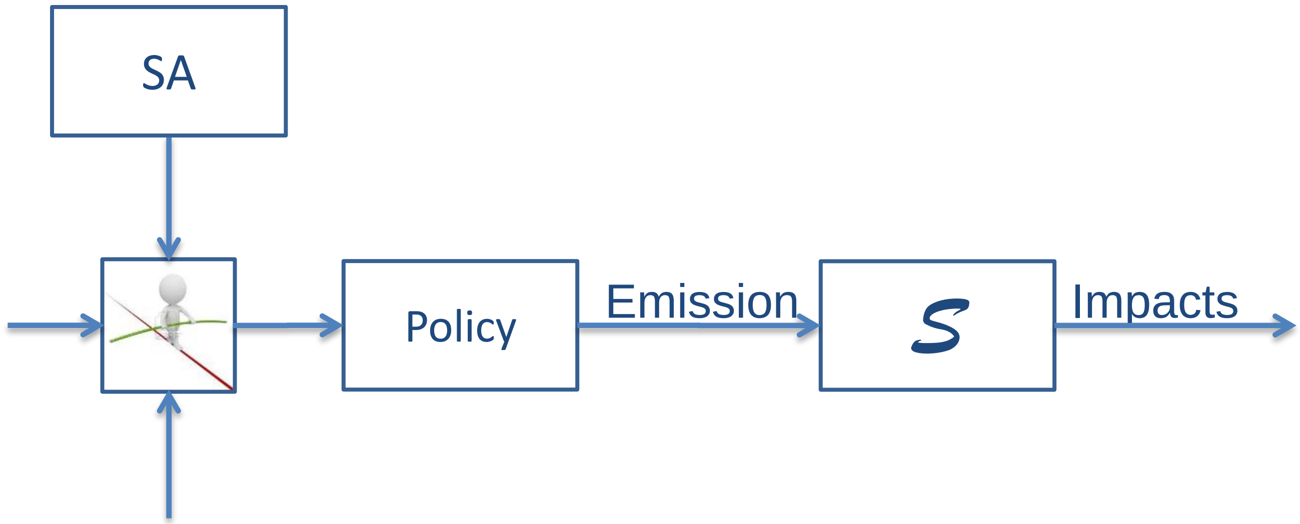
RIAT COURSE

RIAT+ methodology introduction

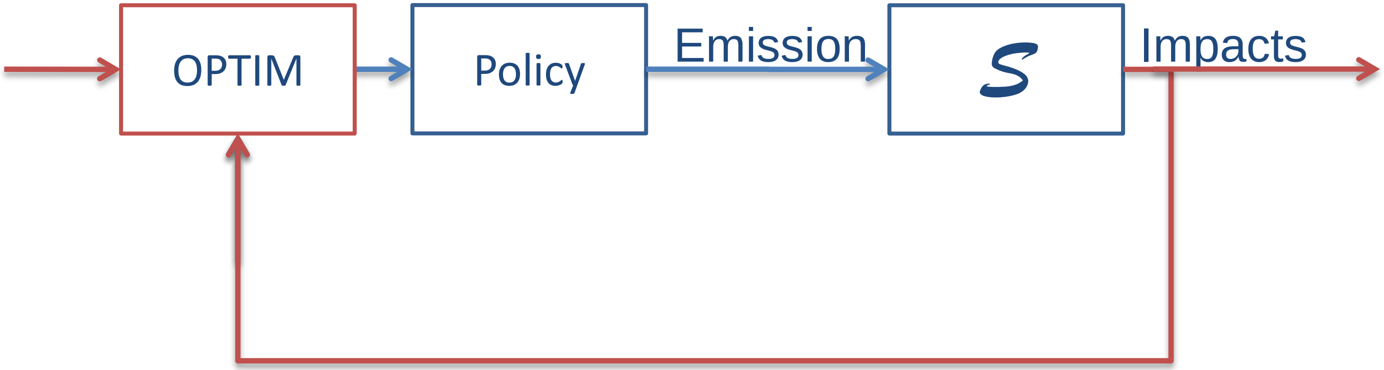
RIAT+

- DSS: Decision Support System
  - Help to Decision Makers
- Taking Decision
  - Scenario
  - Optimization

Taking Decision: Scenario Analysis



Taking Decision:
Scenario Analysis VS Optimization



Taking Decision:
Scenario Analysis VS Optimization

Scenario Analysis

- Ex post evaluation of the impacts
- Using of:
  - Expert Judgement
  - SA algorithm
  - CTM
  - S-R relationship

Optimization

- Inside decision loop evaluation (virtually of every impact)
- Using of:
  - Optimization algorithm
  - S-R relationship

  (always together)

Scenario Analysis

Formalization

$$AQI_n = f(E(\theta)) \qquad n = 1,..,N$$

where:

- E: precursor emissions due to the policy to be assessed (evaluated)
- Ɵ is the decision variable set causing the modification of precursor emissions
- f is the function linking emission and air quality index

Scenario Analysis

- Implementation
  - f is the function linking emission and air quality index
    - CTM
    - S-R relationship

- Policy definition -> Run

Optimization

Formalization

$$\min_{q}\left[f_o(E(q))\right] \quad o = 1, \ldots, O$$

$$q \text{ Î } \text{Q}$$

where:

- E: precursor emissions due to the policy to be assessed (evaluated)
- Ɵ is the decision variable set causing the modification of precursor emissions
- f is the function linking the decision variables and the air quality indexes and the costs

Optimization

Formalization

Multiobjective Problem

$$\min_{\theta}\left[AQI_n(E(\theta)) \quad inC(E(\theta))\right] \quad n = 1,\ldots,N$$

$$\theta \in \Theta$$

Cost Effectiveness Analysis

$$\min_{\theta}\left[AQI_n(E(\theta))\right] \quad n = 1,\ldots,N$$

$$\theta \in \Theta$$

$$inC(E(\theta)) < \overline{C}$$

Optimization

Multi-objective

Output: PARETO CURVE

- The best technology set at each cost

Cost Effectiveness

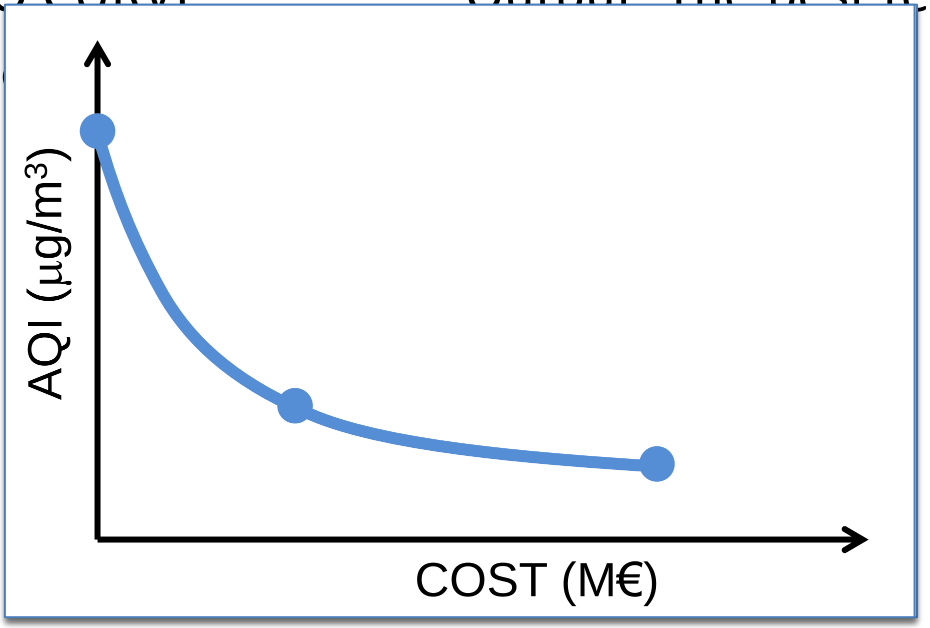
Output: The best technology set at a fixed cost

Optimization

Multi-objective

Output: PARETO CURVE

- The best t
  each cost



Cost Effectiveness

Output: The best technology set

Optimization

Multi-objective

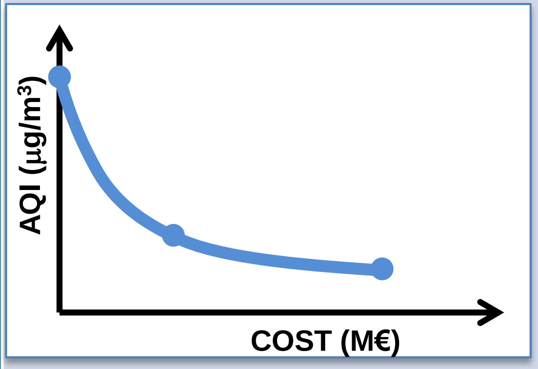
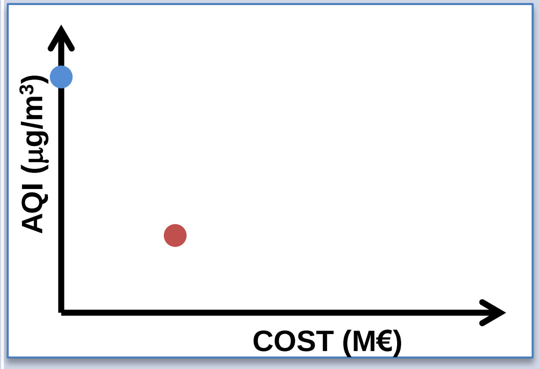
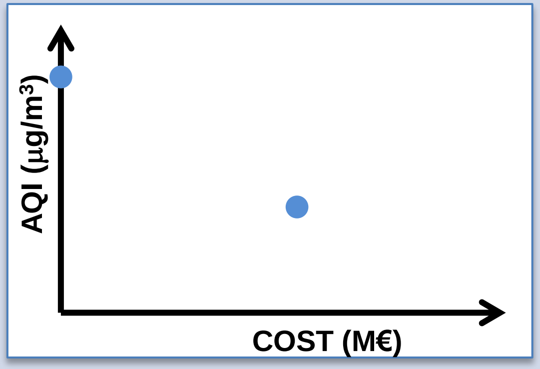
Output: PARETO CURVE

- The best technology set at each cost

Cost Effectiveness

Output: The best technology set at a fixed cost

Taking Decision
Output Information

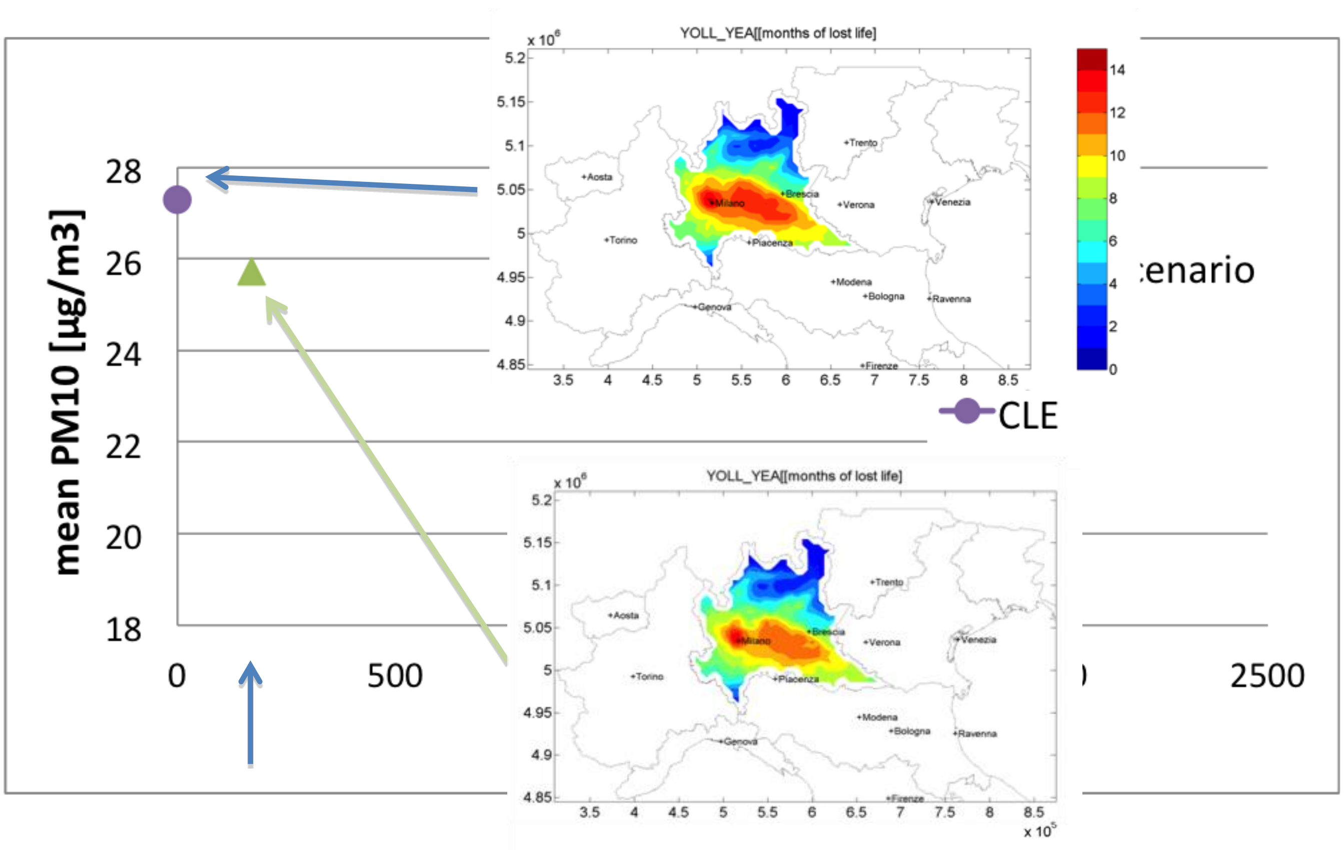
Optimization	Cost-Effectiveness	Scenario
		

Traffic Scenario Analysis

- Vehicle fleet: new EURO standard
- Efficiency Measures:
  - bus investment
  - bicycle path
  - lower speed on highway

Traffic Scenario Analysis

Impacts	CLE	Traffic scenario
Emission reduction costs	0 €	171 M€
PM10 [µg/m3]	27.3	- 6%



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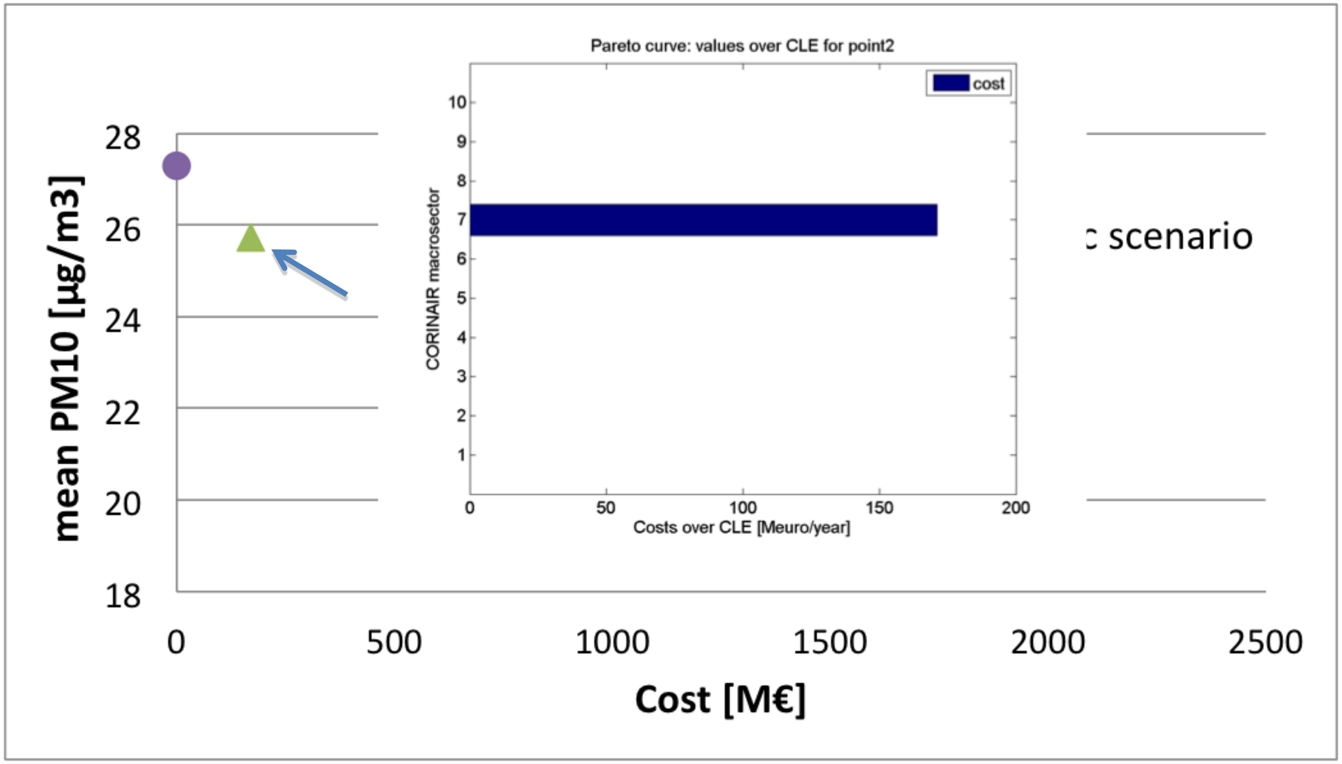
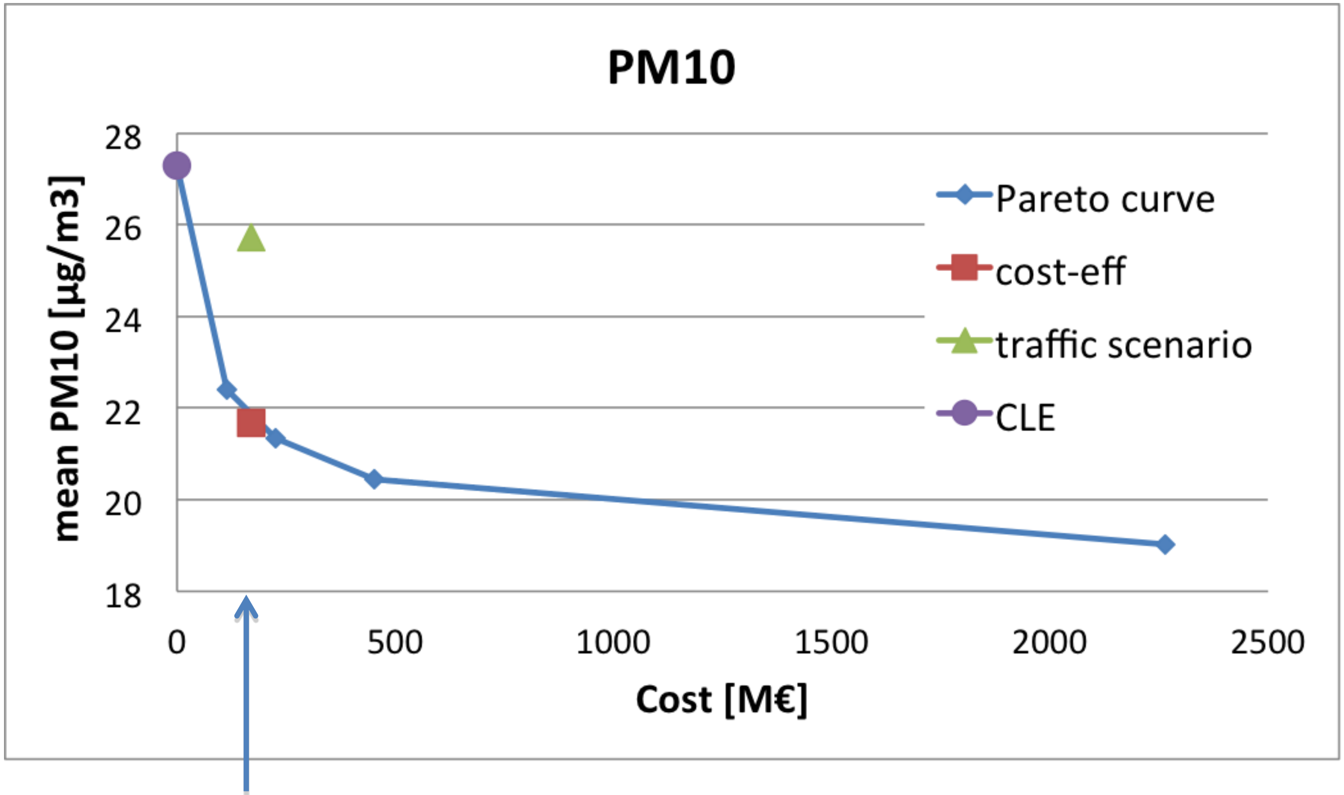


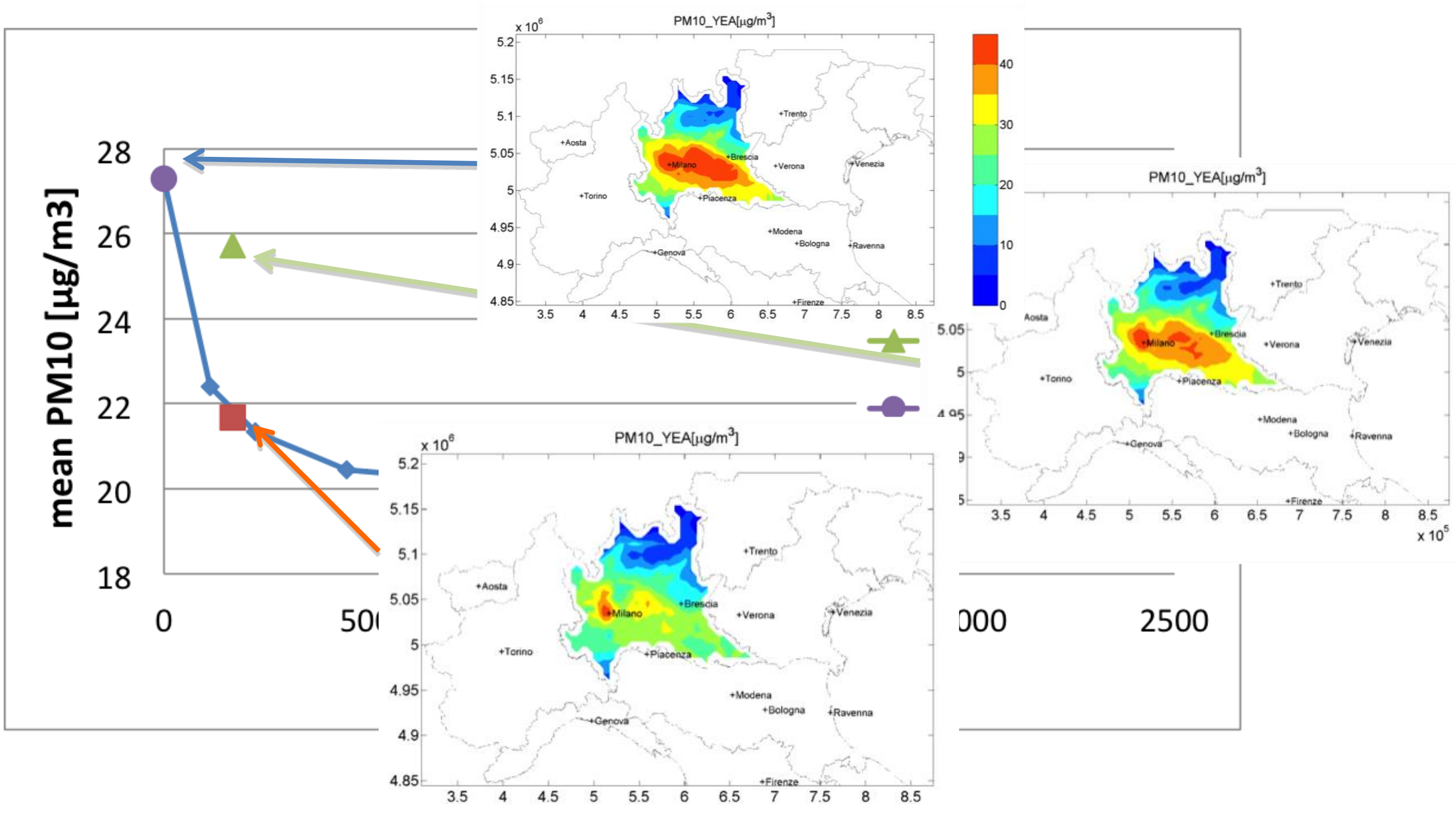
Optimized Scenario

Multi-objective
Cost-effective approach



Optimized Scenario

Impacts	CLE	Traffic scenario	Optimized scenario
Emission reduction costs	0 €	171 M€	171 M€
PM10 [μg/m3]	27.3	- 6%	- 21%



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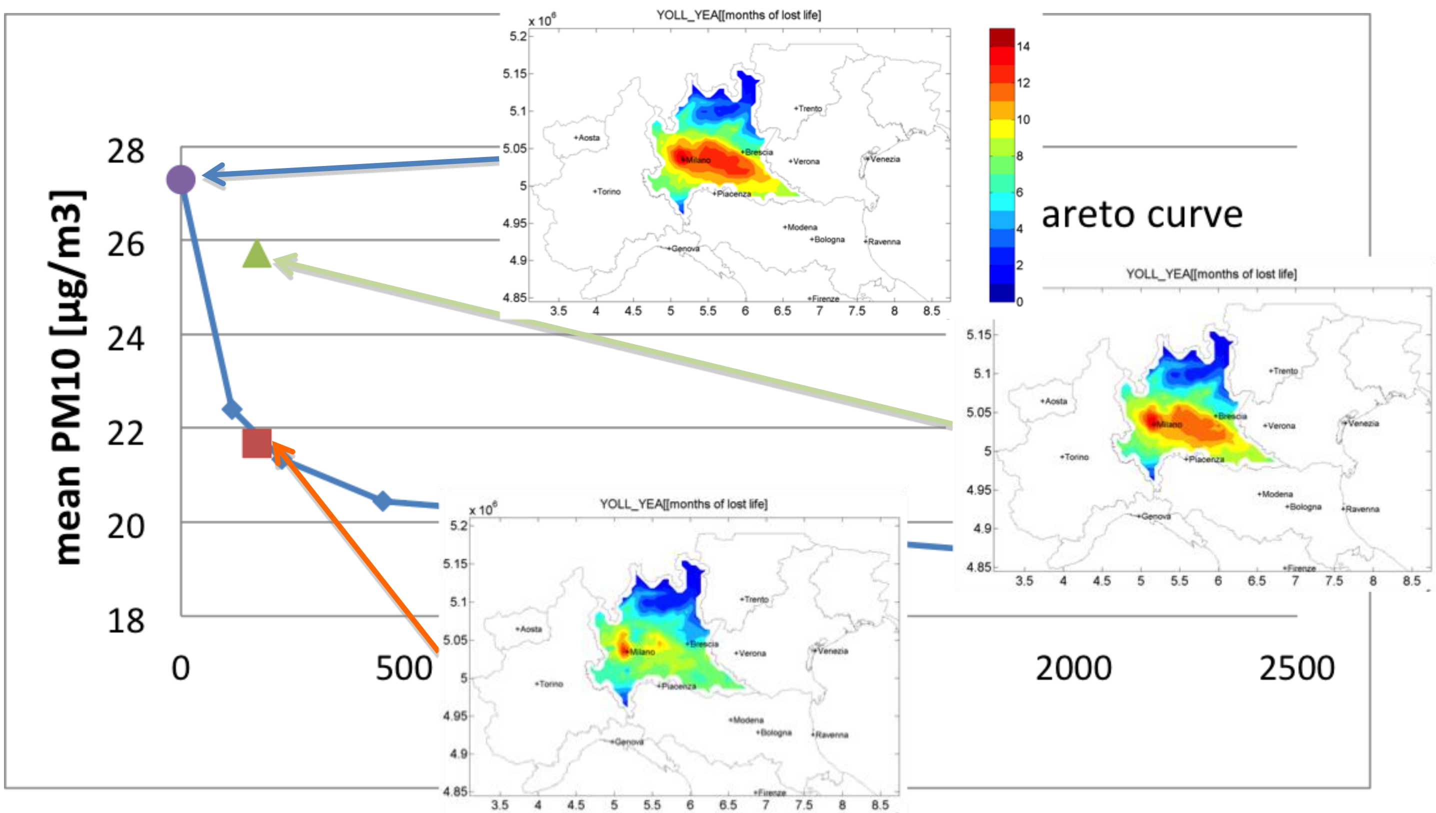

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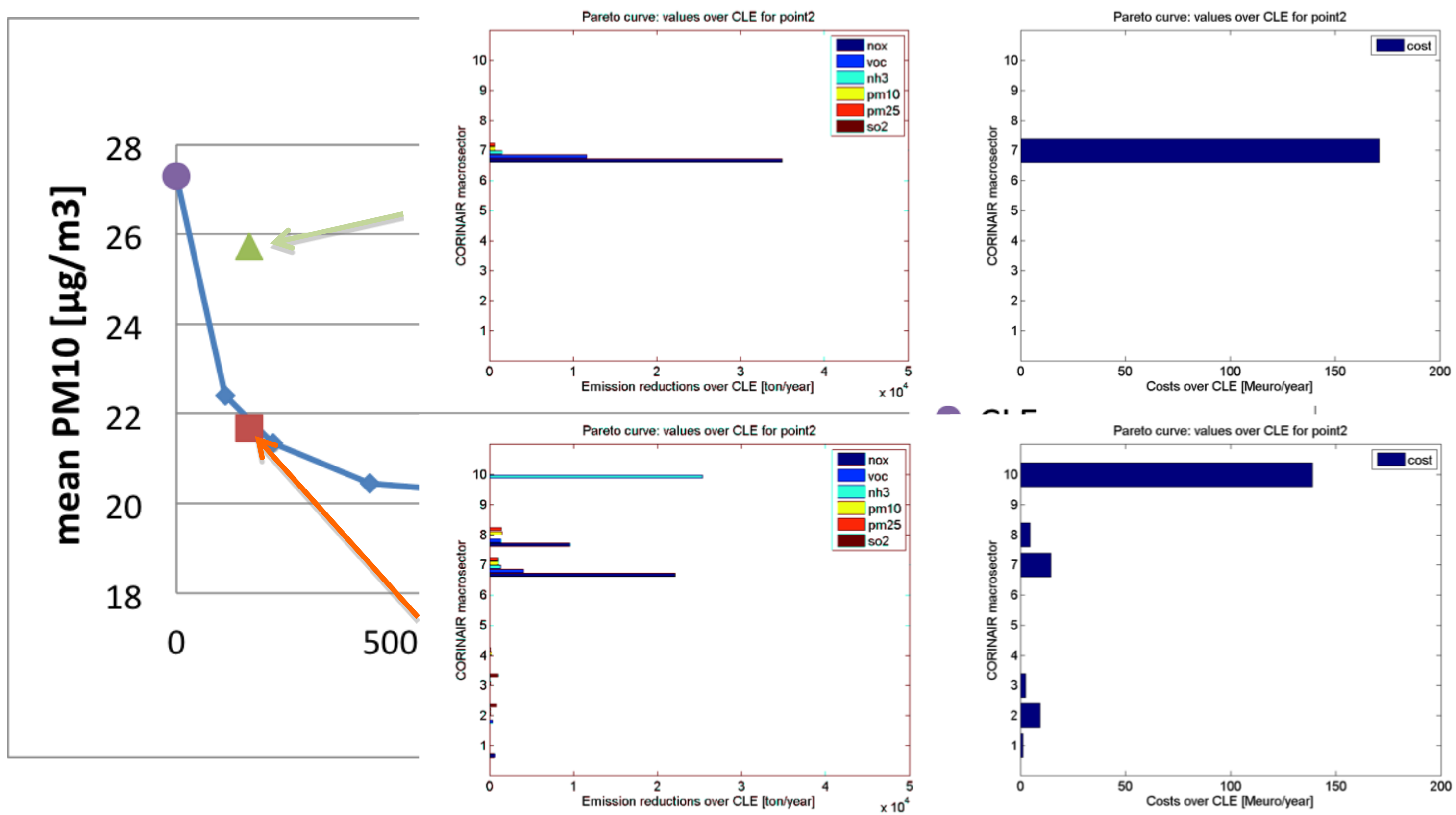
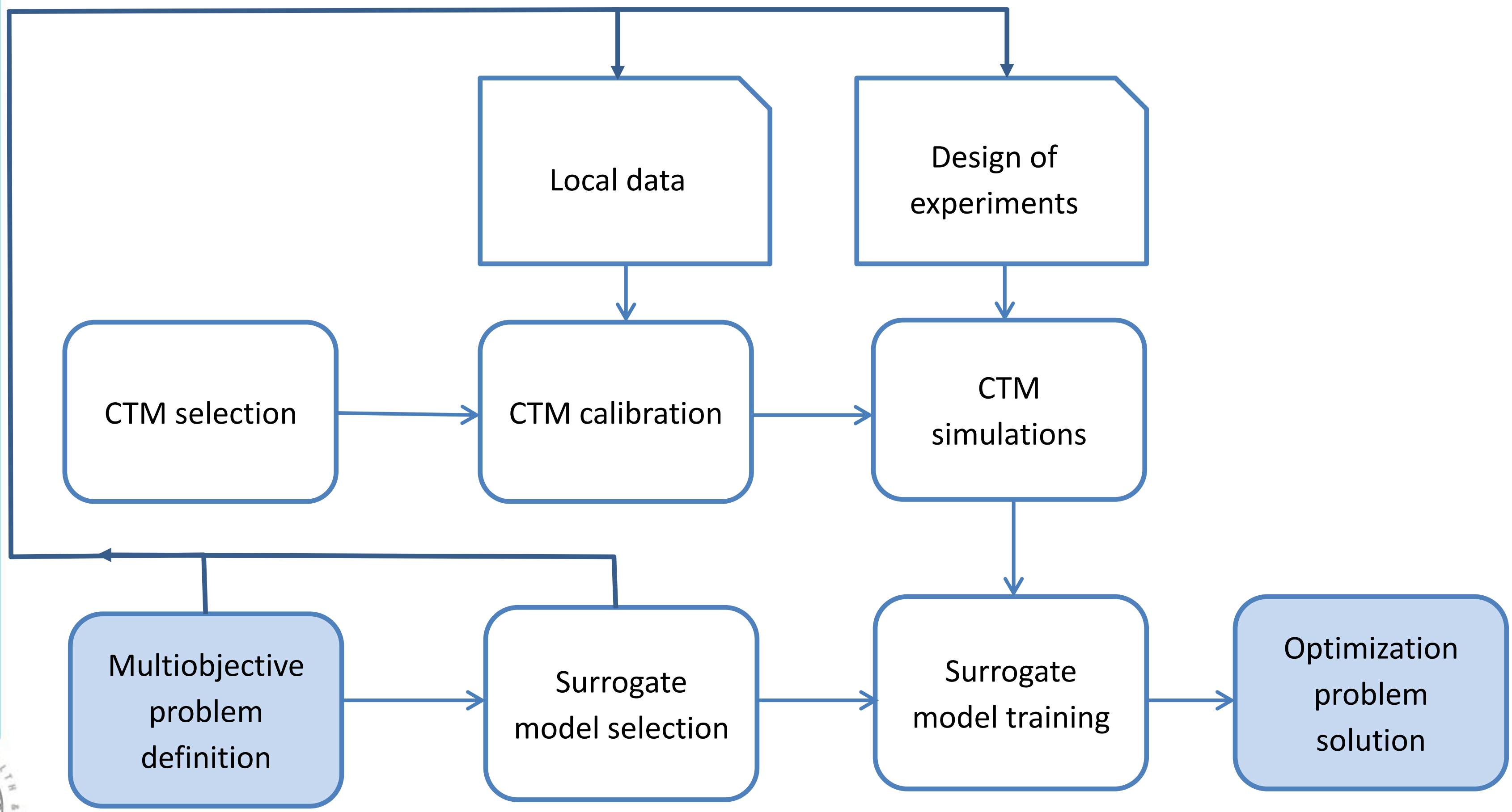


Taking Decision
3 key issues

Issue	Optimization	Cost-Effectiveness	Scenario
Relationship between emission and AQI	Fast S-R models	Fast S-R models	CTM Fast S-R models
Relationship between emission reduction (tech application) and costs	Needed	Needed	Useful
Optimization Algorithm	Needed	Needed	Not needed

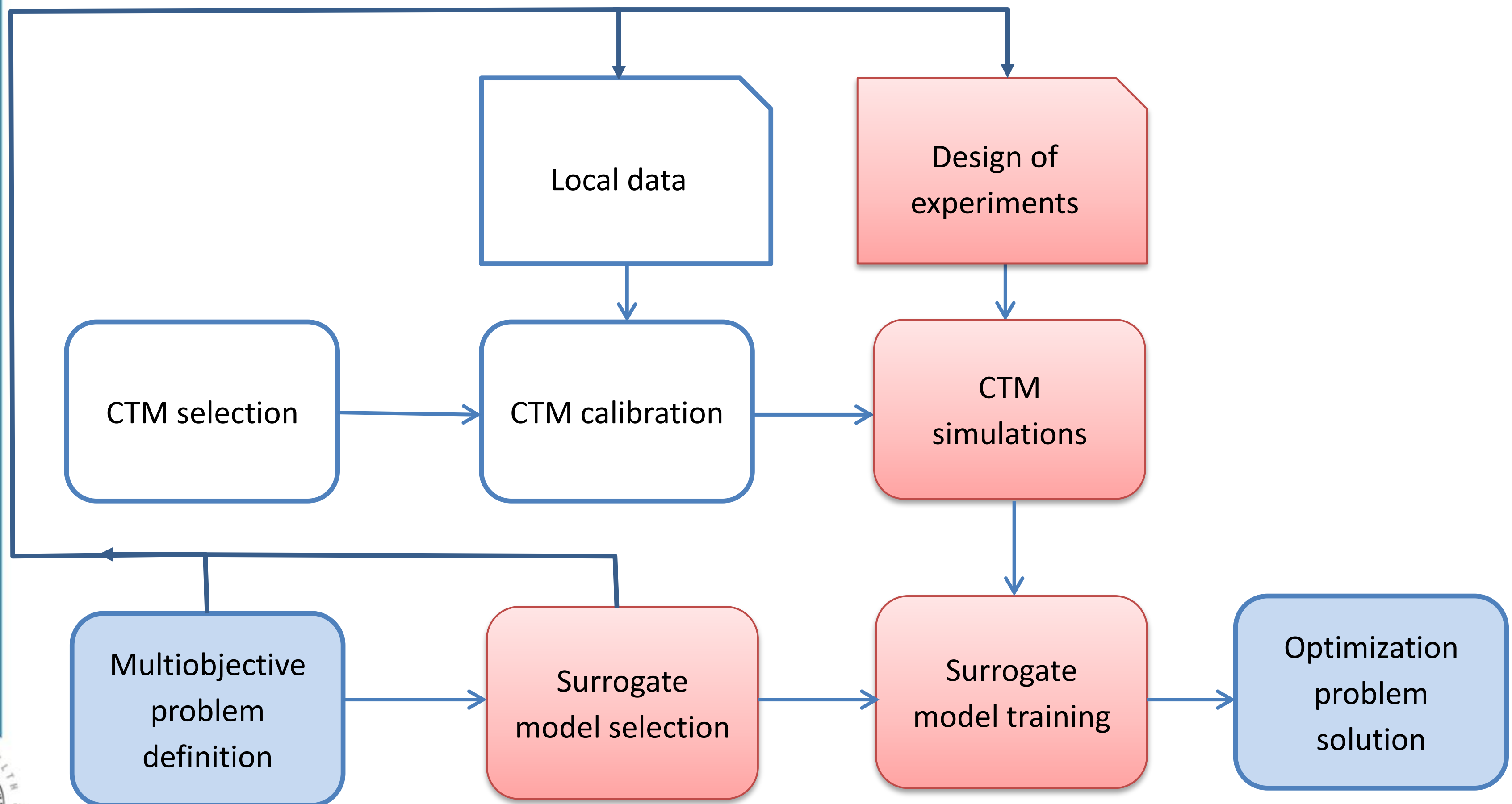
RIAT+ methodological scheme



Surrogate models

- Any model "family" that can fast compute the relationship between emission and AQI
- Why?
  - Optimization
  - Scenario analysis

Surrogate models



Design of Experiment

- Why?
  - S-R are (usually) statistical method
  - Has to consider the dynamics involved in the phenomena
- How?
  - “smart sampling” procedures?
  - Expert judgement
  - (at least) 2 dataset:
    - Computation of the s-r model
    - Validation of the computed model

Design of Experiment

- Dataset?
  - Tuples input-output
- What are the input in the relationship I want to describe?
- What are the output in the relationship I wanto to describe?

Surrogate model family in RIAT+

- Neural networks
- Linear regression

Example of S-R configuration in RIAT+

ANNs models: Inputs & Outputs

Sum of emissions over four quadrants.

- PPM10
- PPM2.5
- NH3
- SO2
- VOC
- NOx

48 INPUTS

- meanPM10
- meanPM2.5

ANNs models: Inputs & Outputs

Sum of emissions over four quadrants.

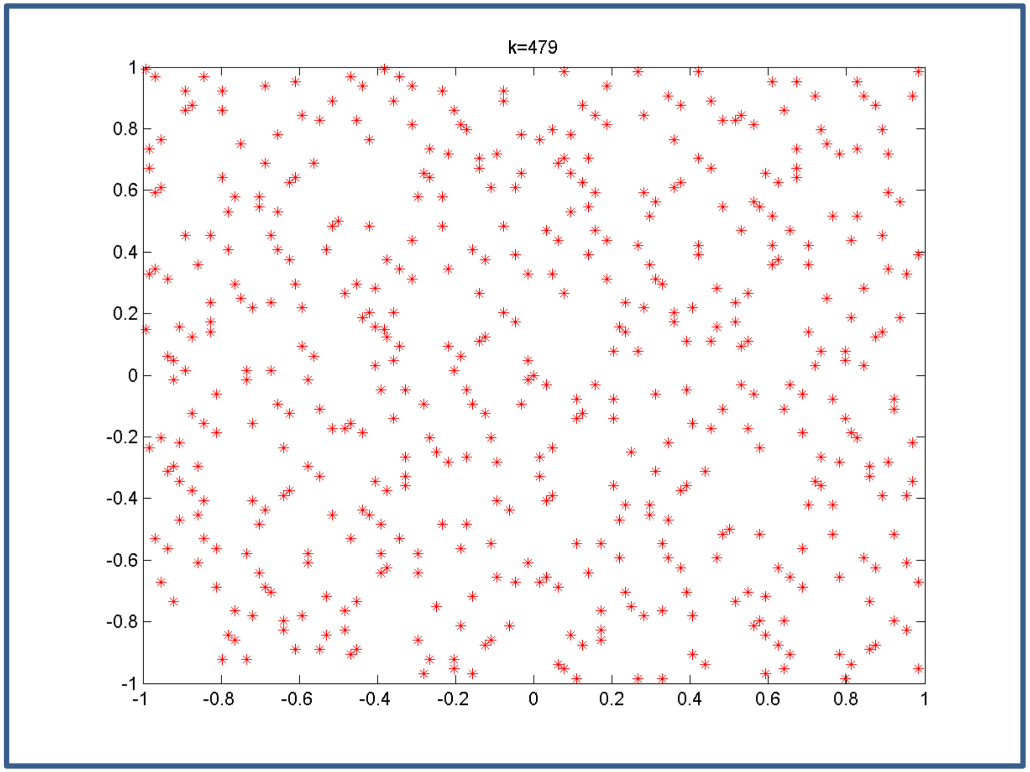
16 INPUTS

- VOC
- NOx

- meanNO2
- meanMAX8H
- AOT40
- SOMO35

Design of Experiment

Radial Basis Sampling based on Sobol number



Design of Experiment

	k1 (coeff. B)					k2 (coeff. H)				
Scenario	NOx	VOC	NH3	SO2	PM10	NOx	VOC	NH3	SO2	PM10
1	1	1	1	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	1	1	1
3	0	1	1	1	1	1	0	0	0	0
4	1	0	1	1	1	0	1	0	0	0
5	1	1	0	1	1	0	0	1	0	0
6	1	1	1	0	1	0	0	0	1	0
7	1	1	1	1	0	0	0	0	0	1
8	0.25	0.25	0.25	0.75	0.25	0.75	0.75	0.75	0.25	0.75
9	0.25	0.75	0.25	0.75	0.25	0.75	0.25	0.75	0.25	0.75
10	0.25	0.75	0.75	0.75	0.25	0.75	0.25	0.25	0.25	0.75
11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
12	0.75	0.25	0.75	0.75	0.25	0.25	0.75	0.25	0.25	0.75
13	0.75	0.75	0.25	0.75	0.25	0.25	0.25	0.75	0.25	0.75
14	0.25	0.25	0.75	0.25	0.75	0.75	0.75	0.25	0.75	0.25

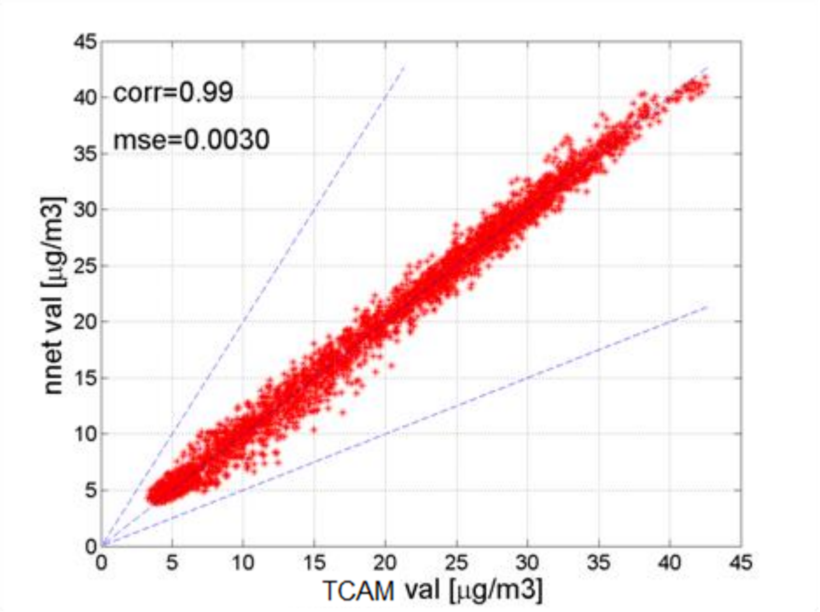
$E(i,j)=k1(i,j)*B+k2(i,j)*H$

i: scenario
j: pollutant

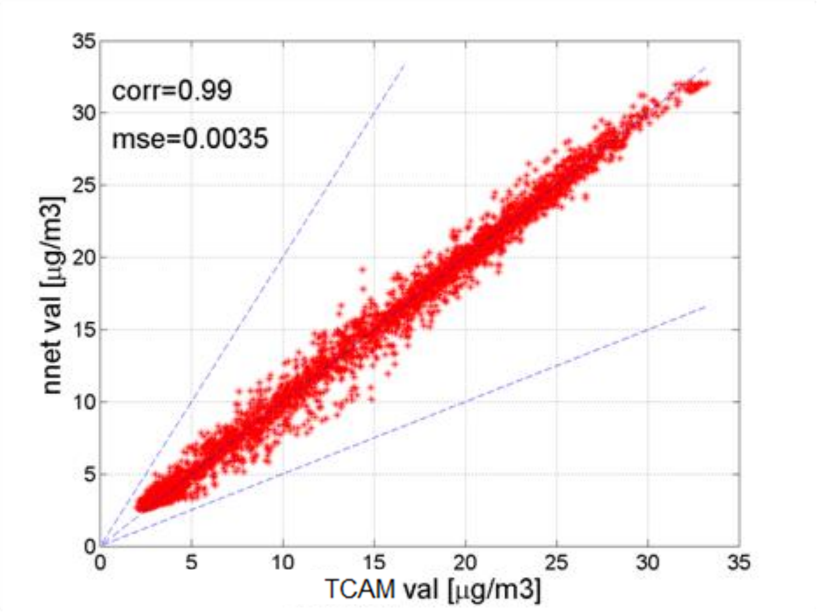
Problem:
B and H?

PM10 – PM2.5

PM10 year

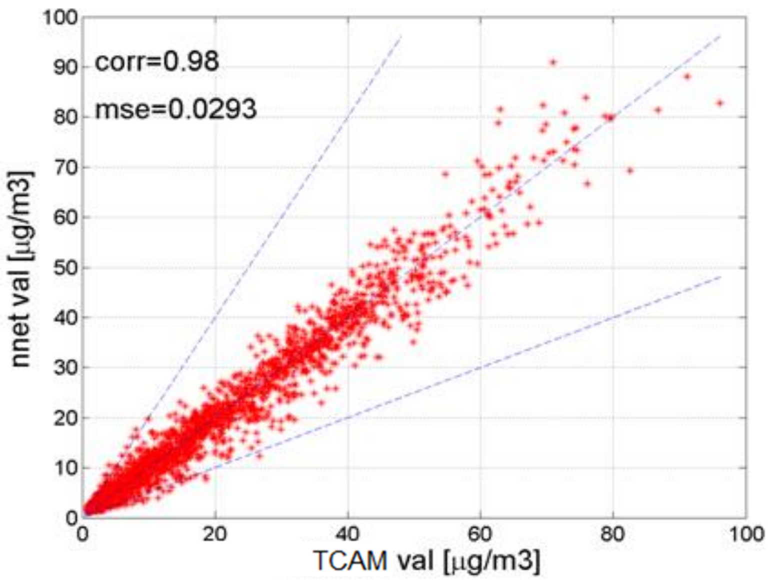


PM2.5 year

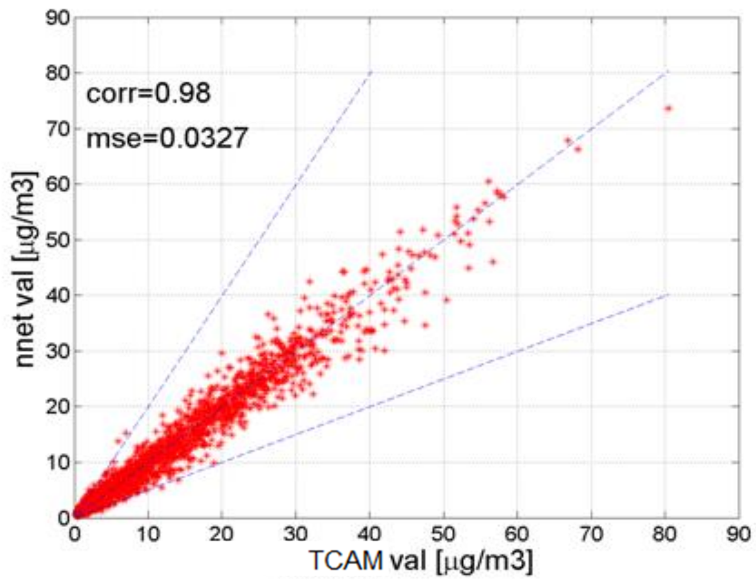


NO2

NO2 year

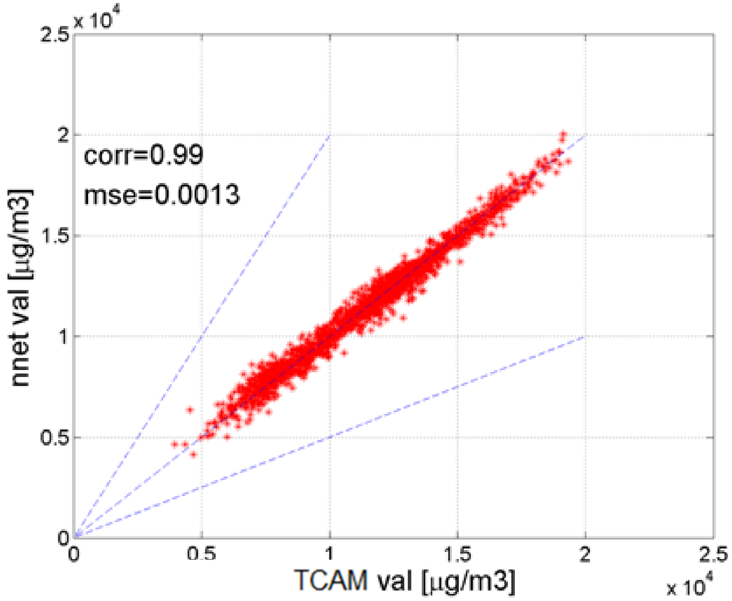


NO2 year

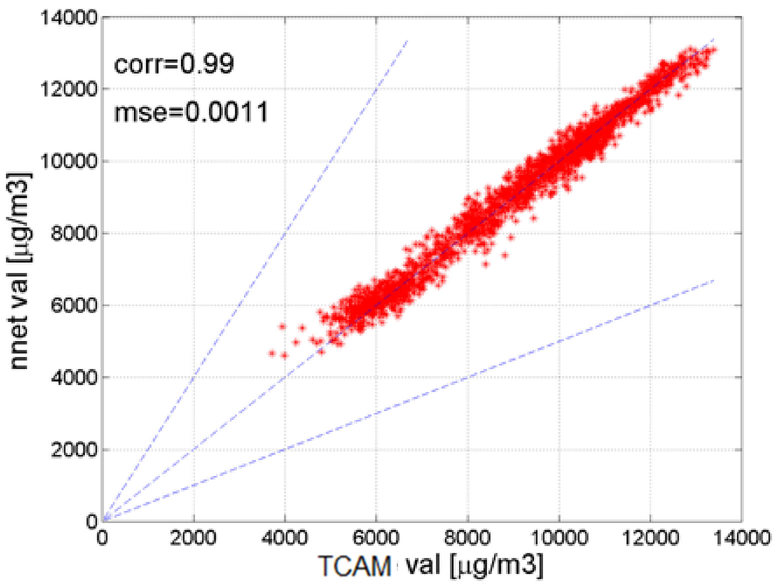


SOMO35

SOMO35 year

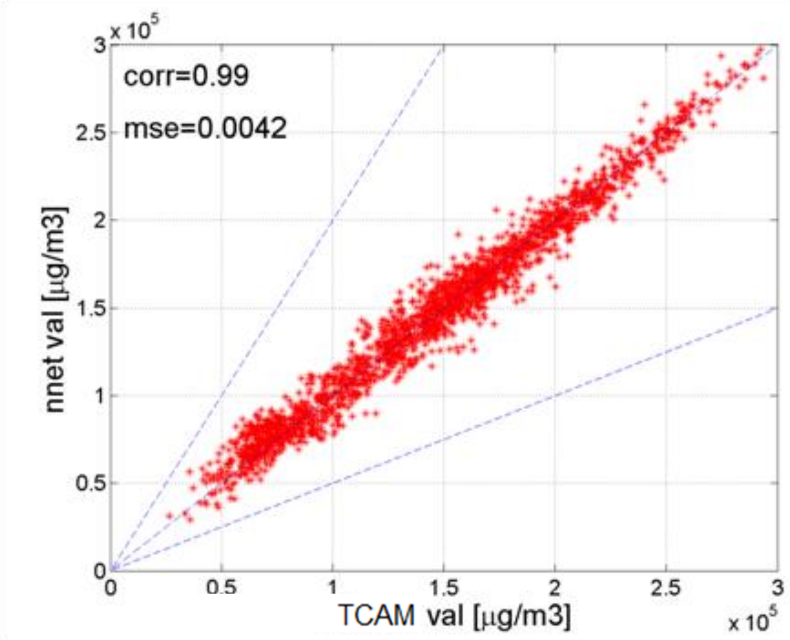


SOMO35 year

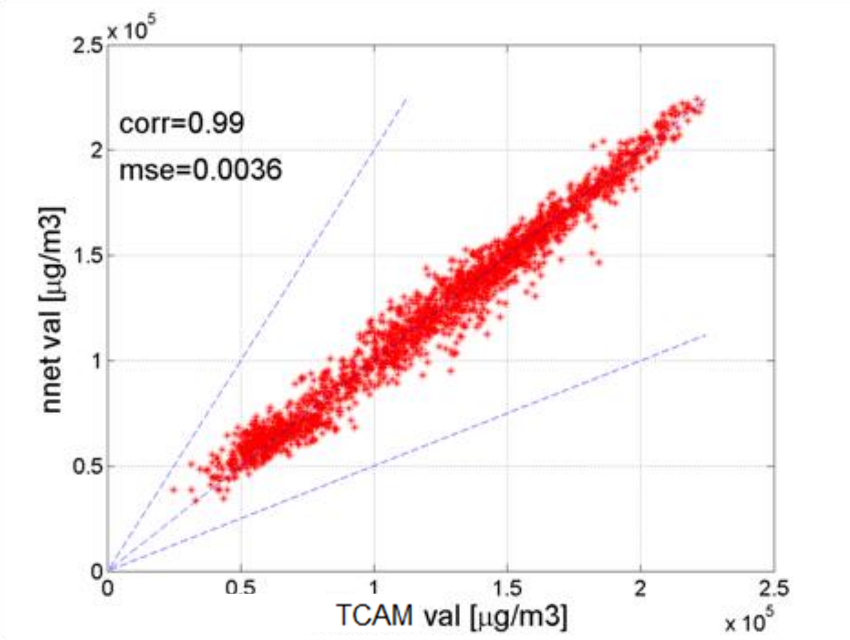


AOT40

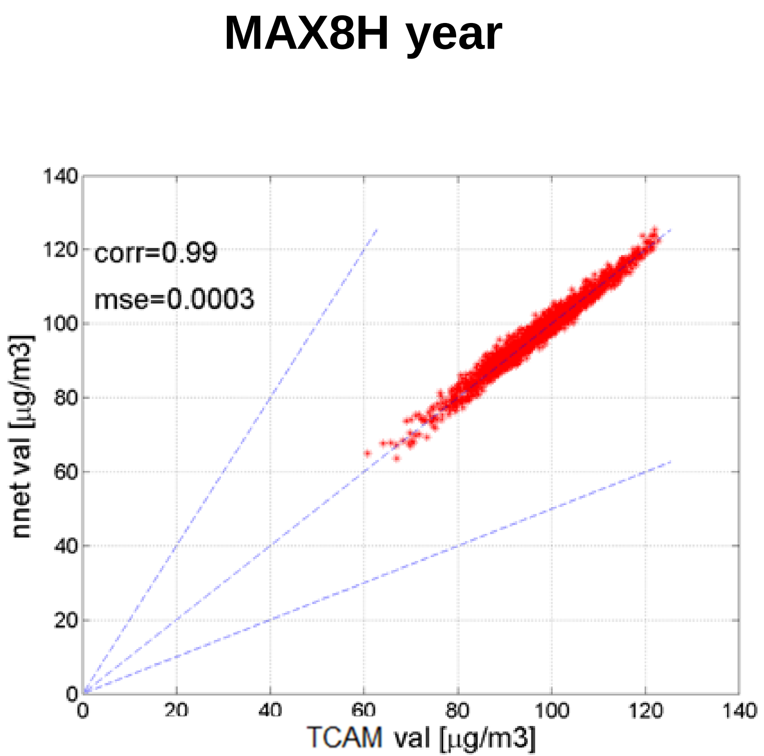
AOT40 year



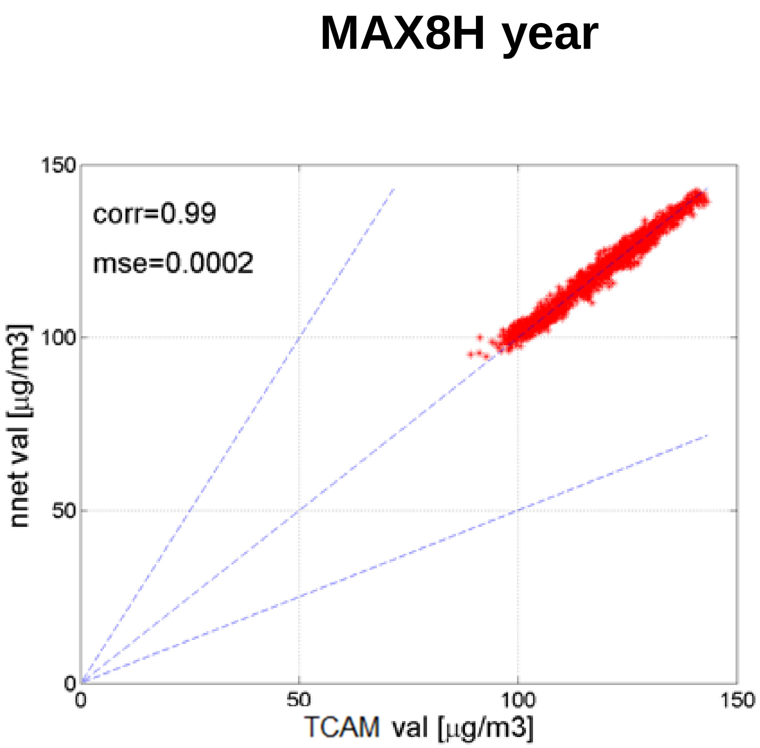
AOT40 year



MAX8H



MAX8H year
corr=0.99
mse=0.0003
nnet val [µg/m3]
TCAM val [µg/m3]
0
20
40
60
80
100
120
140



MAX8H year
corr=0.99
mse=0.0002
nnet val [µg/m3]
TCAM val [µg/m3]
0
50
100
150