Sensitivity of AOT calculation to relative humidity

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GMI meeting
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AOT (550 nm) at April 2001

GMI: Global Modeling Initiative, an off-line model driven by GEOS-4 assimilation meteorological data at 2° latitude x 2.5° longitude and 3-hr time interval.
Mass Extinction Efficient (MEE) vs Relative Humidity (RH)

AOT = dry_mass x MEE (RH)
Motivation

- A small change in RH creates very large uncertainty in MEE
- Support inter-model comparison
Motivation

- A small change in RH creates very large uncertainty in MEE
- Support inter-model comparison

Kinne et al., 2003

<table>
<thead>
<tr>
<th>Model</th>
<th>ECHAM4</th>
<th>GOCART</th>
<th>MIRAGE</th>
<th>GISS</th>
<th>Sprintars</th>
<th>Grantour</th>
<th>ULAQ</th>
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<tr>
<td>Resolution</td>
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<td>2.5 x 2.0</td>
<td>2.8 x 2.8</td>
<td>5.0 x 4.0</td>
<td>1.1 x 1.1</td>
<td>5.6 x 5.6</td>
<td>22.5 x 10</td>
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</table>

Textor et al., 2006

16 models, 2 close to 1 x 1, 11 as 2.5 x 2, 2 as 5 x 4, and 1 as 22.5 x 10

Kinne et al., 2006

20 models, 1 close to 1 x 1, 13 as 2.5 x 2, 4 as 5 x 4, and 1 as 22.5 x 10
Goal

• What is the AOT variation in terms of RH variation due to using different model spatial resolution or using GCM meteorological field averaged over different time interval?
• Where and when is the AOT most sensitive to changes in RH?
Approach

• **Base case (2x2.5_3hr):**
  
  2° (latitude) x 2.5° (longitude),
  3 hour averaged RH

• **Control cases:**
  
  - 1° x1.25°, 3 hours (1x1.25_3hr)
  - 2° x2.5°, 6 hours (2x2.5_6hr)
AOT(1x1.25_3hr) vs AOT(2x2.5_3hr)

- High difference occurs over:
  1. high hygroscopic aerosol areas;
  2. surface escarpment;
  3. land-ocean boundary.
AOT(2x2.5_3hr) vs AOT(2x2.5_6hr)

• High difference occurs over middle latitudes
AOT (sea salt) using mean RH of 3-hr, 6-hr, and 24-hr

April 1, 2001 at 30E, 60S

Calculate AOT first and then average RH first and then calculate AOT
April 2001

AOT (3hr) - AOT (24hr)

Mean RHLand

RH (930 mb)

EA

EU

SH Storm Track

SH mid-lat

Ocean

Land

24 hr

3 hr
AOT (1x1.25) / AOT (2x2.5)

Look at Mountain Andes and Southern Africa !!!
Where and When is the AOT most sensitive to changes in RH?

- Middle Northern Hemisphere
- No apparent time pattern
Where and When

- Middle Northern and Southern Hemisphere
- Southern Hemisphere: late summer and early fall
- Northern Hemisphere: late fall and winter
### Relative change in TOA direct radiative effect (DRE) due to RH at 1x1.25 vs 2x2.5 resolution

<table>
<thead>
<tr>
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<th>Ocean</th>
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**Ocean global DRE:** MODIS/GOCART/GMI (2x2.5)/GMI (1x1.25) (Wm⁻²) -5.9 / -4.1 / -4.8 / -5.3

**Land global DRE:** MO_MI_GO/GOCART/GMI (2x2.5)/GMI (1x1.25) (Wm⁻²) -4.4 / -4.1 / -4.0 / -4.5

Yu et al., 2006 (ACP)
Relative change in TOA direct radiative effect (DRE) due to RH averaged over 3-hr vs 6-hr

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|       | Global mean | 3 | 3 |   |   |   |   |   |

Ocean global DRE: MODIS/GOCART/GMI (3hr)/GMI (6hr) (Wm$^{-2}$) -5.9 / -4.1 / -4.8 / -4.7

Land global DRE: MO_MI_GO/GOCART/GMI (3hr)/GMI (6hr) (Wm$^{-2}$) -4.4 / -4.1 / -4.0 / -3.9

Yu et al., 2006 (ACP)
Conclusions

• Global AOT is increased by using RH at higher model spatial resolutions, as well as by using mean RH at shorter periods.

• Global AOT is 11% higher by using RH in spatial resolution 1° by 1.25° instead of 2° by 2.5°. Accordingly, the TOA DRE increases by 10% and 14% over ocean and land respectively.

• The AOT is most sensitive to middle NH and surface escarpment regions when RH spatial resolution doubles. No apparent time pattern is found.
Conclusions

• **4%** higher global AOT is derived from using mean RH over 3-hr period instead of 6-hr period and the corresponding TOA DRE is **3%** higher globally.

• The AOT is most sensitive to middle latitudes of both hemispheres. The maximum AOT change occurs during late summer and early fall in SH and late fall and winter in NH.