Progress report on multi-model results for HTAP2 assessment

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A few words about HTAP2

- Hemispheric transport of air pollution (HTAP) is a UN TF HTAP coordinated international assessment activity
- 2nd phase (HTAP2) Objectives include:
  - Examine the transport of aerosols, including anthropogenic, dust, and biomass burning, from source regions to downwind regions
  - Assess the emission and transport impacts on regional and global air quality, ecosystems, public health, and climate
  - Provide information on potential emission mitigation options
- AeroCom is coordinating the HTAP2 aerosol modeling activity
- Models use the same prescribed HTAP anthropogenic emissions and perform base simulations and perturbed regions/source types simulations
HTAP2 Tier 1 regions of interest

Anthropogenic source regions:
NAM, EUR, EAS, SAS, RBU, MDE

Dust source regions:
NAF, CAS, EAS, MDE

Fire source region:
GLO
Report of multi-model aerosol results on:

1. Evaluate model simulated surface aerosol concentrations over North America, Europe, and Asia with available surface measurements
2. Calculate the source attributions in the NH regions of NAM, EUR, SAS, EAS, and ARC (Arctic)
3. Estimate the “Response to extra-regional emission reduction (RERER)”

This analysis is based on model simulations for 2010
## Models with aerosol-relevant results

<table>
<thead>
<tr>
<th>Models</th>
<th>ID</th>
<th>Institute</th>
<th>Spatial gridcells #lon x #lat x #lev (lon°x lat°)</th>
<th>Simulation period</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-IFS*°</td>
<td>IF</td>
<td>ECMWF, Europe</td>
<td>512 x 256 x 54 (0.7°x0.7°)</td>
<td>2008, 2010</td>
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<tr>
<td>CAMchem°</td>
<td>CA</td>
<td>NCAR, USA</td>
<td>144 x 96 x 56 (2.5°x1.875°)</td>
<td>2008, 2009, 2010</td>
</tr>
<tr>
<td>CHASER_re1</td>
<td>C1</td>
<td>Nagoya University, Japan</td>
<td>128 x 64 x 32 (2.8°x2.8°)</td>
<td>2008, 2009, 2010</td>
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<td>CHASER_t106</td>
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<td>Nagoya University, Japan</td>
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<td>2010</td>
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<tr>
<td>GEOS5</td>
<td>G5</td>
<td>NASA GSFC, USA</td>
<td>288 x 181 x 72 (1.25°x1°)</td>
<td>2008, 2010</td>
</tr>
<tr>
<td>GOCARTv5</td>
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<td>NASA GSFC, USA</td>
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<td>2008, 2010</td>
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<tr>
<td>OsloCTM3.v1°</td>
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<td>CICERO, Norway</td>
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<td>SPRINTARS</td>
<td>SP</td>
<td>Kyushu University, Japan</td>
<td>320 x 160 x 56 (1.1°x1.1°)</td>
<td>2008, 2009, 2010</td>
</tr>
</tbody>
</table>

*Only used in model evaluation because incomplete information submitted for source attribution and RERER

°No od550aer submitted
1a. Comparisons between measured and model simulated surface concentrations in North America, Europe, and Asia

North America: 140 IMPROVE network sites, BC, OM, SO$_4^{2-}$
Europe: 37 EMEP network sites, SO$_2$, SO$_4^{2-}$
Asia: 42 EANET network sites, SO$_2$, SO$_4^{2-}$
Overall comparisons with IMPROVE $\text{SO}_4^{2-}$

- $R=0.7-0.9$, $B=0.9-2$
- Models show similar features (e.g., more overestimate at lower concentrations)
Overall comparisons with IMPROVE BC

- $R=0.3-0.5$, $B=0.6-1.5$
- Models show similar features (e.g., more underestimate at lower concentrations)
Overall comparisons with IMPROVE OA

- $R=0.3-0.5$, $B=0.6-2.3$
- Models show different behavior of biases
EMEP 2010 monthly mean

SO₂ (μg/m³)

SO₄²⁻ (μg/m³)

CH0002R 46.82N 6.95E 510m

C-IFS
CAMchem
CHASER_re1
CHASER_t106
GOCARTv5
GEOSS5
SPRINTARS
OsloCTM3.v2

DK0003R 56.35N 9.60E 13m

PL0004R 54.75N 17.53E 2m
Overall comparisons with EMEP SO$_2$

- R=0.2-0.5, B=0.6-2.9
- Models show similar features, e.g., seven models show a factor of 2 overestimation of EMEP SO$_2$
Overall comparisons with EMEP $\text{SO}_4^{2-}$

- $R=0.3-0.5$, $B=0.5-1.7$
- Models show similar features (e.g. two branches in the scatter plots)
Overall comparisons with EANET SO$_2$

- $R=0.3-0.5$, $B=0.7-3$
- Models show similar degree of scatter
Overall comparisons with EANET $\text{SO}_4^{2-}$

- $R=0.3-0.6$, $B=0.5-1.7$
- Most models (except one) show similar scatter and similar feather (high bias at low concentration)
1b. Comparisons between measured and model simulated AOD

Total 271 sites in 2010 with monthly data
Comparisons of AOD at selected sites
Overall comparisons with AERONET AOD

- 2 CHASER model simulations are significantly different from other 3 models with much more scatter
- R=0.13-0.15 for CHASERS, R=0.6-0.8 for other models, B=0.75-1.5
2. Source Attribution

- Model calculated regional averaged concentrations can differ by a factor of 2 to 5. The model diversity is larger for OA and over the Arctic.
- Surface concentrations in the source regions are dominated by regional pollution sources except OA in NAM.
- Over the Arctic, NH mid-lat non-BB anthropogenic source contributes to no more than half of the surface aerosol concentrations.
3. Response to extra-regional emission reduction (RERER)

- RERER (or $R$) for each region $i$ is the regional concentration change due to the extra-regional emission reduction relative to that due to the global emission reduction (regional + extra regional), which can be written as

$$R_i = \frac{\Delta C_{i,glo} - \Delta C_{i,rgn}}{\Delta C_{i,glo}}$$

- The lower the $R_i$, the less sensitive the amount within a region to the extra-regional emission reduction (or the more sensitive to the emission reduction within its own region)
Model average RERER for surface concentration

EUR is most sensitive to extra-regional SO$_2$ emission change

SAS and EAS are least sensitive to extra-regional BC emission change

EUR is most and SAS is least sensitive to extra-regional OA emission change
Summary

- HTAP2 models seem to have considerable improvements over HTAP1 in simulating the surface aerosol concentrations over NH polluted regions.
- Although there are still large differences among models in terms of regional averaged sulfate, BC, and OA concentrations, models show a general agreement on source attributions and regional response to extra-regional emission reduction, which is useful for HTAP assessment.
- So far only three models have done tagged dust and fire regions – not enough for statistics.
## Appendix: evaluation statistics at-a-glance

<table>
<thead>
<tr>
<th>Network data</th>
<th>C-IFS</th>
<th>CAM chem</th>
<th>CHASER_re1</th>
<th>CHASER_t106</th>
<th>GOCARTv5</th>
<th>GEOS5</th>
<th>SPRINTARS</th>
<th>OsloCTM3_v2</th>
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<th>Mean</th>
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<td>IMPROVE</td>
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<td>0.472</td>
<td>0.371</td>
<td>0.530</td>
<td>0.500</td>
<td>0.265</td>
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<td>0.501</td>
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<tr>
<td></td>
<td>SO$_2^-$</td>
<td>0.829</td>
<td>0.776</td>
<td>0.697</td>
<td>0.765</td>
<td>0.805</td>
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<td>0.480</td>
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<td>0.290</td>
<td>0.422</td>
<td>0.472</td>
<td>0.155</td>
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<td>SO$_2^-$</td>
<td>0.235</td>
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<td>0.320</td>
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<td>0.371</td>
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<td>EANET</td>
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<td>0.408</td>
<td>0.450</td>
<td>0.470</td>
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<td>SO$_2^-$</td>
<td>0.431</td>
<td>0.335</td>
<td>0.536</td>
<td>0.539</td>
<td>0.591</td>
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<td>-999.9</td>
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<tr>
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<td>0.971</td>
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<td>0.696</td>
<td>1.152</td>
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<td>0.993</td>
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<tr>
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<td>1.665</td>
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<td>1.527</td>
<td>0.517</td>
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<td>AOD 550 nm</td>
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<td>-999.9</td>
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<td>1.114</td>
<td>0.970</td>
<td>0.751</td>
<td>0.841</td>
<td>-999.9</td>
<td>0.830</td>
</tr>
</tbody>
</table>

- R ≥ 0.7, B ≤ 20% (0.833 < B < 1.2)
- 0.5 ≤ R < 0.7, 20% ≤ B < 50% (B = 0.677-0.833, 1.2-1.5)
- 0.3 ≤ R < 0.5, 50% ≤ B < 100% (B = 0.5-0.677, 1.5-2)
- R < 0.3, B > 100% (B < 0.5 or B > 2)