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Scenarios analysis at urban & regional scales

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Outline

AQM analyses to support mid- / long-term policy issues, as impact assessment of planned infrastructures and emissions reduction plans

Examples:

- Regional impact assessment of relevant point sources
- Regional Air Quality Plan
- Traffic-specific scenarios
- Impact of new infrastructures

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Example 1

Regional impact assessment of relevant point sources

Future power plants configuration in N Italy

Ministero dell'Ambiente
e della Tutela del Territorio

ENEA

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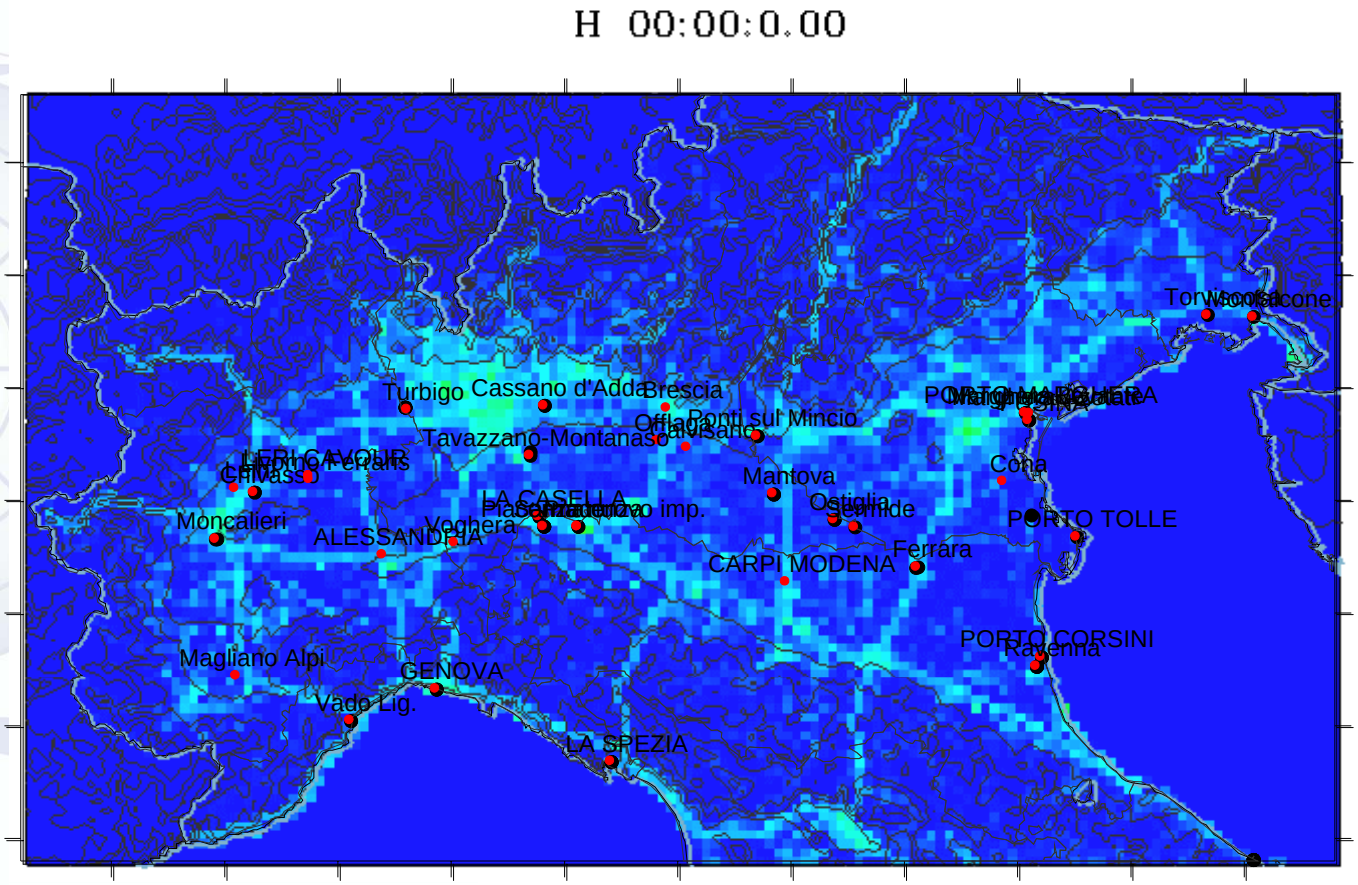
National AQM

Emissions

Diffuse emissions, base case (4 km) + thermal power plants
Example of daily winter cycle - NO



Year 2010

Processing from APAT 2000 national inventory data

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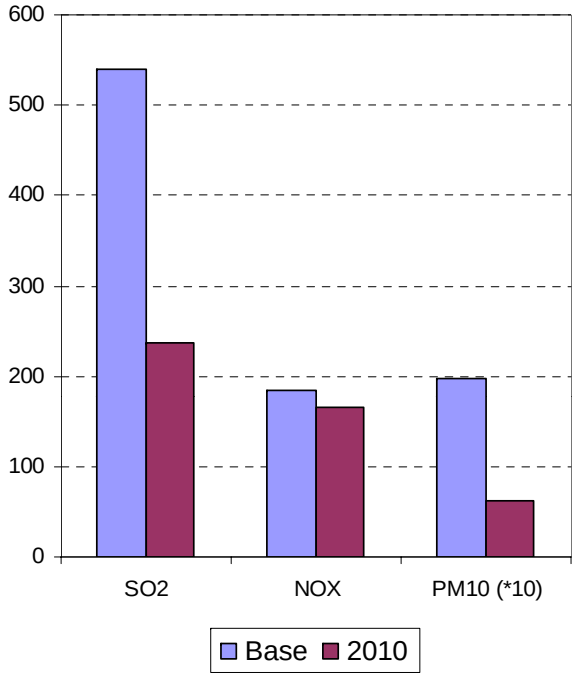
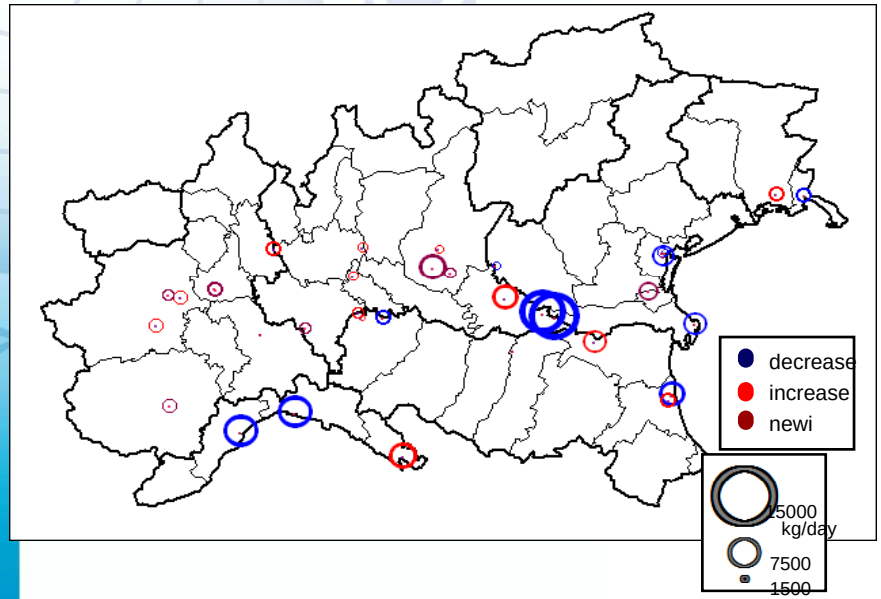
Thermal power plants at year 2010

Emissions

	SO2	NOx	PM10
Base	540	184	20
Year 2010	237	166	6
Variation (resp. to LPS total)	-56%	-10%	-68%
Variazione (resp. to grand total)	-33%	-1%	-5%
Diffuse N Italy	367	1706	253

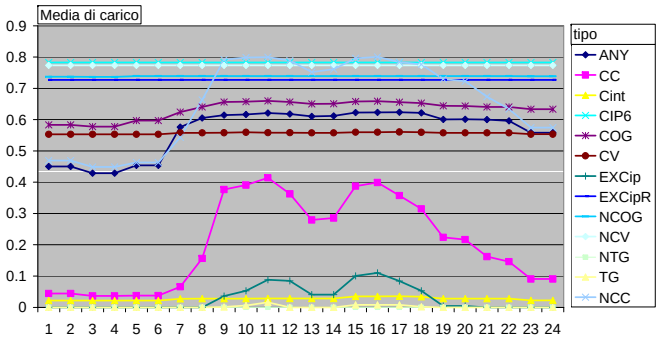


Variations of NO_x emissions



Data from Ministry of Industry & Authority for Electricity and Gas

Load curves by plant type



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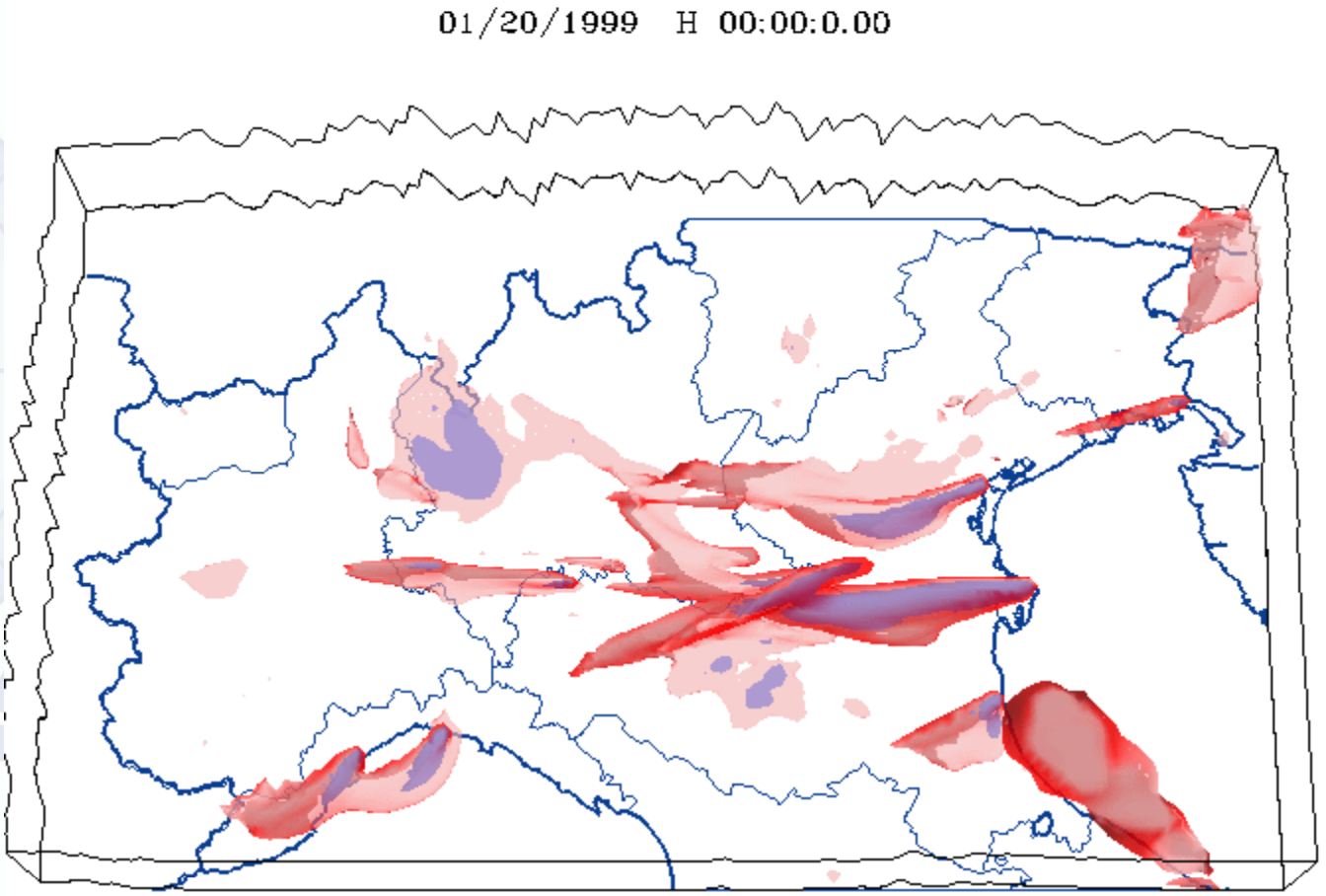
Concentrations from AQM

Example: SO_2



Isosurfaces at 10 and 20 ppb

27 54

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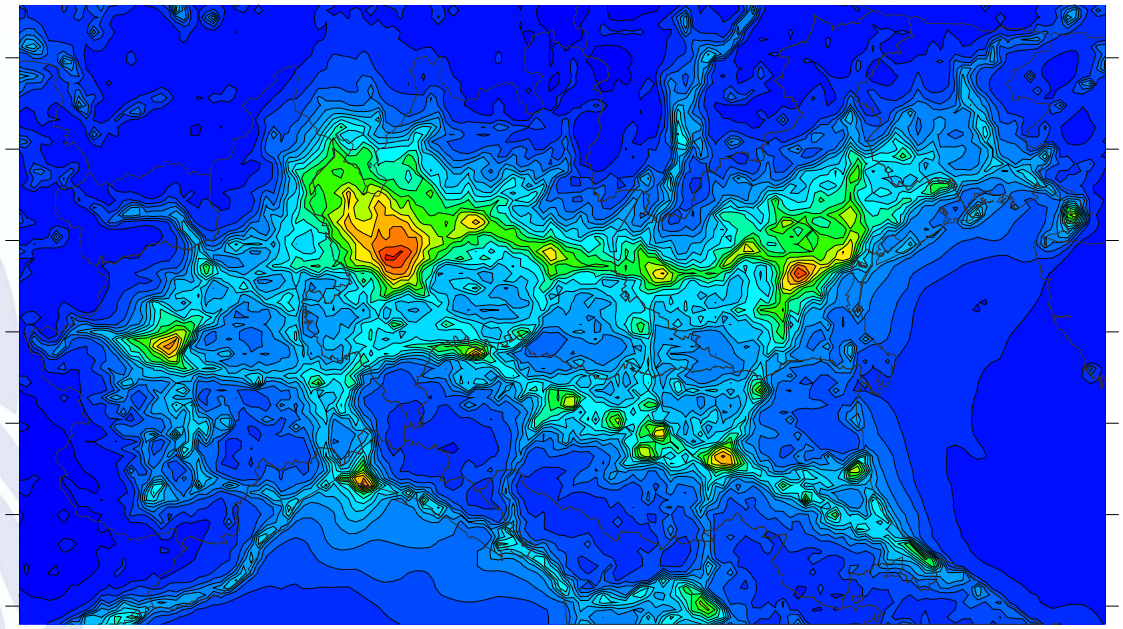
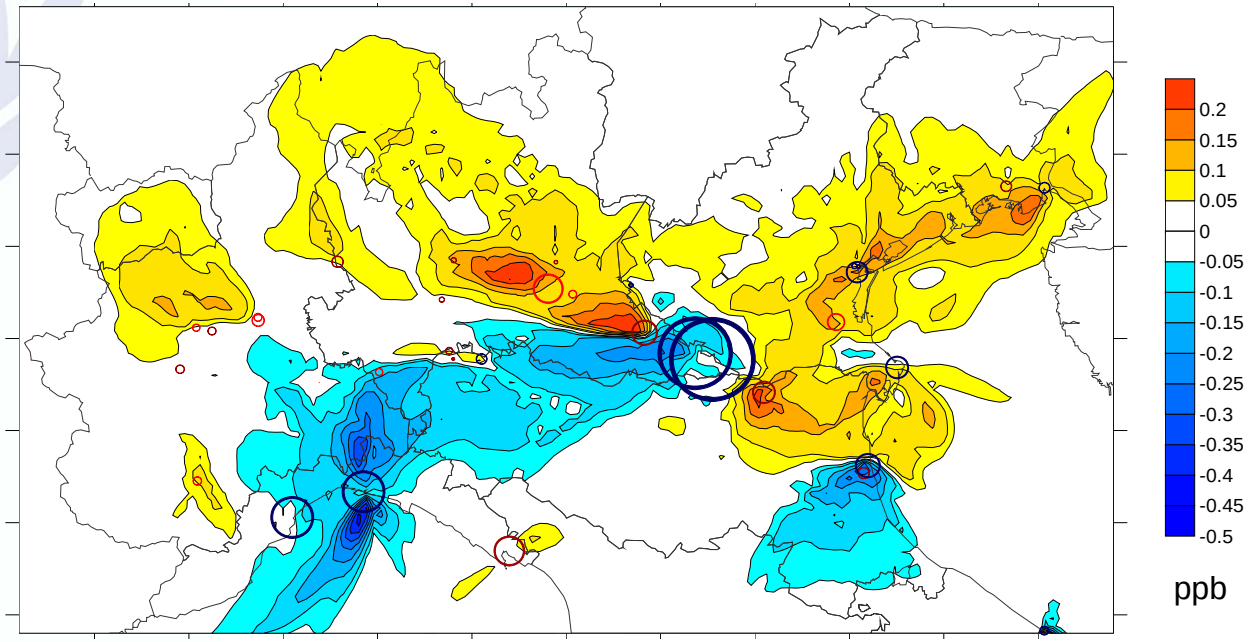
Results on concentrations (1)

Base case

NO_2 avg., winter



Variations



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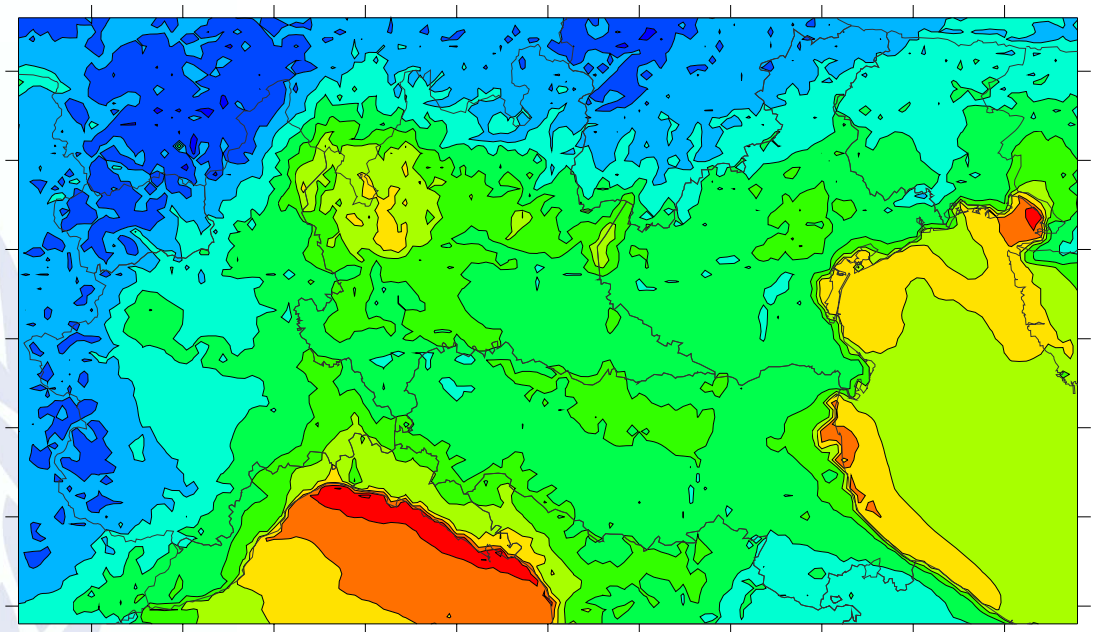
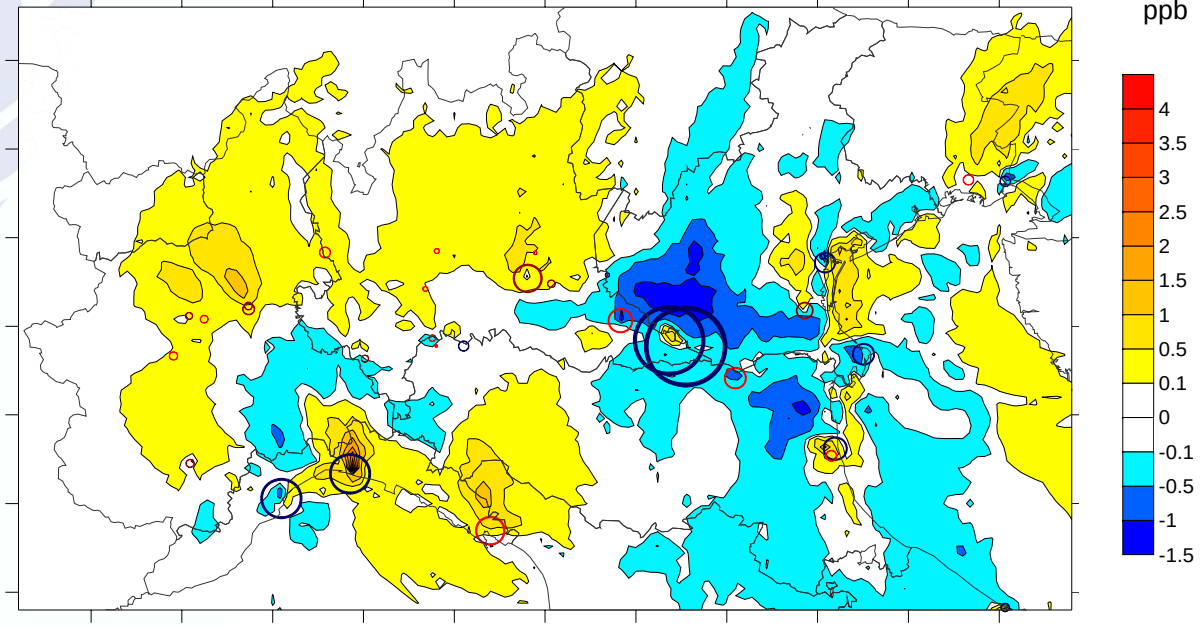
Results on concentrations (2)

Base case

O_3 avg. of daily max



Variations



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Example 2

Regional Air Quality Plan

The case of Turin & Piemonte

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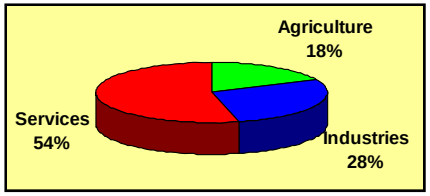
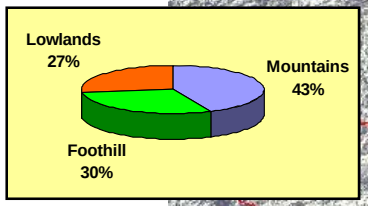
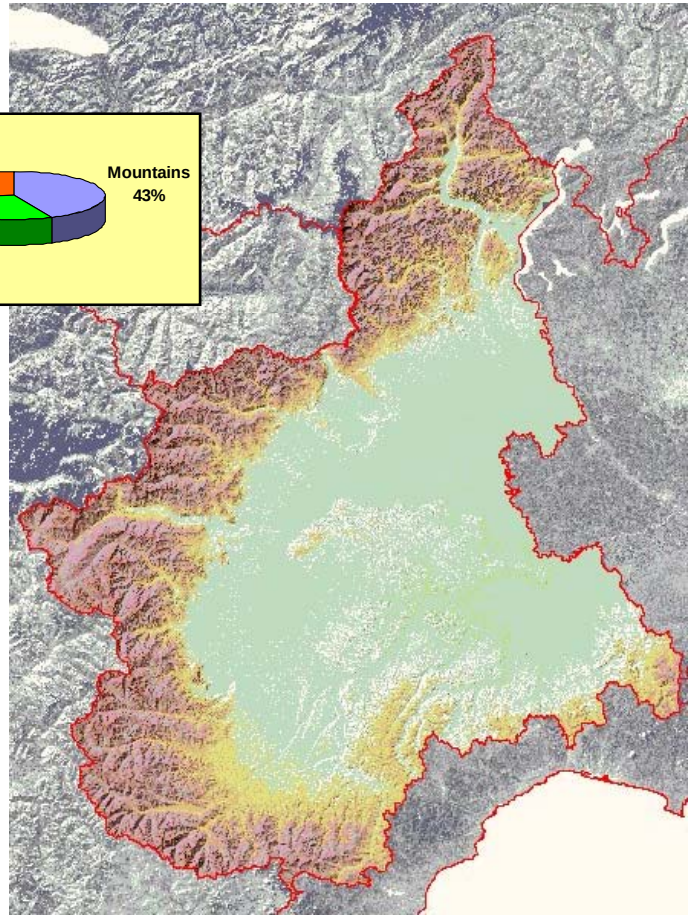
Turin & Piemonte (N Italy)

- Population: 4,290,000
- Turin agglomerate: 1,297,000
- Vehicles: 3,481,736
- Roadnet: 22,630 Km







- Climate:
  - winters: cold, dry and banks of fog
  - summers: cool in the hills and quite hot in the plains
- Temperature range during the year (plains): - 5°C / +30°C

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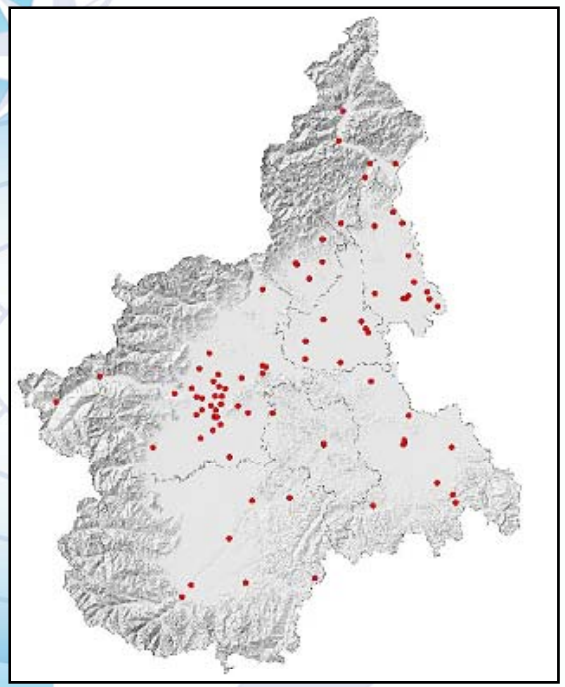
The Piemonte case

Resources

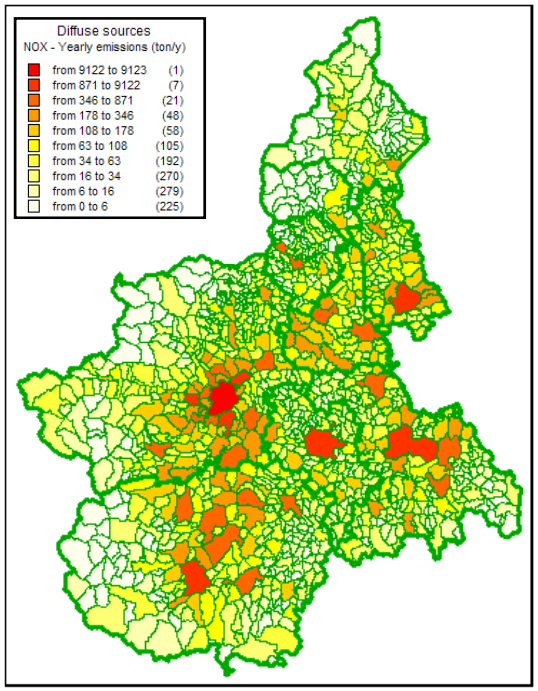
Regional Air Quality Network



- 74 public fixed stations
- 6 public mobile stations
- 11 private fixed stations

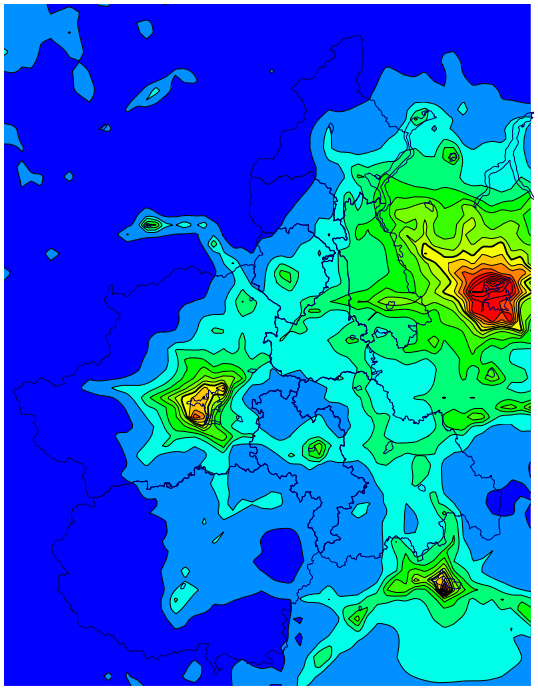
(NO_x, CO, PM_{10}, $PM_{2.5}$, SO_2, O_3)

Emission inventory



1200 munic.

Modelling system



4 km res.

AQM routinely used:

- **yearly air quality evaluation (since 2004)**
- **regional & urban air quality forecast (4 & 1 km, since 2005)**

Major AQ issues: NO_2, PM, O_3

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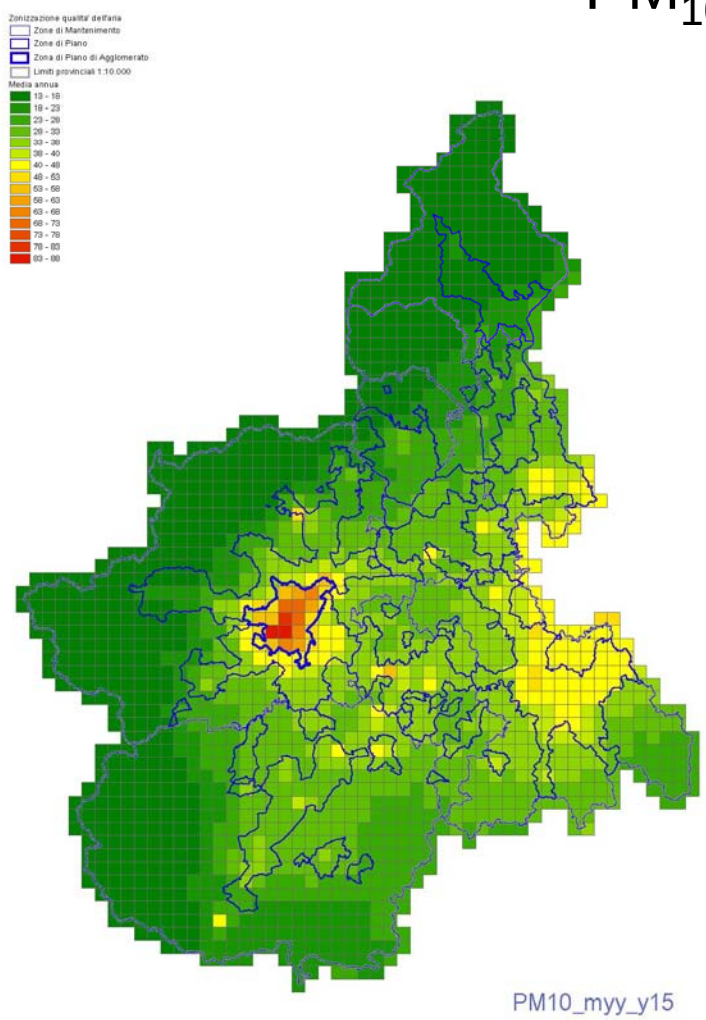
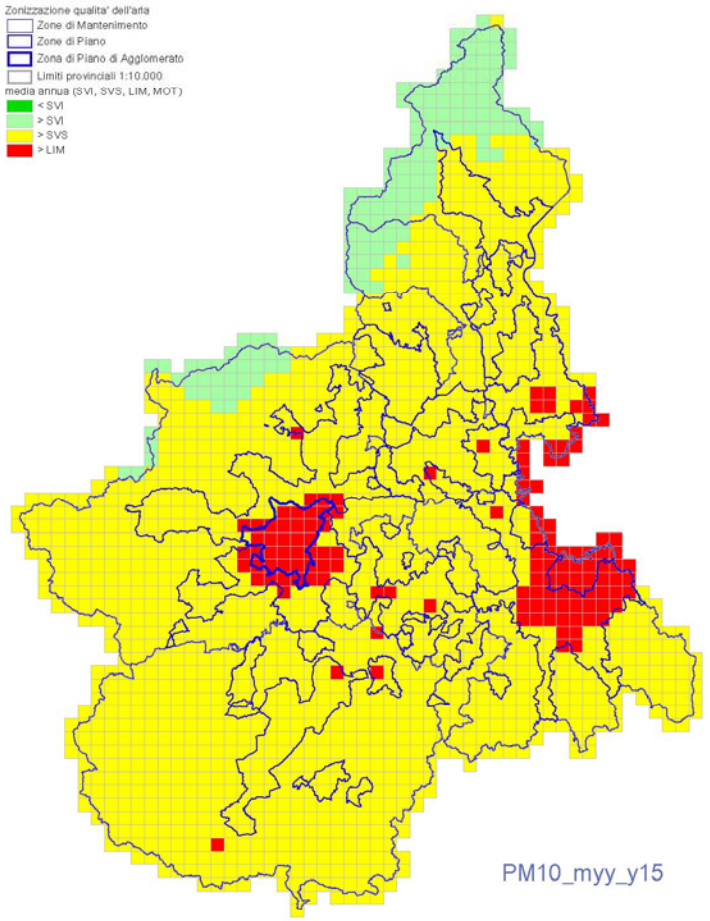
The Piemonte case

Situation at 2005 (1)

PM_{10}





EU legislation:

- limit value at 2005: 40 μg/m³
- target value at 2010: 20 μg/m³

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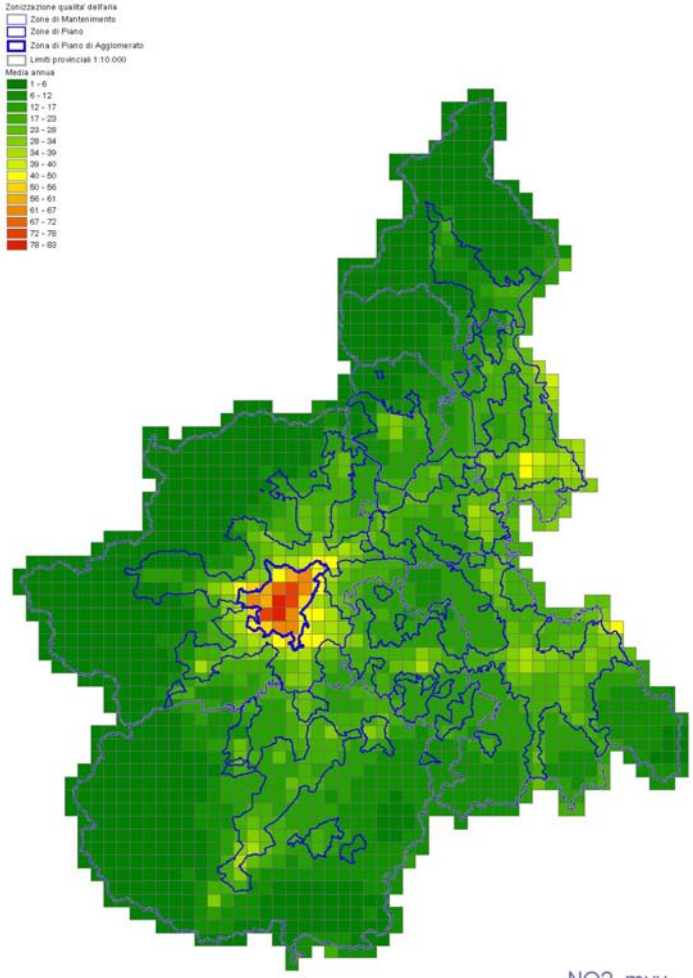
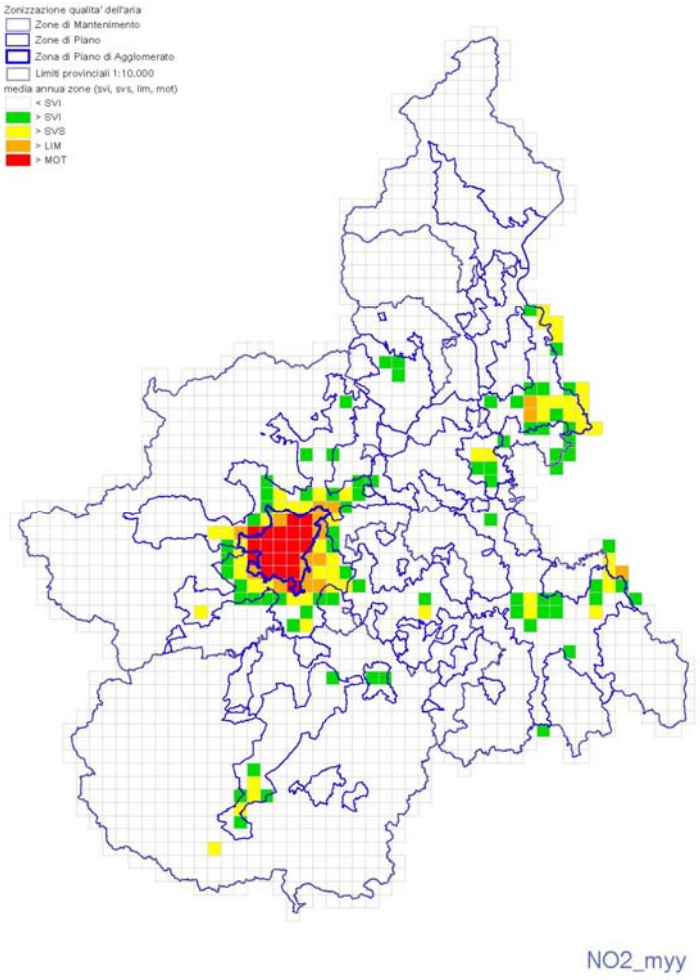
The Piemonte case

Situation at 2005 (2)

NO_2





EU legislation:

- target value at 2010: 40 μg/m³

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Context: EU legislation

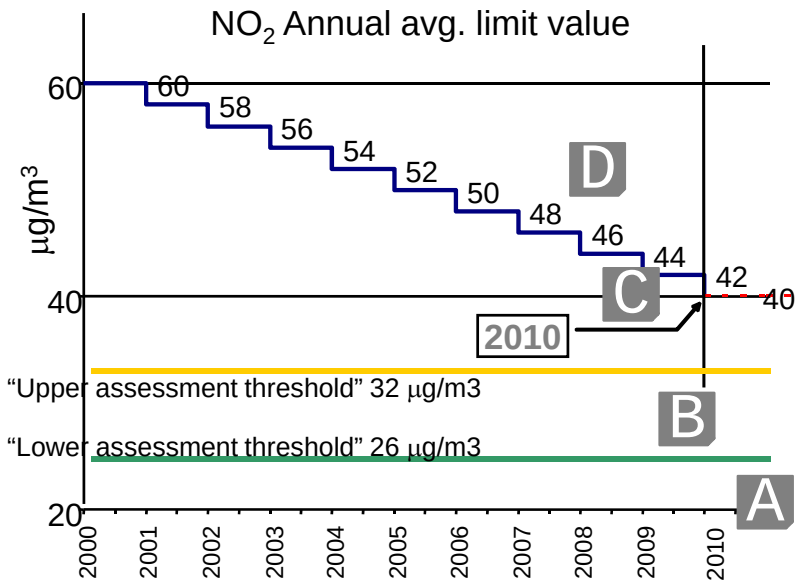
- Air Quality Framework Directive 96/62/EC & Daughter Directives
- New Air Quality Directive (2008/50/EC)

- AIR quality Plans

”**Where**, in given zones or agglomerations, the levels of pollutants in ambient air **exceed any limit value** or target value, plus any relevant margin of tolerance in each case, Member States shall ensure that **air quality plans are established** for those zones and **agglomerations in order to achieve the related limit value** or target value”

Assessment

A. modelling techniques or objective estimation
B. combination of fixed measurements and modelling techniques
C.,D fixed measurements



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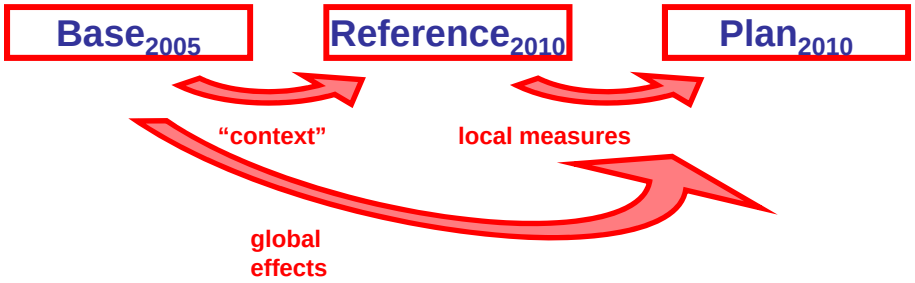
Future policy scenarios

Scenarios @ 2010



- **Reference: CLE (Current Legislation)**

- **Regional Air Quality Plan (RAQP) measures**

  Heating
  - energy efficiency (new & renovated)
  - boilers: efficiency & emission limits
  - ban of dirtier fuels (coal and distillate oil)
  - incentives for solar heating for sanitary water
  - district heating expansion

  Transport
  - whole region: progressive ban of the most polluting vehicles
  - "Plan Zones": restricted traffic zones in municipalities > 10000 inh.
  - adoption of DPF (diesel particles filters)

Regional decision maker:

… LV will be respected?
… role of local measures?

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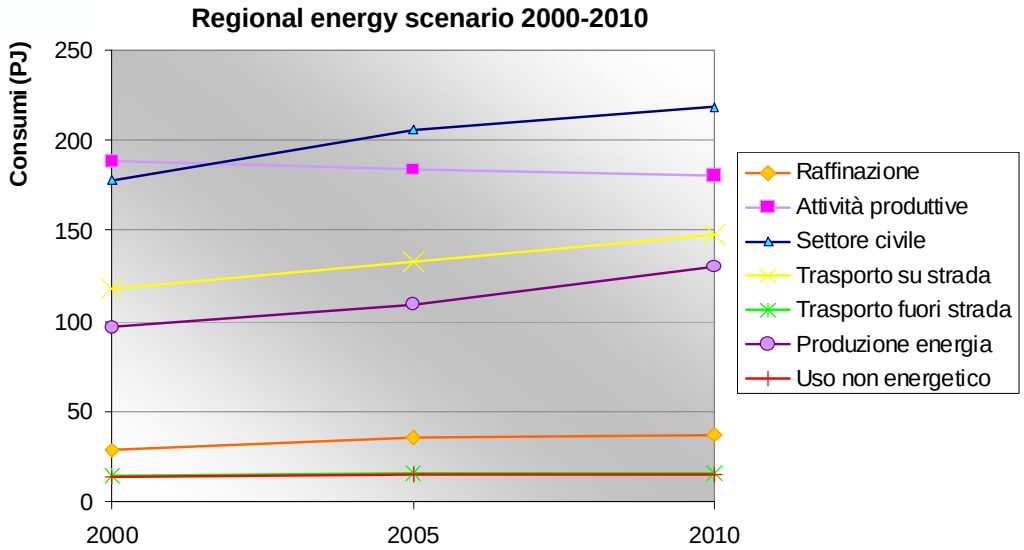
Reference future scenario (1)

- **Projection of emissions "driving forces"**
  - energy
  - industrial production
  - mobility demand
  - fertilizers use

- **Baseline energy scenario: national MARKAL+RAINS models**
  - population (stable, changing composition)
  - changes in production system
  - changes in energy demand
  - energy prices
  - …and others (e.g. incentives on renewable sources)



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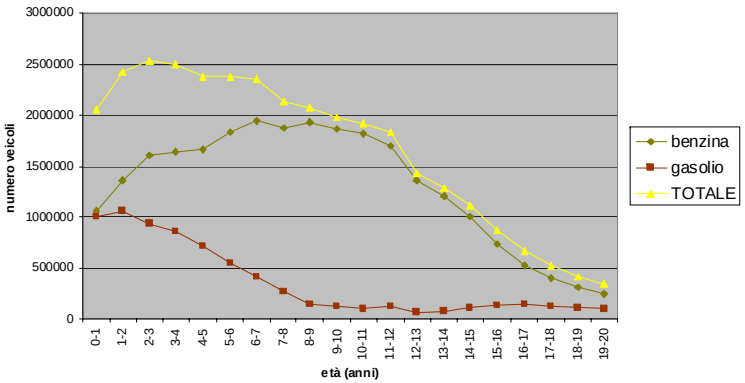
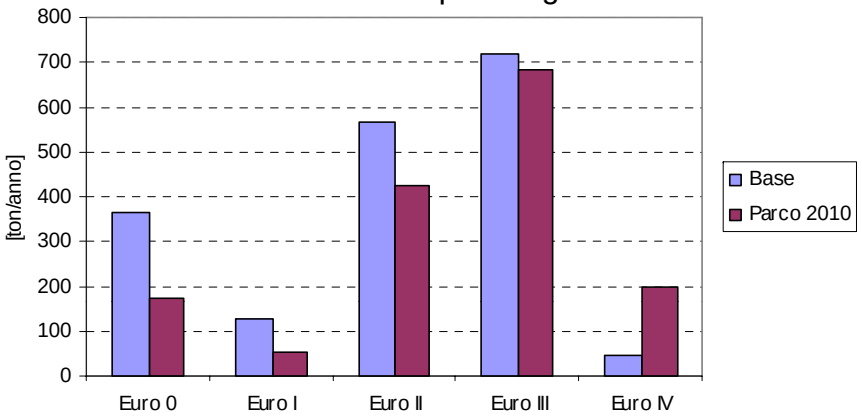
Reference future scenario (2)

Projection of vehicles fleet:

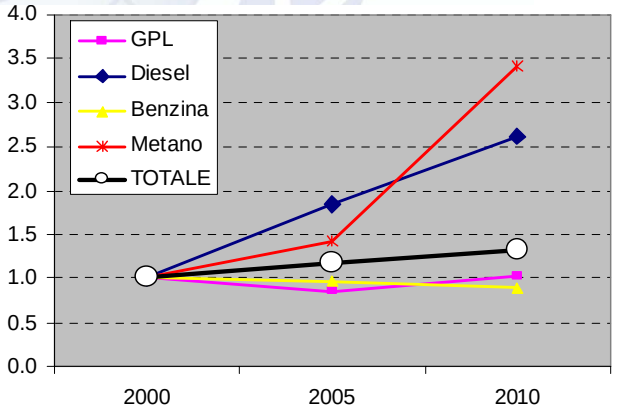
- use of “age curves” for gasoline and diesel vehicles
- future sells (2004-2008): same gasoline/diesel partition
- Euro IV (COPERT III methodology)



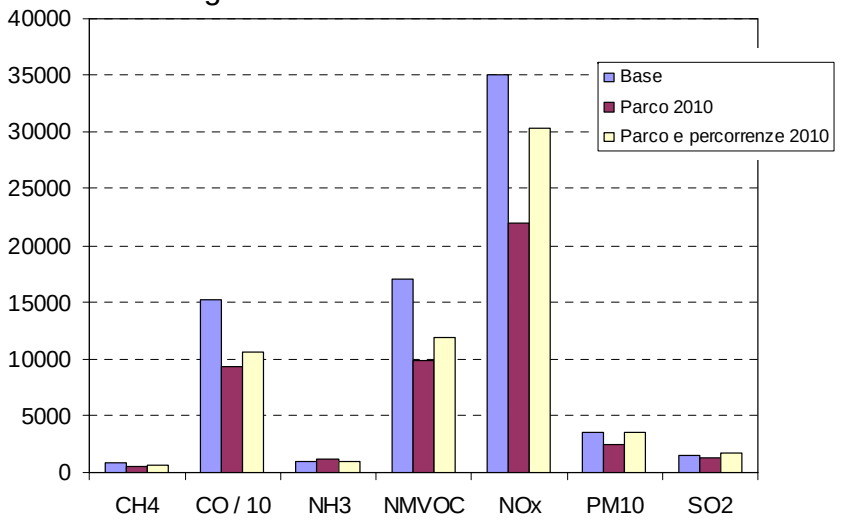
PM10 emissions from passenger cars



Fuels demand for passenger cars & LDV



Regional emissions from road traffic



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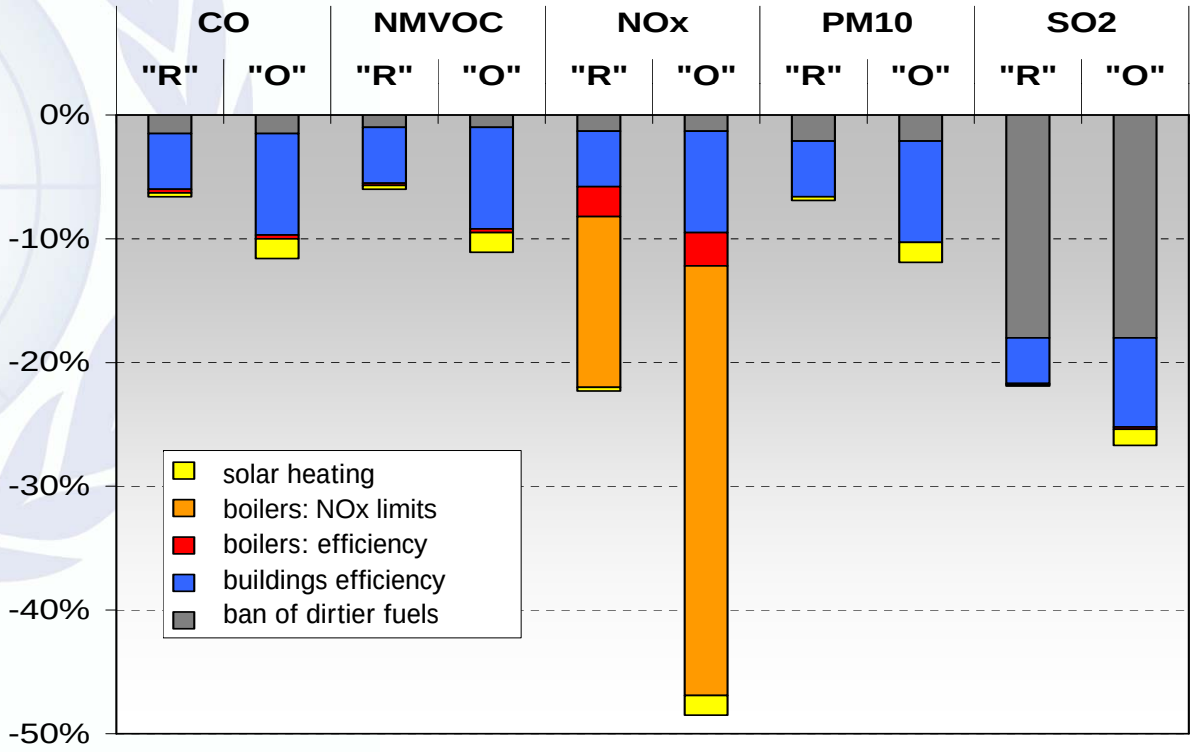
RAQP measures (1 - Heating)

Effects on emissions

- **Translation of individual measures**
- **Allow for different hypothesis**

"Plan 2010" vs. "Reference 2010" variations, by measure



("local" measures)

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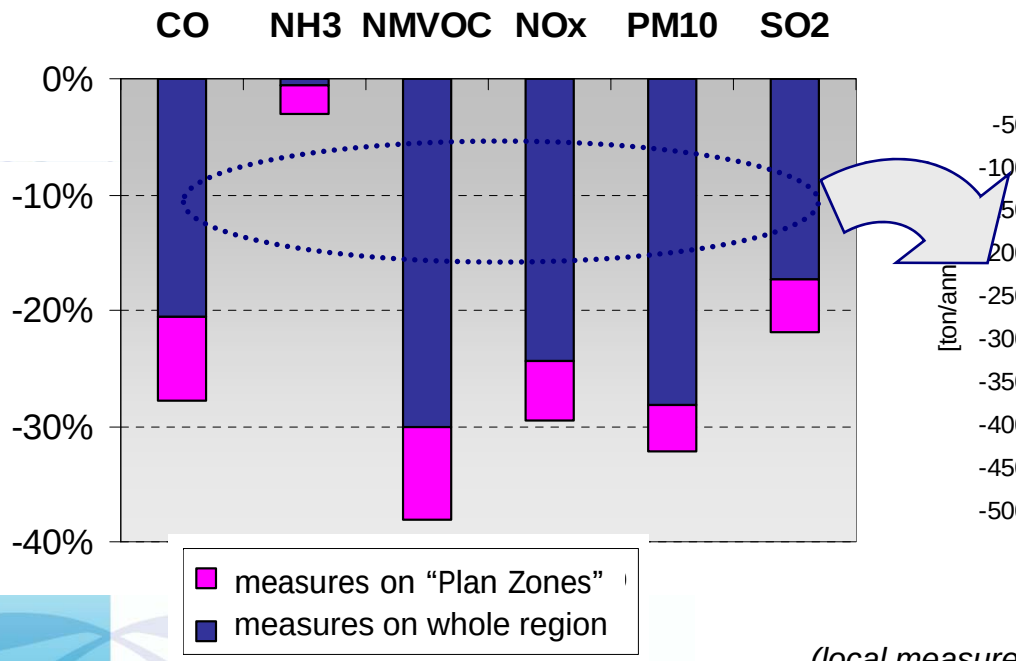
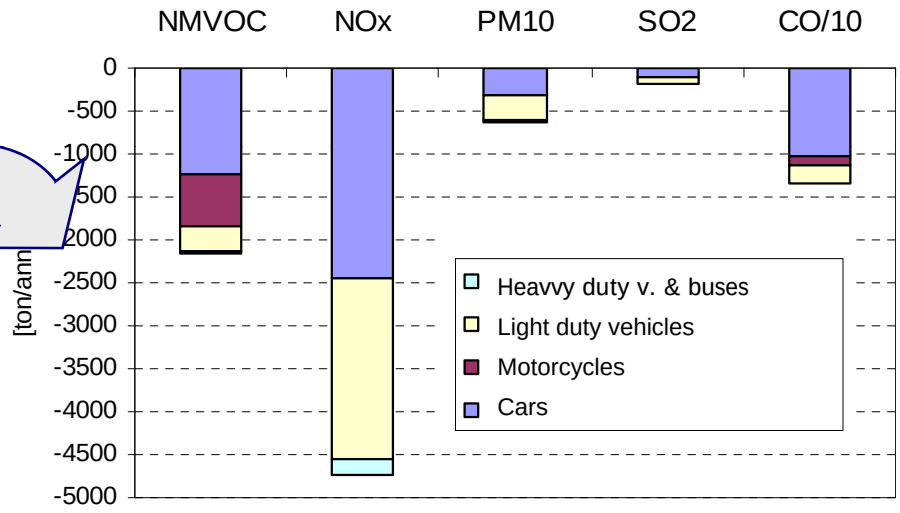
RAQP measures (2 – Road traffic)

Effects on emissions

"Plan 2010" vs. "Reference 2010" variations, by type



Measures on whole region: absolute contributions by vehicles categories



(local measures)

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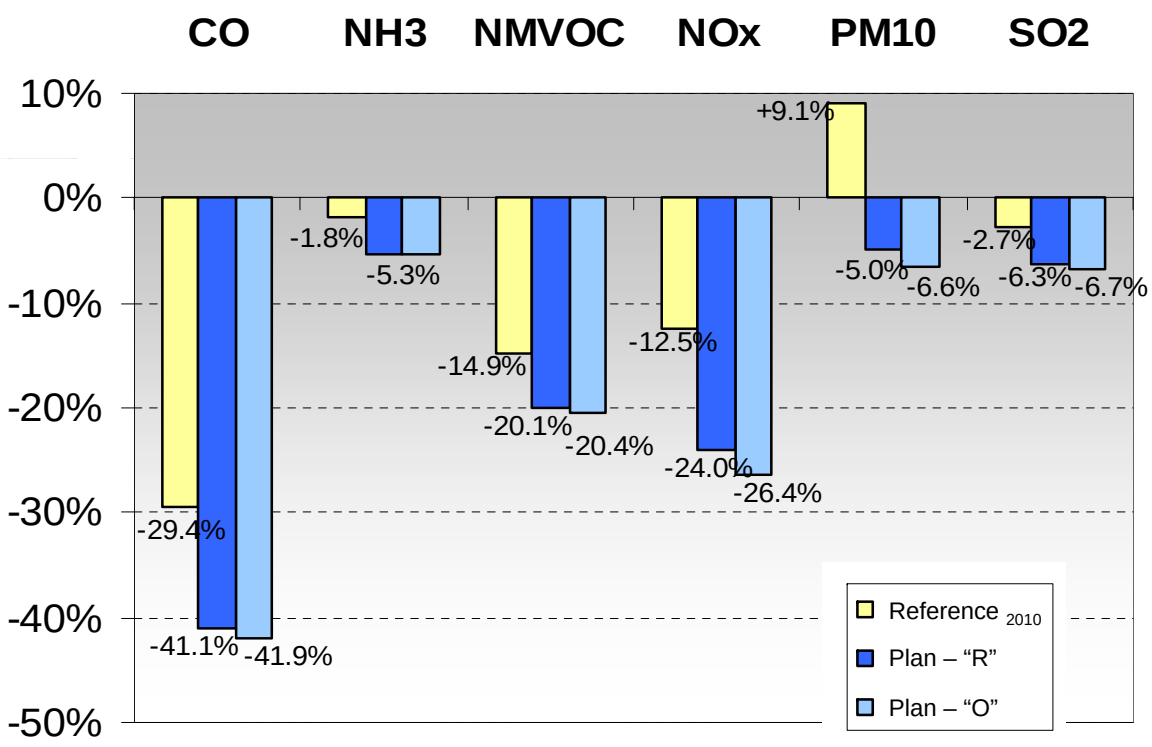
RAQP scenarios (all sectors)

Effects on emissions

Regional emissions

Variations for 2010 scenarios respect to "Base 2005"



(CLE + local measures)

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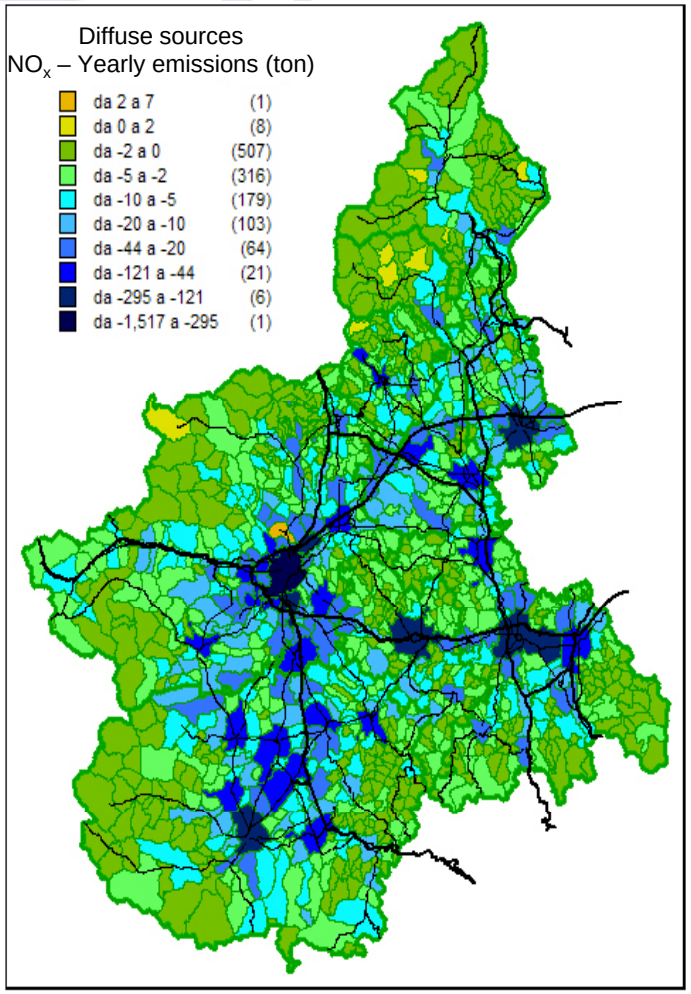
Effects on emissions

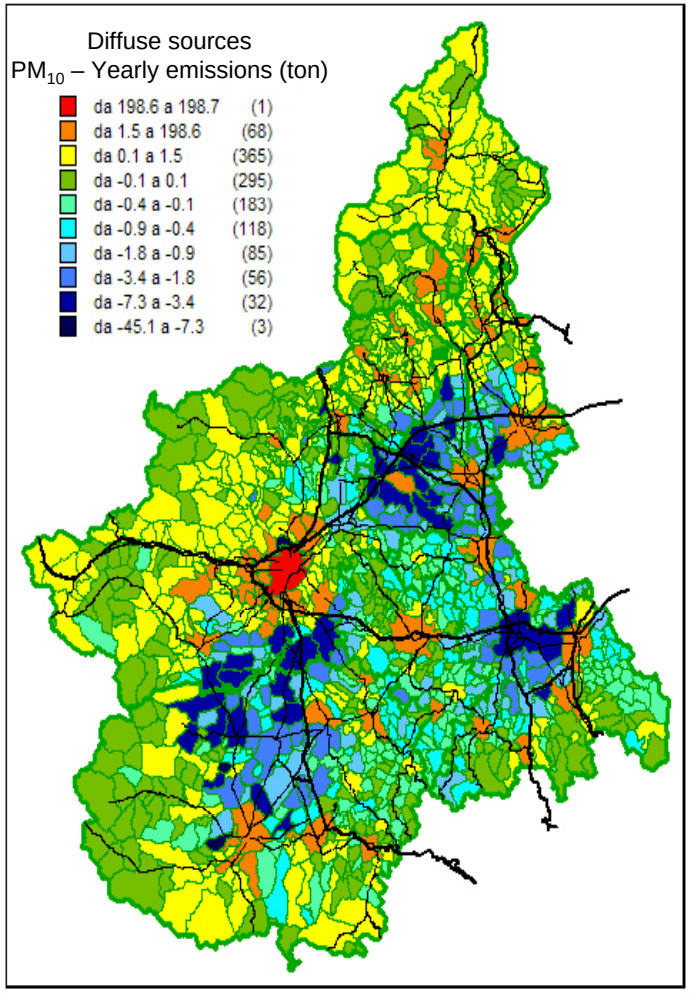
Details on municipalities

Variations "Base 2005" ⇒ "Reference 2010"

NOx



Primary PM_{10}



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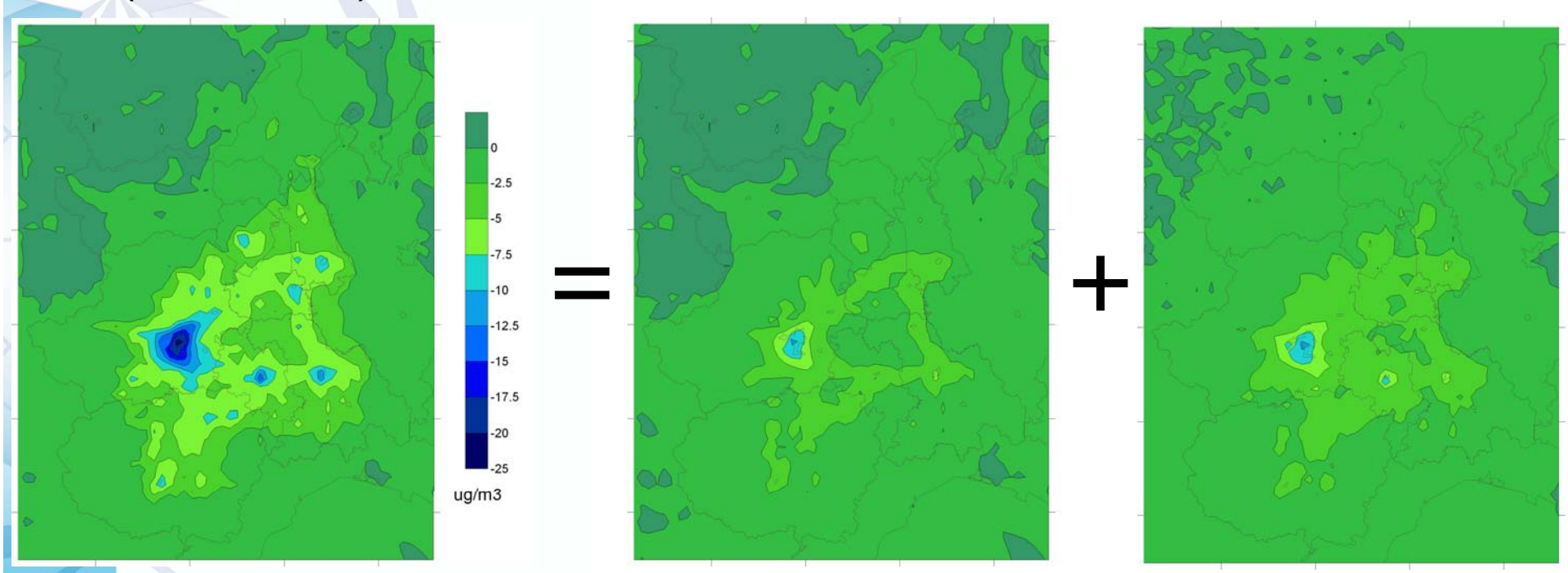
Effects on concentrations

NO_2, yearly averages

"Plan-R 2010" vs. "Baseline 2005"
(CLE + local measures)

"Ref. 2010" vs. "Baseline 2005"
(CLE)

"Plan-R 2010" vs. "Ref. 2010"
(local measures only)



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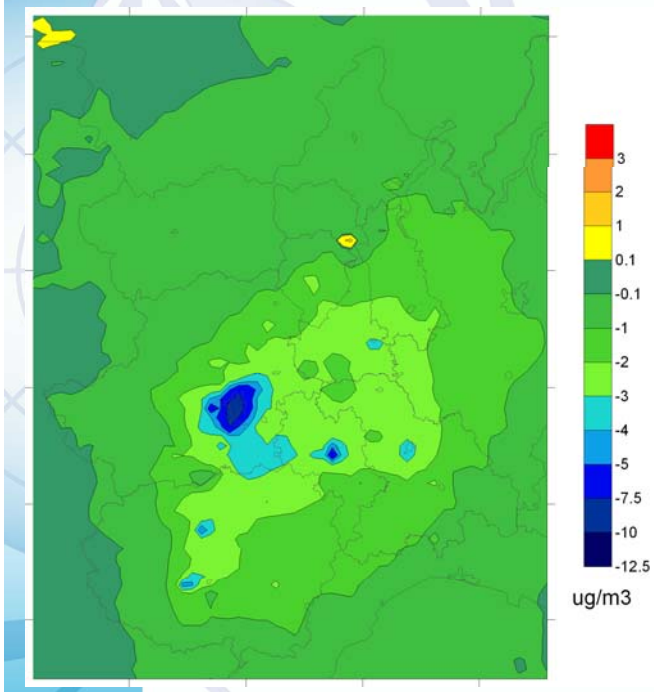
Effects on concentrations

PM_{10}, yearly averages

"Plan-R 2010" vs. "Baseline 2005"
(CLE + local measures)



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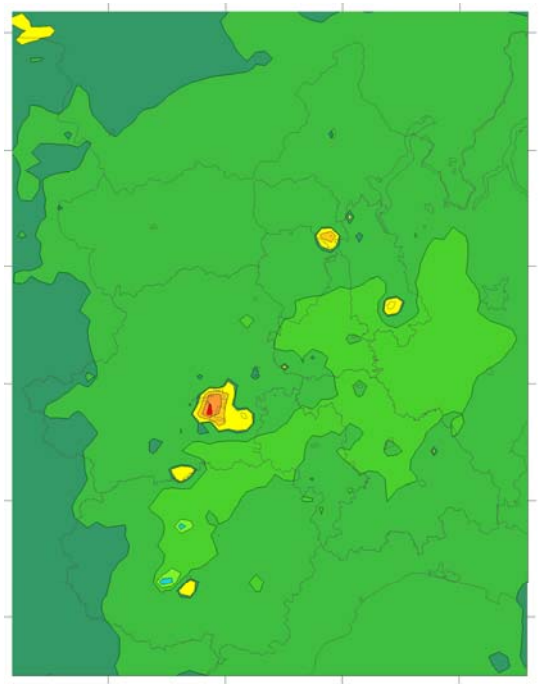
"Ref. 2010" vs. "Baseline 2005"
(CLE)



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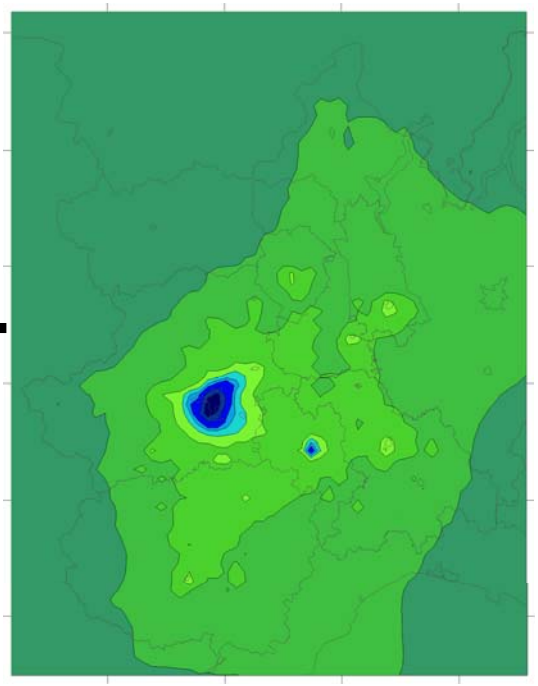
"Plan-R 2010" vs. "Ref. 2010"
(local measures only)



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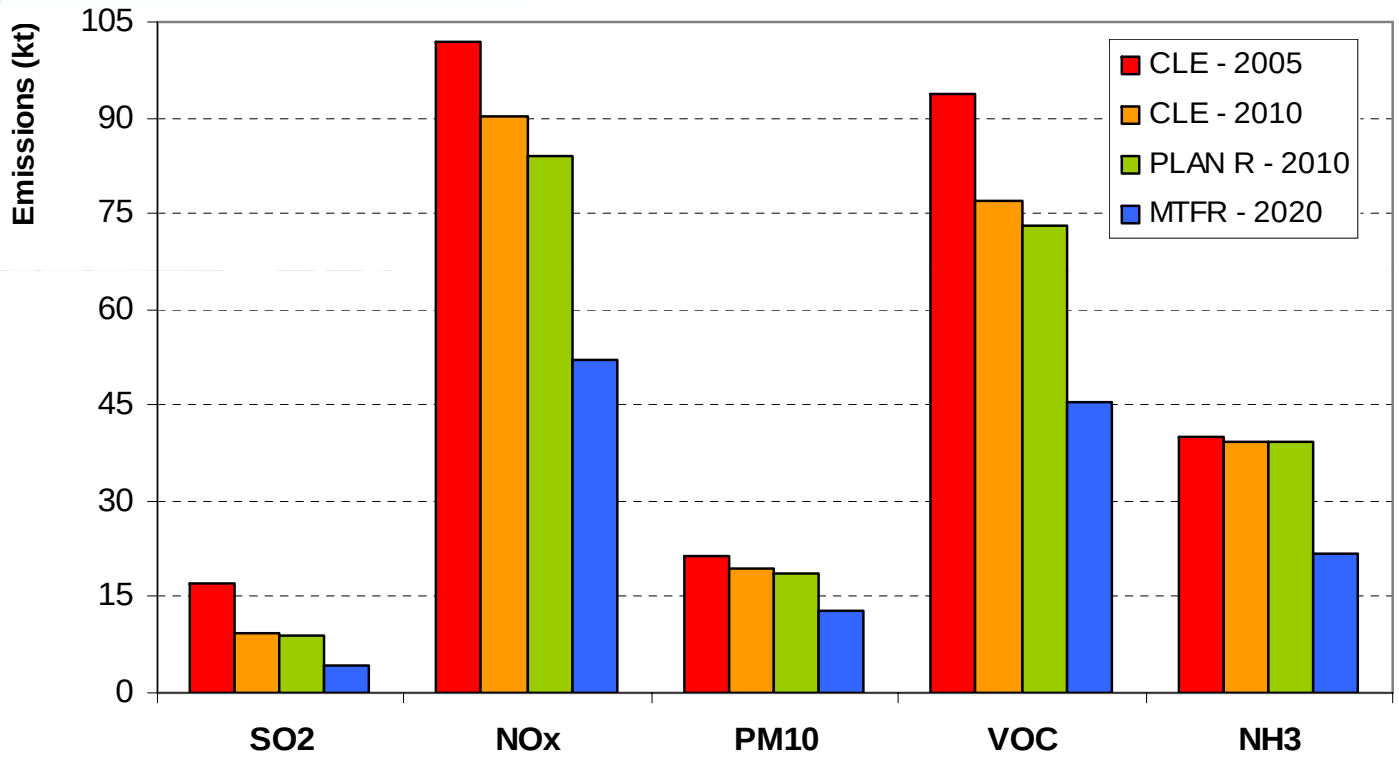
In perpective …

Room for improvement?



(RAINS – technical measures)

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Methodology

- Regional AQM

- AQ current status (model & monitoring)
- Legislation compliance

- Project emissions: future baseline scenario
- Translate RAQP measures
- Effects on concentrations, through AQM
- Comparison (vs. current status & future baseline)

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AQM for policy support

Example 3

Traffic-specific scenarios - 1

Effects of traffic bans
in Milano metropolitan area

Regione Lombardia
Qualità dell'Ambiente

ARPA Agenzia Regionale per la Protezione dell'Ambiente della Lombardia

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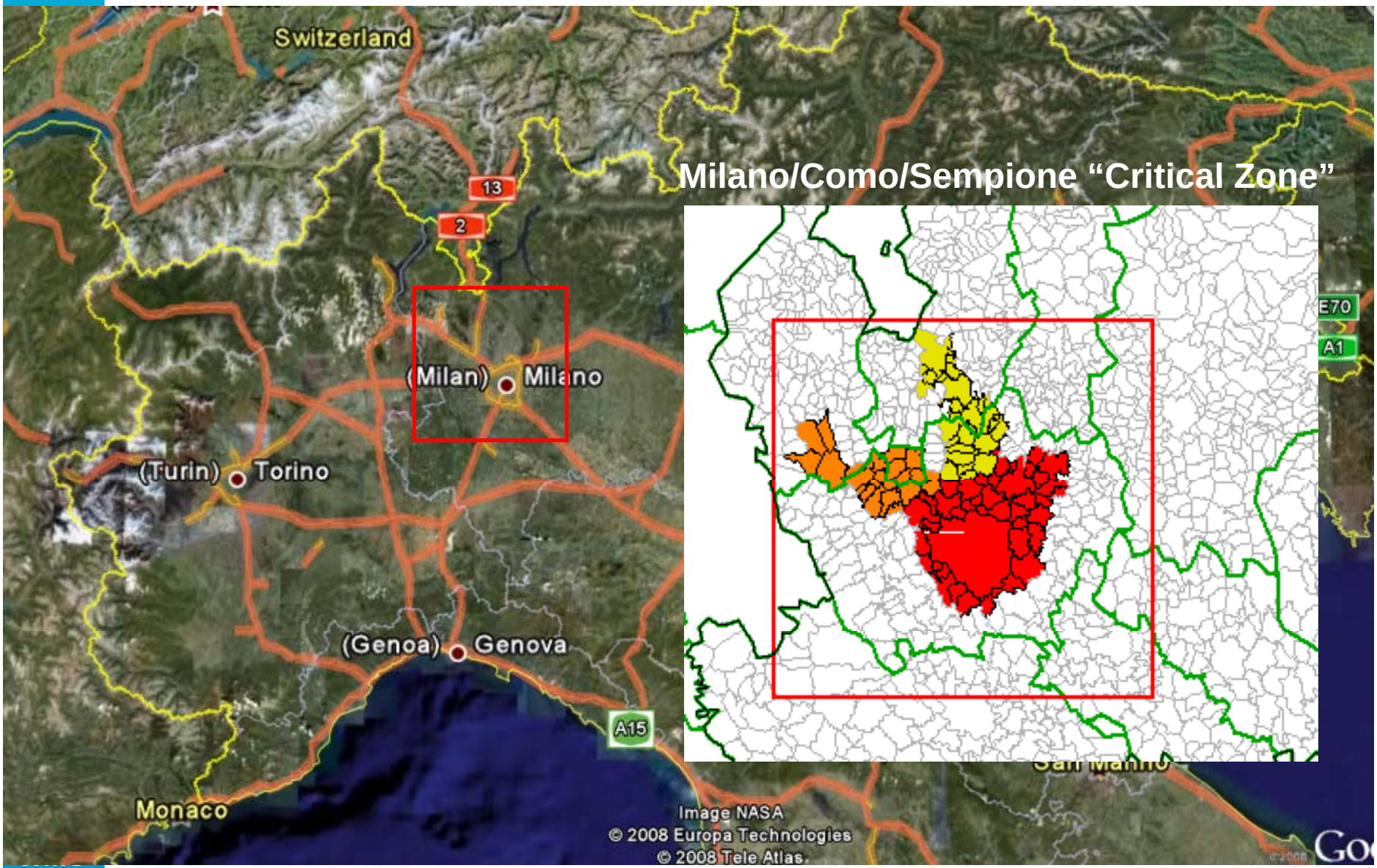
Milano area



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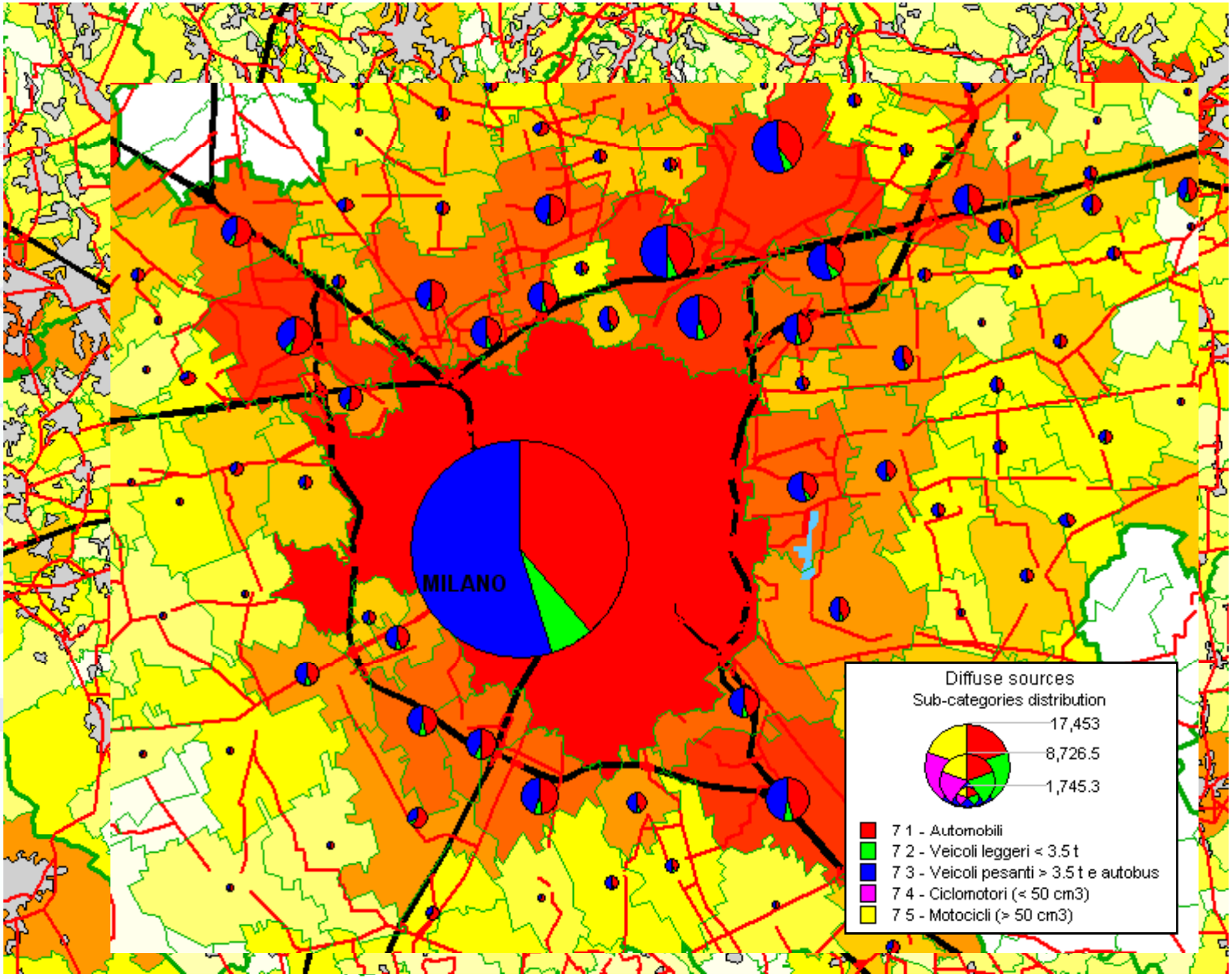
Regional emission inventory

ARPA-Lombardia



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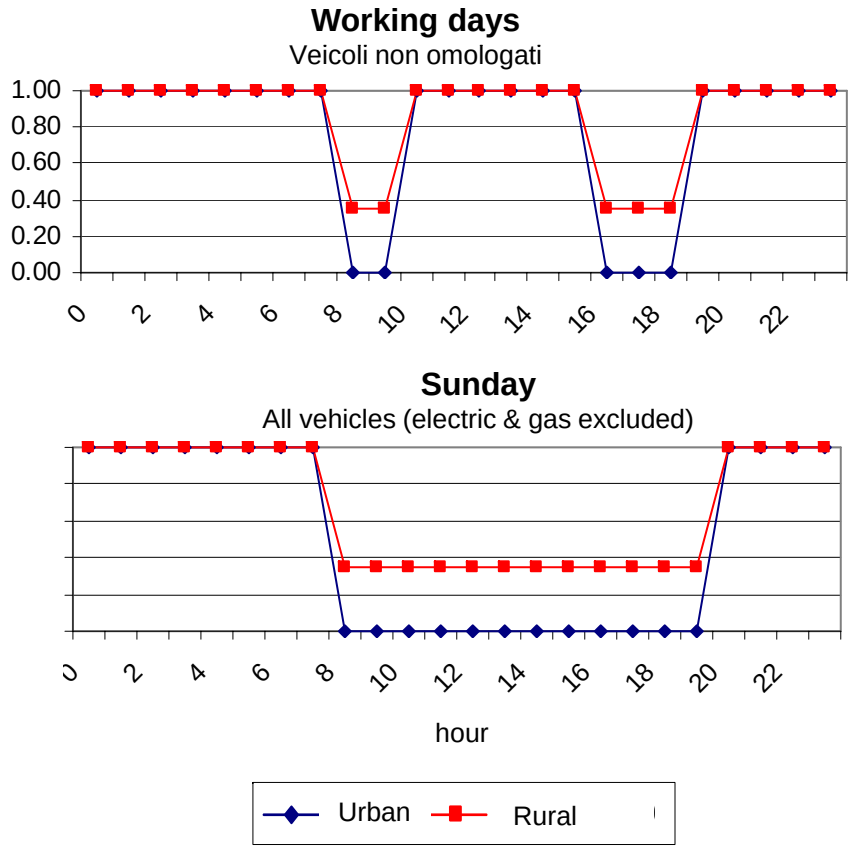
Traffic mesures during 2003-04 winter

Policy options:

- Regional Resolution:
  - working days: ban of most polluting vehicles during working days, 8-10 and 16-19 (5 hours total)
  - Sunday ban: private traffic from 8 to 20
- Extended ban: as above, but from 8 alle 20 for a total of 12 hours

Period	*Scenarios*	
Working days	Base case	
	Reg. Resol.	A
	Extended ban	C
Week-ends	Caso Base	
	Sunday ban	B



… wich effects on AQ ?

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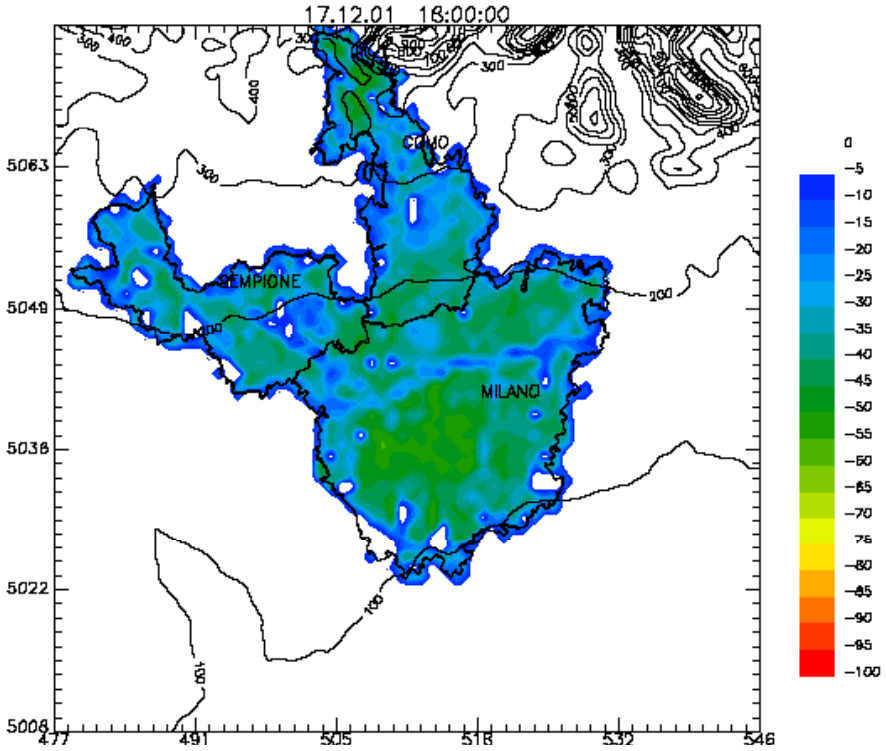
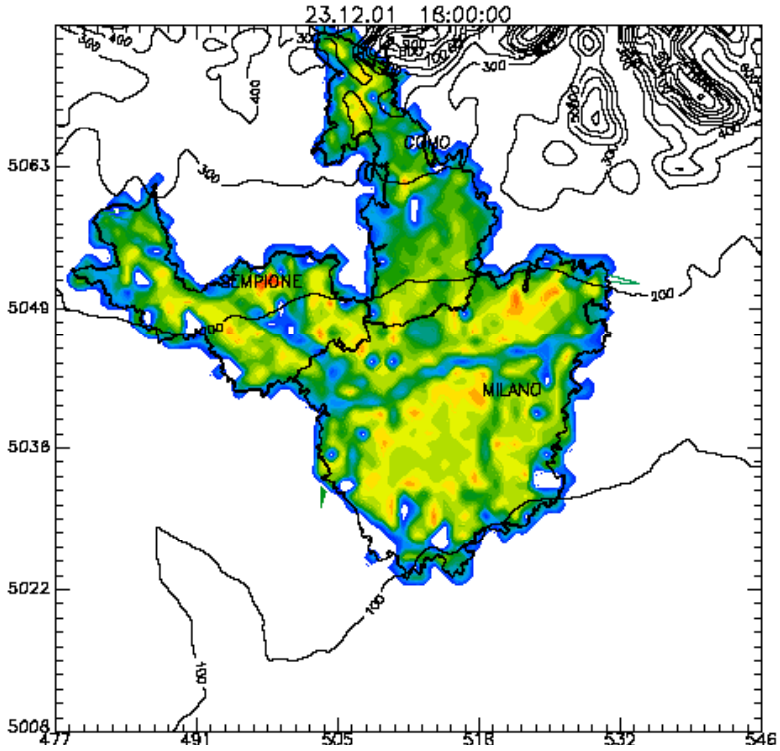
Emissions reductions

CO – Variations respect to base case at 18

Working days **A**



Sundays **B**



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Total emissions in “critical zones”

Giorno	Scenario	CO	NO	NO_2	PM10
Feriale	Caso Base	672.8	122.9	20.9	15.8
	Delibera (5 ore) A	601.4 (-10.6%)	114.7 (-6.7%)	19.5 (-6.7%)	14.7 (-7.1%)
	Blocco Esteso (12 ore) C	512.8 (-23.8%)	103.1 (-16.2%)	17.6 (-16.2%)	13.1 (-17.3%)
Domenica	Caso Base	561.9	67.5	11.5	9.1
	Delibera (12 ore) B	379.0 (-32.6%)	54.8 (-18.8%)	9.3 (-18.8%)	7.2 (-20.4%)

Daily values (t/d)

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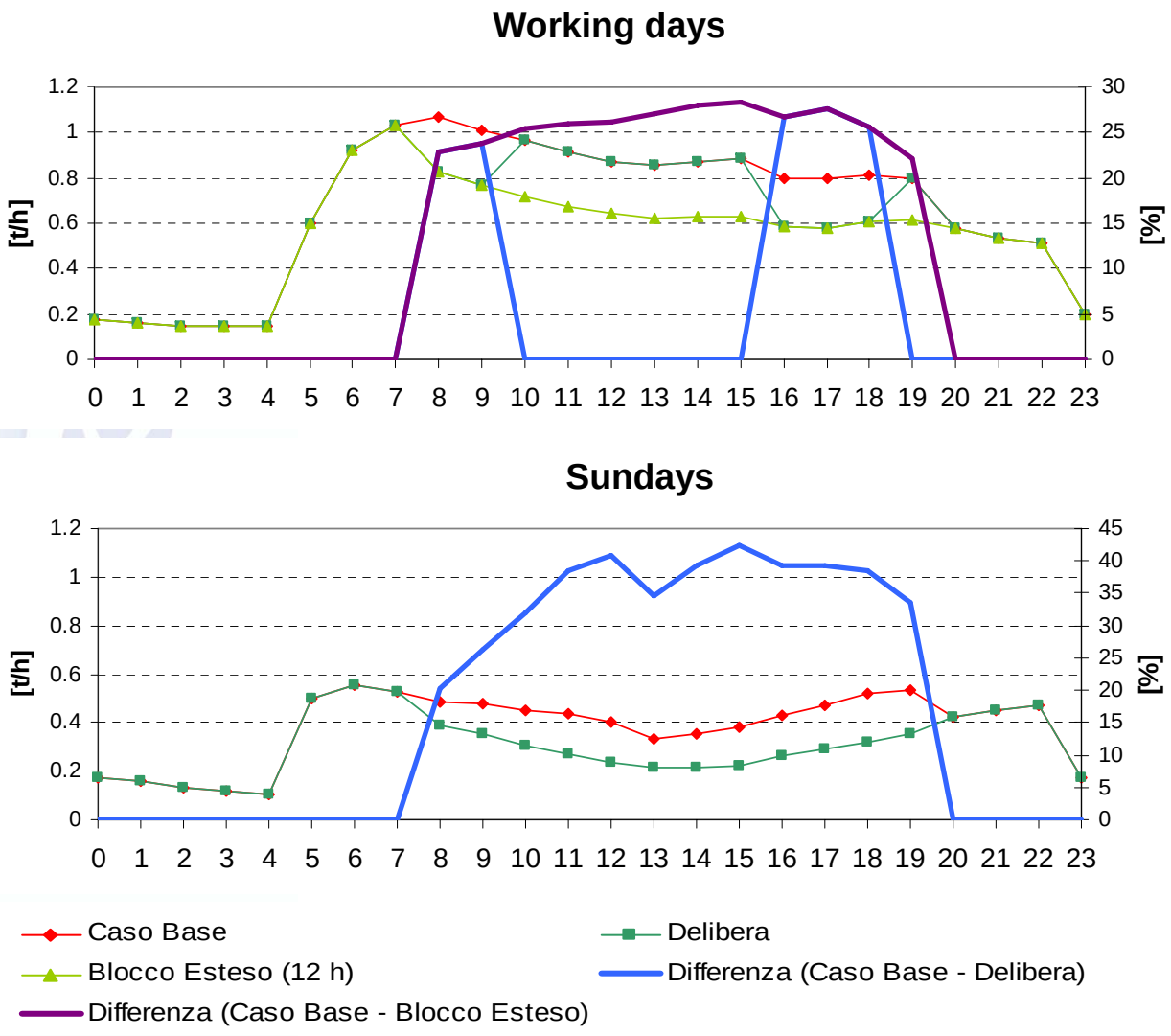
Variation of emissions during day

PM10 - Total values in “critical zones”



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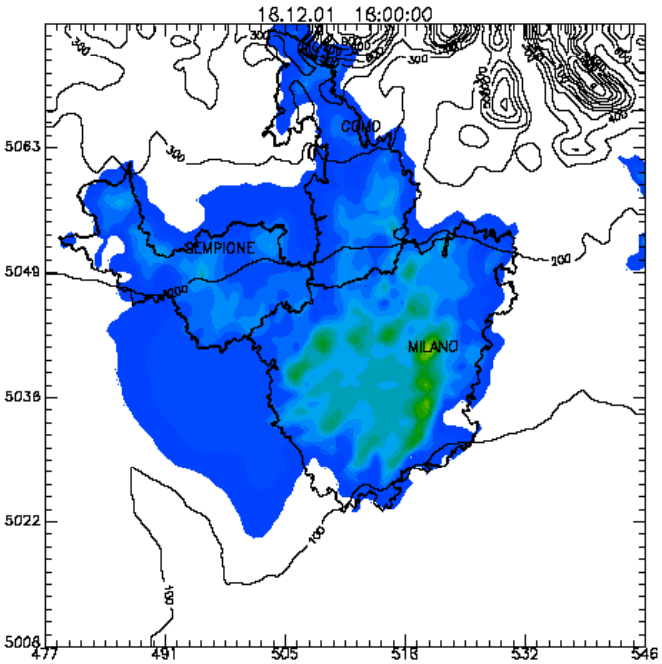
Effects on concentrations (1)

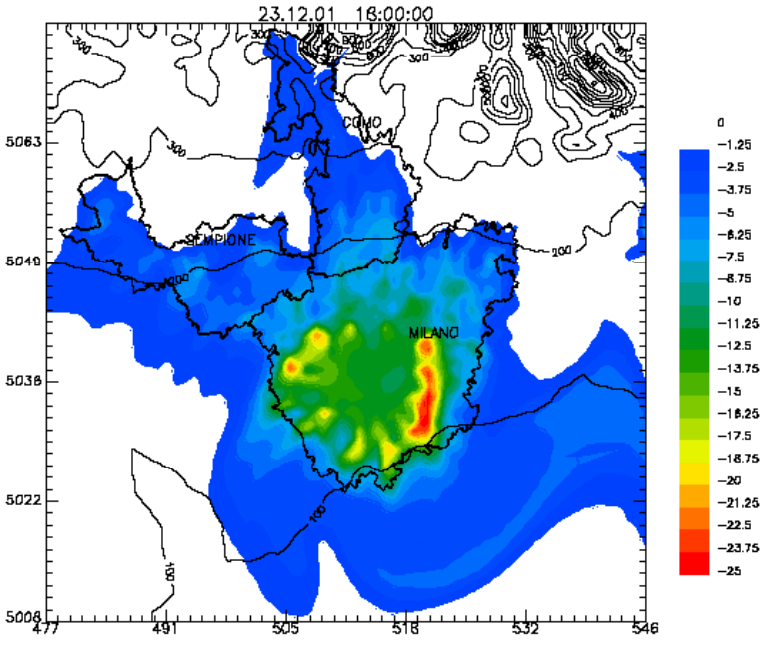
PM_{10} – Variations respect to base case at 18

Regional Resolution

Working days **A**



Sundays **B**



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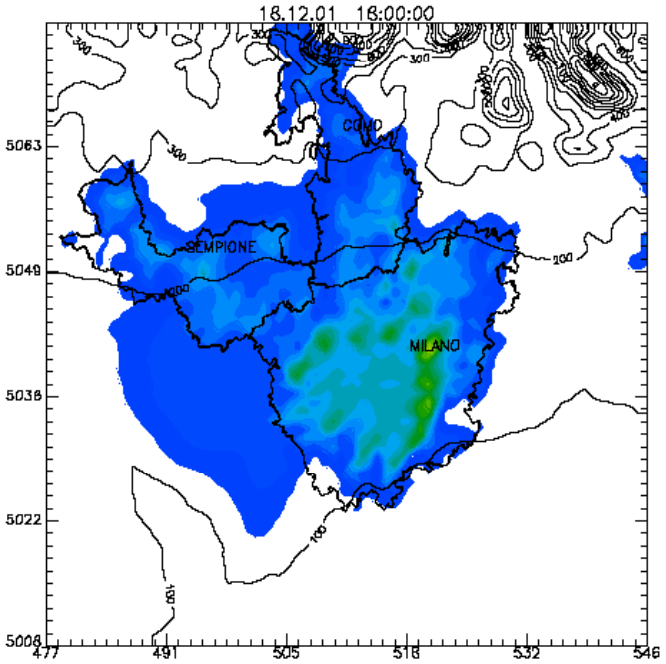
Effects on concentrations (2)

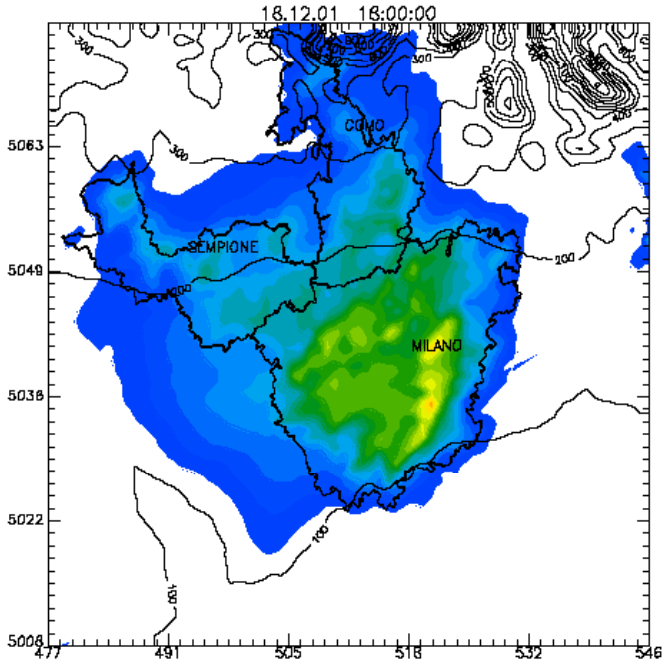
PM_{10} – Variations respect to base case at 18

Working days

Regional Resolution **A**



Extended ban **C**



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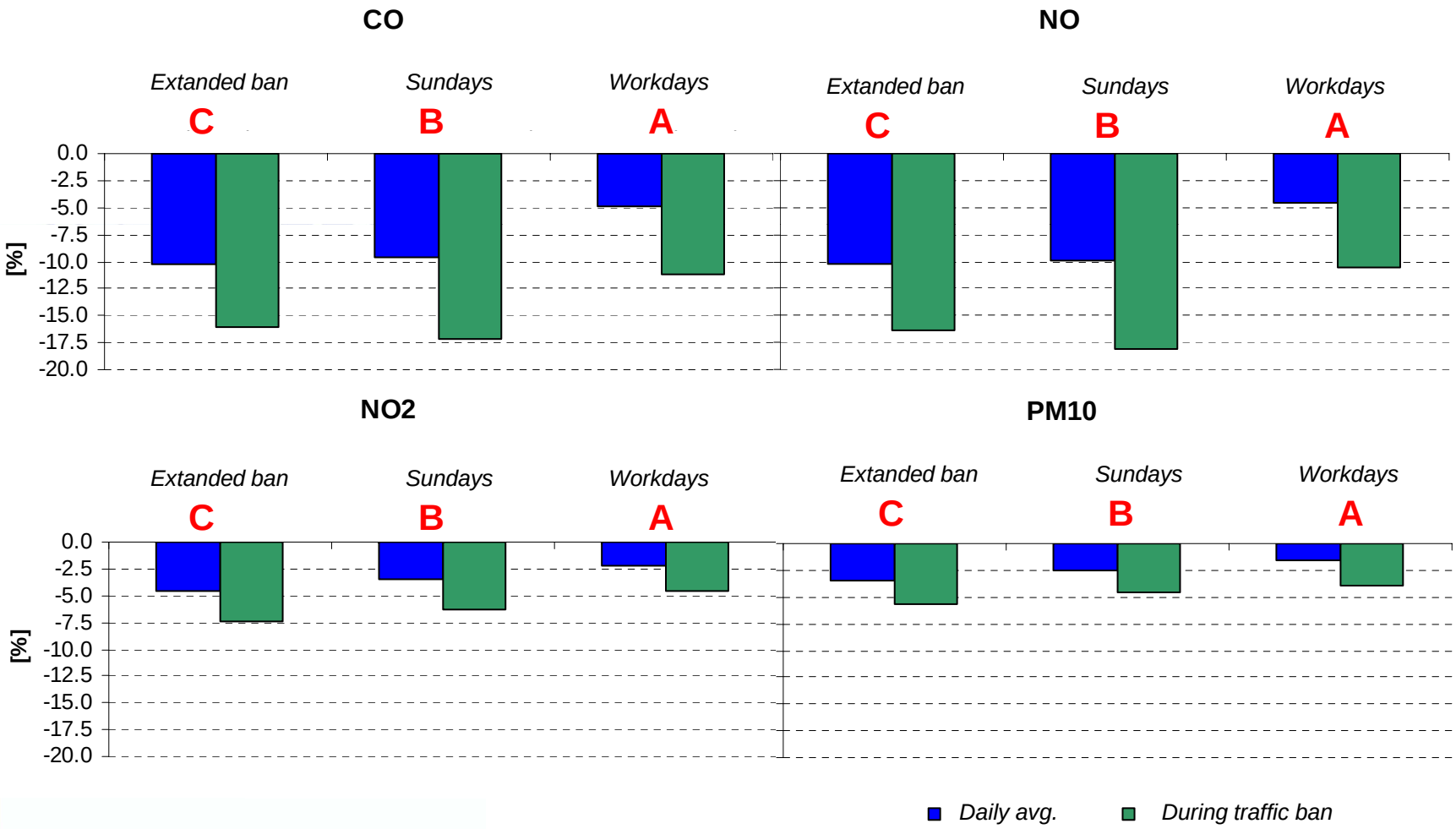
Effects on concentrations (3)

Variations inside "critical zones" respect to base case:
daily averages and during hours of traffic bans



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AQM for policy support

Example 4

Traffic-specific scenarios - 2

KALAIR LIFE Project:

- KALiningrad AIR pollution induced by traffic

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Evaluation of policy options on traffic

Scenarios:

0. Present situation (2006)
1. Reference at 2015 (business as usual)
2. Construction and renovation of bridges and bridge passages
3. Development of city road network and optimization of traffic flows
4. Improvement of the public transport
5. Renewal and improvement of the Kaliningrad vehicle fleet
6. Improvement of fuel quality

Traffic model

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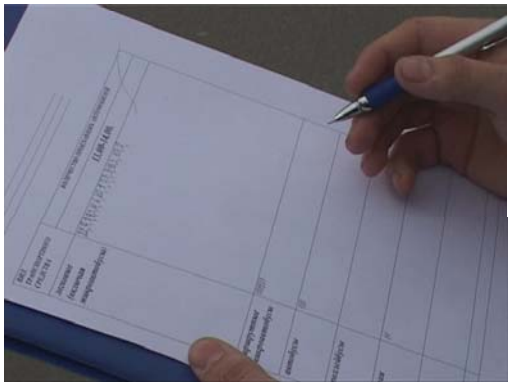
Traffic data collection (1)

- Traffic network description in GIS form

- Traffic counting:
  - ✓ on 48 different roads in Kaliningrad
  - ✓ during 3 different days
  - ✓ at 5 different time periods of the day



- Fleet composition evaluation
  - ✓ The traffic counting was divided on 5 different vehicle categories (cars, trucks, trams, trolleys, buses and minibuses)

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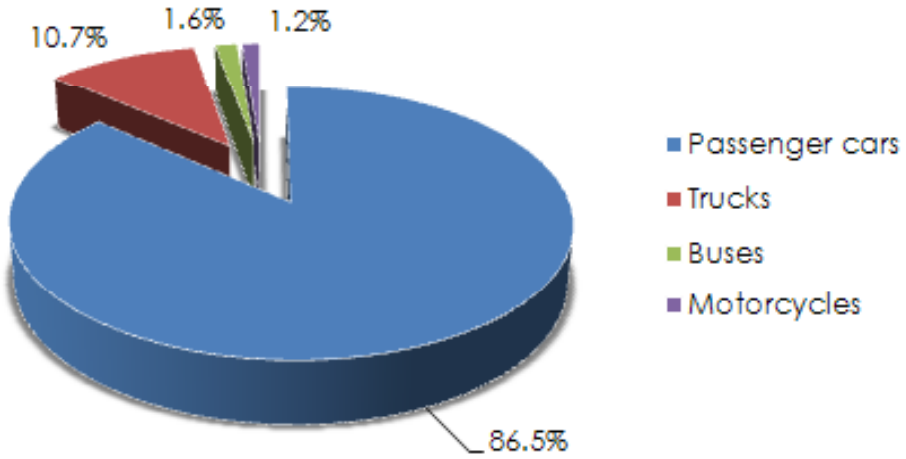
Traffic data collection (2)

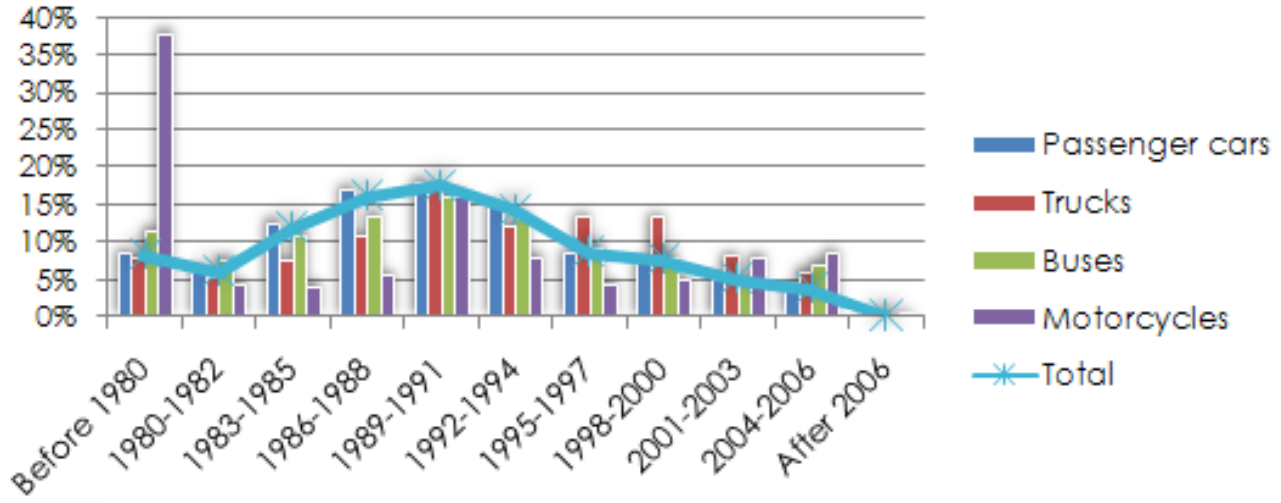
Fleet composition



Fleet data based on registered vehicles in Kaliningrad

Year 2006

Vehicle age distribution



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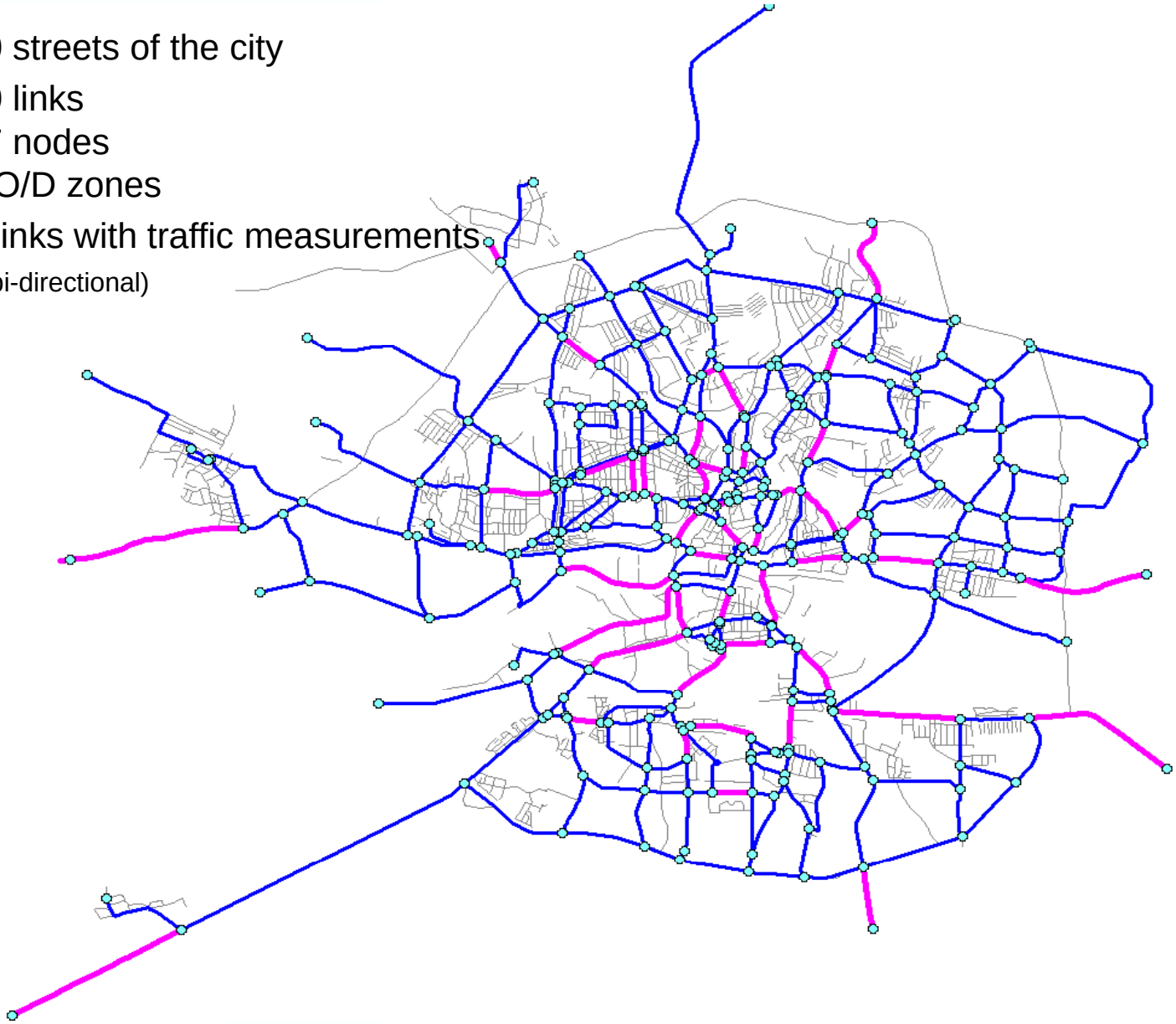
Modelled network

- 900 streets of the city
- 410 links
- 267 nodes
- 42 O/D zones
- 41 links with traffic measurements
  (66 bi-directional)



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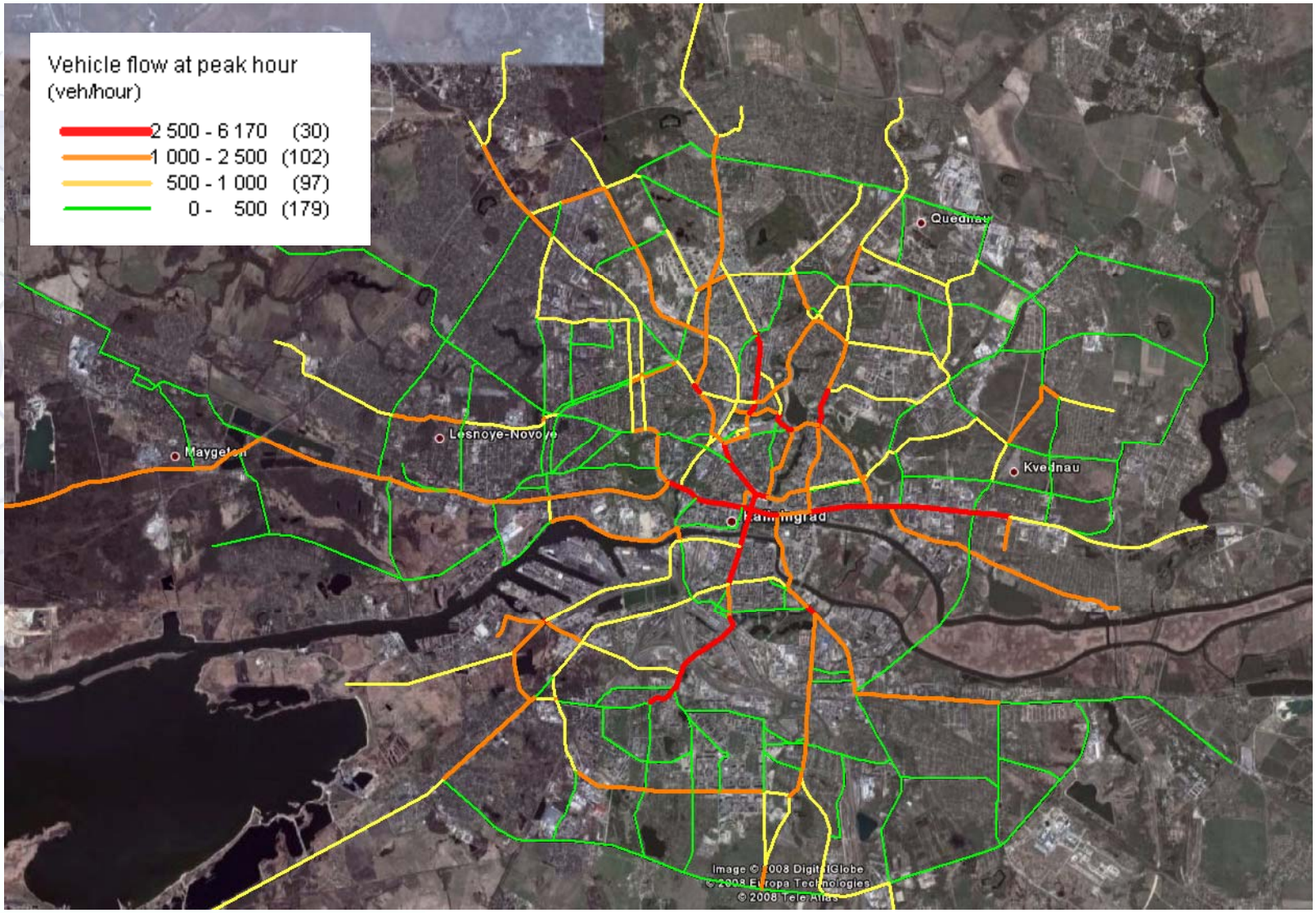
Traffic assignment model

Calculation of vehicles flow and speed on each link



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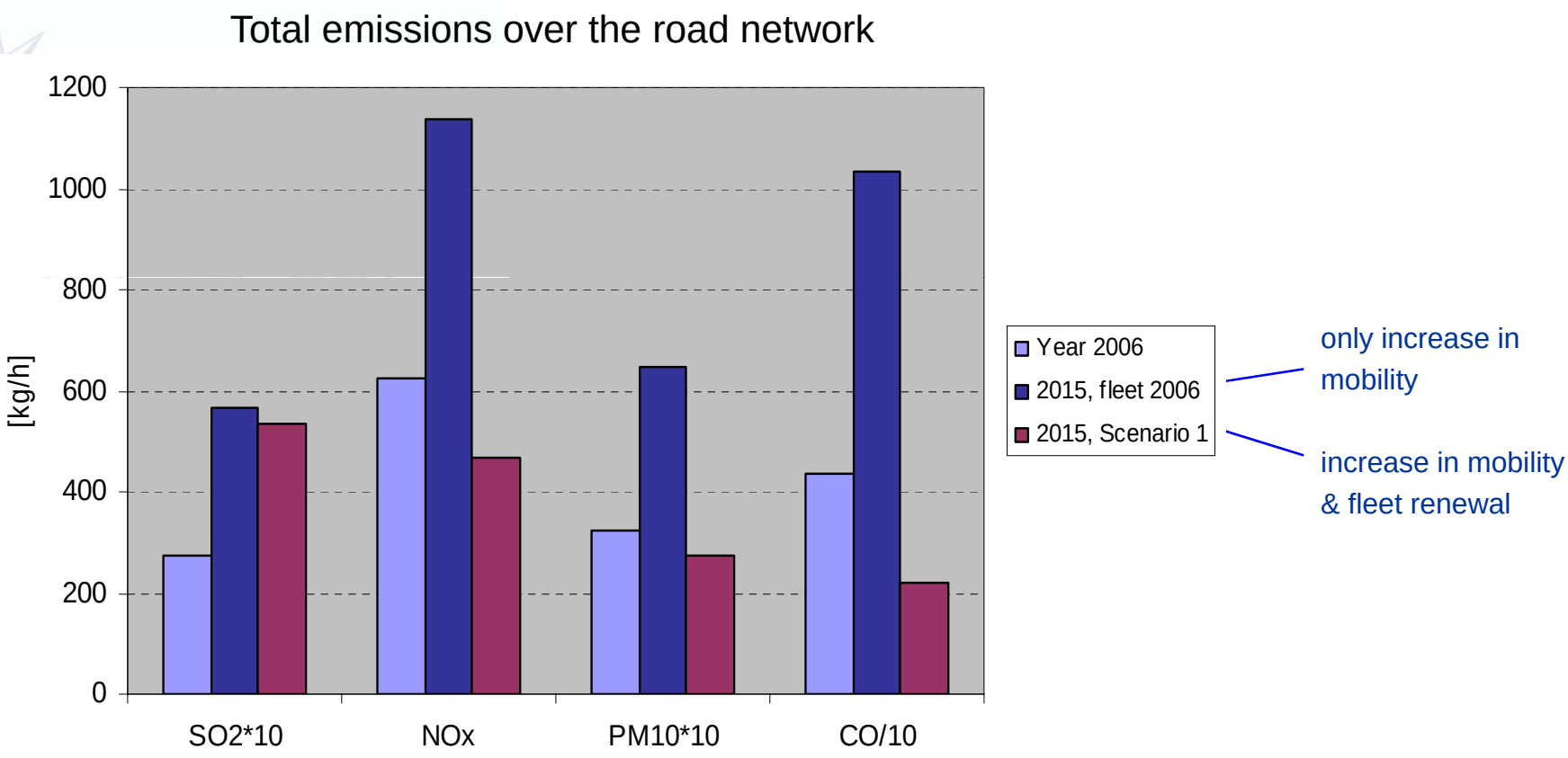
Reference scenario at 2015 (Scenario 1)

Emissions projection



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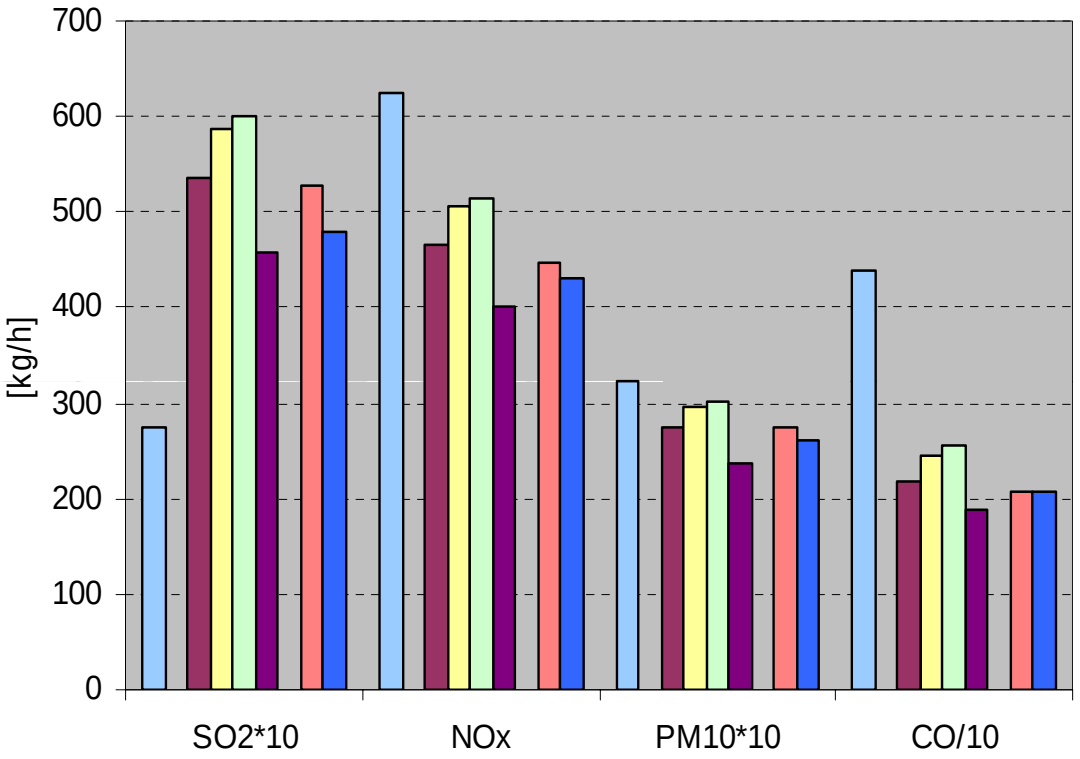
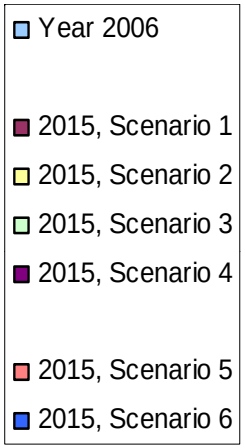
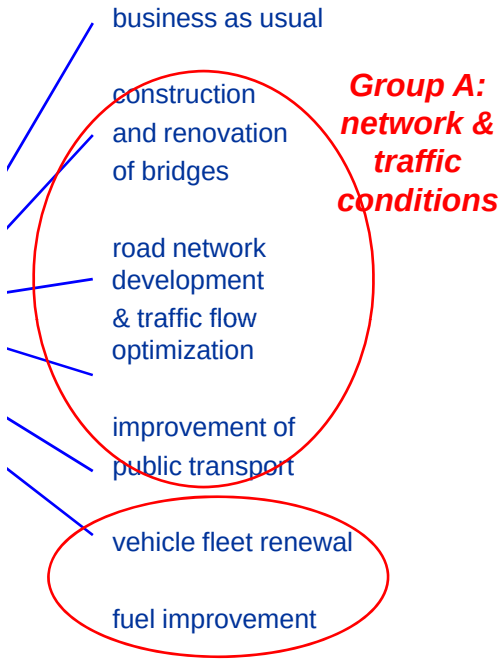
Traffic scenarios

Total emissions over the road network







SO2	NOx	PM10	CO	
+9%	+8%	+8%	+12%	Scenario 2 vs. Scen. 1
+2%	+2%	+2%	+4%	Scenario 3 vs. Scen. 2
-24%	-22%	-22%	-27%	Scenario 4 vs. Scen. 3
-1%	-4%	-1%	-5%	Scenario 5 vs. Scen. 1
-10%	-8%	-5%	-5%	Scenario 6 vs. Scen. 1

Variations

WMO OMM

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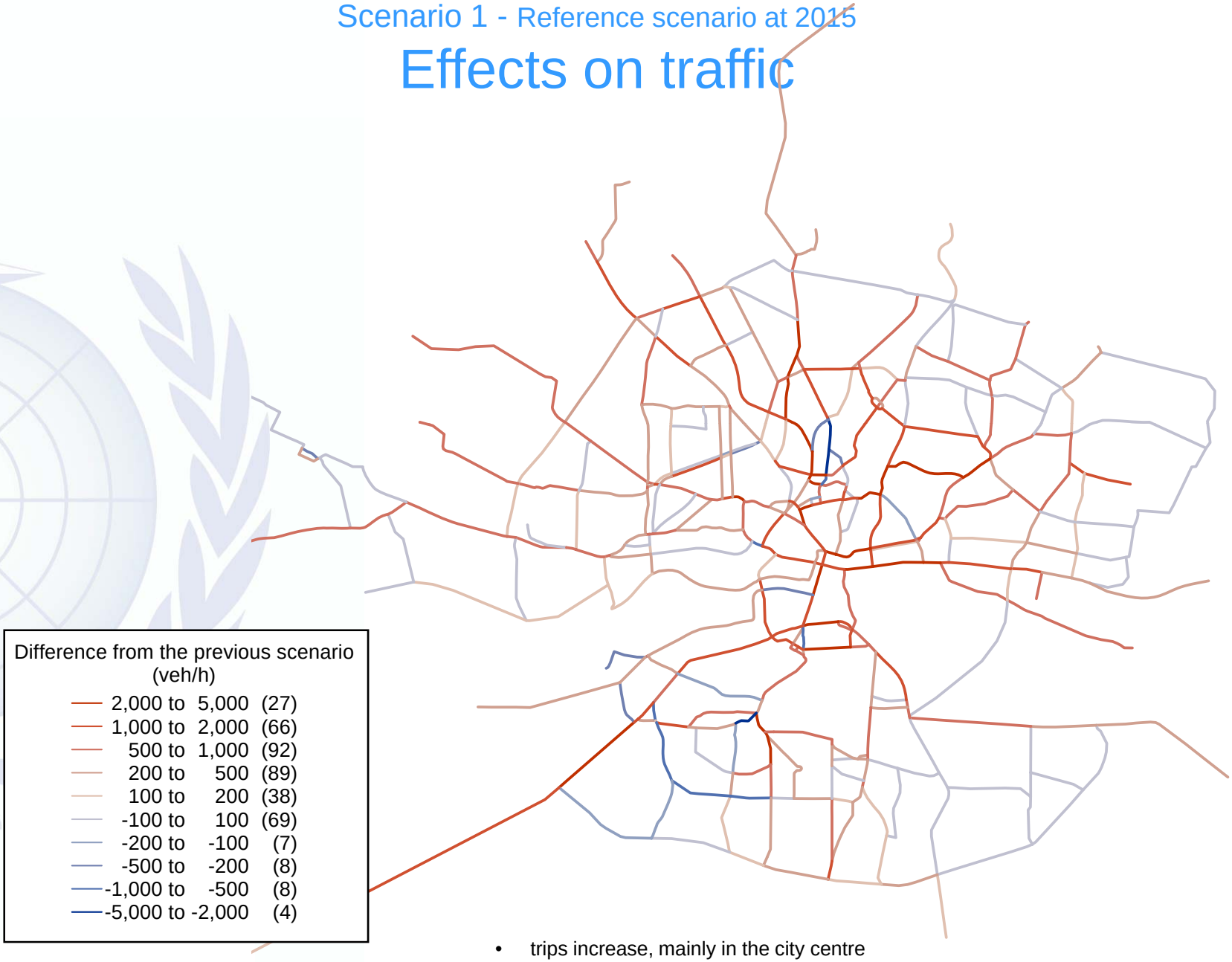
Scenario 1 - Reference scenario at 2015

Effects on traffic



- trips increase, mainly in the city centre

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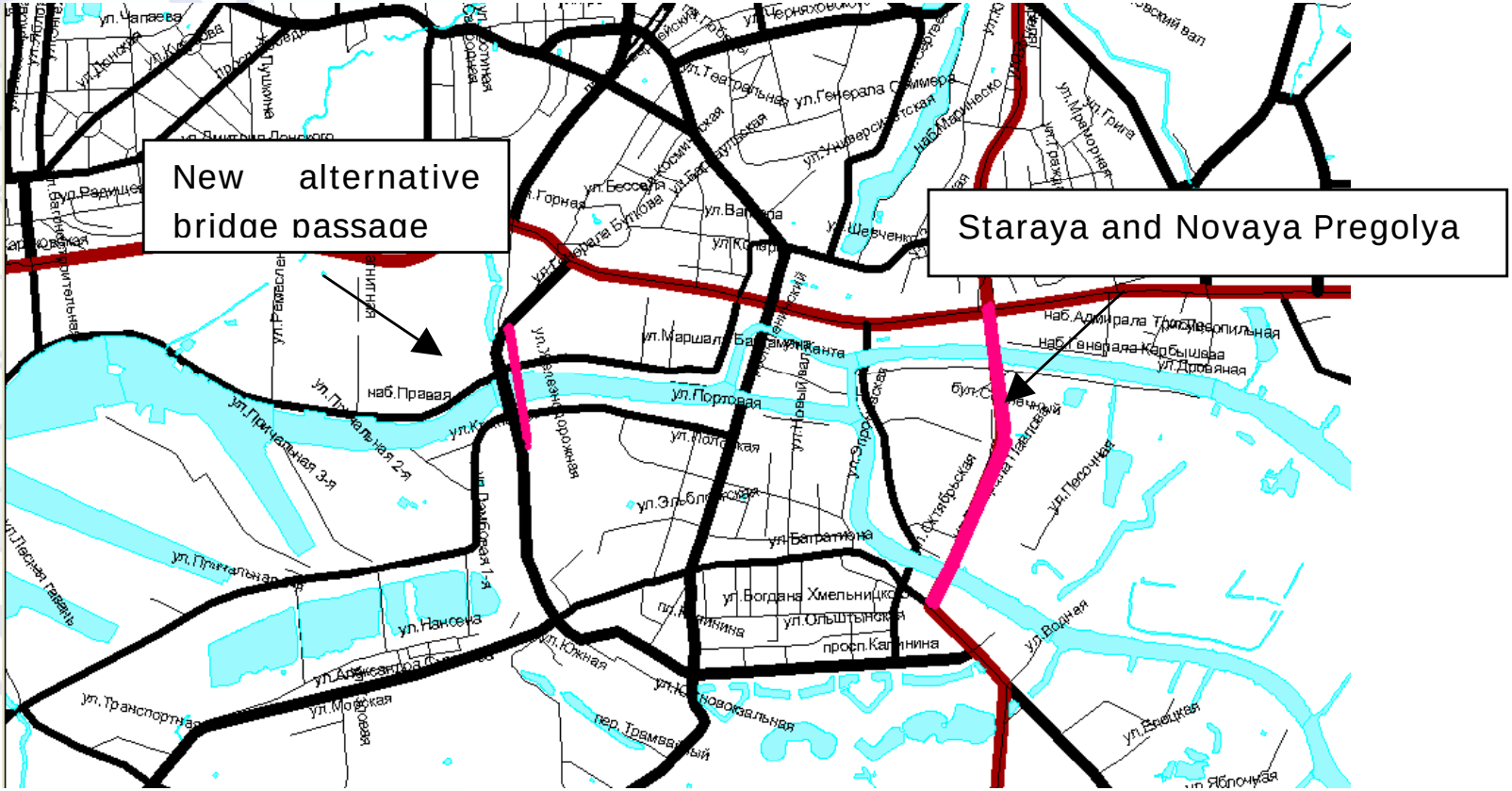
Scenario 2

Construction and renovation of bridges and bridge passages



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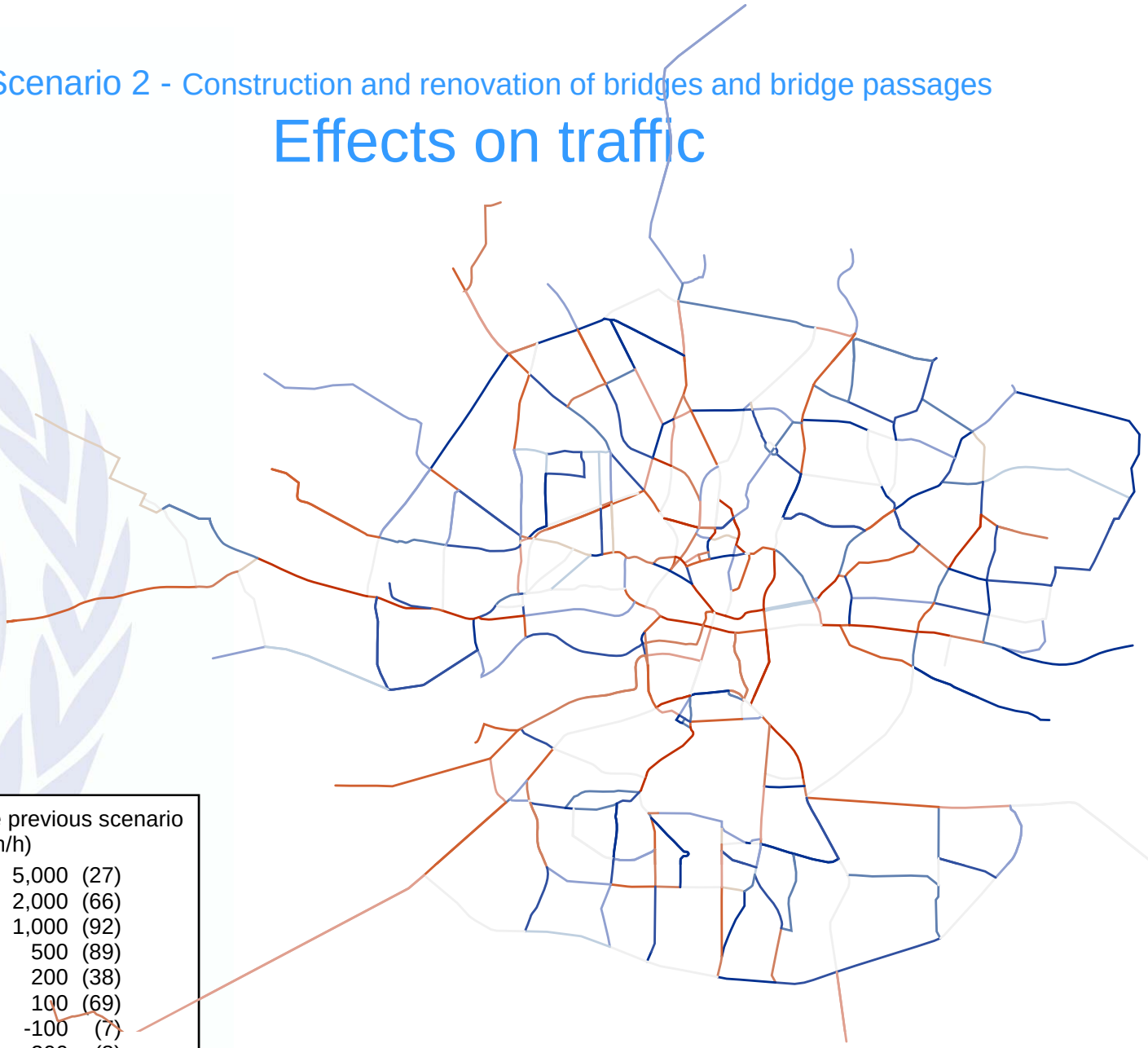
AREP GAW

WMO OMM

Scenario 2 - Construction and renovation of bridges and bridge passages

Effects on traffic



- improvement of central and “main” peripheral paths
- accesses rationalization

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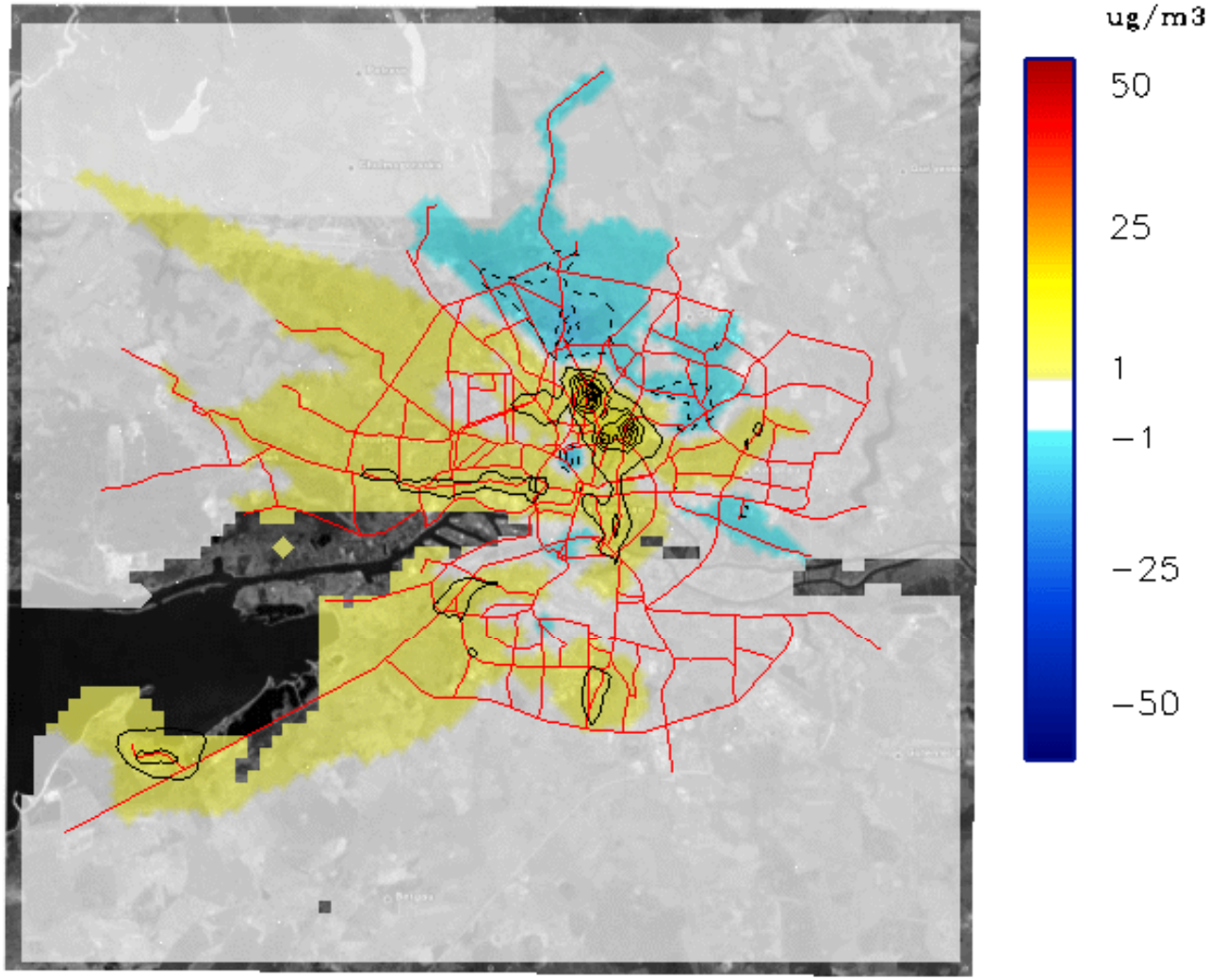
Scenario 2 - Construction and renovation of bridges and bridge passages

Effects on concentrations

Variations of NO_2 average concentrations, respect to Scenario 1



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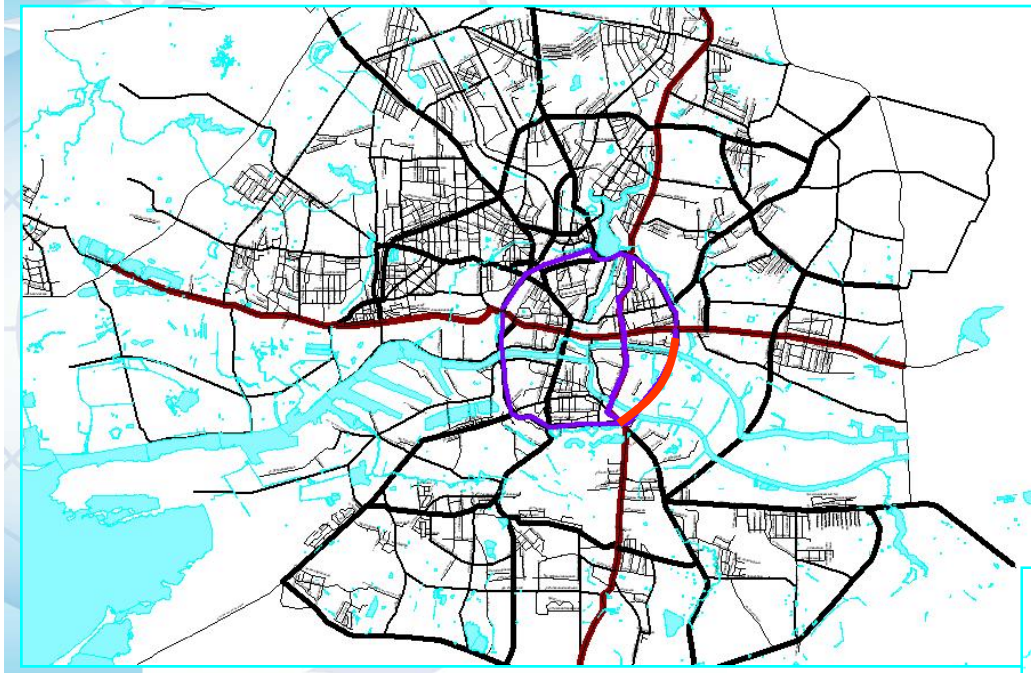
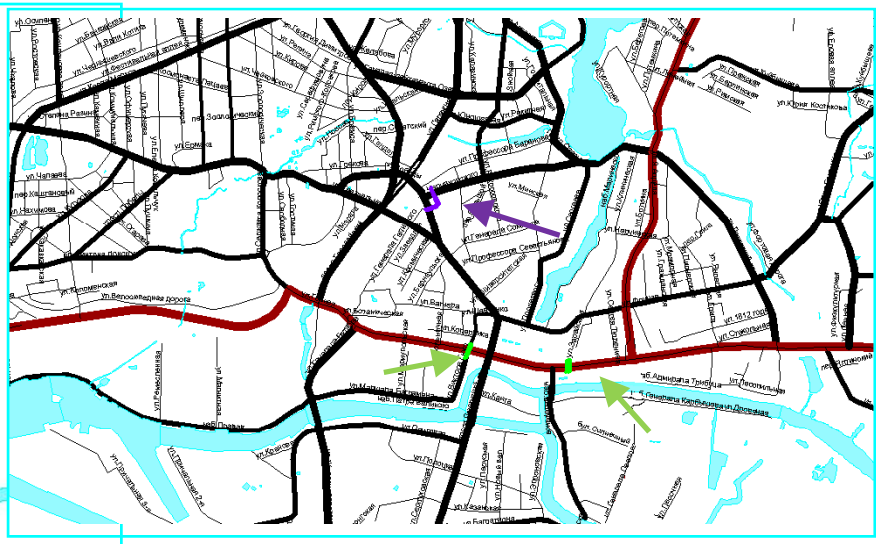
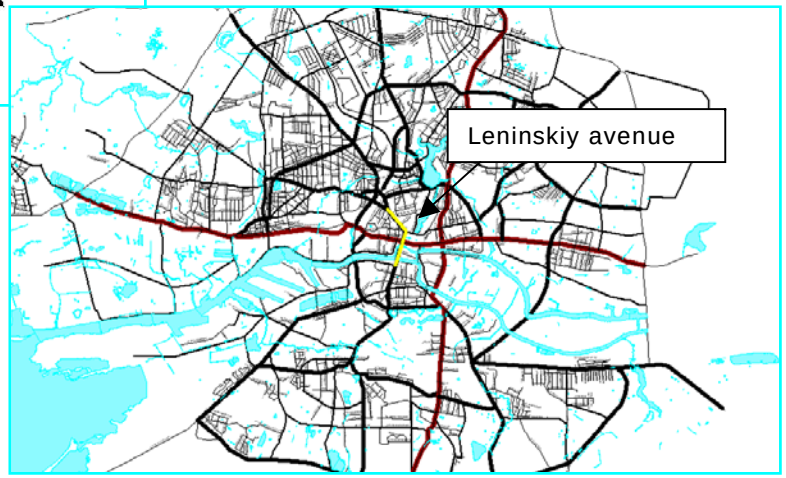
Scenario 3

Development of city road network and optimization of traffic flows







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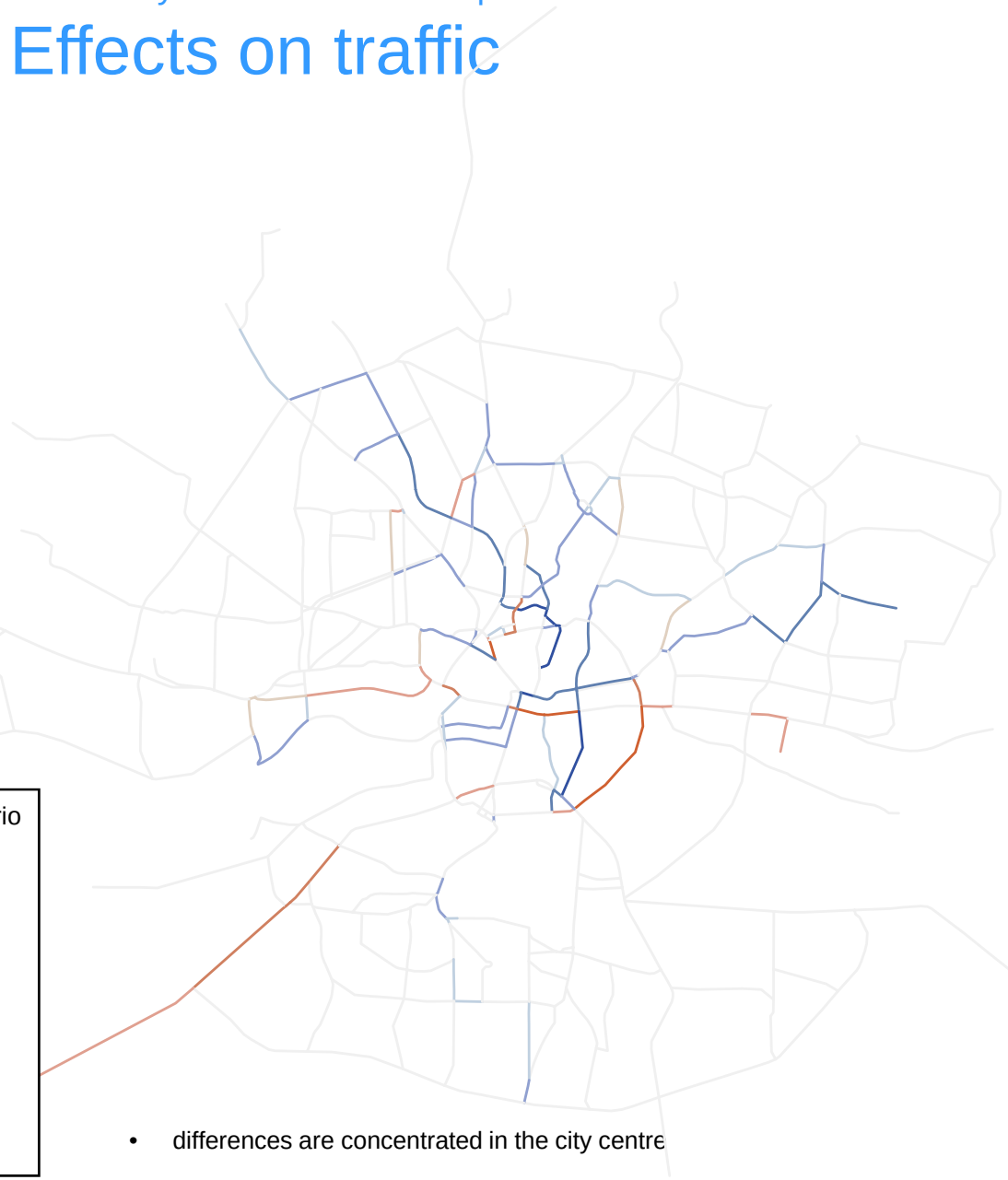
Scenario 3 - Development of city road network and optimization of traffic flows

Effects on traffic



Difference from the previous scenario (veh/h)

2,000 to	5,000	(27)
1,000 to	2,000	(66)
500 to	1,000	(92)
200 to	500	(89)
100 to	200	(38)
-100 to	100	(69)
-200 to	-100	(7)
-500 to	-200	(8)
-1,000 to	-500	(8)
-5,000 to	-2,000	(4)

- differences are concentrated in the city centre

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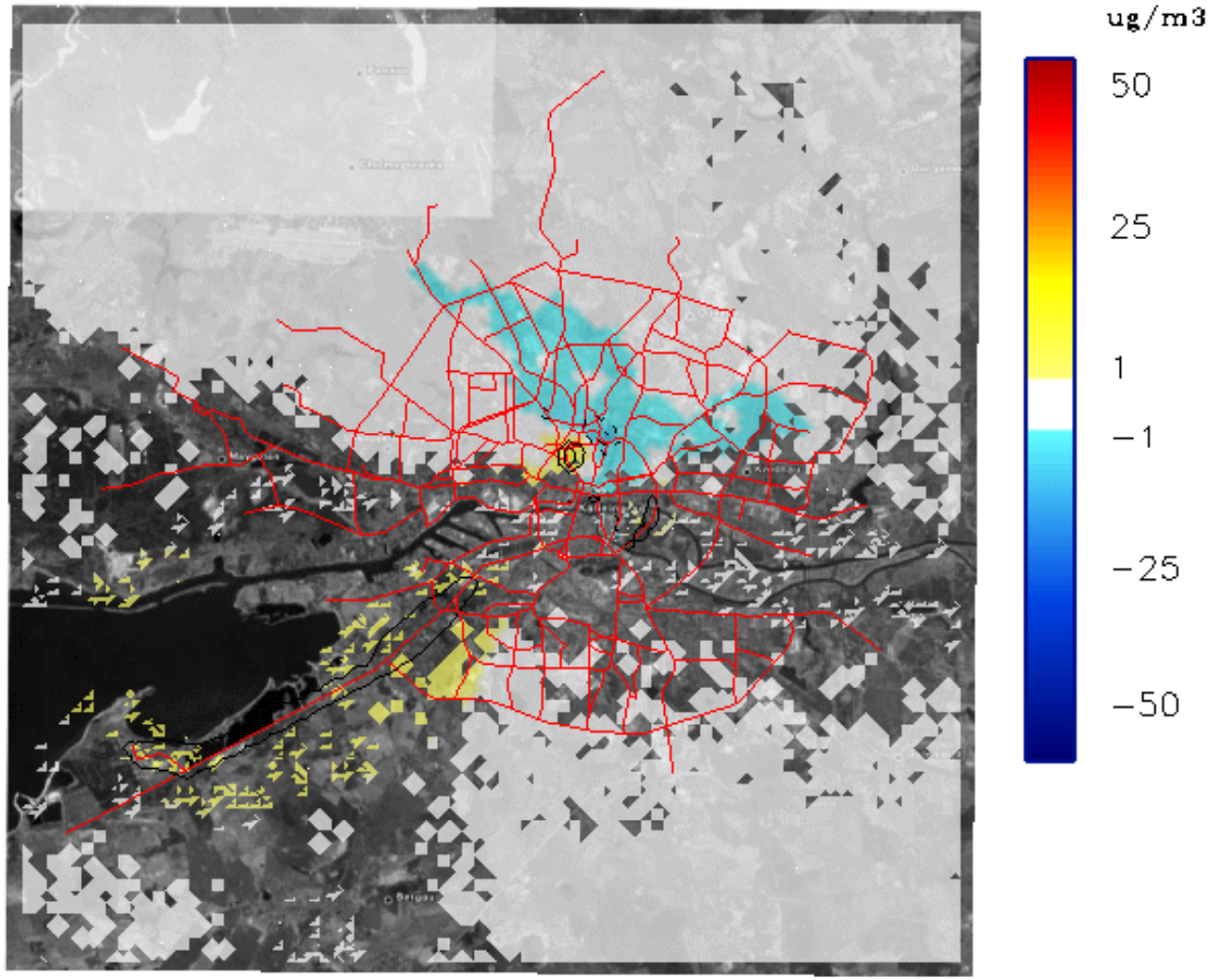
Scenario 3 - Development of city road network and optimization of traffic flows

Effects on concentrations

Variations of NO_2 average concentrations, respect to Scenario 2



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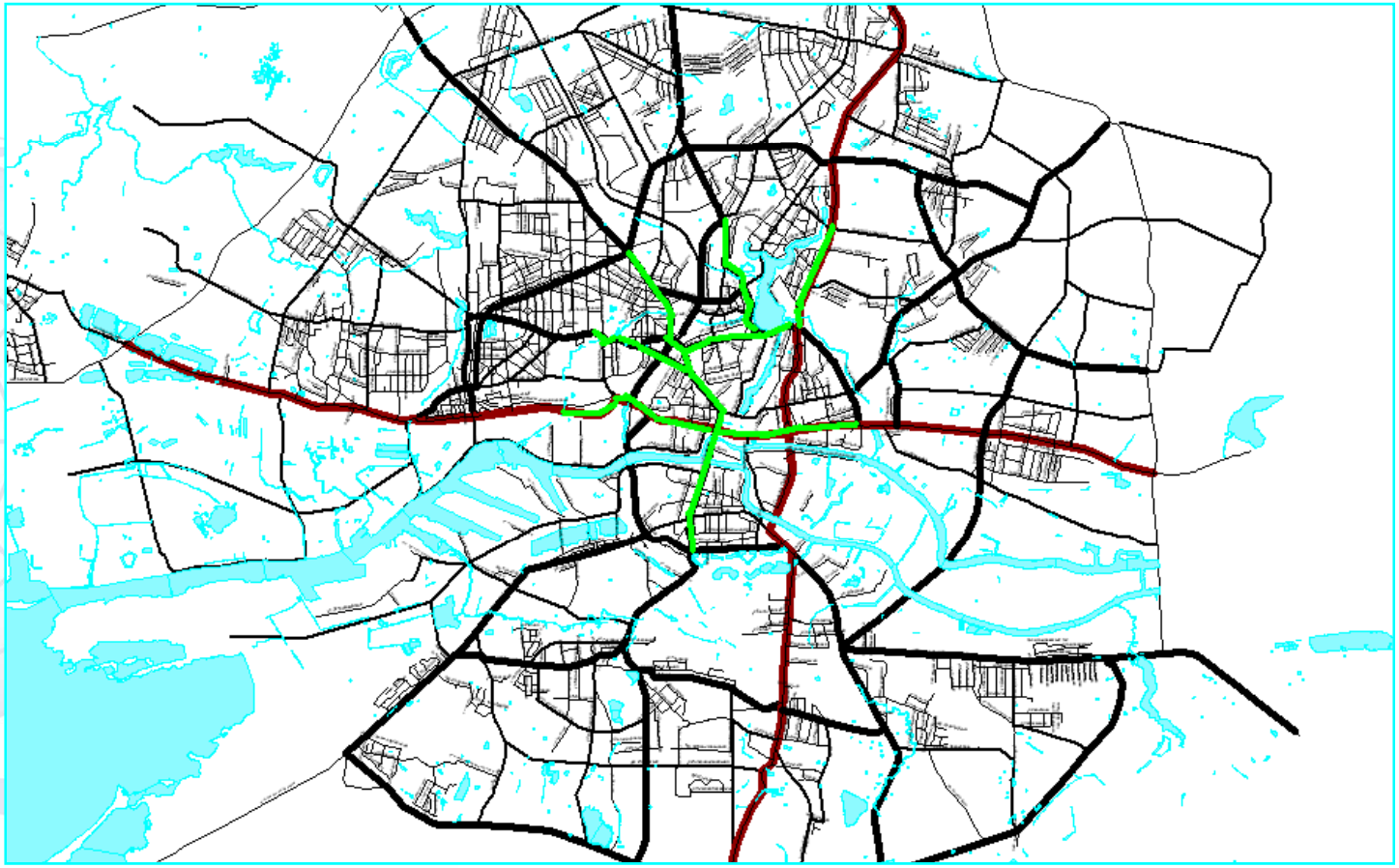
Scenario 4

Improvement of public transport



- +30% buses on the green lines
- modal shift from passenger cars to busses (1 bus = 40 cars)

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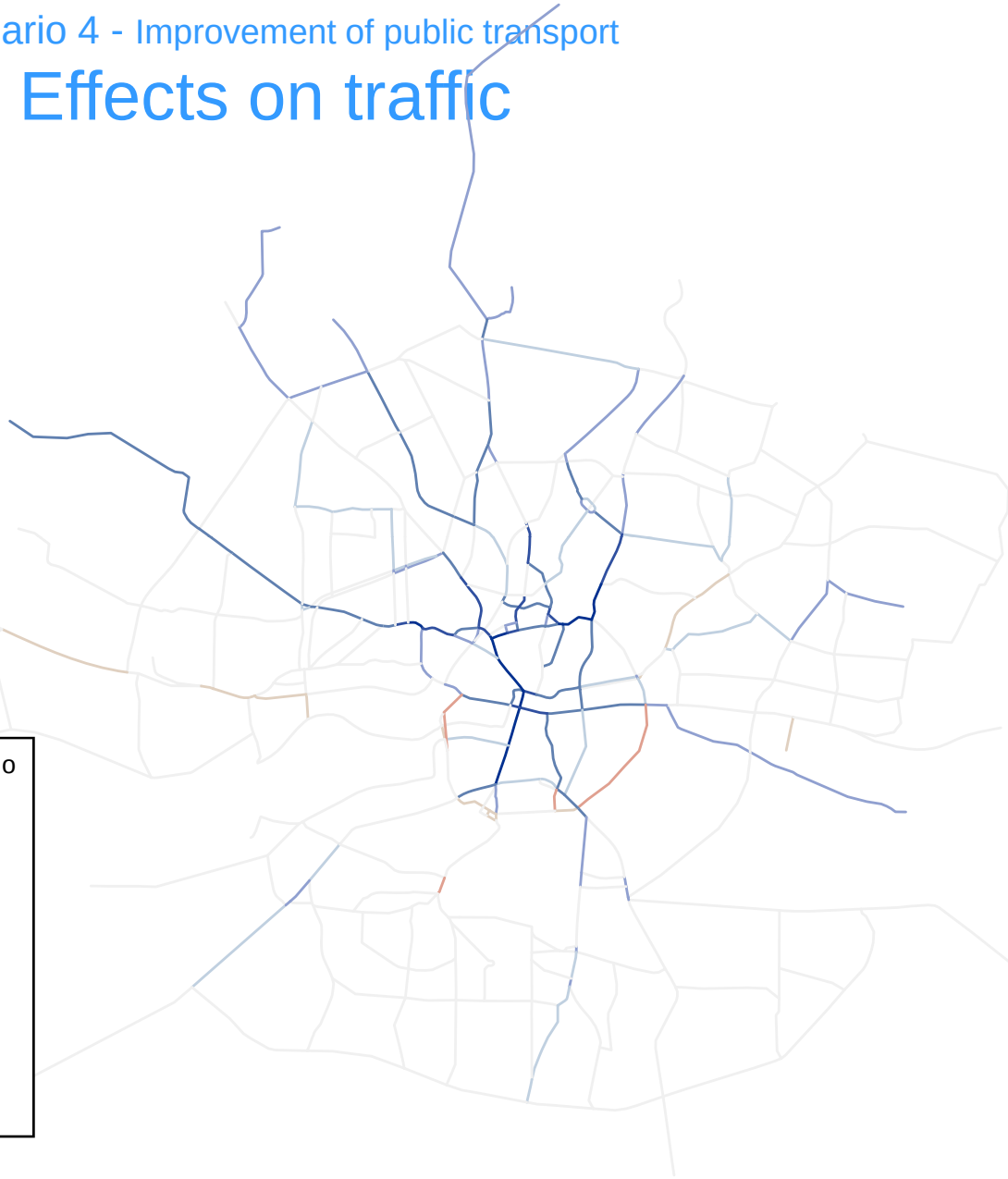
Scenario 4 - Improvement of public transport

Effects on traffic



Difference from the previous scenario (veh/h)

2,000 to 5,000	(27)
1,000 to 2,000	(66)
500 to 1,000	(92)
200 to 500	(89)
100 to 200	(38)
-100 to 100	(69)
-200 to -100	(7)
-500 to -200	(8)
-1,000 to -500	(8)
-5,000 to -2,000	(4)

- the city centre is decongested
- a new bridge and the new ring link are loaded

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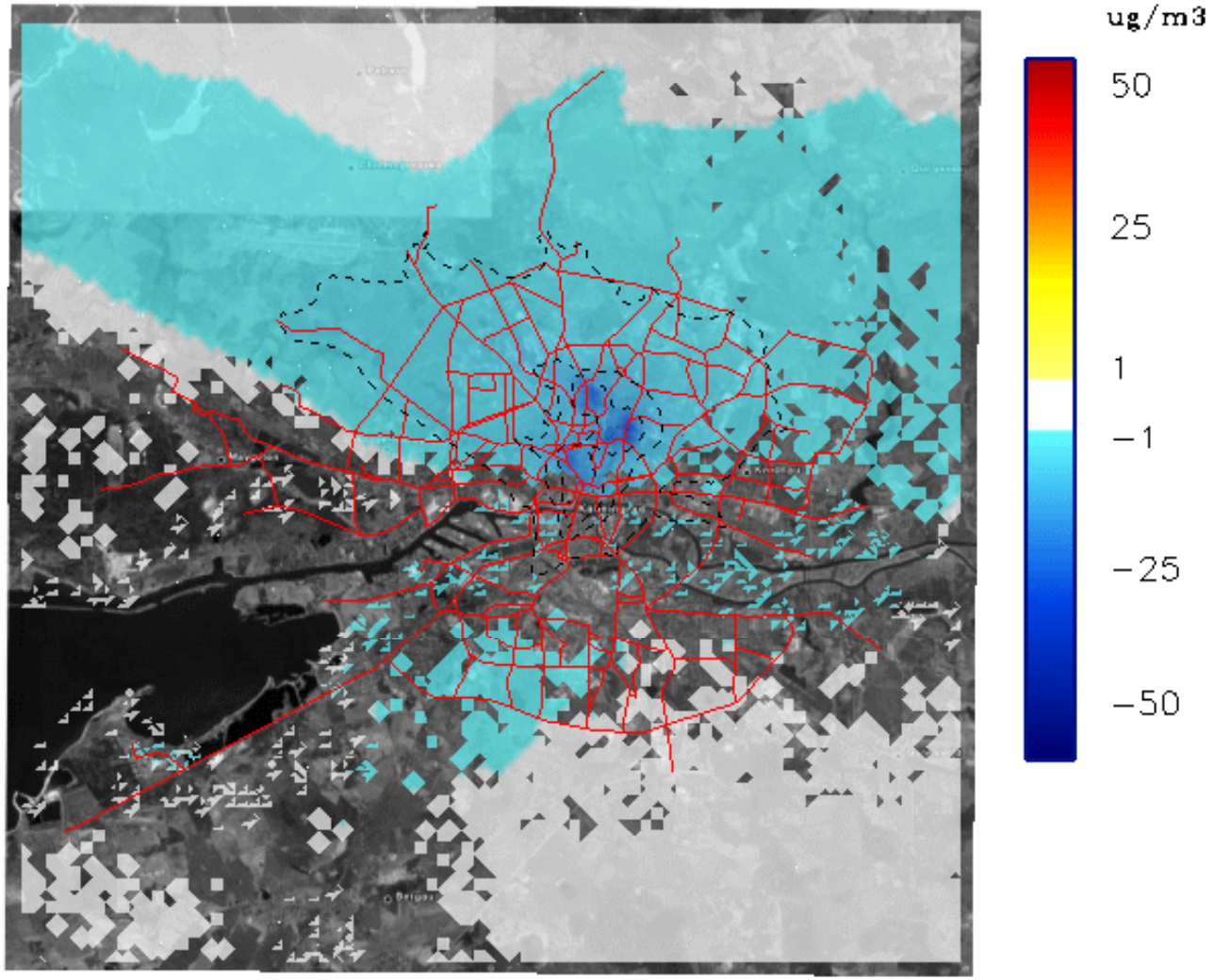
Scenario 4 - Improvement of public transport

Effects on concentrations

Variations of NO_2 average concentrations, respect to Scenario 3



AQM for planning purposes

Mid- and long-term policies:

- … supported by regional- and urban-scale AQM analyses (spatial details, hotspots)
- … linked to broader context
- … multiple models: consistent tools & data - harmonization
- …. multidisciplinary connections (e.g. traffic, energy, agriculture …) especially on “quantitative approaches”

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Scenarios analysis through AQM

- Regional Air Quality Plan
- Emissions projection
- Translation of measures / actions
- Sector modelling, e.g. traffic
- New infrastructures

- Quantifying the expected impacts
- Assessing the relative importance of measures /actions
- Compliance respect to AQ limits

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Increasing the reliability and trust

- Measurements + inventories + modelling: a continuously evolving process
- Collaboration between “inventory makers” & AQ modellers
- Interplay between forecast & planning / assessment
- Dialogue with stakeholders & policy makers

WMO
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AREP
GAW

Credits

Many thanks to colleagues from …

- Regione Piemonte
- ENEA
- ARPA Lombardia
- ECAT Kaliningrad
- ARIA Technologies
- ARIANET

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