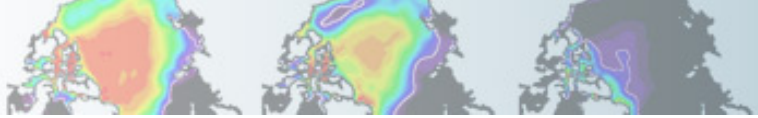
CESM Whole Atmosphere Working Group Session
Tuesday, 18 June 2013
The Village – Aspen / Blue Spruce Room – Breckenridge, Colorado

Webcast Instructions and Information: http://www.cesm.ucar.edu/events/webcasts/

8:50 a.m.	Mike Mills – Emissions-based volcanic aerosol development
9:15 a.m.	Yunqian Zhu – Polar stratospheric clouds modeling using SD-WACCM / CARMA mode
9:40 a.m.	Doug Kinnison (given by Dan Marsh) – Status and results from CCMI WACCM simulations
10:05 a.m.	Nick Pedatella – Data assimilation in the Whole Atmosphere Community Climate Model
10:30 a.m.	*Break*
11:00 a.m.	Dan Marsh – Meteoric metal chemistry in WACCM
11:25 a.m.	Hanli Liu – Ionosphere variability due to lower atmosphere driving
11:45 a.m.	Discussion
12:00 p.m.	Adjourn



Emissions-based volcanic aerosol development

Mike Mills
WACCM Liaison

With help from Dick Easter, Steve Ghan, Ryan Neely, Jean-François Lamarque, Andrew Conley, Jason English, and Xiaohong Liu

Happy Birthday to our favorite (Dan) Marshian!

WHAT'S NEW IN CESM1.2.0 - SCIENCE

The CESM1.2 release has numerous new key features among which are the addition of CLM4.5, new science changes to CAM5 running with the CAM-SE dynamical core, and new scripting infrastructure for the generation of component sets, grids and model testing.

Additional information regarding these updates is also available in the CESM User's Guide and in the individual model component documentation.

CAM-WACCM

Functional updates for WACCM include:

- New compsets for WACCM4 with CARMA sectional microphysics code for aerosols:
  - BNUKE_C4WBC_L40CN - Stratospheric black carbon for nuclear winter studies (RCP4.5, functional)
  - FGEOS_C4WSF_L40CN - Stratospheric sulfate coupled to heterogenous chemistry, nudged by specified dynamics (SD-WACCM, functional)
- WACCM spectral element (SE) dycore support (functional)
- Updates and bug fixes for specified chemistry (SC-WACCM, functional)
- ozone file fixed
- Updates for specified dynamics (SD-WACCM and SD-CAMchem, functional)
- SSI/TSI and Kp files updated for 2012
- SPE and SAD file updates for 2012 to be created
- new namelist specification for nudging factor (time scale, rather than percent)
- WACCM5 updates and bug fixes (functional)
- Chemistry updates in waccm_mozart (functional)
- Removed obsolete waccm_mozart_v1 chemistry package

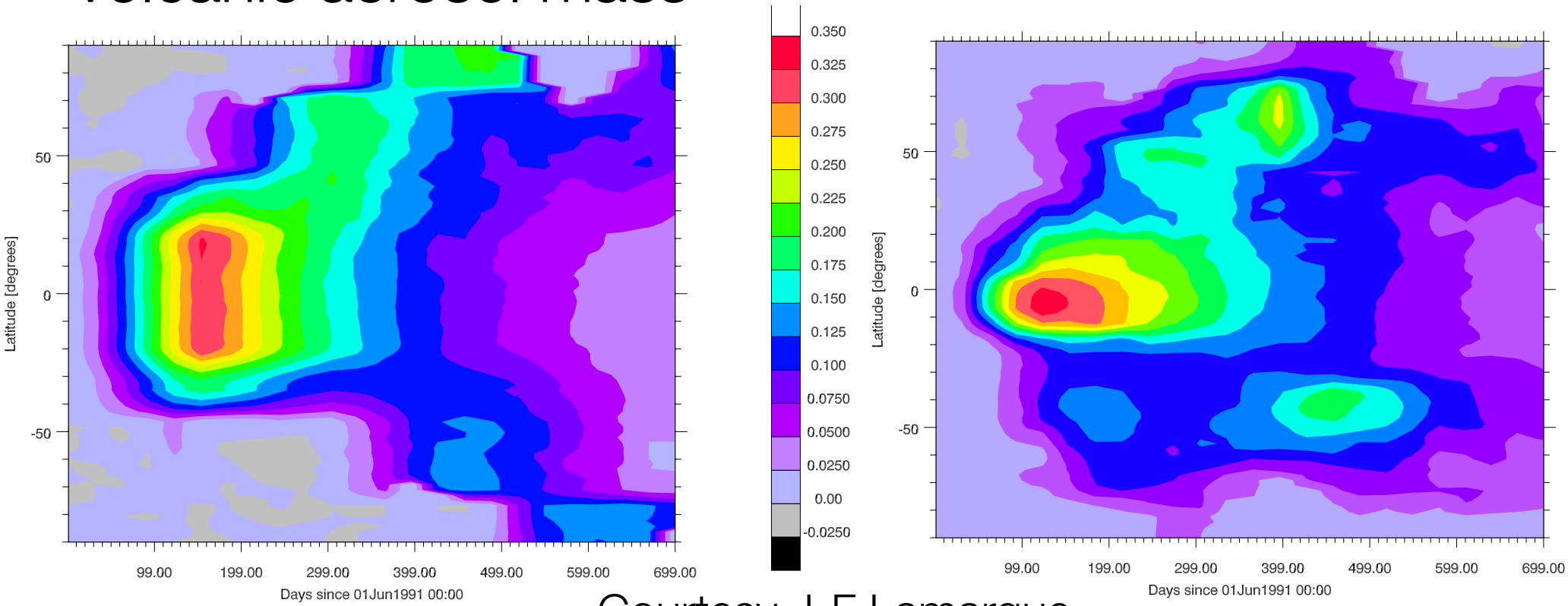
No scientifically supported WACCM compsets in 1.2.0 yet

CISM

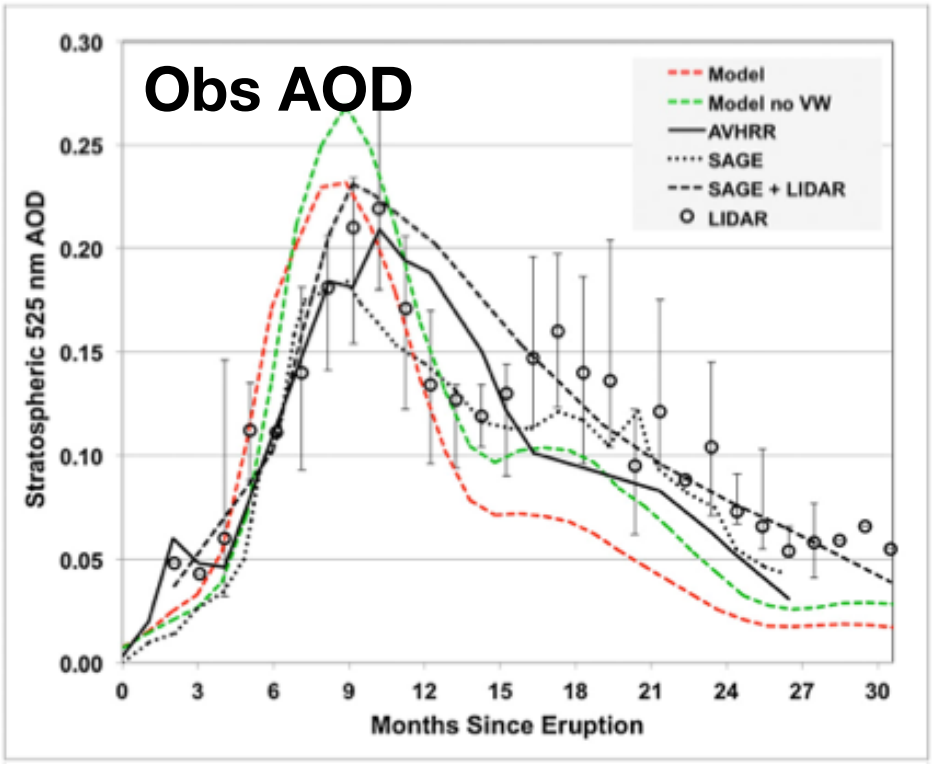
Prescribed volcanic aerosol in WACCM4 and CAM

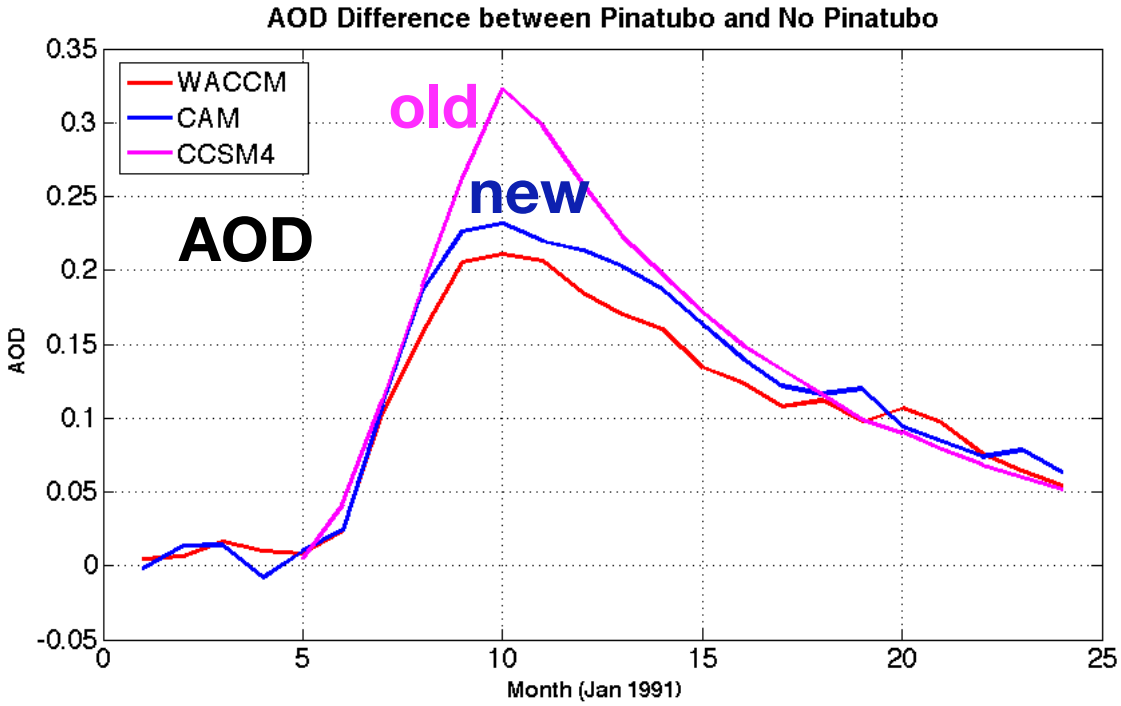
CCSM4 optical depth based on prescribed volcanic aerosol mass

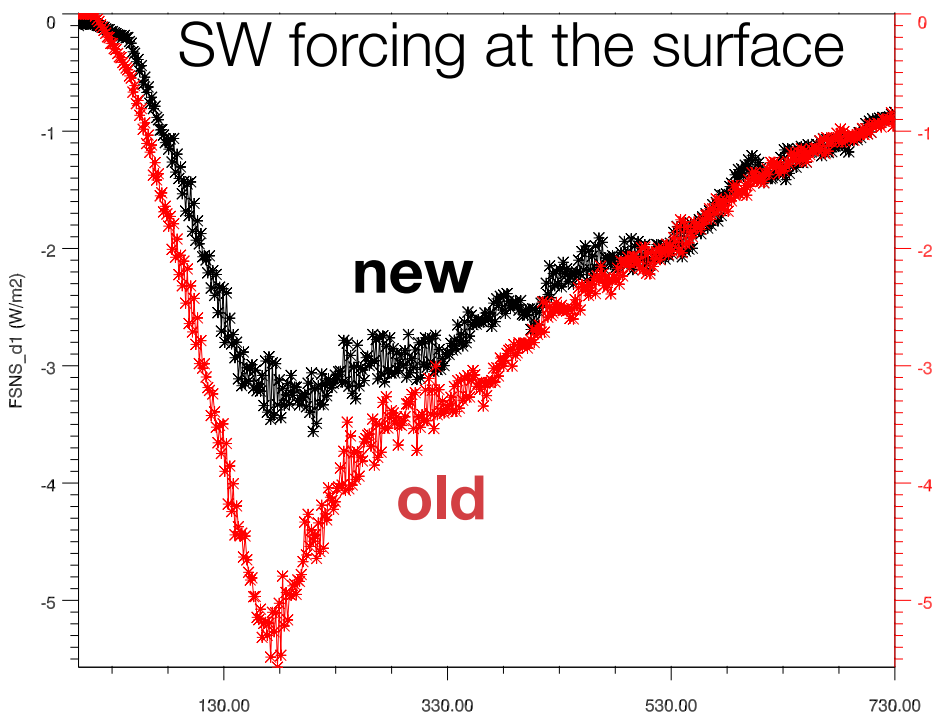
Improved optical depth based on prescribed volcanic aerosol mass and radius

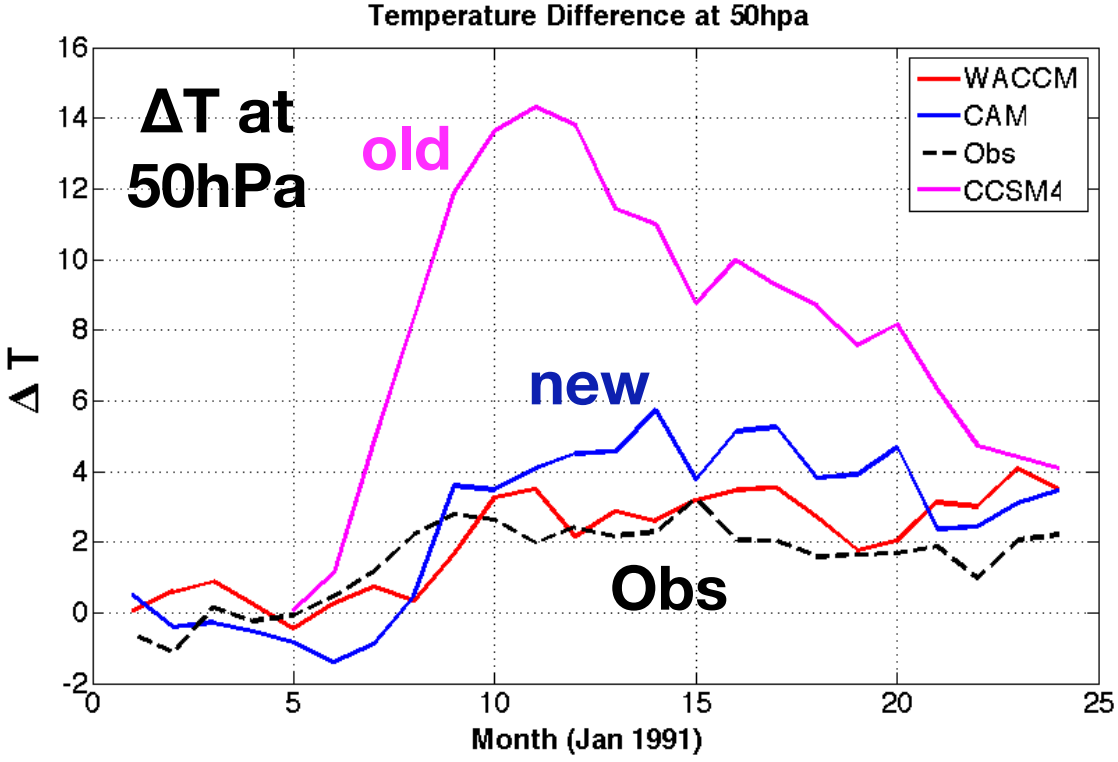


Courtesy J-F Lamarque

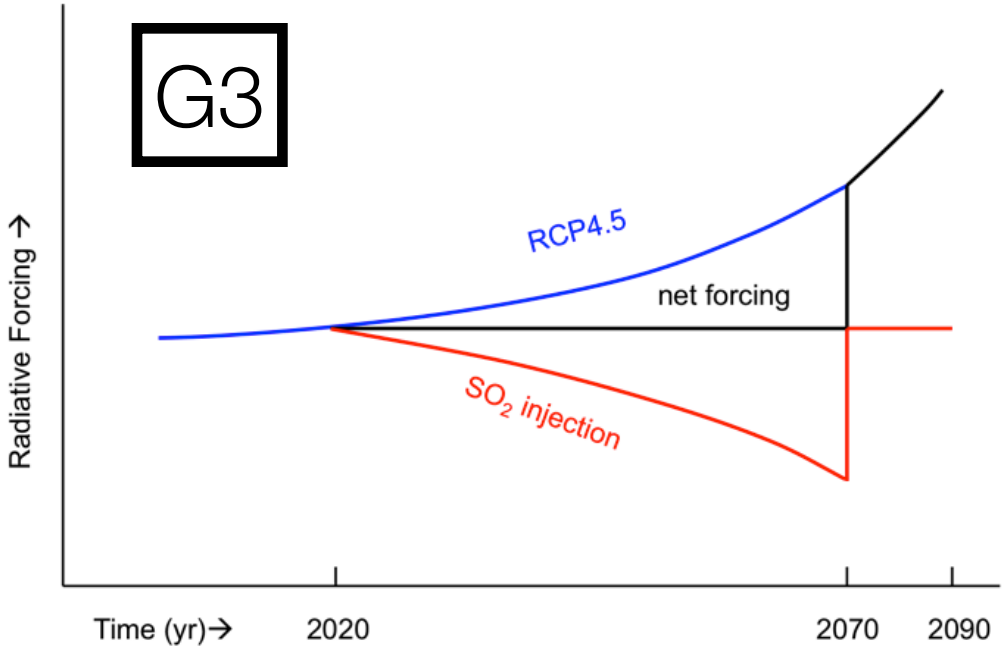

Obs AOD
Model
Model no VW
AVHRR
SAGE
SAGE + LIDAR
LIDAR
Stratospheric 525 nm AOD
Months Since Eruption

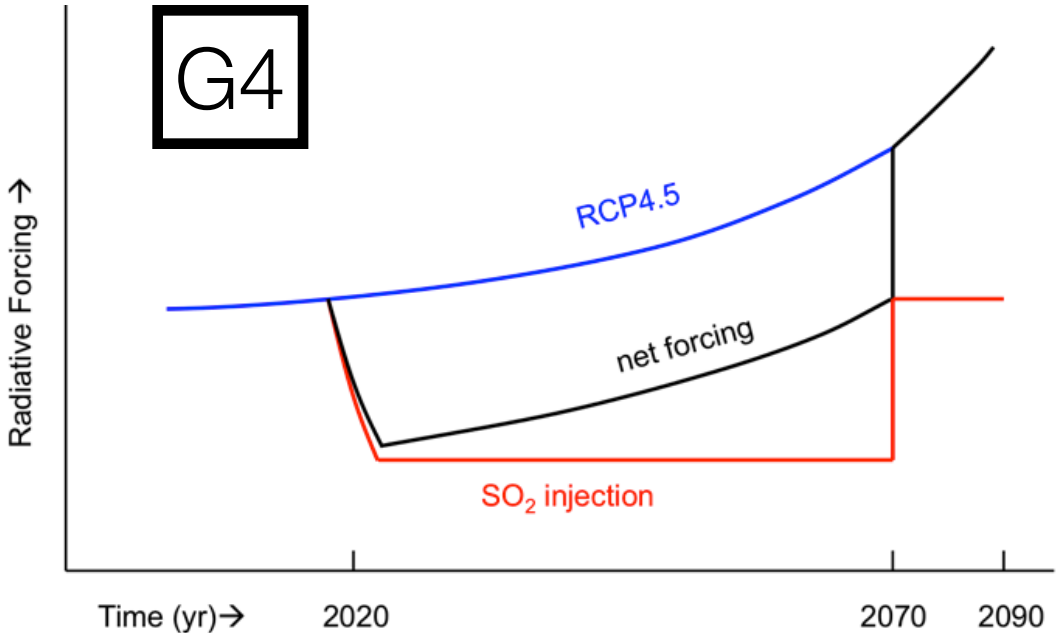

AOD Difference between Pinatubo and No Pinatubo
WACCM
CAM
CCSM4
old
new
AOD
AOD
Month (Jan 1991)


SW forcing at the surface
new
old
FSNS_d1 (W/m2)


Temperature Difference at 50hpa
ΔT at 50hPa
WACCM
CAM
Obs
CCSM4
old
new
Obs
Δ T
Month (Jan 1991)

The Geoengineering Model Intercomparison Project

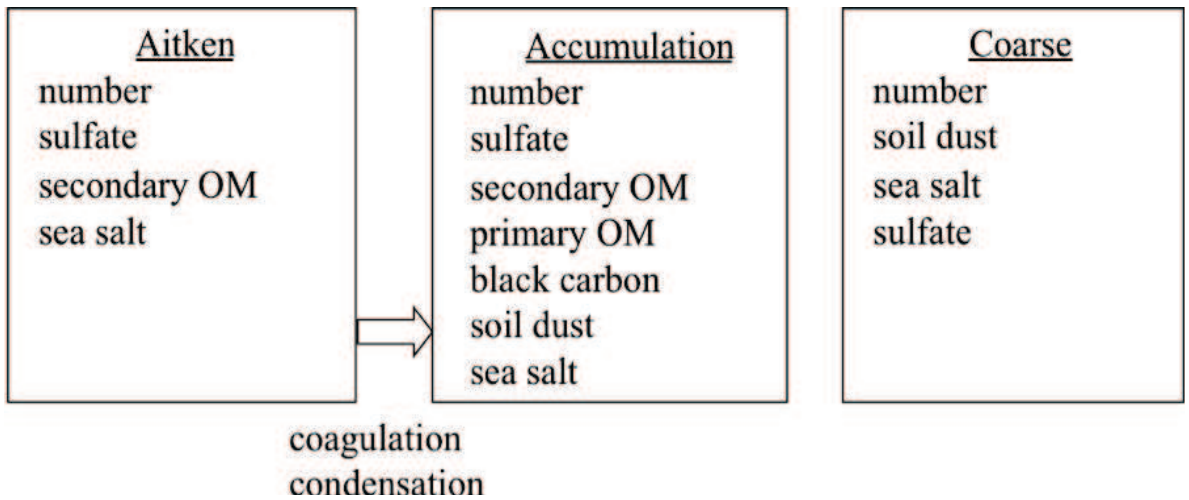




Modeling geoengineering schemes and unobserved (including historic and paleo) volcanoes requires an emissions-based volcanic aerosol scheme.

- CARMA microphysics
  - sectional (bin) model with detailed aerosol microphysics
  - incorporated in CESM
  - stratospheric sulfate model exists
  - Showstopper for CAM4/WACCM4: radiative code (CAM-RT) is only compatible with aerosols of fixed size.
    - For the shortwave, there are flags in the code for different wavelengths that trigger absorption calculations for water vapor, CO2, and CO2/H2O overlap. The optics for each aerosol in each of these bands has to be computed using complex formula using an original radiation code, not readily accessible.
    - Additionally, computation of the longwave effects requires an offline computation to optimize the heating rates compared to a reference line-by-line computation.
  - CAM5/WACCM5 has an entirely new radiation code (RRTMG) that is more flexible to connect outside models. However, coupling CARMA sulfates to radiation in CAM5/WACCM5 will require significant development work to avoid competing for sulfur sources with the existing modal aerosol module (MAM) in CAM5, which treats sulfates as an internal mixture with many other aerosol types.
- Use MAM for stratospheric sulfates?

Modal Aerosols in MAM-3



	a1 accum	a2 Aitken	a3 coarse
SO4	✔	✔	✔
POM	✔		
SOA	✔	✔	
BC	✔		
dust	✔		✔
salt	✔	✔	✔
number	✔	✔	✔

Gas-phase species: H_2SO_4, SO_2, DMS, SOA (gas)

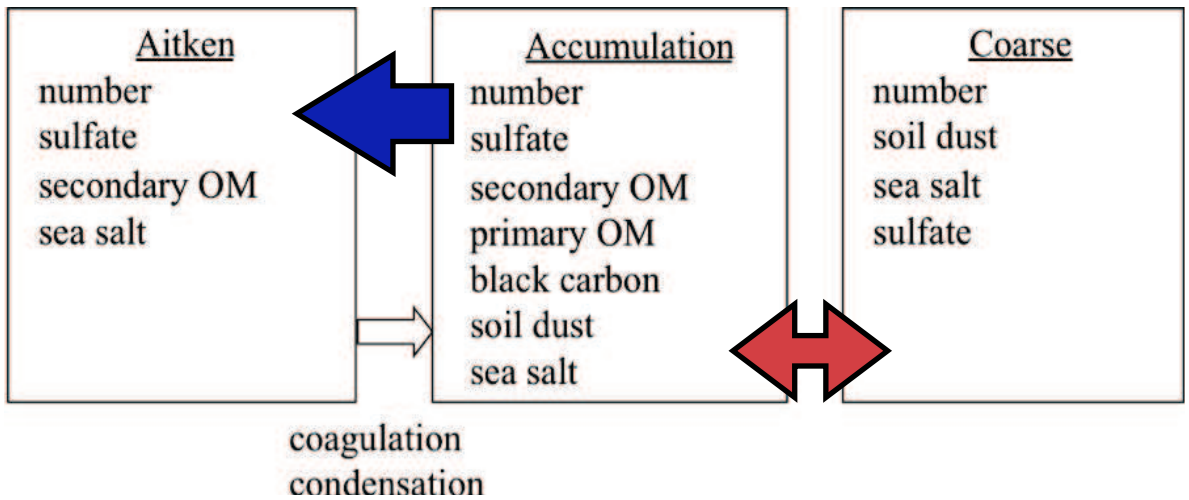
"Sulfate is partially neutralized by ammonium in the form of NH_4HSO_4, so ammonium is effectively prescribed and NH_3 is not simulated. We note that in MAM-3 we predict the mass mixing ratio of sulfate aerosol in the form of NH_4HSO_4 while in MAM-7 it is in the form of SO_4."

- CAM5 scientific description

Mode	σ_g	Size range (μm)
MAM3	geometric std. dev.	dry diameter
Aitken	1.6	0.015–0.053
Accumulation	1.8	0.058–0.27
Coarse	1.8	0.80–3.65

Liu et al., 2012

Stratospheric Aerosols in MAM-3



	a1 accum	a2 Aitken	a3 coarse
SO4	✔	✔	✔
POM	✔		?
SOA	✔	✔	?
BC	✔		?
dust	✔		✔
salt	✔	✔	✔
number	✔	✔	✔

Gas-phase species: H_2SO_4, SO_2, DMS, SOA (gas)

Added: OCS, S, SO, SO_3, HSO_3

Added evaporation from accumulation to Aitken

Need to add growth and evaporation between accumulation and coarse

Will this require adding POM, SOA, BC to the coarse mode?

Mind the gap!

Mode	σ_g	Size range (μm)
MAM3	geometric std. dev.	dry diameter
Aitken	1.6	0.015–0.053
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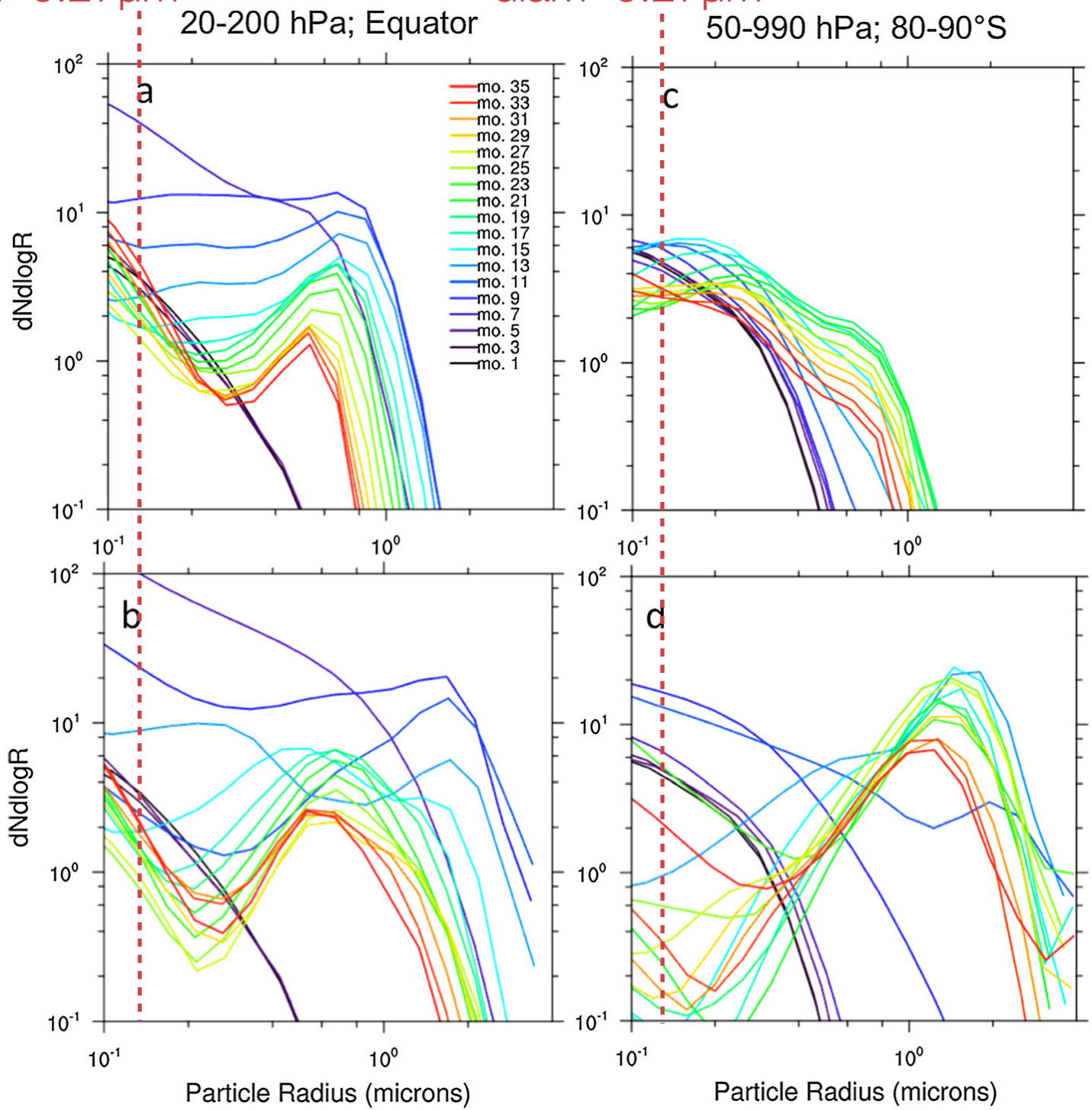
Coarse	1.8	0.80–3.65

Liu et al., 2012

JGR, 2013

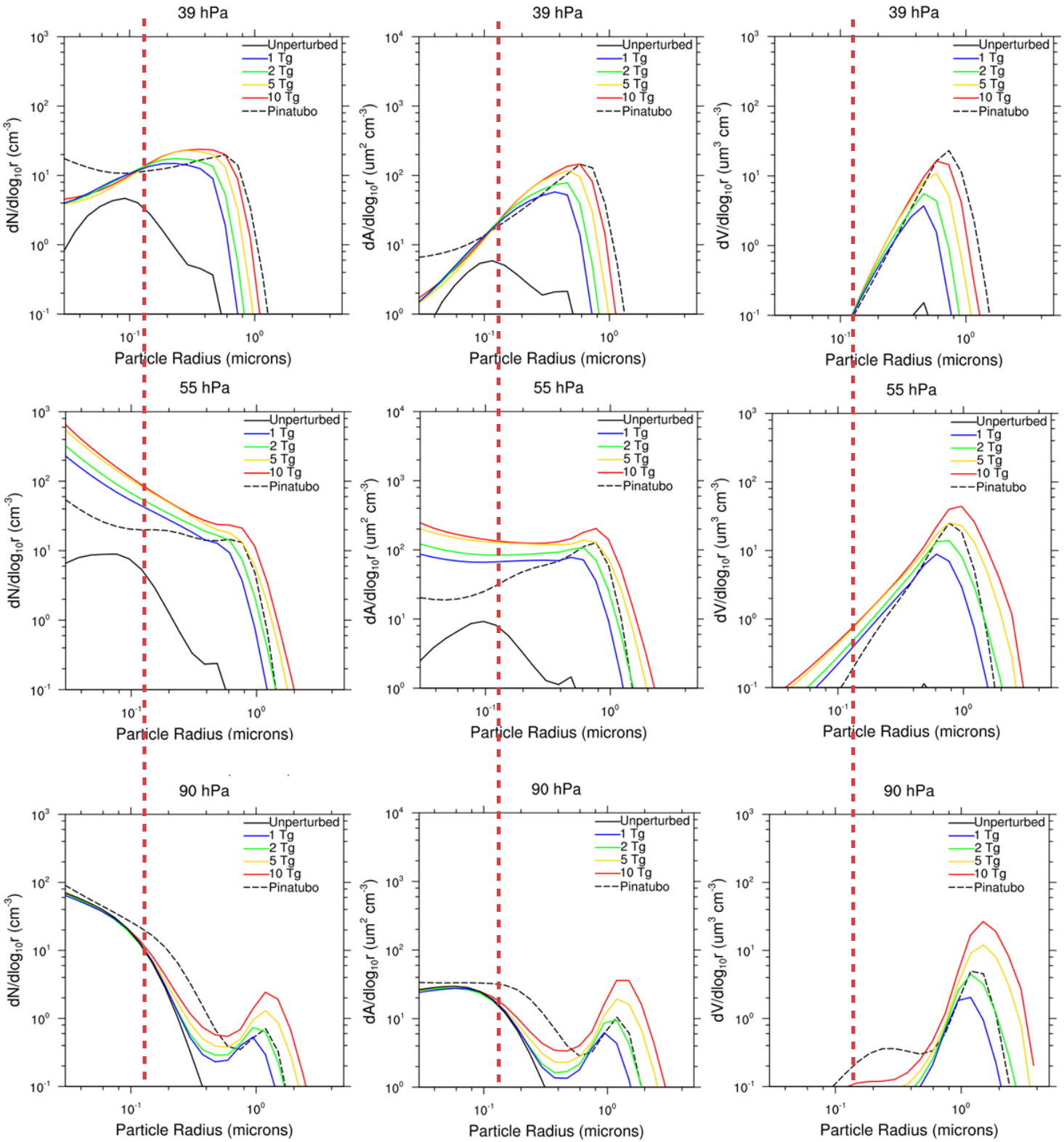
diam=0.27μm

diam=0.27μm



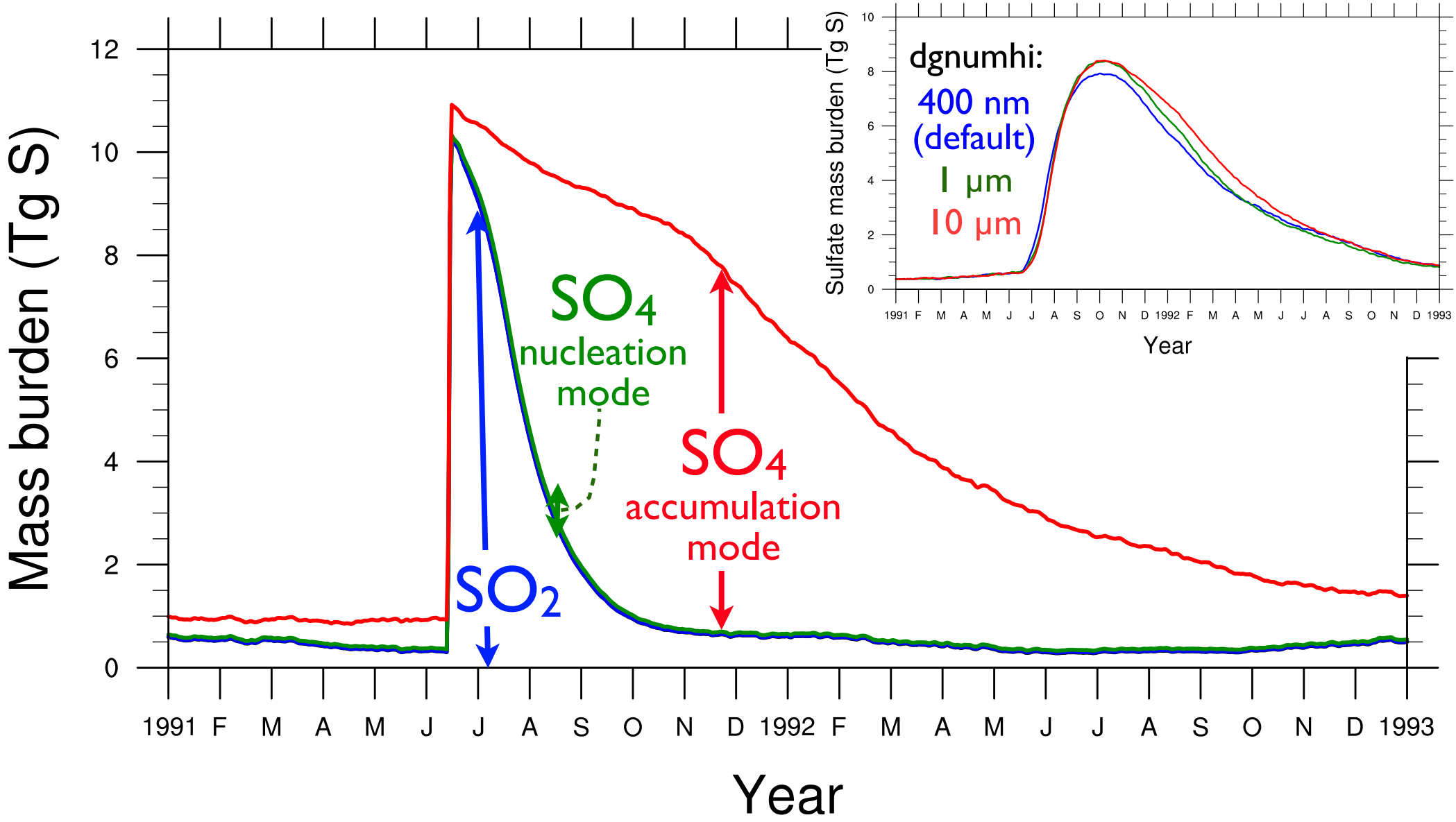
Pinatubo

Toba (10 x Pinatubo)



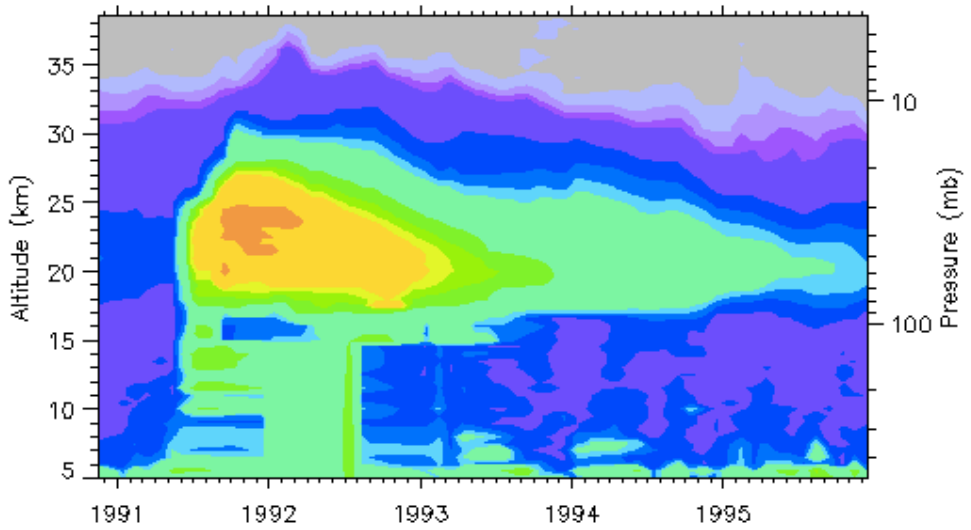
J.M. English et al., Microphysical simulations of sulfur burdens from stratospheric sulfur geoengineering, ACP, 2012

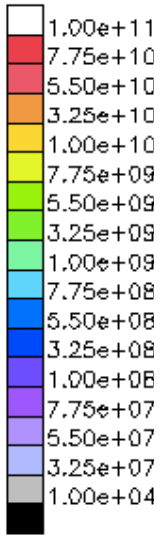
Pinatubo eruption, June 15, 1991: 20 Tg SO_2, 16-20 km



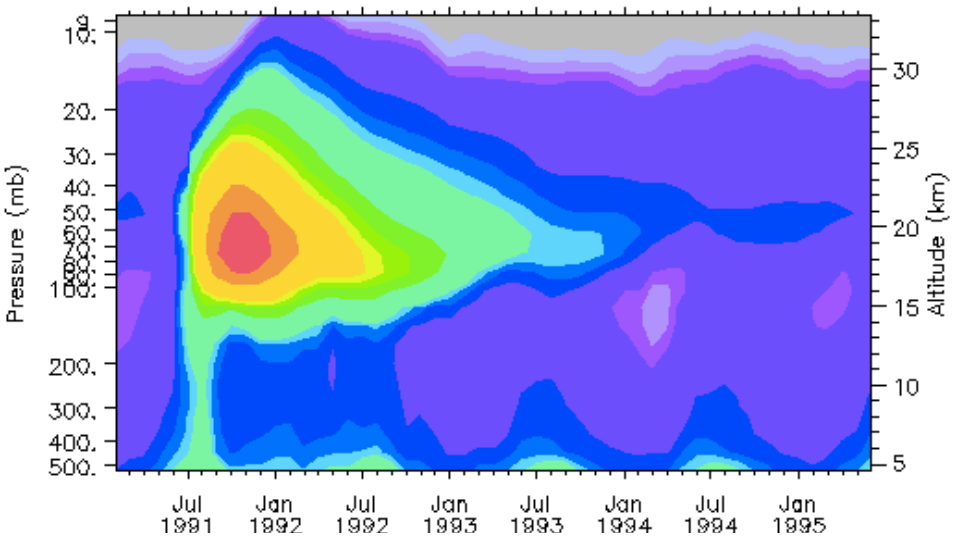
Sulfate (molec/cm3) at 12.5°N

Based on observations

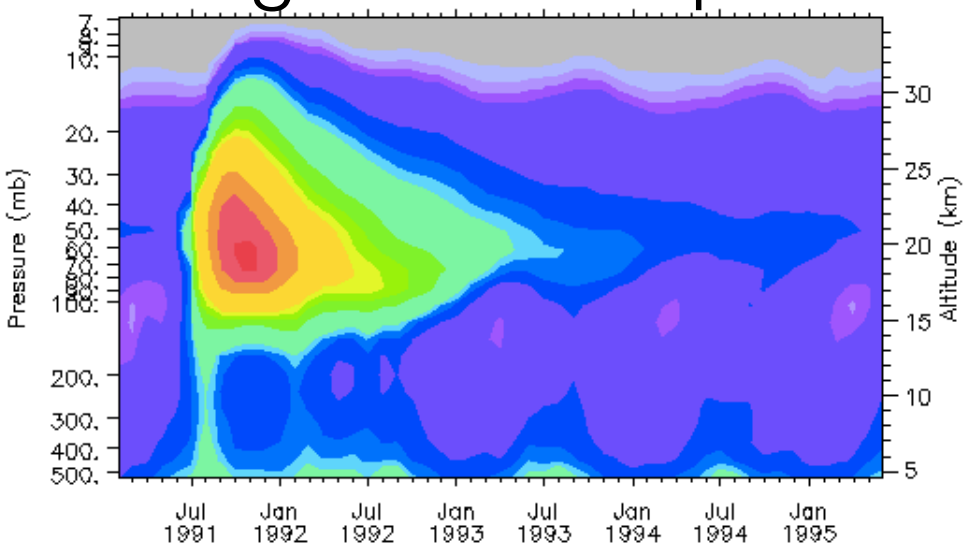


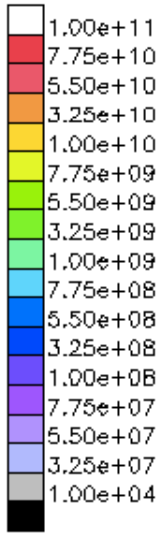


dgnumhi = 400 nm

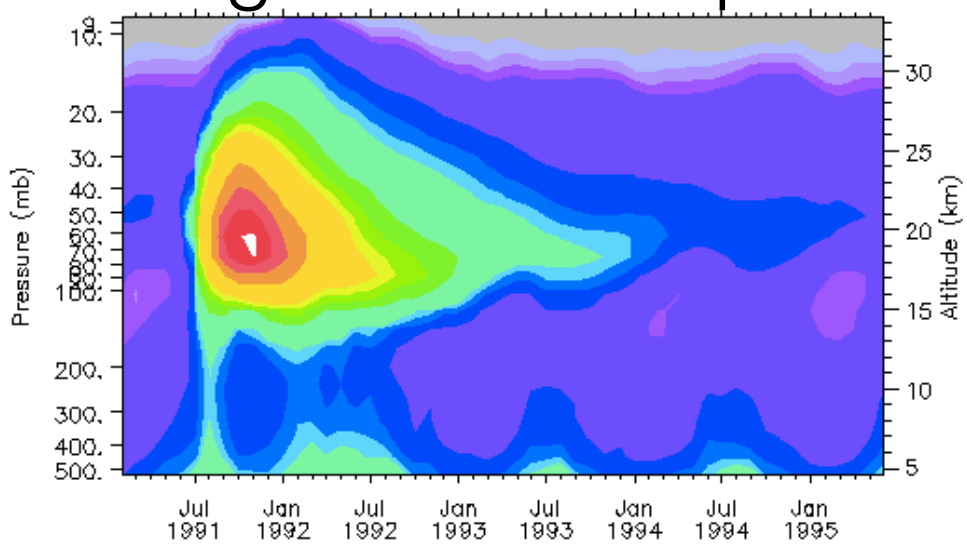


dgnumhi = 1 µm



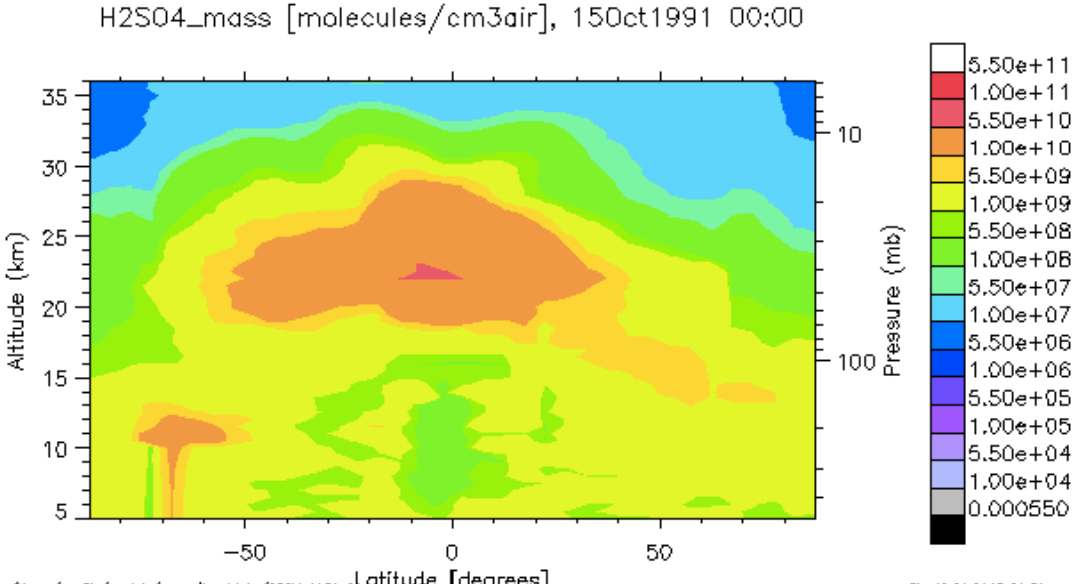


dgnumhi = 10 µm

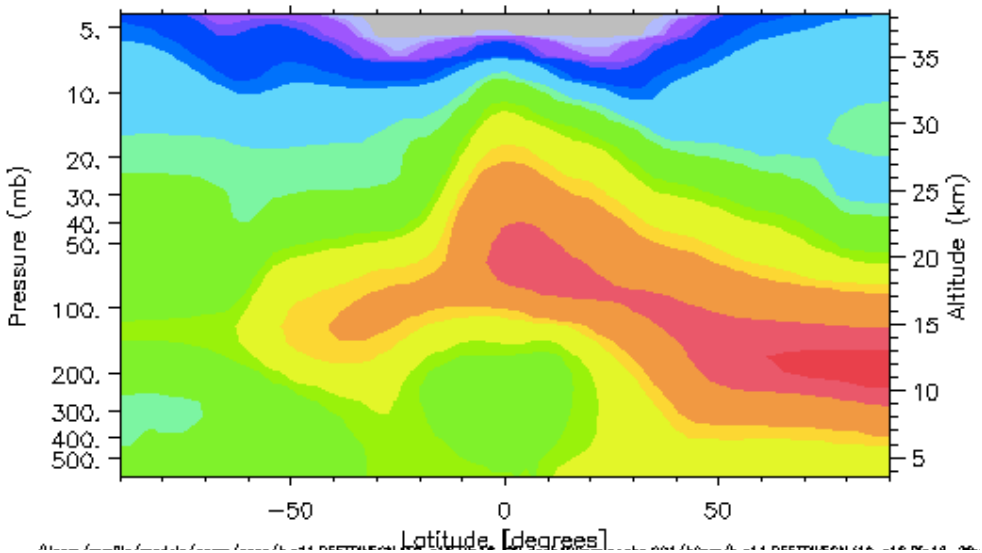


Sulfate (molec/cm3), October 1991

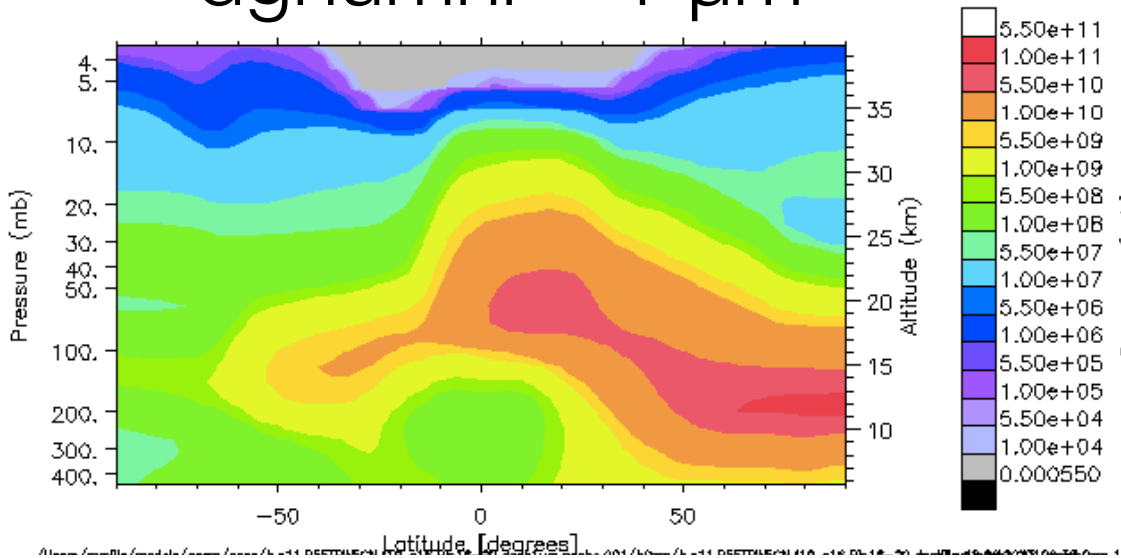
Based on observations



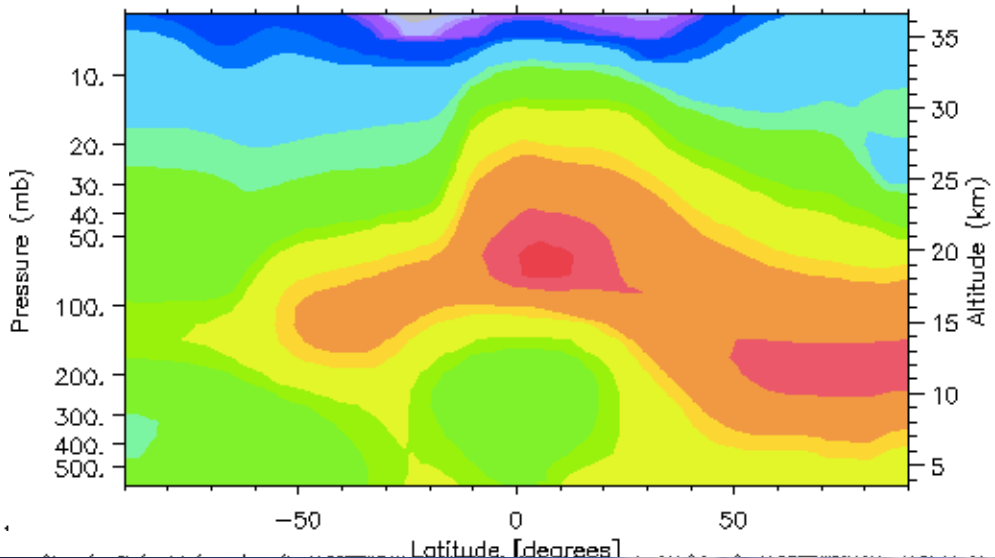
dgnumhi = 400 nm



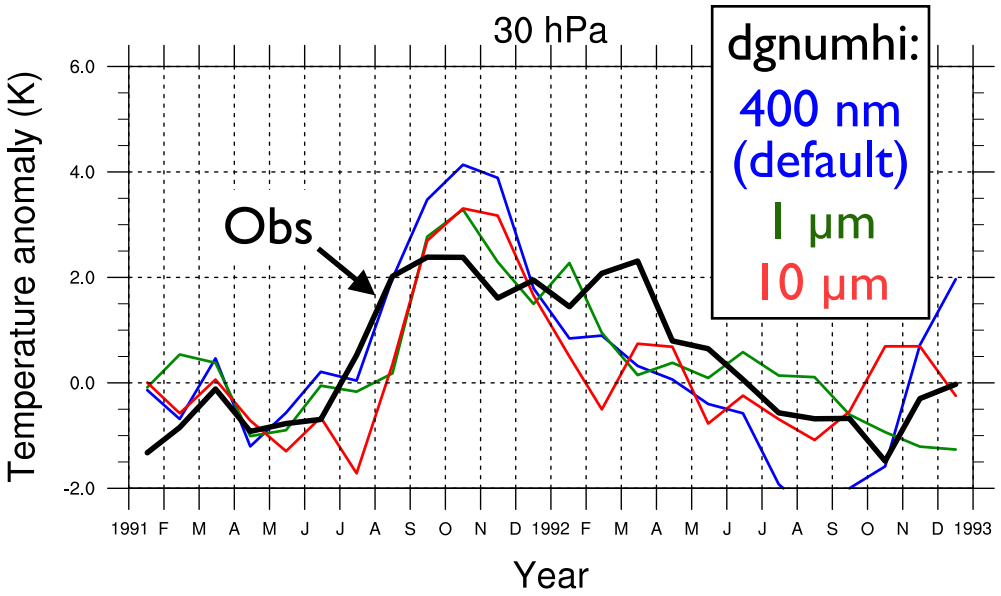
dgnumhi = 1 μm

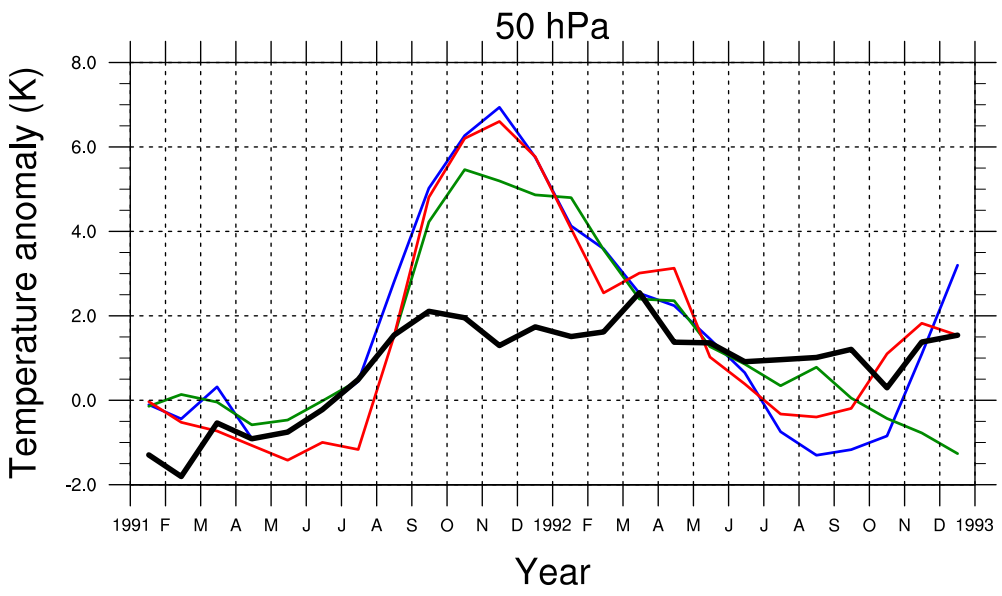


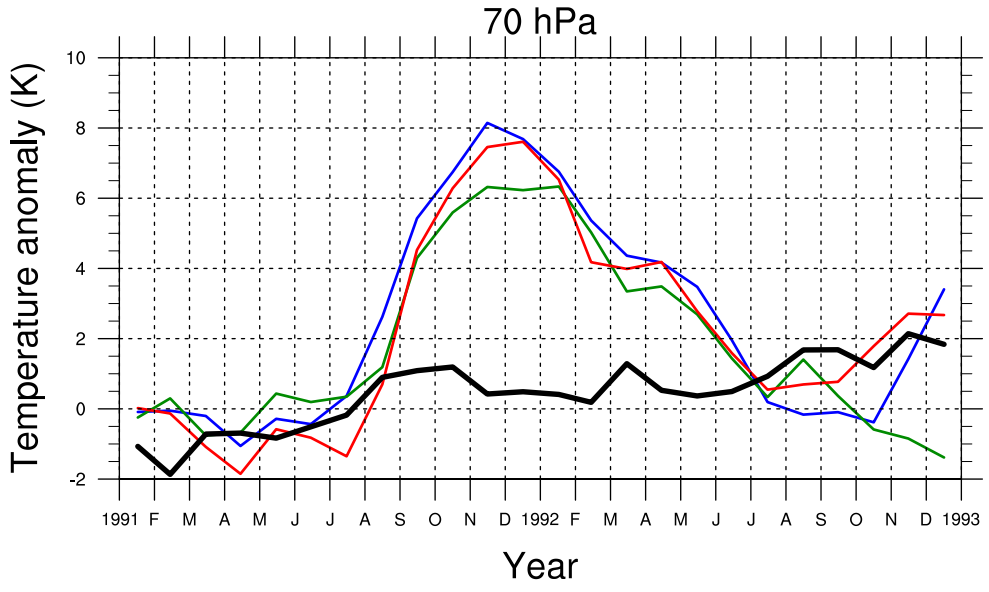
dgnumhi = 10 μm

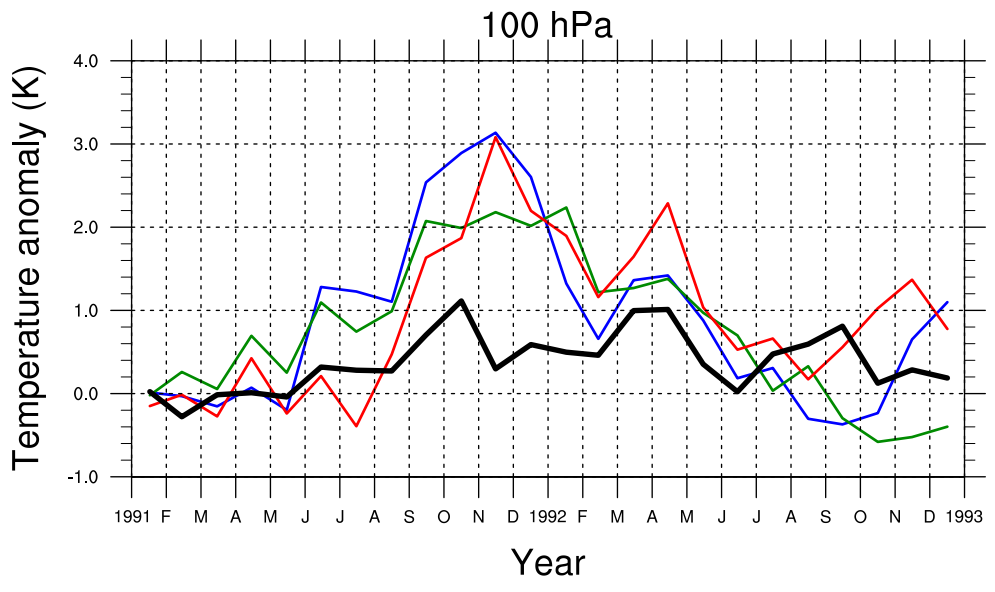


Tropical temperature anomalies

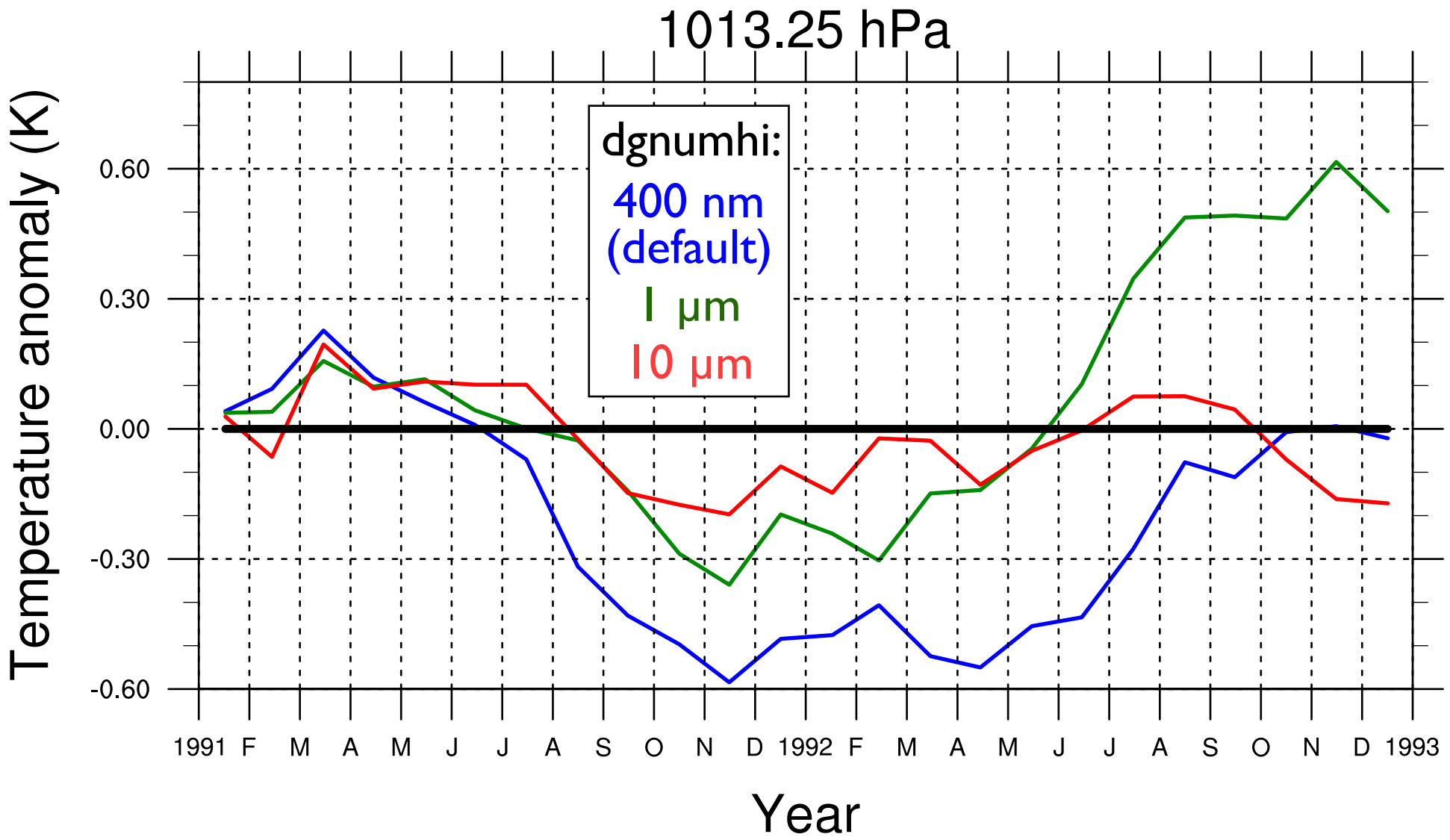


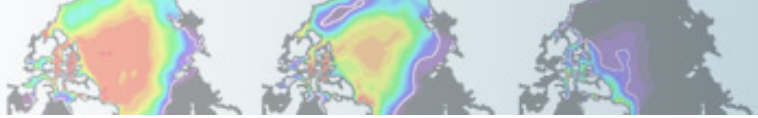






Surface temperature anomalies





Questions

- Can MAM3 be adapted for exchange between the accumulation and coarse modes?
- Can the gap between the accumulation and coarse modes be filled?
- Will these changes result in significant disruption of tropospheric aerosols?
- Will MAM3 with these adaptations represent volcanic aerosol evolution and radiative anomalies reasonably?
- Would this be better done with CARMA?
- What will be the role for emissions-based volcanic aerosols in climate models?