EMEP Dispersion Modelling

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Atmosphera Congress Side event, St. Petersburg, 17.04.2012

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OUTLINE

- Short introduction to EMEP Programme (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe).
- Brief EMEP Model description.
- Source Receptor Calculation basics.
- Capacity building regarding data inventory and air pollution assessment with the EMEP and GAINS models - applied on Oblasts of the Russian Federation.

INTRODUCTION

- The European Monitoring and Evaluation Programme for Transboundary Long-Range Transported Air Pollutants (EMEP) started in 1977.
- The Convention on Long-range Transboundary Air Pollution (CLRTP) was signed in 1979.
- The main objective of the EMEP programme is to regularly provide governments and subsidiary bodies under the LRTAP Convention with qualified scientific information to support the development and further evaluation of the international protocols on emission reductions negotiated within the Convention.

INTRODUCTION (Contd.)

- The EMEP programme relies on three main elements:
  (1) collection of emission data, .
  (2) measurements of air and precipitation quality .
  (3) modelling of atmospheric transport and deposition of air pollutions.
- Four different Task Forces are included in the process of discussion and scientific exchange.
- They are:
  - The Task Force on Meaurements and Modelling (TFMM)
  - The Task Force on Emission Inventories and Projections (TFEIP)
  - The Task Force on Integrated Assessment Modellling (TFIAM)
  - Task Force on Hemispheric Transport of Air Pollutants (TFHTAP).

INTRODUCTION (Contd.)

- The co-ordination and intercalibration of chemical air quality and precipitation measurements are carried out at the Chemical Coordinating Centre (CCC) .
- The Meteorological Synthesizing Centres - West and East (MSC-W and MSC-E) are responsible for the modelling assessment.
- Integrated assessment on past modelling work, in particular the RAINS model is carried out at into the Center for Integrated Assessment Modelling (CIAM) .
- The EMEP Centre on Emission Inventories and Projections (CEIP) has the task to collect emissions and projections of acidifying air pollutants, heavy metals, particulate matter and photochemical oxidants.

The Unified EMEP Model

- The EMEP model is a chemical transport model developed at the Meteorological Synthesizing Centre - West (MSC-W) at the Norwegian Meteorological Institute (met.no)
- Designed to calculate air concentration, deposition and the long-range transport and fluxes across national boundaries for:
  acidiying and eutrophying compounds (S,N)
  ground level ozone (O_3), POPs, Heavy metals
  particulate matter ($PM_{2.5}$, PM_{10})
- The Unified EMEP model is constantly under development and is validated, reported and also constantly under revision by the Executive Body for LRTAP.

HISTORY (EMEP Grid)

- The EMEP grid system was based on a polar-stereographic projection with real area at latitude 60°N.
- From 1984 until 1997 a 150x150 km^2 grid were used.(44X37)
- In 1997, the grid resolution was changed to 50x50 km^2, while the area covered by the finer resolution EMEP grid remained unchanged.(132X111)
- In 2008, the 50x50 km^2 EMEP domain was extended to to include EECCA countries.(132x159)
- A lat-lon projection of the model is also in use now.
- EMEP global domain was also made available in 2008. Horizontal resolution is 1X1° lat-lon.

EMEP Physical Description

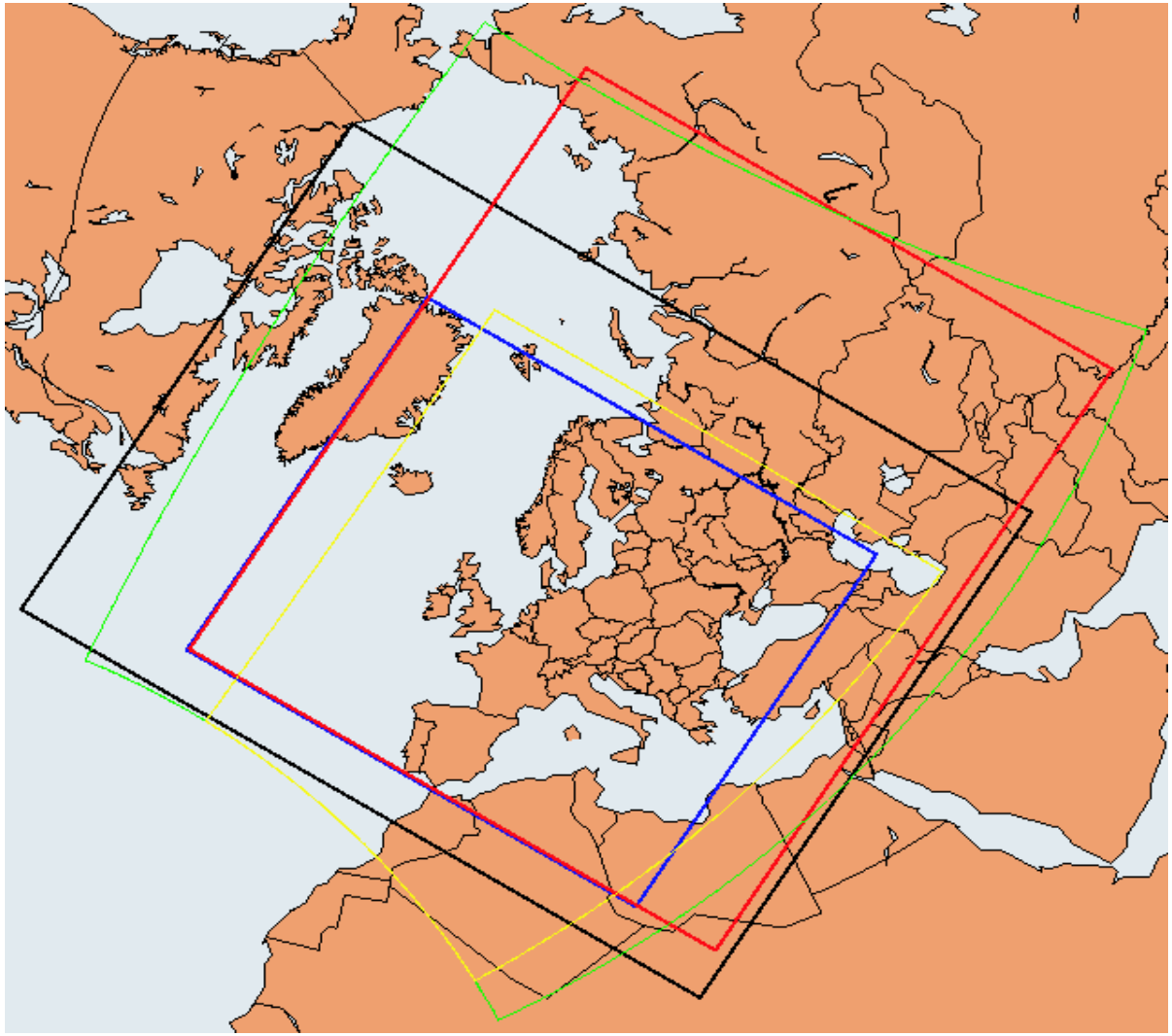
Horizontal Grid

- As per now, the available Grids are:
- EECCA50 (132x159)
- EECCA25 (264318)
- EECCA10 (560480)
- MACC02 (301x221)
- Global (360x180)

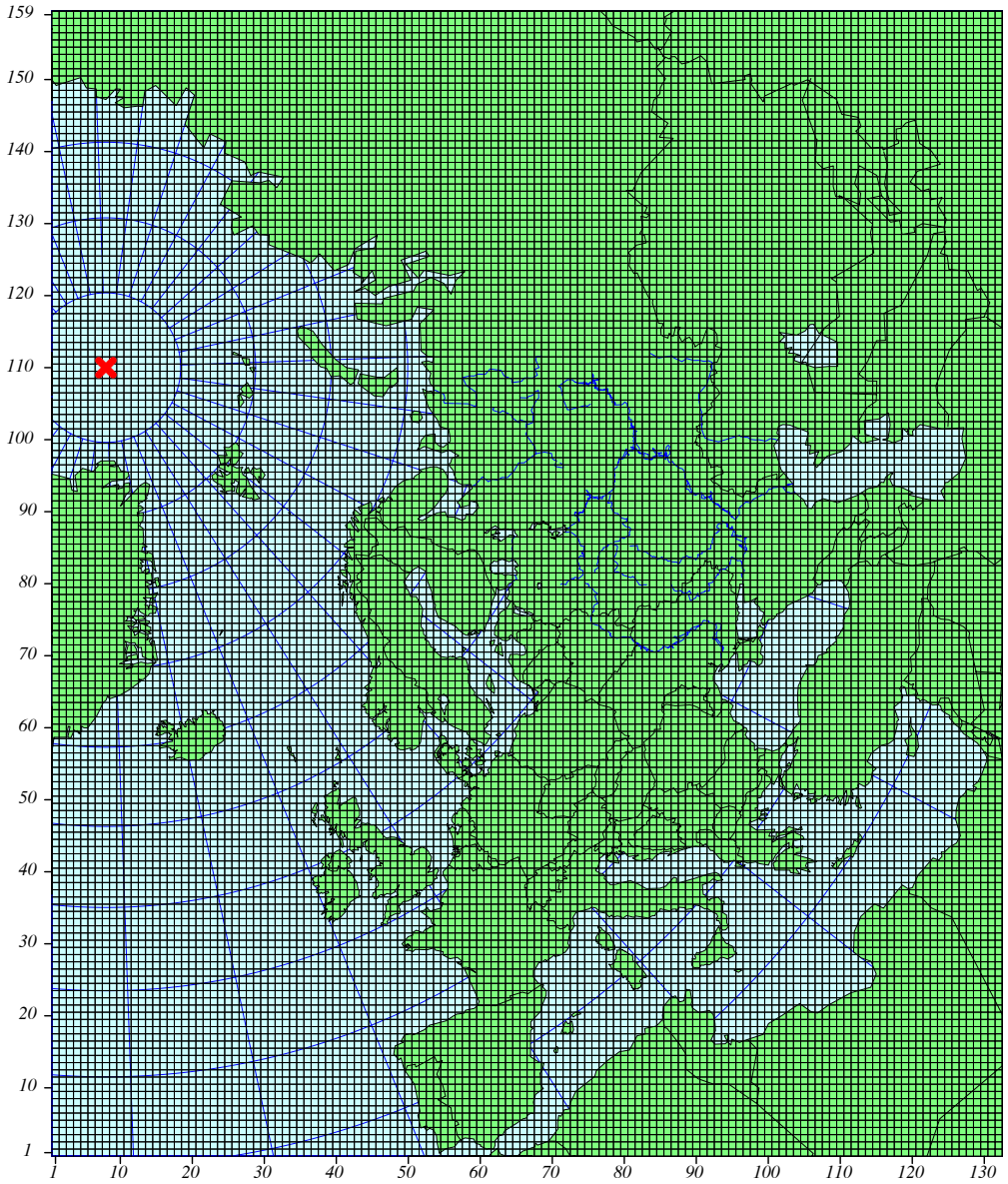
Vertical Grid

- 20 sigma levels with top at 100 mb.

EMEP Domain



EMEP Domain


159
150
140
130
120
110
100
90
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70
60
50
40
30
20
10
1
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30
40
50
60
70
80
90
100
110
120
130

INPUT DATA

Meteorology

- ECMWF Meteorology is used for all lat-lon domains with 3hr time interval.
- HIRHAM Meteorology for Polarstereographic Projection.

Boundary and Initial conditions

- Initial concentrations of major long-lived species are required in order to initialise model runs.
- This file contains concentrations of CH_3COO_2, H_2O_2, OH and O_3.

Emissions

- Gridded emissions of the 7 compounds (CO, NH_3, NO_x, $PM_{2.5}$, PM_{co}, SO_x and VOC). Data received from CEIP as country totals and compiled at MSC-W according to the EMEP requirements.
- These are provided for 10 anthropogenic and one natural source sectors called SNAP codes.

SNAP SECTORS

- Combustion in energy and transformation industries.
- Non-industrial combustion plants.
- Combustion in manufacturing industry.
- Production processes.
- Extraction and distribution of fossil fuels and geothermal energy.
- Solvent and other product use.
- Road transport.
- Other mobile sources and machinery.
- Waste treatment and disposal.
- Agriculture.
- Other sources and sinks.

Emission Maps

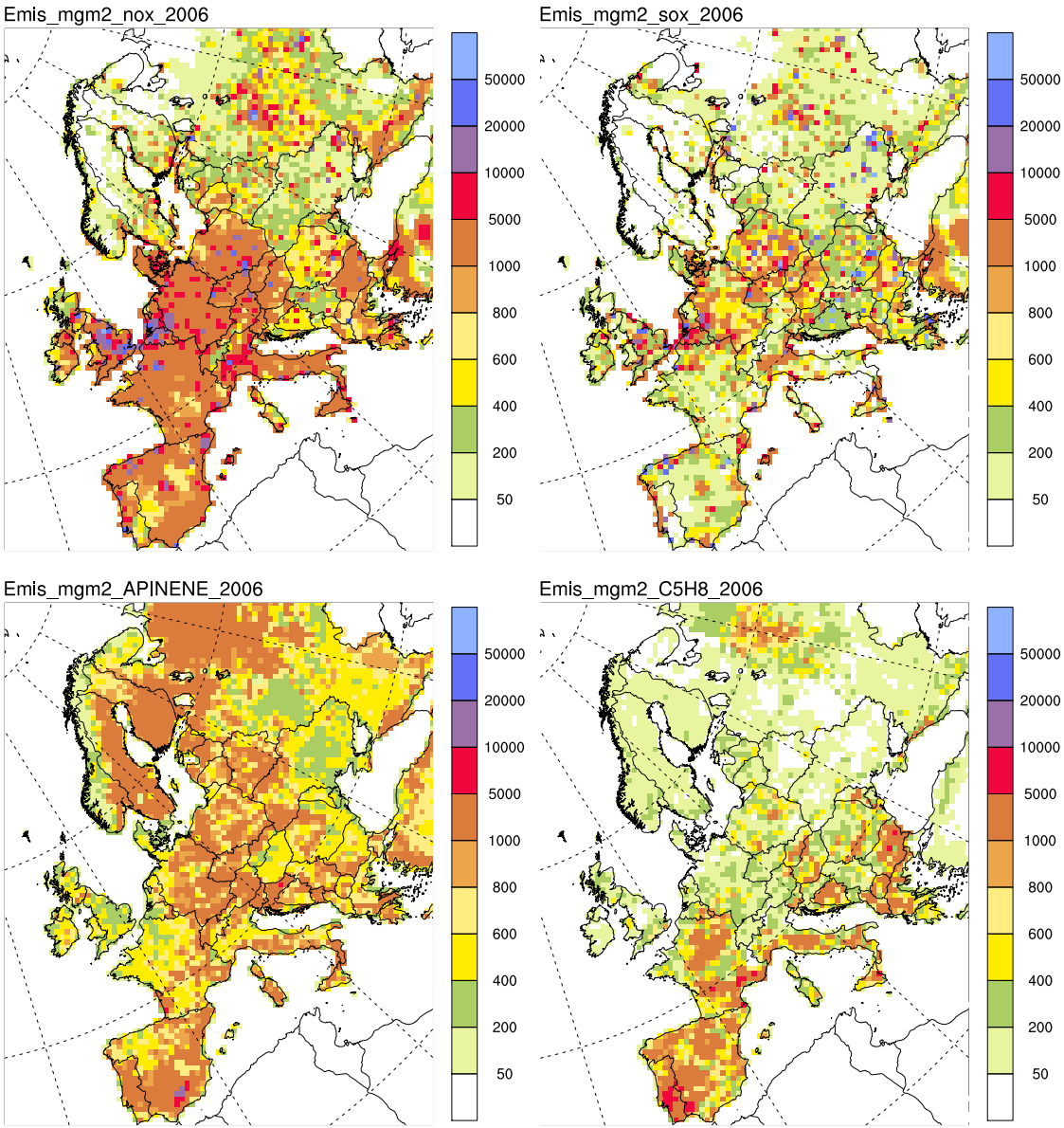


Fig. 5. Emissions of NOx, SO_2, monoterpenes (surrogate APINENE) and isoprene in the EMEP grid for the year 2006. Units: mg m^{-2}.

Post Processing and Visualisation Tools

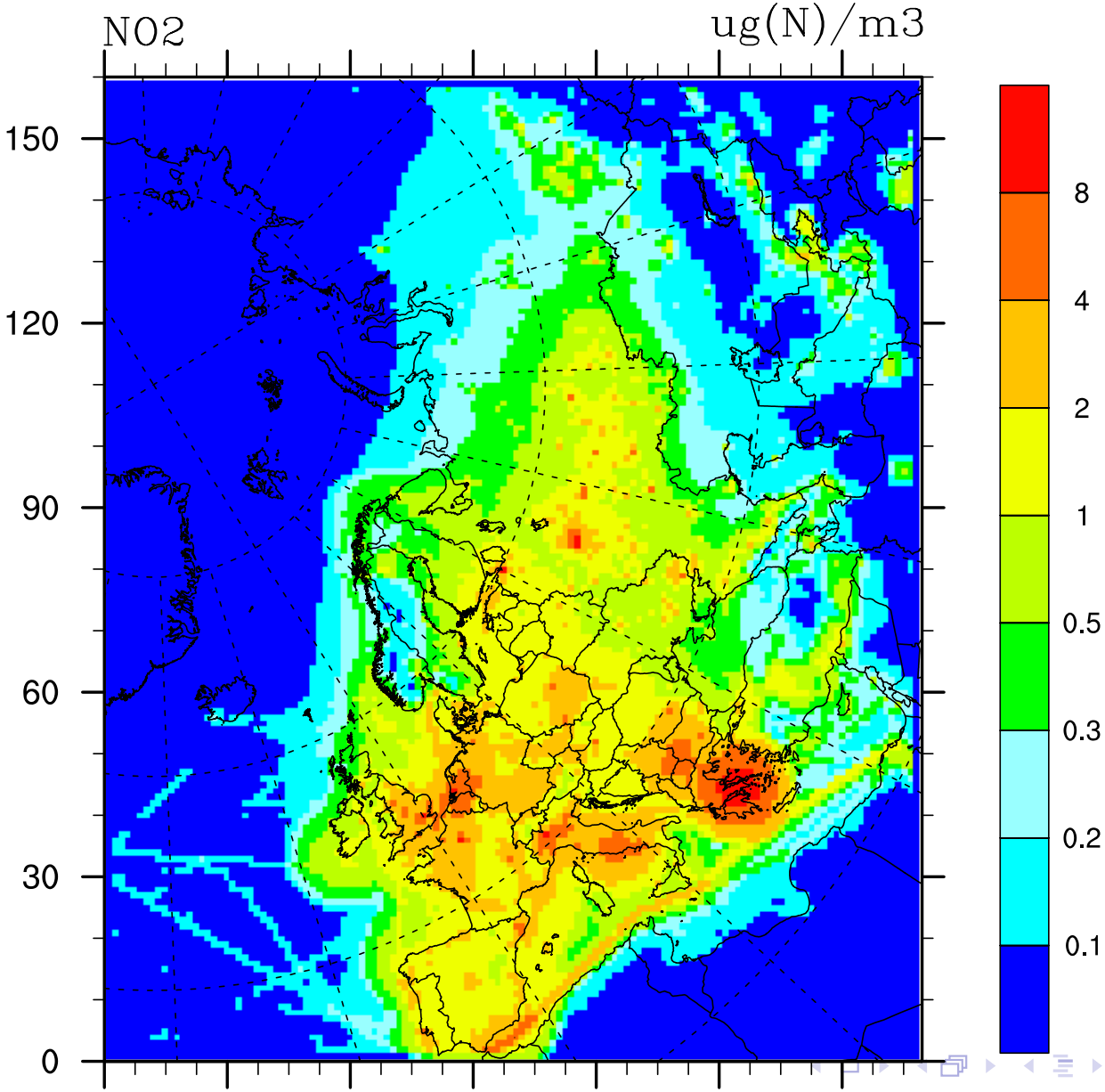
- Output data is in netCDF format.
- NCO, CDO, Perl, NCL, FERRET, GrADS.

Control Run or Base Run

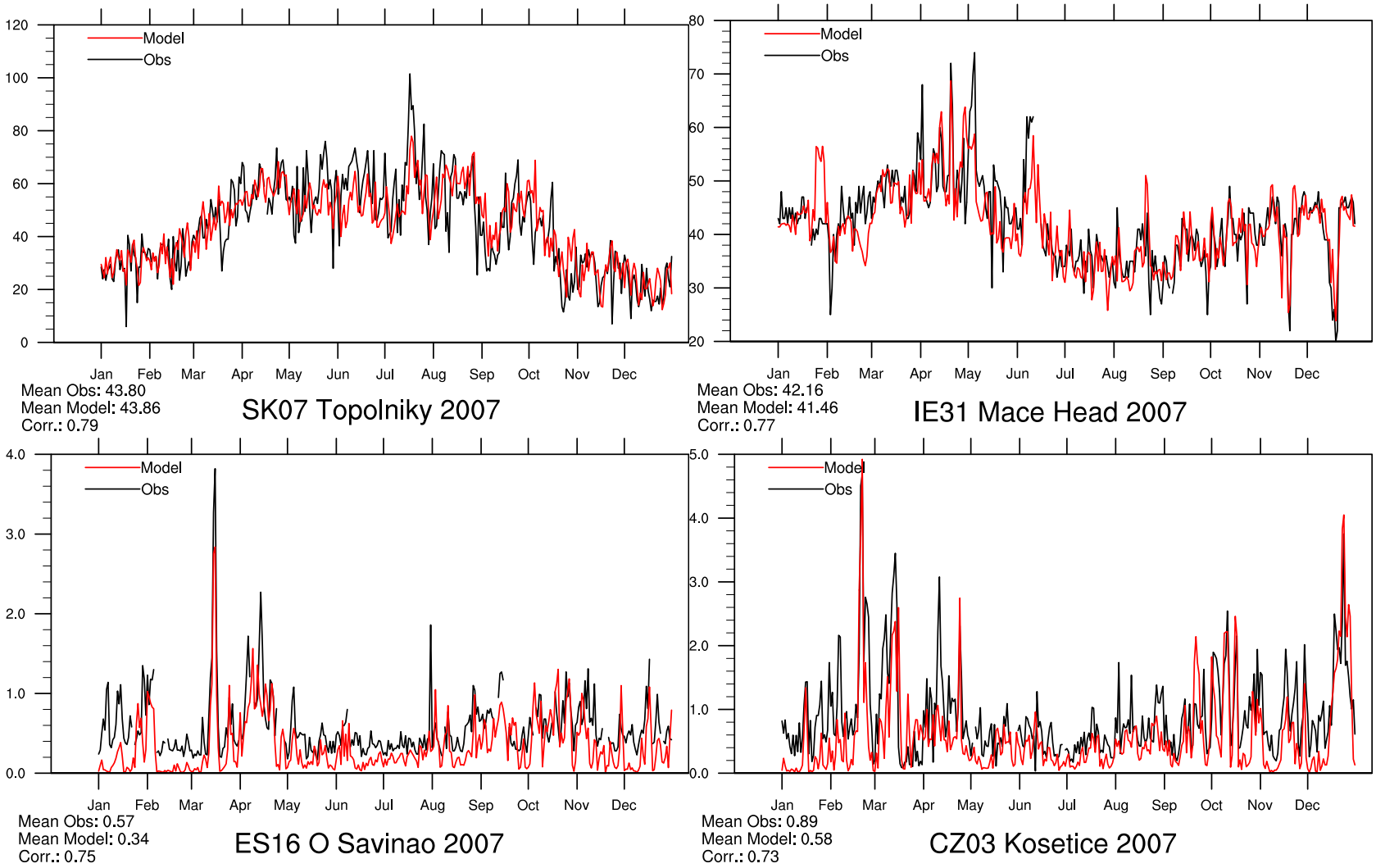
- Basic run performed with the set of input data.
- Objective is to determine the fate of emissions.

Deposition Maps

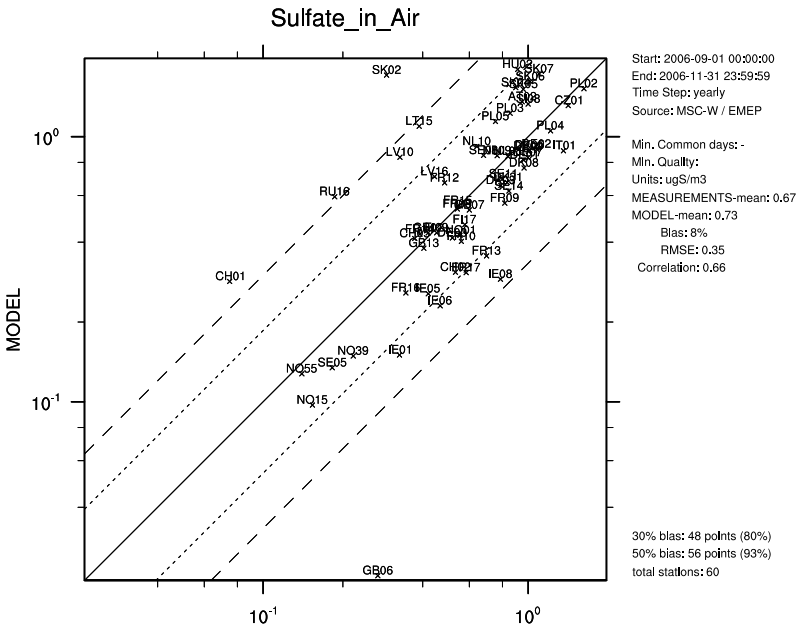
Annual mean NO_2 deposition for the year 2007

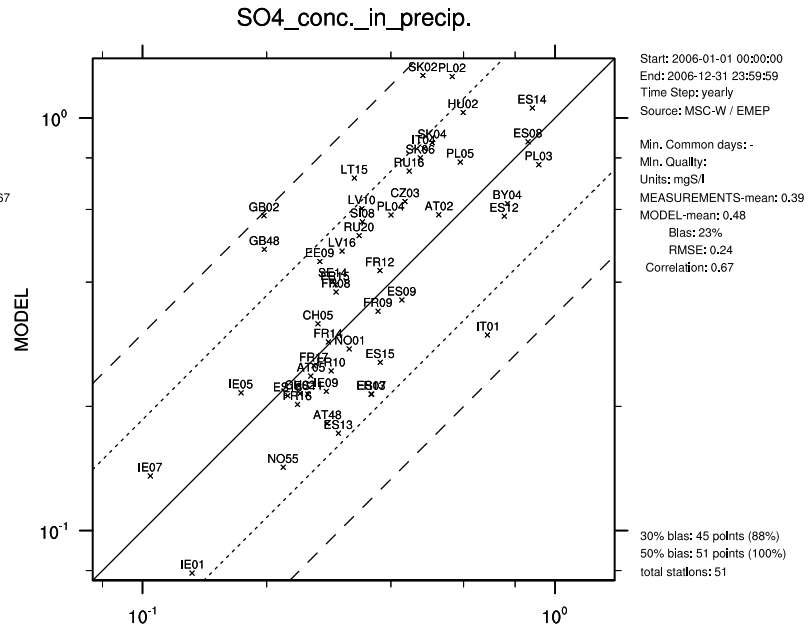


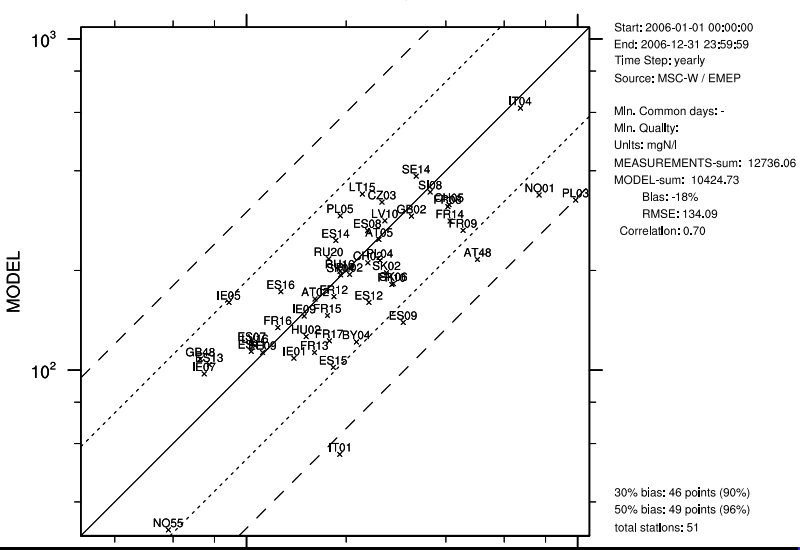
Daily time series of O_3 and NO_3

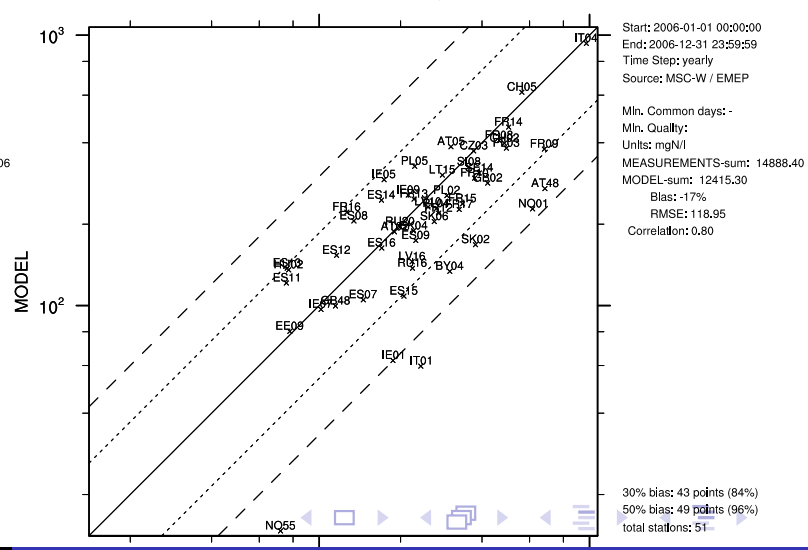


Scatter diagrams









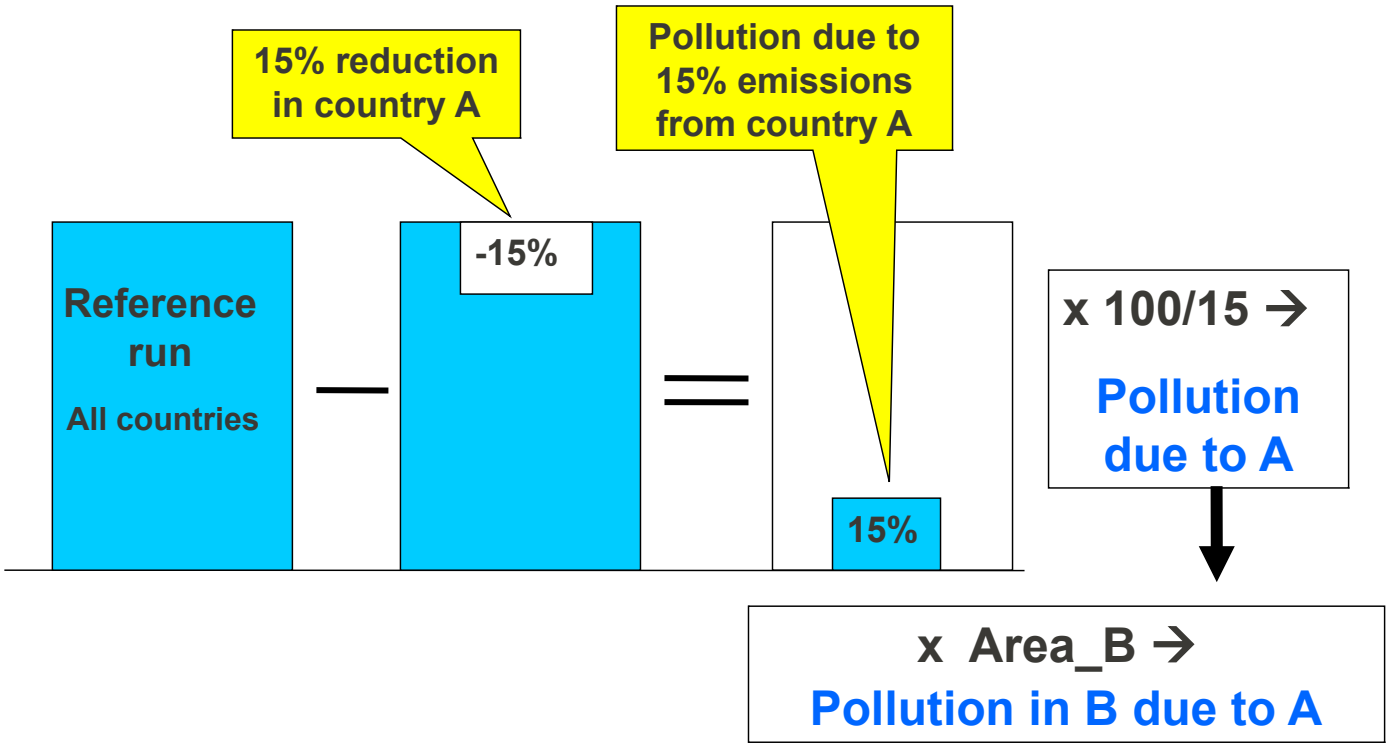
Source Receptor Calculations

- For any kind of emission there is a source and a receptor.
- Objective is to determine the fate of individual emissions, i.e., what fraction ends up where (receptor) and vice versa.

Nonlinearity test and Methodology

- A Base run for each year with full emissions (Control run)
- One run each for the pollutants S,N,A,V and P for each country with 15% reduced emissions (SR Runs)
- Scale the simulated deposition resulting from the 15% reduced emission, back to 100%

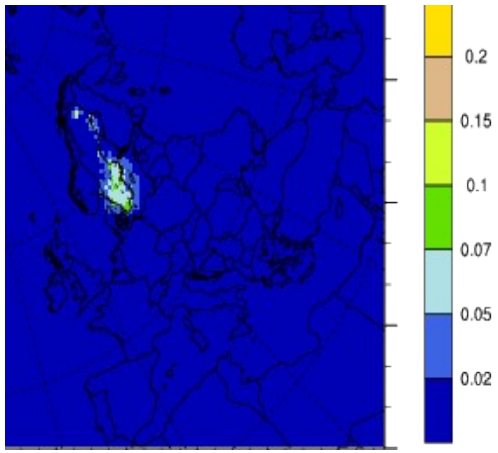
Schematic Diagram showing SR Calculations



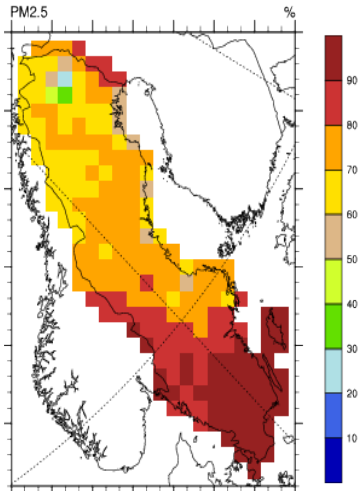
Source Receptor Calculations

PM2.5 in Sweden

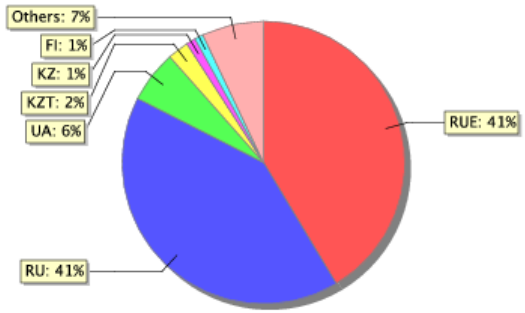
due to Swedish emissions



TB contribution



Sources of PM2.5 in Sweden



Source Receptor Calculations

	AL	AM	AT	AZ	BA	BE	BG	BY	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GE	GR	HR	HU	IE	IS	IT	KZ	LT	LU	LV	
AL	4	0	1	0	2	0	7	0	0	0	1	2	0	0	2	0	2	1	0	25	1	2	0	0	9	0	0	0	0	AL
AM	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	AM
AT	0	0	26	0	1	1	0	0	0	0	4	5	0	0	1	0	3	2	0	0	1	5	0	0	3	0	0	0	0	AT
AZ	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	AZ
BA	0	0	2	0	20	0	2	0	0	0	3	4	0	0	2	0	2	2	0	1	2	6	0	0	8	0	0	0	0	BA
BE	0	0	1	0	0	26	0	0	0	0	1	23	0	0	2	0	12	13	0	0	0	0	1	0	1	-0	0	1	0	BE
BG	0	0	1	0	2	0	28	1	0	0	1	3	0	0	1	0	1	1	0	5	1	2	0	0	3	0	0	0	0	BG
BY	0	0	0	0	0	1	1	4	0	0	1	4	1	1	0	2	2	4	0	0	0	1	0	0	1	0	1	0	0	BY
CH	0	0	3	0	0	1	0	0	19	0	1	6	0	0	2	0	7	2	0	0	0	0	0	0	6	-0	0	0	0	CH
CY	0	0	0	0	0	0	1	0	0	5	0	1	0	0	0	0	1	1	0	5	0	0	0	0	2	0	0	0	0	CY
CZ	0	0	4	0	1	1	0	0	0	0	19	7	1	0	1	0	3	4	0	0	0	2	0	0	2	0	0	0	0	CZ
DE	0	0	4	0	0	2	0	0	1	0	4	30	1	0	1	0	5	9	0	0	0	1	0	0	1	-0	0	0	0	DE
DK	0	0	1	0	0	2	0	1	0	0	2	4	16	0	1	1	4	21	0	0	0	1	1	0	1	-0	1	0	0	DK
EE	0	0	0	0	0	1	0	1	0	0	1	5	1	3	0	4	1	4	0	0	0	0	0	0	0	-0	1	0	0	EE
ES	0	0	0	0	0	0	0	0	0	0	0	2	0	0	37	0	8	3	0	0	0	0	0	0	4	0	0	0	0	ES
FI	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	7	0	2	0	0	0	0	0	0	0	0	0	0	0	FI
FR	0	0	1	0	0	2	0	0	1	0	1	5	0	0	7	0	50	7	0	0	0	0	0	0	5	0	0	0	0	FR
GB	0	0	0	0	0	1	0	0	0	0	1	4	1	0	3	0	5	39	0	0	0	0	2	0	1	-0	0	0	0	GB
GE	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	GE
GL	-0	0	0	-0	-0	0	-0	0	0	-0	0	0	0	0	0	0	0	0	-0	-0	0	0	0	0	0	0	0	0	0	GL
GR	1	0	1	0	1	0	13	1	0	0	1	2	0	0	1	0	2	1	0	24	0	2	0	0	7	0	0	0	0	GR
HR	0	0	2	0	10	1	2	0	0	0	3	5	0	0	2	0	3	3	0	1	10	8	0	0	12	0	0	0	0	HR
HU	0	0	2	0	3	1	2	1	0	0	4	6	1	0	1	0	2	3	0	1	2	32	0	0	5	0	0	0	0	HU
IE	0	0	0	0	0	1	0	0	0	0	0	2	0	0	2	0	3	16	0	0	0	0	4	0	1	-0	0	0	0	IE
IS	-0	0	0	-0	-0	0	-0	0	0	-0	0	1	0	0	0	0	1	4	-0	-0	0	0	0	0	1	0	-0	0	0	IS
IT	1	0	2	0	3	1	2	0	1	0	2	4	0	0	5	0	8	2	0	2	2	3	0	0	45	0	0	0	0	IT
KZ	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	KZ
LT	0	0	1	0	0	1	0	1	0	0	1	5	2	1	1	2	2	5	0	0	0	1	0	0	1	-0	0	0	1	LT
LU	0	0	1	0	0	2	0	0	0	0	2	30	0	0	1	0	14	9	0	0	0	0	0	0	2	-0	0	1	0	LU
LV	0	0	0	0	0	1	0	1	0	0	1	5	2	1	1	3	2	4	0	0	0	1	0	0	1	-0	-0	0	1	LV
MD	0	0	1	0	1	1	3	3	0	0	1	4	1	0	0	1	1	3	0	1	0	1	0	0	2	0	1	0	0	MD
ME	2	0	1	0	3	0	3	0	0	0	1	3	0	0	2	0	2	1	0	3	1	2	0	0	9	0	0	0	0	ME
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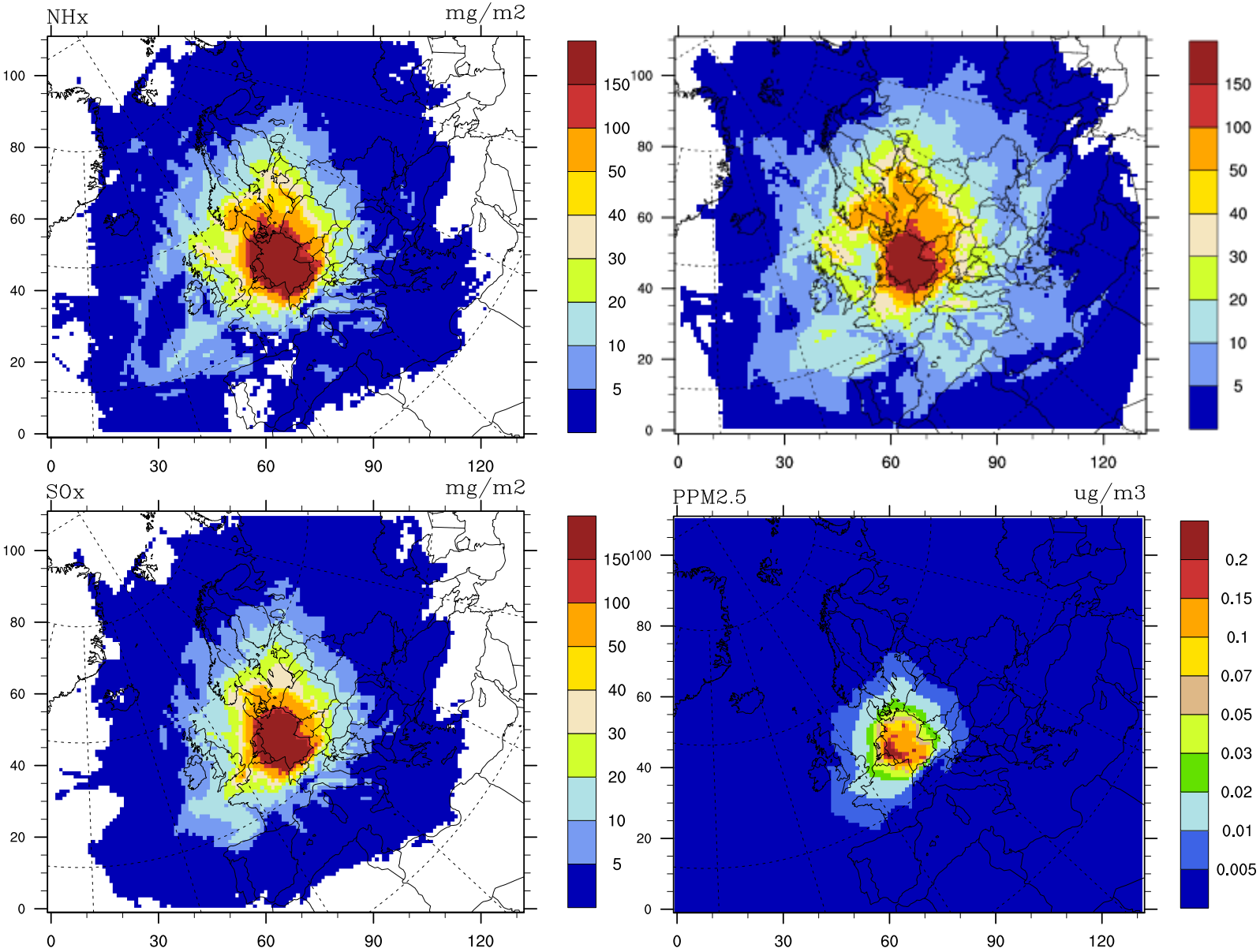
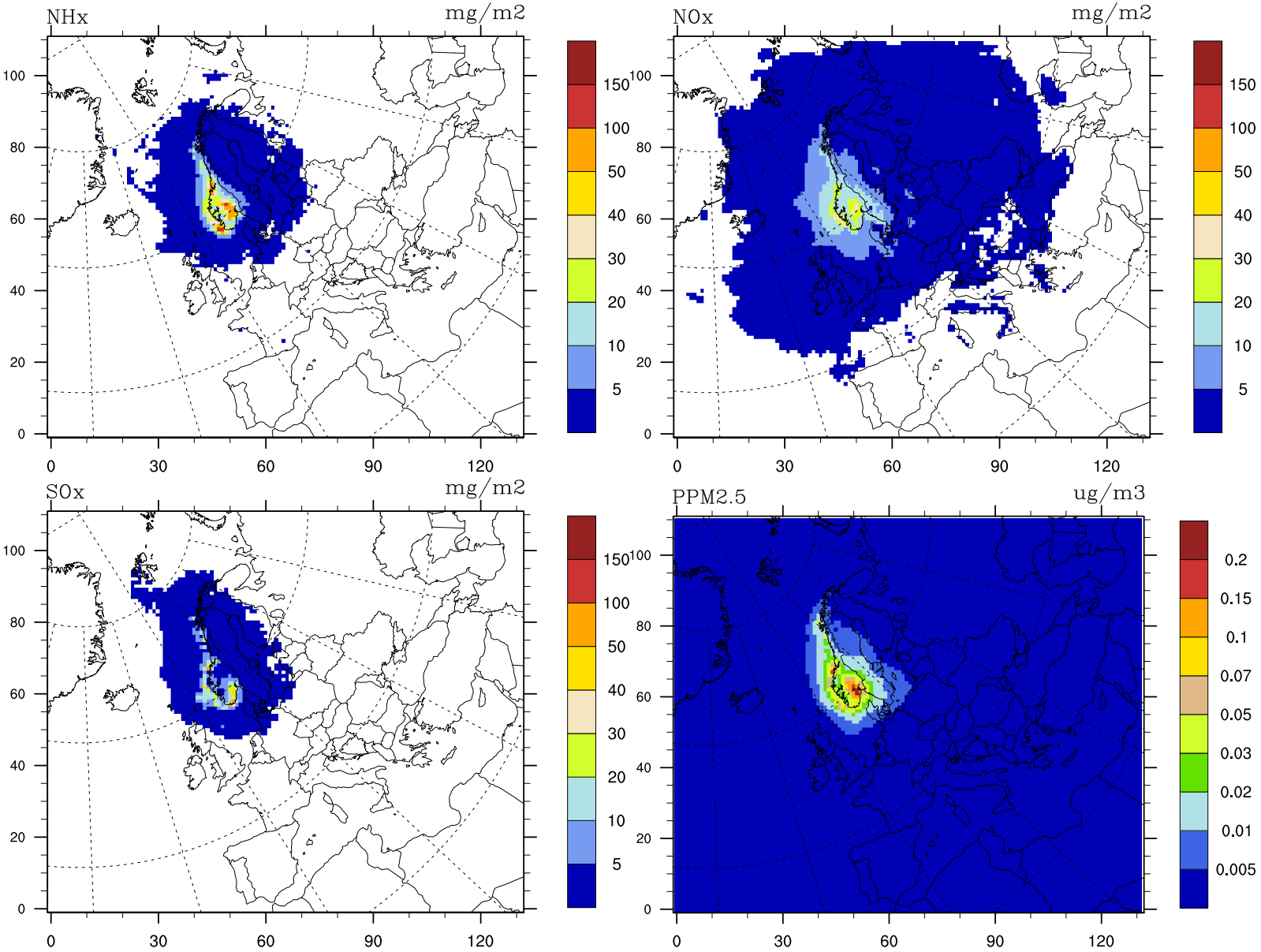
RS	0	0	2	0	6	1	8	0	0	0	3	4	0	0	1	0	2	2	0	2	1	5	0	0	5	0	0	0	0	RS
RU	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	RU
SE	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	3	1	4	0	0	0	0	0	0	0	0	0	0	0	SE
SI	0	0	4	0	3	1	1	0	0	0	3	5	0	0	2	0	3	2	0	1	11	7	0	0	9	0	0	0	0	SI
SK	0	0	2	0	1	1	1	1	0	0	4	5	1	0	1	0	2	3	0	0	1	10	0	0	3	0	0	0	0	SK
TR	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	1	1	0	2	0	0	0	0	1	0	0	0	0	TR
UA	0	0	1	0	0	1	2	2	0	0	1	4	1	0	0	1	1	3	0	1	0	1	0	0	1	0	1	0	0	UA
ATL	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	2	4	-0	0	0	0	0	0	0	0	0	0	0	ATL
BAS	0	0	0	0	0	1	0	1	0	0	1	5	3	1	1	6	3	8	0	0	0	1	0	0	1	-0	1	0	1	BAS
BLS	0	0	1	1	0	0	4	2	0	0	1	3	1	0	0	0	1	2	1	2	0	1	0	0	1	0	0	0	0	BLS
MED	1	0	1	0	2	1	3	0	0	0	1	4	0	0	9	0	11	2	0	8	1	2	0	0	23	0	0	0	0	MED
NOS	0	0	1	0	0	2	0	0	0	0	1	7	2	0	2	1	8	35	0	0	0	1	2	0	1	-0	0	0	0	NOS
ASI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	ASI
NOA	0	0	1	0	0	0	2	0	0	0	0	2	0	0	6	0	4	1	0	5	0	1	0	0	11	0	0	0	0	NOA
EMC	0	0	1	0	0	1	1	1	0	0	1	3	0	0	2	1	4	3	0	1	0	1	0	0	2	0	0	0	0	EMC
EU	0	0	2	0	1	1	1	0	0	0	2	6	1	0	7	1	10	7	0	1	0	2	0	0	6	-0	0	0	0	EU
	AL	AM	AT	AZ	BA	BE	BG	BY	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GE	GR	HR	HU	IE	IS	IT	KZ	LT	LU	LV	

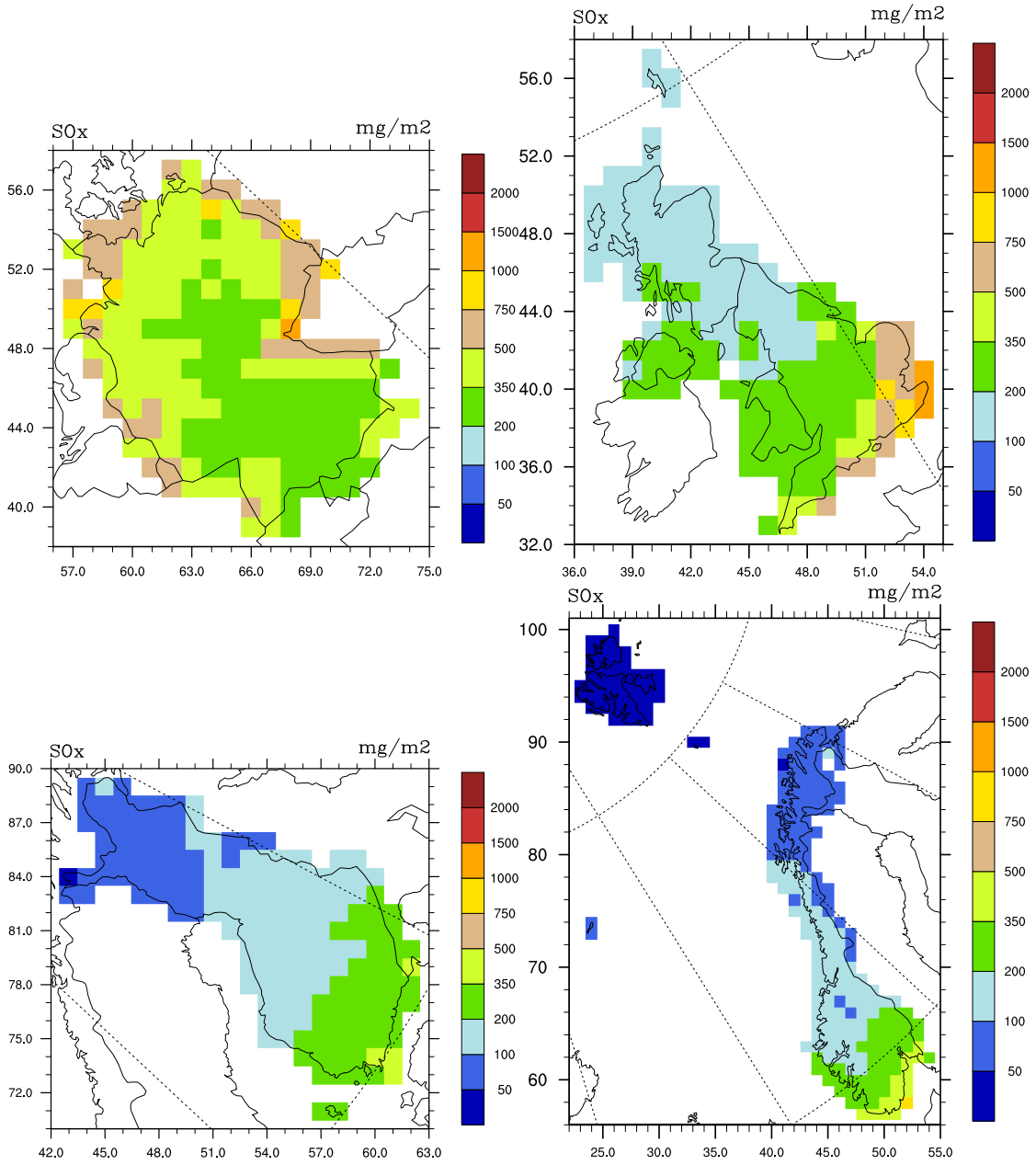
Deposition due to emissions from DE



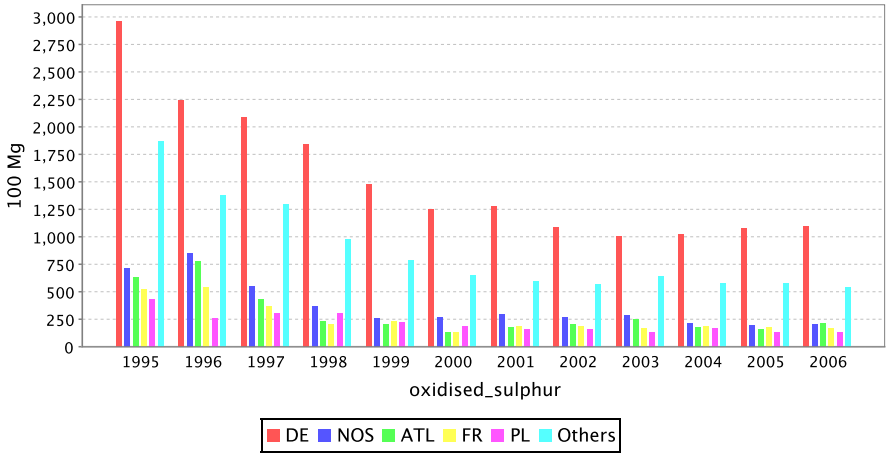
Deposition due to emissions from NO

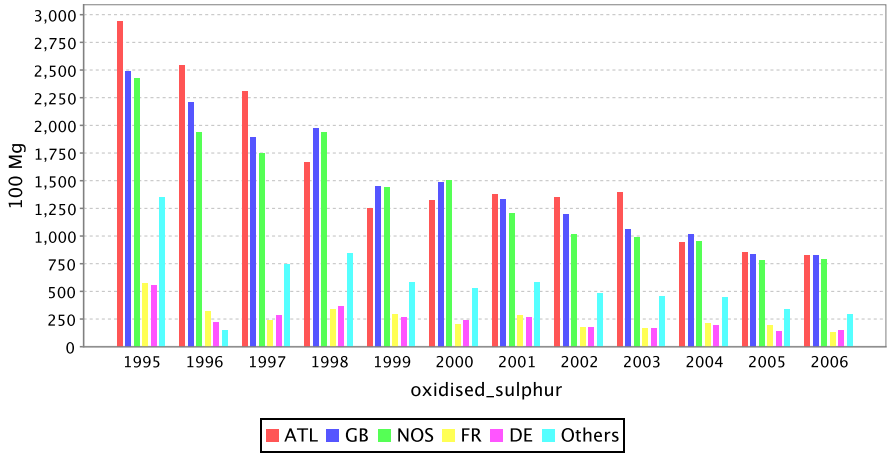


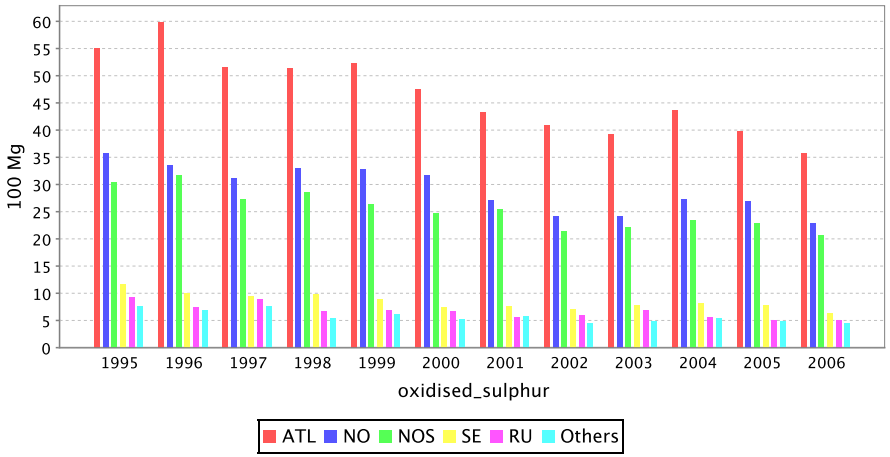
Imported to Countries

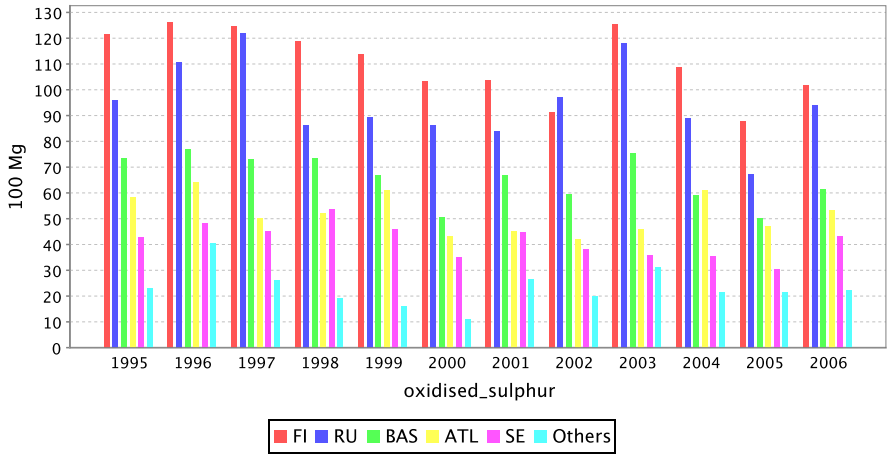


SOX Deposition Trends (DE,GB,NO,FI as Emitters)









Chemical Weather Forecasting

Monitoring atmospheric composition & climate

macc Monitoring atmospheric composition & climate

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- Source-receptor relationships (LRTAP)
- Policy-user workshops

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- Ensemble Forecasts
- Model Dossiers
- EMEP Home
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- Unified EMEP model

Unified EMEP model forecasts - test pages

Source-receptor relationship

The system for the estimation of country-allocated contributions to forecasted air pollution episodes, developed by MET.NO under WP O-POL_1, is being applied to two identified past air pollution episodes. The air pollution episodes under study, selected in coordination with WP O-POL_2 partner INERIS, are:

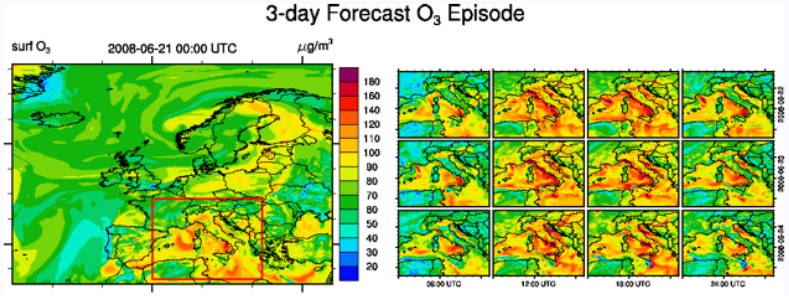
- 2008.02.10---2008.02.22: Particularly strong PM10 episode over western and central Europe
- 2008.06.21---2008.07.02: High ozone concentrations over the Mediterranean area and Balkan countries

For each episode, two sets of SR forecast ensembles have been defined:

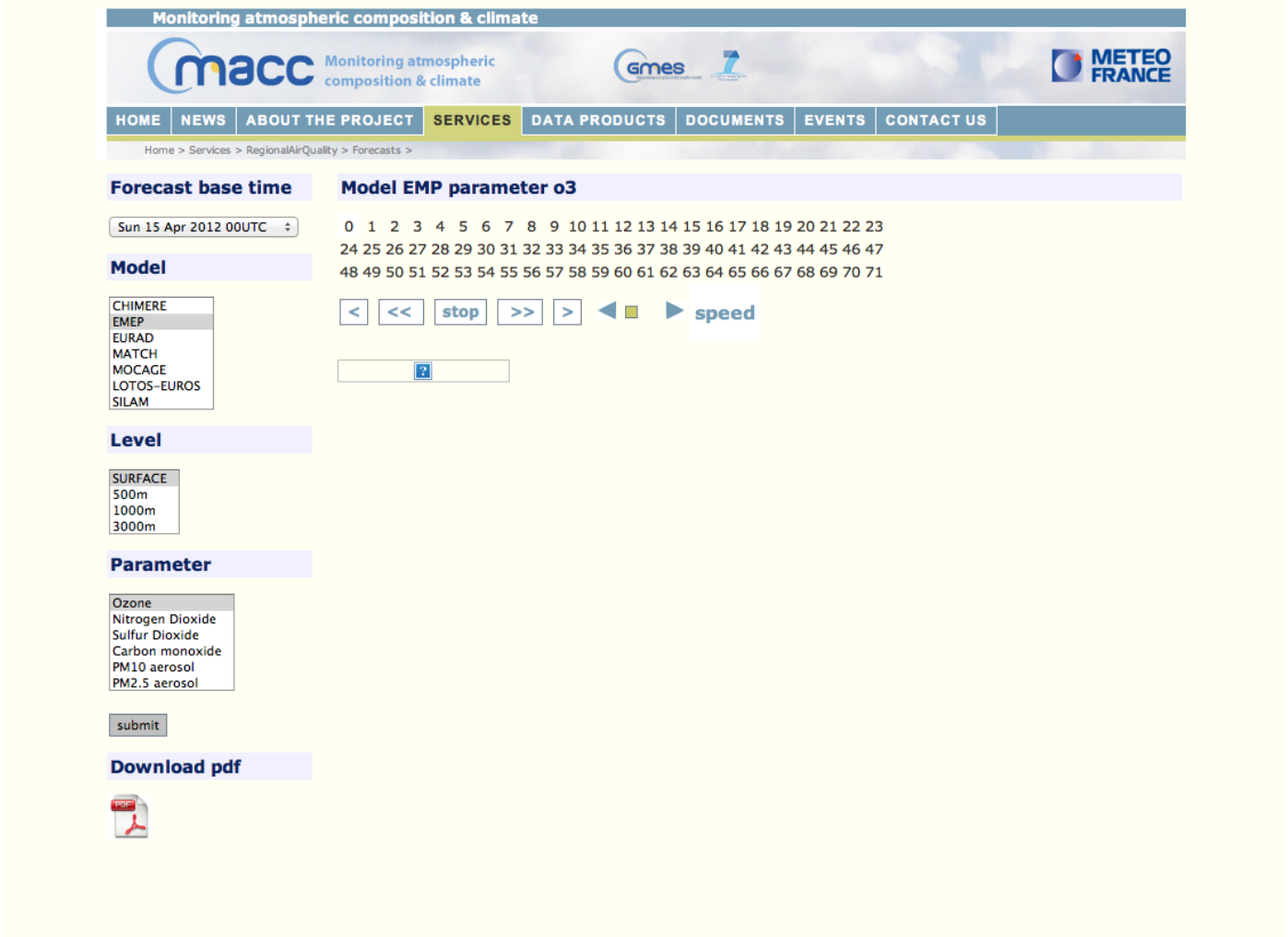
- Quick response: SR ensemble initialized at the first day of the episode. This ensemble is dedicated to identifying the potential effect of reductions implemented as soon as the episode is forecasted.
- Attribution: SR ensemble initialized 20 days before the fitst day of the episode. This ensemble is dedicated to allocating the main precursor areas, over the weeks leading to the episode.

First results

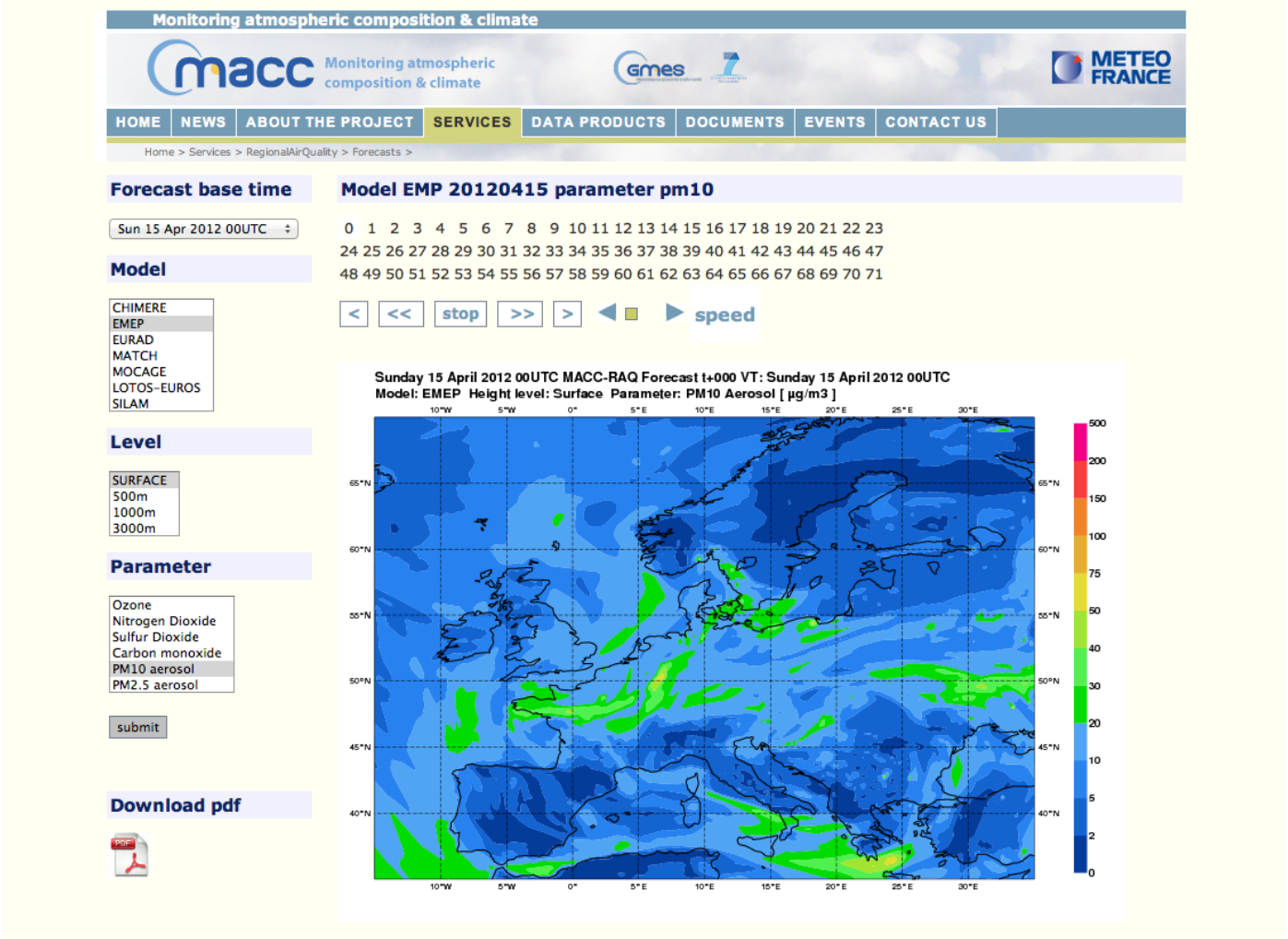
Reference simulations (base runs) have been performed for both episodes. The results form the Quick Response Ensembles (QRE) are currently under evaluation.
The figure below shows horizontal plots of the forecast of the high ozone episode regenerated with the EMEP model in the upper two panels. The right panel shows the zoomed area (receptor area) for the three days of the forecast and for different times of day. The lower left panel shows time evolutions of main pollutants in the receptor area. The contributors to the receptor area, and the time evolution of their relative contributions is shown in the lower right panel.



Chemical Weather Forecasting

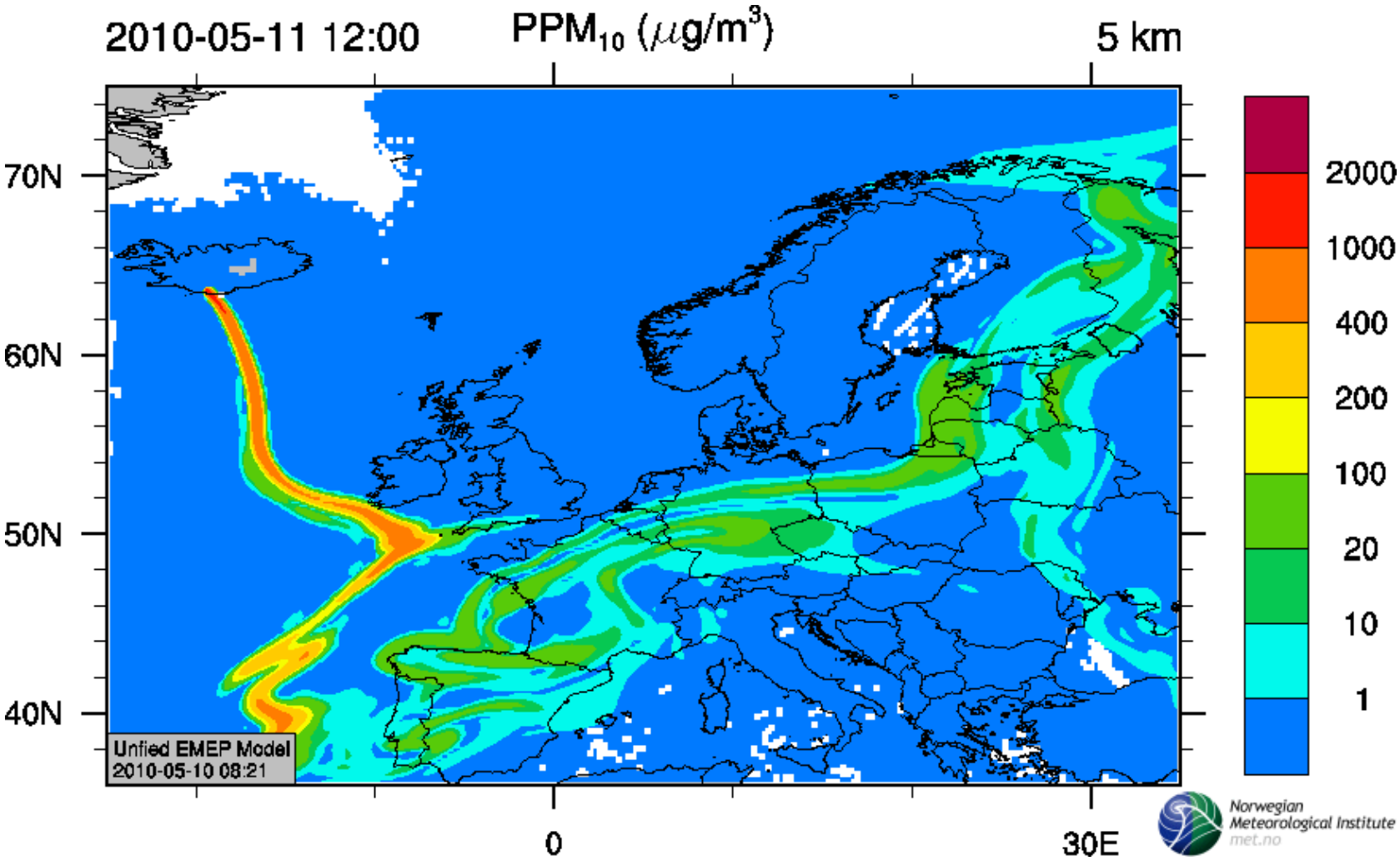


Chemical Weather Forecasting



Emergency Modelling

- Volcanic ash tracking

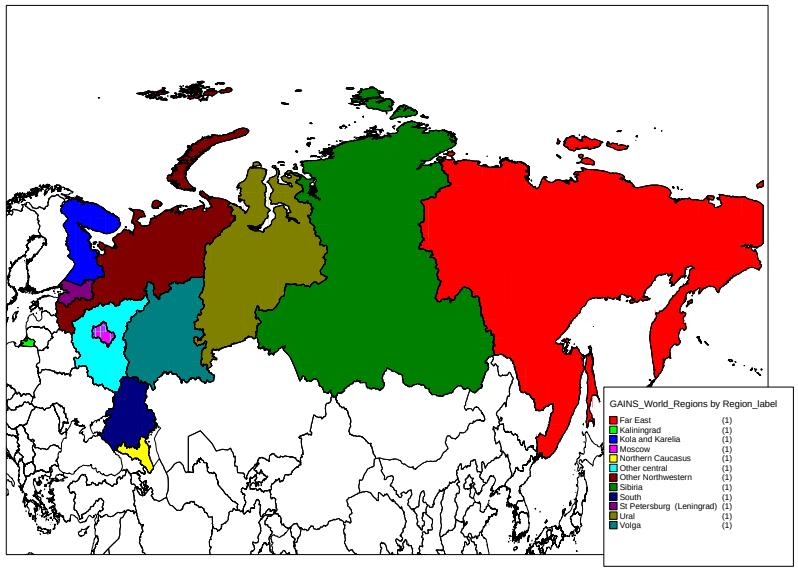


Capacity building regarding data inventory and air pollution assessment with the EMEP and GAINS models - applied on Oblasts of the Russian Federation

- This project is financed by the Nordic Council of Ministers.
- Purpose is to establish knowledge and capacity to aid Russia's work with CLRTAP.
- met.no's task is to perform dispersion modelling for selected regions of the Russian Federation.
- Meteorological year 2008
- Pollutants: SO_2,NO_x,NH_3,$PM_{2.5}$, PM_{10}, VOC

Russian subregions are:

- Moskowskaya oblast including the city of Moscow
- Central federal district excluding region 1
- Central federal district including region 1 (not included in GAINS)
- Volga federal district
- North-Western federal district
- North Causasian federal district
- Southern federal district



Tasks accomplished by met.no

- SR calculations for the 7 subregions of Russia for 6 pollutants SO_2,NO_x,NH_3,$PM_{2.5}$, PM_{10}, VOC are done for the year 2008.
- These are 30 model runs including the base runs for the corresponding SR runs.
- Data delivered to IIASA.

To do:

- SR Calculations for Urals Federal District for 6 pollutants SO_2,NO_x,NH_3,$PM_{2.5}$, PM_{10}, VOC for the meteorological year 2008.

Model developments planned for this year

- Merging the SNAP model with EMEP
- Run the SR in forecast mode.

EMEP Web: *emep.int*