EMEP/MSC-E Hg modeling system: application to TF HTAP intercomparison study

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EMEP/MSC-E

Joint UNEP F&T and TF HTAP meeting, Rome 2008
Outline

- EMEP/MSC-E Hg model description
- TF HTAP Hg models intercomparison study
- Modeling Hg atmospheric dispersion in the Northern Hemisphere
- Intercomparison of modeling results
- Major uncertainty sources of Hg modeling on a global scale
EMEP/MSCE-E Hg modeling system

Global model (MSCE-HM-Glob)
- Coverage – global
- Resolution – 1° 1°

Regional model (MSCE-HM)
- Coverage – EMEP region
- Resolution – 50 50 km²

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Model processes

### Atmospheric dispersion:
- Eulerian framework
- Met input – ECMWF, NCEP/DOE
- Met driver – SDA, GEMCVC

### Atmospheric chemistry:
- Gas-phase oxidation by O₃, OH, Cl₂
- Aqueous-phase oxidation by O₃, OH, HOCl, OCl⁻
- Aqueous-phase reduction by SO₃²⁻
- No halogen chemistry in MBL
- No explicit treatment of AMDE

### Air-surface exchange:
- Dry and wet deposition
- Prescribed evasion fluxes from land and ocean
- No explicit treatment of Hg cycling between media (atmosphere, ocean …)
TF HTAP intercomparison study

Aims of the TF HTAP model intercomparison study:

- Assessment of intercontinental source-receptor relationships
- Evaluation of current models variability and uncertainties
- Guidance of future model developments

Participants of Hg hemispheric/global models comparison:

- MSCE-HM (EMEP/MSC-E)
- GRAHM (Environment Canada, Canada)
- ECHMERIT (CNR-IIA, Italy)
- GEOS-Chem (Harvard University, USA)
- CTM-Hg (AER, USA)
TF HTAP intercomparison study

Simulation experiment conditions:

- Reference year 2001
- **Baseline simulation** with all emission sources
- Perturbation runs with **20% emission reduction** in four source regions (Europe & N. Africa, North America, East Asia, South Asia)
Hg emissions data

Anthropogenic Hg emissions for 2000 (Pacyna et al., 2006)

- East Asia: 839 t/y (38%)
- South Asia: 178 t/y (8%)
- Europe: 273 t/y (12%)
- North America: 144 t/y (7%)
- Other: 756 t/y (35%)

Evasion from land and ocean

Based on Lamborg et al., 2002 (ca. 1800 t/y)
Evaluation of modeling results

Long-term simulation of Hg dispersion in the Northern Hemisphere (1990-2004)

Spatial variation (annual means)

- Air concentrations
- Wet deposition flux

C_{mod} = 0.93 C_{obs}
R_{corr} = 0.69

C_{mod} = 1.18 C_{obs}
R_{corr} = 0.3
Evaluation of modeling results

Long-term simulation of Hg dispersion in the Northern Hemisphere (1990-2004)

Temporal variation (monthly means)

**Monthly statistics**

<table>
<thead>
<tr>
<th></th>
<th>NO99</th>
<th>FL05</th>
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</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.41</td>
<td>0.40</td>
</tr>
<tr>
<td>Bias</td>
<td>-10%</td>
<td>-3%</td>
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</tbody>
</table>
Baseline simulation

Total deposition of Hg in the Northern Hemisphere in 2001

Average deposition flux

Deposition flux, g/km²/y

Evasion

Europe & N.Africa

North America

East Asia

South Asia

Arctic

North Atlantic

North Pacific

0 2 4 6 9 12 20 50 g/km²/y

North America

Europe & N.Africa

South Asia

Other

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Perturbation runs

Decrease of Hg deposition in the Northern Hemisphere due to 20% emission reduction

in Europe

in North America
Perturbation runs

Decrease of Hg deposition in the Northern Hemisphere due to 20% emission reduction

in East Asia

in South Asia
Seasonal variability

Decrease of Hg deposition in the Northern Hemisphere due to 20% emission reduction in Europe
Response of Hg deposition to emission reduction

Deposition decrease due to 20% emission reduction in different source regions

Receptors

Deposition decrease, %

Europe & N.Africa
North America
East Asia
South Asia
Arctic
North Atlantic
North Pacific

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**Models intercomparison**

**Global Hg emissions used by the models**

<table>
<thead>
<tr>
<th>Emissions (t/y)</th>
<th>MSCE-HM</th>
<th>GRAHM</th>
<th>GEOS-Chem</th>
<th>CTM-Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropogenic</td>
<td>2200 (55%)</td>
<td>3400 (37%)</td>
<td>2200 (34%)</td>
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</tr>
<tr>
<td>Natural</td>
<td>1800 (45%)</td>
<td>5830 (63%)</td>
<td>4340 (66%)</td>
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<tr>
<td>Total</td>
<td>4000</td>
<td>9230</td>
<td>6540</td>
<td></td>
</tr>
</tbody>
</table>
Preliminary conclusions

- In general models agree in assessment of Hg deposition response to emission reduction.
- Hg depositions to most receptor regions (except North America) are the most sensitive to reduction of own emissions.
- The largest deposition response is predicted for East Asia and the smallest for North America.
- Total sensitivity of Hg deposition to emission reduction varies between the models and depends on relative contribution of anthropogenic emission.
Sources of modeling uncertainty

- Anthropogenic (incl. speciation) and natural emissions
- Ignoring Hg dispersion and cycling between different media (atmosphere, ocean, soil etc.)
- Hg chemistry in atmosphere and other media (reaction rates, halogen chemistry in MBL, AMDE, photoreduction in snow and seawater etc.)
- Lack of measurements to evaluate the models