INTERCONTINENTAL TRANSport OF AIR POLLUTION WITH GMI AND PLANS FOR THE NEW HEMISPHERIC TRANSPORT OF AIR POLLUTANTS (HTAP) MODEL INTERCOMPARISON STUDY

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GMI meeting, October 12, 2006
UN-ECE LRTAP Task Force on Hemispheric Transport of Air Pollution (TF-HTAP)

Chairs: Terry Keating (EPA) and Andre Zuber (Eur. Commission)

**Key HTAP questions:**

1) How does the intercontinental or hemispheric transport of air pollutants affect air pollution concentrations in the northern hemisphere for ozone, aerosols, and their precursors?

2) Can we define source-receptor relationships and the influence of intercontinental pollution transport on the exceedance of standards or policy objectives for the pollutants?

3) How confident are we of our ability to predict these source-receptor relationships?

4) How will changes in emissions in each of the other countries change pollutant concentrations?

5) How will these source-receptor relationships change due to changes in emissions in the future?

6) How will these source-receptor relationships be affected by changes in climate?

**CHARGE:**

- develop a fuller understanding of the hemispheric transport of air pollution;
- estimate the hemispheric transport of specific air pollutants for the use in reviews of protocols to the LRTAP Convention;
- prepare technical reviews thereon for submission to the Steering Body of EMEP

First meeting: Brussels, Jun 1-3, 2005
Second meeting: Washington, DC, Jan 30-31, 2006
Third meeting: Beijing, China, Oct 18-20, 2006
The first set of multi-model experiments focuses on the source-receptor relationships between individual continents for ozone and its precursors, PM, and others, and will be concluded by May 2007 and the interim report due in June 2007.

1) Base case simulation for year 2001 with 'best' emission inventory and fixed CH4 concentrations globally at 1760 ppbv.

2) CH4 global mixing ratio reduced to 1408 ppbv (-20%).

3) Delta emission experiments with each of NOx, NMVOC and CO reduced by 20% for anthropogenic emissions over each of four source regions (Europe, North America, East Asia, and South Asia).

4) Combined reduction of all anthropogenic emissions for NOx/NMVOC/CO/SO2/NH3/POM/EC over each region.

5) Passive CO tracer experiment with tagging by sources and regions.

Currently 22 institutions from Europe and North America participate including Harvard and GMI.

Detailed information is given at [http://aqm.jrc.it/HTAP/](http://aqm.jrc.it/HTAP/).
## PROPOSED LIST OF AUTHORS FOR 2007 TF HTAP INTERIM REPORT

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April SURFACE O₃ COMPARISONS: CMAQ vs. GEOS-Chem vs. GMI-DAS

CMAQ, GEOS-Chem, and GMI have comparable surface ozone over continents but CMAQ is lower across Pacific. In the United States, GMI appears to be higher than GEOS-Chem.

Rokjin Park (Harvard), Carey Jang (EPA/OAQPS), and Susan Strahan (NASA)
CMAQ vs. GEOS-Chem TROPOSPHERIC OZONE

Ozone concentrations at 25-50°N vs. pressure and longitude (April 2001)

Evaluation w/ mean TRACE-P obs in Asian outflow (<140E)

Low free tropospheric ozone in CMAQ likely due to processes usually neglected in regional models: STE, lightning, ...

Rokjin Park (Harvard) and Carey Jang (EPA/OAQPS)
CMAQ vs. GEOS-Chem ASIAN POLLUTION ENHANCEMENT OF OZONE (April 2001)

ΔOzone in surface air

ΔOzone at 25-55 N vs. pressure and longitude

Springtime O$_3$ observed at the clean north western U.S. sites has increased by 10 ppbv over the past 20 years likely due to increases in Asian anthropogenic emissions [Jaffe et al., 2003]

Ozone enhancement over the Pacific due to Asian pollution is lower in CMAQ than GEOS-Chem.

[Jaffe et al., 2003, GRL]
Asian pollution influence in U.S. surface air in CMAQ is 5x that in GEOS-Chem
EVALUATING ASIAN SULFATE OUTFLOW:

TRACE-P aircraft observations (Mar-Apr 2001, <140°E)

Suggests insufficient scavenging in CMAQ during venting to free troposphere

Rokjin Park (Harvard) and Carey Jang (EPA/OAQPS)
THE U.S. EPA REGIONAL HAZE RULE MANDATES VISIBILITY IMPROVEMENT AT LARGE NATIONAL PARKS TO NATURAL VISIBILITY CONDITION BY 2064

Background is defined by suppression of U.S. anthropogenic emissions but allowance for present-day foreign emissions and associated import of pollution

The schedule of emission reductions required in the 2004-2018 implementation period is very sensitive to the visibility endpoint by 2064

[Park et al., 2006]
PLAN FOR GMI SIMULATIONS

• For a given GMI coupled aerosol-chemistry tropospheric configuration, conduct several 1-year simulations with 2°x2.5° resolution for year 2001
  – Standard simulation to be submitted to HTAP as well as for comparison with GEOS-Chem, observations from TRACE-P, U.S. surface sites
  – Perturbed anthropogenic emissions following HTAP recommendations of 20% reduction in four source regions

• Conduct simulations with different GMI meteorological fields if available, same emissions and chemistry

• Important results of this work will provide an assessment of intercontinental transport including characterization of errors due to differences in treatment of model transport, etc and will also be delivered to the 2007 interim and the 2009 final HTAP report

• Conduct GMI simulation for year 2006 to examine transpacific transport of ozone and aerosol together with observations from TES, INTEX-B
INTEX-B aircraft campaign in spring, 2006 observed transpacific pollution transport events

C130 flight on May 8

DC8 flight on May 9

Melody Avery and Glen Sachse [Nasa Langley]
Additional slides
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OBJECTIVES OF SECOND MEETING:

• Define model metrics for intercontinental transport of pollution;
• Develop protocols for model intercomparisons
• Coordinate modeling efforts, data bases;
MECHANISM FOR TRANSPACIFIC TRANSPORT OF ANTHROPOGENIC OZONE AND AEROSOLS

HEMISPHERIC POLLUTION

Free troposphere
2 km
Boundary layer

NOx, SO2, VOC

warm conveyor belts, convection

PAN (~10%)
O3

VOCs (long-lived)

Sulfate (10%)
OC aerosol

entrainment, dilution

subsidence

ozone, sulfate, OC

aerosols, HNO3

Asia

PaciFic

North America
MODEL METRIC FOR INTERCONTINENTAL INFLUENCE

(1) **Standard** simulation; compare w/ observations

(2) Set N. American anthropogenic emissions to zero ⇒ estimate **background**

(3) Set global anthropogenic emissions to zero ⇒ estimate **natural background**

Difference between (1) and (2) ⇒ regional pollution

Difference between (2) and (3) ⇒ intercontinental pollution

To avoid difficulty to interpret changes associated with complete reductions, HTAP intercomparison suggests to apply small perturbations (20%) to emissions from individual continents.
Surface ozone at Yellowstone National Park, Wyoming, 2.5 km altitude (March-May 2001)

CASTNet observations

* Model
△ Background
▽ Natural O₃ level
× Stratospheric

Δ = Regional pollution
Δ = Intercontinental pollution

Background: 30-50 ppbv
Natural: 15-30 ppbv

Fiore et al. [2003]
CMAQ vs. GEOS-Chem TRANSPACIFIC TRANSPORT OF OZONE (April 2001)

Asian pollution influence in U.S. surface air in CMAQ is similar to that in GEOS-Chem.
WET SCAVENGING OF ASIAN AEROSOLS DURING LIFTING TO THE FREE TROPOSPHERE

TRACE-P observations over NW Pacific (Feb-Mar 2001) and GEOS-Chem simulations

Sulfate is most importantly exported anthropogenic aerosol in model

Park et al. [2005]
Mean Asian pollution enhancement in NW U.S. in spring: 0.16 ± 0.08 µg m⁻³

Heald et al. [2006]
ASIAN POLLUTION CONTRIBUTION TO ANNUAL SULFATE CONCENTRATIONS IN SURFACE AIR (IMPROVE SITES)

**ASIAN SO$_4^{2-}$ (GEOS-CHEM)\textsuperscript{2}**

<table>
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<th>$\mu g/m^3$</th>
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<tr>
<td>&lt; 0.00</td>
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<tr>
<td>2.33</td>
</tr>
<tr>
<td>4.67</td>
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<td>7.00</td>
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**R$^2$: 0.88\textsuperscript{2}**
Slope: 1.1

ASIAN SO$_4^{2-}$ CONTRIBUTIONS ARE COMPARABLE TO EPA NATURAL VALUES.