

**GMI Aerosol Module Intercomparison III:
2-D Model Intercomparison of Modal
and Sectional Aerosol Approaches**

by

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Microphysical Representations:

AER: 40 bins, 0.39 nm - 3.2 μm , 2x volume

UMaer: 3 modes, 2 moments, fixed lognormal widths

$$\sigma_1=1.2, \sigma_2=1.514, \sigma_3=1.78$$

$$\sigma_1=1.2, \sigma_2=1.514, \sigma_3=1.6$$

$$R_{merge} = 0.005 \mu\text{m}, 0.05 \mu\text{m}$$

UMaer: 4 modes, 2 moments, fixed lognormal widths

$$\sigma_1=1.3, \sigma_2=1.6, \sigma_3=1.6, \sigma_4=1.45$$

$$R_{merge} = 0.001 \mu\text{m}, 0.01 \mu\text{m}, 0.1 \mu\text{m}$$

2-D Intercomparison in AER Framework: Stratosphere and Troposphere

Previous comparison done in box model [Herzog et al., 2004]

Sulfate aerosol only - *Tropospheric aerosol not realistic*

Pole to Pole, 0-60 km, 9.5° x 1.2 km

Transport: Advection, Eddy Diffusion,
Sedimentation (accumulation from above)

Multi-year integrations to steady-state

Timing: 3-mode runs 53 minutes/year with dynamical time steps

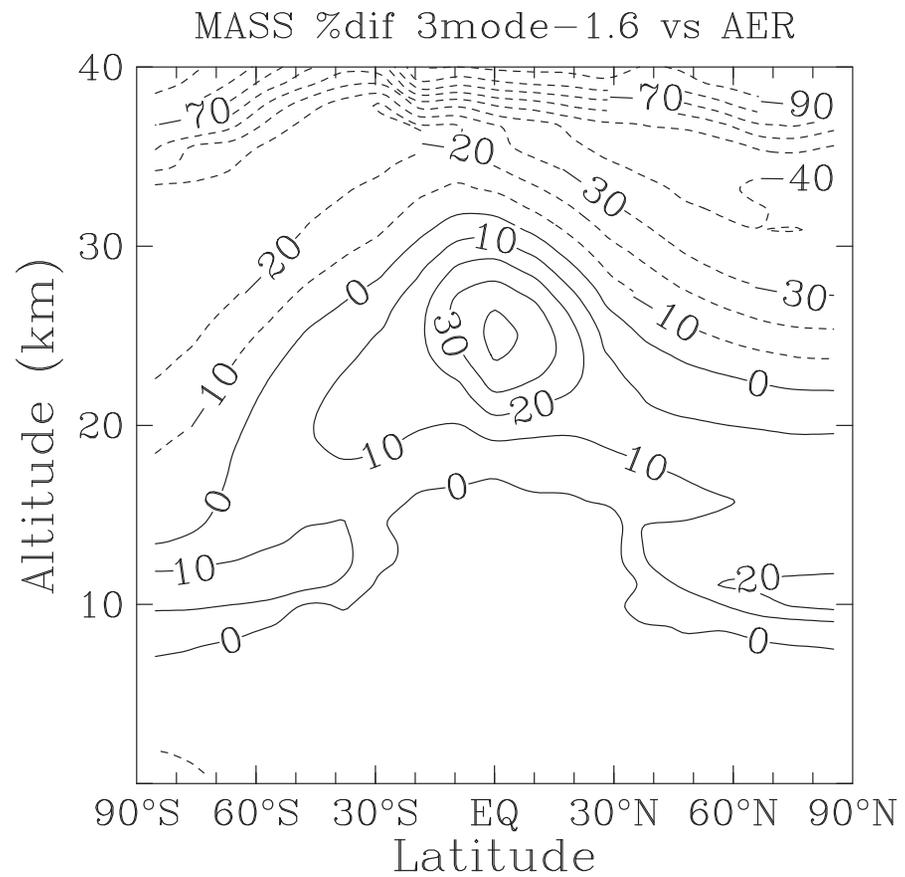
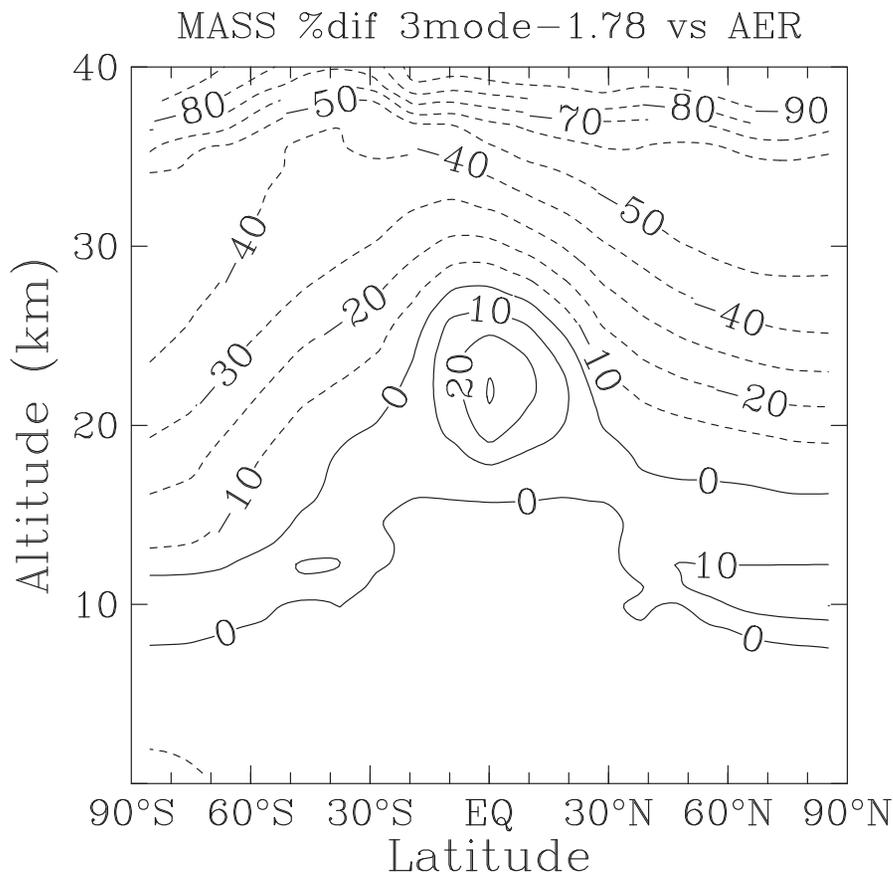
4-mode runs 70 minutes/year with dynamical time steps

40 bin runs 104 minutes/year with 1 hour time step

40 bin runs 417 minutes/year with 15 minute time step

AER used 20 substeps over nucleation and condensation

Mass Density Comparison, Annual Average

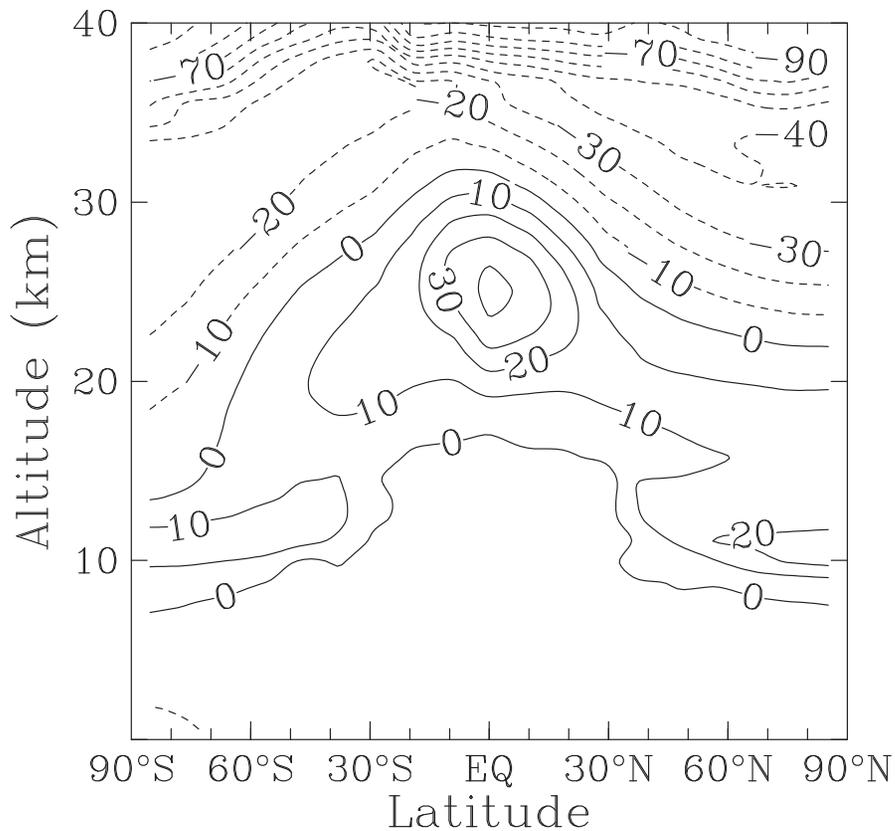


3mode-1.78 vs AER: Strat burdens same

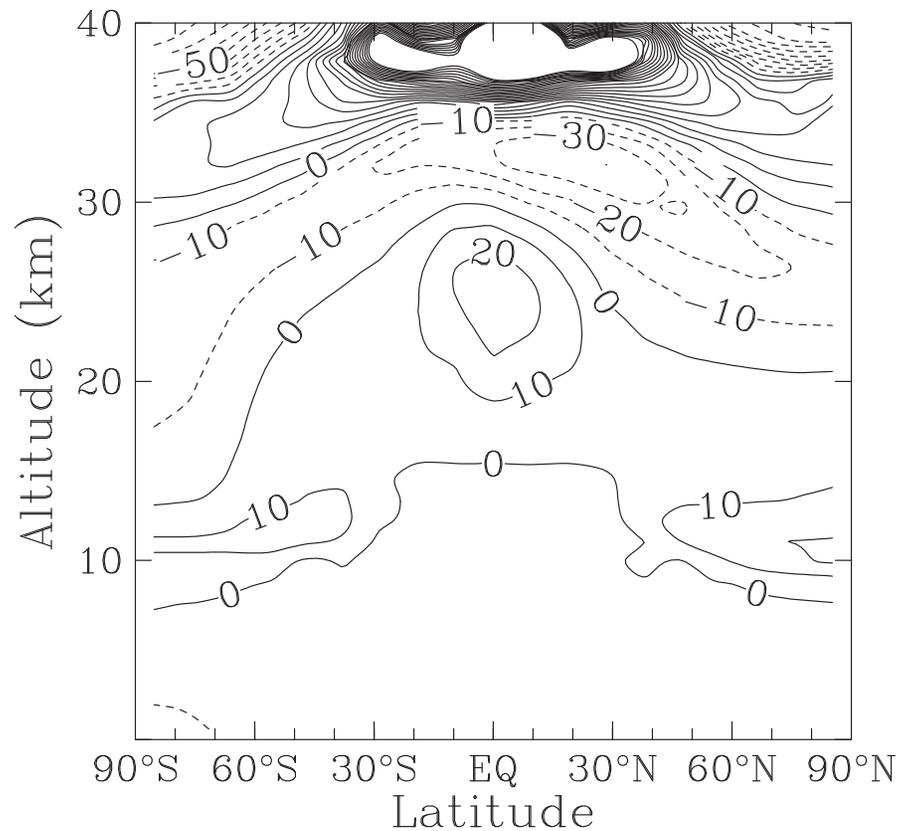
3mode-1.6 vs AER: UMaer 10% greater strat burden

Mass Density Comparison, Annual Average

MASS %dif 3mode-1.6 vs AER



MASS %dif 4mode vs AER

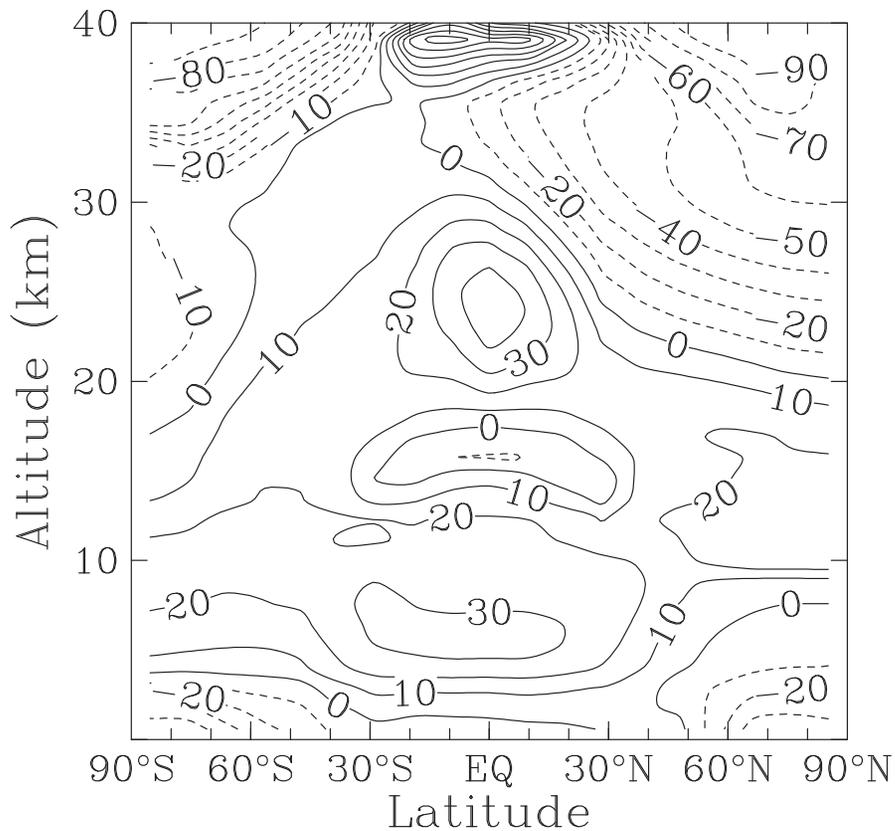


3mode-1.6 vs AER: UMaer 10% greater strat burden

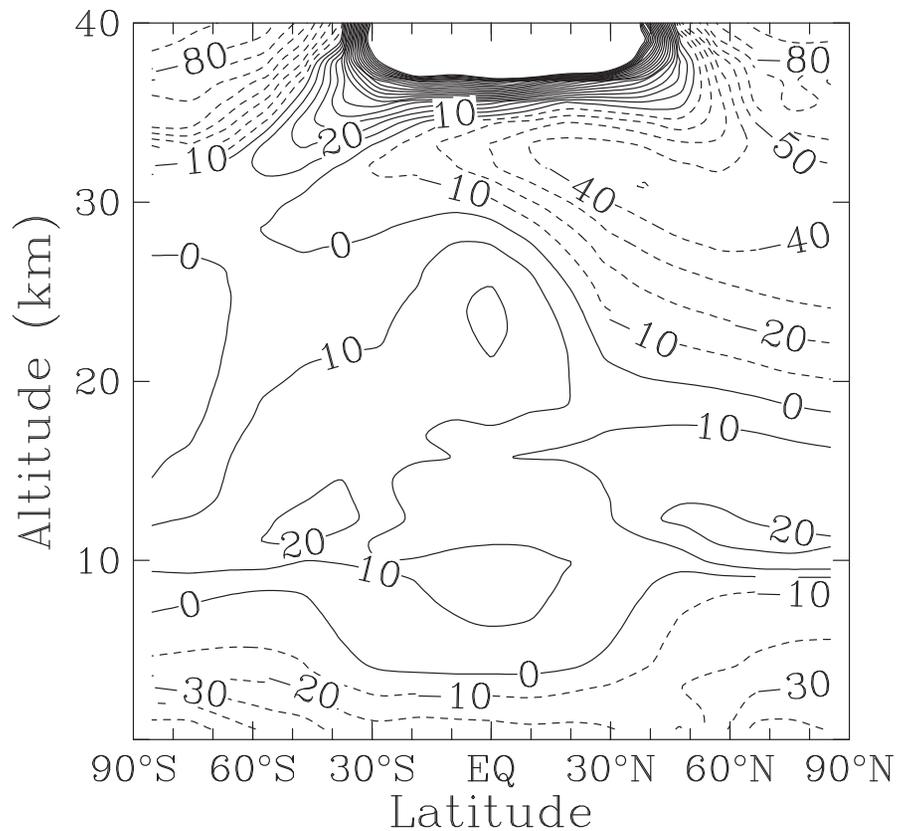
4mode vs AER: UMaer 6% greater strat burden

Surface Area Comparison, Annual Average

SAD %dif 3mode-1.6 vs AER

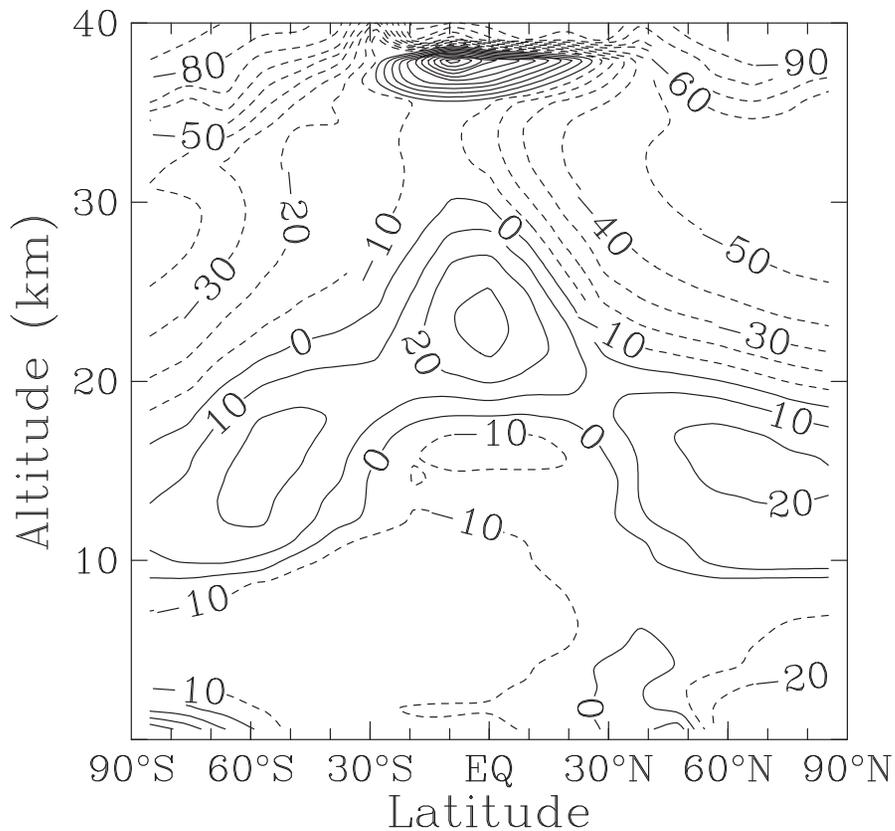


SAD %dif 4mode vs AER

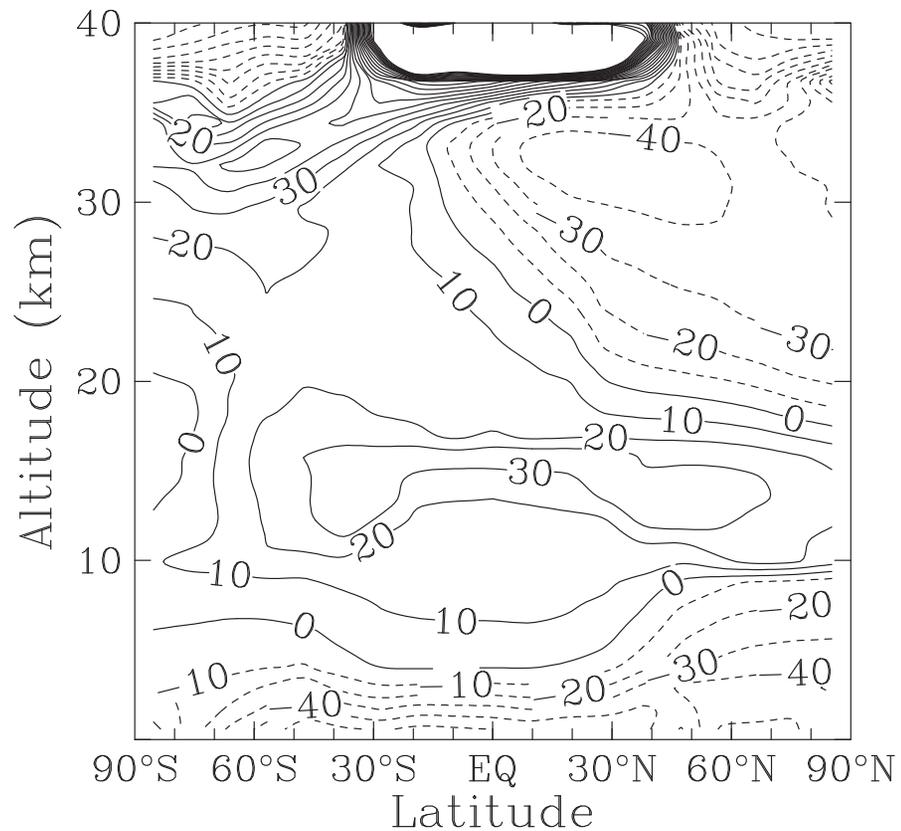


Particle Number Density Comparison, Annual Average

PARTICLES > 0.05 μm %dif 3mode-1.6 vs AER

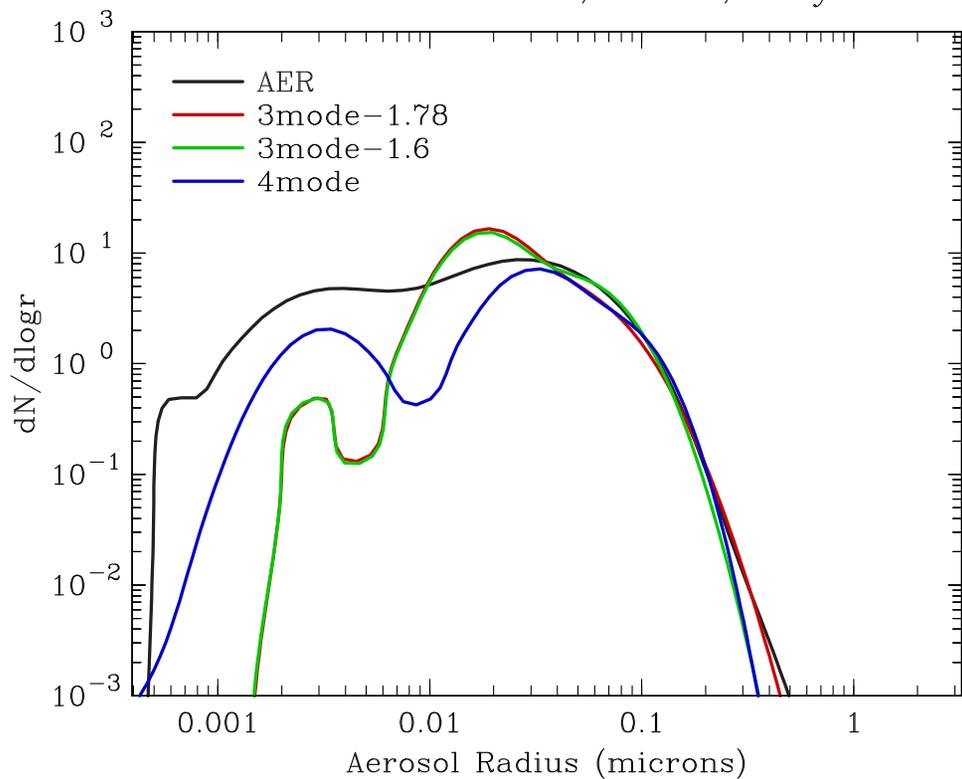


PARTICLES > 0.05 μm %dif 4mode vs AER

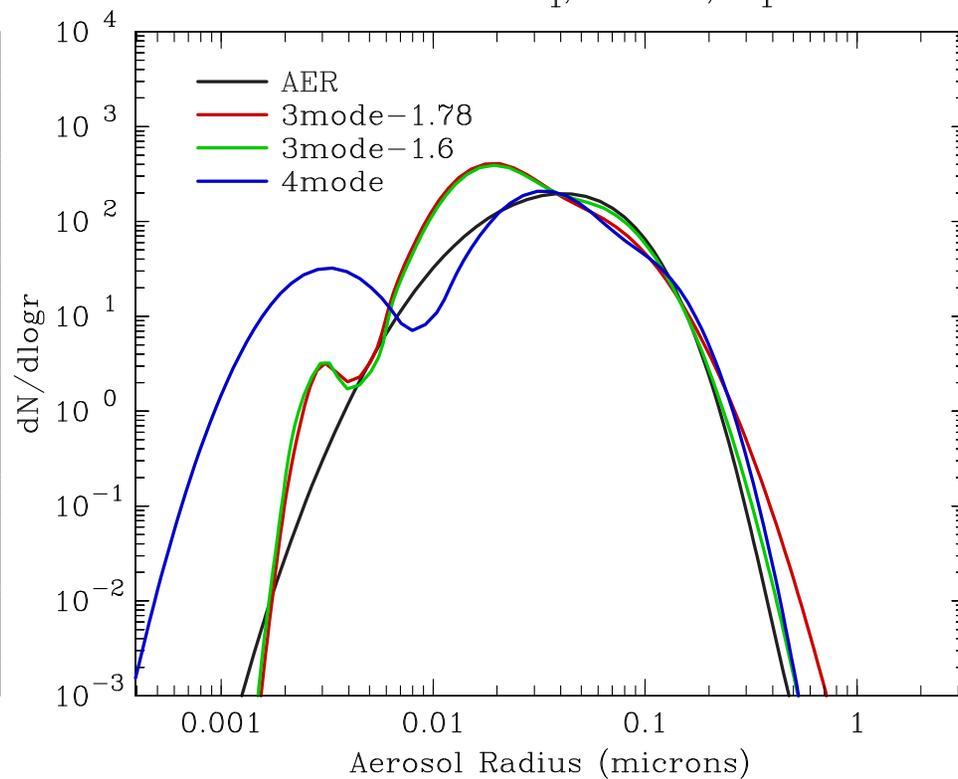


Size Distribution at Equator, Troposphere

Sizedist at 66S, 2 km, July

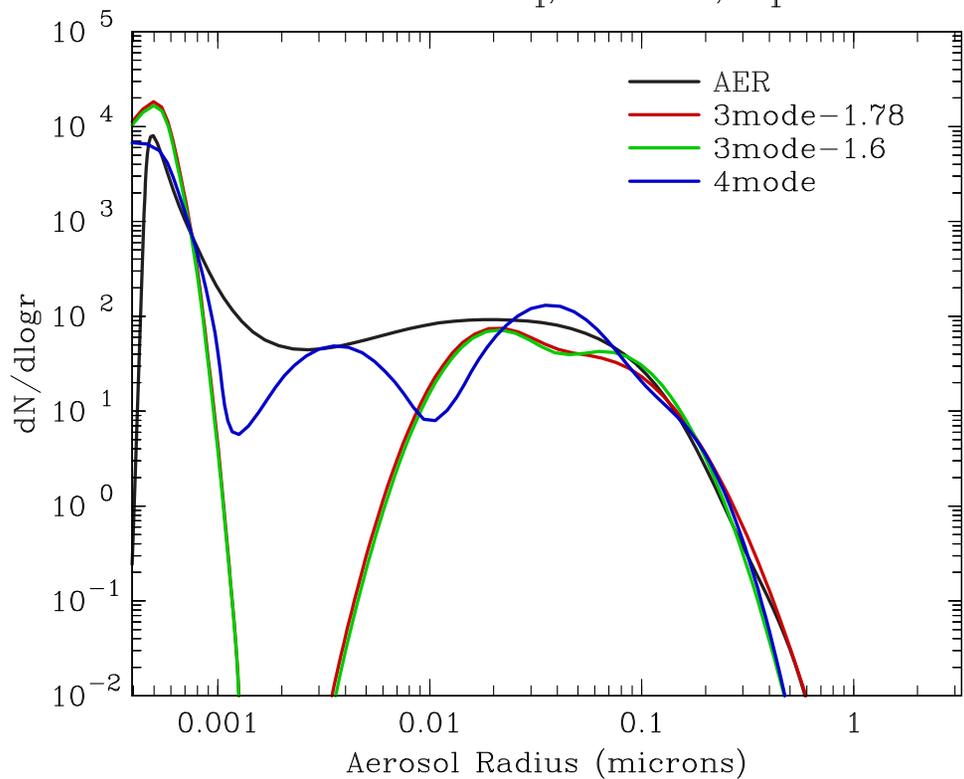


Sizedist at Eq, 2 km, April

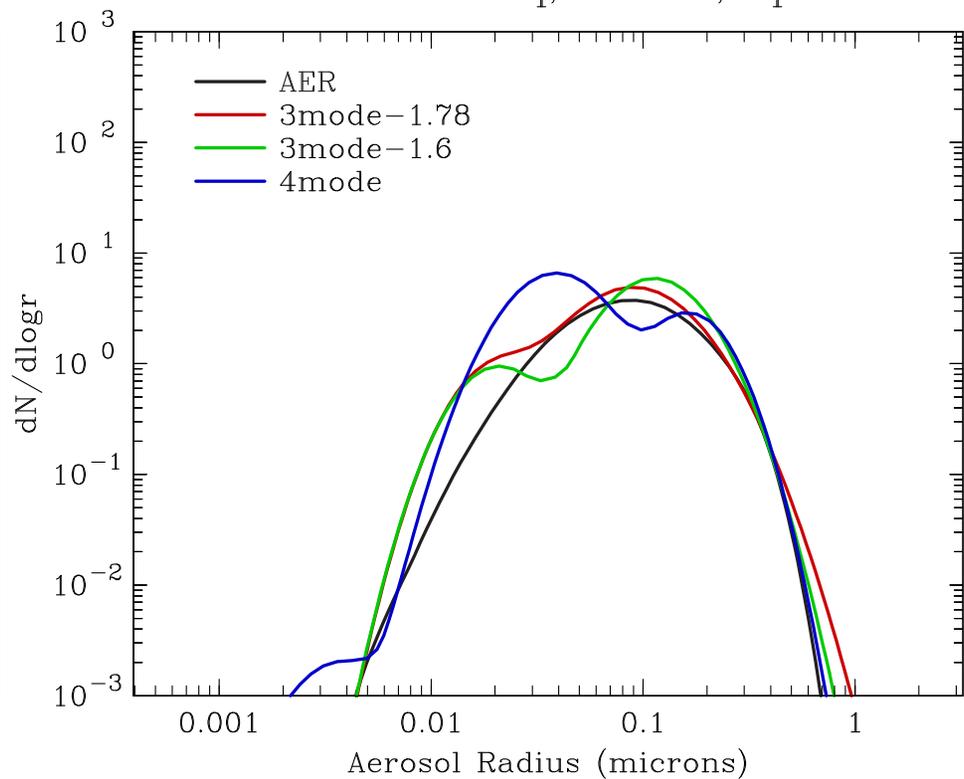


Size Distribution at Equator, Stratosphere

Sizedist at Eq, 17 km, April

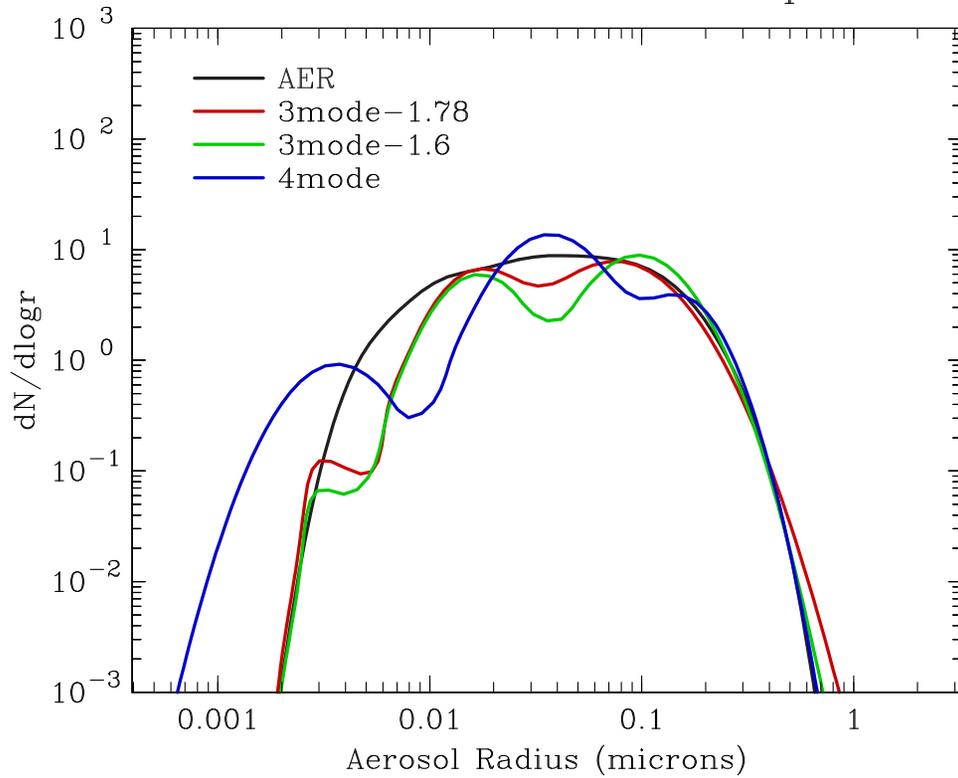


Sizedist at Eq, 25 km, April

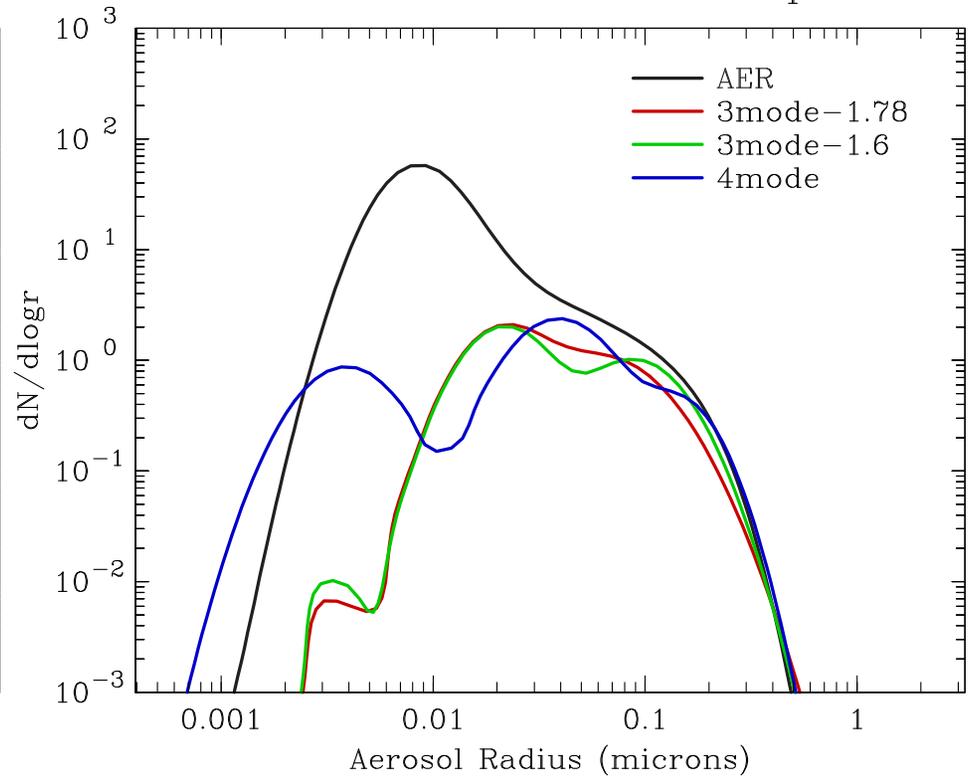


Size Distribution at 45°N, Stratosphere

Sizedist at 45N, 20 km, April



Sizedist at 45N, 30 km, April



Pinatubo Experiment

20 MT of SO₂ injected on June 15, 1991
between 16 and 29 km, 5°S-15°N

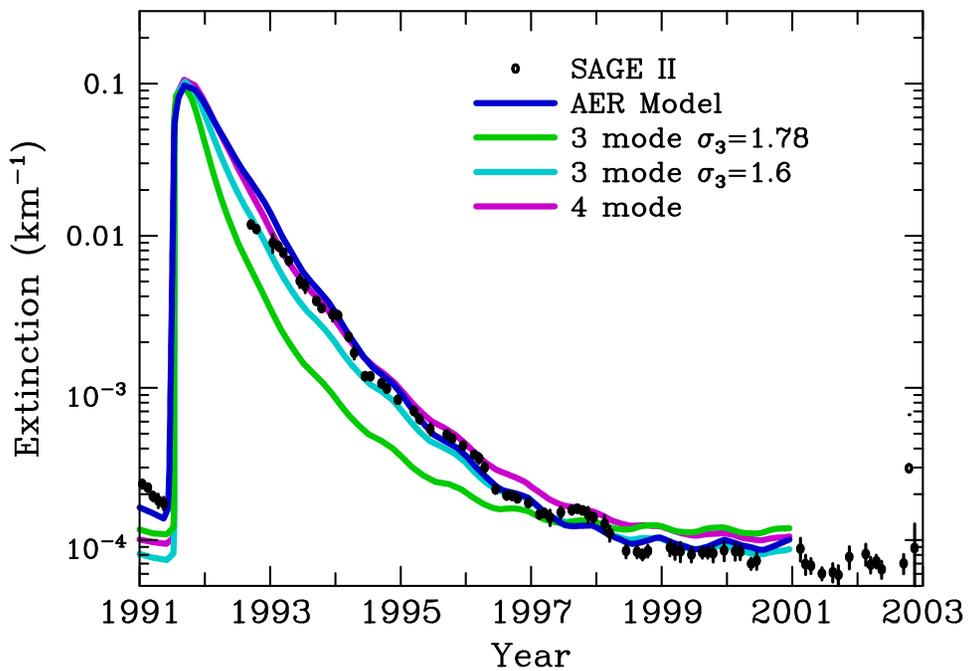


H₂SO₄ condenses onto existing particles
resulting in larger particles for several years

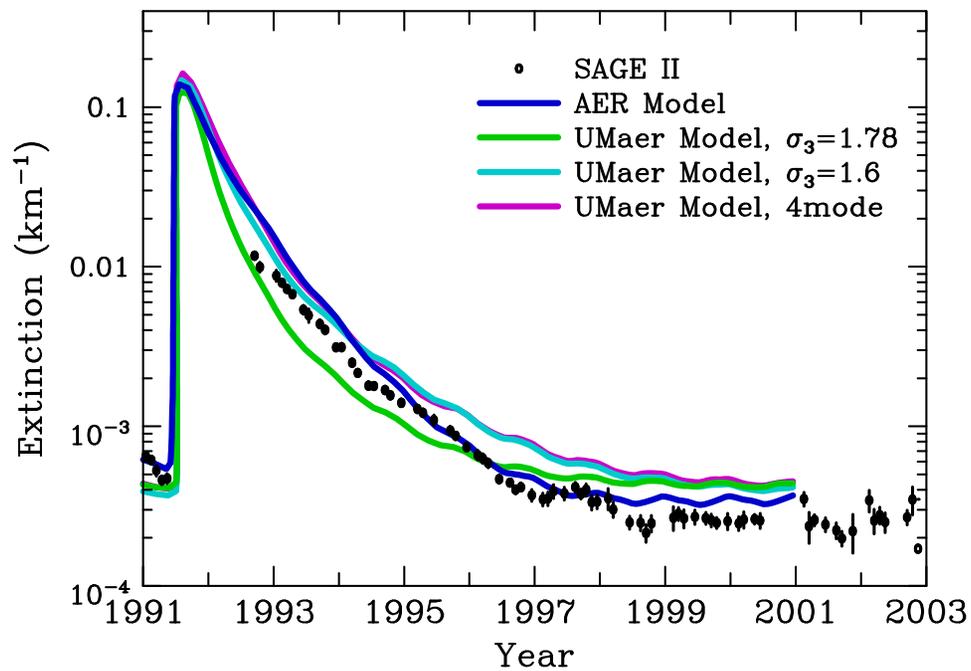
Removal time reflects increased sedimentation rate
which decreases with time

Pinatubo Impact on Aerosol Extinction 1991-2001

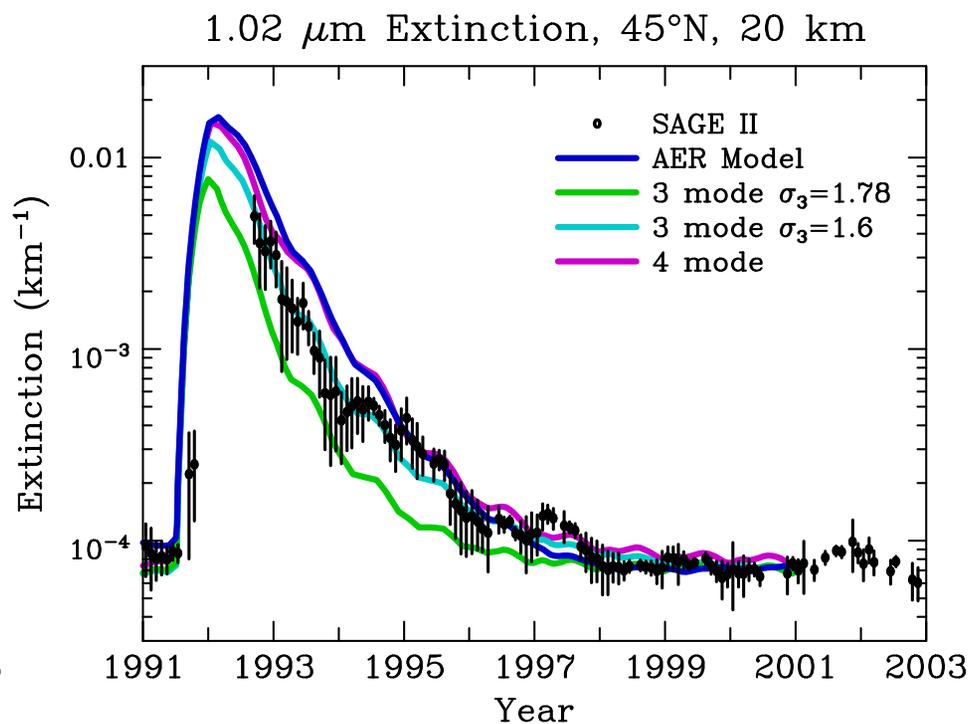
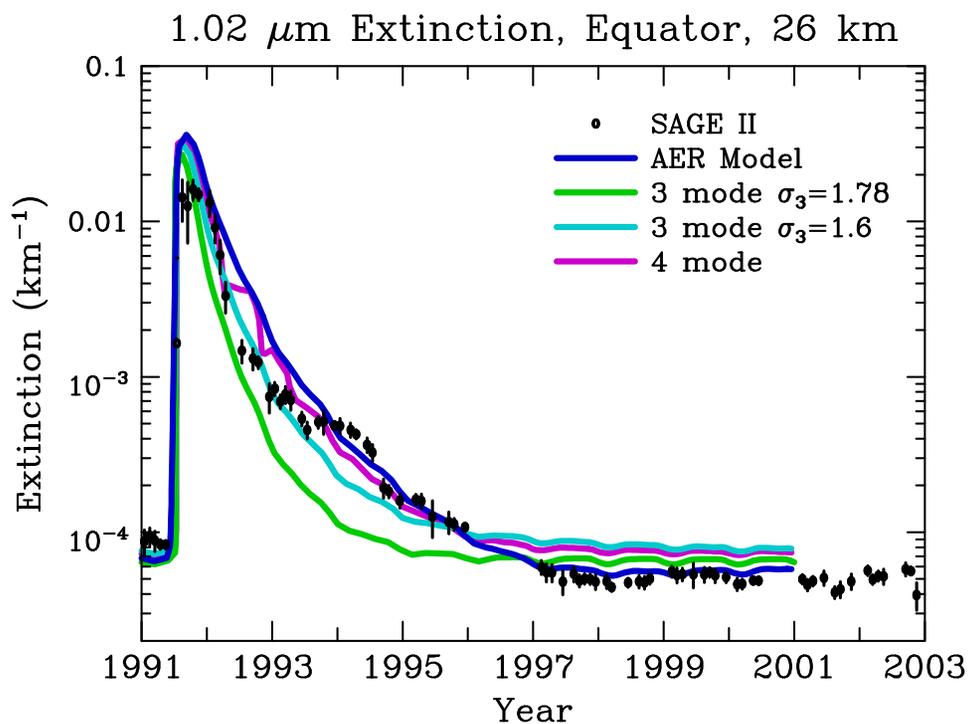
1.02 μm Extinction, Equator, 20 km



0.525 μm Extinction, Equator, 20 km



Pinatubo Impact on Aerosol Extinction 1991-2001



Summary and Conclusions

- UMaer module with 3 or 4 modes successfully implemented in AER 2-D model
- AER slower by 2x (1 hr step) or 8x (15 min step) vs 3 mode
- Models obtain global aerosol burdens within 10%
- Sedimentation more efficient in UMaer \implies less mass above 25 km
- Integrated aerosol quantities within 30% below 20 km.
- Width of modal distributions impacts sedimentation rates and volcanic removal rates
- More modes generally produces more accurate results but at expense of computational efficiency

Future Work

- Implement non-sulfate aerosols in 2 modes for each type: oc, bc, dust, ss
- Coagulation between 2-mode non-sulfate particles and sulfate particles in 40 bins
- Implement 40 bin scheme in GMI with same interface as UMaer