Emissions data for heavy metal and POP modelling

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EMEP officially reported emissions data

Completeness of reported HMs emission totals for 1990-2011

- Complete datasets of emission totals are available for **28** countries
- There is no national emissions data for **9** EMEP countries
EMEP officially reported emissions data

- Complete datasets of emission totals are available for **22** countries
- There is no national emissions data for **8** EMEP countries
Data completeness: Emission sectors

Contribution of major source categories to HCB emissions

France
- Public electricity and heat production (1A1a)
- Road transport (1A3)
- Iron and steel production (2C1)
- Agriculture (4G)
- Waste incineration (6C)
- Other

Spain
- Public electricity and heat production (1A1a)
- Road transport (1A3)
- Iron and steel production (2C1)
- Agriculture (4G)
- Waste incineration (6C)
- Other

United Kingdom
- Public electricity and heat production (1A1a)
- Road transport (1A3)
- Iron and steel production (2C1)
- Agriculture (4G)
- Waste incineration (6C)
- Other
Spatial distribution and gaps filling

Example: Pb anthropogenic emissions in 2011

Emission totals:
- Reported data (40 countries)
- TNO inventory for 2000 and projections for 2010

Gridded data:
- Reported grids (27 countries)
- TNO inventory for 2000 and projections for 2010
- CGEIC global Pb emissions inventory (1°×1°) for 1989 scaled to present
Global sources and intercontinental transport

Hg deposition over the globe and in EMEP region (2010)

Contribution of regional vs. global sources to HM and POP pollution

- EMEP sources
- Global sources
## Available ‘expert estimates’

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Chemicals</th>
<th>Years</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TNO inventory</td>
<td>Pb, Cd, Hg, BaP, PCDD/Fs, HCB</td>
<td>2000, 2010/20</td>
<td>50×50 km²</td>
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<td></td>
<td></td>
<td>(projections)</td>
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<tr>
<td>POPCYCLING-Baltic</td>
<td>BaP, PCDD/Fs, HCB</td>
<td>1970-1995</td>
<td>50×50 km²</td>
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<tr>
<td>ESPREME</td>
<td>Pb, Cd, Hg, ...</td>
<td>2000</td>
<td>50×50 km²</td>
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<tr>
<td>DROPS</td>
<td>PCDD/Fs, PCBs</td>
<td>2000</td>
<td>50×50 km²</td>
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<tr>
<td><strong>Global</strong></td>
<td></td>
<td></td>
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<tr>
<td>NILU/CGEIC</td>
<td>Pb</td>
<td>1989</td>
<td>1°×1°</td>
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<tr>
<td>AMAP/UNEP</td>
<td>Hg</td>
<td>2010</td>
<td>0.5°×0.5°</td>
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<tr>
<td>Tao et al., 2009</td>
<td>PAHs</td>
<td>2004</td>
<td>n/a</td>
</tr>
<tr>
<td>Bailey et al., 2001</td>
<td>HCB</td>
<td>1995</td>
<td>n/a</td>
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<tr>
<td>NILU inventory</td>
<td>PCBs</td>
<td>1930-2100</td>
<td>1°×1°</td>
</tr>
</tbody>
</table>

No global data for Cd and PCDD/Fs
Chemical speciation of emissions: Hg

**Hg species:** $\text{Hg}^0$, $\text{Hg(II)}_{\text{gas}}$, $\text{Hg(II)}_{\text{part}}$

**Reported emissions:** total Hg

**Expert estimates:** Axenfeld et al., 1991; Pacyna et al., 2001

**Effect of emission speciation on Hg deposition (2010)**

- All Hg emissions as $\text{Hg}^0$
- All emissions as $\text{Hg(II)}$
Chemical speciation of emissions: PAHs


Reported emissions: depends on a country

Expert estimates: TNO inventory

Reporting of PAHs emissions (2011)

- No data: 5 countries (11%)
- Sum of 4 PAHs: 7 countries (14%)
- Only some PAHs: 5 countries (11%)
- All 4 PAHs: 30 countries (64%)
Chemical speciation of emissions: PCDD/Fs

PCDD/F composition: 17 toxic congeners

Reported emissions: total toxicity equivalent

Expert estimates: POPCYCLING-Baltic project

Congener composition of PCDD/Fs emissions (EMEP region)
Temporal variation of emissions: BaP

Sectors of BaP emissions in EMEP countries (2010)

- Others
- Waste incineration
- Industrial processes
- Road transport
- Residential heating

Industry and road transport (Schaap et al., 2005)

Seasonal variation of BaP air concentration at Kosetice (CZ8)

- Observations
- Model (emission)

Residential heating (Aulinger et al., 2010)

- Single location in Czech Republic
Emissions from large point sources

Contribution of large point sources to Cd deposition

Pruněřov II Power Station
*Emission: 207 t/y (6%)*

Arcelor-Mittal Ostrava Steel Plant
*Emission: 859 kg/y (26%)*

**Note:** Contribution of single LPS can exceed 10-20% of Cd total anthropogenic deposition over large areas of the country
Emissions from large point sources

Estimates of effective emissions height (Brigg’s approach)

Pruněrov II Power Plant

Change in annual Pb deposition due to vertical redistribution of emissions

Required parameters:
- Stack height
- Stack diameter
- Gas outflow velocity
- Gas temperature

TFEIP Workshop, Istanbul, May 2013
Historical emissions of POPs

HCB global emissions (1945-2010)

HCB air concentration (2011)

HCB accumulation in different media

EMEP secondary sources

Global anthropogenic sources

Global secondary sources

TFEIP Workshop, Istanbul, May 2013
Emissions of POPs to other media

PCDD/Fs emissions in Europe (17 EU countries)
- to land: 85%
- to air: 15%

[Wenborn et al., 1999]

PCDD/Fs emissions to land and air (model vs. observations)

- Pesticide production
- Accidental fires
- Waste incineration
- Waste disposal
- Pesticide use
- Other

PCDD/F air concentration
- Observed, fg TEQ/m³
- Modelled, fg TEQ/m³

Emission to air only
- Observed: 0.1 to 1000
- Modelled: 0.1 to 1000

Emission to air & soil
- Observed: 0.1 to 1000
- Modelled: 0.1 to 1000

Underestimation by a factor of 5
Adjoint modelling

Application of adjoint modelling for evaluation of emission fields

Adjoint model:
An adjoint model to a CTM provides estimates of spatially resolved influence functions $\frac{\partial C}{\partial E}$ for a chosen receptor:

$$\Delta C_R = \sum_{ij} \left( \frac{\partial C}{\partial E} \right)_{ij} \cdot \Delta E_{ij}$$

Applied approach:
- Simulation of daily influence functions for particular receptor (CZ3)
- Variational optimization of emission fields (anthropogenic and re-suspension) to minimize model-measurement discrepancies at selected receptor
- Analysis of the optimized fields from the viewpoint of possible emission uncertainties

Influence function for CZ3

Pb concentration in air (2007)

Košetice (CZ3)
Application of adjoint modelling

Optimization of HM anthropogenic emissions distribution

Pb concentration in air (2007)

Optimized (anthrop.)

- Observed
- Model
- Optimized

October 2007

Influence function

Changes of total Pb emission

- Original
- Optimized

Anthrop. emissions
Summary (wish list)

Completeness of officially reported data:

- National totals and gridded emissions for EMEP countries
- Coverage of all reporting years (1990-present)
- Emissions differentiation by source categories and coverage all sectors
- Information on large point sources (emissions, co-ordinates, height, etc.)
- Uncertainty estimates or lower/upper limits
Summary (wish list)

**Expert estimates:**

- Gridded emissions for missed EMEP countries and non-EMEP regions
- Chemical speciation or congener composition of emissions (Hg, PCDD/Fs, PAH, PCBs)
- Temporal variation of emissions (monthly, weekly, daily)
- Emissions to other media (soil, water)
- Historical emissions (HCB, PCDD/Fs, Hg)
- Global scale inventories (Hg, HCB)
- Projections of future emissions