EMEP model simulations of PM levels in Europe under the Gothenburg Protocol and Measures to reduce further NH_3 emissions from agriculture

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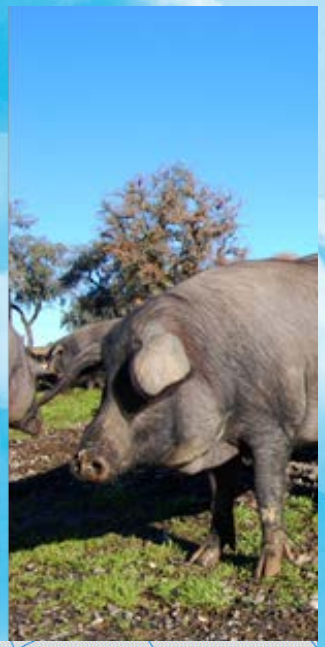
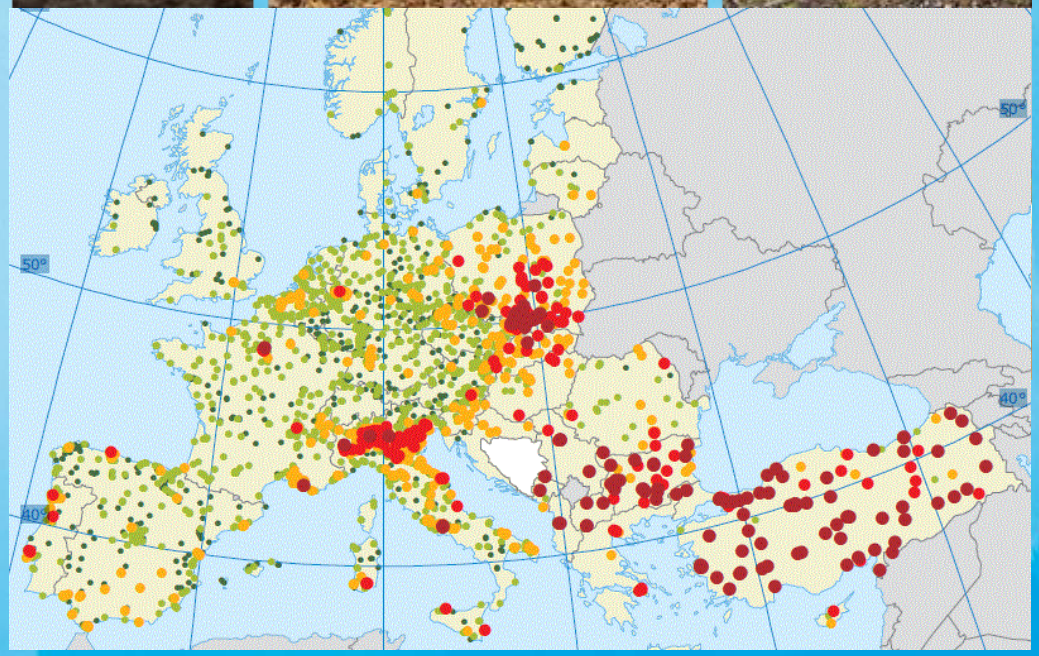
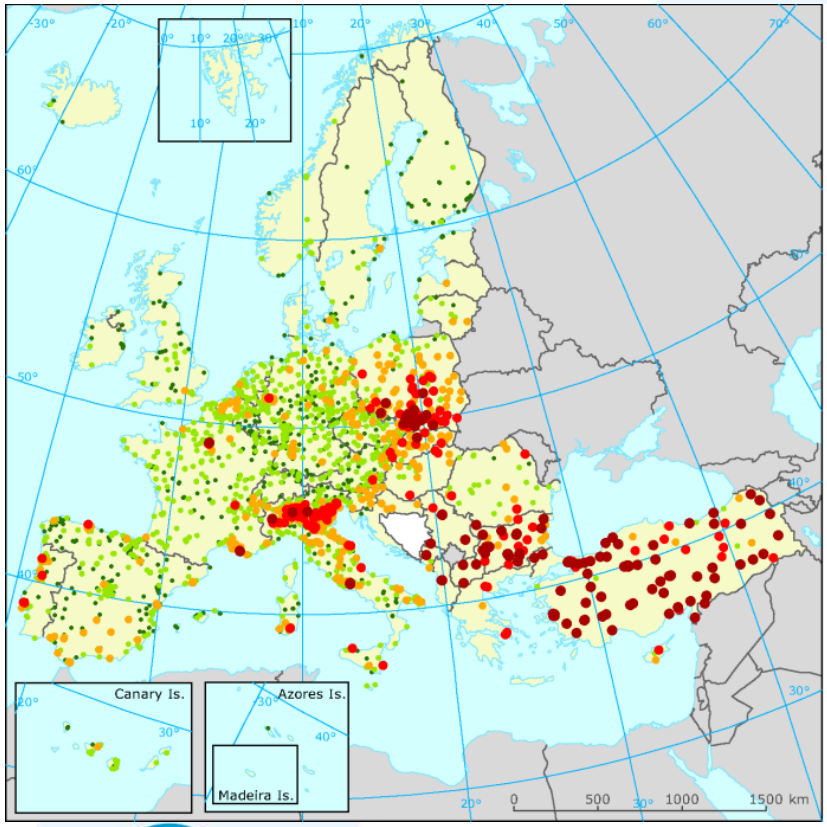




Motivation: PM_{10} levels in Europe

PM10 annual mean 2011



Annual mean particulate matter (PM_{10}) 2011, based on daily average with percentage of valid measurements ≥ 75 % in µg/m³

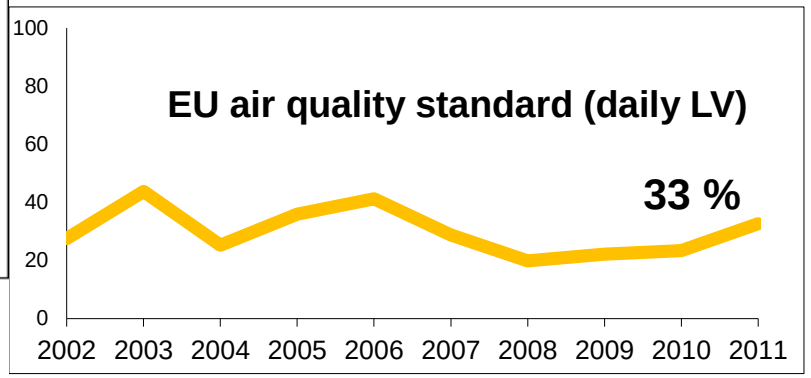
- ≤ 20
- 20–31
- 31–40
- 40–50
- > 50

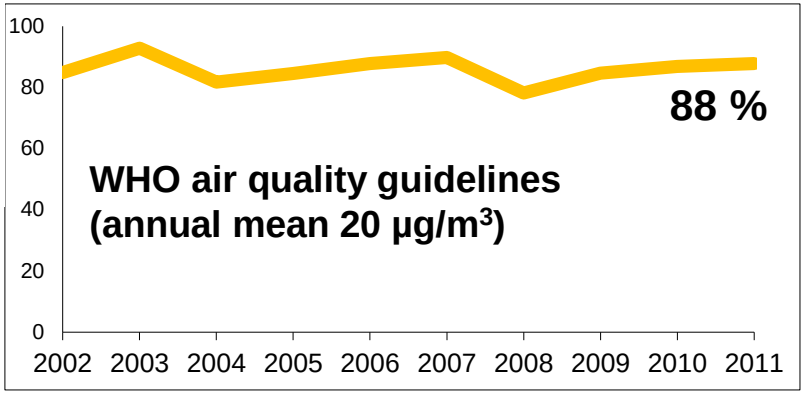
No data

Countries/regions not included in the data exchange process

In orange and red: above EU limit values to be met by 2005

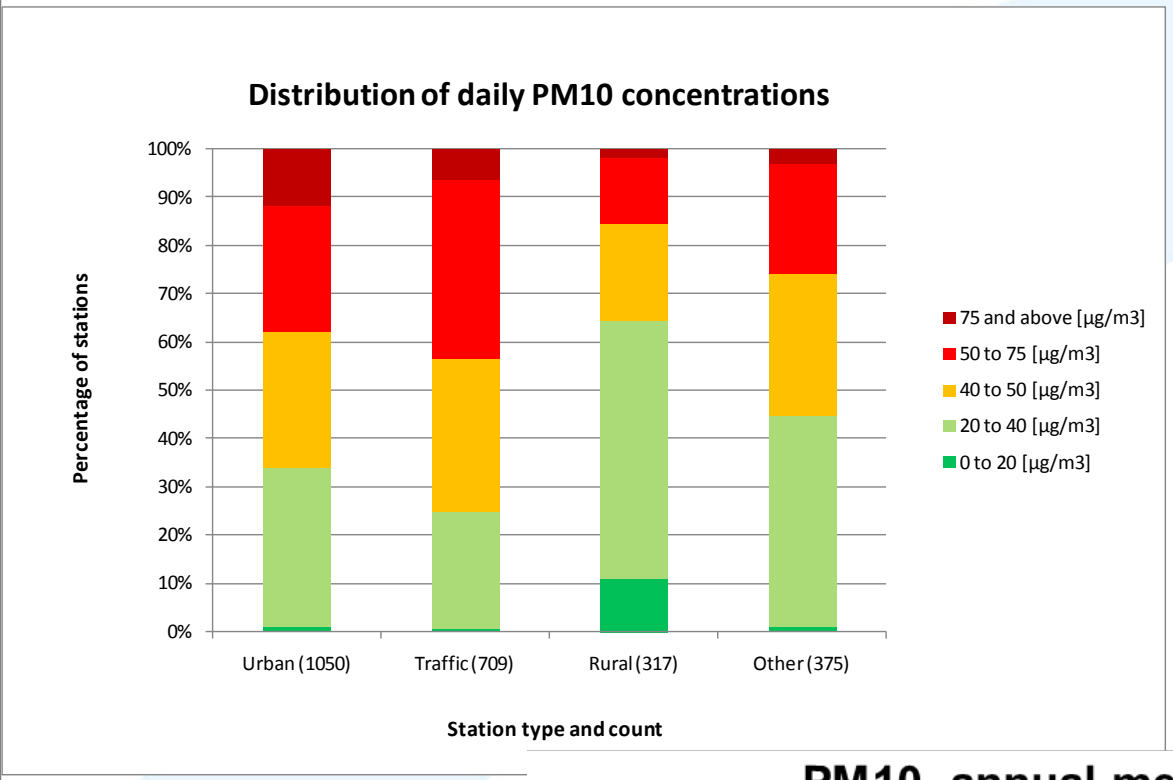
% of the EU's urban population exposed to PM10 exceeding



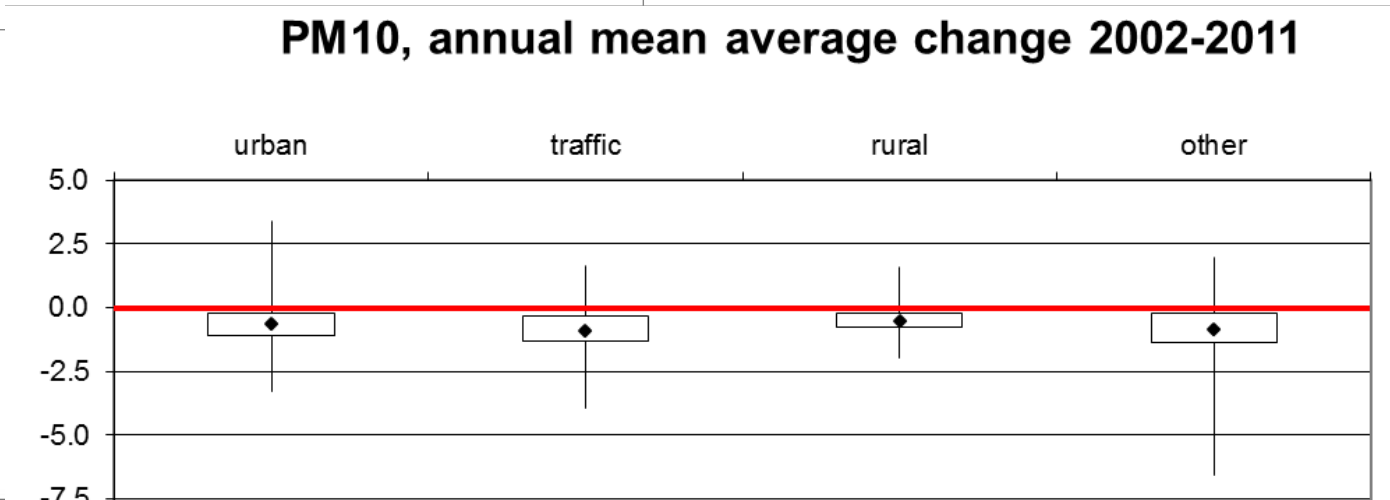


Source: EEA, 2013

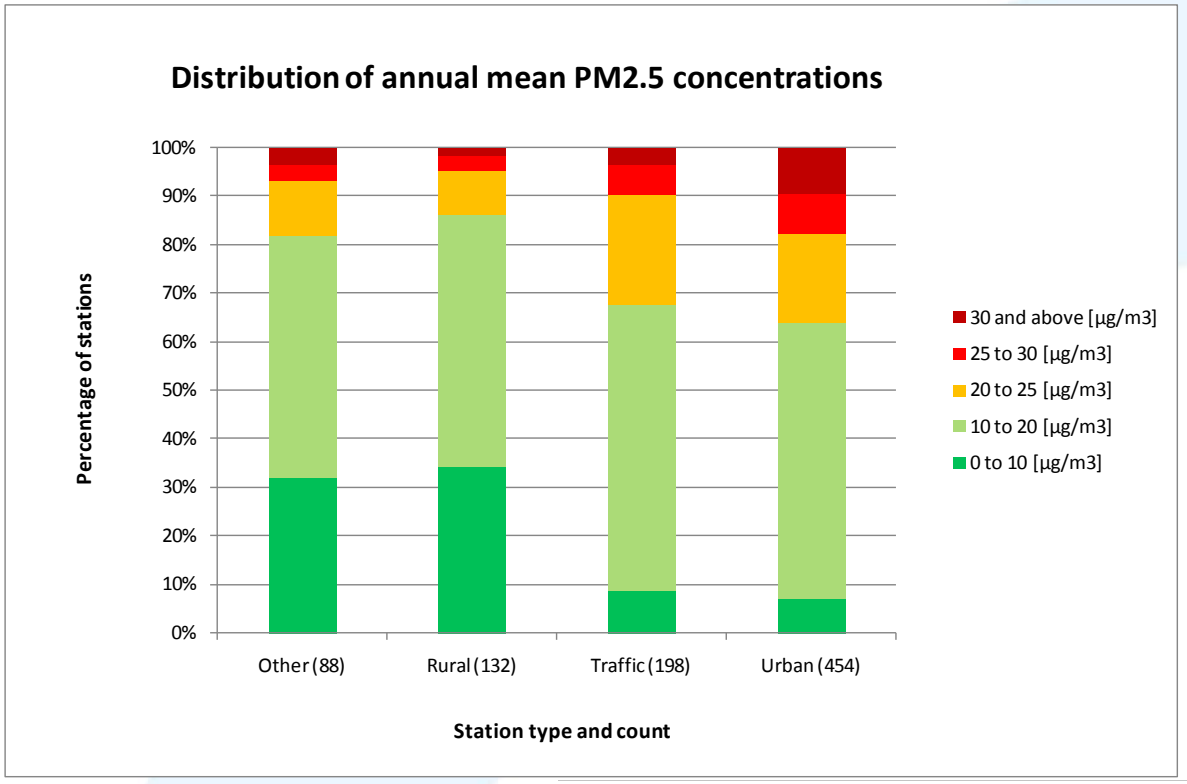
Motivation: PM_{10} exceedances 2011



Source: EEA, 2013

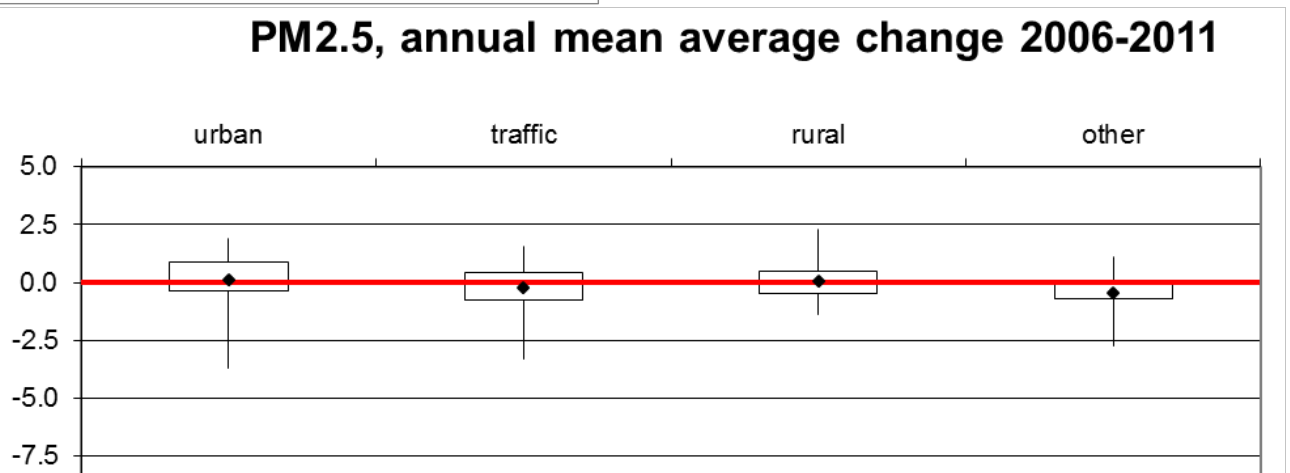


Motivation: $PM_{2.5}$ exceedances 2011



Indicative LV for 2020 is 20 µg/m^3

Source: EEA, 2013



Motivation: PM composition

SIA accounts for ~1/3 of PM_{10} and ~1/2 of $PM_{2.5}$ measured at regional background stations

Main components of SIA :

ammonium (NH_4^+),

nitrate (NO_3^-) and

sulphate (SO_4^{2-})

$$NHO_3 + NH_3 \leftrightarrow NH_4NO_3$$

$$H_2SO_4 + NH_3 \rightarrow NH_4HSO_4 \quad (1)$$

$$NH_4HSO_4 + NH_3 \rightarrow (NH_4)_2SO_4 \quad (2)$$

Several studies point out the importance of agricultural emissions of NH_3 to PM, but few quantify. E.g. EURODELTA II (Thunis et al, 2008)

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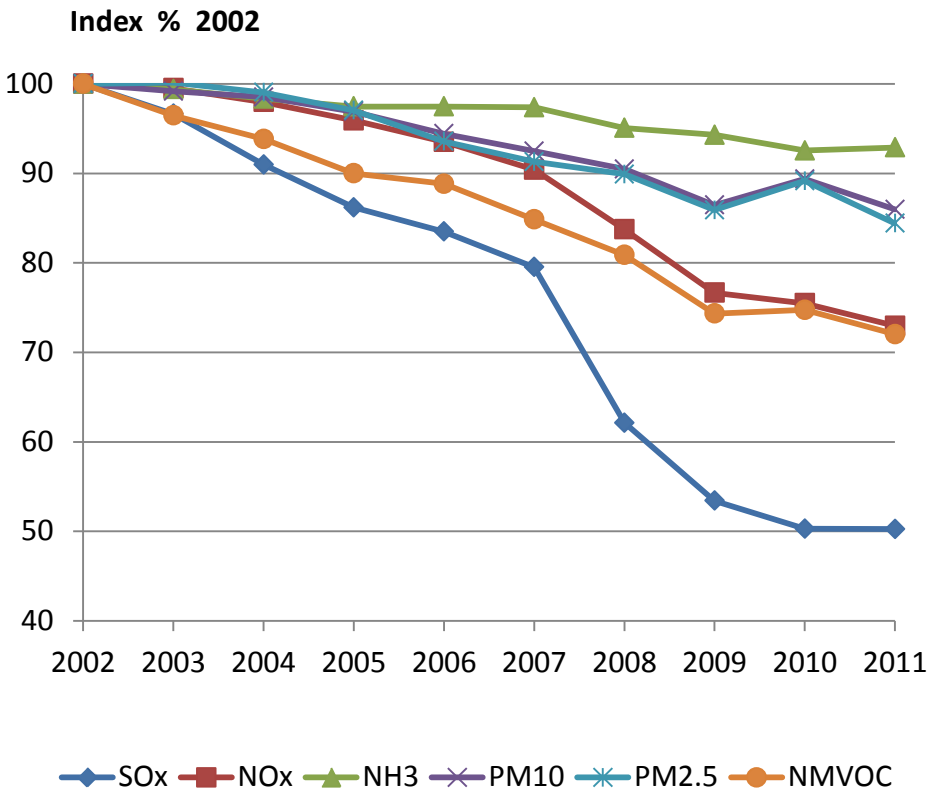
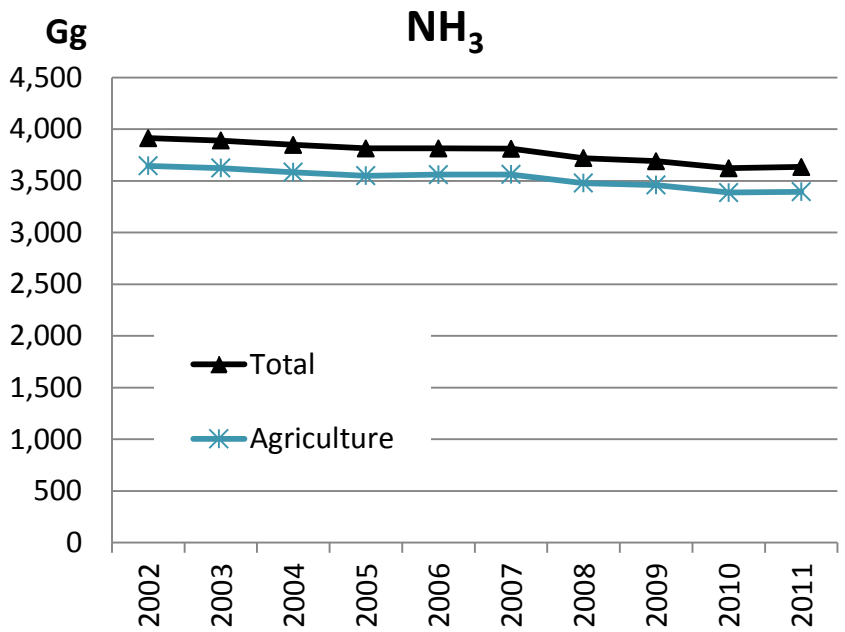
Motivation: development of emissions of PM precursor gases and PPM





Source: European Union emission inventory report 1990–2011 to UNECE LRTAP Convention (EEA, 2013)

Question

How much can the implementation of feasible measures to reduce NH_3 emissions from agriculture contribute to reduce PM levels and PM exceedances across Europe, beyond the Gothenburg protocol?

- NH_3 emission reduction expected by the Gothenburg Protocol by 2020 (compared to 2005) is 6% for EU27.
- there is less ambition in reducing NH_3 emissions, than other PM precursors,
- available measures could cut NH_3 emissions in the EU27 by about 30% on top of current legislation in 2020 (Amman et al., 2012).

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Method: EMEP model

- 2009 meteorology
- Resolution: 0.25°(~28 km lat.) x 0.25° (8-20 km long.)
- $PM_{10} = PPM_{coarse} + PPM_{fine} + SO_4^{2-} + NO_3^{-} + NH_4^{+} + Sea\ Salt + SOA + Dust$

EU emissions GP-2009	Change (%)
NH3	-2.1
NMVOC	-13.8
NOx	-28.8
SO2	-32.8
PM2.5	-14.1
PM10	-12.3

- ***Emission scenarios:***
  - ✓ Reference using 2009 emissions
  - ✓ Gothenburg protocol (GP) emissions
  - ✓ GP & -10% NH_3 agricultural emissions
  - ✓ GP & -20% further reduction of NH_3 agricultural emissions
  - ✓ GP & -30% further reduction of NH_3 agricultural emissions

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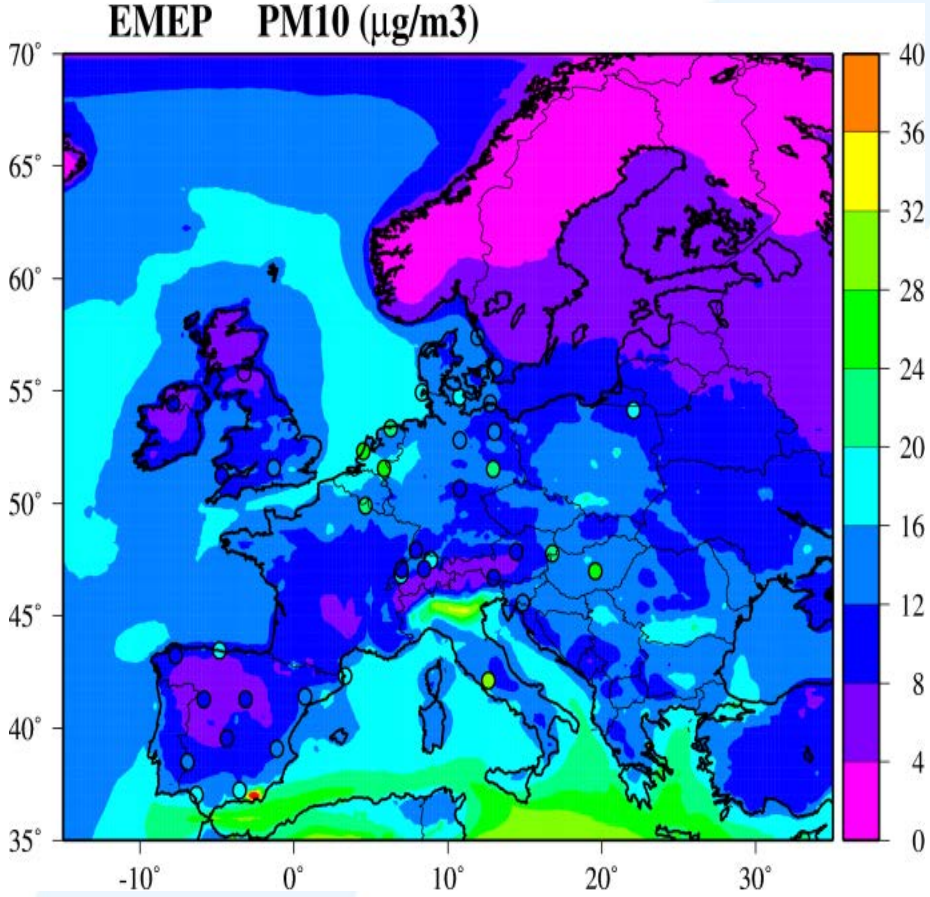
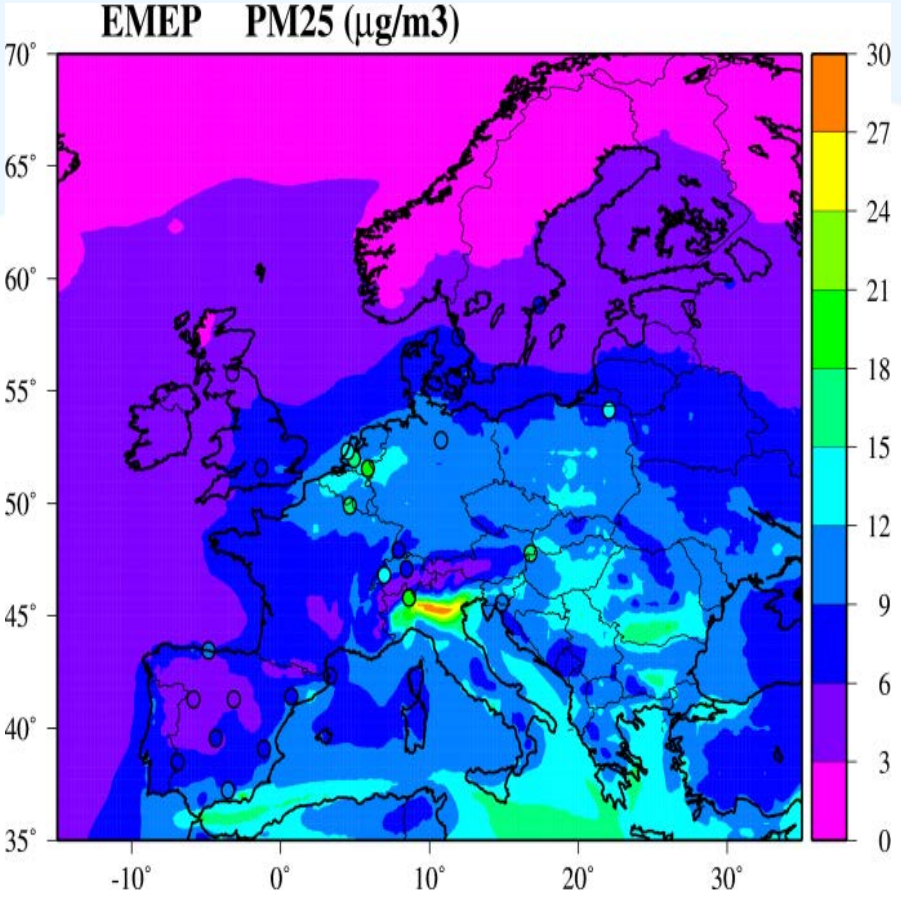
Model evaluation: 2009 EMEP stations





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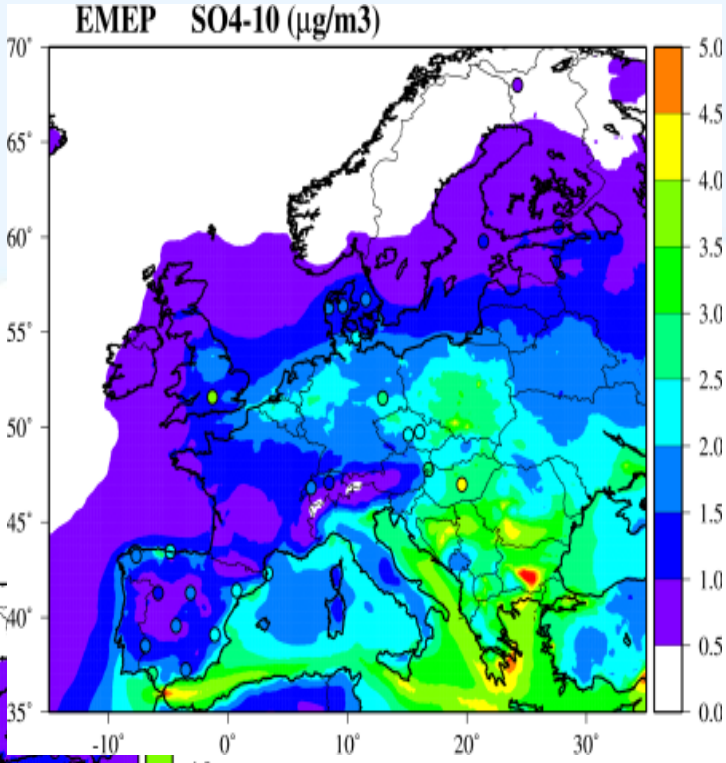
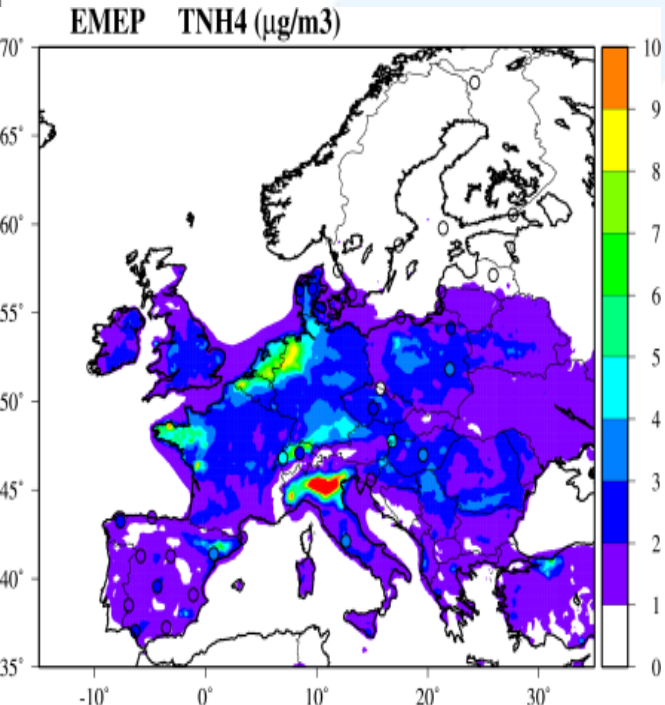
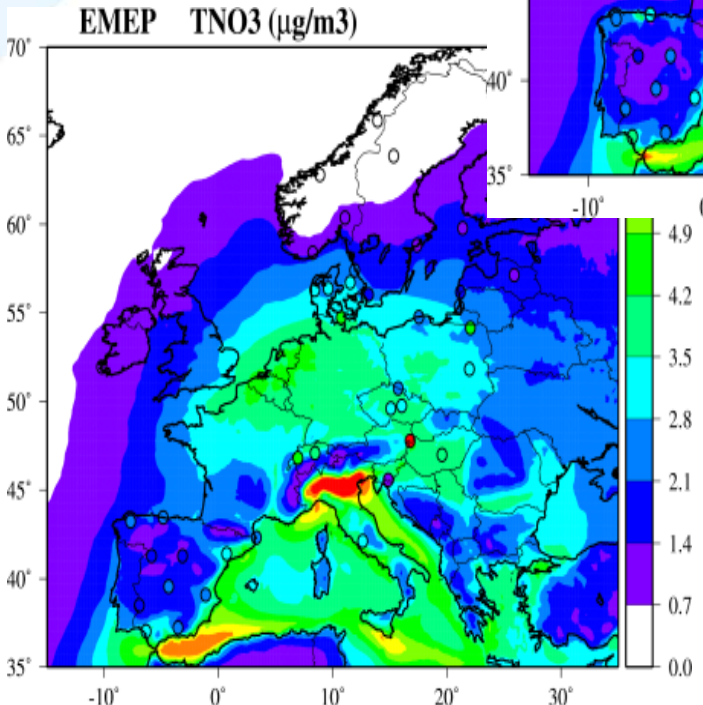
Model evaluation: 2009 EMEP stations

Pollutant	Obs.	Model	Bias	Cor	RMSE	Nb
PM10	15.65	11.76	-3.89	0.55	10.63	16405
PM2.5	10.71	8.17	-2.55	0.63	7.56	11043
SO_4-10	1.93	1.41	-0.53	0.59	1.49	9975
TNH_4	1.92	1.70	-0.22	0.52	1.88	13354
TNO_3	2.39	2.32	-0.07	0.34	4.28	15261

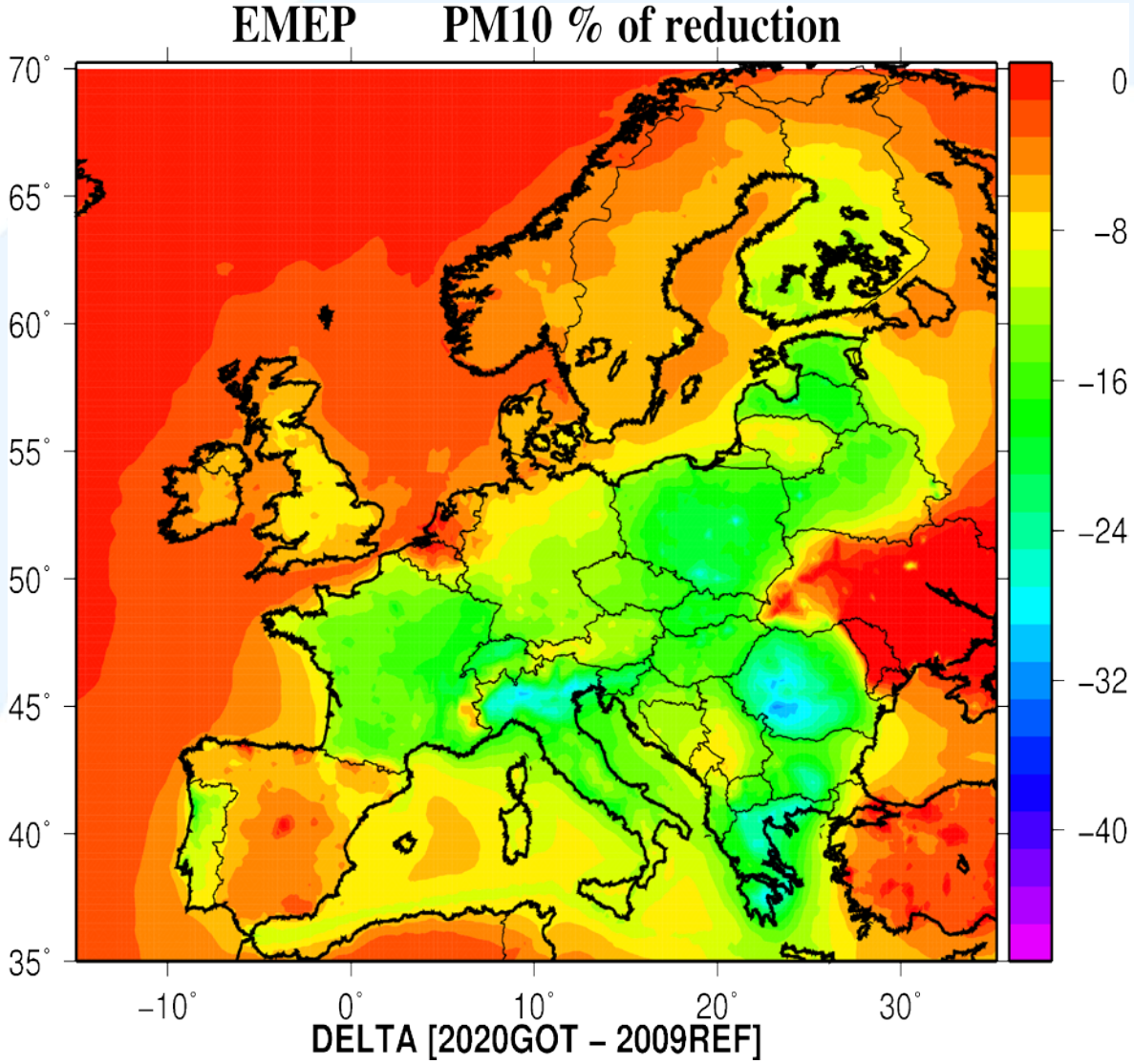
TNO_3: Total nitrate ($TNO_3 = NO_3\text{-}10 + HNO_{3eq.\ Nitrate}$)
TNH_4: Total ammonium ($TNH_4 = NH_4\text{-}10 + NH_{3eq.\ Ammonium}$)







Results: Reduction of annual mean PM_{10} due to the Gothenburg Prot.



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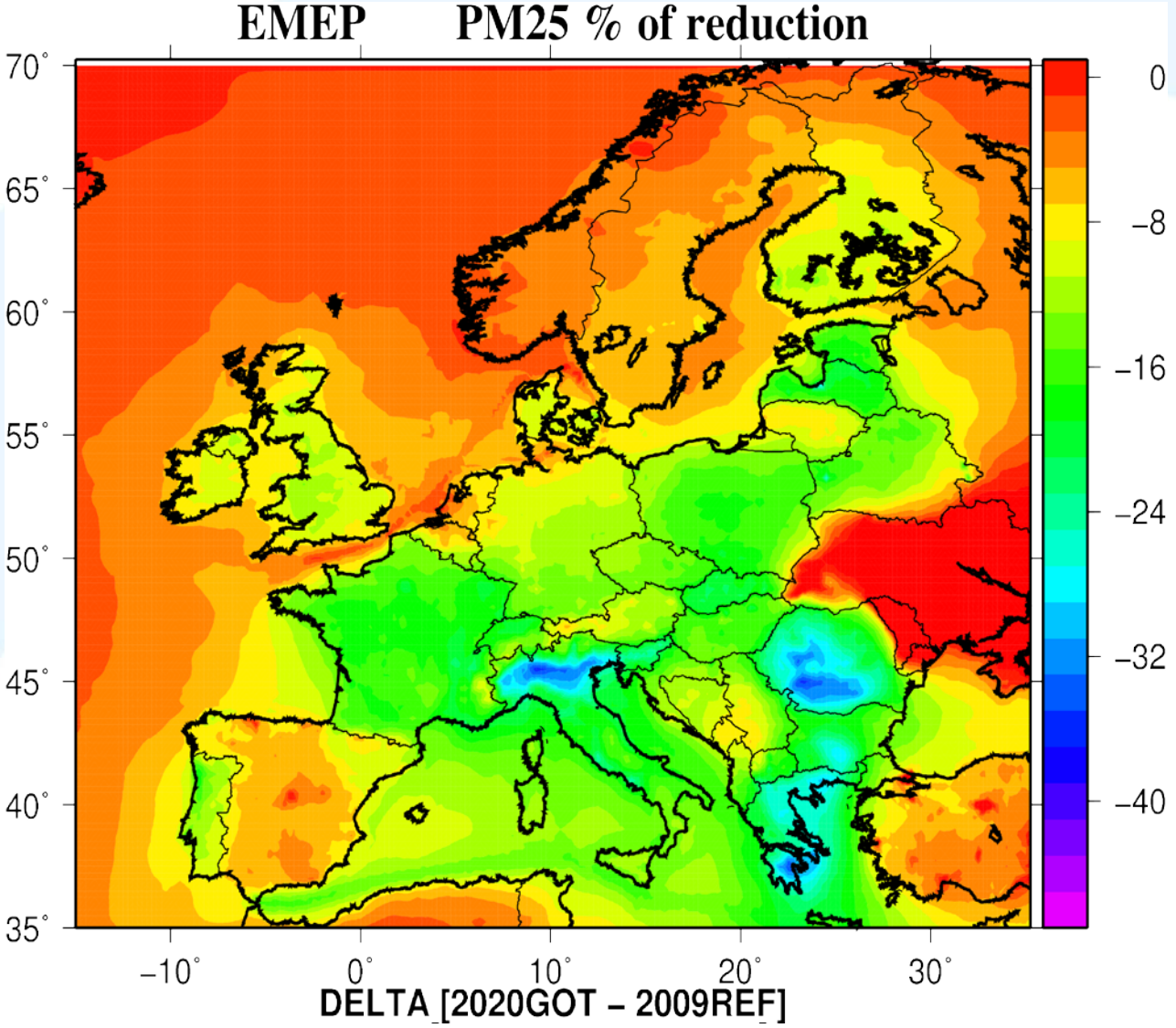
Results: Reduction of annual mean $PM_{2.5}$ due to the Gothenburg Prot.



Number of stations in exceedances		OBS 2009	*GOT*	*G10*	*G20*	*G30*
PM_{10} LV : 35 days > 50µg.m^{-3}	*rural*	16	9	9	7	7
	suburban	65	51	50	48	48
	urban	267	210	204	197	189
	traffic	175	143	142	141	136
	industrial	89	73	73	69	66
	Total	**612**	**486 (-21%)**	**478**	**462**	**446 (-8%)**
PM_{10} LV : annual mean > 40 µg.m^{-3}	*rural*	3	2	2	2	2
	suburban	13	11	11	11	11
	urban	69	51	50	50	49
	traffic	43	29	28	28	26
	industrial	13	8	8	8	8
	Total	**141**	**101(-28%)**	**99**	**99**	**96 (-5%)**
$PM_{2.5}$ LV : annual mean > 20 µg.m^{-3}	*rural*	7	3	2	2	2
	suburban	12	8	8	8	8
	urban	48	34	33	31	28
	traffic	26	19	19	19	19
	industrial	12	9	9	9	8
	Total	**105**	**73(-30%)**	**71**	**69**	**65 (-11%)**

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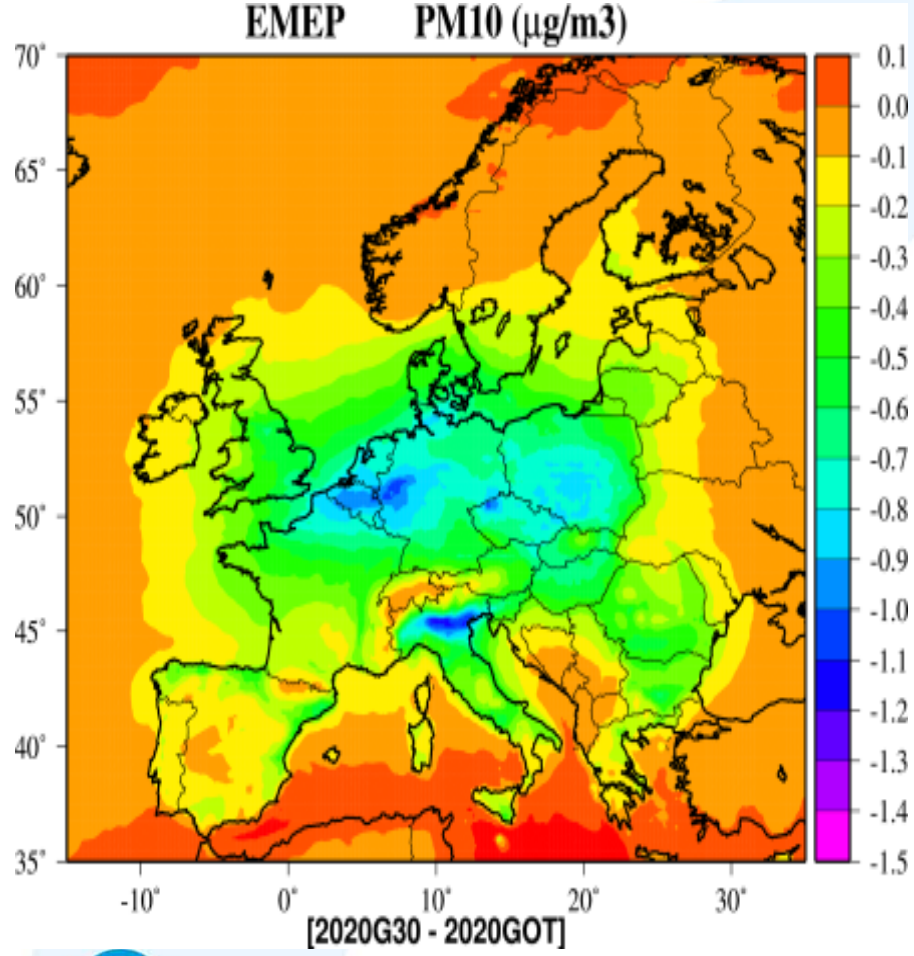
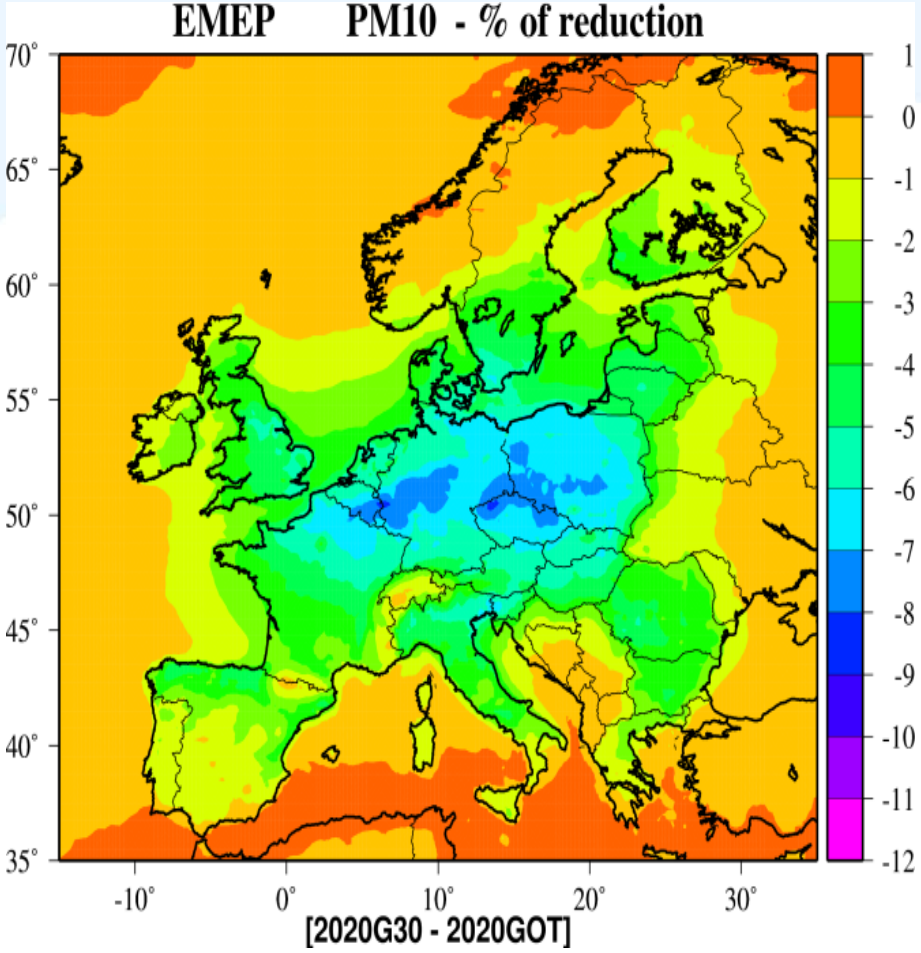
Results: Further reduction PM_{10} with -30% NH_3 agriculture emissions





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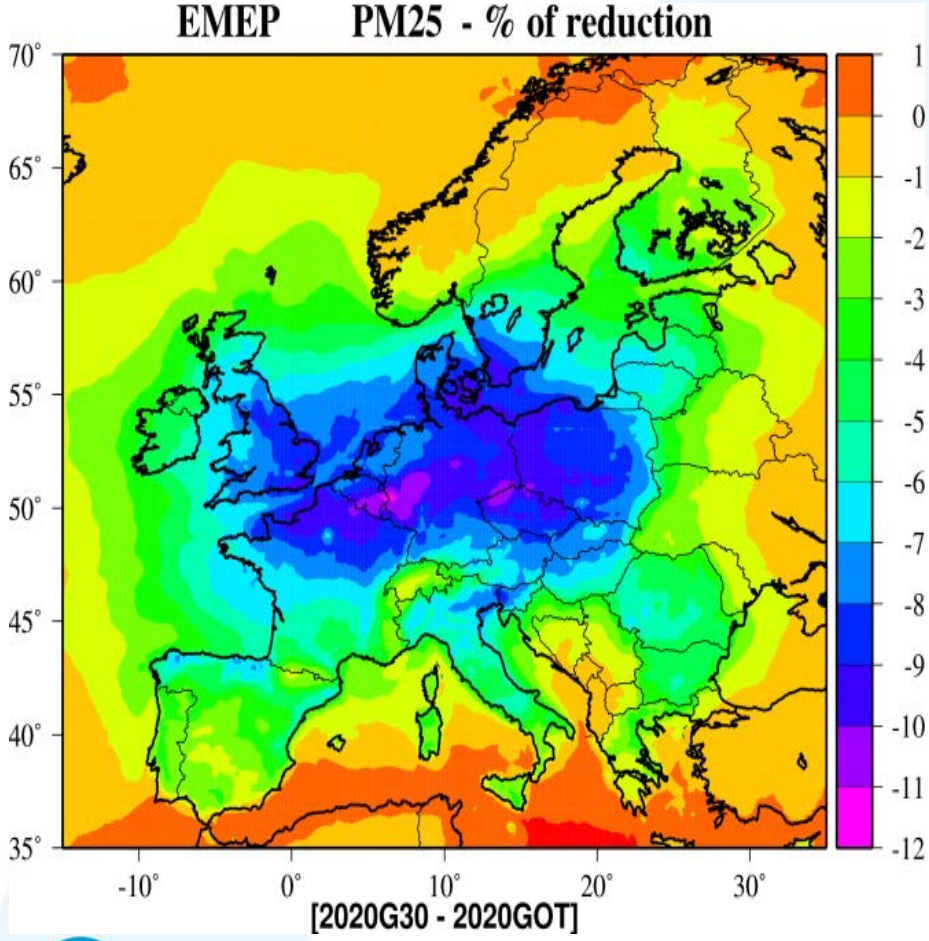
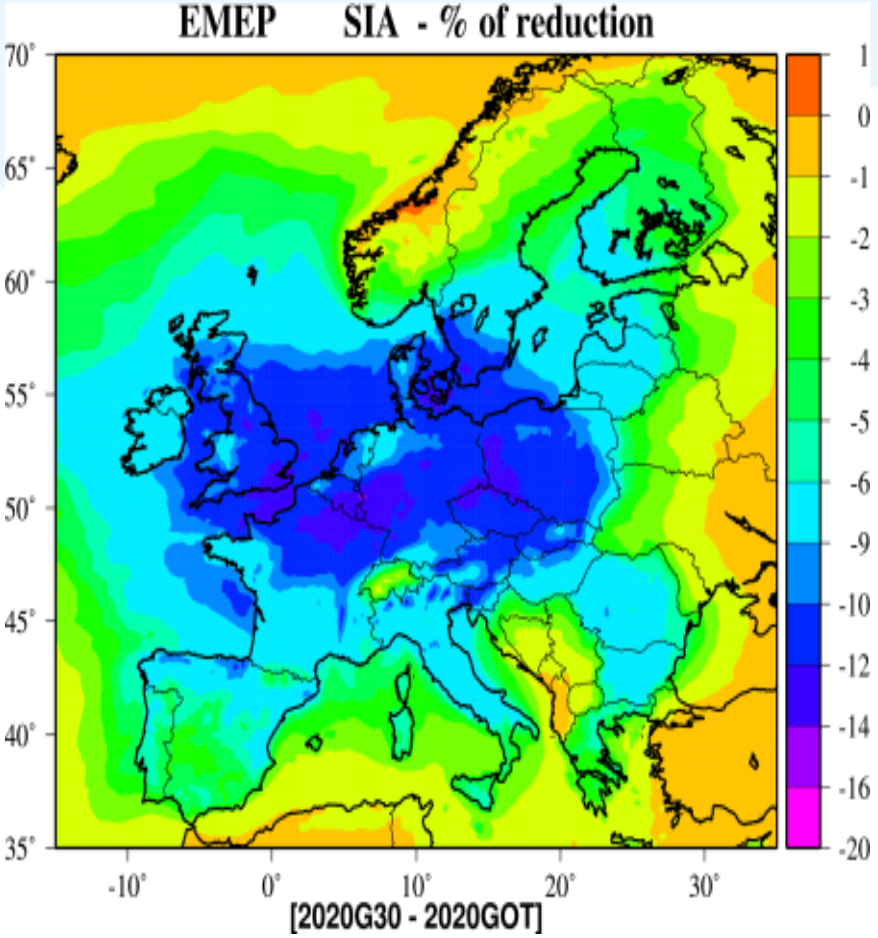
Further reduction $PM_{2.5}$ & SIA with -30% NH_3 agriculture emissions





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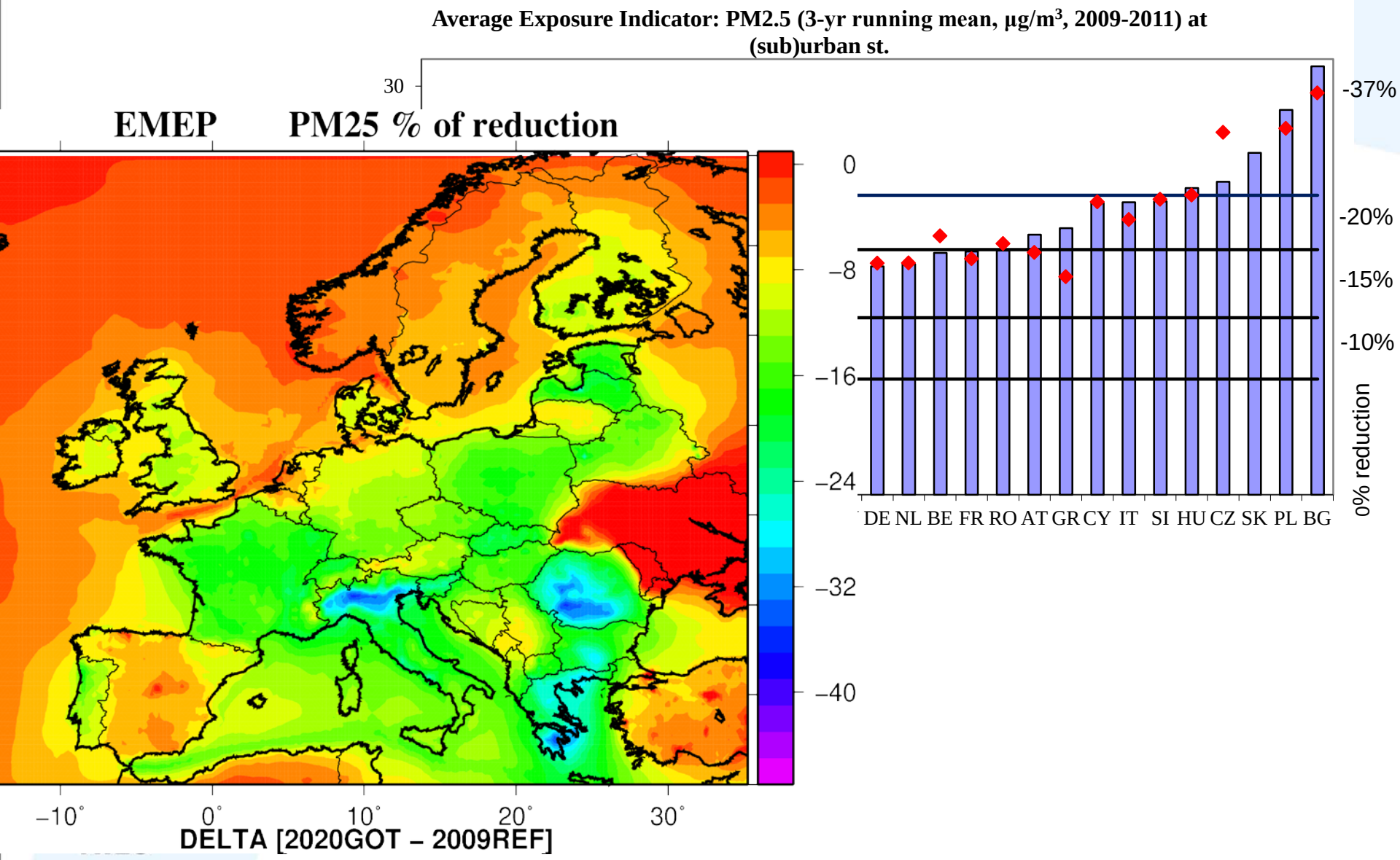
$PM_{2.5}$ % reduction 2009-2020 G30



Conclusions I

The Gothenburg protocol will contribute to the reduction of PM levels in Europe in 2020, but only reduce the number of stations in exceedance (compared to 2009) by:

- 21% for PM10 daily LV,
- 28% PM10 annual LV and
- 30% for the PM2.5 LV.

➢ **Further measures are necessary!**

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Conclusions II

A further 20-30% reduction of NH_3 emissions from agriculture will reduce :

- Up to 5-8% of the annual mean PM_{10} in Central and Eastern Europe,
- Up to 7-11% of $PM_{2.5}$ in Central and Eastern Europe,
- 5-8% of exceedances of the daily PM_{10} LV,
- 5-11% of exceedances of the annual $PM_{2.5}$ LV
- Contribute to achieve the AEI reductions in 2020

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