An Aerosol Branch

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Aerosol Science Questions

- What are the direct and indirect effects of anthropogenic aerosol on the past, present and future planetary energy balance?
- What are the effects of anthropogenic aerosol on the global and regional water balance?
- What are the impacts of anthropogenic aerosol on past and future climate?
- What is the role of aerosol deposition in surface biology?
- How much does climate-wildfire feedback contribute to climate variability?
- What is the role of climate-dust feedback?
- How strong is the climate-DMS feedback?
- What are potential impacts of engineered aerosol?

Aerosol Options in CAM

- Bulk Aerosol Model (BAM)
- Modal Aerosol Model (MAM)
- Community Aerosol-Radiation-Microphysics for Atmospheres (CARMA)
- LLNL Sectional Model

A Modal Aerosol Model Branch

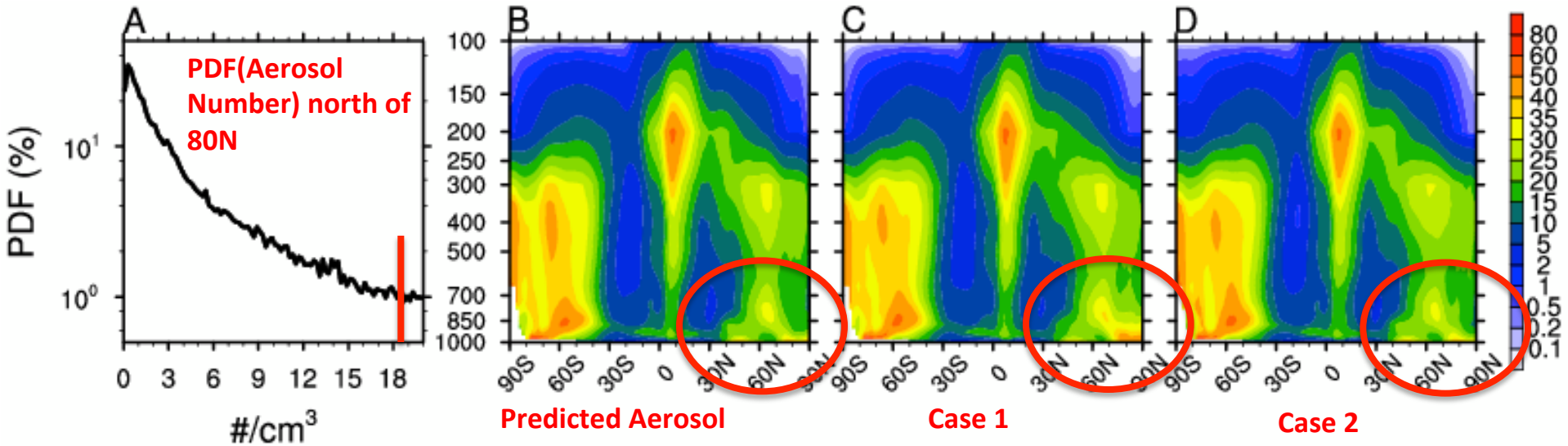
- Coordinate MAM development efforts
- Facilitate coupling of atmosphere and surface models
- Simplify merge onto trunk

Current MAM Branch

https://svn-ccsm-models.cgd.ucar.edu/cam1/branches/aerosol/

- Updated to cesm1.2
- Prescribed aerosol option (in cesm1.2)
- Diagnostic radiation for any MAM specie (in cesm1.2)
- AeroCom diagnostics (in cesm1.2 as history_aero_optics)
- Modal optics coefficients calculations
- MAM4: primary hydrophobic carbon mode added to MAM3
- Less absorbing dust physprops file
- Improved aerosol scavenging (H. Wang GMD)

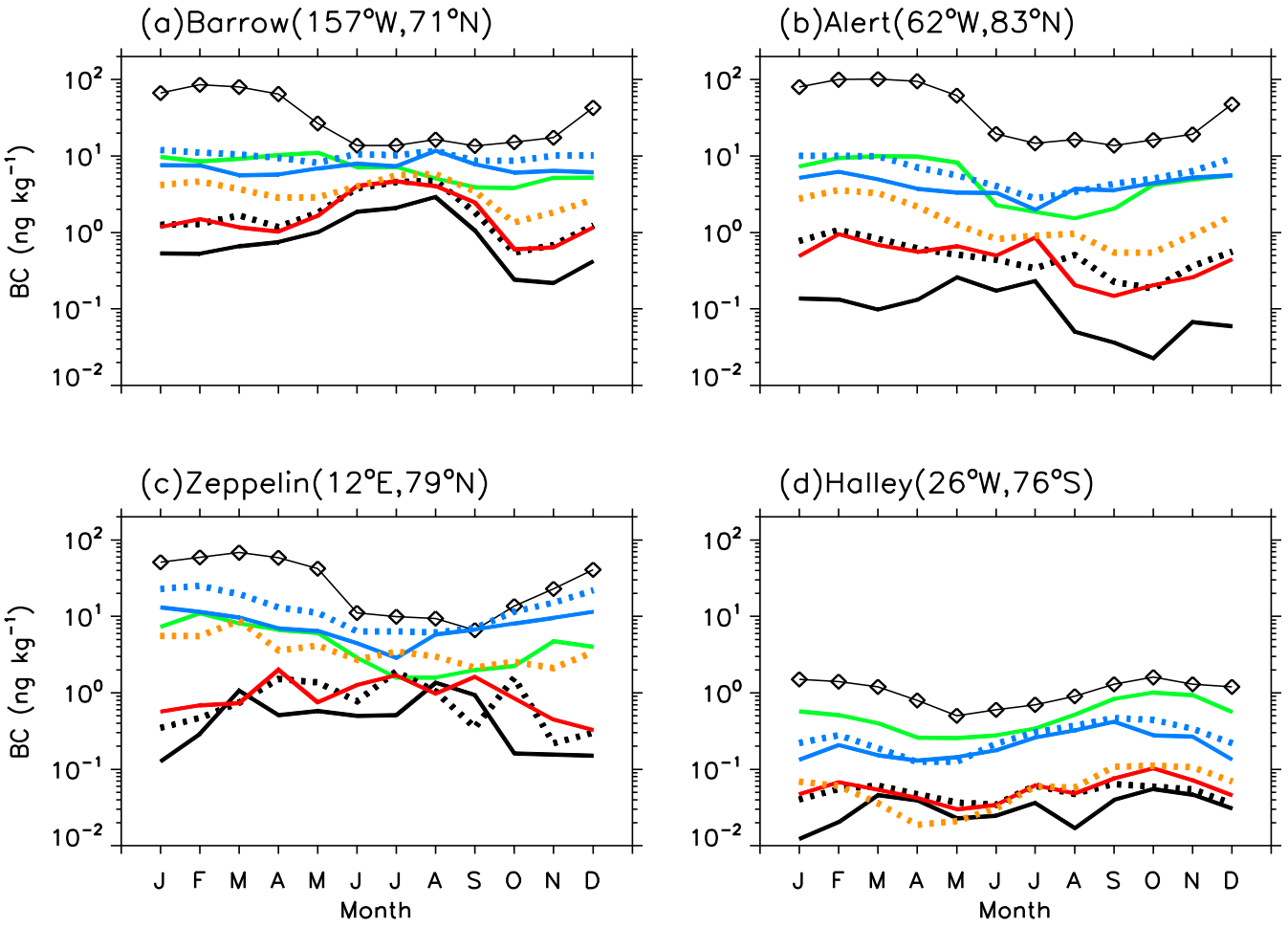
Prescribed Aerosol in CAM5: Random sampling based on log-normal distribution approach produces very similar climate to predicted aerosol



- Case 1: Conditionally sampled approach results in **excessive Arctic low cloud** during northern summer season and large difference in TOA energy balance. This is due to high frequency of very low aerosol number and mass concentrations simulated by CAM5.
- Case 2: Random sampling approach based on log-normal frequency distribution solves the problem and produces climate very similar to fully coupled (TOA energy difference is less than 0.03 W m^{-2}). Computational efficiency increases by 50%. It is on the CAM5 trunk.

Yoon, Rasch & Ghan

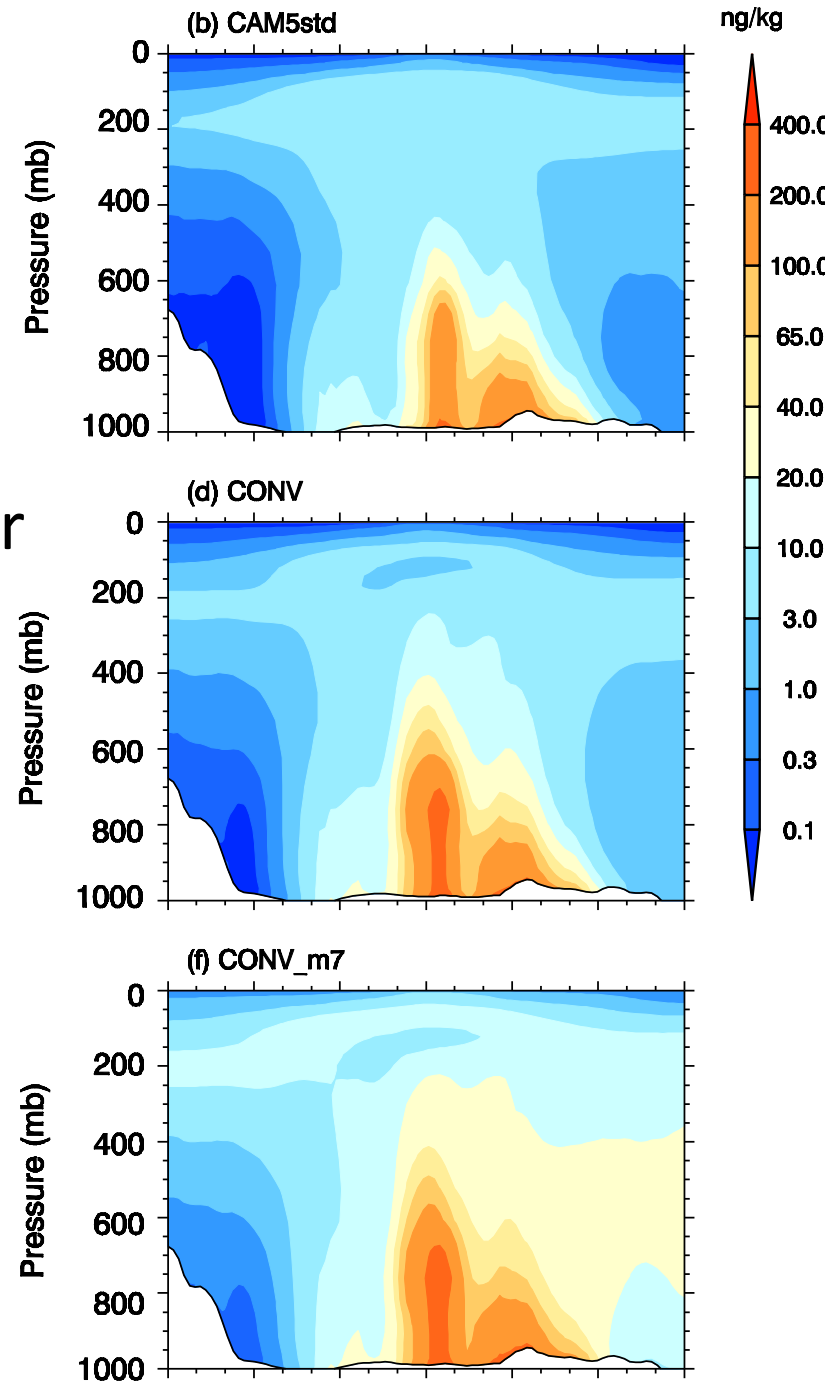
Improved Aerosol Scavenging



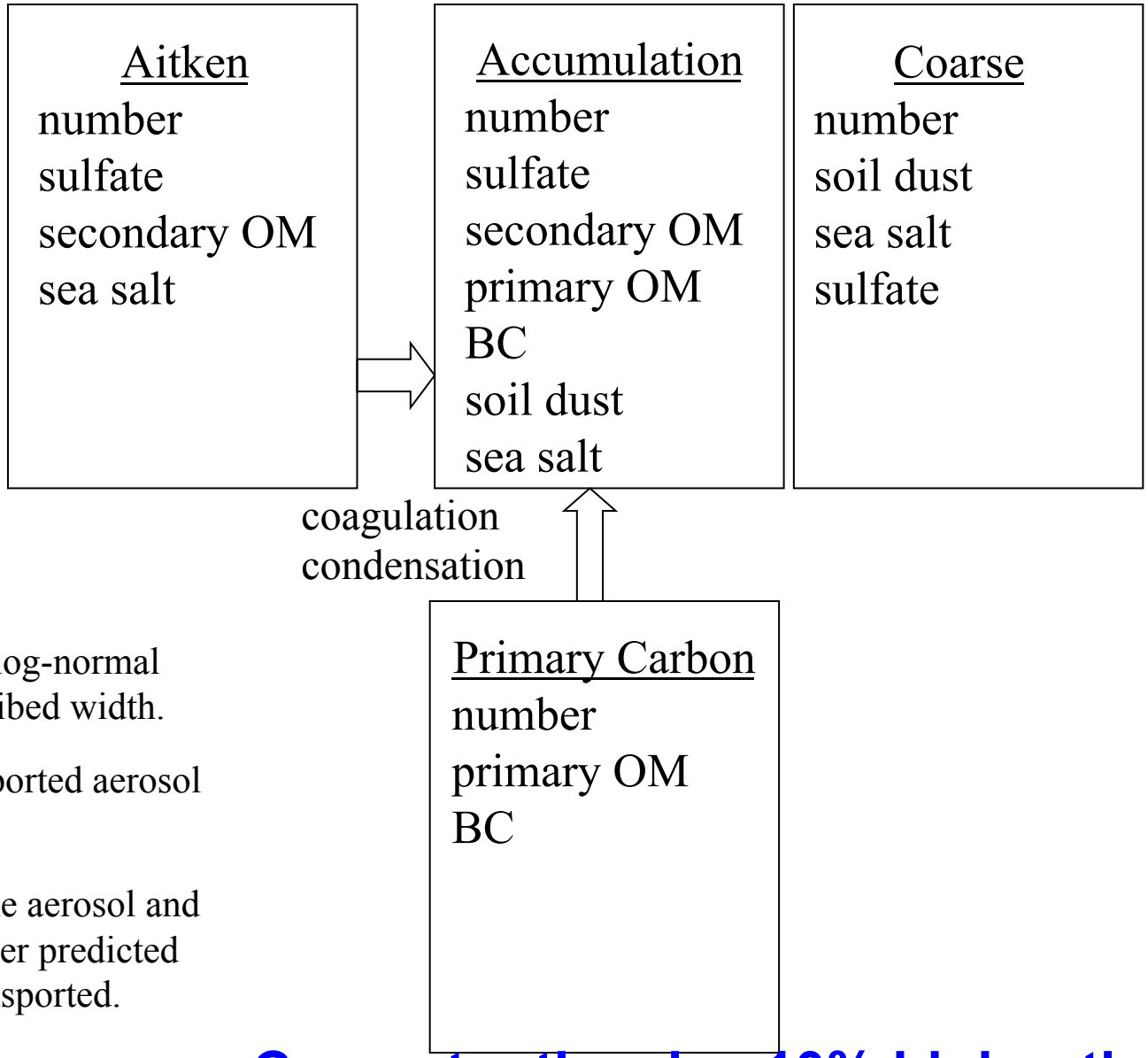
H. Wang et al., GMDD, 2013

BC vertical distribution

- Convective scavenging and transport mods increase polar concentrations in lower troposphere
- Externally-mixed mode puts much more BC in the Arctic middle troposphere



4-Mode version of MAM



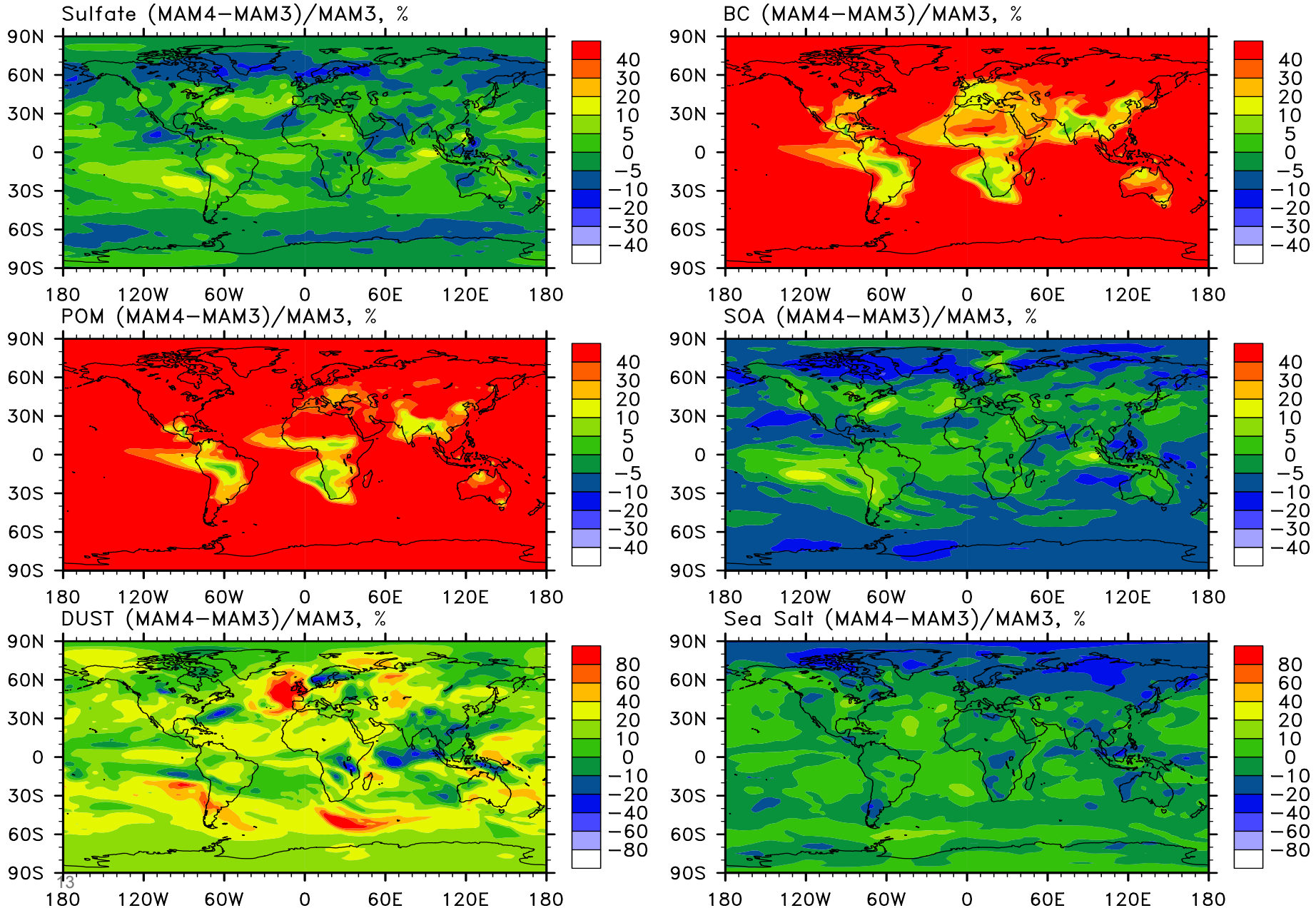
All modes log-normal with prescribed width.

Total transported aerosol tracers: **18**

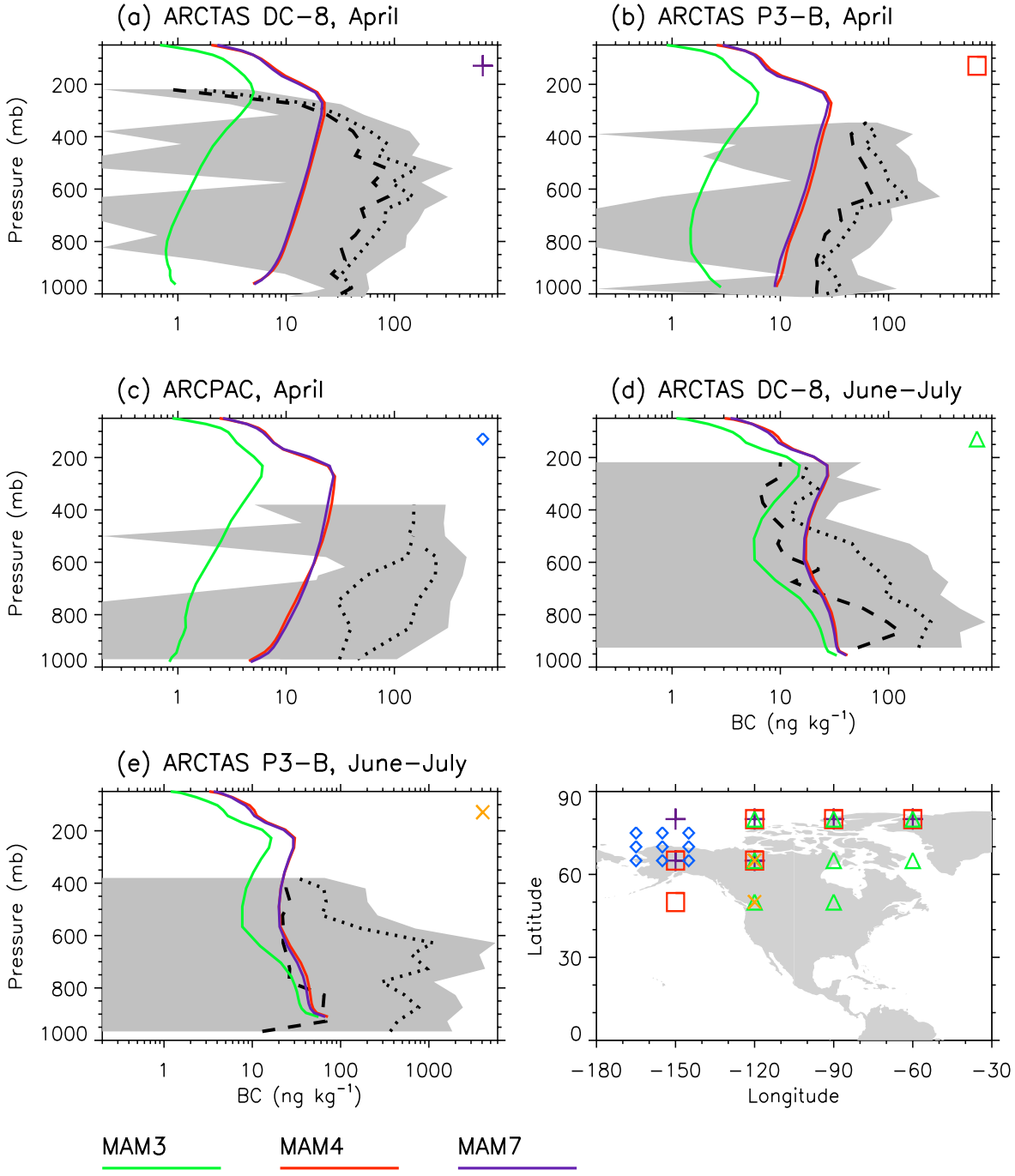
Cloud-borne aerosol and aerosol water predicted but not transported.

Computer time is ~10% higher than MAM3

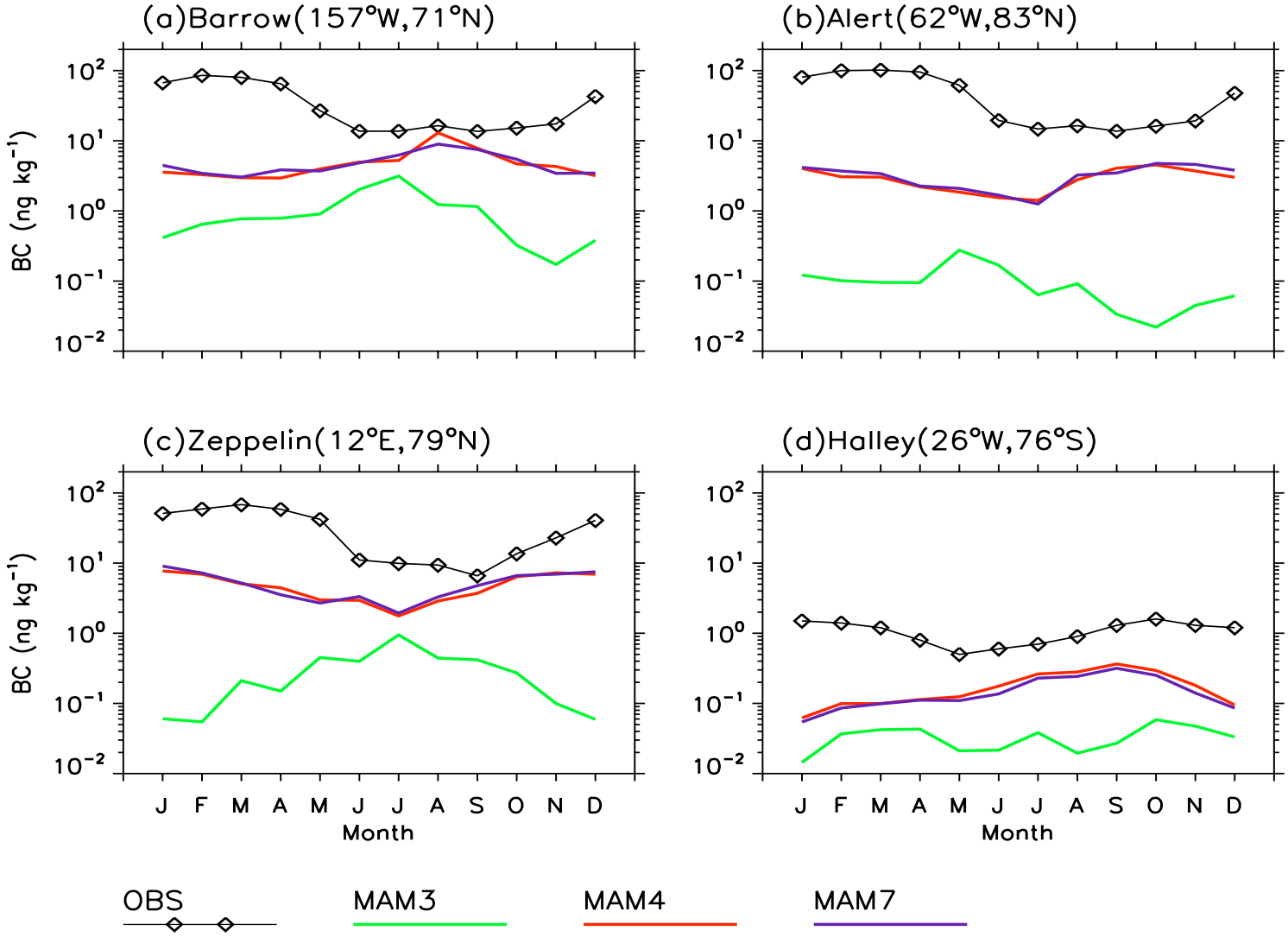
Aerosol mass burden %diff. (MAM4-MAM3)/MAM3



BC compared with SP2 (highlat.)



Seasonal BC at surface (highlat.)



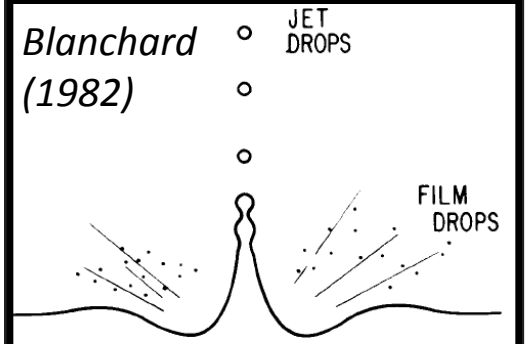
Future MAM Branch

- Prescribed aerosol option (in cesm1.3)
- Diagnostic radiation for any MAM specie (in cesm1.3)
- AeroCom diagnostics (in cesm1.3 as history_aero_optics)
- MAM4: primary hydrophobic carbon mode added to MAM3
- Less absorbing dust physprops file
- Improved aerosol scavenging (H. Wang GMDD)
- Improved dust emission size distribution (Cornell, PNNL)
- Speciation of dust: optics (Cornell) & ice nucleation (PNNL)
- More general aerosol thermodynamics (PNNL)
- Ammonium & nitrate (NCAR)
- Speciation of POM: hygroscopicity (PNNL)
- Ion-induced nucleation & subgrid homogeneous nuc (SUNY-Albany, PNNL)
- Marine organic sources (NC State, Harvard, LANL, Scripps, PNNL)

MBL

Aerosolization of film by bubble bursting.

Blanchard (1982)



SML

Bubbles rest on surface; film drains, preferentially reducing non-surfactants.

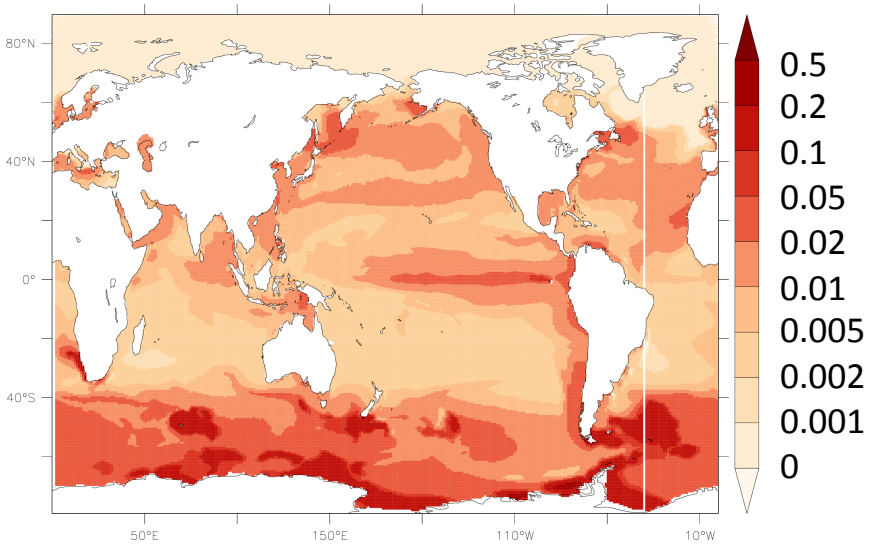
BLK

Collection of surfactants on bubble surfaces by impaction, interception and diffusion, followed by adhesion/adsorption. Upward transport and deposition in SML.

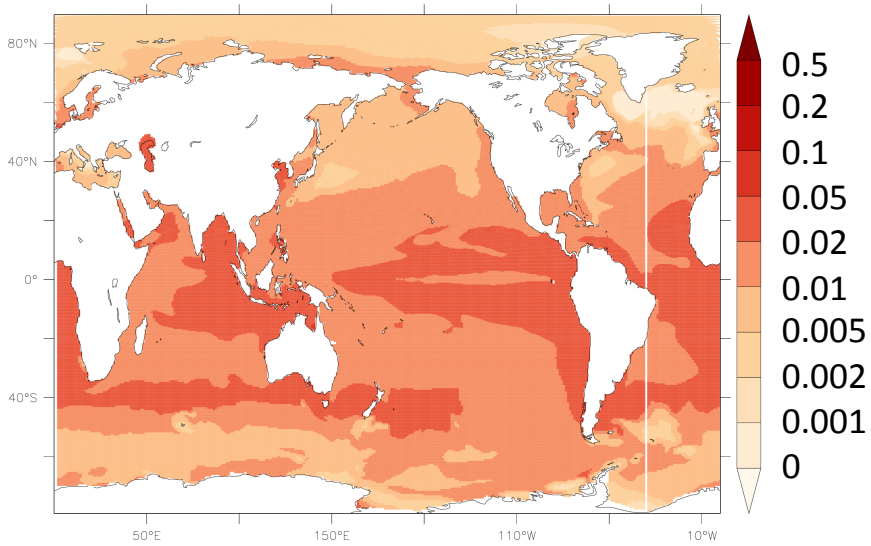
S. Burrows, S. Elliott et al., 2013, in prep.

Chemically-resolved submicron sea spray aerosol
Dry mass fraction, February

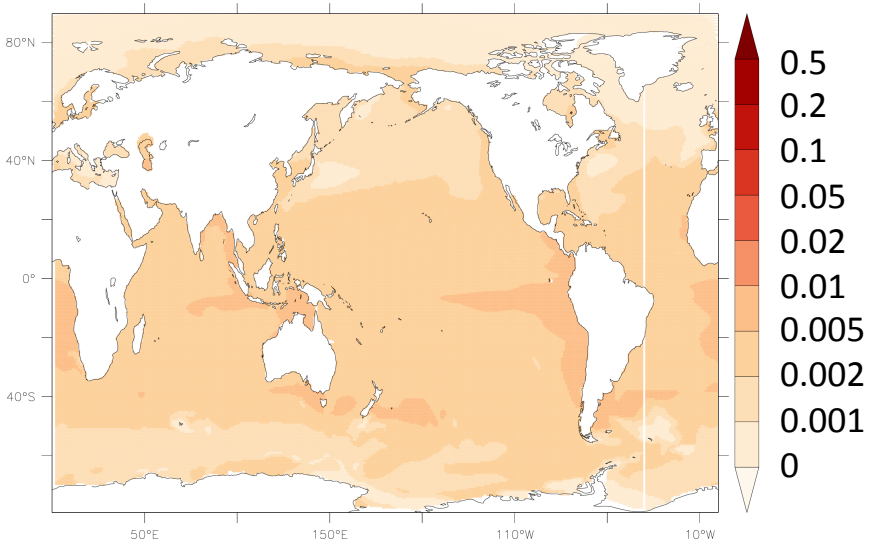
Lipids



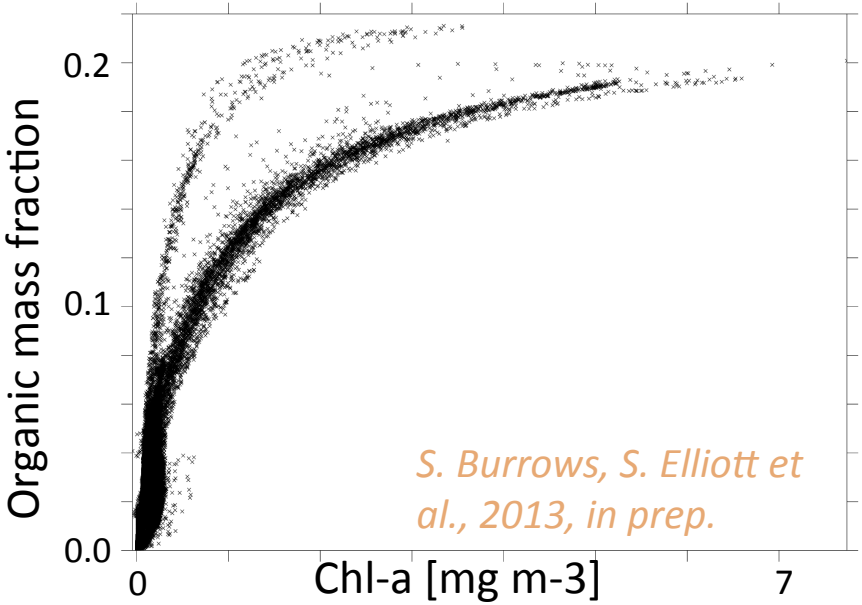
Proteins



Polysaccharides



Organic mass fraction vs. chl-a



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- Marine organic sources (NC State, Harvard, LANL, Scripps, PNNL)
- Secondary organic aerosol intercomparison (MIT, NCAR, PNNL, LLNL, UM)
- Coupled fire smoke emissions (Cornell & PNNL)
- Coupled DMS emissions (LANL, ORNL, LLNL, PNNL)
- Coupling MAM to SNICAR (Flanner & PNNL)
- MAM volcanic aerosol (NCAR, PNNL)
- Geoengineering stratosphere, CCN (NCAR, PNNL)
- Frost flower sources (Scripps, LANL)

Beyond MAM

- Generalize as many aerosol processes as possible to accommodate other aerosol representations
  - Primary emissions
  - Condensation of sulfuric acid
  - Water uptake
  - Aerosol optical properties
  - Aerosol activation
  - Nucleation scavenging
  - Impaction scavenging
  - Sedimentation
  - Dry deposition
  - Impacts on snow albedo

Dust at high resolution

- Strong resolution dependence of soil erodability
- Do not use
  - inputdata/atm/cam/dst/dst_0.9x1.25_c100121.nc
  - inputdata/atm/cam/dst/dst_0.47x0.63_c100121.nc
  - inputdata/atm/cam/dst/dst_0.23x0.31_c100121.nc