Composition and physical properties of ATAL and NATAL

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Brian Toon, Ryan Neely, Bengt Martinsson, Carl Brenninkmeijer

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Briefly review: previous studies show pathway from Trop to Stratosphere, i.e. Asian summer monsoon

Transport pathways of carbon monoxide in the Asian summer monsoon diagnosed from Model of Ozone and Related Tracers (MOZART)

Mijeong Park, William J. Randel, Louisa K. Emmons, and Nathaniel J. Livesey

Asian Monsoon Transport of Pollution to the Stratosphere

William J. Randel, Mijeong Park, Louisa Emmons, Doug Kinnison, Peter Bernath, Kaley A. Walker, Chris Boone, Hugh Pumphrey
We are using a sectional aerosol model.

CAM5/CARMA Model

1. Emissions
   - POA/BC: GFEDv3&FINN, GAINS
   - Sea Salt: Fan and Toon (2011)
   - Dust: Su and Toon (2009)
   - Sulfate: English et al. (2011)
   - VOC: monoterpenes, isoprene, benzene, toluene and xylene

2. Chemistry
   - SOA: Gas/Particle partitioning
   - Sulfur chemistry
   - Aqueous chemistry

3. Nucleation

4. Condensational growth
   - Wt %: Tabazadeh et al. (1997)

5. Coagulation

6. Dry deposition

7. Aerosol activation/cloud Evaporation

8. Wet deposition

Yu et al., 2015, JAMES

CAM5

Dynamics/Transport

CARMA

56 levels
RRTMG
MG Cloud

20*6=120 bins

BHN: Zhao and Turco (1995)
H₂O vp over H₂SO₄: Lin and Tabazadeh (2001)
H₂SO₄ vp: Giauque (1959), Ayers et al. (1980), Kulmala (1990)
CARMA has broader size distribution compared with modal aerosol schemes.

POA includes biomass burning organics, anthropogenic organics, marine organics and biological particles.
56-level CAM5/CARMA has similar vertical resolution around UTLS compared with WACCM.
CARMA captures Global AOD distribution, while underestimates AOD over ocean.
Model captures 89% of AeroNet AOD on average.
OC is about equal to sulfate mass at TTL, as simulated and observed.
Sulfate effective radius is between 0.1 to 0.18 um in stratosphere.

Mixed particles effective radius at UTLS is 0.16 um.
Simulated Extinction Ratio is larger than observation by a factor of 2-3

Vernier et al., 2013, ACP
CARMA extinction ratio has maximum in ATAL and NATAL

Vernier et al., 2013, ACP
High latitude gradient of Organics/Sulfate mass ratio is simulated and observed.
ATAL is POA and sulfate; NATAL is mostly SOA and sulfate
Observations suggest optical depth of ATAL increased in last decade

Vernier et al., GRL, 2015
Optical depth changed from 2000-2010 due to changing emissions of sulfate and organics.
Summary

- CARMA is a sectional aerosol model and documented in Yu et al. [2015, *JAMES*]
- At UTLS, organics is about equal to sulfate mass;
- At UTLS, aerosol effective radius is 0.1-0.2 μm;
- ATAL and NATAL is simulated in CARMA;
- The intensity of ATAL is overestimated by a factor of three;
- ATAL is mainly composed of sulfate, SOA and POA;
- NATAL is mainly composed of sulfate and SOA;
- Asian anthropogenic emission may explain observed intensity trend of ATAL;
Evaluations of tropospheric aerosol properties simulated by the community earth system model with a sectional aerosol microphysics scheme

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Composition and physical properties of the Asian Tropopause Aerosol Layer and the North American Tropospheric Aerosol Layer

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SAGE II retrieval filter by Vernier et al. [2013]
We care about the impact of emissions on stratospheric aerosols because it may explain part of “warming hiatus”

Neely et al., GRL, 2013
OC is about equal to sulfate mass at TTL, as simulated and observed.