Multi-scale assessment of heavy metal pollution

Oleg Travnikov on behalf of MSC-E and CCC

EMEP Steering Body, Geneva, 2011
Scope of EMEP activities on HMs in 2011

- 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)
- Research and development (multi-scale assessment):
  - Global modelling system GLEMOs
  - National/local scale pollution assessment (MSC-E, CCC, TFMM, Parties)
  - Improvement of model parameterisation and global scale assessment (MSC-E, Parties)
- Co-operation with national experts, international organizations and programmes
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- Research and development (multi-scale assessment):
  - Global modelling system GLEMOS (MSC-E)
  - National/local scale pollution assessment – Case study (MSC-E, CCC, TFMM, Parties)
  - Improvement of model parameterisations for regional and global scale assessment (MSC-E, Parties)
- Co-operation with national experts, international organizations and programmes

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MSC-E publications on heavy metals

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.
Multi-scale pollution assessment

Support of pollution assessment within EMEP

Global scale

Regional scale (EMEP)

National/local scale

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Multi-scale pollution assessment

Why different scales are needed?

**Regional scale (EMEP):**
- Operational assessment of transboundary pollution
- Support of policy decisions within CLRTAP

**Global scale:**
- Contribution of intercontinental transport to pollution levels within EMEP
- Effect of long-term accumulation and cycling

**National/local scale:**
- Refinement of transboundary pollution on a country scale
- Process studies and model improvement

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Global scale: GLEMSOS modelling system

Global EMEP Multi-media Modelling System (GLEMSOS)

New developments:

- Testing atmospheric transport module with a tracer dispersion
- Improvement of meteorological driver
- Development of the oceanic transport module
- Updates and evaluation of the mercury chemistry module
Testing atmospheric transport module

Simulation of a tracer transport from Fukushima-1 accident

Atmospheric dispersion of $^{131}$I from Fukushima-1 (Mar-Apr 2011)

Conventional source:
Tracer: $^{131}$I
Half-life: 8.02 days
Release: $2.5 \times 10^{16}$ Bq/day
Location: Fukushima-1
Testing atmospheric transport module

Simulation of a tracer transport from Fukushima-1 accident

Acknowledgements: Measurement data were provided by Swedish Radiation Safety Authority (SSM)

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Improvement of meteorological driver
Implementation and testing of WRF model on a global scale

WRF advantages as met driver:

• Multi-scale applications (from global to local)
• Possibility to use on different projections
• Flexible choice of physical parameterizations and input data
• Well developed, tested and supported
• Freely available

WRF generated global precipitation field (2009)
Implementation of oceanic transport

Development of oceanological driver for GLEMOS

Oceanological driver:
- Based on the Parallel Ocean Program (LANL, USA)
- Driven by ECMWF ORA-S3 re-analysis
- Provides full set of oceanological parameters
- Evaluated against observations
Update and evaluation of Hg modules

Further improvement of Hg chemical scheme

Model updates:

- Further study and evaluation of Hg chemistry with halogens (Br, BrO)
- Improvement of the atmospheric Hg depletion mechanism in the Arctic (AMDEs)
- Detailed evaluation of simulated Hg species concentration (Hg$^0$, Hg(II)$_{gas}$, HgP) and wet deposition on a global scale

Note: This activity will be continued in the framework of EU GMOS project
EU FP7 project GMOS
Global Mercury Observation System (GMOS)

Major project components:

- Global monitoring system for Hg (land-based, over-water and aircraft observations)
- Updates of Hg emissions inventory and future scenarios
- Development and application of global and regional scale models
- Evaluation of modelling results against observations

**Role of MCS-E:** Lead of global scale modelling activity
Downscaling: from regional to national/local

Refinement of transboundary pollution within EMEP

National/local scale assessment requires:

- Model application with finer spatial resolution (e.g. 5×5 km)
- Supply of emissions data with fine resolution
- Involving additional (national scale) measurements
- ...

Note: Downscaling of pollution assessment to national/local level is principally country-specific

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Country-specific assessment: Case study

Main objectives:

- Detailed assessment of HM pollution with fine spatial resolution
- Evaluation of the resolution effect on the assessment results
- Analysis of factors affecting quality of pollution assessment
- Improvement of the assessment means (model, measurements, emissions data)

Countries involved: Czech Republic, Croatia, the Netherlands, Spain

Note: The Case Study results were presented and discussed at TFMM meeting (Zurich, May 2011)
Czech Republic: Results and analysis

Recent activities:

- Collection, processing and evaluation of national scale input data (emissions, monitoring, meteorology etc.)
- Simulations of Cd pollution levels with resolution 5x5 km²
- Evaluation of modelling results against observations
- Analysis of the effect of spatial resolution on the assessment results
Czech Republic: Results and analysis

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Cd deposition over Czech Republic (2007)

Resolution: 50x50 km²

Resolution: 5x5 km²
Effect of spatial resolution
(50×50 km² vs. 5×5 km²)

Step 1: Refinement of meteorological data
Step 2: Refinement of emissions data

Meteorology 50×50 km²
Emission 50×50 km²

Meteorology 5×5 km²
Emission 50×50 km²

Meteorology 5×5 km²
Emission 5×5 km²
Effect of spatial resolution

Step 1: Refinement of meteorological data

Cd concentration in air (model vs. observations)
Effect of spatial resolution

Step 2: Refinement of emissions data

Cd concentration in air (model vs. observations)

0.0 0.2 0.4 0.6
Concentrations in air, ng/m³

Model (50x50 km)
Model (5x5 km, met)
Observed

Cd emissions (2007)

Rudolice v Horach
Observed Model (5x5 km, meteorol + emis)

Rudolice v Horach

Concentrations in air, ng/m³

0.0 0.2 0.4 0.6 0.8 1.0

Step 2: Refinement of emissions data

Cd concentration in air (model vs. observations)

Concentrations in air, ng/m³

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Model (5x5 km, met)
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Observed

Cd emissions (2007)

Rudolice v Horach
Observed Model (5x5 km, meteorol + emis)
Effect of spatial resolution

Step 2: Refinement of emissions data

Cd concentration in air (model vs. observations)

Cd emissions (2007)
Croatia: Results and preliminary analysis

Recent activities:

- Simulations of Pb pollution levels with resolution 10x10 km²
- First evaluation of modelling results against measurements at EMEP and non-EMEP national sites
- Study of the effect of heavy metal wind re-suspension on pollution levels in the country
The Netherlands: Pilot results

Recent activities:

• Simulations of Pb pollution levels with resolution 5x5 km²
• First evaluation of modelling results against measurements at EMEP and non-EMEP national sites

Pb deposition (Netherlands)

Pb concentration in air (2007)
Spain: Data submission

Submitted data:
- Meteorological observations
- Measurements of HM in air from 98 sites (Pb, Cd, Hg, other)
- Mineral dust concentration in air
- HM concentration in soil

Further activities:
- Data collection (emission)
- Model simulation and analysis
- Intercomparison with national model
Multi-scale assessment: Summary

- Pollution assessment on different scales is required to support EMEP operational modelling.
- Global modelling framework GLEMOS is developed for multi-media simulations of global scale pollutants.
- Pollution assessment on a national/local scale is country-specific.
- Application of finer resolution improves quality of the assessment but the improvement depends on availability of detailed input information (meteorology, emissions, etc.).
- Evaluation and analysis of national/local scale assessment results also require involvement of detailed observations.
- Quality of the assessment would be improved applying consistent modelling approaches on different scales (projection, grids etc.).
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New EMEP projection and grid

Improvement of pollution assessment within EMEP

Suggestions for new EMEP grid:
- Move to geographical (lat-lon) projection to improve consistency of the multi-scale pollution assessment
- Apply the grid resolution depending on a scale and particular task

Efforts required:
- Modification of the emissions grid
- Update of land cover dataset in collaboration with WGE
- Re-evaluation of monitoring sites' representativeness at local scale

Note: Details of new projection and grid require comprehensive discussion at TFMM
Workplan elements on HMs for 2012-13

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 of the GLEMOS modelling system (nesting procedure, chemical reactants and aerosol modules) (MSC-E)
- Improvement and evaluation of heavy metal re-suspension scheme (MSC-E, CCE, Parties)
- Study of major physical and chemical processes governing mercury cycling in the atmosphere in co-operation with EU GMOS project (MSC-E, Parties)

Co-operation:

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