LIFE09 ENV/IT/092

OPERA:

AN INTEGRATED ASSESSMENT MODEL TO PLAN EFFECTIVE AIR QUALITY POLICIES

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RIAT - OPERA

RIAT

- JRC
- Beneficiaries
  - UNIVERSITY of BRESCIA
  - TERRARIA
- RIAT
- Lombardia

OPERA

- LIFE+
- Beneficiaries
  - ARPA-ER
  - UNIVERSITY of BRESCIA
  - TERRARIA
  - CNRS
  - JRC, RER, ASPA
- RIAT+
- Emilia Romagna, Alsace

IAM architecture

Input databases

- emission inventories and projections
- emission reduction measures:
  - ✓ technical measures
  - ✓ non-technical measures
  - ✓ costs
- Emission-concentration relationships (CTM simulations)

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Decision model

- what-if analysis
- cost-benefit analysis
- cost-effective analysis
- multi-objective analysis

Source-receptor models

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Deliverables

- efficient policies
- objective values
- post-processing:
  - ✓ *ex-post analysis*
  - ✓ sensitivity

Decision model approaches

- what-if analysis
- cost-benefit analysis
- cost-effective analysis
- multi-objective analysis

Decision model

- what-if analysis
- cost-benefit analysis
- cost-effective analysis
- multi-objective analysis

$$\underset{x}{opt}[J(x)]$$

$$x \in \Theta$$

J(x) is the objective function to be optimized
x is the set of decision variables
Θ is the set of feasible decisions

Decision model

Cost-benefit analysis:

J(x) is a scalar function

all benefits and costs are monetized and assessed in a single function

Rabl, A., Spadaro, J. V., &Zwaan, B. V. D. (2005). Uncertainty of air pollution cost estimates: To what extent does it matter. Environmental Science & Technology, 39, 399–408.

Reis, S., Nitter, S., & Friedrich, R. (2005). Innovative approaches in integrated assessment modelling of European air pollution control strategies - Implications of dealing with multipollutant multi-effect problems. Environmental Modelling & Software, 20, 1524–1531.

Vlachokostas Ch., Achillas Ch., Moussiopoulos N., Hourdakis E., Tsilingiridis G., Ntziachristos L., Banias G., Stavrakakis N., Sidiropoulos C. (2009). Decision support system for the evaluation of urban air pollution control options: Application for particulate pollution in Thessaloniki, Greece, Science of the Total Environment, 407, 5937–5948.

Decision model

Cost-effective analysis

J(x) is a scalar function

a single objective is optimized, while others required performances are included as constraints

RAINS/GAINS system, APD IIASA

Carslon, D., Haurie, A., Vial, J.-P., & Zachary, D. (2004). Large-scale convex optimization methods for air quality policy assessment. Automatica, 40, 385–395.

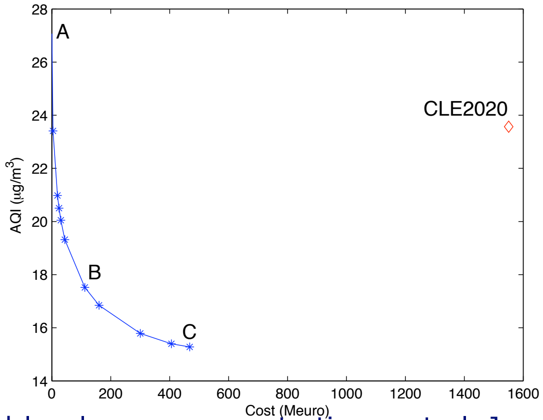
Shih, J.-S., Russell, A., & McRae, G. (1998). An optimization model for photochemical air pollution control. European Journal of Operational Research, 106, 1–14.

Decision model

Multi-objective analysis:

J(x) is a vector

J(x) represents different and often conflicting objectives.



Guariso, G., Pirovano, G., Volta, M. (2004). Multi-objective analysis of ground-level ozone concentration control. Journal of Environmental Management, 71, 25–33.

Pisoni, E, Carnevale, C., Volta, M. (2009). Multi-criteria analysis for PM10 planning. Atmospheric Environment, 43, 4833-4842

Decision problem

$$\min_{x} J(x) = \min_{x} \left[AQI(x) \quad inC(x) \right]$$

Internal Costs

Air Quality Index: PM10, PM2.5, Ozone, NOx

$$x \in \Theta$$

Set of feasible decisions

Set of decision variables
(precursor emission reduction measures)

AQI: Source-Receptor models

$$\frac{\partial AQI(x)}{\partial x} = \frac{\partial AQI(x)}{\partial E} \cdot \frac{\partial E}{\partial x}$$

Source-Receptor models

- S-R models identified processing CTM model simulations
- Non linear processes
- Local features
- Design of experiments

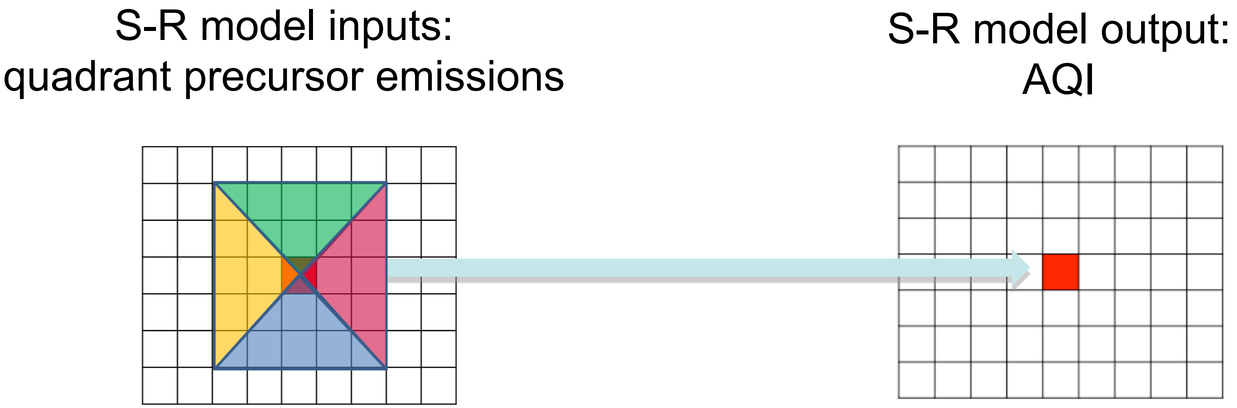
DoE: CTM simulations

Scenario	NOx	VOC	NH3	PM	SO2
0	C	C	C	C	C
1	B	B	B	B	B
2	A	A	A	A	A
3	A	B	B	B	B
4	B	A	B	B	B
5	B	B	A	B	B
6	B	B	B	A	B
7	B	B	B	B	A
8	B	A	B	A	B
9	A	A	B	A	A
10	A	B	A	B	B

- C = CLE2010 + 10%
- A = MFR2020
- B = (CLE2015 + MFR2015)/2

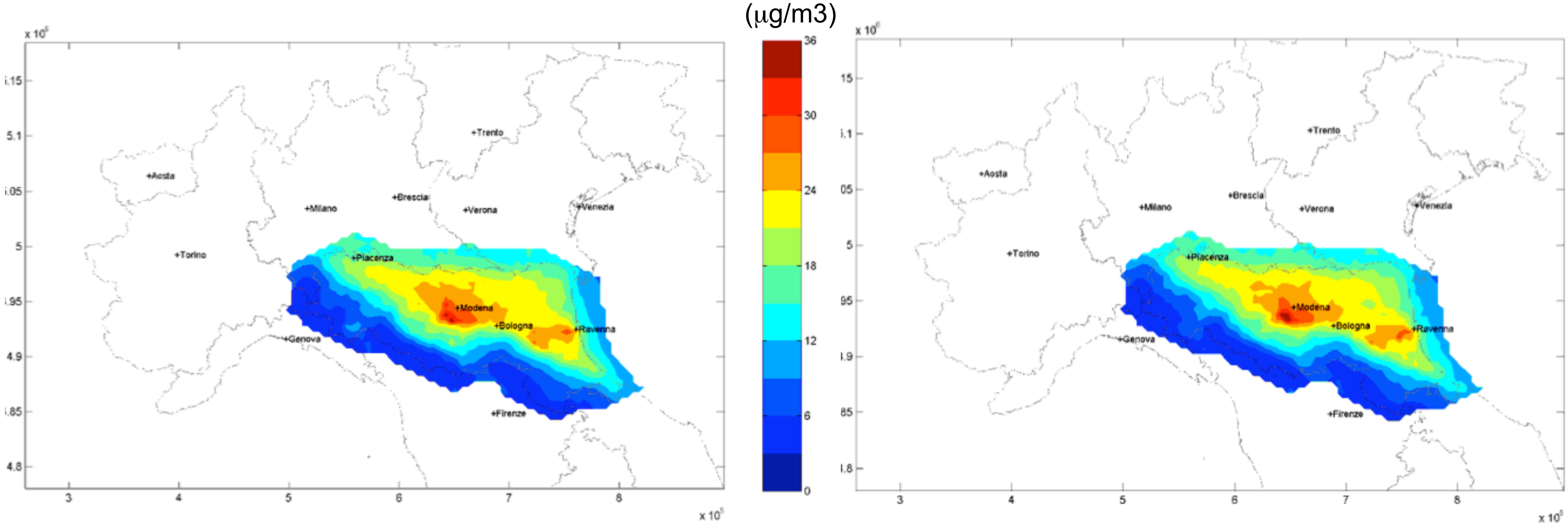
Source-receptor models

- Input data: precursor emissions
- Target data: AQI



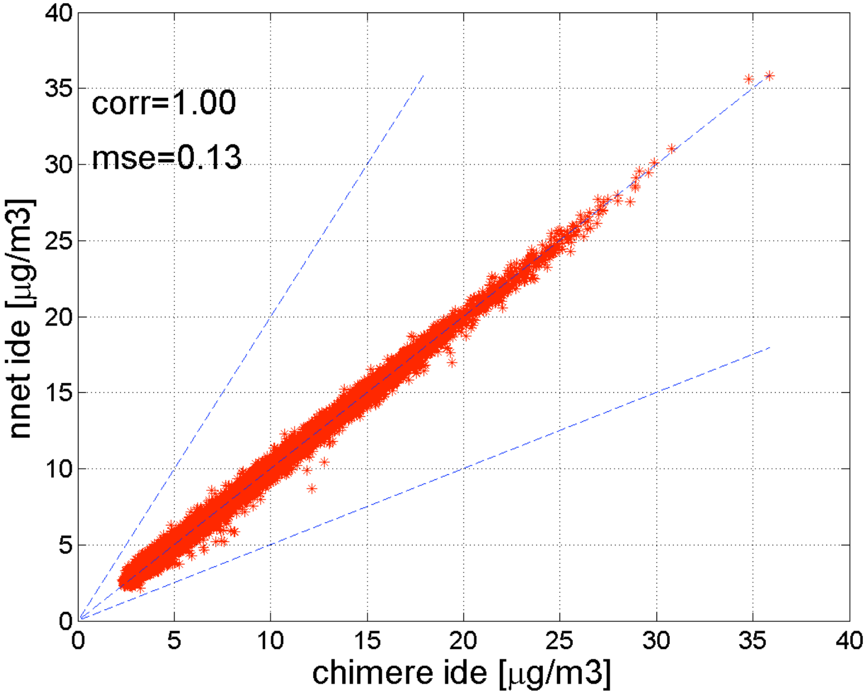
PM10: basecase

CHIMERE | S-R models

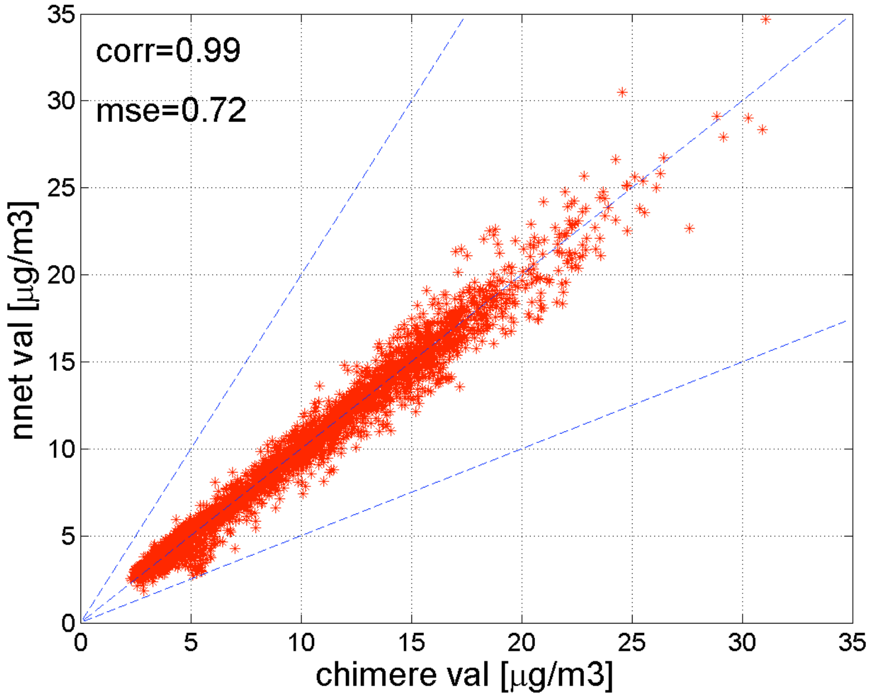


S-R models

Identification



Validation



Decision variables

Detailed approach

- Technical measures:
  - Actual technical measures spreading
  - Actual technical measures spreading and replacing
- Non technical measures

Lumped approach

- Technical measures:
  - Macrosector precursor emission reductions

Costraints

- Technical measures feasibility
- Technical and non technical measure mix
- National and European plan harmonization
- Emission reduction measures replacing
- Budget constraints due to on going or foreseen AQ policies

Problem formalization

$$\min_{X_{i,j,k,t}} J(X_{i,j,k,t}) = \min_{X_{i,j,k,t}} AQI(X_{i,j,k,t})$$

$$(X_{i,j,k,t} = \text{appl. rates})$$

$$inC(X_{i,j,k,t}) \leq L \qquad 0 \leq L \leq \overline{L}$$

If no technology replacement:

- to ensure the technology feasibility:

$$X^{CLE}_{i,j,k,t} \leq X_{i,j,k,t} \leq \overline{X}^{CLE}_{i,j,k,t} \quad \forall i,j,k,t$$

- to ensure the emission conservation:

$$\sum_{t\in T_{i,j,k}} X_{i,j,k,t} \leq 1$$

If technology replacement:

- to ensure the technology feasibility:

$$0 \leq X_{i,j,k,t} \leq \overline{X}^{CLE}_{i,j,k,t} \quad \forall i,j,k,t$$

- to ensure the emission conservation:

$$\sum_{t\in T_{i,j,k}} X_{i,j,k,t} \leq 1$$

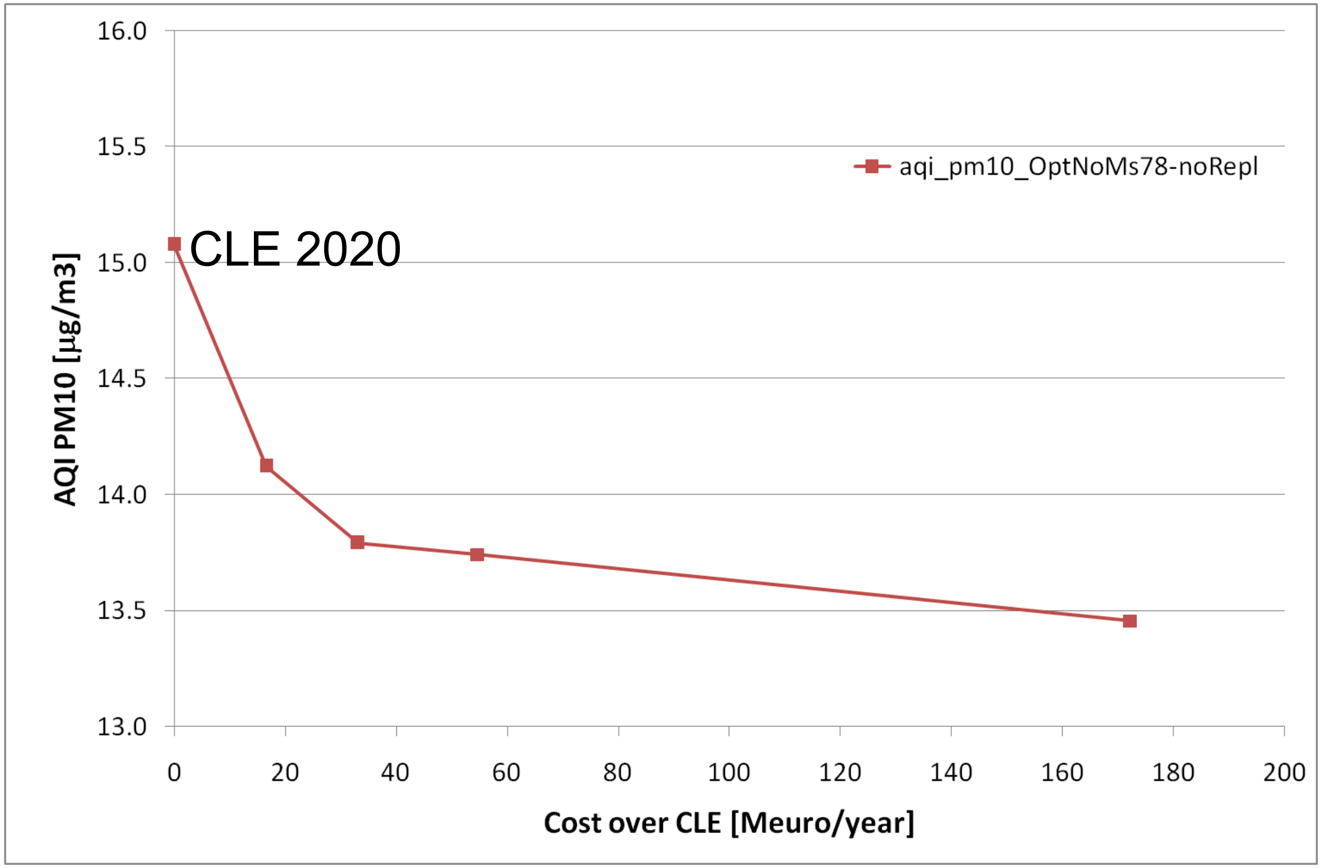
- to ensure optimal reduced emissions > CLE

$$\sum_{t\in T_{i,j,k}} eff_{i,j,k,t,p} \cdot X_{i,j,k,t} \geq \sum_{t\in T_{i,j,k}} eff_{i,j,k,t,p} \cdot X^{CLE}_{i,j,k,t} \quad \forall i,j,k,t$$

- to ensure no controlled emission in CLE remains without control

$$\sum_{t\in T_{i,j,k}} X_{i,j,k,t} \geq \sum_{t\in T_{i,j,k}} X^{CLE}_{i,j,k,t}$$

Effective solutions



Problem options

- Seasonal air quality indexes
- Point and area emission sources
- Optimization domains
- Population exposure
- GHGs budget

System tests

- Emilia Romagna
- Alsazia
- Standard methodology for European regions

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