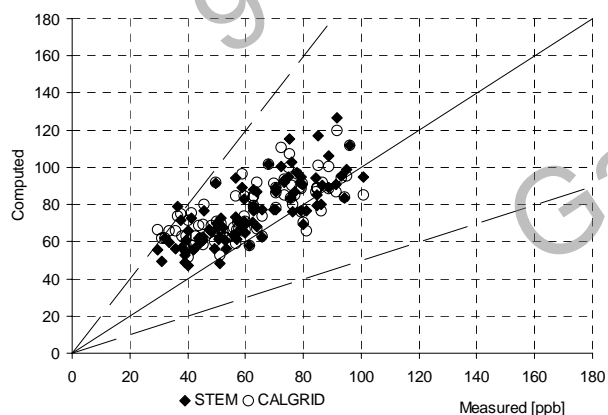
# Case II:
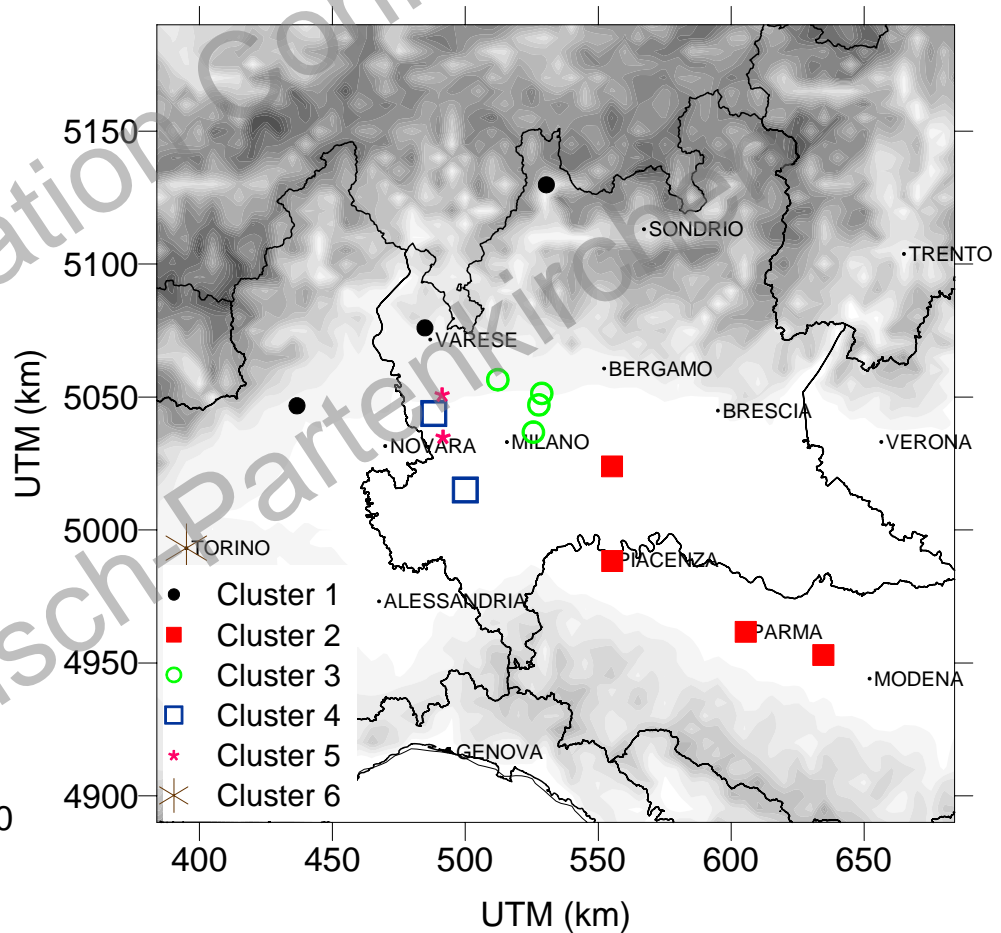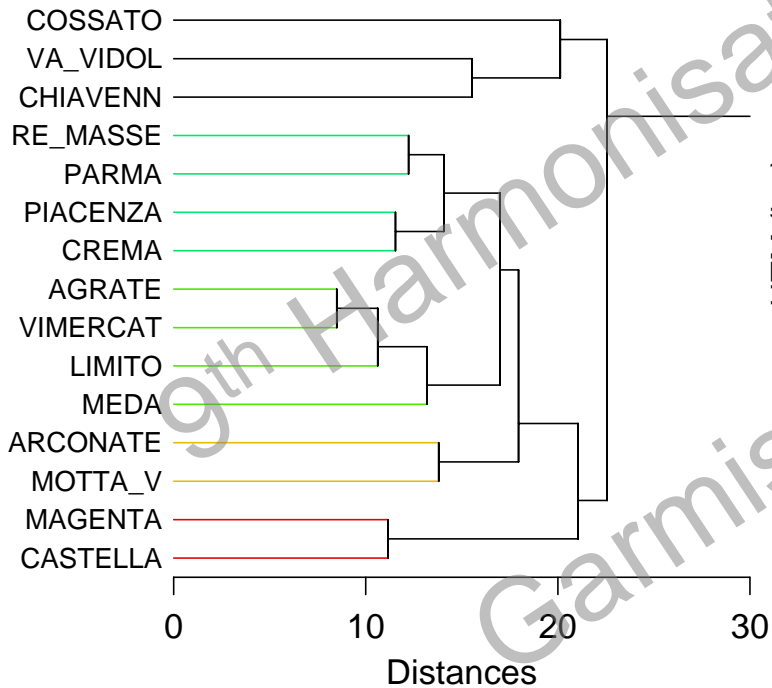# the selected domain



- 300km x 300km

- the simulated period: April-September 1999

# Ozone pattern classification (I)

Cluster Tree
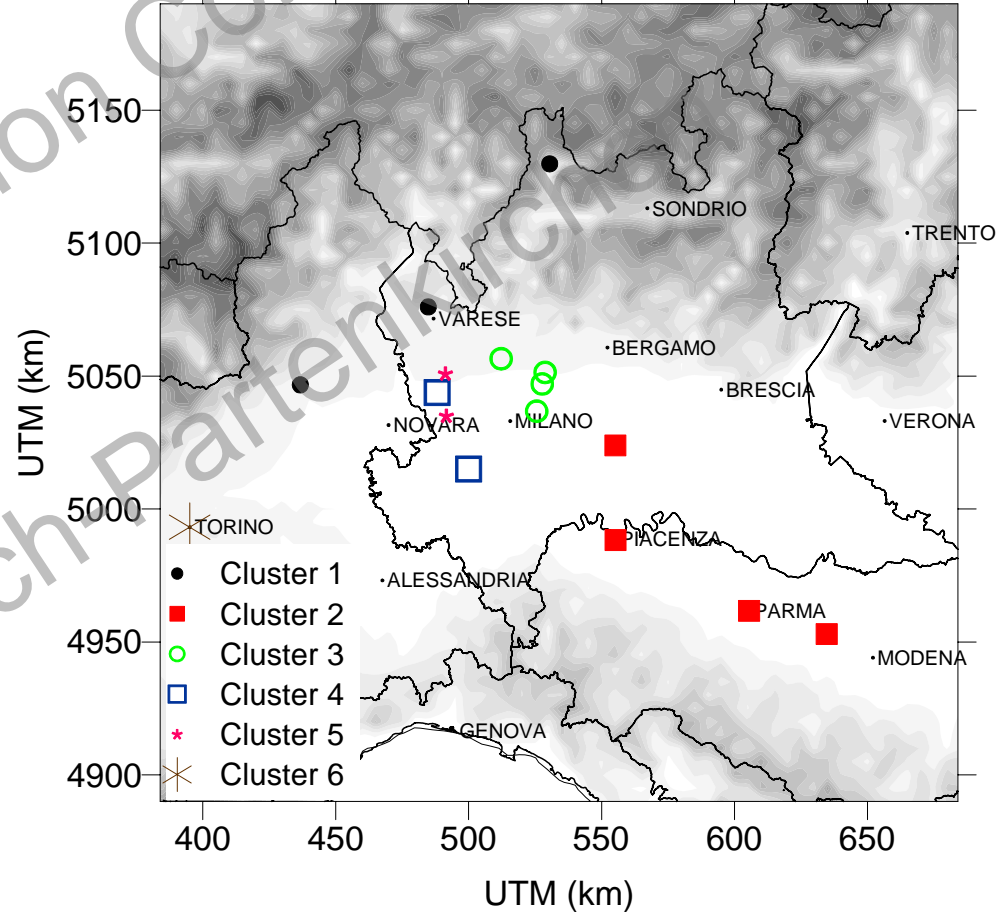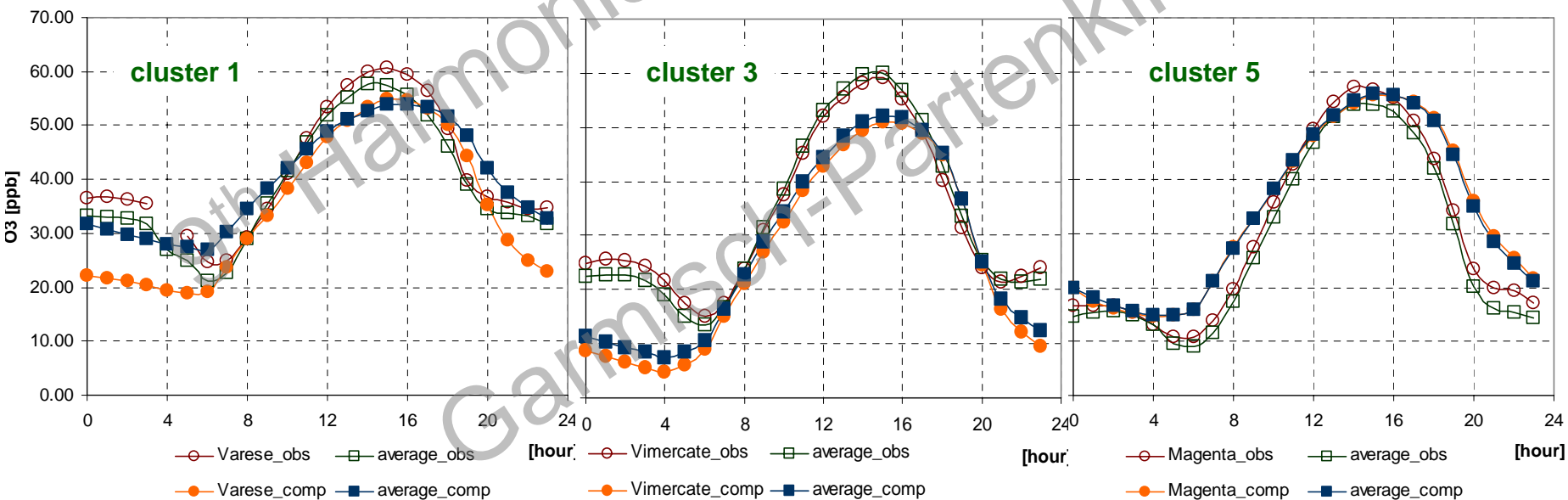
# Ozone pattern classification (II)
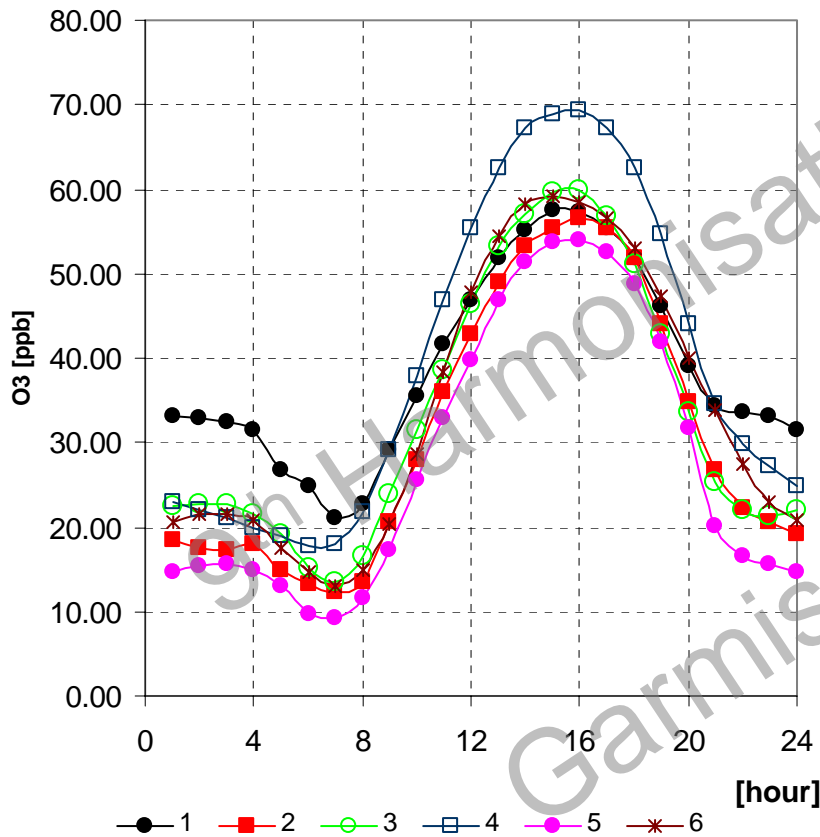
# Representative station definition

-Representative station ⟶ new clustering process

-Virtual station ⟶ averaging, hour by hour, the measurements recorded in the stations belonging to the group



Rural cluster

Urban cluster

Suburban cluster

# Model evaluation (I)

## Performance evaluation

- Graphical analysis:
  - time series, scatter plots,...
- Statistical indicators:
  - US EPA guidelines:
    - Mean Normalized Bias Error (MNBE), ±5÷15%
    - Mean Normalized Gross Error (MNGE), 30÷35%

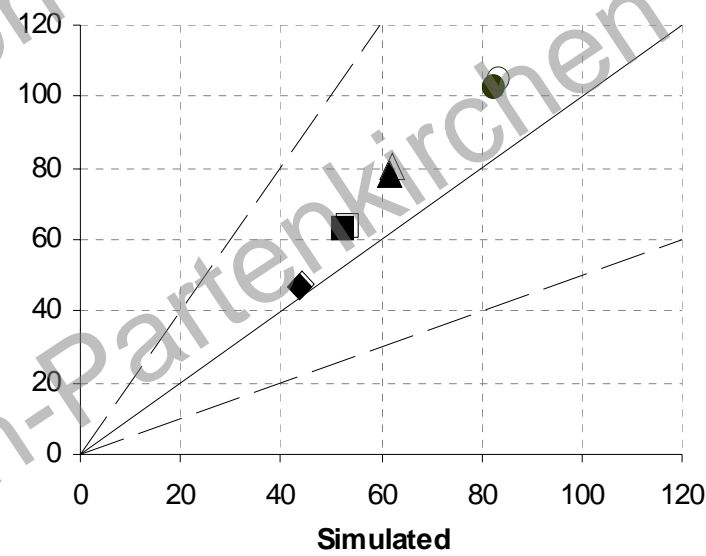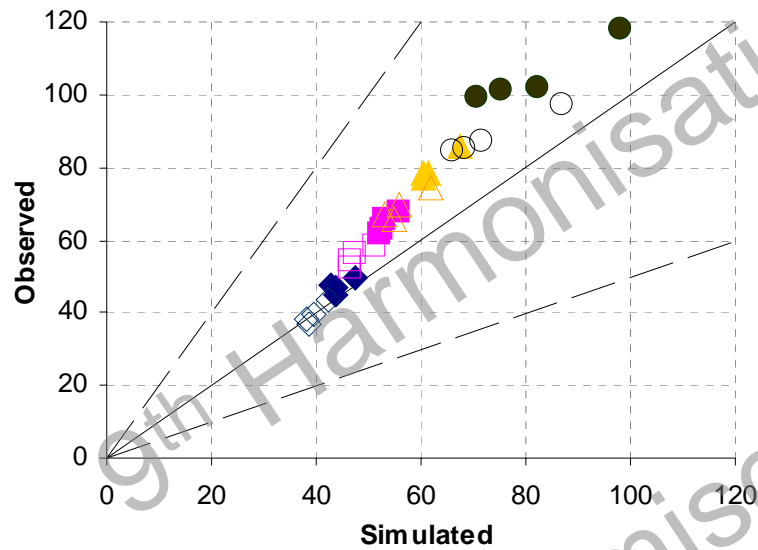| | Max 1h | | | | Max 8h | | | |
|---|---|---|---|---|---|---|---|---|
| Cluster | MNBE | MNGE | R | RMSE | MNBE | MNGE | R | RMSE |
| 1 | -7 | 22 | 0.37 | 17.52 | -2 | 11 | 0.41 | 14.05 |
| 2 | 13 | 26 | 0.6 | 14.48 | 28 | 13 | 0.61 | 15.34 |
| 3 | -10 | 25 | 0.63 | 20.11 | -3 | 15 | 0.64 | 16.47 |
| 4 | -18 | 23 | 0.62 | 22 | -14 | 12 | 0.65 | 17.66 |
| 5 | 15 | 33 | 0.59 | 17.24 | 19 | 16 | 0.69 | 14.15 |

O3 concentrations

# Model evaluation (II)

Urban cluster

# Conclusions

- Methodological approach to evaluate seasonal photochemical simulation

  - Simulations performed in complex domains

    - 1996 Summer Season (SATURN) – model inter-comparison

    - 1999 Summer Season (CityDelta Project)

- Main issues:

  - Statistical and graphical methods

  - Each station or representative station

The evaluation of representative stations should be preferred with long-term simulation assessments