Comparing modeled and measured aerosol optical properties – results from the AeroCom INSITU Project


Acknowledgements:
Derek Hageman (programmer extraordinaire)


https://wiki.met.no/aerocom/phase3-experiments#in-situ_measurement_comparison
Evaluate AeroCom model simulations of aerosol optical properties using long-term, in-situ surface aerosol measurements

Three-tiered project:

I. Evaluation of dry, surface aerosol optical parameters (this talk)
II. Trend analysis of dry, surface aerosol optical properties (Schulz talk - yesterday)
III. Evaluation of hygroscopicity of aerosol scattering (Zieger talk – next!)

https://wiki.met.no/aerocom/phase3-experiments#in-situ_measurement_comparison
**PROCESS**

- Acquire and review in-situ surface aerosol optical data – EBAS data archive

- Obtain high frequency model output from AeroCom community
  - dry, spectral extinction and absorption at surface
  - consistent with in-situ data

- Sample model output at station locations

- Compare model output with in-situ measurements:
  - Scattering
  - Absorption
  - Scattering and Absorption Ångström exponent (SAE & AAE)
  - Single scattering albedo (SSA)

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In-situ Aerosol Optical Properties

Aerosol light scattering
- Nephelometer (TSI or Ecotech)

Aerosol light absorption
- Instruments: MAAP, PSAP, or CLAP

Data Collection
- Low RH (<40% RH)
- 1 min resolution (typically)
- 1 & 10 um size cuts (at some sites)
  - CONTINUOUS!

Data Processing
- QC’d and corrected
- Averaged (H, D, M, Y),
- Absorption and scattering reported at STP

Data are primarily from the EBAS data archive
In-situ Measurement Sites

- Sites with aerosol light scattering and/or absorption (~70 sites)
- Fewer sites than AERONET
- Gaps in S. America, Africa, Middle East, Russia, Asia

→ In-situ data have been acquired and reviewed through 2014
→ Working on generating consistent format - ‘benchmark data files’
# AeroCom Models Used in this Analysis

<table>
<thead>
<tr>
<th>Model name</th>
<th>Gridbox size</th>
<th>Output Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM5</td>
<td>3.0° x 2.0°</td>
<td>2010</td>
</tr>
<tr>
<td>GEOS-Chem</td>
<td>2.4° x 2.0°</td>
<td>2010</td>
</tr>
<tr>
<td>CAM5</td>
<td>2.4° x 1.9°</td>
<td>2010</td>
</tr>
<tr>
<td>ECHAM6-SALSA</td>
<td>1.8° x 1.9°</td>
<td>2010</td>
</tr>
<tr>
<td>GEOS5-Globase</td>
<td>1.25° x 1°</td>
<td>2010</td>
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<td>GEOS5-MERRAero</td>
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<td>OsloCTM2</td>
<td>2.8° x 2.8°</td>
<td>2008</td>
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<td>GOCART</td>
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<tr>
<td>MPIHAM</td>
<td>1.8° x 0.9°</td>
<td>2006*</td>
</tr>
<tr>
<td>SPRINTARS</td>
<td>1.1° x 1.1°</td>
<td>2006*</td>
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</tbody>
</table>

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## Comparisons

Compare models/measurements from two perspectives...

<table>
<thead>
<tr>
<th><strong>CLIMATOLOGY</strong></th>
<th>Tells us how well the model is doing at given locations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHARACTERISTICS &amp; BEHAVIOR</strong></td>
<td>Information about how well the model is simulating aerosol processing, transport, etc.</td>
</tr>
</tbody>
</table>
Aerosol Climatology: **Big Picture**

- Annual pattern of absorption and scattering is similar for models and in-situ measurements.
- Differences are observed for some sites.

CAM5 output for AEROCOM P3 INSITU project
Aerosol Climatology: Modelled Absorption

Similar patterns amongst models
Wide range in values (log color scale!)
Aerosol Annual Climatology: Absorption and Scattering

- Models tend to over-predict absorption and scattering at mountain sites
- Modelled absorption tends to be over-predicted
- Scattering tends to be under-predicted at non-mountain sites
- More range (relatively) in model prediction of absorption than scattering

Vertical bar shows range of model medians, horizontal bar is measurement uncertainty based on Sherman et al. (2015), only 2010 model output (CAM5, ECHAM6-SALSA, GLOBASE, GEOS-CHEM, MERRAERO, TM5)
Aerosol Annual Climatology: SSA and Ångström exponent

- Model SSA tends to be lower (more absorbing) than in-situ SSA → partly driven by model under-prediction of scattering

- Modelled Ångström exponents suggest larger particles than observed by in-situ measurements

Vertical bar shows range of model medians, horizontal bar is measurement uncertainty based on Sherman et al. (2015), only 2010 model output (CAM5, ECHAM6-SALSA, GLOBASE, GEOS-CHEM, MERRAERO, TM5)
Aerosol Seasonal Climatology: **Scattering**

Models do very well at predicting seasonality and/or loading at some sites.

Need to explore reasons for observed differences

- Site not representative of model gridbox
- Emissions or processing discrepancies
- ???
Aerosol Behavior: **Systematic Variability**

- Models and in-situ tend to exhibit similar relationships between SSA and SAE at many sites (especially marine sites).
- Anthropogenically-influenced sites may be hard to characterize this way.
Aerosol Behavior (Annual Climatology): Co-Variability

Systematic variability studies:
→ determine if model is simulating realistic aerosol
→ identify processes which may need a closer look (meteorology, emissions, atmospheric processes, model parameterizations)

In-situ annual median values for each site

- Continental
- Marine
- Mountain
- Polar
Model data exhibit similar overall relationships between SSA and SAE:
- general pattern of decreasing SSA with increasing SAE
- models tend to have darker, larger particles
Aerosol Behavior: Systematic Variability

Model data exhibit very different relationships between AAE and SAE → differences amongst models → differences between models and insitu

Suggests very different aerosol types.

Continental
Marine
Mountain
Polar
Takeaways

- Climatological comparisons tell us how models are doing now and may identify regions of difficulty for models
  - models tend to see lower scattering than in-situ
  - models tend to see darker aerosol (lower SSA) than in-situ
  - models tend to see larger aerosol (lower Ångström exponent) than in-situ

- Behavioral comparisons may indicate discrepancies in aerosol modules in terms of atmospheric sources/processes
  - models have varying success in reproducing observed co-variance amongst aerosol optical properties

→ Lots to do!!!
→ Lots to learn!!!