HTAP2: Coordinated AeroCom III experiments - initial results

Mian Chin, Huisheng Bian, Tom Kucsera, Xiaohua Pan, Anton Darmenov, Omar Torres, Michael Schulz

Acknowledgement: Results from MODIS, MISR, OMI, AERONET, IMPROVE, HIPPO and funding from NASA
Background

- AeroCom made key contributions to the HTAP 2010 assessment (see HTAP 2010 report)
- In 2012, TF HTAP launched a new phase of cooperative experiments and analysis and AeroCom participation is crucial (HTAP Work Package 3.5)
  - HTAP2 – perturbation of anthropogenic, dust, and biomass burning emissions in different regions
Other two AeroCom III model experiments

- **HTAP2** – perturbation of anthropogenic, dust, and biomass burning emissions in different regions
- **Biomass burning** – perturbation of biomass burning emission amount and injection height
- **Nitrate** – evaluation of global model simulation of nitrate; perturbation of precursor emission amounts and meteorological conditions

- These three experiments are closely coordinated
- All experiments base on HTAP2 emission inventory for BASE case study
Related AeroCom III experiments

- HTAP2-AeroComIII source-receptor study  
  (Mian Chin, mian.chin@nasa.gov)

AeroCom III biomass burning study  
(Mariya Petrenko, mariya.m.petrenko@nasa.gov)

AeroCom III nitrate study  
(Huisheng Bian, huisheng.bian@nasa.gov)

- Output requirement and further sensitivity experiments are provided by:  
https://wiki.met.no/aerocom/phase3-experiments
HTAP2: Current status

- 10 models (and versions) have submitted aerosol results
  CHASER, C-IFS, EMAP, GEOS5, GEOSCHEM, GOCART, OsloCTM3, RAQMS, SPRINTARS

- Please sign up if you are working or will work on the simulation!
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| wet2d            | ✓     | ✓     | ✕     | ✕    | ✓      | ✓       |
| sconc2d          | ✓     | ✓     | ✕     | ✓    | ✓      | ✓       |
| conc3d           | ✓     | ✓     | ✓     | ✕    | ✓      | ✓       |
| stations         | ✕     | ✕     | ✕     | ✕    | ✕      | ✓       |
| Sat/3h           | ✕     | ✕     | ✕     | ✕    | ✓      | ✓       |
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Initial results - demonstrate the HTAP2 aerosol analysis from GOCART and GEOS-5

- Model setup
- Global distributions - comparisons of AOD with MODIS, MISR, and OMI
- Comparisons with OMI and AERONET on AOD and AAOD
- Comparisons of surface concentrations and vertical profiles
- RERER
- Source attributions
Model setup

- **Emissions:**
  - Anthropogenic: HTAP2, 0.1x0.1 deg, 4 sectors (energy, industry, residential, transportation)
  - Biomass burning: GFED v3 (recommended)
  - Volcanic: HTAP2/AeroCom-MAP (Thomas Diehl)
  - Dust and sea salt: Model calculated

- **High priority runs:**
  - BASE, 2008-2010
  - 20% reduction of anthropogenic emissions in GLO, NAM, EUR, EAS, SAS, RBU, and MDE
  - Zero-out dust emissions in NAF, CAS, EAS, MDE
  - Zero-out global fire emissions
AAOD

OMAERUV V147 AAOD 500 nm 200802

OMI AAOD 200802

GOCART AAOD 200802

GEOS5 AAOD 201002

g5e550IIk GO AAOD 550 nm 200802 avg=0.0057

HTAP2_GLOBASE GO AAOD 550 nm 200802 avg=0.0051

OMAERUV V147 AAOD 500 nm 200809

OMI AAOD 200809

GOCART AAOD 200809

GEOS5 AAOD 201009

g5e550IIk GO AAOD 550 nm 200809 avg=0.0071

HTAP2_GLOBASE GO AAOD 550 nm 200809 avg=0.0056
Comparisons with AERONET

12 land regions, ocean, and the polar regions
(Circles: AERONET sites with data available in 2008-2010)
Comparisons (GOCART) with AERONET AOD and AAOD – polluted regions

- GSFC (USA) 38.99N 76.84W 87m
  - AERONET
  - OMI
  - SU
  - Dust
  - POM
  - Seasalt

- Barcelona (EUR) 41.39N 2.12E 125m
  - AERONET
  - OMI
  - SU
  - Dust
  - POM
  - Seasalt

- Beijing (EAS) 39.98N 116.38E 92m
  - AERONET
  - OMI
  - SU
  - Dust
  - POM
  - Seasalt

- Kanpur (SAS) 26.51N 80.23E 123m
  - AERONET
  - OMI
  - SU
  - Dust
  - POM
  - Seasalt
Comparisons with AERONET AOD and AAOD – biomass burning regions

GOCART

- AERONET
- OMI
- SU
- BC
- POM
- Dust
- Seasalt
Comparisons with AERONET AOD and AAOD – dust regions

- Banizoumbou (NAF) 13.54N 2.68E 250m
- SACOL (EAS) 35.95N 104.14E 1985m
- Kuwait University (MDE) 29.33N 47.97E 42m
- Dushanbe (CAS) 38.55N 68.86E 821m

**AERONET**
- **OMI**
- **SU**
- **Dust**
- **Seasalt**

GOCART

- **BC**
- **POM**

**R**: 0.713 E: 0.209 B: 1.117 S: 0.690

**R**: 0.506 E: 0.110 B: 0.870 S: 0.634

**R**: 0.040 E: 0.032 B: 1.547 S: 0.391

**R**: 0.485 E: 0.013 B: 0.714 S: 0.466

**R**: 0.797 E: 0.153 B: 1.178 S: 0.845

**R**: 0.550 E: 0.116 B: 0.707 S: 0.775

**R**: 0.640 E: 0.023 B: 1.354 S: 0.694

**R**: 0.589 E: 0.023 B: 0.457 S: 0.200
Comparisons of surface concentrations – IMPROVE site ACAD1
Overall Comparison with IMPROVE data
Comparisons with BC vertical profile from the HIPPO measurements – Still no good

HIPPO flight tracks

Black line: HIPPO
Red line: GOCART

Only HIPPO-1, 2, 3 were used

(Figure from Schwarz)
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)
Surface concentration RERER (GOCART) in NAM, EUR, SAS, and EAS - anthropogenic

- EUR is most sensitive to extra-regional SO2 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 OC emission change
AOD RERER (GOCART) in NAM, EUR, SAS, and EAS - anthropogenic

NAM and EUR are much more sensitive to extra-regional SO2 emission change than SAS and EAS.

NAM is most sensitive and SAS is least sensitive to extra-regional BC emission change.

NAM is most sensitive and SAS is least sensitive to extra-regional OC emission change.
% of regional and extra-regional contributions to surface BC concentration

- On regional average, BC concentrations in SAS and EAS are much higher than that in NAM and EUR.
- Over the source regions of NAM, EUR, SAS, and EAS, BC is predominantly from the regional pollution sources, especially in SAS and EAS.
% of regional and extra-regional contributions to column BC AOD

- In contrast to the surface, the atmospheric column over the pollution regions is much more affected by long-range transport especially NAM that is prone to pollution transported from Asia.
- Meanwhile, regional pollution is still the dominant source of column BC over SAS and EAS.

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<th>EUR</th>
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In the Arctic – where are the carbonaceous aerosols from?

- 2/3 of POM over the Arctic is from biomass burning in 2010
- Among the pollution regions, EAS now surpasses EUR to be the most influential region for the Arctic BC at both surface and column
Conclusions

- We have demonstrated the initial HTAP2 aerosol analysis.
- We have targeted the model evaluations of AOD, AAOD, surface concentrations, and vertical profiles with satellite and suborbital observations.
- We have shown the policy-relevant HTAP matric of impacts of regional vs. extra regional sources on regional air quality and column AOD.
- We would like to have more models involved.