

AIR QUALITY INFLUENCE OF AMMONIA AND NITROGEN OXIDES EMISSIONS REDUCTION OVER THE PO VALLEY

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1. ARPA - Regional Environmental Protection Agency – Lombardia
www.arpalombardia.it



2. ARIANET Srl – www.aria-net.it

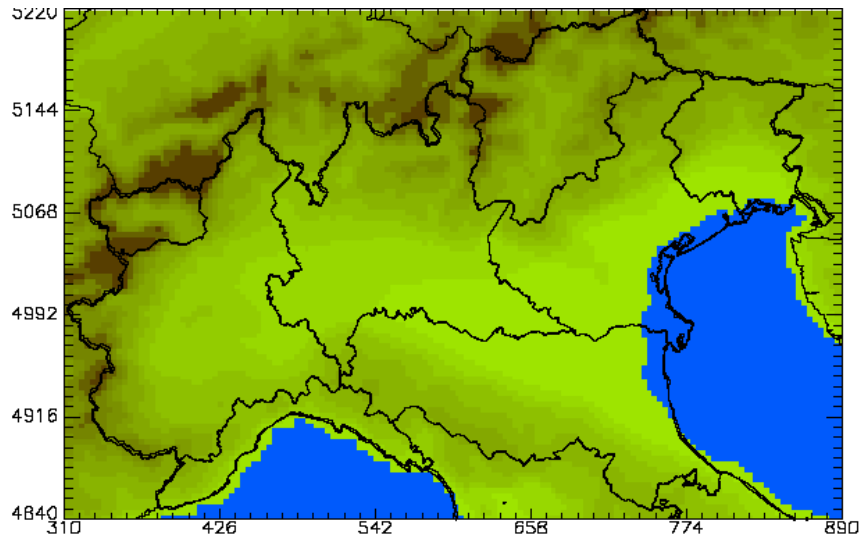
A few words of introduction...

- ❑ Why 1: in the Po valley, 30-40% of PM is secondary inorganic;
- ❑ Why 2: need for our local Administration to investigate whether stricter command and control policies should be applied to ammonia or nitrogen oxides emissions (or both);
- ❑ We are interested into determining if Lombardy plain can be considered either ammonia or NO_x limited;

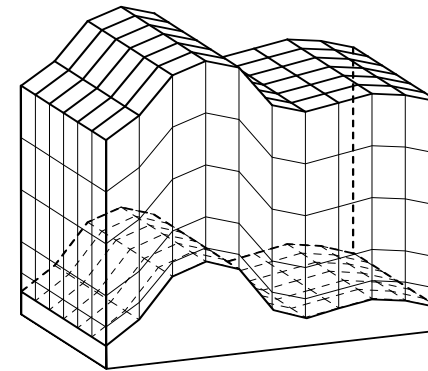
These slides:

- ❑ Base case: Domain, Emissions, Meteorology, Bc, Results [3-22]
- ❑ Scenarios: Hypothesis, Results, Discussion [23-33]

Simulation domain



Nr. of grid points along x, y: 146, 96
 Horizontal resolution: 4 km
 Domain area: 584x284 km²



Grid face heights [m]:

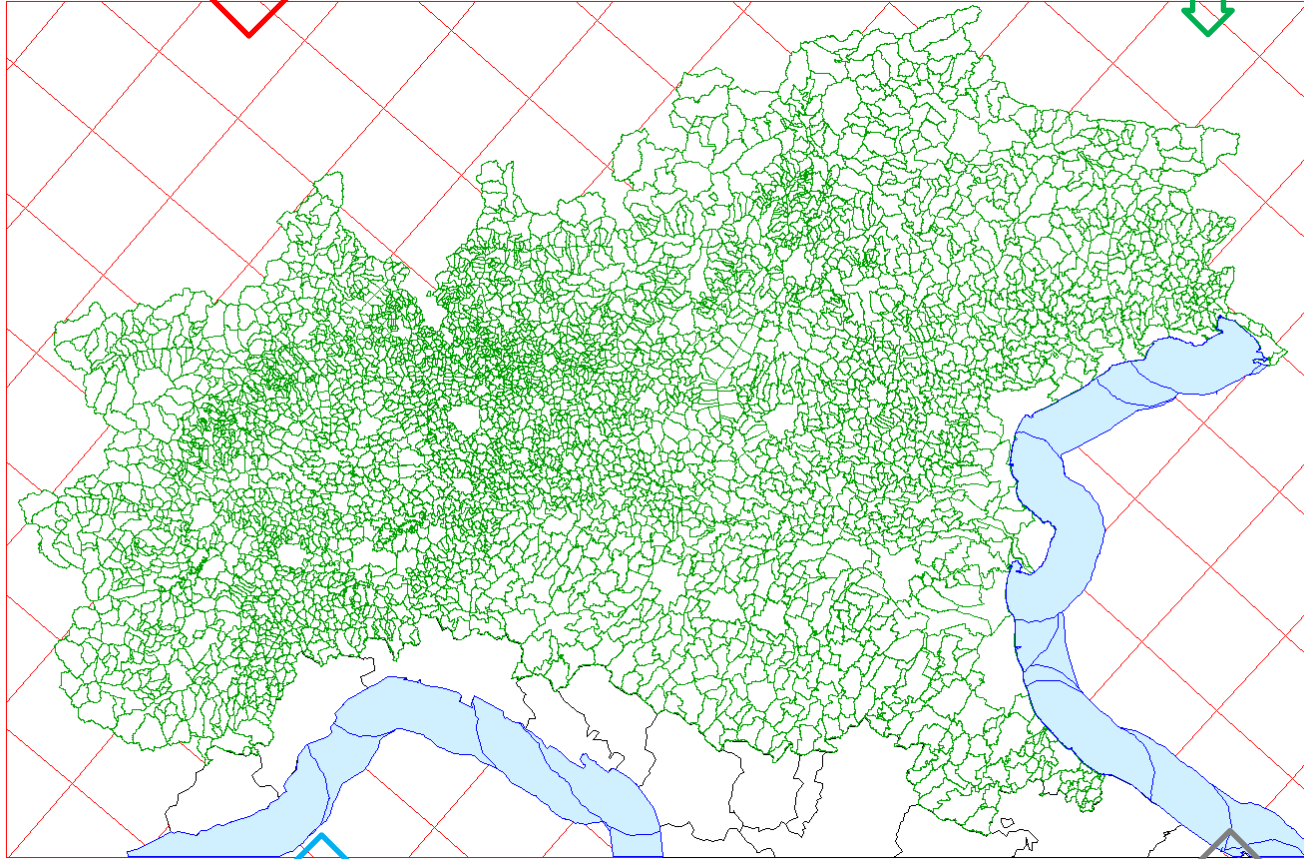
1 = 40.
 2 = 90.
 3 = 160.
 4 = 260.
 5 = 390.
 6 = 570.
 7 = 810.
 8 = 1140.
 9 = 1580.

 16 = 10040.

Emissions

EMEP 2009 – 50 x 50 km²

Local Inventories 2011 – Municipal level*



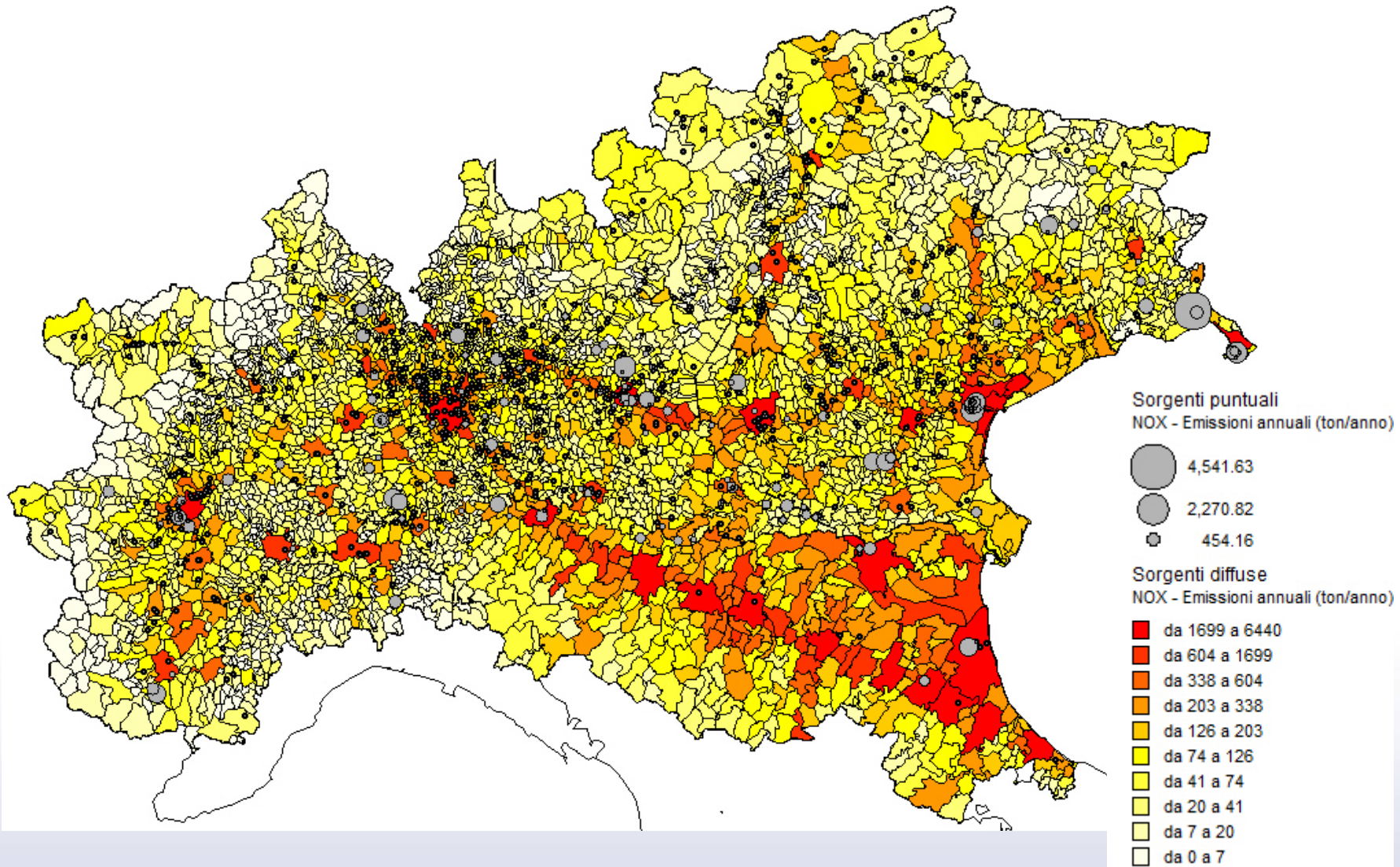
* INEMAR inventory (www.inemar.eu) except for Vallée d'Aoste

* Originally referred to 2005 and updated with GAINS trends

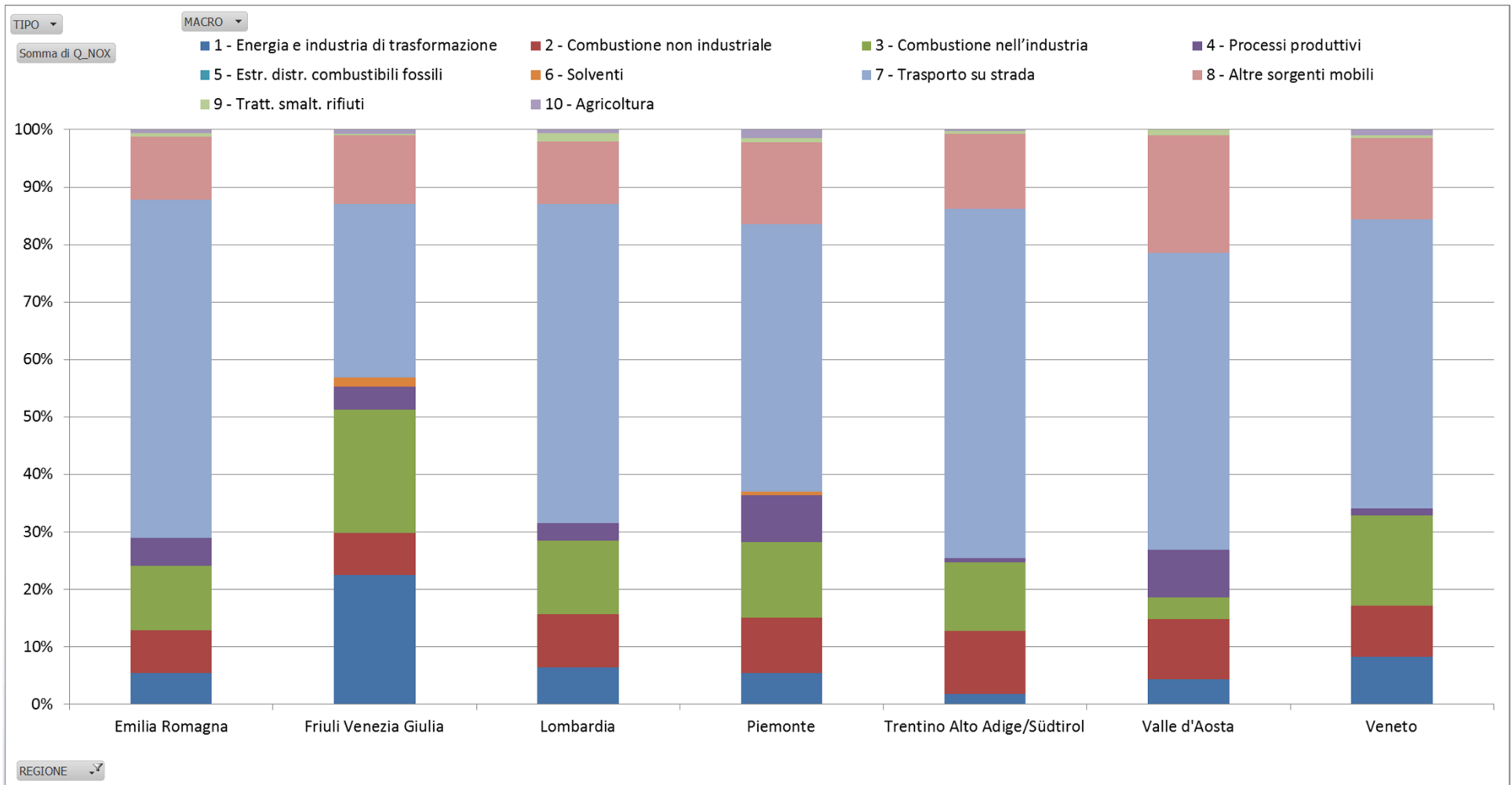
Naval emissions – District level

National Inventory 2009 – District level*

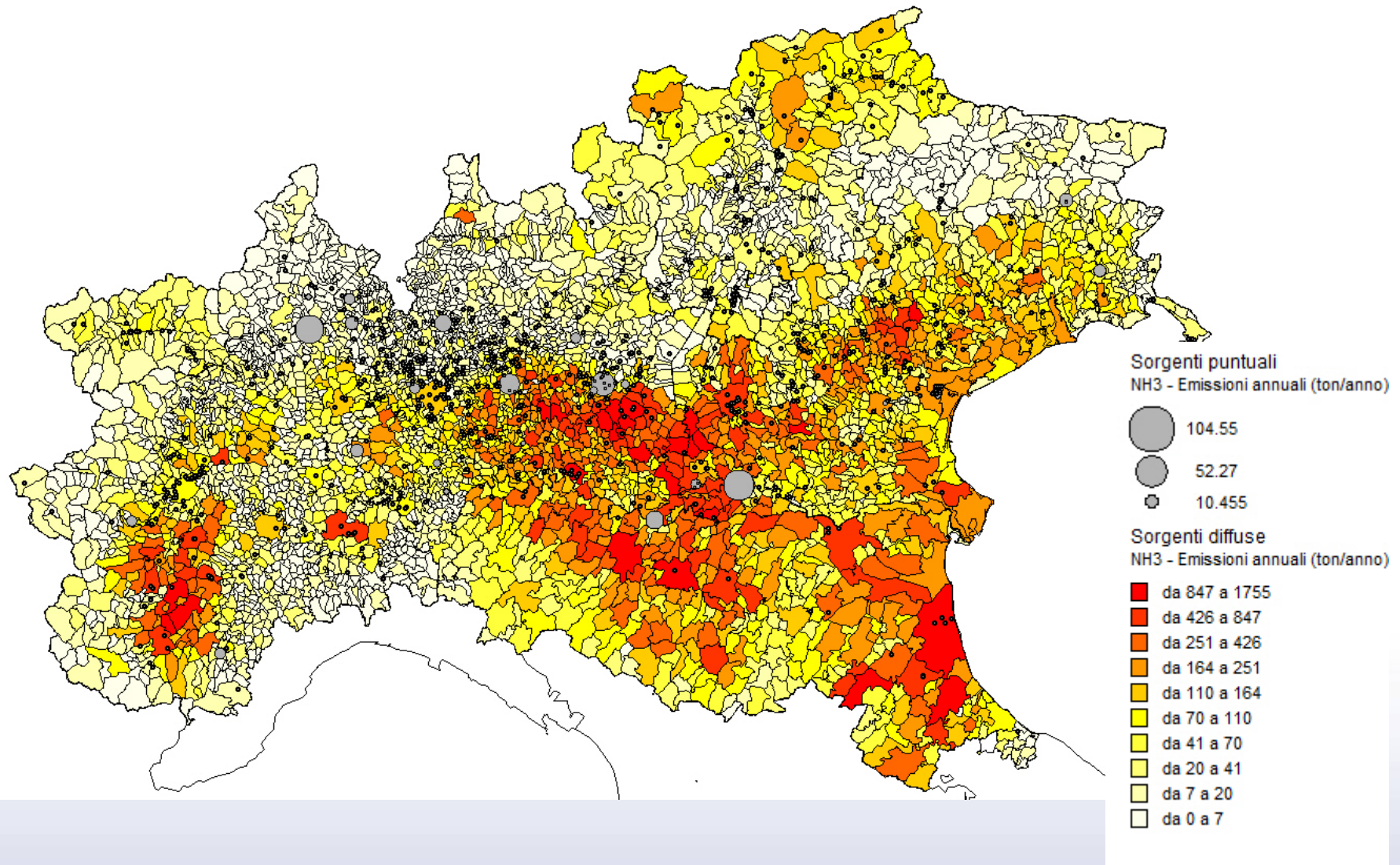
NO_x emissions



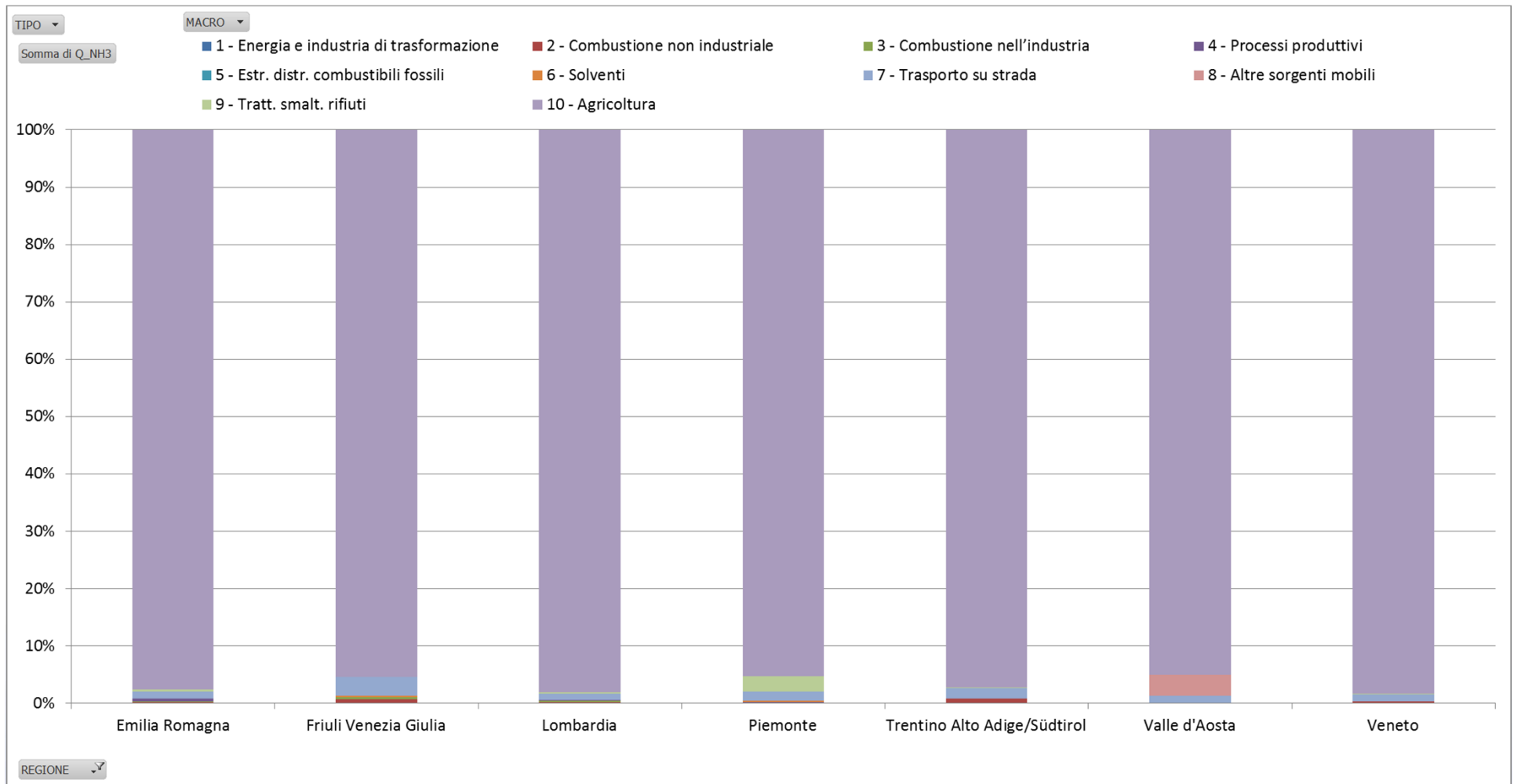
Sectors weight (%) - NO_x



NH₃ emissions



Sectors weight (%) – NH₃



Two months were simulated – one in spring and one in autumn – when liquid manure is spread and measurements were available

17/3/2011-19/4/2011

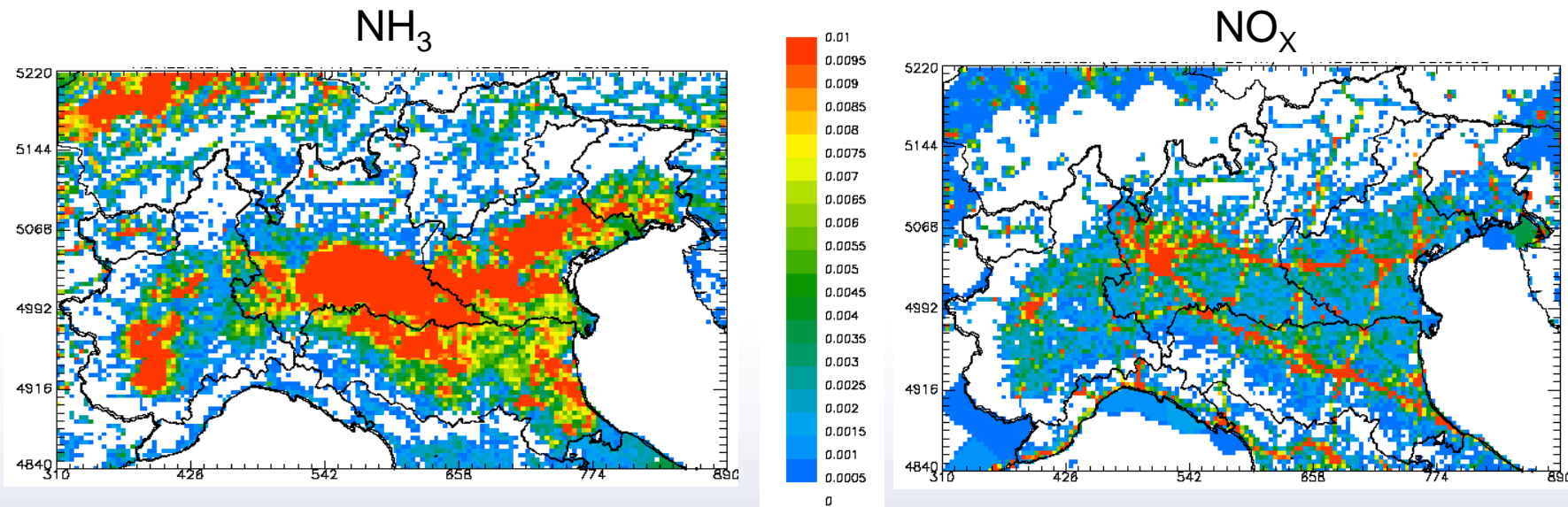
NH₃ max rate = 0.0702 μmol/m²s

NO_x max rate = 0.2092 μmol/m²s

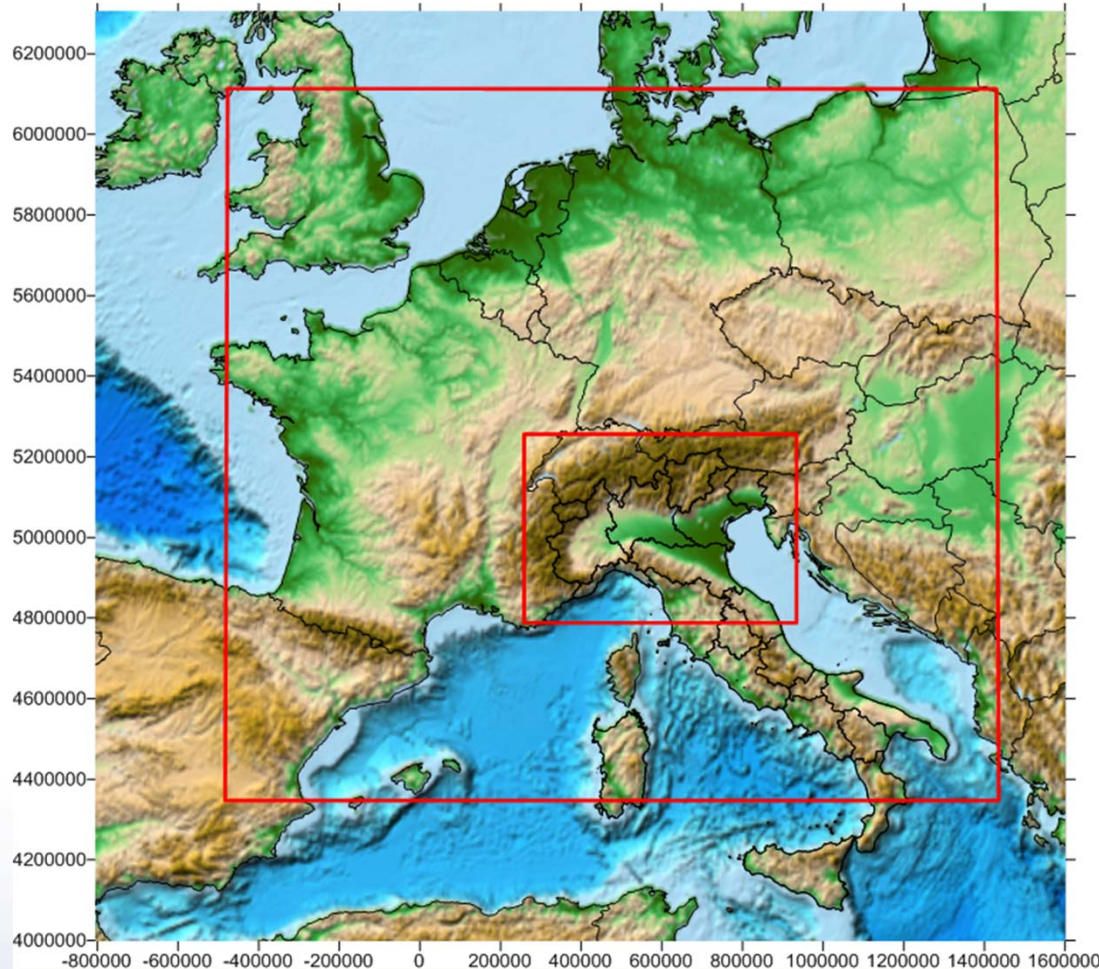
16/09/2011-16/10/2011

NH₃ max rate = 0.1010 μmol/m²s

NO_x max rate = 0.1924 μmol/m²s



* Non-anthropogenic: MEGAN+CORINE land cover+CH GEOSTAT; meteorological parameters by RAMS+SURFpro



Meteorological driver: RAMS+REVU

Simulated periods:

- 16/03-20/04/2011
- 14/09-16/10/2011

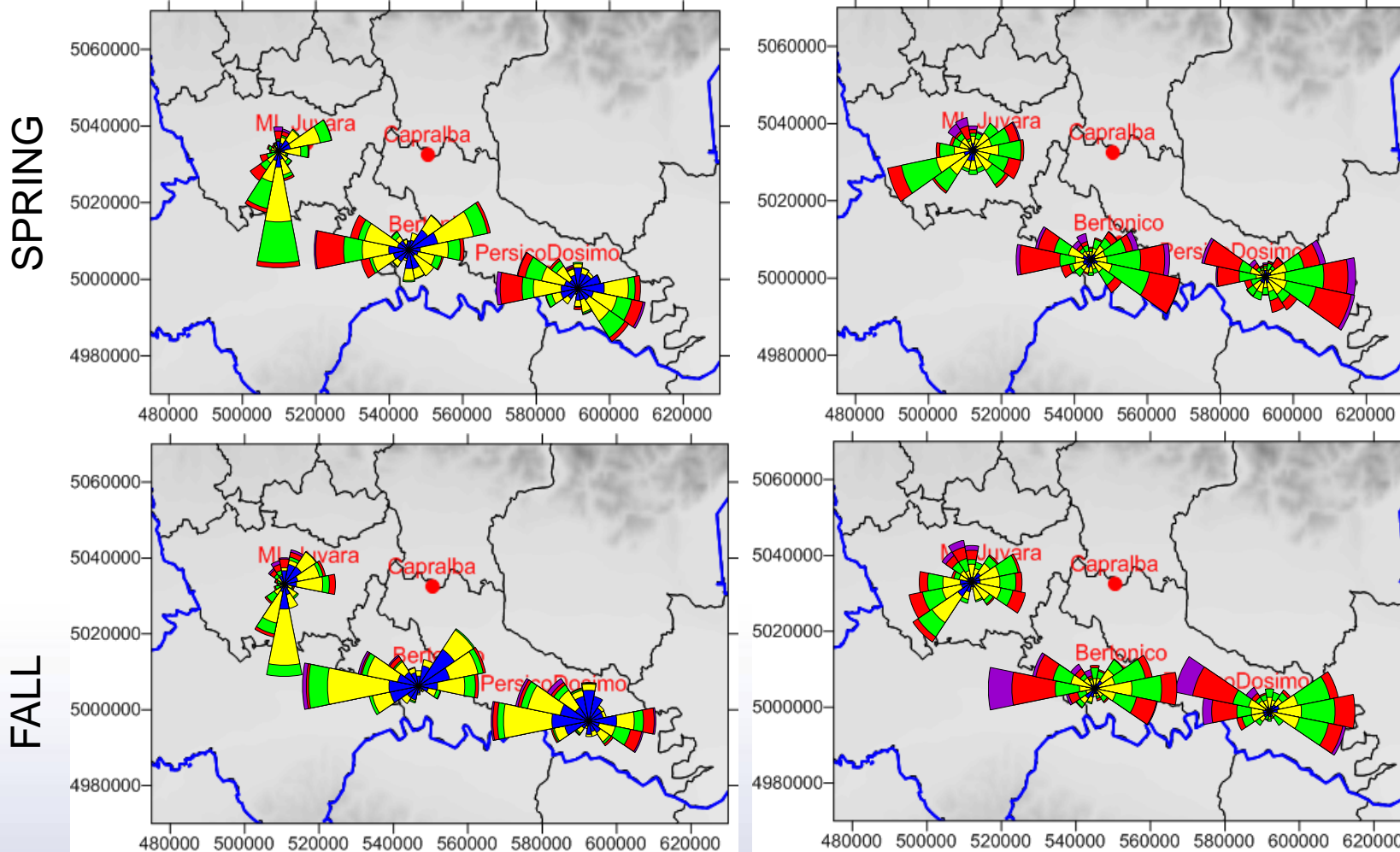
Howto:

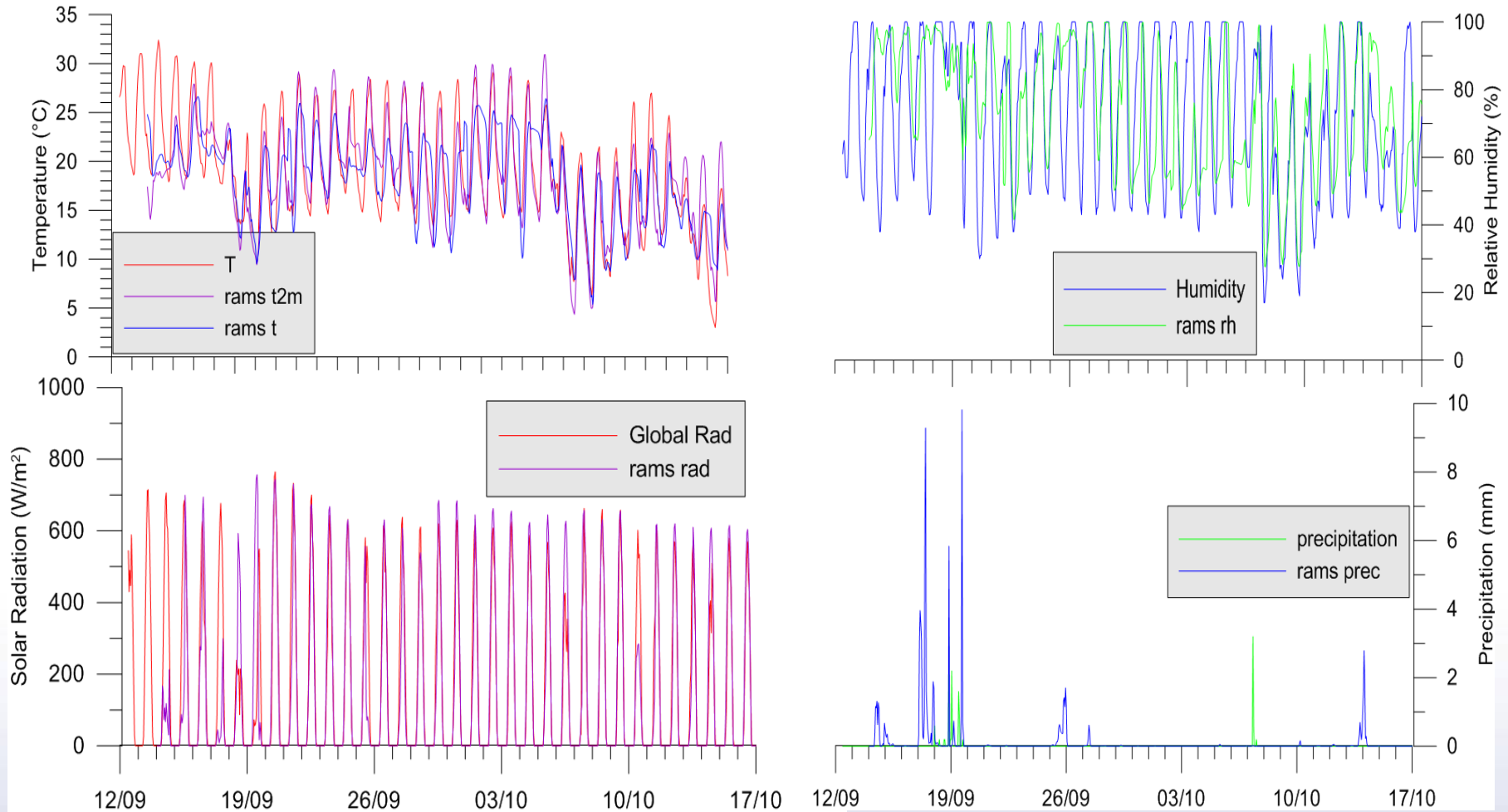
- Every 5 days of simulations+ 1 spin-off day

	Grid 1	Grid 2
Δxy (km)	16	4
Nx	121	170
Ny	111	118
Nz	32	32

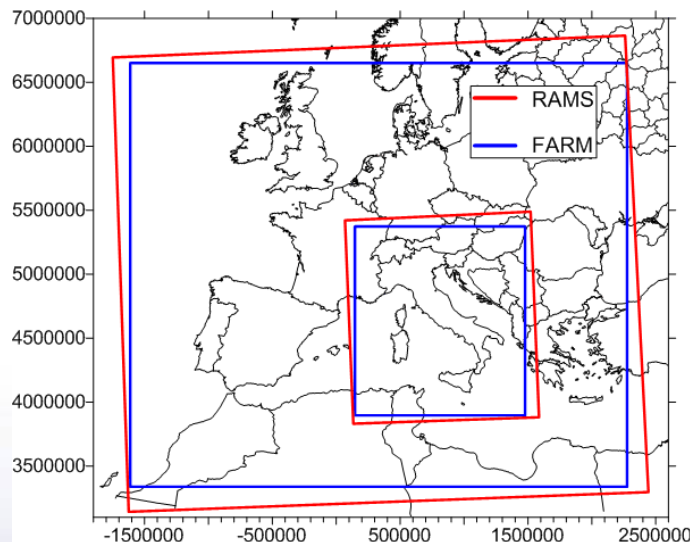
Obs.

RAMS + REVU

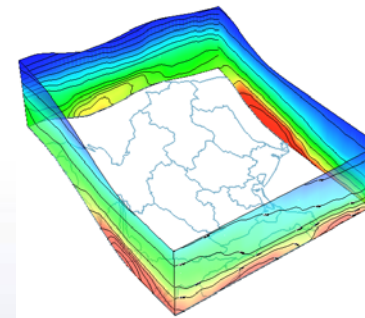




- Derived from *QUALEARIA* daily runs over Italy
- Emissions: National Inventory 2005 @ district level updated to 2009 with GAINS trends + TNO 2005 European Inventory (http://megapoli.dmi.dk/publ/MEGAPOLI_sr10-17.pdf)
- Eulerian model FARM + SAPRC99 + ISORROPIA



Larger domain: 48 km grid pace.
Nested domain: 12 Km grid pace

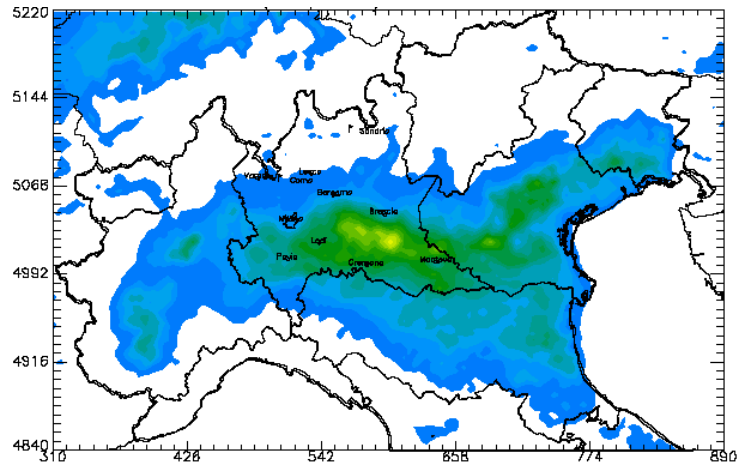


Hourly BC conditions

Results: NH₃ and NO₂ averages

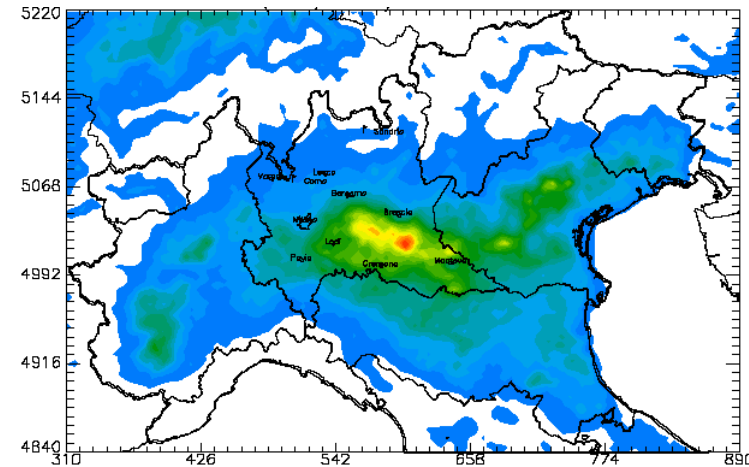
17/3/2011-19/4/2011

NH₃: Min=0.1 – Max=29.8 µg/m³

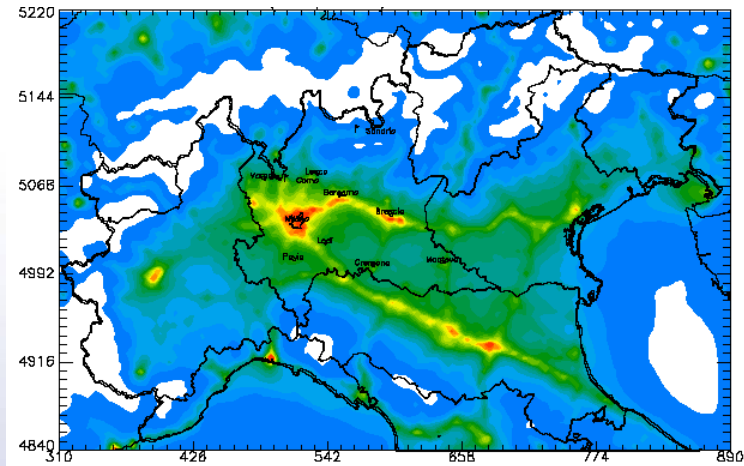


14/09/2011-16/10/2011

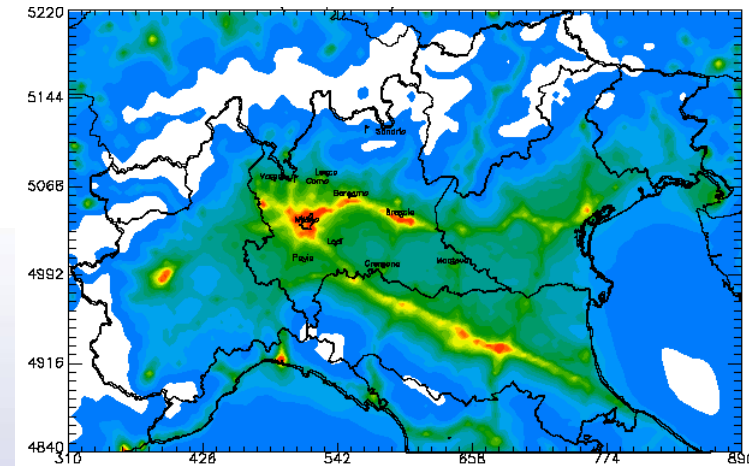
NH₃: Min=0.3 – Max=41.2 µg/m³

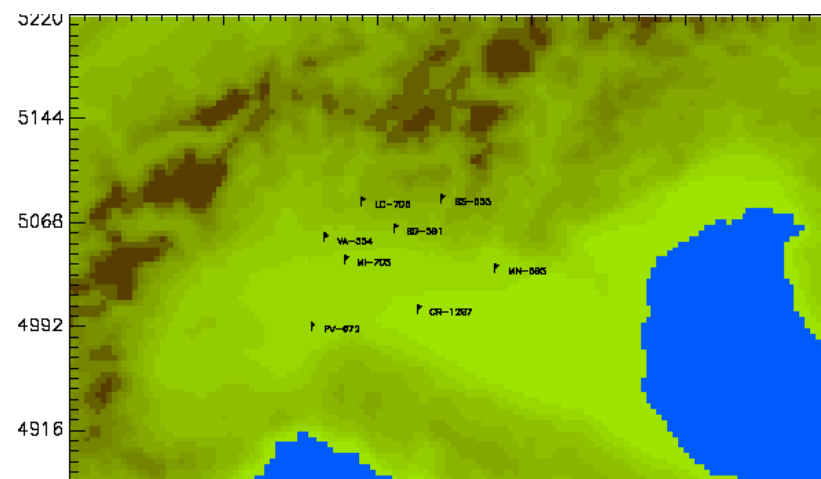
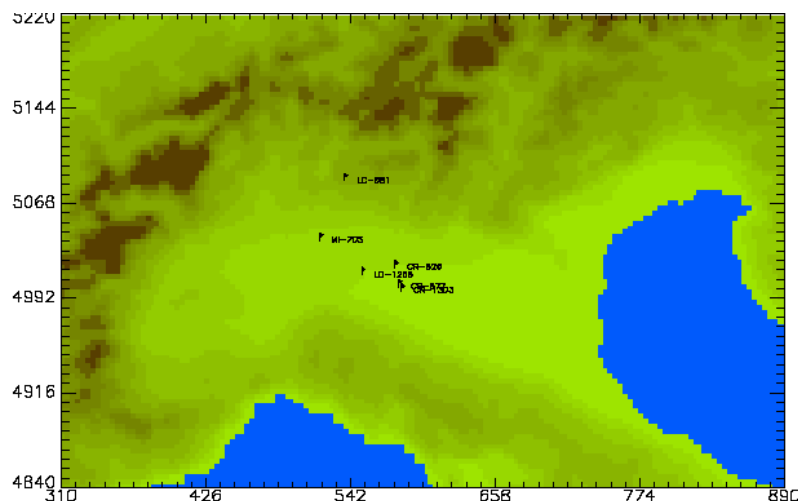


NO₂: Min=0.7 – Max=55.7 µg/m³



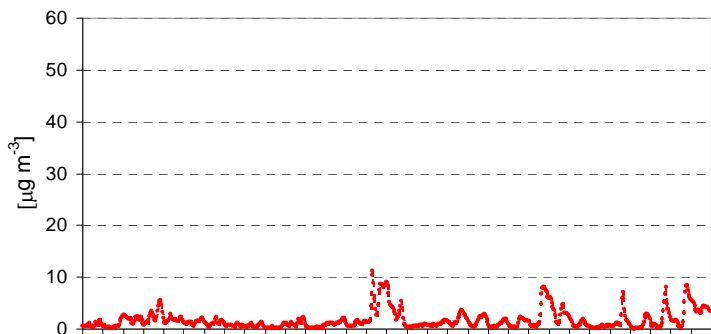
NO₂: Min=0.6 – Max=53.6 µg/m³



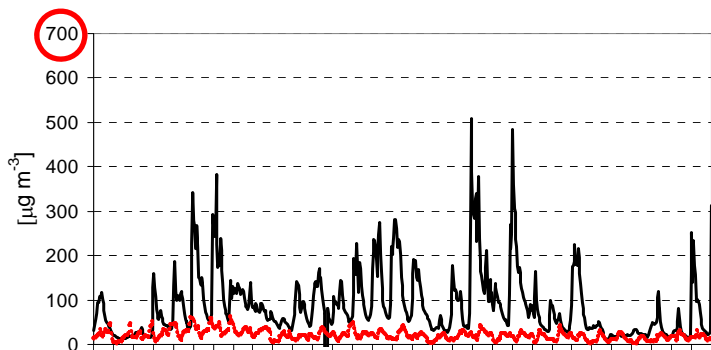


	<i>Name</i>	<i>District</i>	<i>Classification</i>
NH₃	Moggio	LC	Rural Background (FR)
	Milano - Pascal Città Studi	MI	Urban Background (FU)
	Corte de Cortesi	CR	Rural Background (FR)
	Bertonico	LO	Rural Industrial (IR)
	Cremona - Via Fatebenefratelli	CR	Urban Background (FU)
NO₂	Cremona - via Gerre Borghi	CR	Rural Background (FR)
	Saronno - via Santuario	VA	Urban Background (FU)
	Seriate	BG	Urban Background (FU)
	Lecco - Via Sora	LC	Urban Background (FU)
	Milano - Pascal Città Studi	MI	Urban Background (FU)
	Brescia - via Ziziola	BS	Suburban Background (FS)
	Cornale (Voghera Energia)	PV	Rural Background (FR)
	Ponti sul Mincio	MN	Suburban Background (FS)
	Spinadesco	CR	Rural Background (FR)

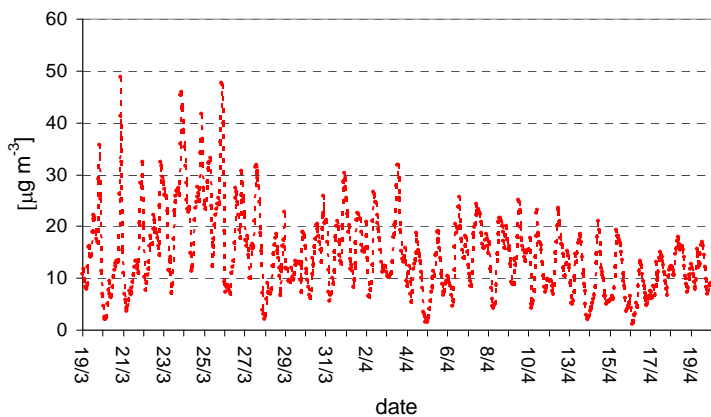
Station: 681 (LC) - Type: FR



Station: 626 (CR) - Type: FR



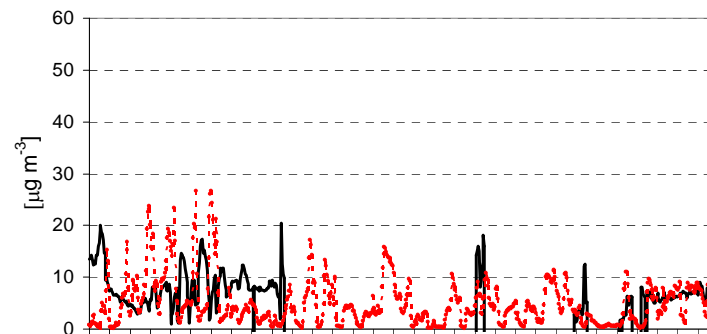
Station: 677 (CR) - Type: FU



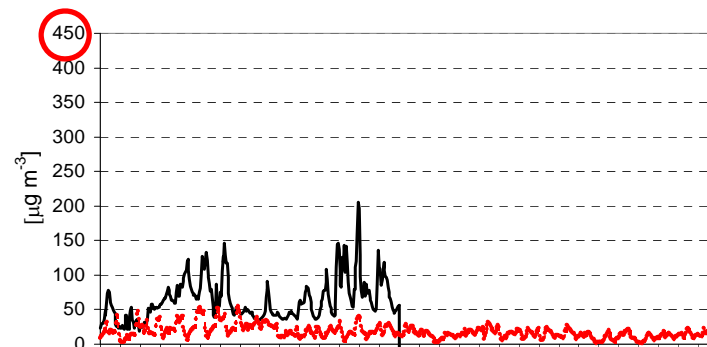
NH₃
(spring)

■ measured ■ computed

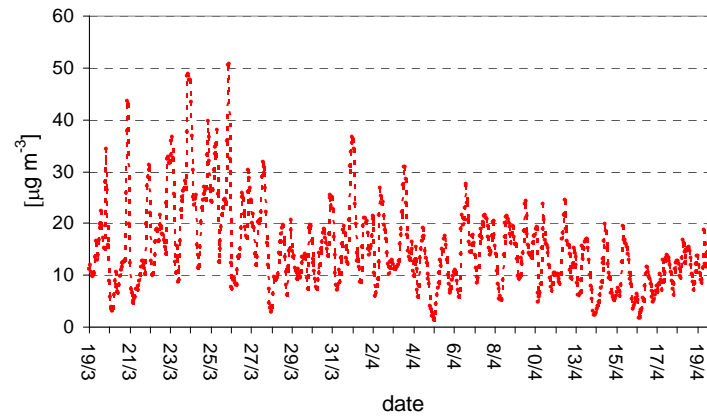
Station: 705 (MI) - Type: FU



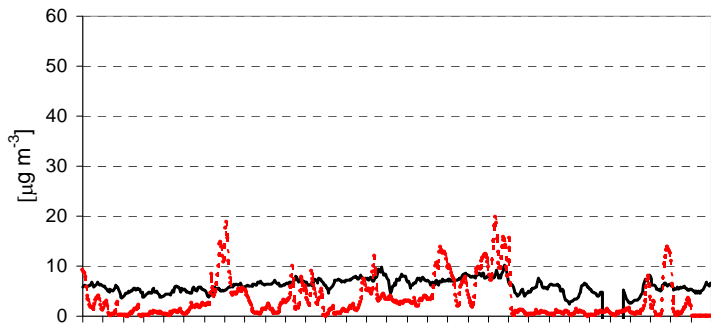
Station: 1266 (LO) - Type: IR



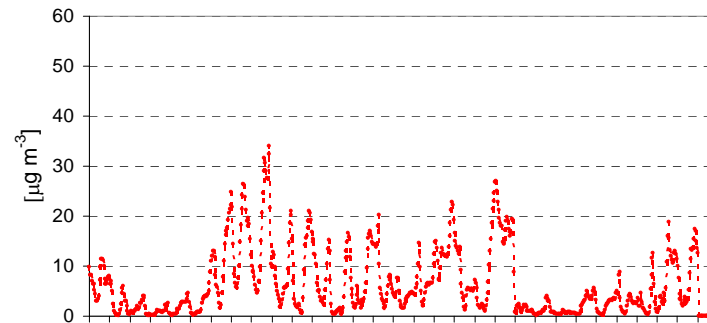
Station: 1303 (CR) - Type: FR



Station: 681 (LC) - Type: FR

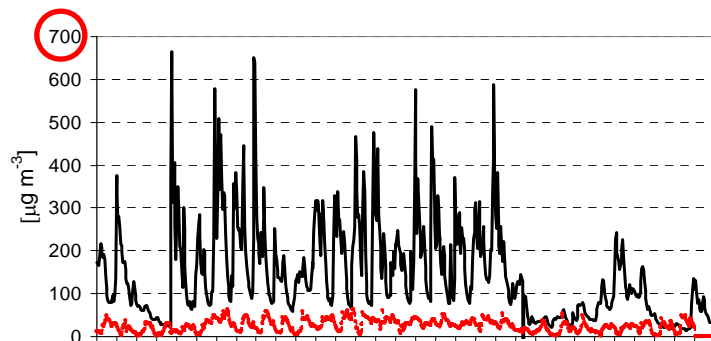


Station: 705 (MI) - Type: FU

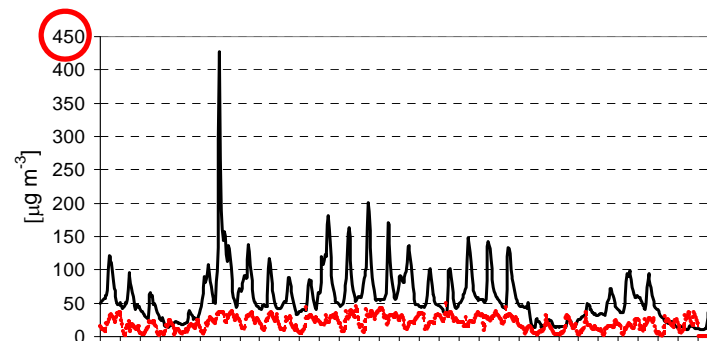


NH₃
(fall)

Station: 626 (CR) - Type: FR

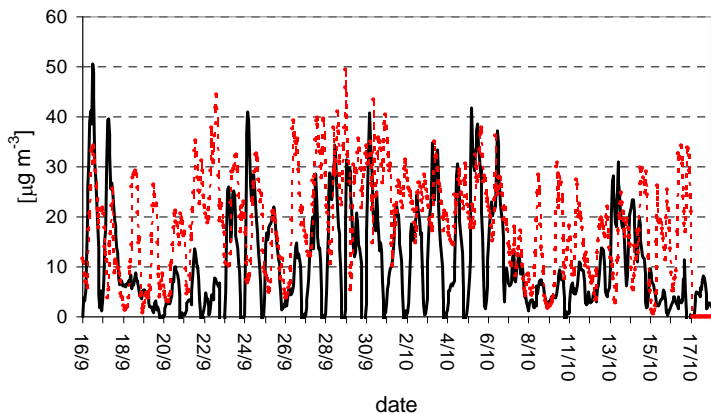


Station: 1266 (LO) - Type: IR

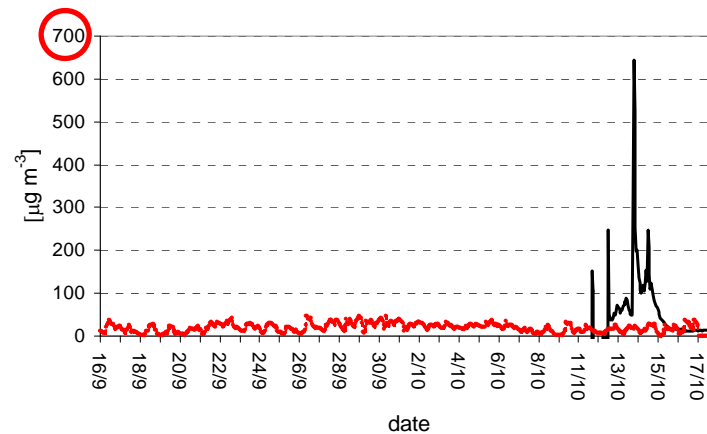


■ measured ■ computed

Station: 677 (CR) - Type: FU



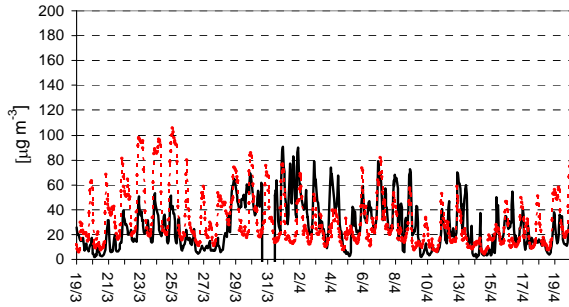
Station: 1303 (CR) - Type: FR



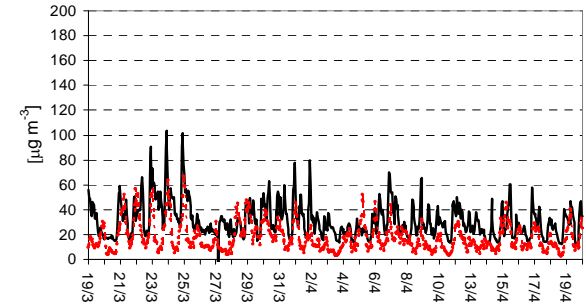
NO₂ (spring)

■ measured ■ computed

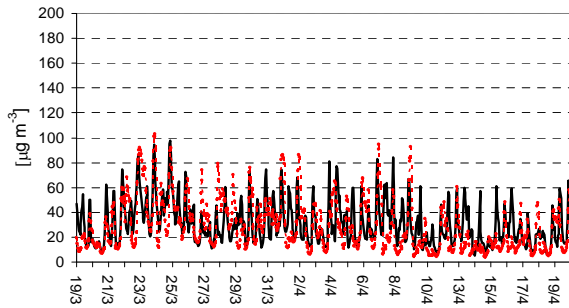
Station: 554 (VA) - Type: FU



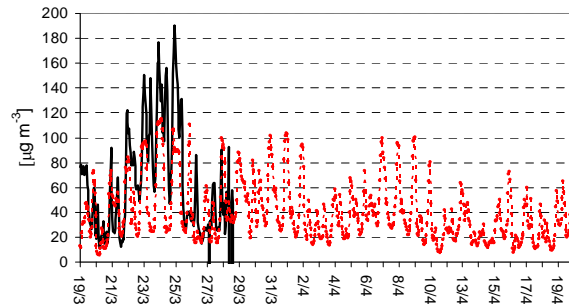
Station: 672 (PV) - Type: FR



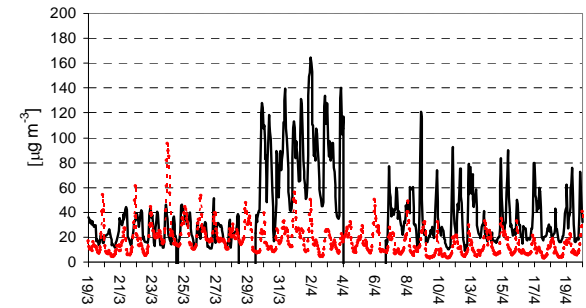
Station: 591 (BG) - Type: FU



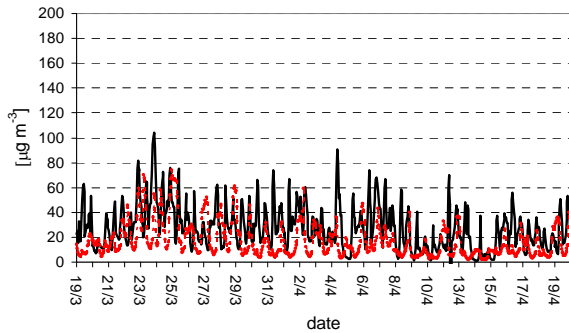
Station: 705 (MI) - Type: FU



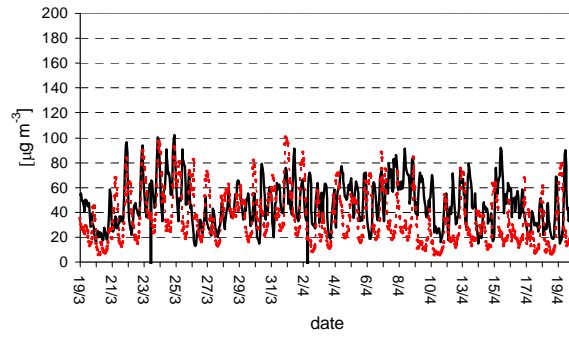
Station: 695 (MN) - Type: FS



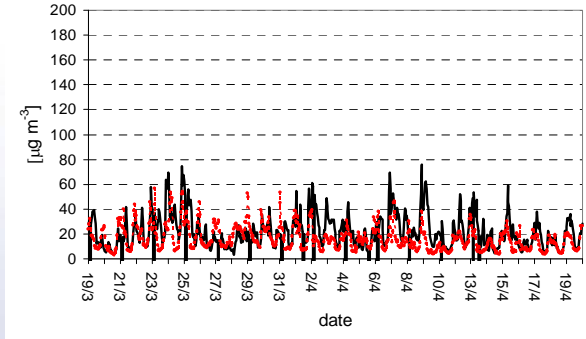
Station: 706 (LC) - Type: FU



Station: 653 (BS) - Type: FS

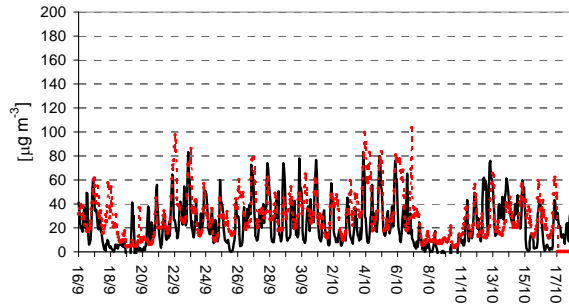


Station: 1297 (CR) - Type: FR

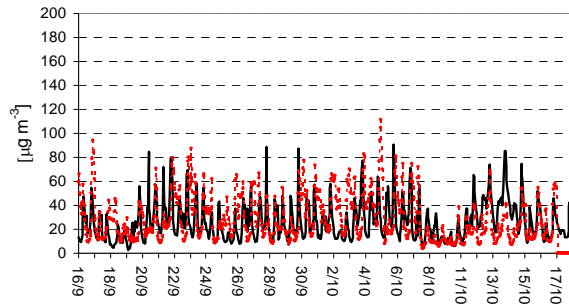


NO₂ (fall)

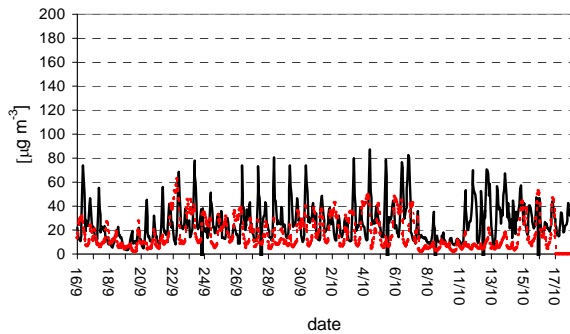
Station: 554 (VA) - Type: FU



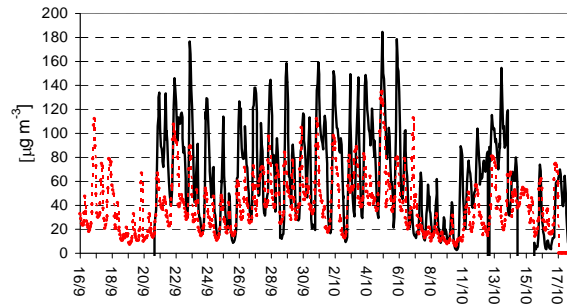
Station: 591 (BG) - Type: FU



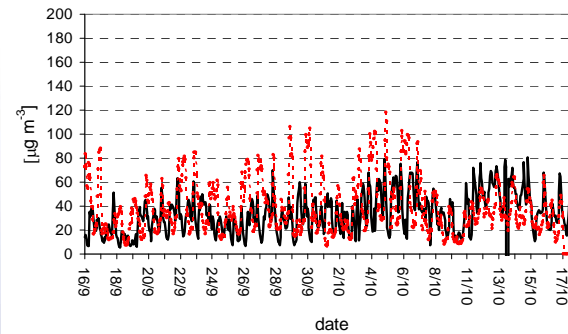
Station: 706 (LC) - Type: FU



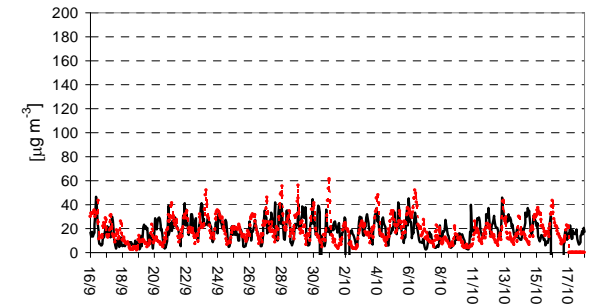
Station: 705 (MI) - Type: FU



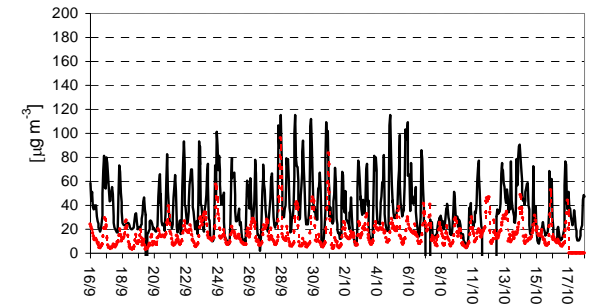
Station: 653 (BS) - Type: FS



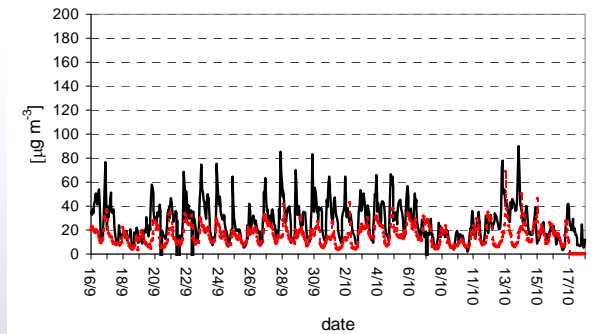
Station: 672 (PV) - Type: FR



Station: 695 (MN) - Type: FS



Station: 1297 (CR) - Type: FR

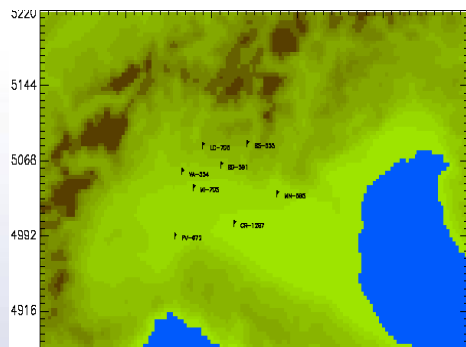
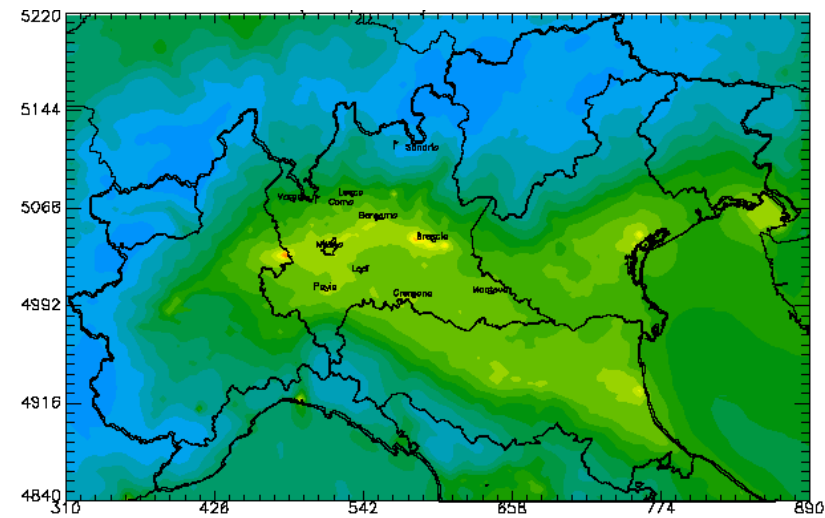
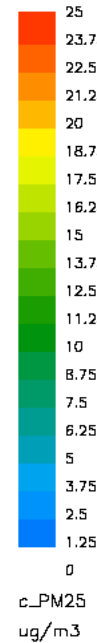
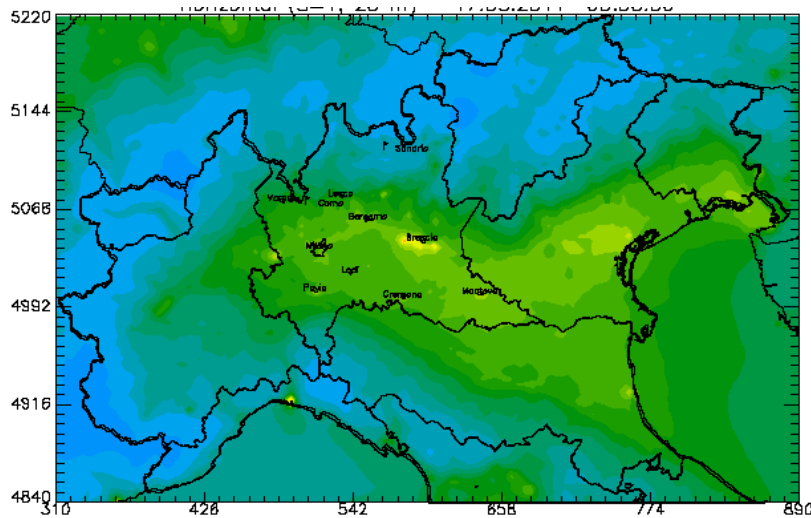


■ measured ■ computed

Results: PM₂₅ averages

17/3/2011-19/4/2011
 PM₂₅: Min=3.1 – Max=22.6 µg/m³

17/3/2011-19/4/2011
 PM₂₅: Min=2.7 – Max=24.3 µg/m³

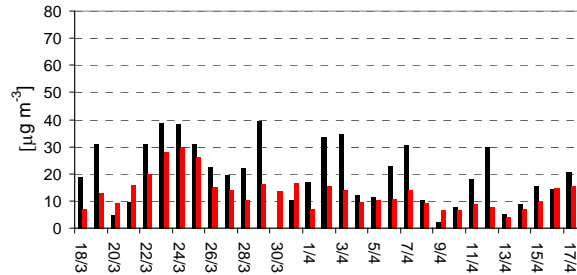


Name	District	Classification
Saronno - via Santuario	VA	Urban Background (FU)
Seriate	BG	Urban Background (FU)
Lecco - Via Sora	LC	Urban Background (FU)
Milano - Pascal Città Studi	MI	Urban Background (FU)
Darfo (aria)	BS	Suburban Background (FS)
Cornale (Voghera Energia)	PV	Rural Background (FR)
Ponti sul Mincio	MN	Suburban Background (FS)
Spinadesco	CR	Rural Background (FR)

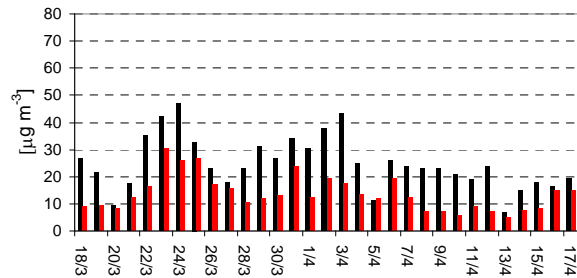
PM₂₅ (spring)

■ measured ■ computed

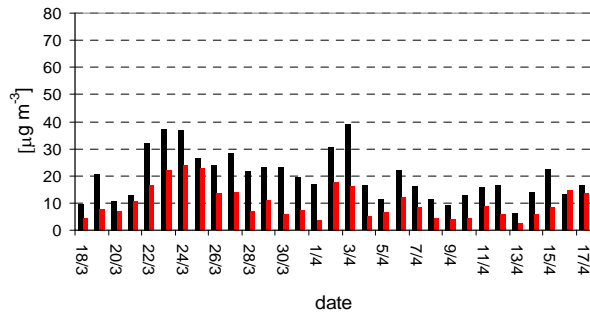
Station: 554 (VA) - Type: FU



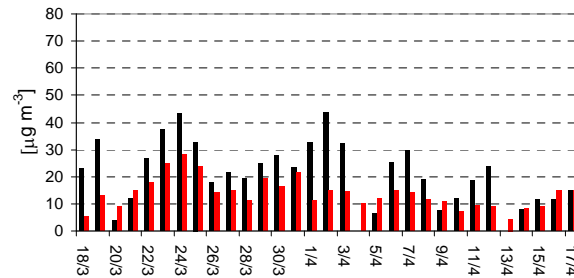
Station: 591 (BG) - Type: FU



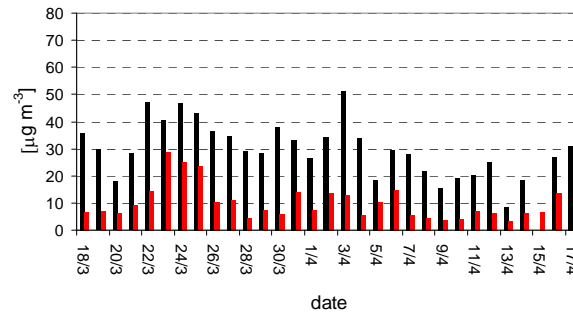
Station: 706 (LC) - Type: FU



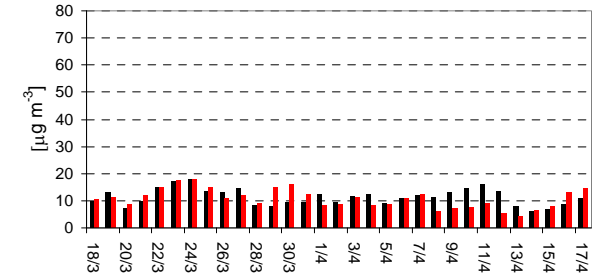
Station: 705 (MI) - Type: FU



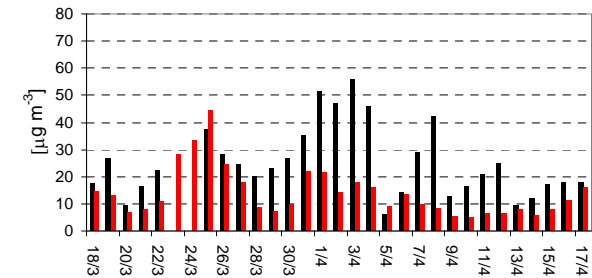
Station: 655 (BS) - Type: FS



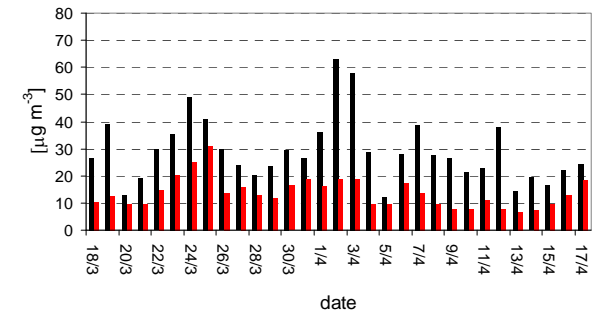
Station: 672 (PV) - Type: FR



Station: 695 (MN) - Type: FS



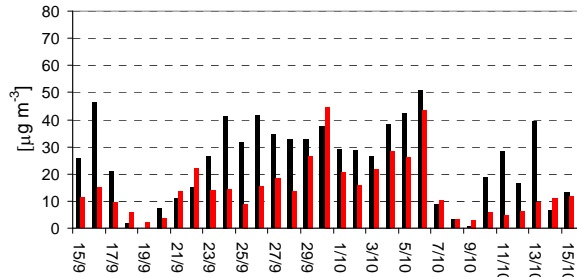
Station: 1297 (CR) - Type: FR



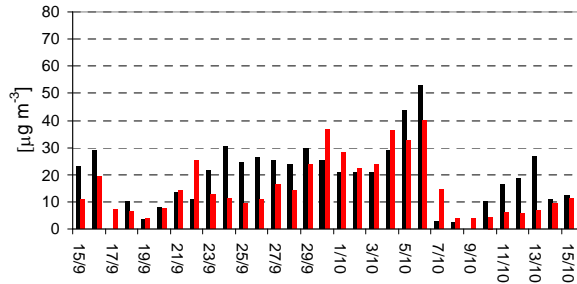
PM₂₅ (fall)

■ measured ■ computed

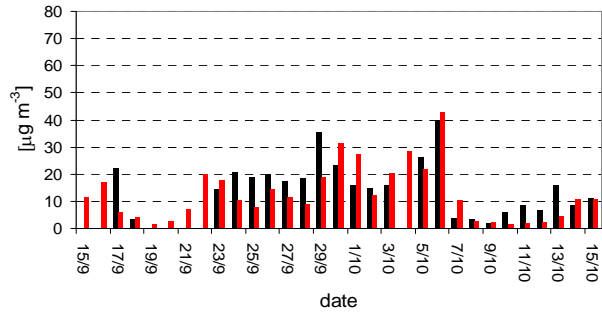
Station: 554 (VA) - Type: FU



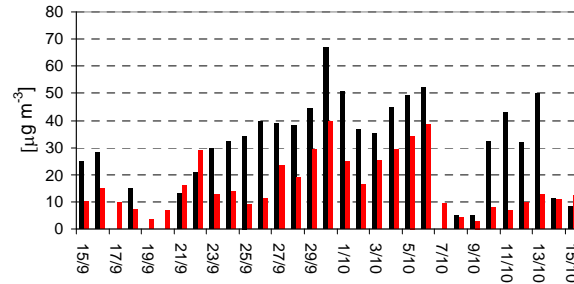
Station: 591 (BG) - Type: FU



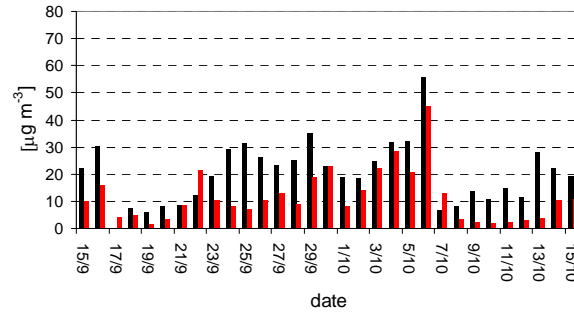
Station: 706 (LC) - Type: FU



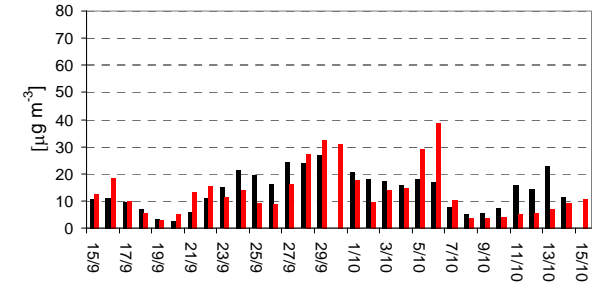
Station: 705 (MI) - Type: FU



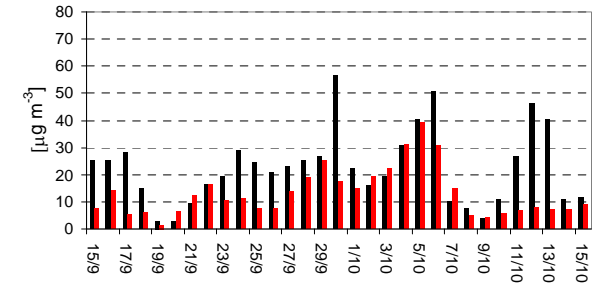
Station: 655 (BS) - Type: FS



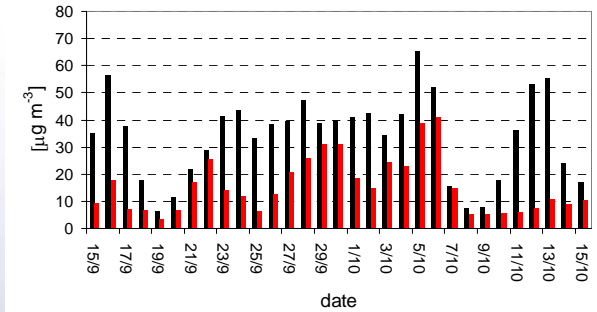
Station: 672 (PV) - Type: FR



Station: 695 (MN) - Type: FS



Station: 1297 (CR) - Type: FR



Not devised to represent actual reductions on emissions connected to real adoptable interventions.

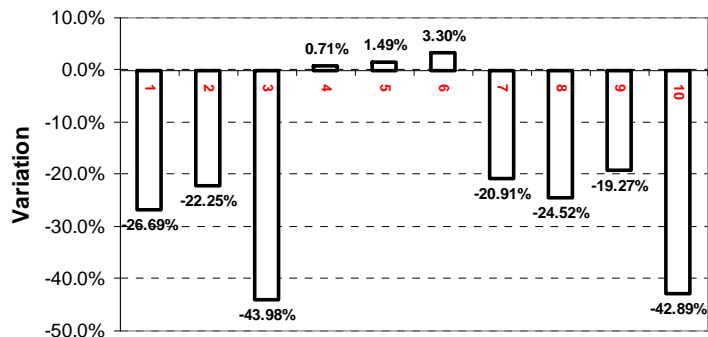
N. Emissions reductions

1. -25% NH₃ on all the simulation domain (the Po valley);
2. -25% NH₃ on Lombardy alone;
3. -50% NH₃ on Lombardy alone;
4. -12.5% NO_x on Lombardy alone;
5. -25% NO_x on Lombardy alone;
6. -50% NO_x on Lombardy alone;
7. -25% NH₃ and NO_x on Lombardy alone;
8. -25% NH₃ e NO_x on all the simulation domain;
9. -25% NH₃ e -50% NO_x on Lombardy alone;
10. -50% NH₃ e -25% NO_x on Lombardy alone.

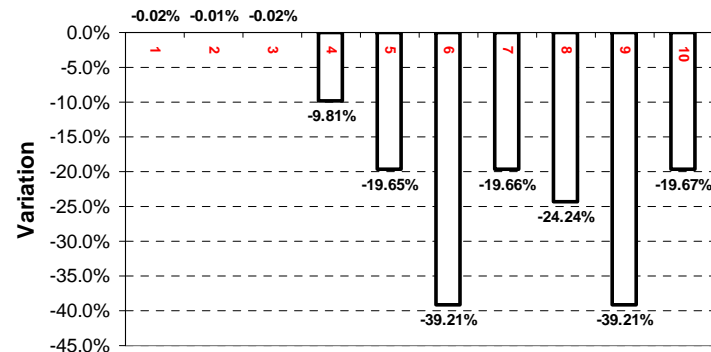
Simulated periods (measured data windows – year 2011):

- 17/03 – 19/04
- 14/09 – 19/10

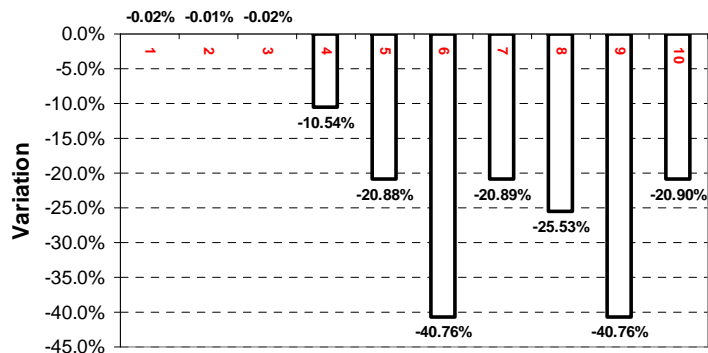
NH3 (17/3 - 19/4/2011)



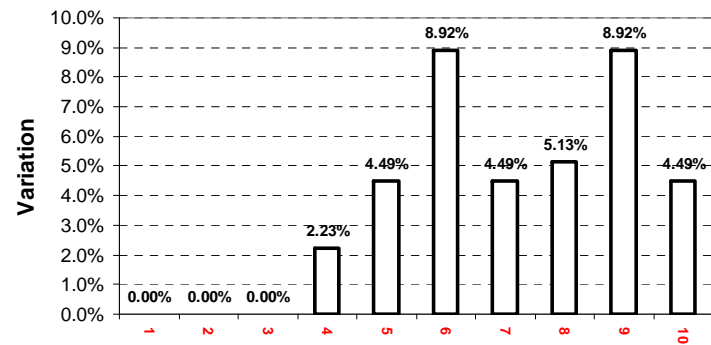
NO2 (17/3 - 19/4/2011)



NOx (17/3 - 19/4/2011)

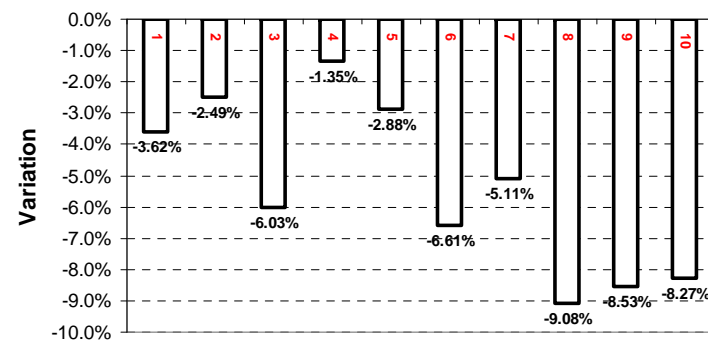


O3 (17/3 - 19/4/2011)

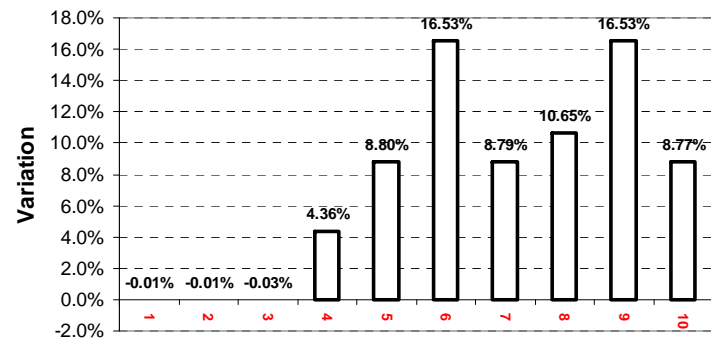


Spring:
% variation with respect to the base case; averages on space and time on AQ stations considered

PM25 (17/3 - 19/4/2011)



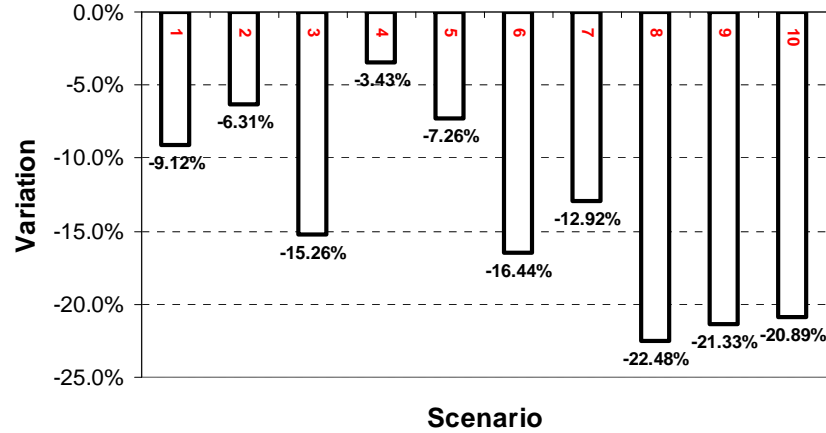
OH (17/3 - 19/4/2011)



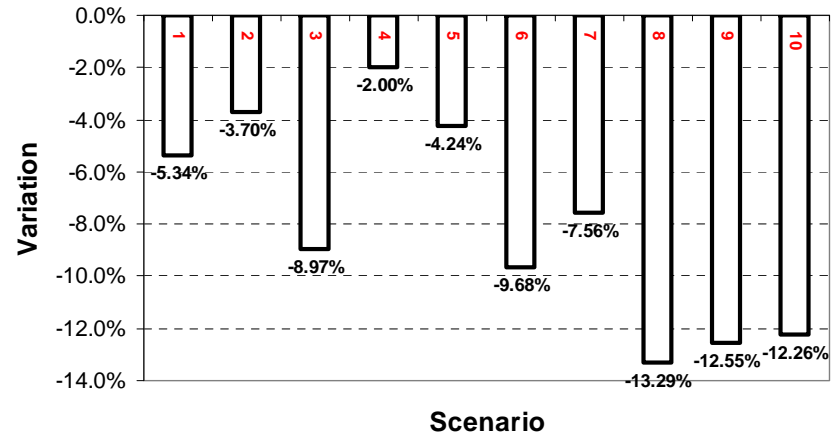
Scenario

Scenario

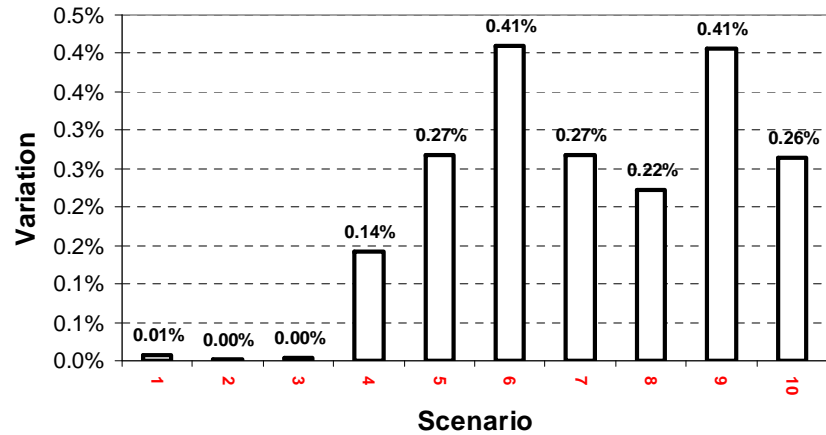
NO3 (17/3 - 19/4/2011)



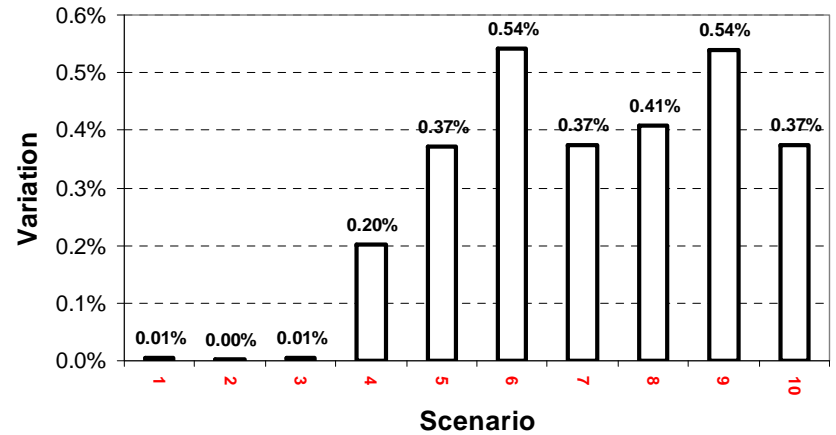
NH4 (17/3 - 19/4/2011)



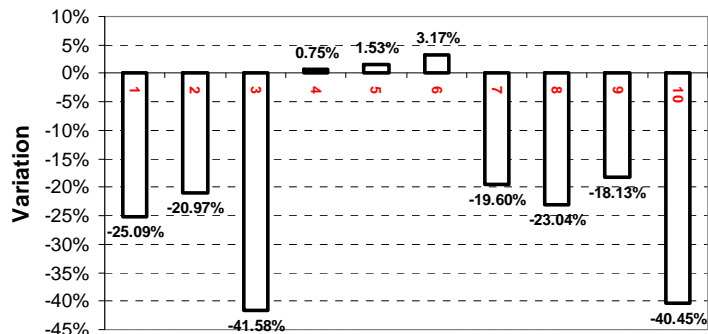
SO4 (17/3 - 19/4/2011)



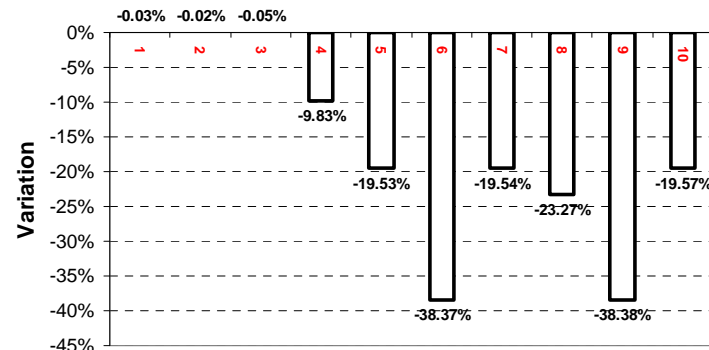
ORG (17/3 - 19/4/2011)



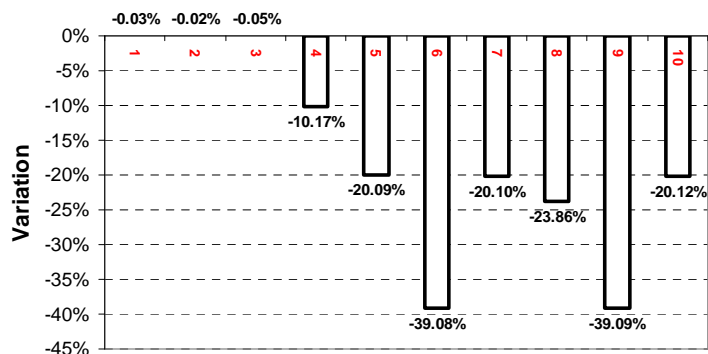
NH3 (14/9 - 16/10/2011)



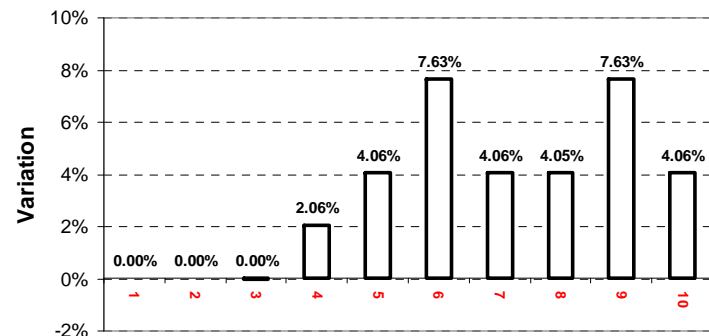
NO2 (14/9 - 16/10/2011)



NOx (14/9 - 16/10/2011)

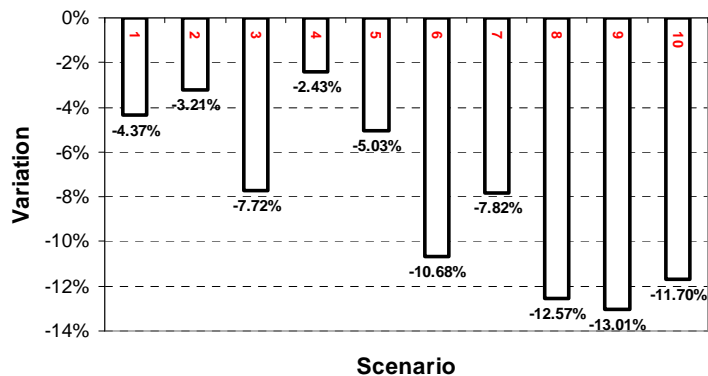


O3 (14/9 - 16/10/2011)

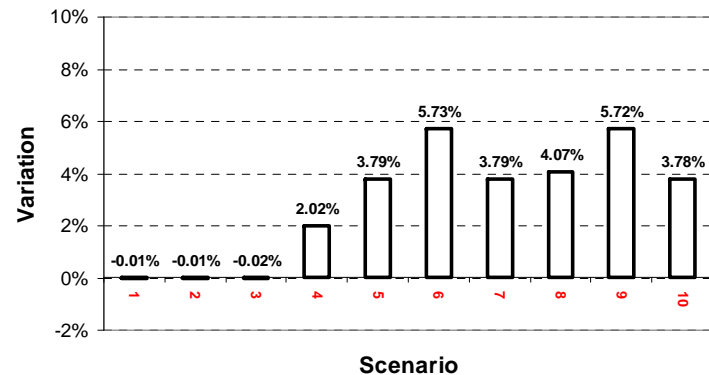


Fall:
% variation with respect to the base case; averages on space and time on AQ stations considered

PM25 (14/9 - 16/10/2011)

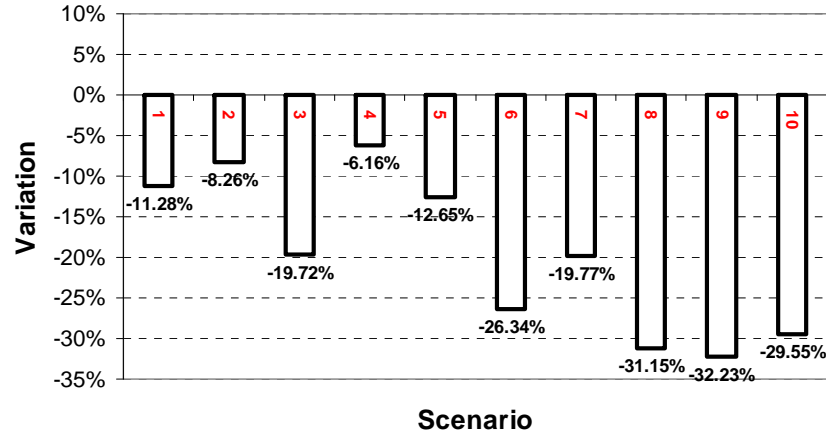


OH (14/9 - 16/10/2011)

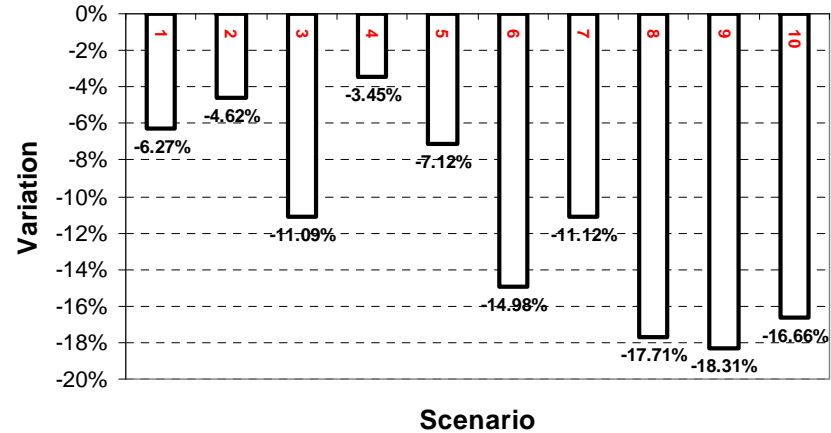


% variation with respect to the base case; averages on space and time on AQ stations considered

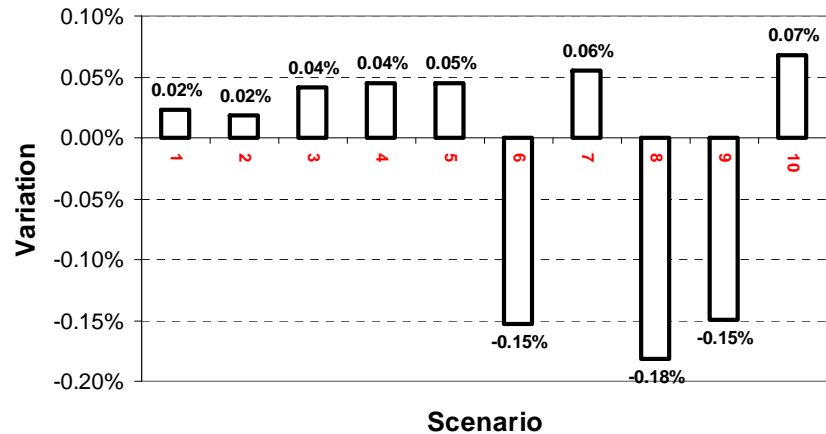
NO3 (14/9 - 16/10/2011)



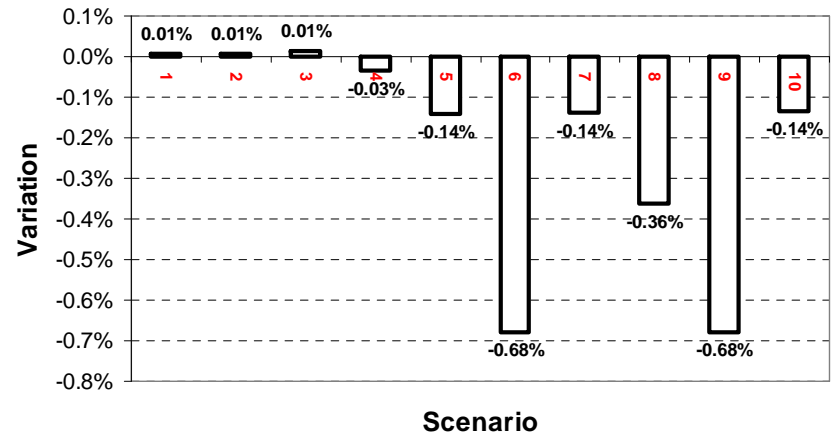
NH4 (14/9 - 16/10/2011)

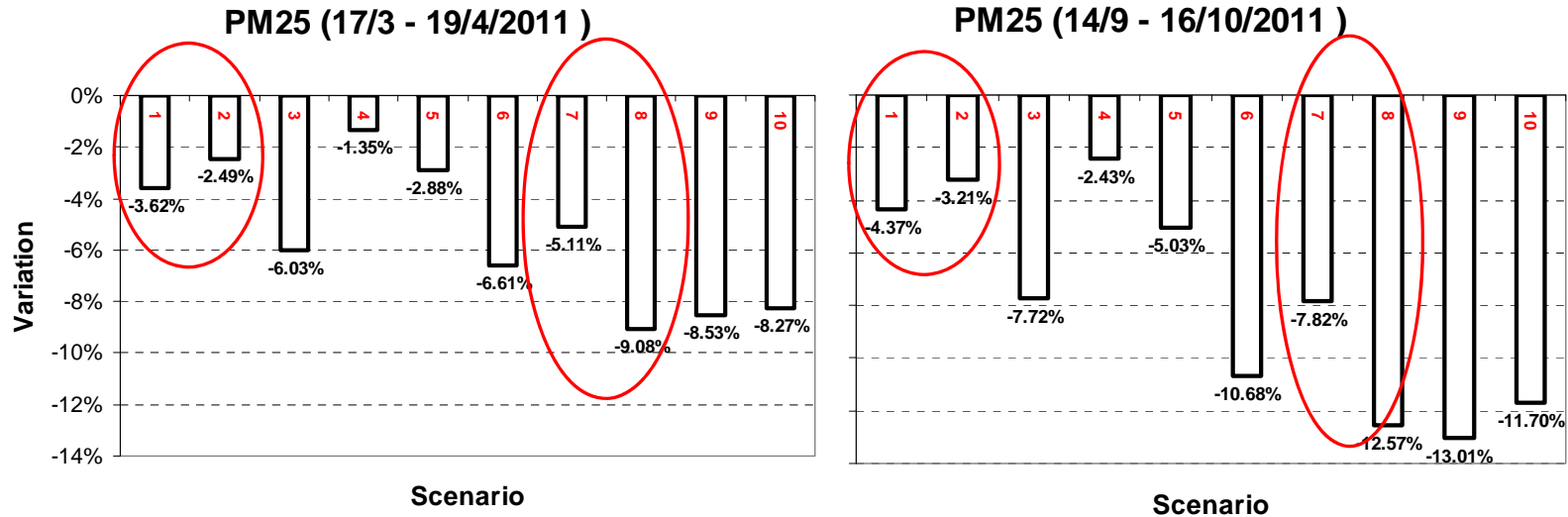


SO4 (14/9 - 16/10/2011)



ORG (14/9 - 16/10/2011)





Reductions over the entire Po Valley are more effective than their counterparts over Lombardy alone

Preliminary results: PM_{2.5} average reductions

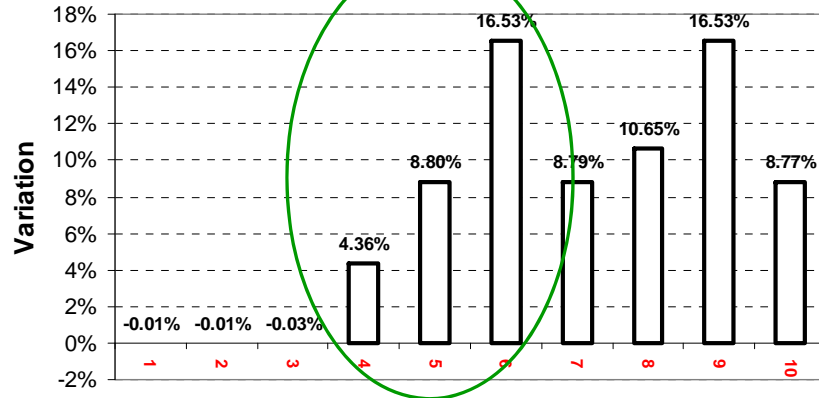
Emissions reduction	Pollutant	PM _{2.5}	
		Spring	Autumn
-25%	NH ₃	-2.49 %	-3.24 %
	NO _x	-2.88 %	-5.03 %
-50%	NH ₃	-6.03 %	-7.72 %
	NO _x	-6.61 %	-10.68 %
-25% NH ₃ , -25% NO _x		-5.11 %	-7.82 %
-25% NH ₃ , -50% NO _x		-8.53 %	-12.57 %
-50% NH ₃ , -25% NO _x		-8.27 %	-11.70 %

Reducing NH₃ appears as effective as reducing NO_x

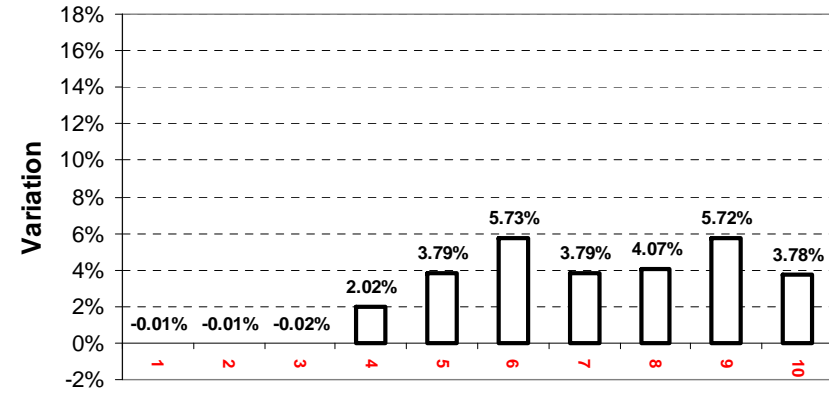
Reducing both precursors at the same time is as effective as the maximum reduction gained by reducing one at times

Less effective impact during spring. NO_x emissions reduction free hydroxyl that reacts with SO₂ and condensable VOC

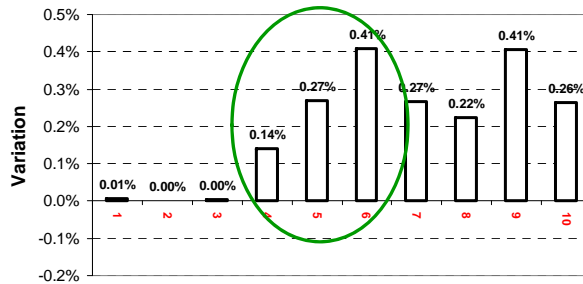
OH (17/3 - 19/4/2011)



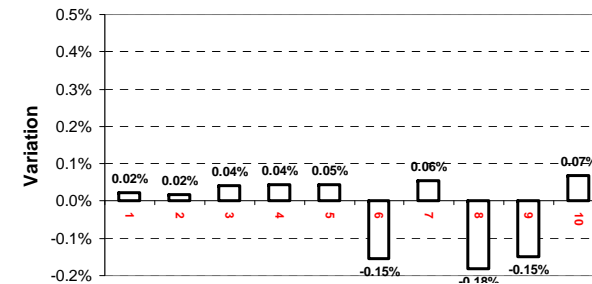
OH (14/9 - 16/10/2011)



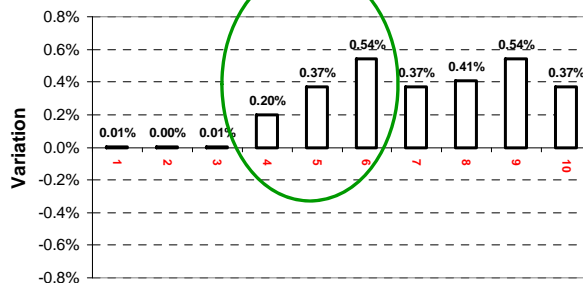
SO4 (17/3 - 19/4/2011)



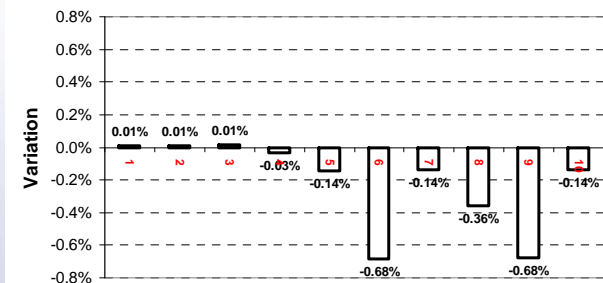
SO4 (14/9 - 16/10/2011)



ORG (17/3 - 19/4/2011)



ORG (14/9 - 16/10/2011)



Preliminary results: PM₂₅ reductions and precursors emissions

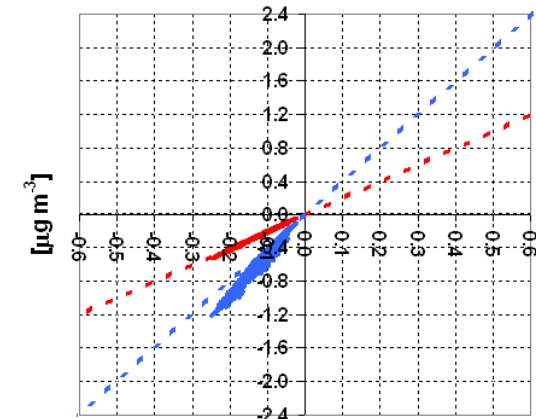
Scenarios 4, 5 and 6 show that decreasing emissions of NO_x lead to near linear results on PM₂₅ concentrations if the amount of the reduction is between 12.5% and 25%

For greater reductions, between 20% and 50%, PM₂₅ concentrations decreases with a more than proportional relation.

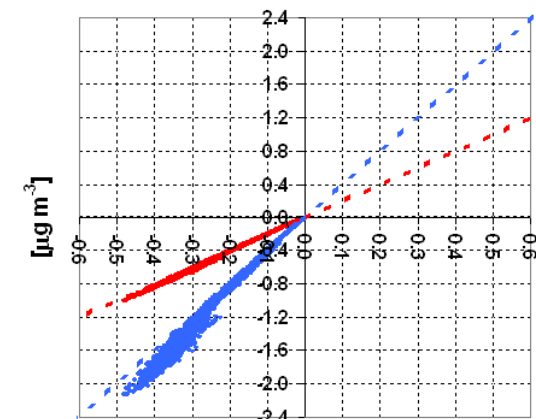
More or less the same holds true for ammonia emissions reductions (scenarios 2 and 3)



PM25 (17/3 - 19/4/2011)



PM25 (14/9 - 16/10/2011)

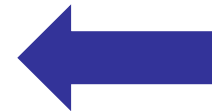


-12.5 % NOx [µg m⁻³]

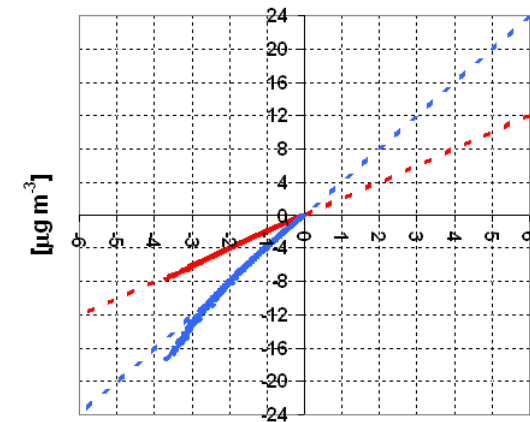
• -25 % NOx • y=-2x • -50 % NOx • y=-4x

But ozone increases...

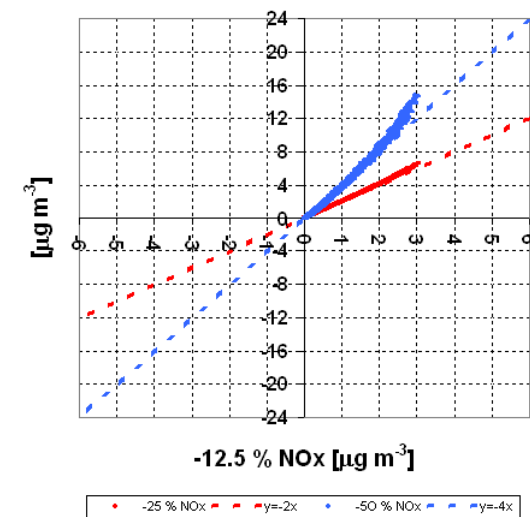
The same non-linearity at higher NO_x reductions conversely affects ozone level



NO_2 (17/3 - 19/4/2011)



O_3 (17/3 - 19/4/2011)



Preliminary conclusions

- Reductions on PM_{2.5}: as far as this results imply, we are in the limit area, where both precursors show similar impact on secondary PM₂₅;
- Linearity up to a certain amount of reduction of precursors emissions (around 20%); greater impact with higher %;
- reduction of NO_x slightly more effective, but with a seasonal pattern (more effective in autumn than in spring);
- One should also account that ammonia concentrations are strongly underestimate in the proximity of cattle and pig breeding areas;
- Expected a fairly limited growth of Sulphates and Organic fraction due to an increase of available hydroxyl, but unexpected that this growth occurs only in spring;
- Clear (and expected) growth of ozone when NO_x are reduced.

Need of further investigations (all year long, with more measured data)

Thanks for your attention!

Slides eventuali



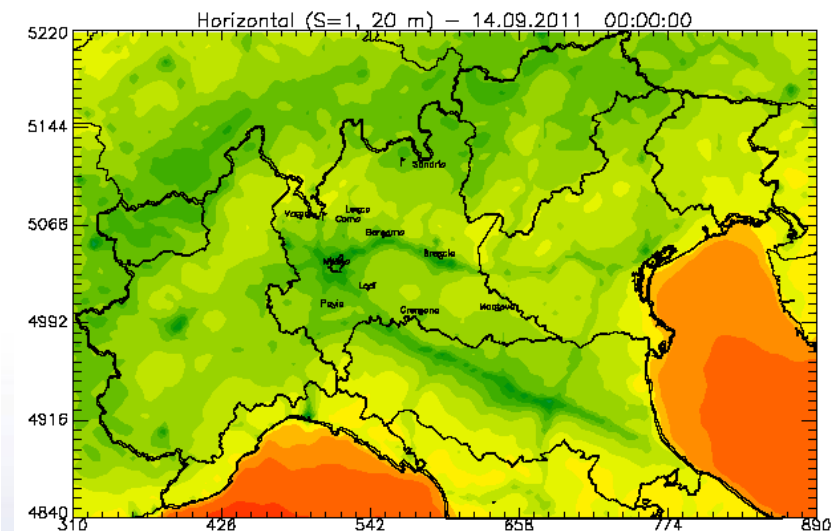
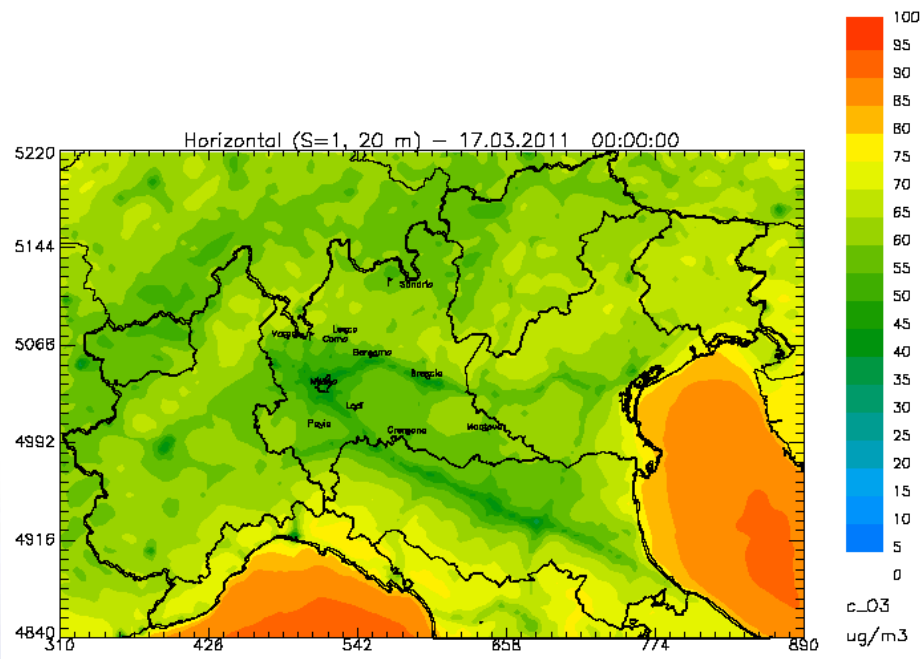
Results: O₃ averages

17/3/2011-19/4/2011

Min = 30.51 - Max = 92.12 [ug/m³]

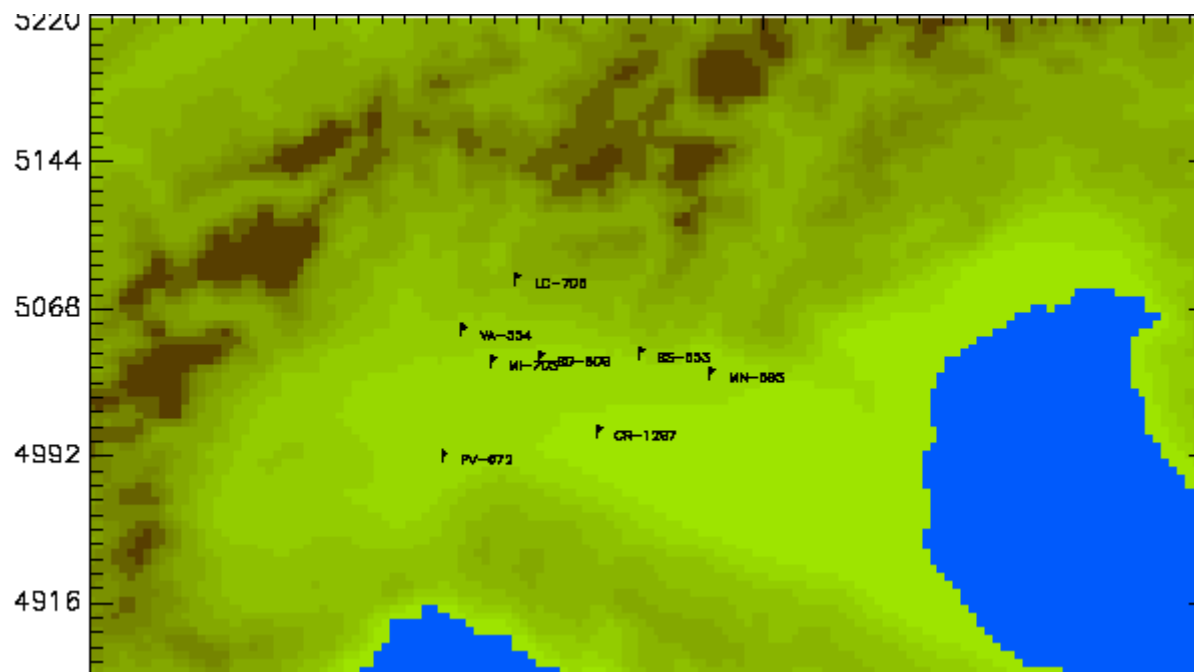
14/9/2011-16/10/2011

Min = 34.03 - Max = 97 [ug/m³]



Stazioni di misura

O₃

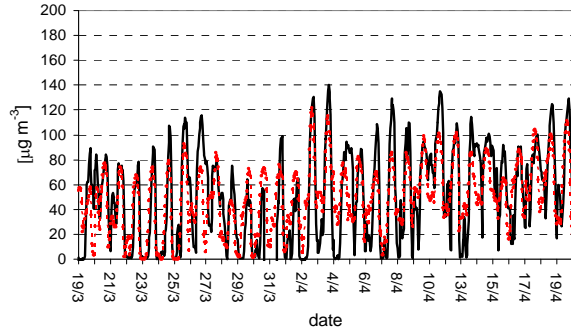


ID	Nome	Provincia	Classificazione
554	Saronno - via Santuario	VA	FU
609	Casirate d'Adda	BG	FR
706	Lecco - Via Sora	LC	FU
705	Milano - Pascal Città Studi	MI	FU
653	Brescia - via Ziziola	BS	FS
672	Cornale (Voghera Energia)	PV	FR
695	Ponti sul Mincio	MN	FS
1297	Spinadesco	CR	FR

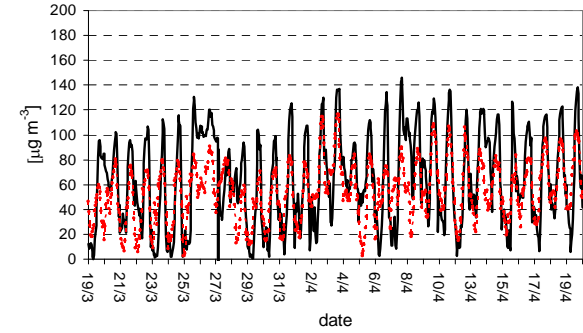
O₃ (19/3-19/4/2011)

■ measured ■ computed

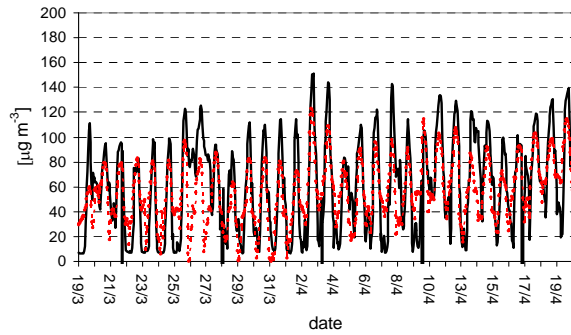
Station: 554 (VA) - Type: FU



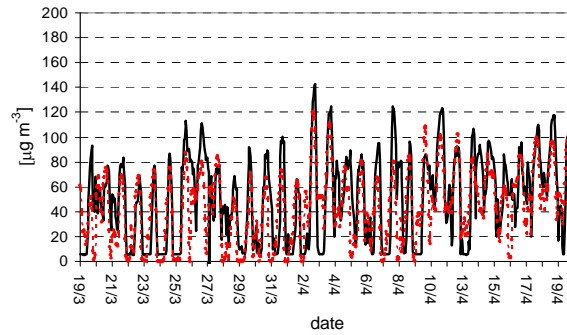
Station: 672 (PV) - Type: FR



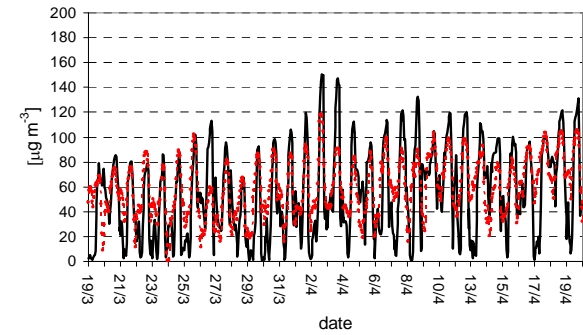
Station: 609 (BG) - Type: FR



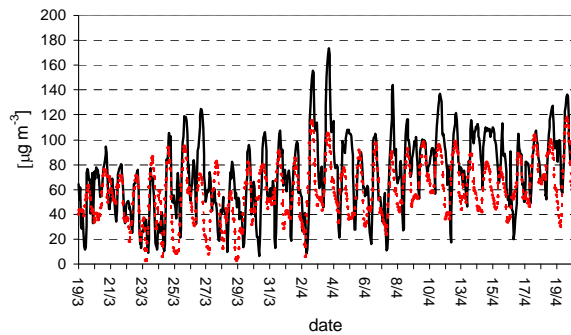
Station: 705 (MI) - Type: FU



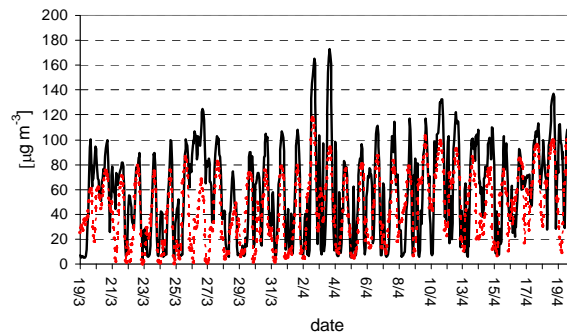
Station: 695 (MN) - Type: FS



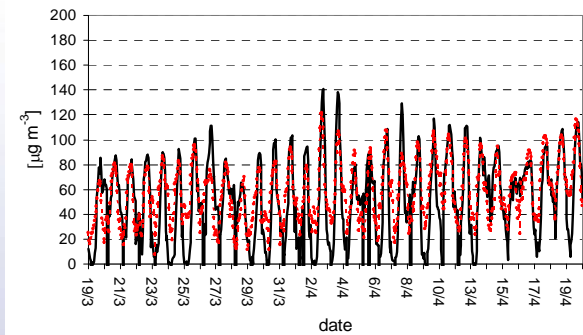
Station: 706 (LC) - Type: FU



Station: 653 (BS) - Type: FS



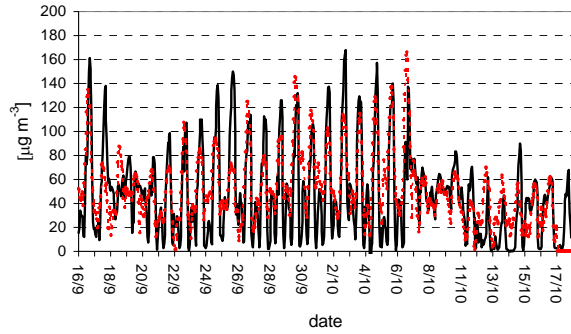
Station: 1297 (CR) - Type: FR



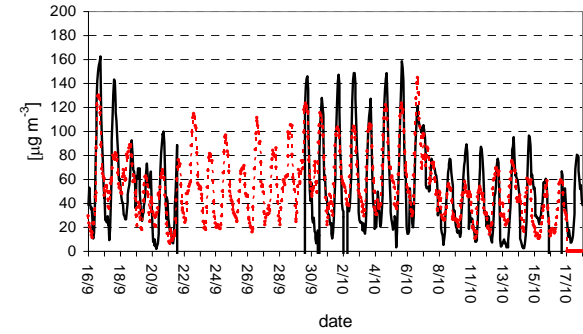
O₃ (16/9-17/10/2011)

■ measured ■ computed

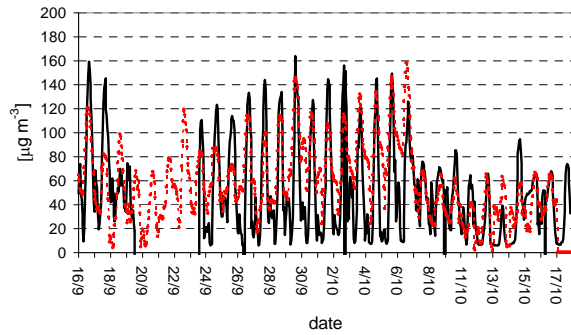
Station: 554 (VA) - Type: FU



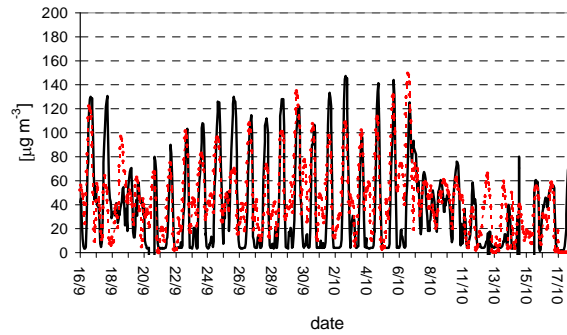
Station: 672 (PV) - Type: FR



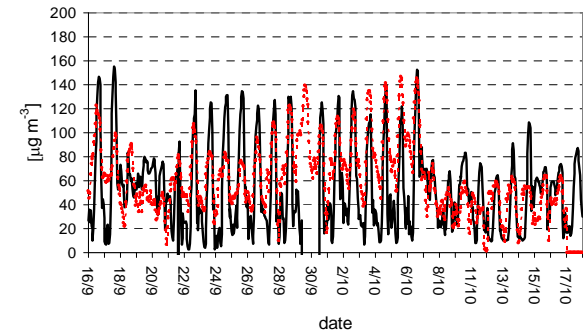
Station: 609 (BG) - Type: FR



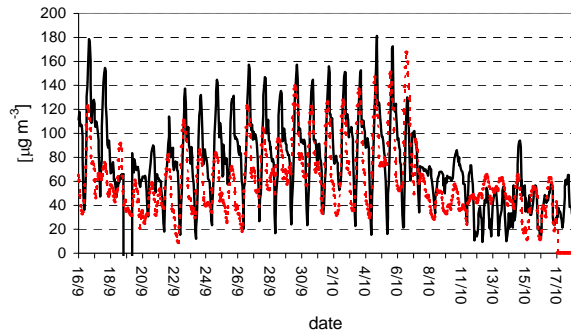
Station: 705 (MI) - Type: FU



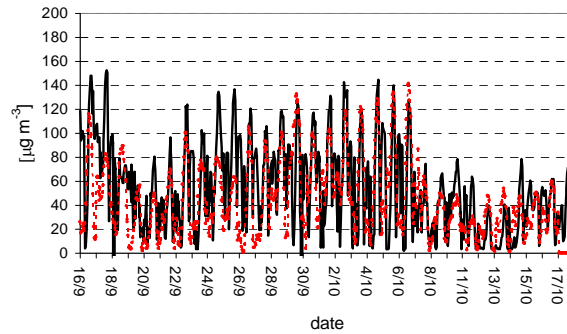
Station: 695 (MN) - Type: FS



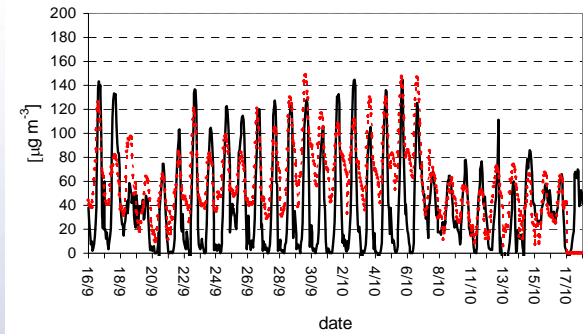
Station: 706 (LC) - Type: FU



Station: 653 (BS) - Type: FS



Station: 1297 (CR) - Type: FR



Simulazione caso base

Concentrazioni espresse in $[\mu\text{g m}^{-3}]$

17/3/2011-19/4/2011

Scenario 0	Min	Avg	Max
NH ₃	0.19	7.78	29.82
PM25	3.64	10.86	21.71
NO _x	1.33	15.21	60.08
NO ₂	0.96	13.34	44.19
O ₃	37.81	58.61	71.77
OH	1.59E-05	3.51E-05	5.36E-05
SO ₄ ⁼	0.69	1.79	6.41
NO ₃ ⁻	1.14	3.50	6.04
NH ₄ ⁺	0.64	1.69	3.84
ORG	0.46	1.86	3.65

14/9/2011-16/10/2011

Scenario 0	Min	Avg	Max
NH ₃	0.48	10.00	41.20
PM25	2.86	11.73	22.16
NO _x	1.12	14.44	60.79
NO ₂	0.79	13.01	46.31
O ₃	39.07	61.65	73.79
OH	1.27E-05	2.58E-05	3.85E-05
SO ₄ ⁼	0.63	2.10	6.56
NO ₃ ⁻	0.57	3.82	5.79
NH ₄ ⁺	0.40	1.89	4.02
ORG	0.78	2.16	3.44

Scenari "solo Lombardia"



4. -12.5% riduzione NO_x sulla sola Lombardia;
5. -25% riduzione NO_x sulla sola Lombardia;
6. -50% riduzione NO_x sulla sola Lombardia.

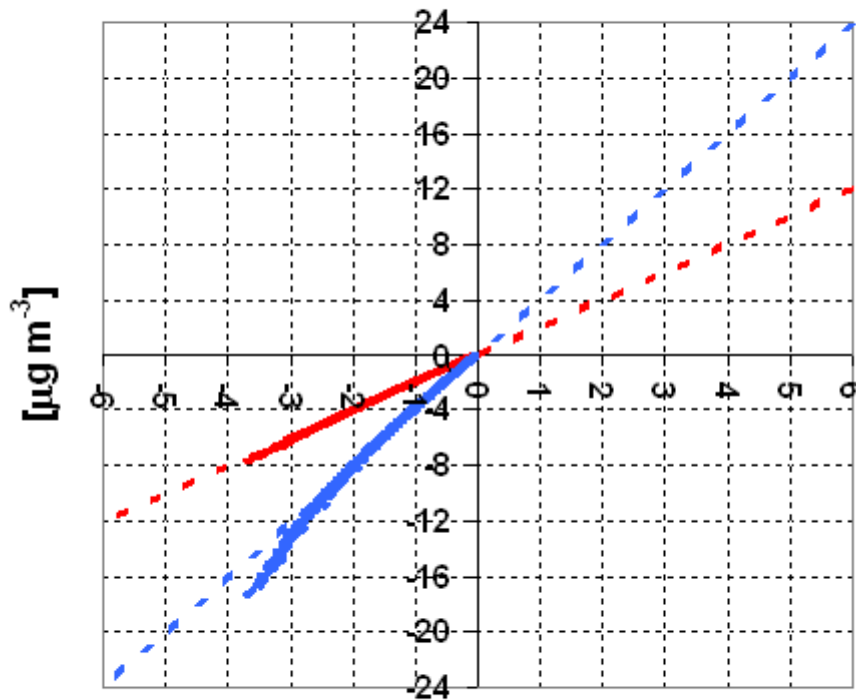
Periodi di Simulazione:

- - dal 17 marzo al 19 aprile 2011;
- - dal 14 settembre al 16 ottobre 2011.

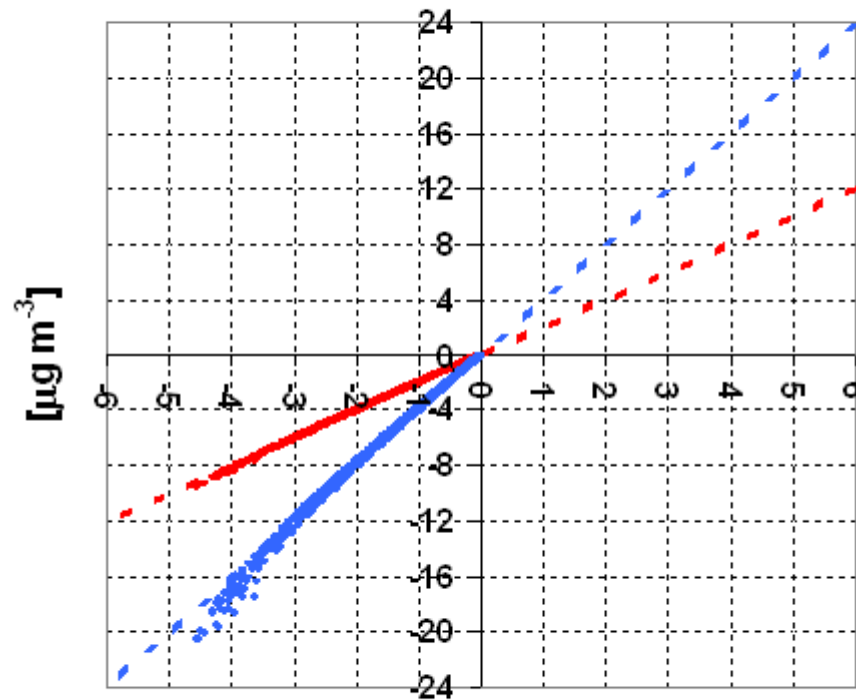
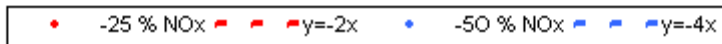
Variazioni assolute rispetto al Caso base

NO2 (17/3 - 19/4/2011)

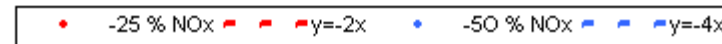
NO2 (14/9 - 16/10/2011)



-12.5 % NOx $[\mu\text{g m}^{-3}]$



-12.5 % NOx $[\mu\text{g m}^{-3}]$





Min = -3.676 - Max = 0.001235 [ug/m3]

NO₂

Min = -7.732 - Max = 0.0003083 [ug/m3]

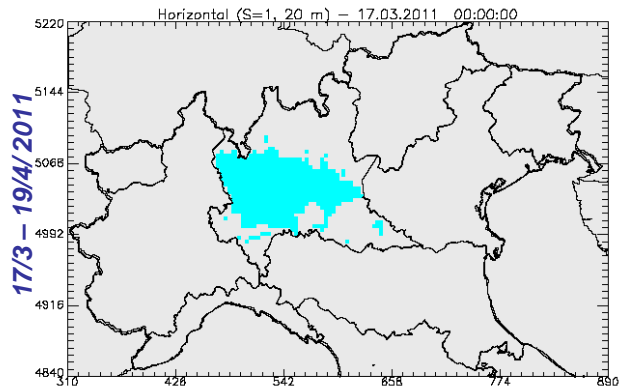


Min = -17.4 - Max = 0.0007551 [ug/m3]

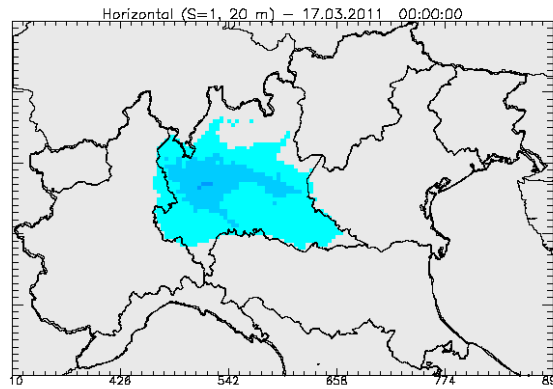
Scenario 4 - Scenario 0

Scenario 5 - Scenario 0

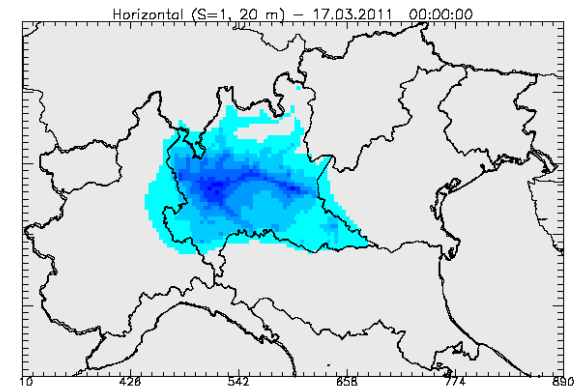
Scenario 6 - Scenario 0



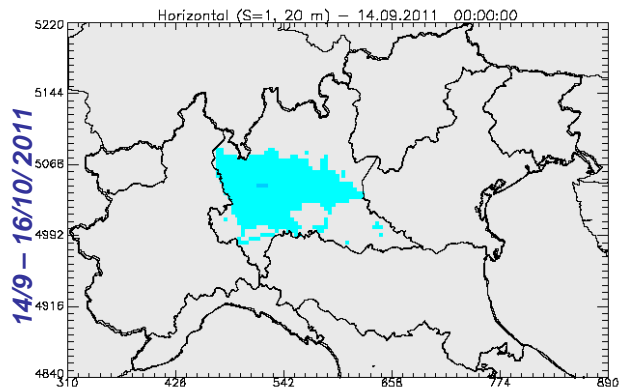
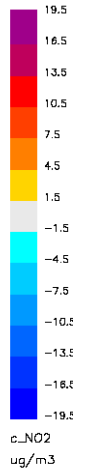
Min = -4.567 - Max = 0.005469 [ug/m3]



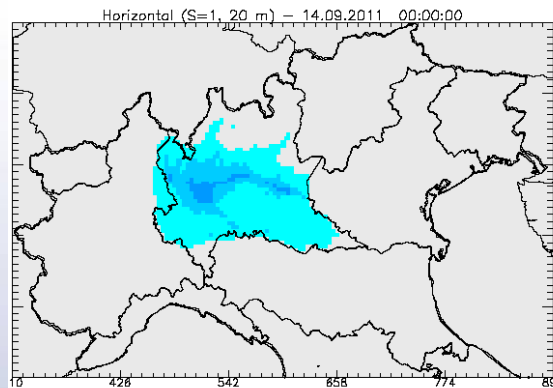
Min = -9.545 - Max = 0.01062 [ug/m3]



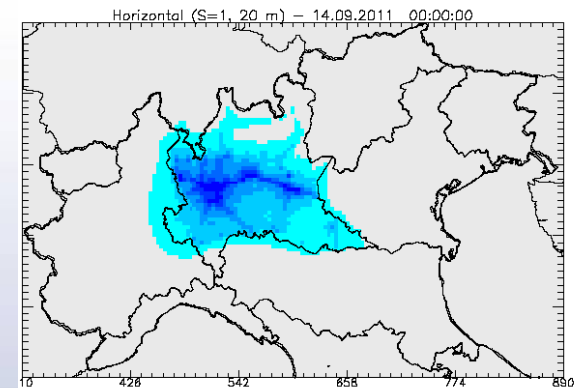
Min = -20.59 - Max = 0.01619 [ug/m3]



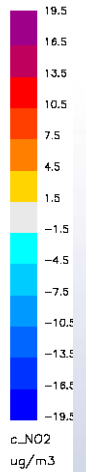
Min = -4.567 - Max = 0.005469 [ug/m3]



Min = -9.545 - Max = 0.01062 [ug/m3]

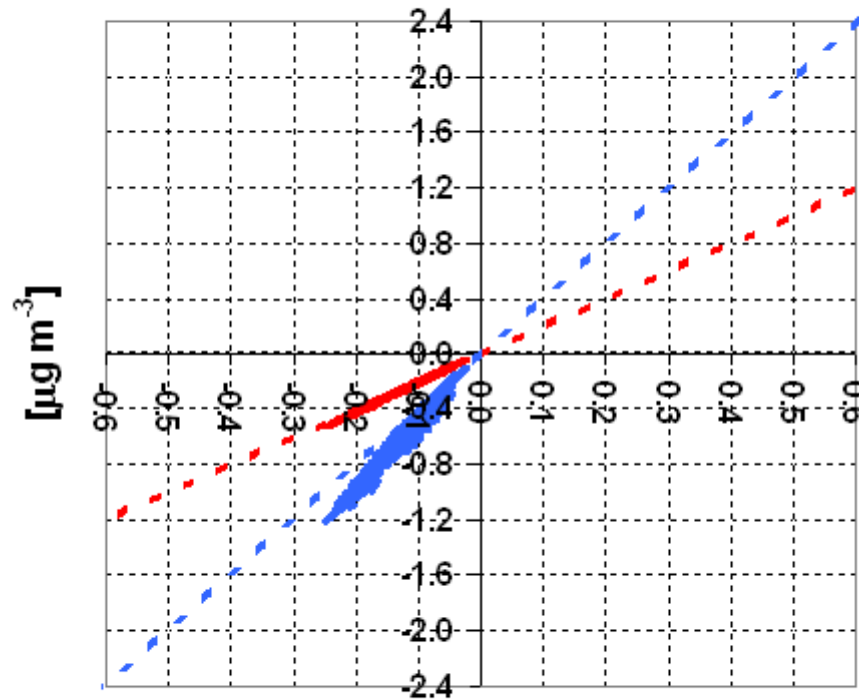


Min = -20.59 - Max = 0.01619 [ug/m3]

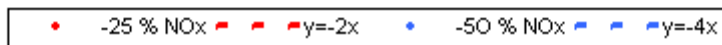


Variazioni assolute rispetto al Caso base

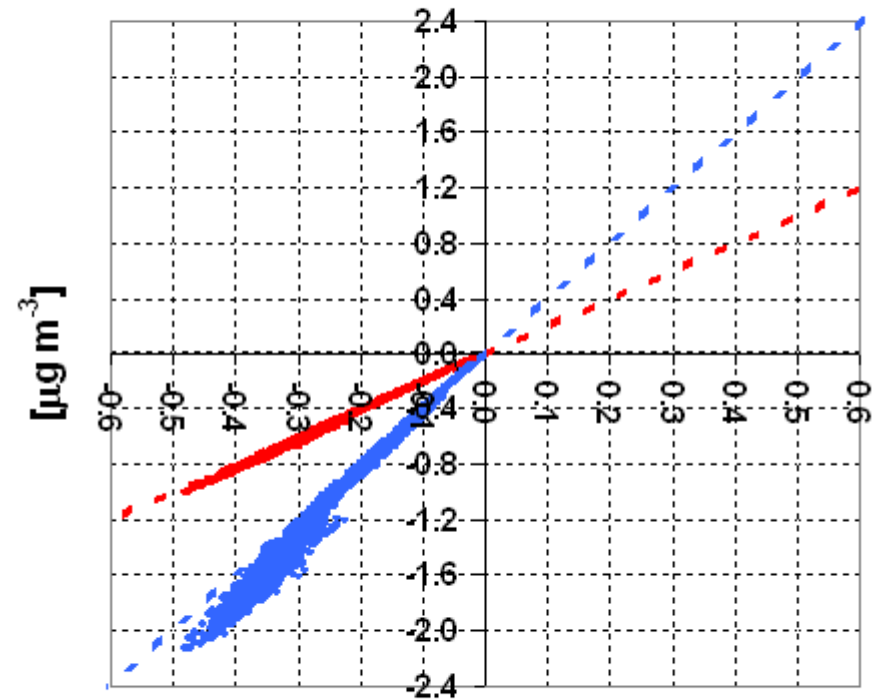
PM25 (17/3 - 19/4/2011)



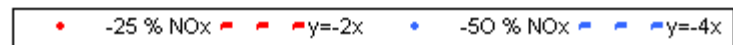
-12.5 % NOx [$\mu\text{g m}^{-3}$]



PM25 (14/9 - 16/10/2011)



-12.5 % NOx [$\mu\text{g m}^{-3}$]





Min = -0.2488 - Max = 0.0001051 [ug/m3]

PM_{2.5}

Min = -0.5324 - Max = -9.70300e-005 [ug/m3]

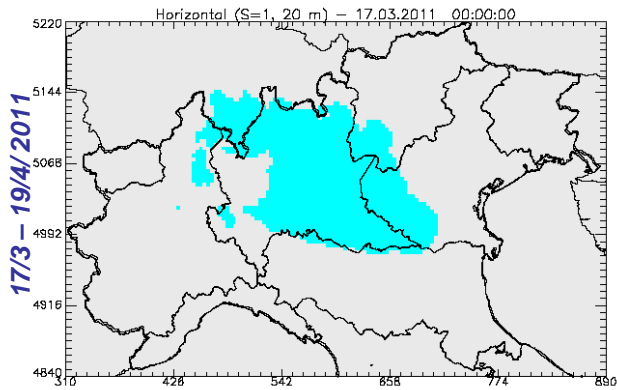


Min = -1.214 - Max = -0.0002781 [ug/m3]

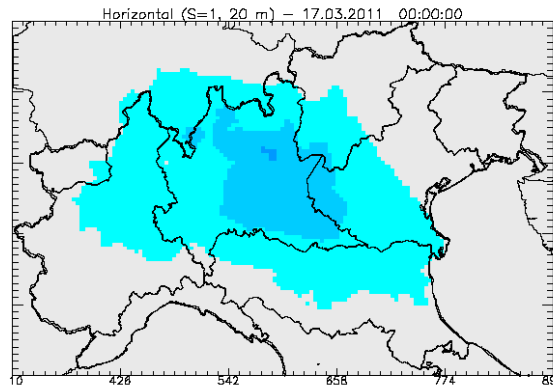
Scenario 4 - Scenario 0

Scenario 5 - Scenario 0

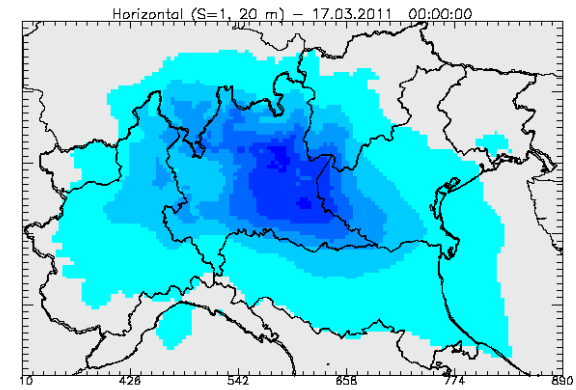
Scenario 6 - Scenario 0



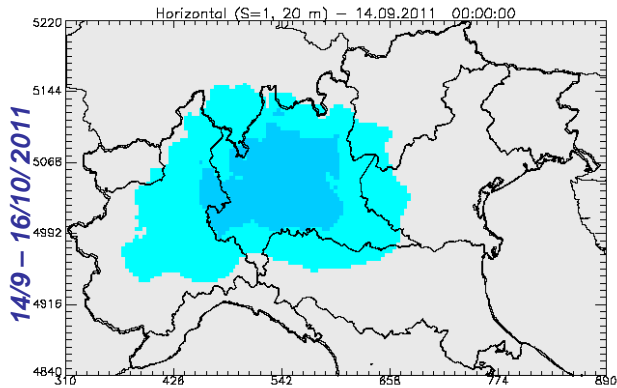
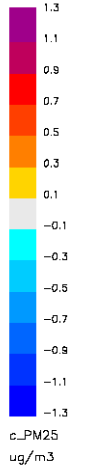
Min = -0.4804 - Max = 0.0003092 [ug/m3]



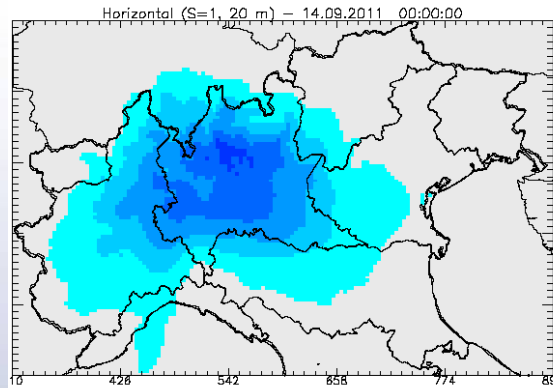
Min = -0.9993 - Max = -3.57100e-005 [ug/m3]



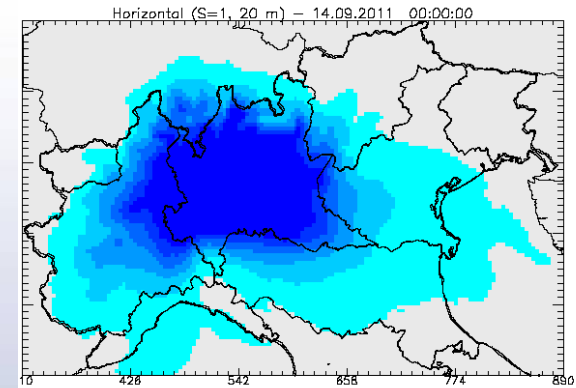
Min = -2.132 - Max = -0.0001185 [ug/m3]



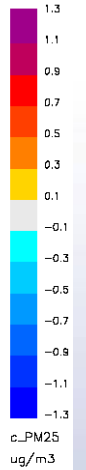
Min = -0.4804 - Max = 0.0003092 [ug/m3]



Min = -0.9993 - Max = -3.57100e-005 [ug/m3]

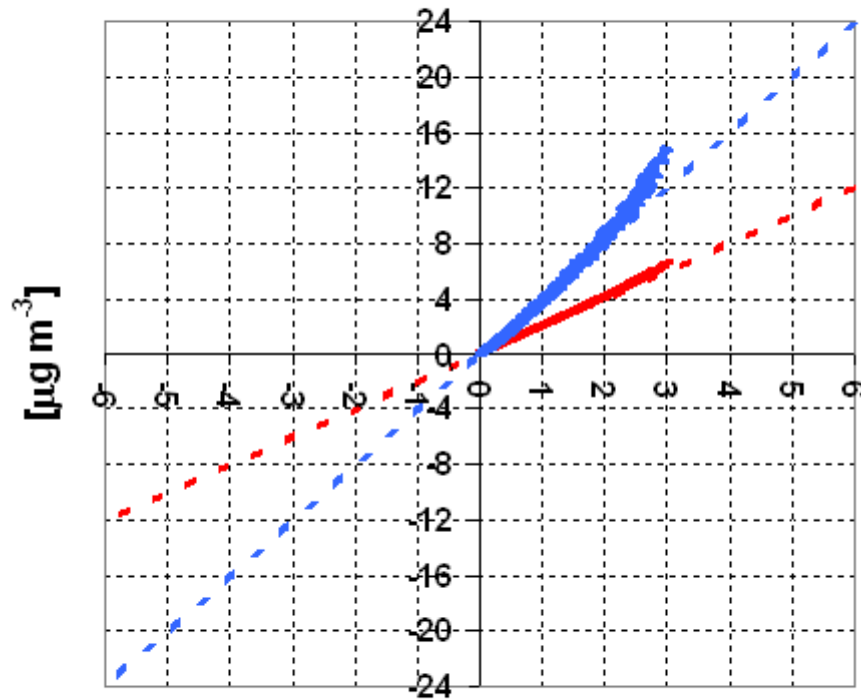


Min = -2.132 - Max = -0.0001185 [ug/m3]

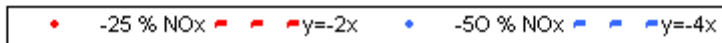


Variazioni assolute rispetto al Caso base

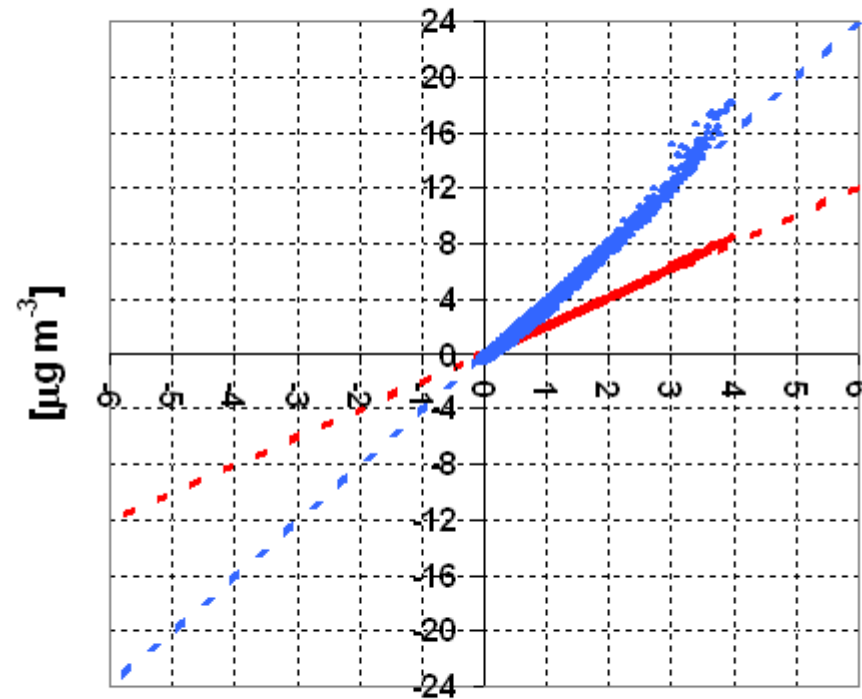
O3 (17/3 - 19/4/2011)



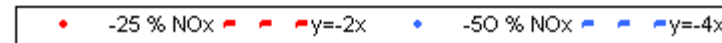
-12.5 % NOx [$\mu\text{g m}^{-3}$]



O3 (14/9 - 16/10/2011)



-12.5 % NOx [$\mu\text{g m}^{-3}$]





Min = -0.02238 - Max = 3.057 [ug/m3]



Min = -0.05279 - Max = 6.524 [ug/m3]

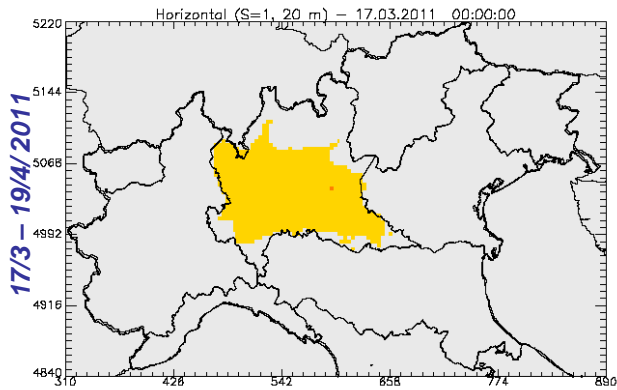


Min = -0.151 - Max = 14.73 [ug/m3]

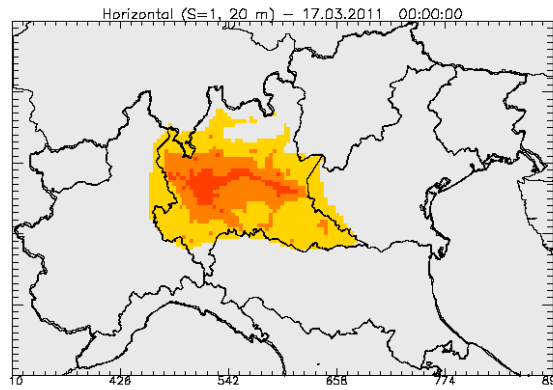
Scenario 4 - Scenario 0

Scenario 5 - Scenario 0

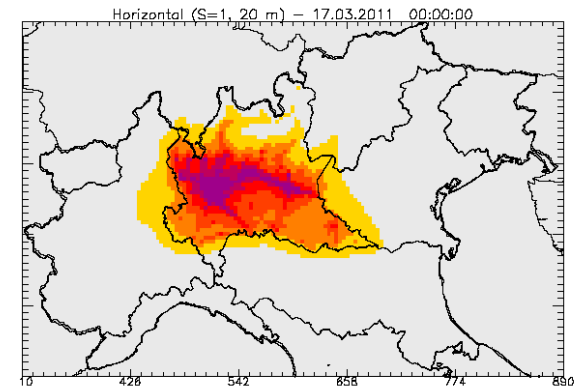
Scenario 6 - Scenario 0



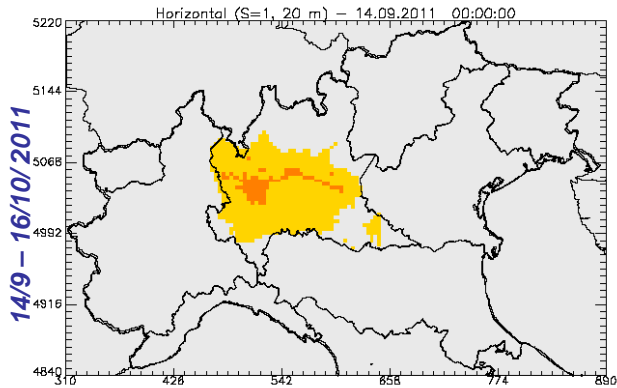
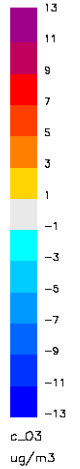
Min = -0.09077 - Max = 3.987 [ug/m3]



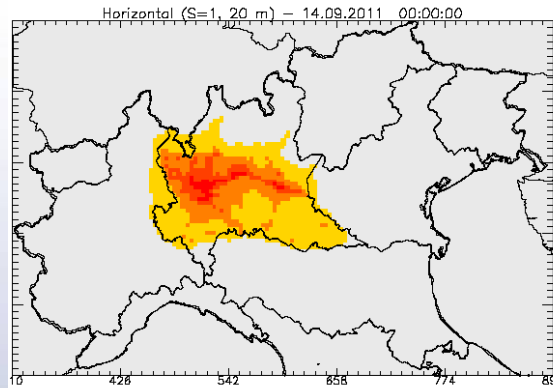
Min = -0.2266 - Max = 6.375 [ug/m3]



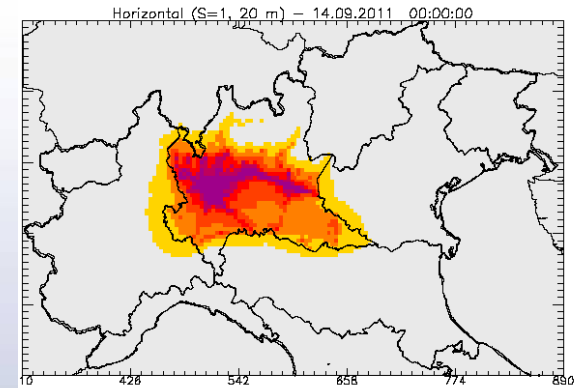
Min = -0.6724 - Max = 18.11 [ug/m3]



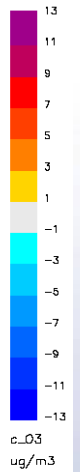
Min = -0.09077 - Max = 3.987 [ug/m3]



Min = -0.2266 - Max = 6.375 [ug/m3]



Min = -0.6724 - Max = 18.11 [ug/m3]



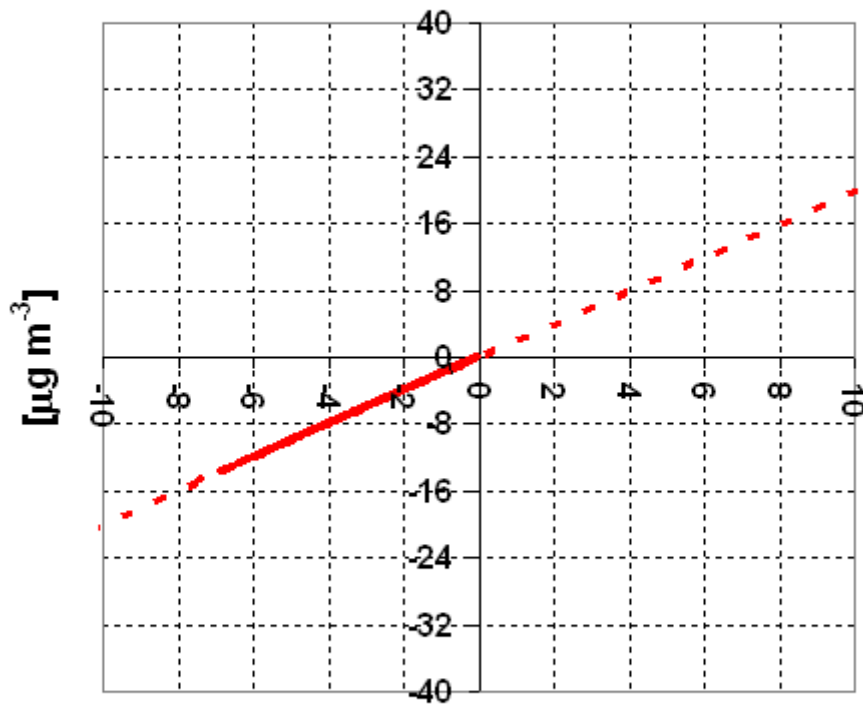
2. -25% riduzione NH_3 sulla sola Lombardia;
3. -50% riduzione NH_3 sulla sola Lombardia.

Periodi di Simulazione:

- - dal 17 marzo al 19 aprile 2011;
- - dal 14 settembre al 16 ottobre 2011.

Variazioni assolute rispetto al Caso base

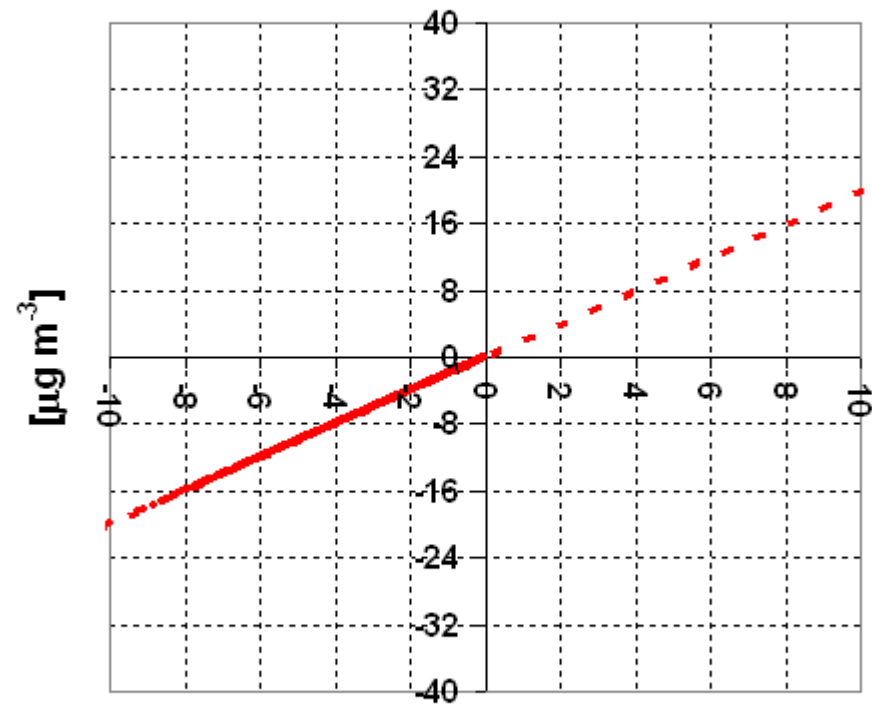
NH3 (17/3 - 19/4/2011)



-25 % NH₃ [µg m⁻³]

• -50 % NH₃ - - y=-2x

NH3 (14/9 - 16/10/2011)



-25 % NH₃ [µg m⁻³]

• -50 % NH₃ - - y=-2x

Min = -7.373 - Max = 2.83600e-005 [ug/m3]

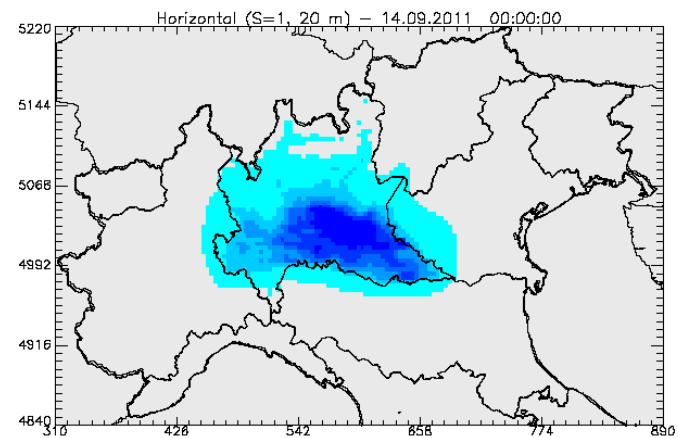
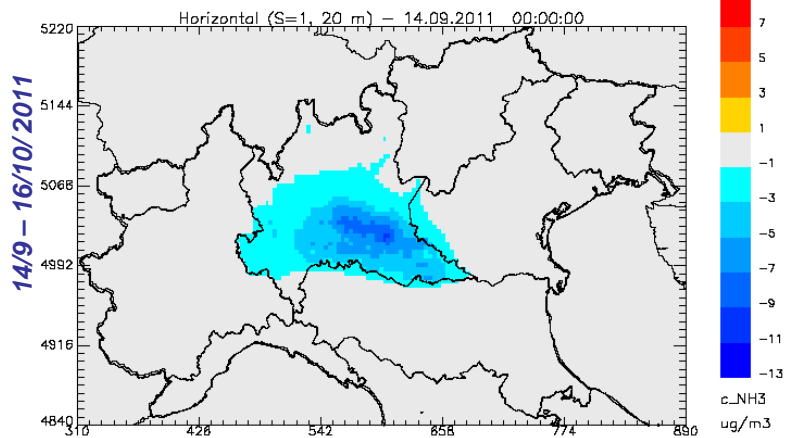
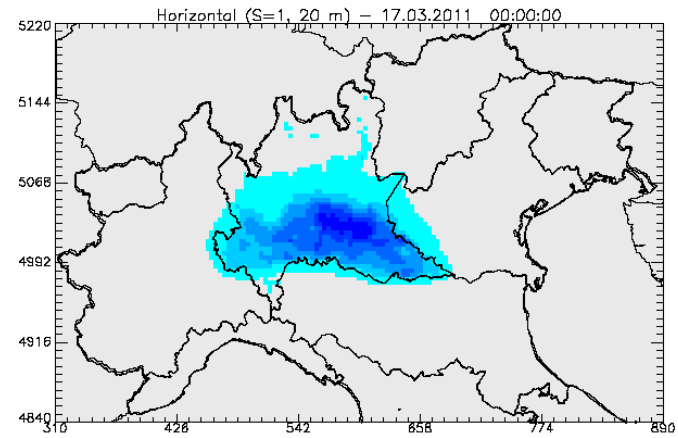
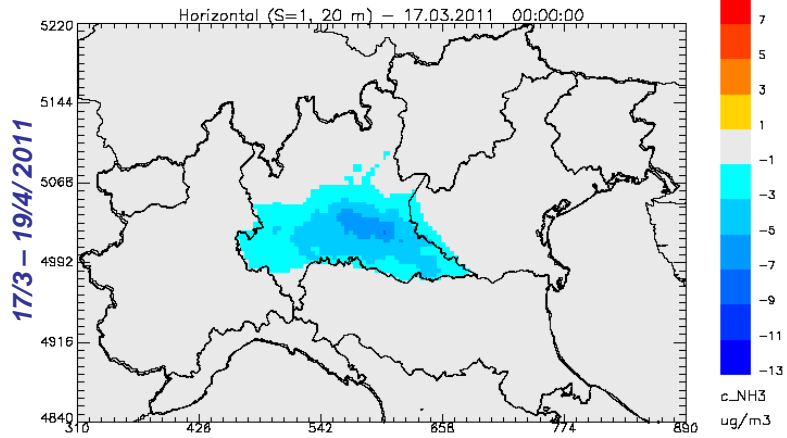
Min = -14.72 - Max = 4.95600e-005 [ug/m3]

NH₃

MBARDIA
dell'Ambiente

Scenario 2 – Scenario 0

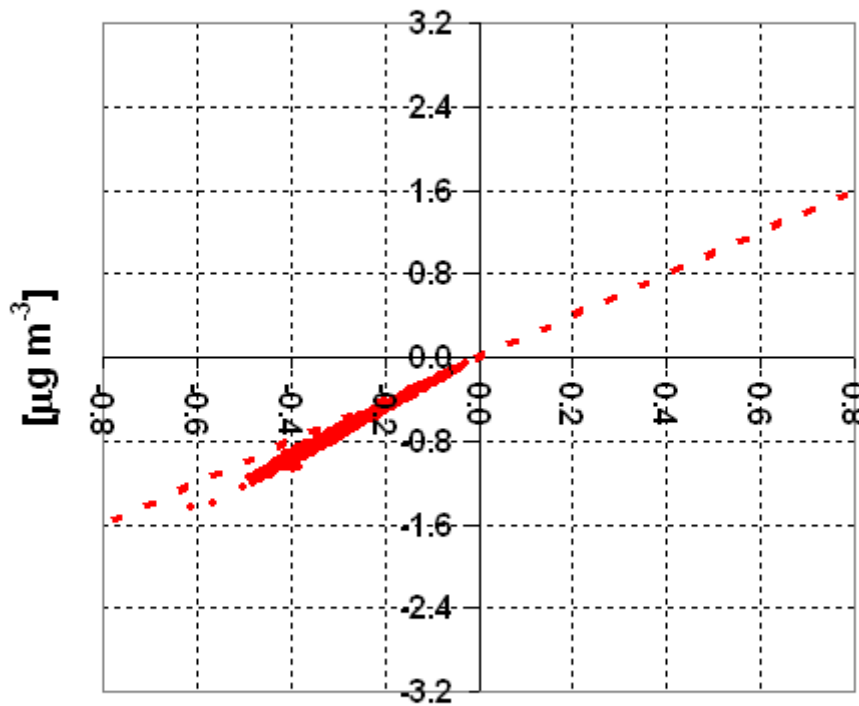
Scenario 3 – Scenario 0



Variazioni assolute rispetto al Caso base

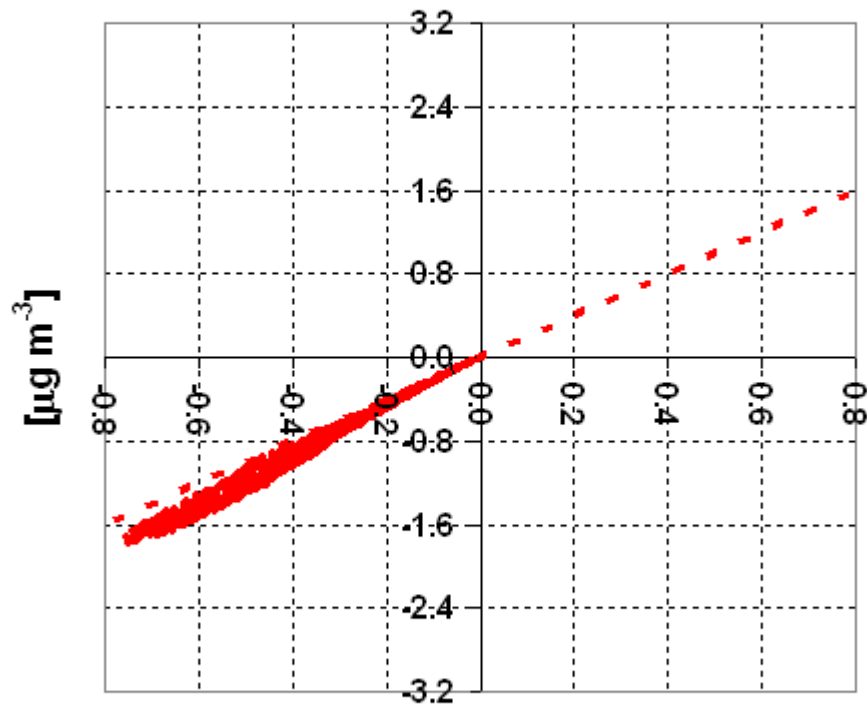
PM25 (17/3 - 19/4/2011)

PM25 (14/9 - 16/10/2011)



-25 % NH₃ [µg m⁻³]

• -50 % NH₃ - - y=-2x



-25 % NH₃ [µg m⁻³]

• -50 % NH₃ - - y=-2x

Min = -0.6137 - Max = 0.000168 [$\mu\text{g}/\text{m}^3$]

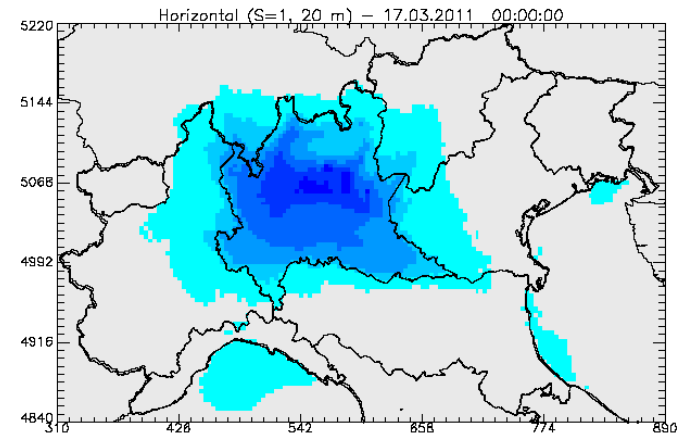
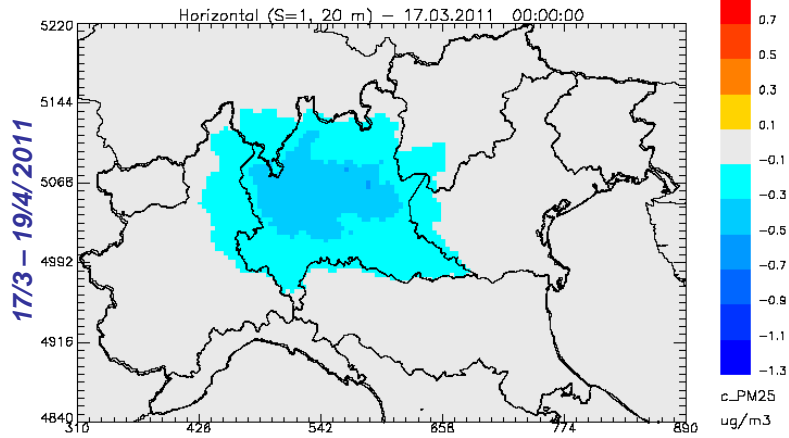
Min = -1.43 - Max = 0.0001117 [$\mu\text{g}/\text{m}^3$]

PM_{2.5}

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dell'Ambiente

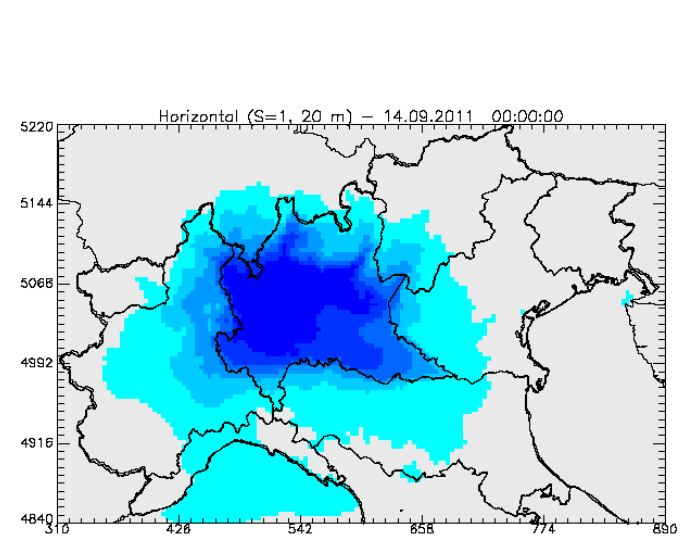
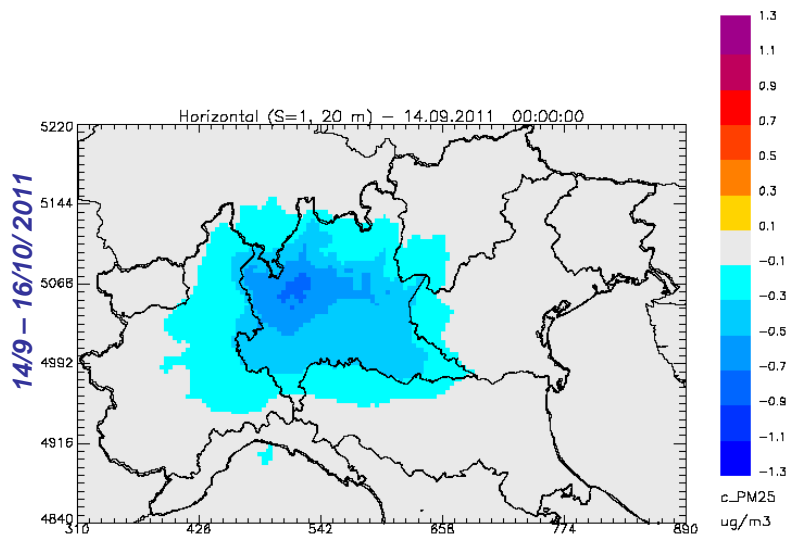
Scenario 2 – Scenario 0

Scenario 3 – Scenario 0



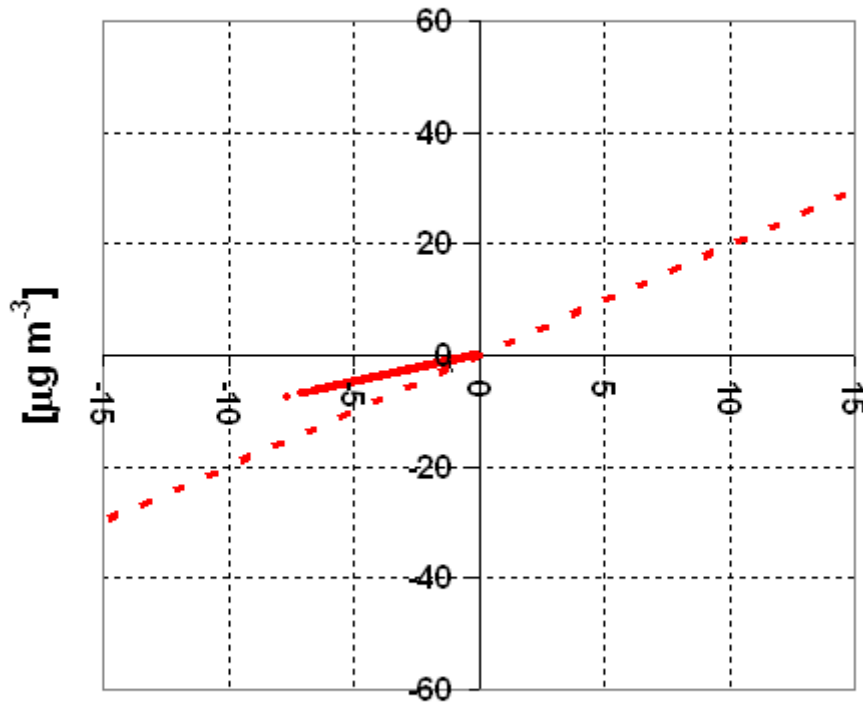
Min = -0.7508 - Max = -2.53000e-005 [$\mu\text{g}/\text{m}^3$]

Min = -1.776 - Max = 0.0003452 [$\mu\text{g}/\text{m}^3$]



Variazioni assolute rispetto al Caso base

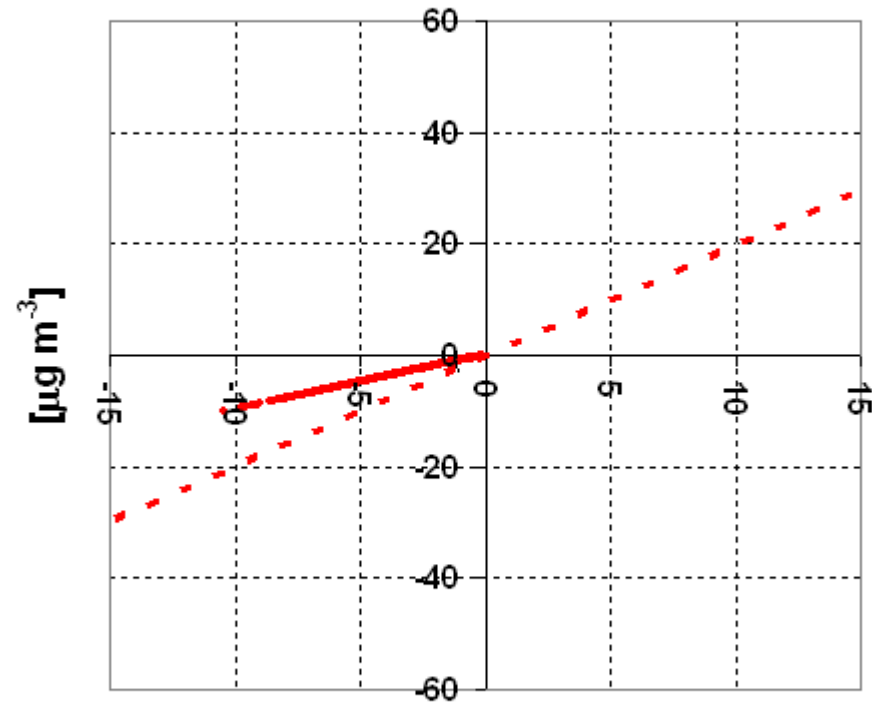
NH3 (17/3 - 19/4/2011)



-25 % NH_3 [$\mu g m^{-3}$]

• -25 % NH_3 , NO_x - - $y=-2x$

NH3 (14/9 - 16/10/2011)



-25 % NH_3 , NO_x [$\mu g m^{-3}$]

• -25 % NH_3 , -50 % NO_x - - $y=-2x$

Min = -7.654 - Max = -0.007307 [ug/m3]

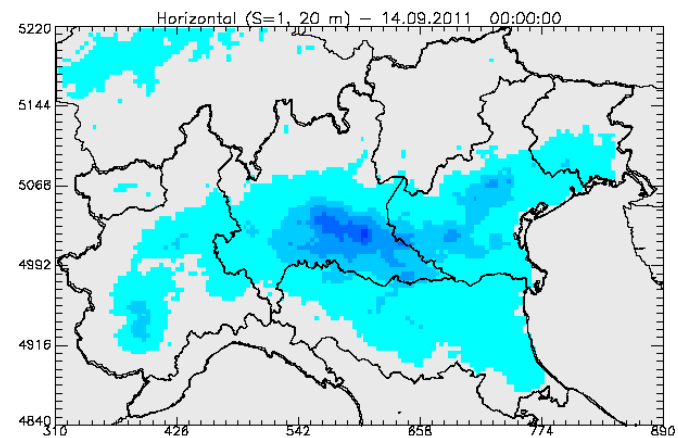
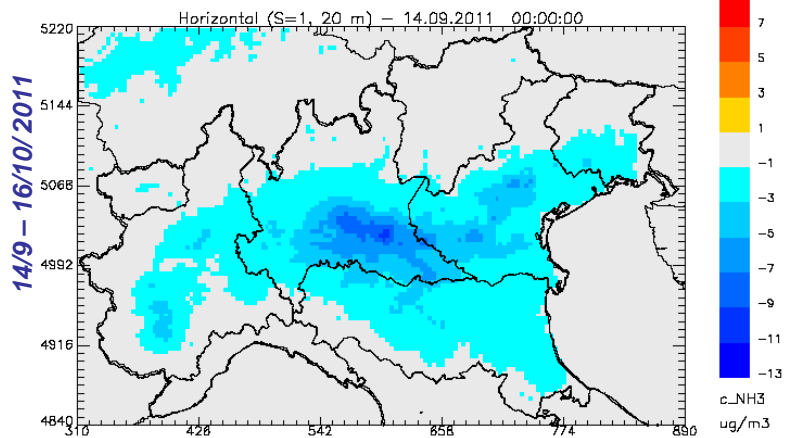
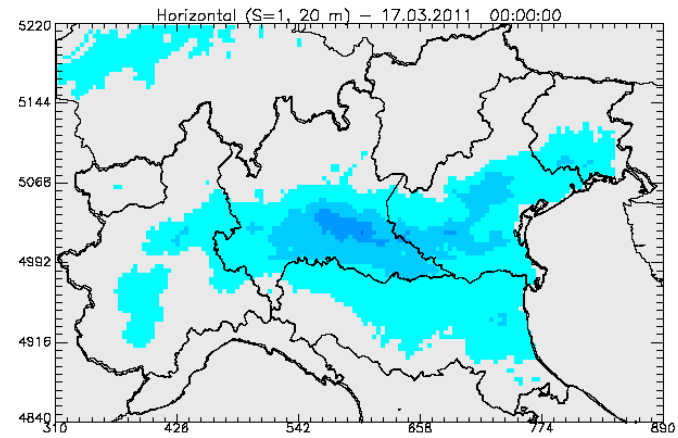
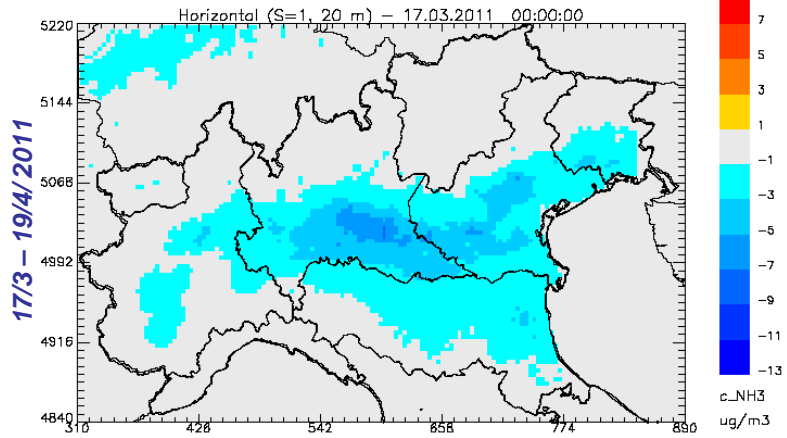
Min = -7.503 - Max = -0.002796 [ug/m3]

NH₃

MBARDIA
dell'Ambiente

Scenario 1 - Scenario 0

Scenario 8 - Scenario 0

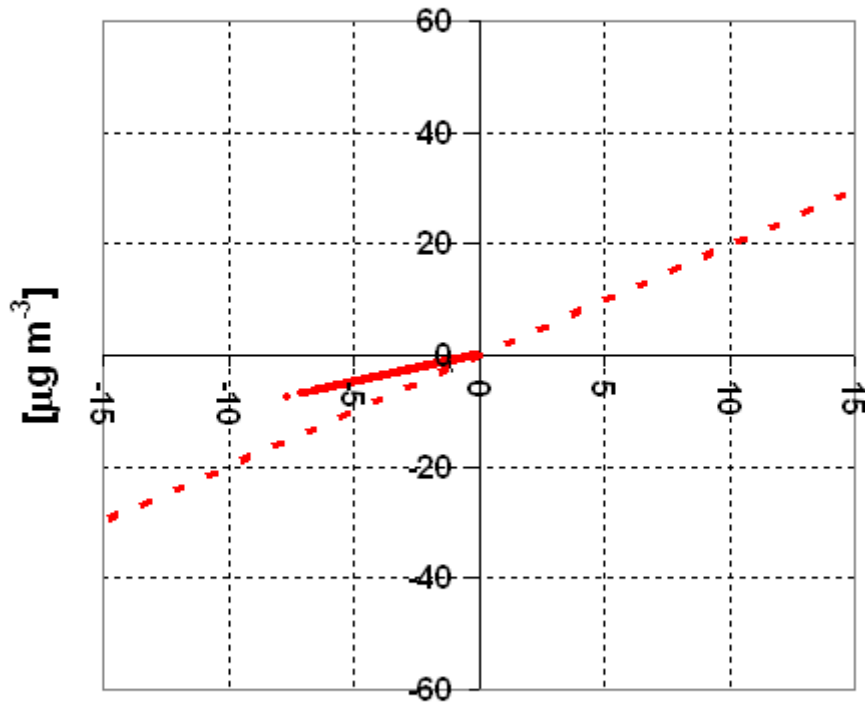


Scenari "bacino"



Variazioni assolute rispetto al Caso base

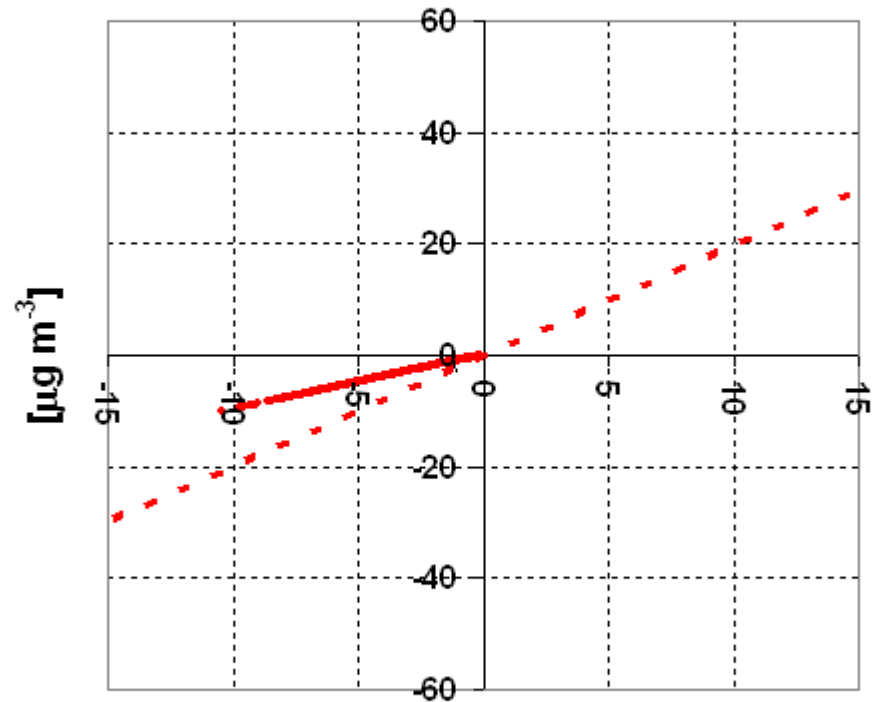
NH3 (17/3 - 19/4/2011)



-25 % NH_3 [$\mu g m^{-3}$]

• -25 % NH_3 , NO_x - - - $y=-2x$

NH3 (14/9 - 16/10/2011)



-25 % NH_3 , NO_x [$\mu g m^{-3}$]

• -25 % NH_3 , -50 % NO_x - - - $y=-2x$

Min = -7.654 - Max = -0.007307 [ug/m3]

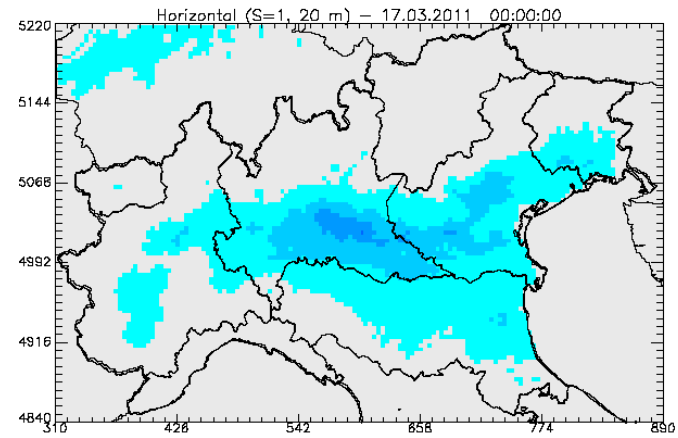
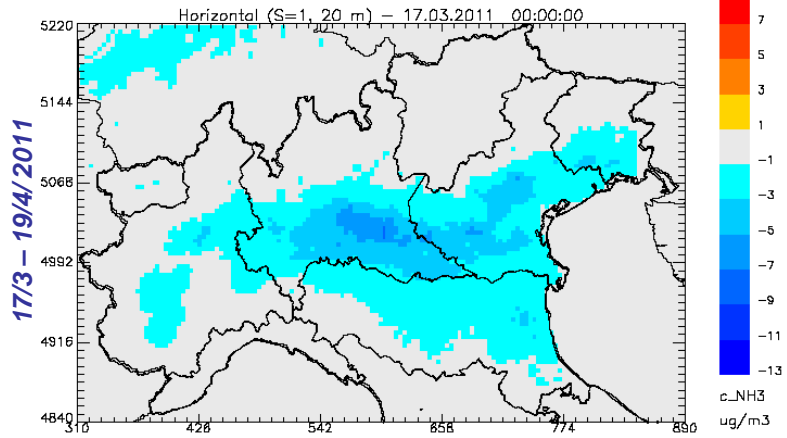
Min = -7.503 - Max = -0.002796 [ug/m3]

NH₃

MBARDIA
dell'Ambiente

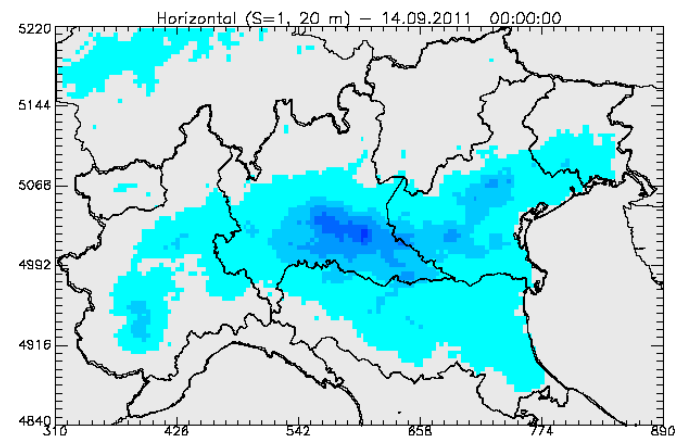
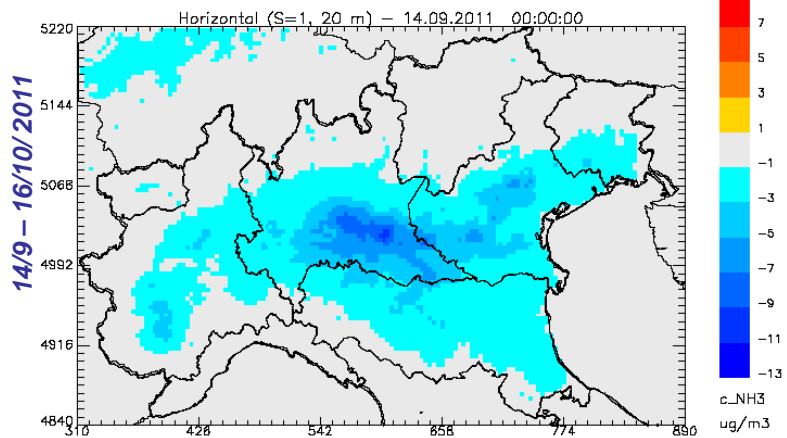
Scenario 1 - Scenario 0

Scenario 8 - Scenario 0



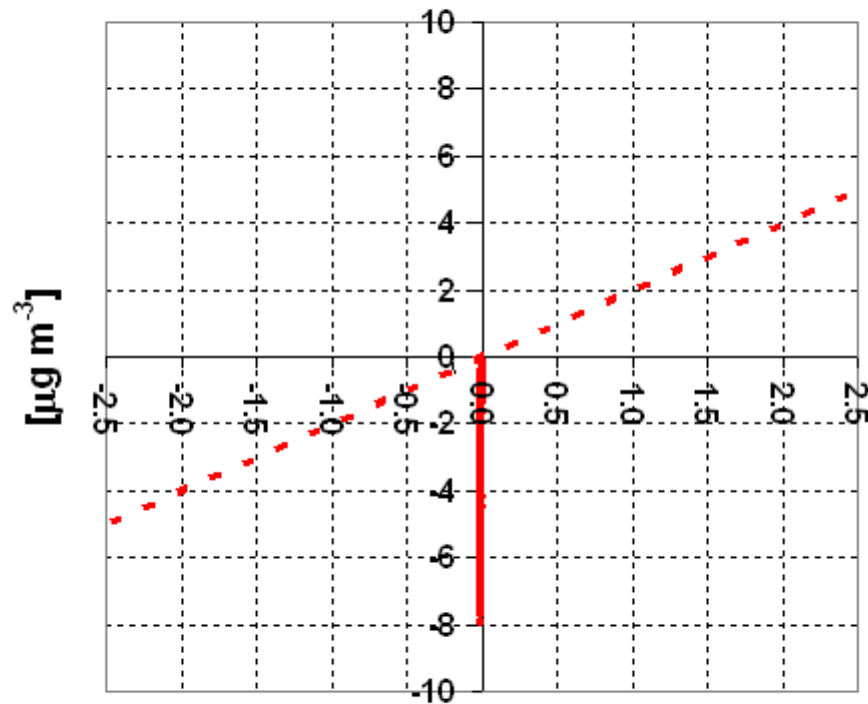
Min = -10.45 - Max = -0.008566 [ug/m3]

Min = -7.503 - Max = -0.002796 [ug/m3]



Variazioni assolute rispetto al Caso base

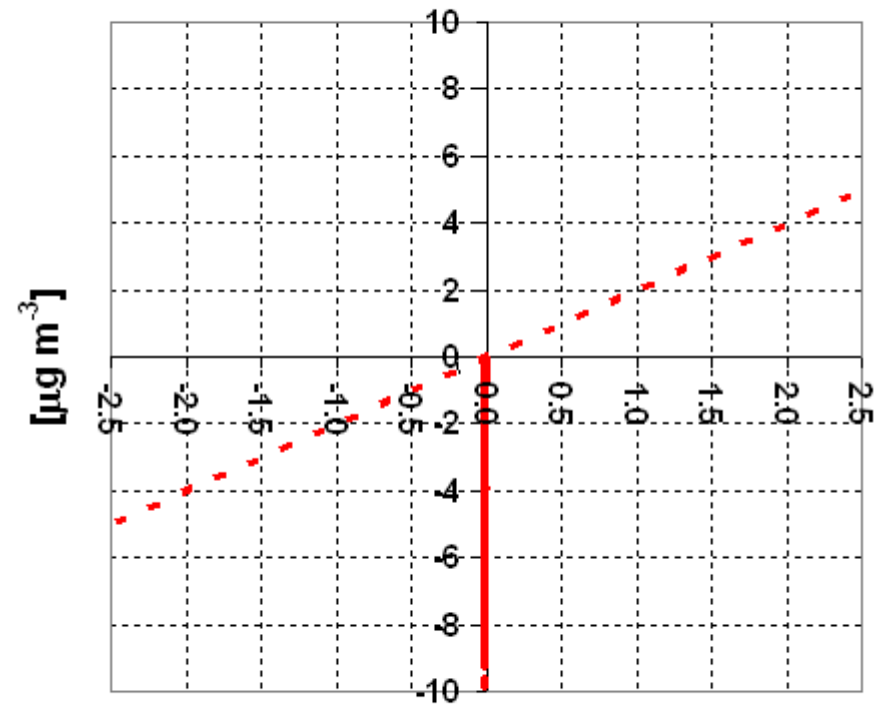
NO₂ (17/3 - 19/4/2011)



-25 % NH₃ [µg m⁻³]

• -25 % NH₃, NO_x - - - y = -2x

NO₂ (14/9 - 16/10/2011)



-25 % NH₃, -50 % NO_x [µg m⁻³]

• -25 % NH₃, -50 % NO_x - - - y = -2x

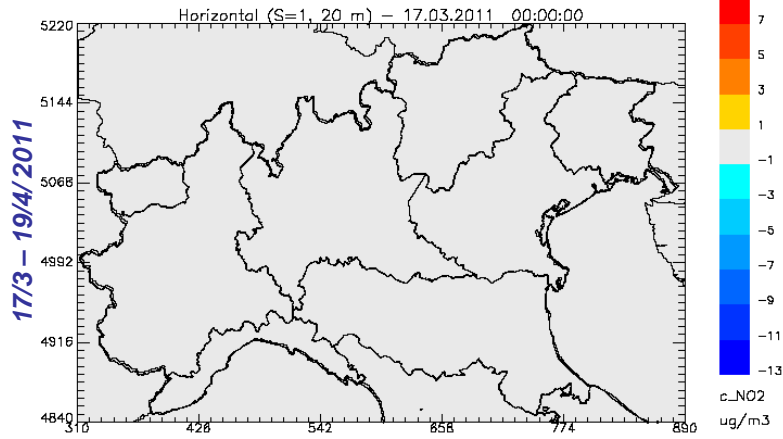
Min = -0.008513 - Max = 0.001195 [$\mu\text{g}/\text{m}^3$]

NO₂

Min = -8.443 - Max = -0.039 [$\mu\text{g}/\text{m}^3$]

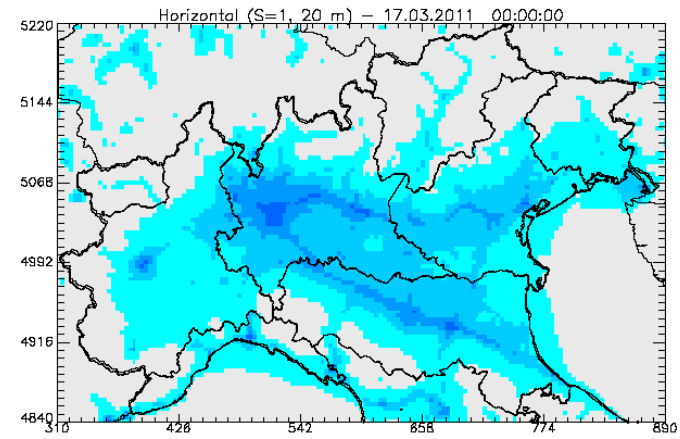
MBARDIA
dell'Ambiente

Scenario 1 - Scenario 0

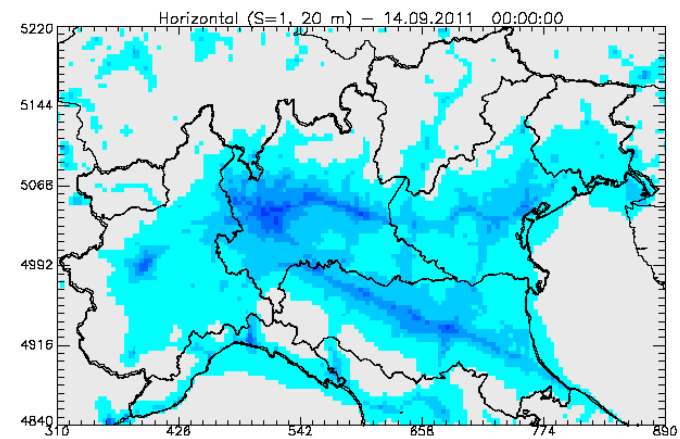
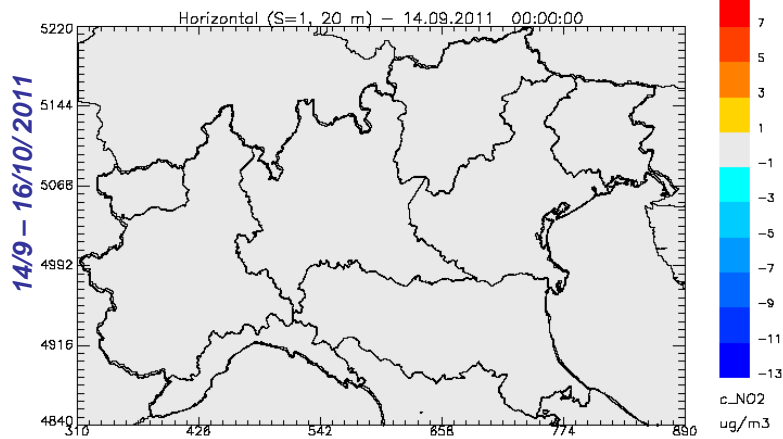


Min = -0.01243 - Max = 0.002658 [$\mu\text{g}/\text{m}^3$]

Scenario 8 - Scenario 0

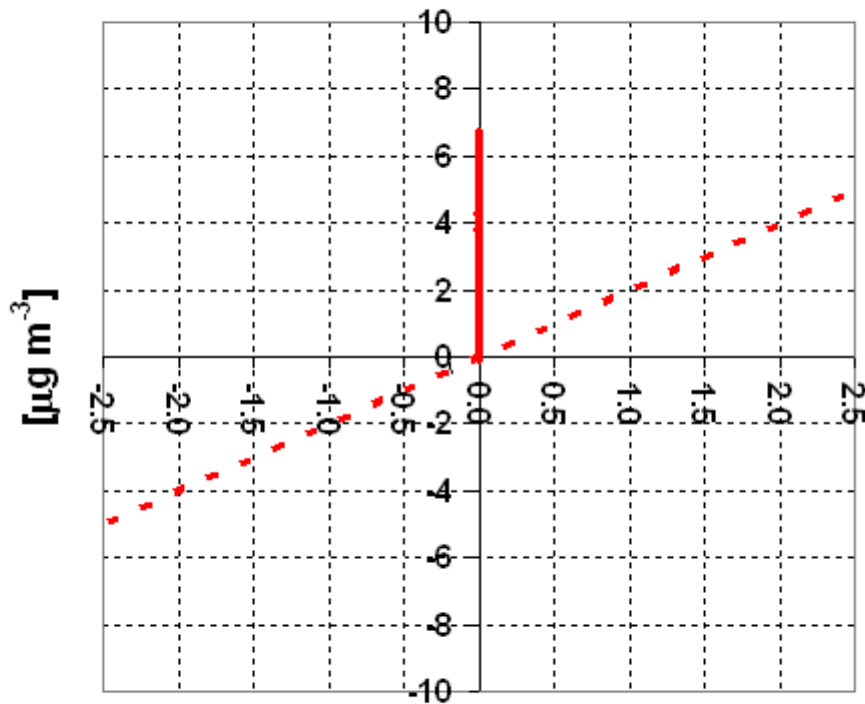


Min = -9.862 - Max = -0.03513 [$\mu\text{g}/\text{m}^3$]

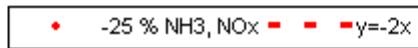


Variazioni assolute rispetto al Caso base

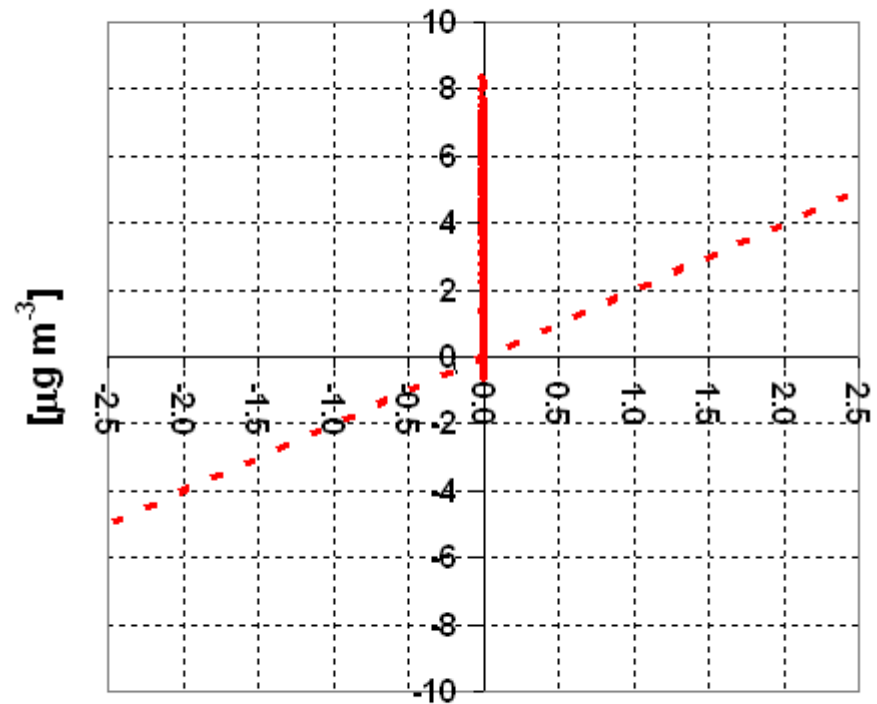
O3 (17/3 - 19/4/2011)



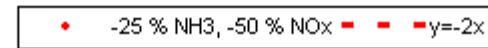
-25 % NH₃ [µg m⁻³]



O3 (14/9 - 16/10/2011)



-25 % NH₃, -50 % NO_x [µg m⁻³]



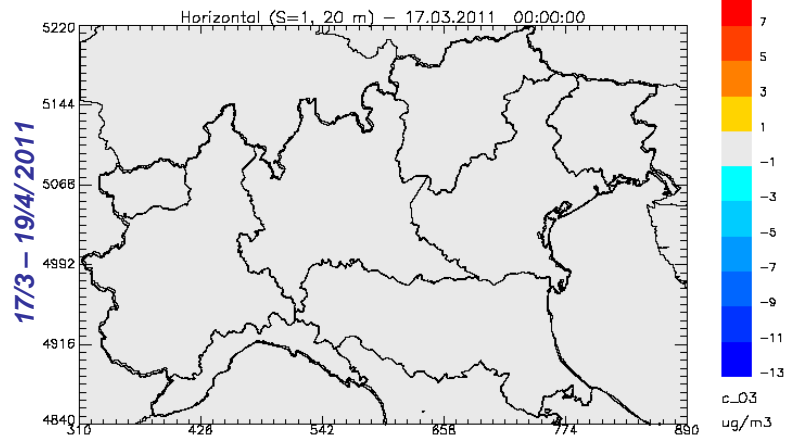
Min = -0.009551 - Max = 0.0127 [ug/m3]

Min = -0.3557 - Max = 7.083 [ug/m3]

O₃

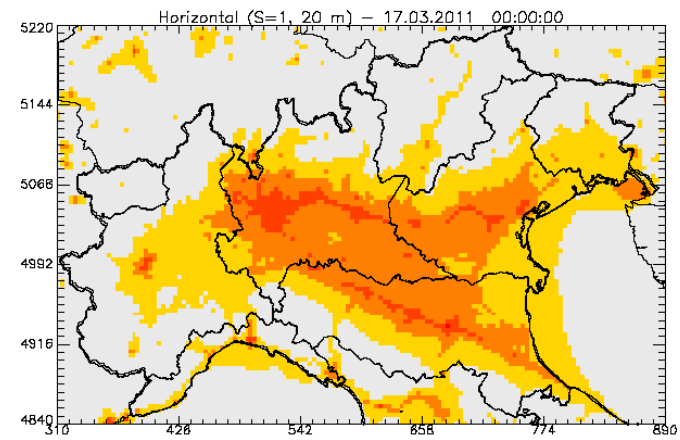
MBARDIA
dell'Ambiente

Scenario 1 - Scenario 0



Min = -0.003968 - Max = 0.003702 [ug/m3]

Scenario 8 - Scenario 0



Min = -0.8231 - Max = 6.295 [ug/m3]

