Aerosol Working Group

Aerosol WG Co-Chairs:

Colette Heald: heald@mit.edu

Peter Adams (outgoing): petera@andrew.cmu.edu

Jeff Pierce (incoming): jeffrey.pierce@colostate.edu

Becky Alexander (incoming): beckya@uw.edu

Fangqun Yu (incoming): fangqun.yu@asrc.albany.edu

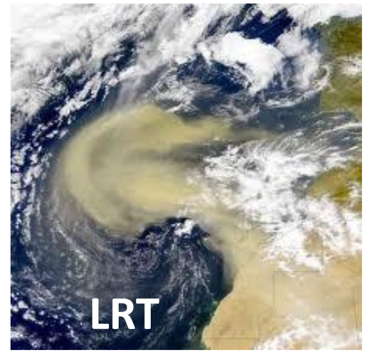
To join email list send email to: geos-chem-aerosols+subscribe@g.harvard.edu

The 8th International GEOS-Chem User's Meeting

May 1, 2017

Aerosols are an Integral Part of GEOS-Chem Simulation and Core to Science Questions of our Community

Air Quality

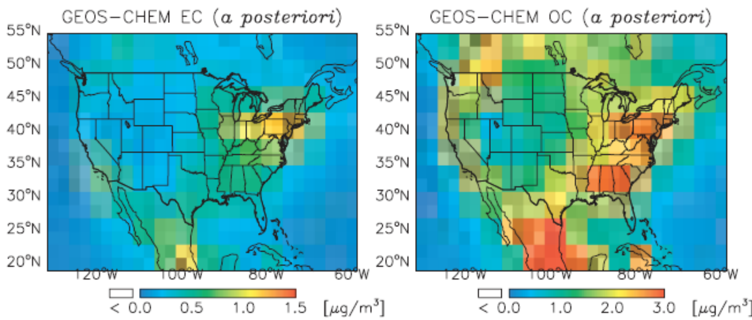


Ecosystem Health

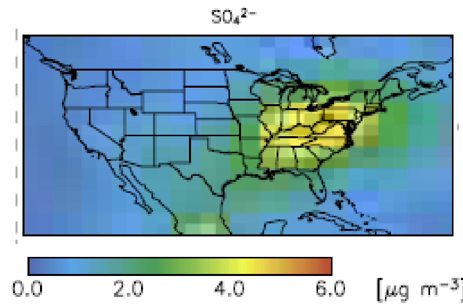
Climate

The History of Aerosols in GEOS-Chem

Carbonaceous Aerosols and **Sulfate-Nitrate Ammonium** based on GOCART



[Park et al., 2003]



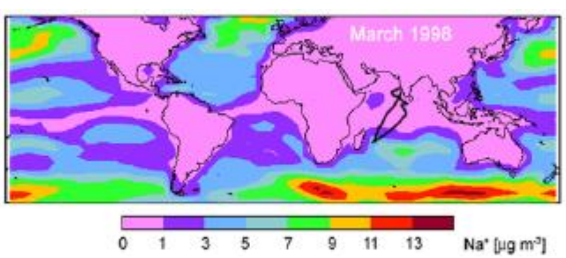
[Park et al., 2004]

Now uses ISORROPIA II (implemented by Pye et al., [2009])

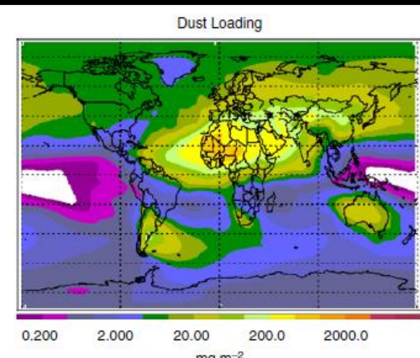
Sea Salt

Dust (DEAD Scheme with GOCART source map)

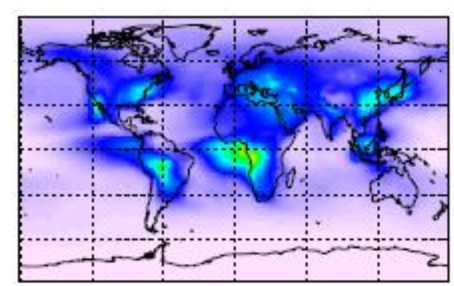
SOA (biogenic & anthropogenic, SV POA)



[Alexander et al, 2005; Jaeglé et al., 2011]



[Fairlie et al., 2007]



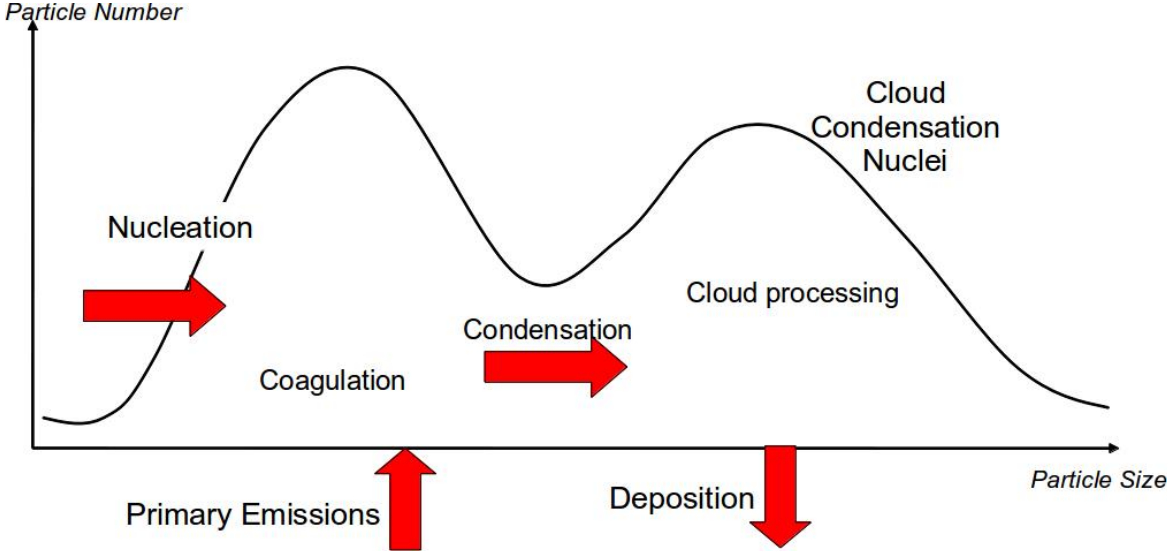
[Liao et al., 2007; Henze et al., 2008; Pye et al., 2010]

- mass based scheme, assumes log-normal size distributions
- full-chemistry with or without detailed SOA (benchmark now includes detailed SOA)

Sectional Scheme Option: TOMAS

TwO-Moment Aerosol Sectional microphysics scheme
(maintained by Jack Kodros, Jeff Pierce and Peter Adams)

- Explicit simulation of the aerosol size distribution.
    - Aerosol/climate effects and aerosol-size/heath effects



Features

- Aerosol number and mass simulated in 12, 15, 30, or 40 size sections
    - explicit aerosol number balance
- 4x5, 2x2.5, and 0.5x0.666 nested grid
- GEOS-Chem aerosol species incorporated into size sections
- Sulfate, primary OC, SOA, EC, sea salt, dust

In the Pipeline:

- tagging
- harmonization with bulk aerosol scheme

Sectional Scheme Option: APM

Advanced Particle Microphysics scheme
(maintained by Gan Luo and Fangqun Yu)

❖ Key Features:

(1) Size-resolved microphysics with **variable size resolution** for particles of different types and sizes

(2) Mixing states: **semi-externally mixed, with coating of primary particles by secondary species explicitly simulated.**

❖ GC-APM AeroCom II and other inter-comparison participation

1) Aerosol direct radiative forcing (Myhre et al., 2013)
2) Host model uncertainties in model radiative forcing estimates (Stier et al., 2013)
3) Aerosol microphysics (Mann et al., 2013)
4) Aerosol organics (Tsigaridis et al., 2014)
5) Aerosols at Poles (Sand et al., 2017)
6) CCN model inter-comparison (Fanourgakis et al., 2017)

❖ Recent advances

(1) APM has been integrated into v10-01

(2) Added a number of new nucleation schemes to study processes controlling CCN number abundance and implications

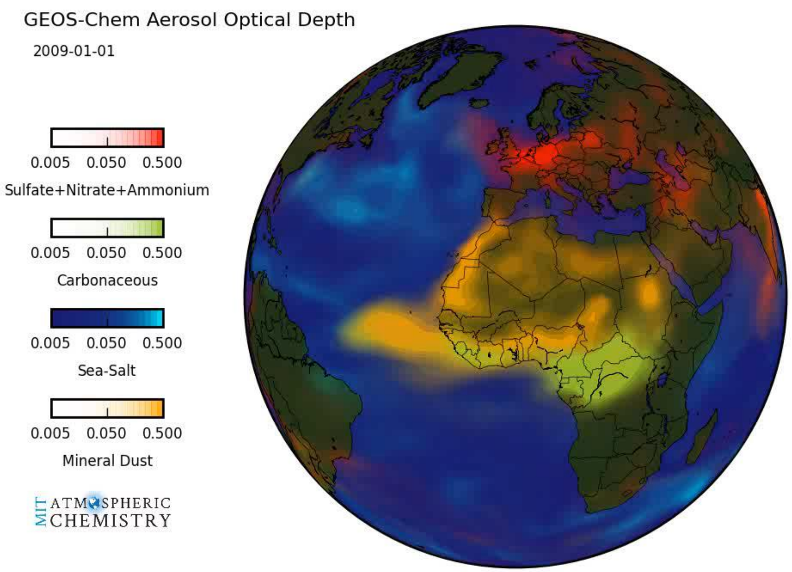
(3) Coupled GC-APM output with WRF-Chem/APM to study long-range transport on aerosol-cloud-precipitation interactions

(4) Developed algorithms to take into account effects of particle sizes of heterogeneous uptake and chemistry

(5) In the process of updating APM to v11-01

Research Topics Being Investigated in the WG

- Aerosol chemistry (e.g. sulfate formation, SOA, aqueous chemistry)
- Black carbon and absorbing aerosol
- Sea salt aerosols and impacts on global tropospheric chemistry
- Dust and metals
- Regional AQ (e.g. Arctic aerosols)
- Historical aerosol trends, future aerosol projections (AQ and climate)
- Satellite-based $PM_{2.5}$ estimation
- Long range transport and impacts
- Estimating associated health impacts
- Aerosol microphysics: new particle formation, optics, mixing state, direct effect, indirect effect, geoengineering



Progress since IGC7

v10-01

- RRTMG online

v11.01

- Uptake of SO_2, nitric acid, and sulfuric acid on mineral dust (default: off)
- Marine emissions of OA (default: off)
- DMS climatology updated to Lana
- BrC impacts on OH (default: off)
- Density of OA update
- Update dust size distribution
- $PM_{2.5}$ diagnostic
- Impaction scavenging for hydrophobic BC
- Homogeneous IN removal
- DST2-DST4 as coarse mode in wet scavenging

Future of SOA in GEOS-Chem

(path mapped out after telecom for Aerosol WG in June 2016)

Major challenge

- "traditional" OA treatments usually under-predict concentrations
- Lots of ideas about what is missing but no consensus

Varying user needs

- Some actively developing new SOA chemistry
- Some mostly want reasonable OA fields in context of broader studies

Option #1: Simpler organic aerosol

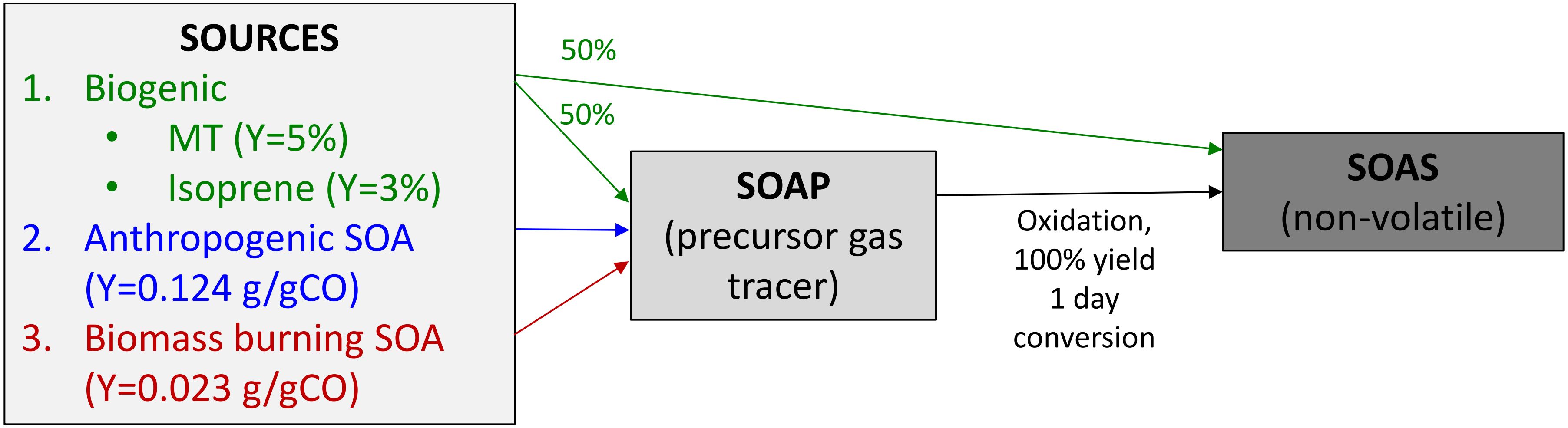
- Users not focused on OA chemistry
- Get approx. correct amount of OA
- Minimal computational cost
- Easily tunable, updateable
- Evolving science: this is "agnostic" about details of processes

Option #2: Process-based organic aerosol

- Users who want to test SOA chemistry schemes etc
- Goal is flexible framework to accommodate new chemistry schemes, data, etc

Update on simple, irreversible SOA scheme

Based on current default scheme with fixed 10% SOA yield from terpenes (added to OCi)



- Currently ~ 93 Tg/yr (Aerosol WG discussion topic: should this be increased?)
- Yields all specified in HEMCO (easily adjustable): defaults based on Kim et al. (2015)
- Capability added to both bulk model and TOMAS

Led by Sal Farina and Jeff Pierce (CSU)

Important Capabilities in the Pipeline

- Updates to simple SOA scheme (Aerosol WG, Jeff Pierce, v11.02b)
- Aqueous isoprene uptake to SOA added to detailed SOA scheme (Eloise Marais, v11.02c)
- Update BC density to 1.8 & add absorption enhancement (Xuan Wang, v11.02c)
- Harmonize Henry's Law coefficient across wet & dry dep (GCST, Duncan Fairlie)
- MOSAIC implementation: tentative (Seb Eastham)
- DMS oxidation scheme updates: tentative (Becky Alexander)

Challenges Ahead, Topics for Discussion

- Maintaining 3rd party code (TOMAS, APM, RRTMG)
- Full integration of gas and particle phase chemical mechanism
- Modernizing aerosol optics
- Evolving SOA development
- Others??