Preliminary analysis for AeroCom III nitrate experiment

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and AeroCom III nitrate modelers

AeroCom 2015
Three objectives:

(1) address the diversity of nitrate simulations by the AeroCom models and understand the reasons for the intermodel differences,

(2) compare model simulated nitrate with measurements from ground networks, aircraft campaigns, and satellite retrievals,

(3) investigate how nitrate formation changes in different models in response the perturbation of precursor emissions and meteorological conditions.
Experiment set up

**Study period:** 2008  
**Met field:** model’s meteorological data for 2008  
**Emission:**
- same for models: 1. anthropogenic ---- HTAP v2 2008 monthly emission (for tracers not provided by HTAP v2, use CMIP5RCP8.5, linear interpolation between 2005 and 2010).
- 2. biomass burning ---- GFED3
- 3. NH3: add ocean source based on GEIA

**Observations:**

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<th>observed</th>
<th>USA</th>
<th>Europe</th>
<th>East Asia</th>
<th>ARCTIC</th>
<th>Global</th>
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<td>Surface (station)</td>
<td>concentration</td>
<td>Castnet/AMon</td>
<td>EMEP</td>
<td>EANET</td>
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Tracer burden (Tg)

- NO3: 0.46 ± 0.31
- SO4: 2.05 ± 1.0
Compare among models

NO3 Surface distributions from 4 Aerocom models
Compare among models

NO3 vertical zonal mean distributions from 4 Aerocom models
Compare among models

NH3 vertical zonal mean distributions from 4 Aerocom models
Compare among models

Global annual fine and coarse mode NO3 and their ratio
Compare among models

Chemistry budget of nitrate simulation

- NO3
- NH4
- HNO3
- NH3

Graphs showing comparisons between GMI and INCA models.
Surface NO3 between model and **Castnet** measurement (USA)

**CHASER**
- $r = 0.338$
- bias = 1.804
- rms = 1.199

**GMI**
- $r = 0.297$
- bias = 0.585
- rms = 0.871

**INCA**
- $r = 0.590$
- bias = 0.650
- rms = 0.742

**OsloCTM2**
- $r = 0.298$
- bias = 1.113
- rms = 0.912

Compare with obs
Surface HNO₃ between model and **Castnet** measurement (USA)

- **CHASER**
  - \( r = 0.335 \)
  - \( \text{bias} = 3.351 \)
  - \( \text{rms} = 2.498 \)

- **GMI**
  - \( r = 0.325 \)
  - \( \text{bias} = 1.156 \)
  - \( \text{rms} = 0.948 \)

- **INCA**
  - \( r = 0.336 \)
  - \( \text{bias} = 0.957 \)
  - \( \text{rms} = 0.958 \)

- **OsloCTM2**
  - \( r = 0.259 \)
  - \( \text{bias} = 0.814 \)
  - \( \text{rms} = 1.009 \)

Compare with obs
Compare with obs

Surface NO3+HNO3 between model and **Castnet** measurement (USA)

**CHASER**
- $r = 0.320$
- bias = 2.689
- rms = 3.357

**GMI**
- $r = 0.321$
- bias = 0.912
- rms = 1.381

**INCA**
- $r = 0.372$
- bias = 0.826
- rms = 1.312

**OsloCTM2**
- $r = 0.269$
- bias = 0.910
- rms = 1.426
Surface NH4 between model and Castnet measurement (USA)

CHASER
- $r = 0.509$
- bias = 1.618
- rms = 0.750

GMI
- $r = 0.448$
- bias = 0.564
- rms = 0.651

INCA
- $r = 0.472$
- bias = 0.405
- rms = 0.658

OsloCTM2
- $r = 0.510$
- bias = 0.512
- rms = 0.629

Compare with obs
Surface NH3 between model and AMoN measurement (USA)

**CHASER**
- $r = 0.056$
- bias = 0.144
- rms = 4.175

**GMI**
- $r = 0.051$
- bias = 0.355
- rms = 4.340

**INCA**
- $r = 0.151$
- bias = 0.271
- rms = 4.084

**OsloCTM2**
- $r = 0.131$
- bias = 0.161
- rms = 4.102
Surface NO3 between model and EMEP measurement (Europe)

- **CHASER**
  - $r = 0.422$
  - bias = 1.187
  - rms = 1.458

- **GMI**
  - $r = 0.545$
  - bias = 0.407
  - rms = 1.206

- **INCA**
  - $r = 0.515$
  - bias = 0.432
  - rms = 1.216

- **OsloCTM2**
  - $r = 0.515$
  - bias = 0.741
  - rms = 1.210

Compare with obs
Surface NO3 between model and **EANET** measurement (East Asia)

**CHASER**
- $r = 0.429$
- bias = 0.789
- rms = 1.817

**GMI**
- $r = 0.435$
- bias = 1.215
- rms = 2.031

**INCA**
- $r = 0.430$
- bias = 0.757
- rms = 1.856

**OsloCTM2**
- $r = 0.365$
- bias = 1.099
- rms = 1.837

Compare with obs
Dry deposition of NO3 between model and **Castnet** measurement (USA)

- **CHASER**
  - $r = 0.318$
  - bias = 2.657
  - rms = 6.476

- **GMI**
  - $r = 0.082$
  - bias = 2.201
  - rms = 0.520

- **INCA**
  - $r = 0.387$
  - bias = 1.287
  - rms = 0.301

- **OsloCTM2**
  - $r = -0.018$
  - bias = 12.137
  - rms = 2.562

*$(HNO_3 + NO_3)$*
Wet deposition of NO₃+HNO₃ between model and **NADP NTN** measurement (USA)

Compare with obs
Wet deposition of HNO$_3$+NO$_3$ between model and **EANET** measurement (East Asia)

**Compare with obs**

**CHASER**
- $r = 0.183$
- bias = 0.479
- rms = 18.387

**GMI**
- $r = 0.314$
- bias = 0.846
- rms = 18.434

**INCA**
- $r = 0.384$
- bias = 0.460
- rms = 17.150

**OsloCTM2**
- $r = 0.141$
- bias = 0.306
- rms = 18.391
Global burden of NH3

Perturbation study

CHASER

GMI

OsloCTM2
Conclusion

Base case study:

• The diversity of NO3 simulation is larger than that of SO4. The mean global burden of NO3 is ~1/4 of that of SO4 in 2008.
• It needs further investigation of the vertical transport, seasonal variation, and ratio of fine and coarse mode NO3 among models.
• Suggest potential improvements:
  • CHASER: check NH4 dry/wet deposition, NO3/HNO3 partition
  • GMI: check NO3 dry deposition
  • OsloCTM2: check NO3 dry deposition, NO3/HNO3 partition

Perturbation study:

• The models give same direction but different magnitude of NO3 in response to proposed perturbations in emission and temperature fields.
• It requires further analysis of NO3 response in regional basis.

Things on to do list: aerosol water, AOT, forcing

https://wiki.met.no/aerocom/phase3-experiments