Heavy metal pollution assessment: from global to local scale

Oleg Travnikov on behalf of MSC-E and CCC
Scope of EMEP activities on HMs

- Monitoring of heavy metals within EMEP (CCC)
- Analytical laboratory intercomparison for heavy metals in precipitation (CCC)
- Collection and processing of heavy metal emissions data (CEIP)
- Operational modelling of heavy metal transboundary pollution (MSC-E)
- New developments: EMEP global modelling framework (MSC-E, MSC-W)
- New developments: Update of Hg chemical scheme (MSC-E)
- New developments: National/local scale pollution assessment – Case study (MSC-E, CCC, Parties)
- Co-operation with national experts, international organizations and programmes (MSC-E, CCC, Parties)
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EMEP global modelling framework

Main requirements:

- Flexible choice of the model domain and resolution
- Multi-pollutant formulation
- Multi-media approach
- Computational efficiency

Practical implementation:

- Modular architecture of existing EMEP global models
- Common input database
- Common library of modules
- Unified format of model output results

Input database
- Meteorology
- Land cover
- Emissions
- Soil properties

Common library of modules
- Atm. transport
- Aerosol dynamics
- Deposition
- Soil, ocean, etc.
- SO\textsubscript{x}/NO\textsubscript{x} chem.
- Hg chemistry
- O\textsubscript{3} chemistry
- POP chemistry

EMEP global models

GLEMOS (MSC-E)
Unified EMEP (MSC-W)

Output results in unified format
- Air concentrations
- Deposition flux
- Source attribution

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**Pilot modular architecture**

Global EMEP Multi-media Modelling System (GLEMOS)

GLEMOS modular architecture

- **Atmosphere**
  - Atmospheric transport
- **Ocean**
  - Oceanic transport
- **Terrestrial**
  - Run-off, diffusion

**Media exchange:** Deposition, evasion, etc.

- **Heavy metals: Pb, Cd**
  - Aerosol dynamics
  - Sorption, settling
  - Leaching, partitioning

- **Mercury**
  - Atmospheric chemistry
  - Oceanic chemistry
  - Partitioning, chemistry

- **POPs**
  - Gas-particle partitioning
  - Partitioning, degradation
  - Partitioning, degradation

**Environmental media:**
- Atmosphere
- Ocean
- Terrestrial media (soil, vegetation, freshwater)

**Groups of substances:**
- Heavy metals (Pb, Cd)
- Mercury
- POPs (PCBs, ...)

EMEP Steering Body, Geneva, 2010
Update of Hg chemical scheme
Implementation of halogen mediated chemistry

Importance of halogen chemistry for Hg cycle:

- Atmospheric mercury depletion events (AMDEs) in Polar Regions
- Quick oxidation and air-surface exchange in marine boundary layer (MBL)
- Intensive oxidation in upper troposphere
- Role in free troposphere - ?

[Diagram of Hg oxidation during AMDEs with labels for processes and sources: UNEP/AMAP, 2008]

[Hg\textsuperscript{0} air concentration in the Arctic graph with data from Alert (Canada), 2005]
Update of Hg chemical scheme

Implementation of halogen mediated chemistry

Model modifications:

- Implementation of Hg oxidation chemistry with halogens (Br, BrO)
- Assimilation of satellite-derived BrO concentrations
- Parameterization of prompt re-emission of newly deposited Hg from snow

![Graph showing Hg\textsubscript{0} air concentration](image-url)
Application of GLEMOS modelling system

Hg simulations on a global scale

Hg\(^0\) concentration in ambient air (2005)

Hg\(^0\) total deposition (2005)
Conclusion: The multi-model study provides consistent estimates of relative source attribution despite the significant differences in emissions and chemistry between the models.
From global to regional and local scale

Global scale simulations

Operational modelling on a regional scale (2008)

National/local scale assessment

Cd in precipitation (CZ1)

- Observed
- Model
Country scale HM pollution assessment: Case study

*Initiated by MSC-E and TFMM [ECE/EB.AIR/GE.1/2009/2]*

**Program of the project:**

**WP1.** Collection and processing of emissions data for modelling

**WP2.** Collection and analysis of monitoring data

**WP3.** Preparation of input meteorological and geophysical data and model modifications

**WP4.** Atmospheric modelling with fine resolution (e.g. 5x5 km²)

**WP5.** Complex analysis of modelling results

**WP6.** Improvements of assessment approach and re-evaluation of pollution levels in the country
**Country scale HM pollution assessment: Case study**

**Participated countries:**

Czech Republic, Croatia, Netherlands, Spain, Italy, Slovakia

**Submitted information:**

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- ✓ - submitted
- ● - available
- × - not available
Case study: Data submission

Czech Republic

Emissions data (submitted):
- Resolution – 5x5 km²
- Source categories
- Large-point sources

Monitoring data (submitted):
- 2 EMEP sites (Košetice, Svratouch)
- National network
- Concentration in air (ca. 30 sites), wet deposition (ca. 70 sites)
- Meteorological data from national network
Case study: Data submission
Croatia

Emissions data (submitted):
- Resolution – 10x10 km²
- Source categories

Monitoring data (available):
- Ongoing development of national network
- Air concentration (4 sites)
- Wet deposition (4 sites)
Case study: Data submission

Netherlands

Emissions data (submitted):
- Resolution – 5x5 km²

Monitoring data (available):
- 4 EMEP sites, national network
- Air concentration (6 sites)
- Wet deposition (4 sites)
Case study: Data submission

Spain

Emissions data (available):
• Resolution – 5x5 km²
• Source categories
• Large-point sources
• Temporal variation

Monitoring data (available):
• 4 EMEP sites, national network
• Air concentration (≥ 9 sites)
• Wet deposition (≥ 7 sites)

National scale model - CHIMERE

EMEP Steering Body, Geneva, 2010
Case study: Data submission

Italy

Emissions data (available):

- Resolution – 4x4 km²
- Source categories
- Large-point sources
- Temporal variation

Monitoring data (available):

- 1 EMEP site, national network
- Lead (33 sites)
- Cadmium (19 sites)

National scale model - MINNI / FARM

EMEP Steering Body, Geneva, 2010
Case study: Data submission

Slovakia

Emissions data available:
- Resolution – 50x50 km²
- Source categories

Monitoring data available:
- 4 EMEP sites, national urban network
- Air concentration (10 sites)
- Wet deposition (4 sites)
Case study: Input data for modelling

Preparation of meteorological and geophysical data (MSC-E)

Data processing:
- Generation of country scale meteorological fields (MM5)
- Evaluation of modelled data vs. observations
- Preparation of fine spatially resolved land cover data
- Processing and adaptation of emissions data
- Wind re-suspension estimates on a country scale
Case study: Pilot modelling results

Country scale simulations of heavy metal pollution (MSC-E)

Cd deposition over Czech Republic (2007)

Resolution: 50x50 km²  Resolution: 5x5 km²

Comment: Detailed analysis and evaluations of the results are planned at the next stage of the study
Case study: Future activities

Czech Republic
- Simulations of HM concentration and deposition with fine resolution (5x5 km²)
- Evaluation of source attribution based on administrative regions, large point sources, source categories etc.
- Joint analysis of the results and improvement of the assessment
- Re-evaluation of HM pollution levels in the country

Croatia and Netherlands
- Elaboration of country-specific programmes
- Start model simulations

Other countries
- Continue data collection and processing
- Development of country-specific programmes
EMEP reports:
- EMEP/CCC-Report 3/2010
- EMEP/CCC-Report 5/2010
- Joint MSC-W/MSC-E Technical Report
- EMEP/MSC-E Status Report 2/2010

International assessments:
- HTAP 2010 Assessment Report
- AMAP Assessment 2010
MSC-E and CCC publications

Peer-reviewed publications:


• Travnikov O. et al. ‘GLEMOS: Application to heavy metal and POP pollution’, *ACP (EMEP special issue)*, in prep.

• Travnikov O. et al. ‘Multi-model assessment of mercury dispersion in the global atmosphere’, *ACP (EMEP special issue)*, in prep.


EMEP Steering Body, Geneva, 2010
Workplan elements on HMs for 2011

Annual activities:

- Operational monitoring and modelling pollution levels in Europe and evaluation of modelling results against measurements (MSC-E, CCC)

Research and development:

- Further development and testing the GLEMOS modelling system including improvement of modular architecture and implementation of multi-media approach for Hg (MSC-E)
- Continue collaboration with MSC-W on development of the EMEP global modelling framework (MSC-E, MSC-W)
- Further research and evaluation of heavy metal re-suspension (MSC-E, CCE, Parties)

Co-operation:

- Case study: Co-operation with national experts for national/local scale HMs pollution assessment (MSC-E, TFMM, Parties)