Emissions in the EMEP MSC-W model

Ágnes Nyíri
MSC-W

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EMEP MSC-W model

- Multi-layer Eulerian dispersion model to simulate long-range transport of air pollution
- Performs model calculations in support of the CLRTAP (Convention on Long Range Trans-boundary Air Pollution) for more than 30 years
- Used in a wide range of scientific and air pollution policy context
- Typically applied to tackle problems within the fields of acid deposition, tropospheric ozone and particles
Standard EMEP emission input

- **Gridded annual emissions**
  - Provided by CEIP based on emission data reported under the LRTAP Convention and NEC Directive
  - NOx, SOx, NH3, NMVOC, CO, PMco, PM2.5
  - 50 x 50 km² polar stereographic (PS) projection, http://www.emep.int/grid/EMEP_domain.pdf
  - 10 anthropogenic SNAP source-sectors
  - New resolution, projection and sector system from 2013 (0.1° x 0.1° lon-lat, GNFR sectors)
## SNAP source-sectors

<table>
<thead>
<tr>
<th>SNAP 1</th>
<th>Combustion in energy and transformation industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNAP 2</td>
<td>Non-industrial combustion plants</td>
</tr>
<tr>
<td>SNAP 3</td>
<td>Combustion in manufacturing industry</td>
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<tr>
<td>SNAP 4</td>
<td>Production processes</td>
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<tr>
<td>SNAP 5</td>
<td>Extraction and distribution of fossil fuels and geothermal energy</td>
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<td>SNAP 6</td>
<td>Solvent use and other product use</td>
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<td>SNAP 7</td>
<td>Road transport</td>
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<tr>
<td>SNAP 8</td>
<td>Other mobile sources and machinery</td>
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<tr>
<td>SNAP 9</td>
<td>Waste treatment and disposal</td>
</tr>
<tr>
<td>SNAP 10</td>
<td>Agriculture</td>
</tr>
<tr>
<td>SNAP 11</td>
<td>Other sources and sinks</td>
</tr>
</tbody>
</table>
Current EMEP domain

Grid indexes used in emission files, counting starts at the lower-left corner of the grid domain.
Example of emission data

- Official NOx emissions for 2010 over the extended EMEP domain in 50 x 50 km² PS projection
Standard EMEP emission input

- Requirements/wishes for improvements
  - As complete and reliable emission data reporting as possible
  - Better documentation/explanation of significant changes in emission totals and spatial distribution (e.g. NH3 in UA is 187Gg in 2009, 25Gg in 2010)
  - Emission trends from international shipping should reflect introduction of SECAs in certain years
  - Emissions from national shipping not always reported, can not be distinguished from other mobile sources
Emissions in the model

- Vertical distribution
  - Default distribution based upon SNAP sectors

<table>
<thead>
<tr>
<th>No.</th>
<th>Sources</th>
<th>Height of Emission Layer (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-92</td>
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<tr>
<td>1</td>
<td>Combustion in energy and transformation industries</td>
<td></td>
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<tr>
<td>2</td>
<td>Non-industrial combustion plants</td>
<td>100(a)</td>
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<td>4</td>
<td>Production processes</td>
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<td>5</td>
<td>Extraction and distribution of fossil fuels and geothermal energy</td>
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<tr>
<td>6</td>
<td>Solvents and other product use</td>
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<td>7</td>
<td>Road transport</td>
<td>100</td>
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<td>8</td>
<td>Other mobile sources and machinery</td>
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<tr>
<td>9</td>
<td>Waste treatment and disposal</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Agriculture</td>
<td>100</td>
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</tbody>
</table>

Notes: (a) Up to version rv4β SNAP-2 was split 90% into the lowest layer, then 10% in the next lowest.
Emissions in the model

- **Vertical distribution**
  - Distribution is originally based upon plume-rise calculations *(Vidic, 2002)*
  - Simplified and adjusted to reflect recent findings *(Bieser et al., 2011; Pregger and Friedrich, 2009)*
  - SNAP2 now reflects the dominance of domestic combustion in this source sector having all emissions in the lowest model level
  - **Possibilities for improvements**
Emissions in the model

- **Temporal distribution**
  - Monthly and day-of-week time factors specific to pollutant, country and SNAP source-sector
  - Based on data from the GENEMIS project (Friedrich and Reis, 2004)
  - For SNAP2 day-of-year time distribution using degree-day factors (function of daily temperatures in grid cells) reflecting that domestic heating varies with temperature
  - Hourly time factors specific to day-of-week and SNAP source-sector (B. Bessagnet, INERIS)

- **Possibilities for improvements**
Emissions in the model

- Chemical speciation
  - Some emission files include a group of compounds (e.g. NOx, SOx, NMVOC, PMs)
  - Default splits are applied normally for each SNAP source-sector
  - More detailed specification (e.g. for particular countries or SNAP sectors) can also be treated in the model
  - Possibilities for improvements
Emissions in the model

- **VOC speciation**
  - Specified for each SNAP source-sector
  - “Lumped molecule” approach (e.g. o-xylene represents all aromatic species)
  - Derived from UK speciation (Passant, 2002)

<table>
<thead>
<tr>
<th>SNAP</th>
<th>C2H6</th>
<th>NC4H10</th>
<th>C2H4</th>
<th>C3H6</th>
<th>C5H8</th>
<th>OXYL</th>
<th>CH3OH</th>
<th>C2H5OH</th>
<th>HCHO</th>
<th>CH3CHO</th>
<th>MEK</th>
<th>GLYOX</th>
<th>MGLYOX</th>
<th>UNREAC</th>
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<td>100.000</td>
</tr>
</tbody>
</table>
Possibilities to improve the use of emissions in the model

- Information from countries on
  - Vertical distribution (emission heights)
  - Temporal distribution (time factors)
  - Chemical speciation of grouped compounds, e.g. VOC and PM
Other emission sources

- **Aircraft**
  - NOx emissions from aircraft from QUANTIFY
  - [www.pa.op.dlr.de/quantify](http://www.pa.op.dlr.de/quantify)
  - Calculated on annual basis and distributed to monthly files according to seasonal variation
  - Spatial resolution 1° x 1°x 610m, interpolated to correct grid during model run

- **Road dust**
  - PM emissions from road traffic
  - Methodology and code from Denier van der Gon et al., 2010
Other biogenic emission sources

- **Natural SO2**
  - DMS (dimethyl sulfide) emissions from sea
  - Monthly fields (Tarrasón et al., 1995)

- **Forest fires**
  - Global daily emissions stored at 0.2°x0.2° resolution from “Fire Inventory from NCAR” (FINNv1) from year 2005
  - For earlier years 8-daily fire emissions from “Global Forest Emission Database” (GFED-2)
  - Pollutants included: SO2, CO, NOx, NMHC, PM2.5, PM10, OC and BC
Other biogenic emission sources

- **Biogenic NMVOC**
  - Foliar emissions of isoprene (and monoterpenes) are calculated in the model for each grid cell and model time-step (function of temperature, solar radiation, land-cover)
  - Default BVOC emission potentials for four forest types and other land-cover types are used
  - Good land-cover information is necessary
  - **Possibilities for improvements**
Other (biogenic) emission sources

- **Soil NO emissions**
  - Emissions of NO from soil of seminatural ecosystems are specified as function of N-deposition and temperature
  - Pre-calculated N-depositions are used
  - Large country-to-country differences, might be significant compared to anthropogenic sources in areas with low population density
  - Depends on ecosystems, thus detailed land-cover data is required
  - Details of soil and vegetation types, timing of growing seasons, fertilization, irrigation
Other (biogenic) emission sources

- Possible problems with soil NO (NH₃)
  - Soil NO emissions might already been included in SNAP 10 by some countries (double counting)
  - Emission factors are uncertain, risk of emission differences from country to country because of country-expert choices rather than due to real emissions changes
  - Very meteorology dependent, better to calculate in the model rather than derive from an annual average
  - Details of soil and vegetation types, timing of growing seasons, fertilization, irrigation
Other biogenic emission sources

- **Lightning**
  - NOx emissions from lightning are included as monthly averages at 5.65° x 5.65° resolution (Köhler et al., 1995)

- **Volcanoes**
  - SO2 emissions from passive degassing of volcanoes are reported for Etna and Stromboli
  - To model SO2 and PM emissions from real eruptions (e.g. Eyjafjallajökul in 2010 and Grímsvötn in 2011) annual total emissions are not sufficient
Other biogenic emission sources

- **Sea salt and natural mineral dust**
  - The model calculates sea salt aerosols with diameters up to 10 μm (Tsyro et al., 2011)
  - The model includes windblown dust within the model domain and dust produced outside, but transported to the model grid (e.g. Saharan dust through boundary conditions)
Possibilities for improvements of non-inventoried emissions

- How to treat non-inventoried emissions?
  - Meteorology dependent emissions might be best treated in the model
  - Detailed auxiliary data might be necessary
  - Other emission databases than those we use?
  - Other methodologies?
More information about emissions in the EMEP MSC-W model and references

- http://www.atmos-chem-phys.net/12/7825/2012/