EMEP Dispersion Modelling

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• 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.
• 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.
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 Measurements and Modelling (TFMM)
- The Task Force on Emission Inventories and Projections (TFEIP)
- The Task Force on Integrated Assessment Modelling (TFIAM)
- Task Force on Hemispheric Transport of Air Pollutants (TFHTAP).
• 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.
• The EMEP grid system was based on a polar-stereographic projection with real area at latitude 60°N.
• From 1984 until 1997 a 150×150 km² grid were used.(44X37)
• In 1997, the grid resolution was changed to 50×50 km², while the area covered by the finer resolution EMEP grid remained unchanged.(132X111)
• In 2008, the 50×50 km² 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.
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
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 $\text{CH}_3\text{COO}_2$, $\text{H}_2\text{O}_2$, 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.
Fig. 5. Emissions of NOx, SO2, 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

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Validations

Daily time series of O$_3$ and NO$_3$

- **SK07 Topolniky 2007**
  - Mean Obs: 43.80
  - Mean Model: 43.86
  - Corr.: 0.79

- **IE31 Mace Head 2007**
  - Mean Obs: 42.16
  - Mean Model: 41.46
  - Corr.: 0.77

- **ES16 O Savinao 2007**
  - Mean Obs: 0.57
  - Mean Model: 0.34
  - Corr.: 0.75

- **CZ03 Kosetice 2007**
  - Mean Obs: 0.89
  - Mean Model: 0.58
  - Corr.: 0.73

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Validations

Scatter diagrams

Sulfate_in_Air

Start: 2006-01-01 00:00:00
Time Step: yearly
Source: MSC-W / EMEP
Min. Common days: 49
Min. Quality: Units: µg/m³
MEASUREMENTS: mean = 0.67
MODEL: mean = 0.73
Bias: 7%
RMSE: 0.36
Correlation: 0.86

30% bias: 49 points (99%)
50% bias: 49 points (99%)
total stations: 60

SO4_conc_in_precip.

Start: 2006-01-01 00:00:00
End: 2006-12-31 23:59:59
Time Step: yearly
Source: MSC-W / EMEP
Min. Common days: 49
Min. Quality: Units: µg/m³
MEASUREMENTS: mean = 0.58
MODEL: mean = 0.48
Bias: 25%
RMSE: 0.24
Correlation: 0.67

30% bias: 49 points (98%)
50% bias: 49 points (98%)
total stations: 51

Nitrate_wet_dep.

Start: 2006-01-01 00:00:00
Time Step: yearly
Source: MSC-W / EMEP
Min. Common days: 49
Min. Quality: Units: mg/l
MEASUREMENTS: mean = 12736.05
MODEL: mean = 10480.23
Bias: 18%
RMSE: 34.32
Correlation: 0.70

30% bias: 49 points (99%)
50% bias: 49 points (99%)
total stations: 51

Ammonium_wet_dep.

Start: 2006-01-01 00:00:00
End: 2006-12-31 23:59:59
Time Step: yearly
Source: MSC-W / EMEP
Min. Common days: 49
Min. Quality: Units: mg/l
MEASUREMENTS: mean = 14488.40
MODEL: mean = 12945.50
Bias: 17%
RMSE: 11.86
Correlation: 0.80

30% bias: 49 points (99%)
50% bias: 49 points (99%)
total stations: 51

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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%
Source Receptor Calculations

Schematic Diagram showing SR Calculations

-15%
15%
All countries
15% reduction in country A
Pollution due to 15% emissions from country A
x 100/15 \rightarrow Pollution due to A
x Area_B \rightarrow Pollution in B due to A
PM2.5 in Sweden due to Swedish emissions

Sources of PM2.5 in Sweden
Deposition due to emissions from DE

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Deposition due to emissions from NO

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Imported to Countries

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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_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 first 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.

3-day Forecast O₃ Episode
Chemical Weather Forecasting

Model EMP 20120415 parameter pm10

Forecast base time: Sun 15 Apr 2012 00UTC

Model:
- CHEMERE
- EMER
- EURAD
- MATCH
- MOGAGE
- LOTOS-EUROS
- SELAM

Level:
- SURFACE
- 500m
- 1000m

Parameter:
- Ozone
- Nitrogen Dioxide
- Sulfur Dioxide
- Carbon monoxide
- PM10 aerosol
- PM2.5 aerosol

Download pdf

Sunday 19 April 2012 00 UTC MACC-RAQ Forecast t=000 VT: Sunday 19 April 2012 00 UTC
Model: EMER Height level: Surface Parameter: PM10 Aerosol [µg/m³]
Emergency Modelling

- Volcanic ash tracking
• 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 Caucasian federal district
- Southern federal district
Tasks accomplished by met.no

- SR calculations for the 7 subregions of Russia for 6 pollutants $\text{SO}_2, \text{NO}_x, \text{NH}_3, \text{PM}_{2.5}, \text{PM}_{10}, \text{VOC}$ 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 $\text{SO}_2, \text{NO}_x, \text{NH}_3, \text{PM}_{2.5}, \text{PM}_{10}, \text{VOC}$ 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