ICP Materials

Preparation for ex post analysis

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Targets / tolerable levels 2020/2050

as in "Indicators and targets for air pollution effects, ECE/EB.AIR/WG.1/2009/16"

Table 13. Targets for protecting materials of infrastructure and cultural heritage monuments for 2050 and 2020 by ICP Materials

Year	Target	Indicators	Remarks
2050	Corrosion	Carbon steel <16 µm a^{-1}; zinc < 0.9 µm a^{-1}; limestone < 6.5 µm a^{-1}	Indicator values correspond to 2.0 times current background levels
	Soiling	Loss in reflectance (<35 per cent compared to unsoiled surface after 20 years)	Tolerable value is based on replies from people confronted with photographs of different soiling levels of actual monuments
2020	Corrosion	Carbon steel <20 µm a^{-1}; zinc <1.1 µm a^{-1}; limestone <8.0 µm a^{-1}	Indicator values correspond to 2.5 times current background levels
	Soiling	Loss in reflectance (<35 per cent compared to unsoiled surface after 10 years)	ibid. 2050

Note: All indicators are calculated with dose-response functions.

Examples of what can be done

- Carbon steel
  - Dose response function (DRF)
  - Criteria in Table 13
- Soiling
  - Synthesis of several DRFs
  - Criteria in Table 13

Carbon steel, DRF

Draft mapping manual Ch4

$$R = 6.5 + 0.178[SO_2]^{0.6}Rh_{60}e^{f(T)} + 0.166Rain[H^+] + 0.076PM10$$

R	= Corrosion, µm
$[SO_2]$	= SO_2 concentration, µg m^{-3}
Rh	= Relative humidity, %
Rh_{60}	= Rh–60 (Rh>60); 0 (otherwise)
T	= Temperature, ^oC
f(T)	= 0.15(T-10) (T>10); -0.054(T-10) (otherwise)
Rain	= Amount of precipitation, mm
$[H^+]$	= H^+ concentration of precipitation, mg l^{-1}
PM10	= PM10 concentration, µg m^{-3}

Data

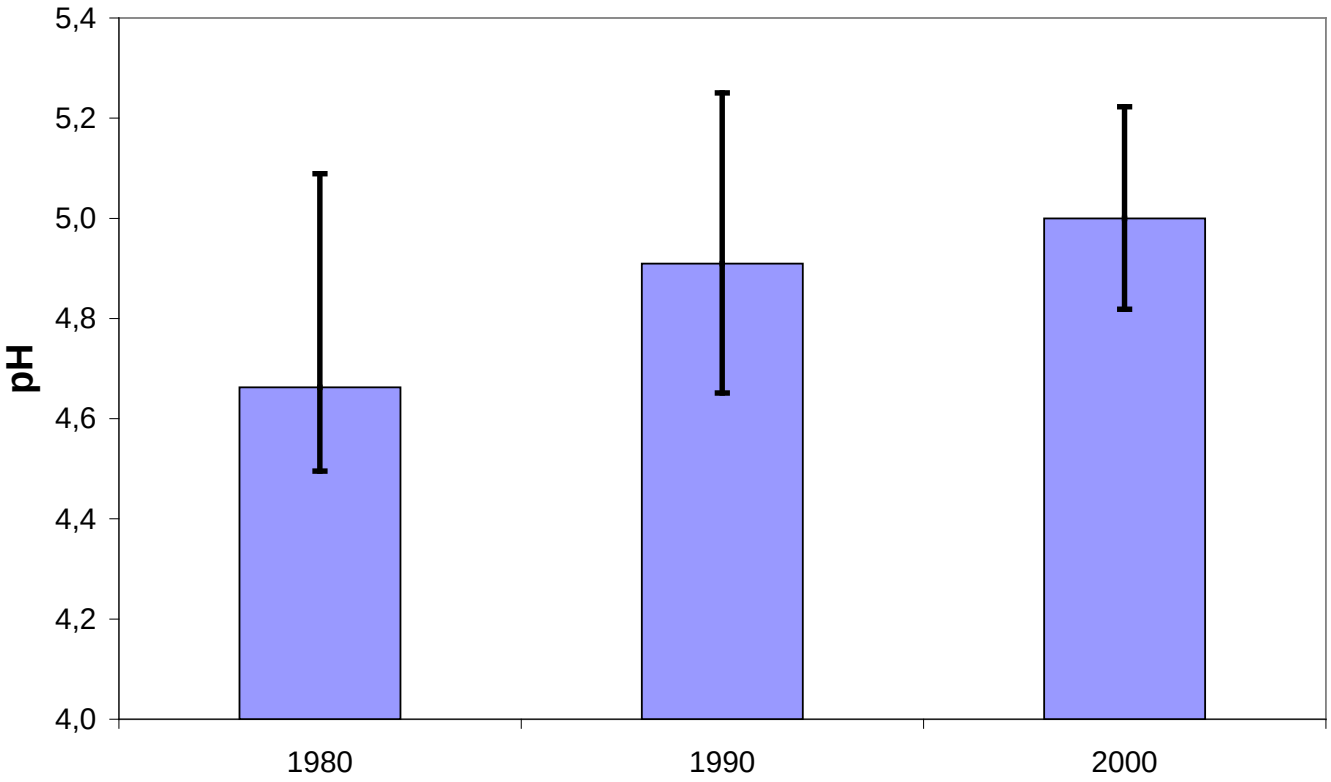
$$R = 6.5 + 0.178[SO_2]^{0.6}Rh_{60}e^{f(T)} + 0.166Rain[H^+] + 0.076PM10$$

- Climate normals (1961-1990) of T, Rh and Rain from the Climate Research Unit, University of East Anglia are used as scenario-independent variables
- H^+ is calculated from pH (2000) and used as a scenario-independent variable – more details will follow on next slide
- SO_2 and PM10 are taken from EMEP (2005) – these are the scenario-dependent variables that are needed for corrosion of carbon steel in the ex-post analysis.

pH trend

Average over the EMEP region

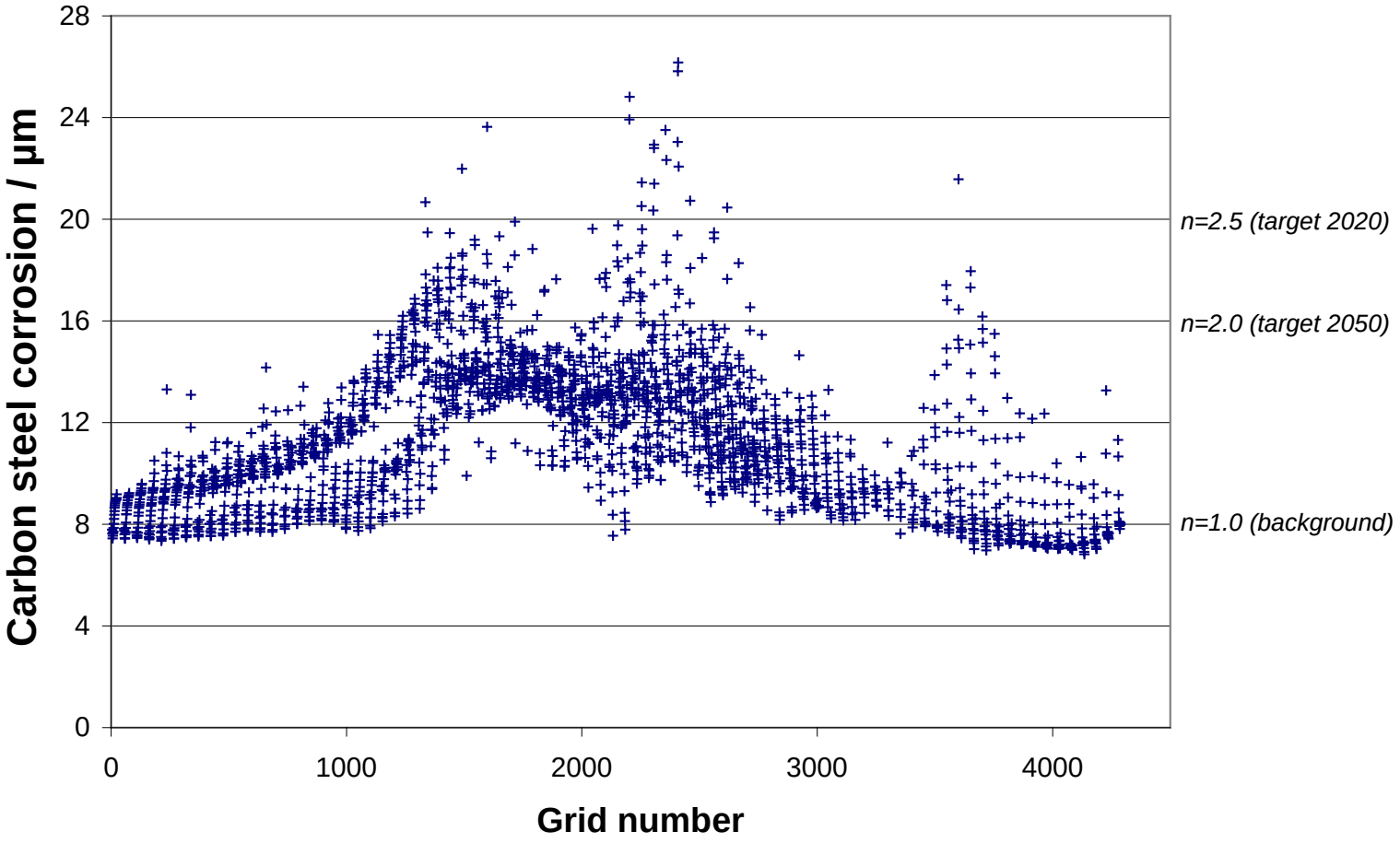
Kriging of measured station data from EMEP and other sources



- Data from 2000 taken as scenario-independent variable

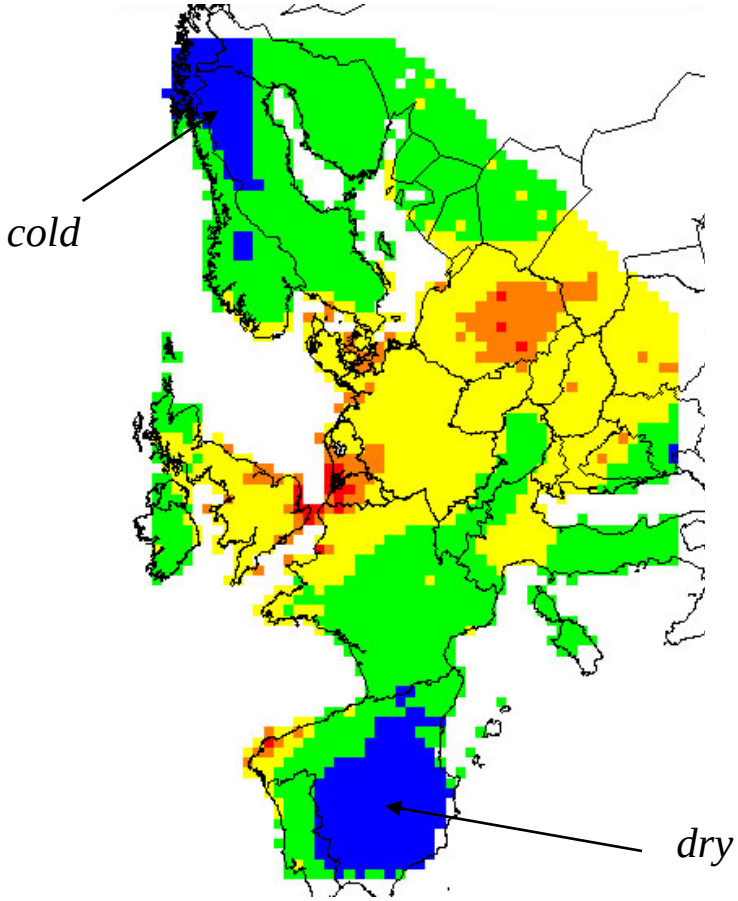
Results EMEP 2005 “scenario”

Distribution of calculated corrosion data



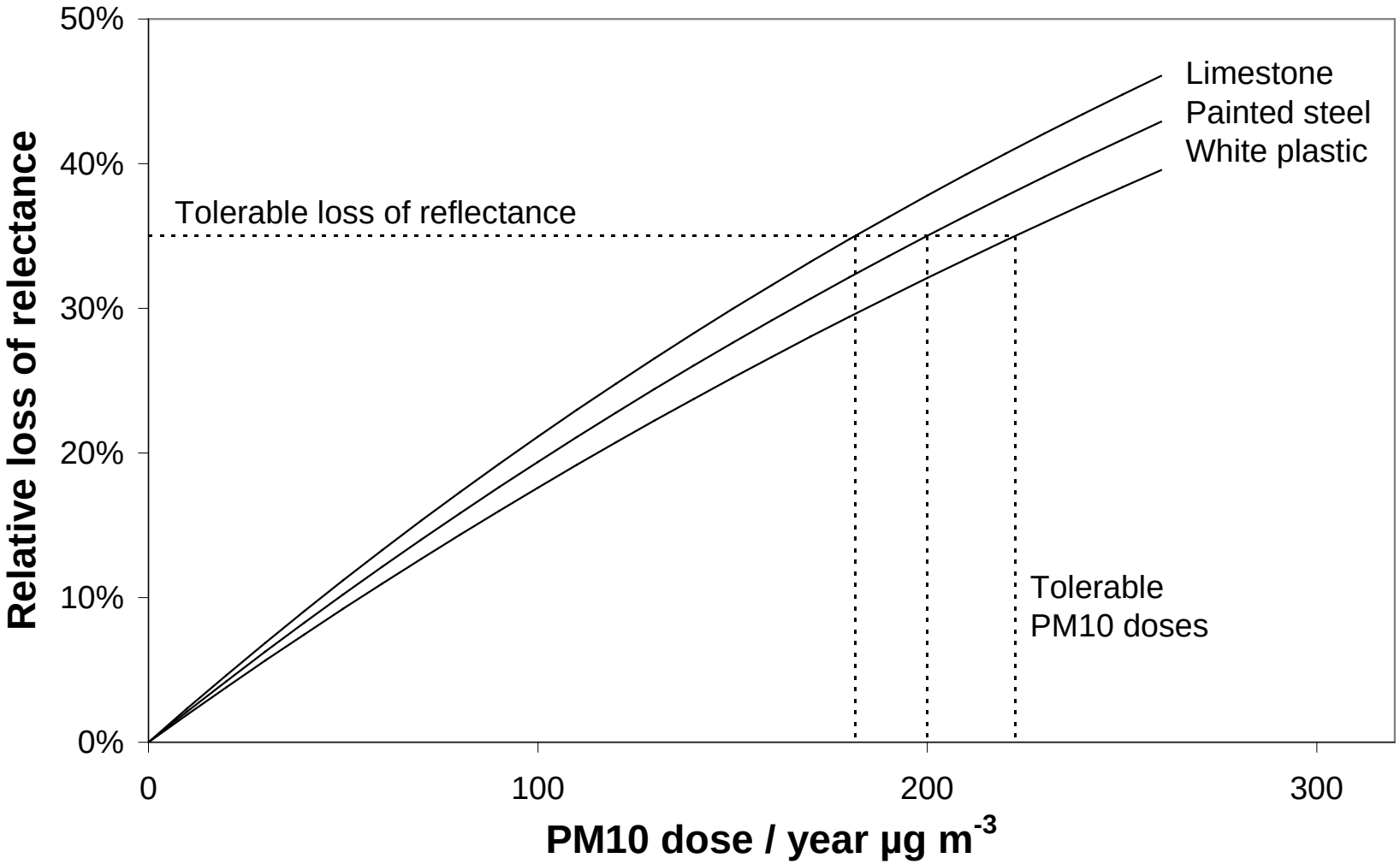
Results EMEP 2005 “scenario”

Corrosion map



- < 8 µm
- 8 – 12 µm
- 12 – 16 µm
- 16 – 20 µm (exceeding 2050 target)
- >20 µm (exceeding 2020 target)

Soiling, DRFs



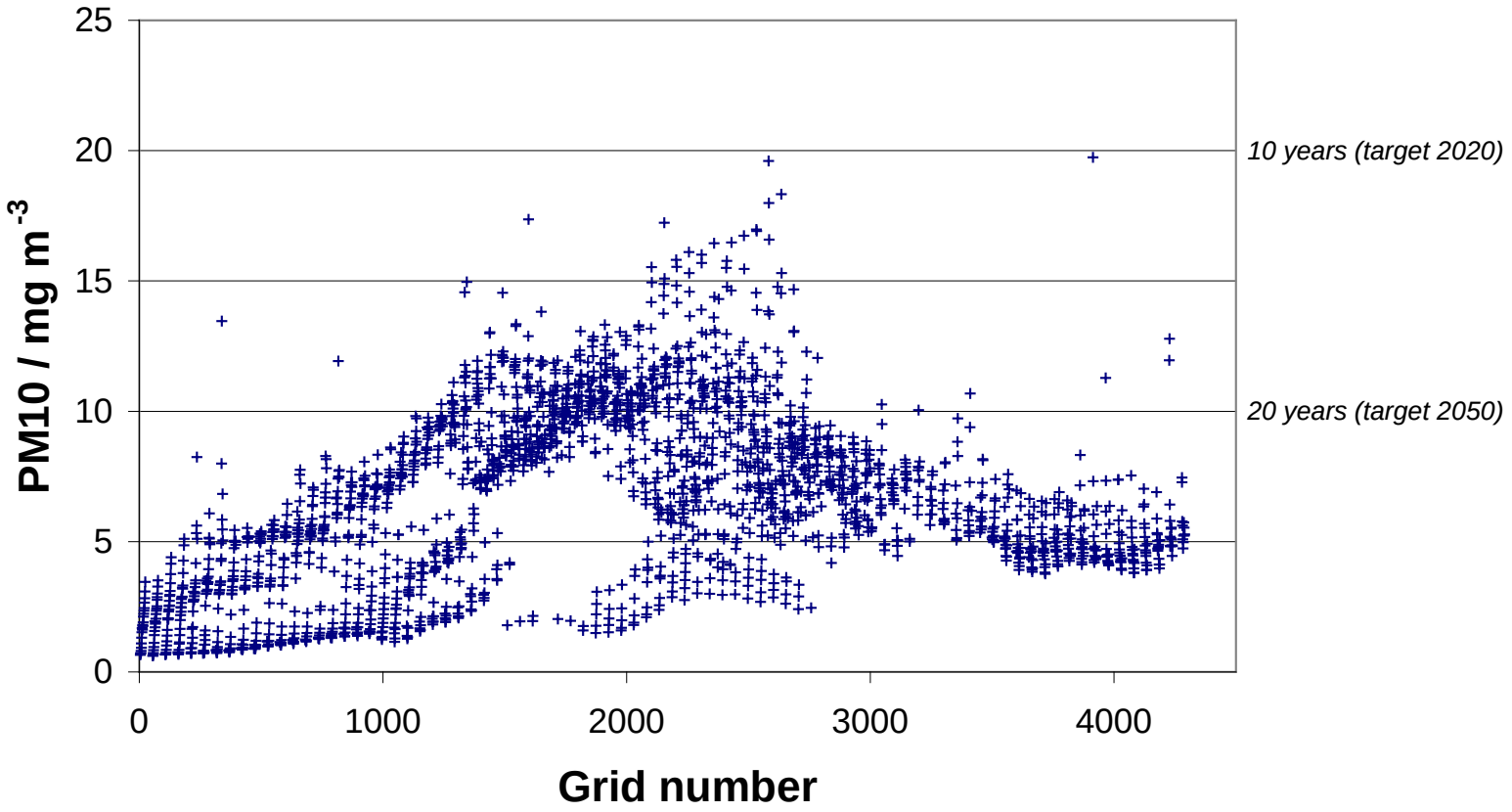
Soiling, analysis

Soiling dose = time x PM10 < 200±20 year µg m^{-3}

- ECE/EB.AIR/WG.1/2009/16, Table 13, 2020
  - time = 10 years ⇒ PM10 < 20 µg m^{-3}
- ECE/EB.AIR/WG.1/2009/16, Table 13, 2050
  - time = 20 years ⇒ PM10 < 10 µg m^{-3}

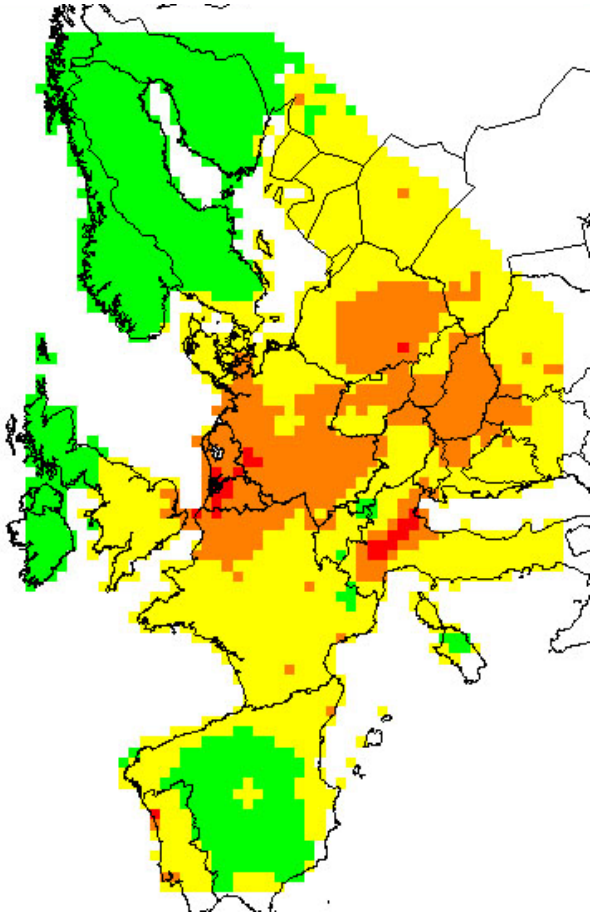
Results EMEP 2005 “scenario”

Distribution of PM10 data



Results EMEP 2005 “scenario”

Soiling (PM10) map



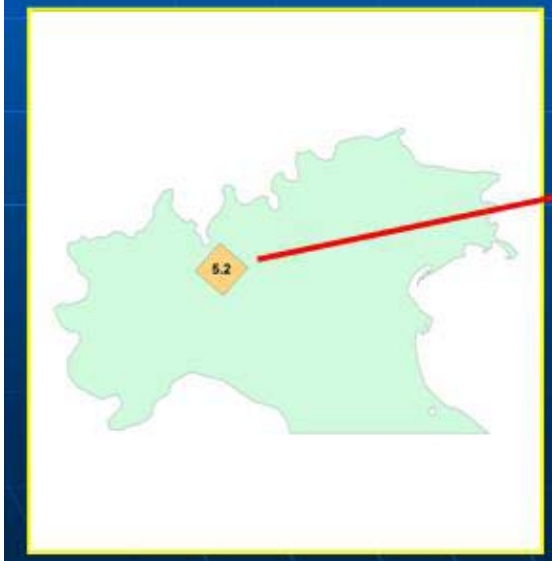
- < 5 µg m^{-3}
- 5 – 10 µg m^{-3}
- 10 – 15 µg m^{-3} (exceeding 2050 target)
- 15 – 20 µg m^{-3} (exceeding 2050 target)

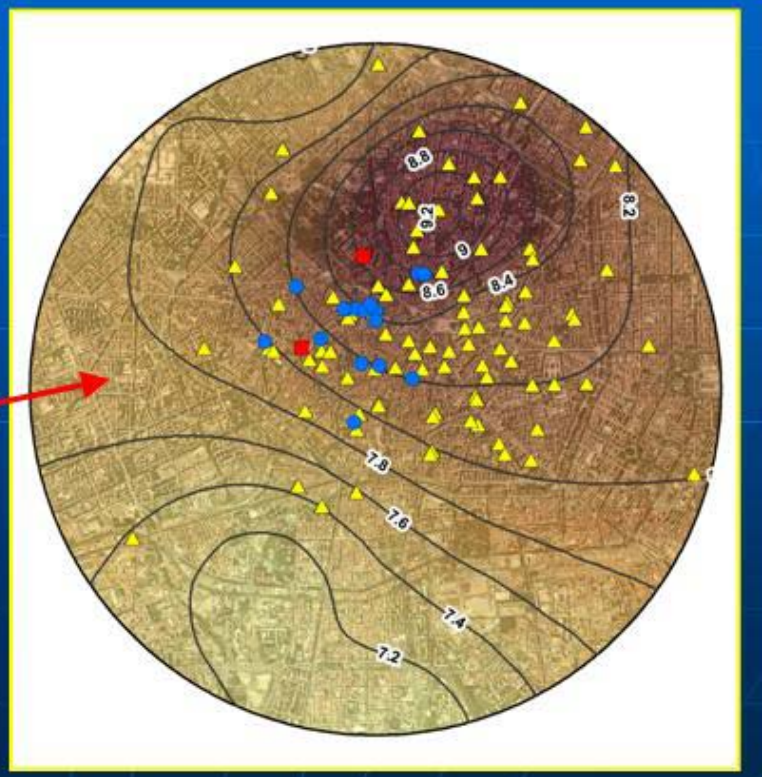
Importance of grid resolution

Map of Milan city centre

with location of the most important CH sites and Recession rate for Limestone in the year 2000. Comparision between EMEP 50x50 grid value with the local measured values.

$R=4.0+0.0059[SO_2]RH_{60}+$
$0.054Rain[H^+]+0.078[HNO_3]Rh_{60}+$
$0.0258PM_{10}$
Unit is: µm/year





Additional maps

- Corrosion maps of zinc and limestone showing areas exceeding 2020/2050 targets as specified in "Indicators and targets for air pollution effects, ECE/EB.AIR/WG.1/2009/16"
- Additional required scenario-dependent variables are NO_2 and O_3 or HNO_3
  - It is not clear at this stage if the EMEP variable "HNO3 + NO3" is equivalent to measured HNO_3 that ICP Materials use in the dose-response functions. If not, it is possible to use the HNO_3 equation in the mapping manual, which requires the parameters T, Rh, NO_2 and O_3.
- No additional scenario-independent variables are required

Summary

- ICP Materials can perform ex post analysis for the EMEP region showing areas exceeding 2020 and 2050 targets for
  - Corrosion of carbon steel, zinc and limestone
  - General soiling
- Required scenario-dependent variables are
  - SO_2 and PM10
  - HNO_3 or NO_2 + O_3
- Calculated corrosion/soiling levels based on the EMEP 50 km x 50 km grid can be an underestimation for urban areas. However, the results can be used to compare the relative effects of different scenarios.
- Climate change will introduce a bias, especially for 2050, since climate variables (T, Rh and Rain) are from the period 1961-1990. This bias can, however, be estimated.