Volcanic aerosols with MAM

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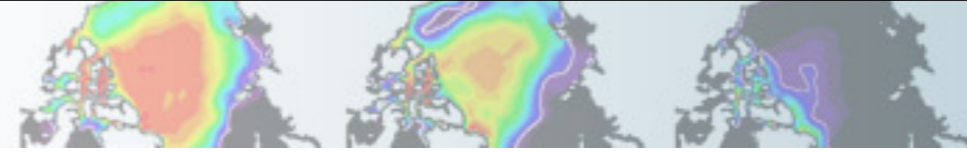
NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
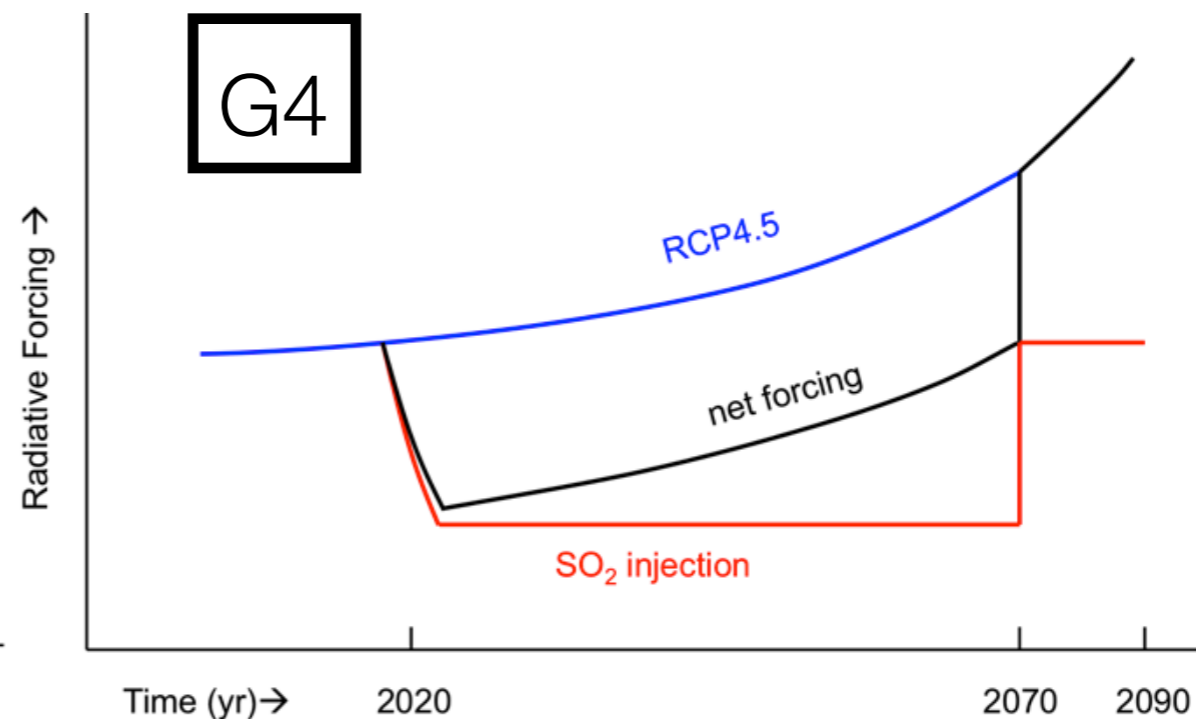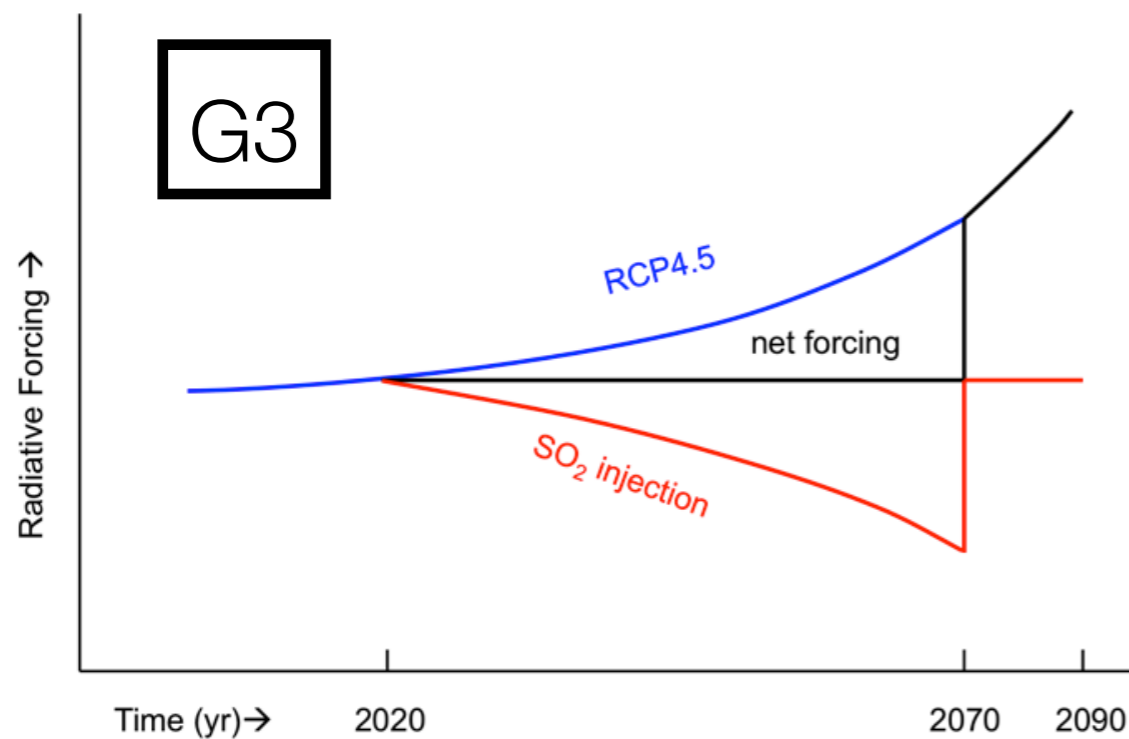
NSF

WACCM
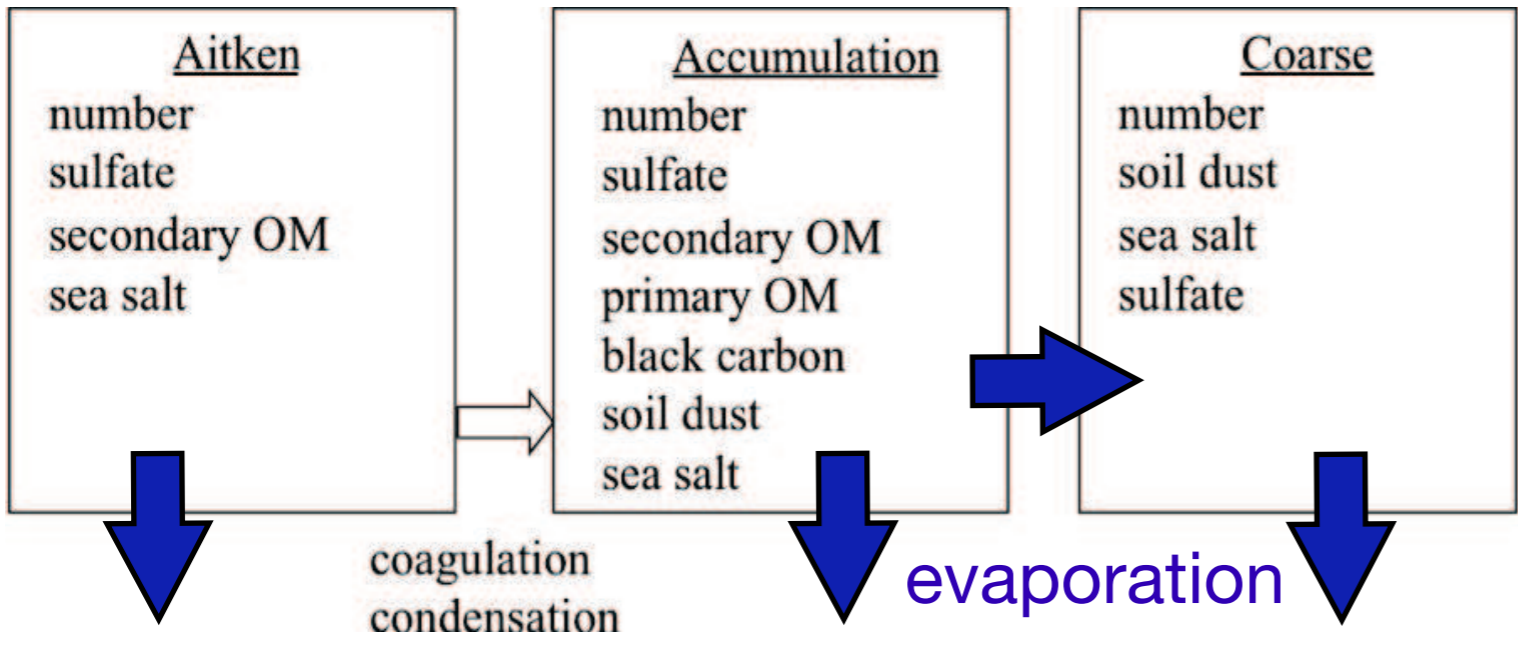
**Whole Atmosphere
Community Climate Model**

NCAR

Motivation for emission-based volcanoes in CESM

- Model development is increasing self-consistency

- Volcanic aerosol remains one of the few prescribed climate forcings

- Enables study of historical and theoretical eruptions

- Geoengineering studies: "artificial volcanoes"

MAM3 for stratospheric aerosols

Aitken
number
sulfate
secondary OM
sea salt

Accumulation
number
sulfate
secondary OM
primary OM
black carbon
soil dust
sea salt

Coarse
number
soil dust
sea salt
sulfate

coagulation
condensation

evaporation

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

Added: OCS, S, SO, SO_3, HSO_3

Added evaporation

Added growth between modes

Adjusted diameter ranges, mode widths:

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

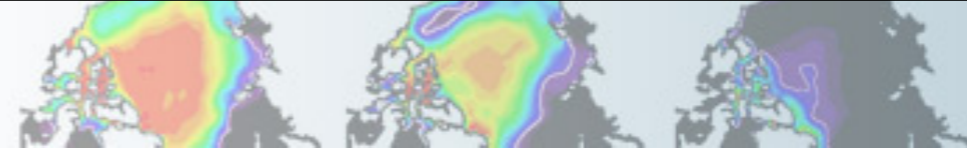| Mode	Aitken	Accumulation	Coarse
CAM5-MAM3 diameter (µm)	0.0087 - 0.052	0.0535 - 0.44	1.0 - 4.0
CAM5-MAM3 geom. std. dev.	1.6	1.8	1.8
WACCM5-MAM3 diameter (µm)	0.0087 - 0.052	0.0535 - 1.1	0.9 - 4.0
WACCM5-MAM3 geom. std. dev.	1.6	1.6	1.8
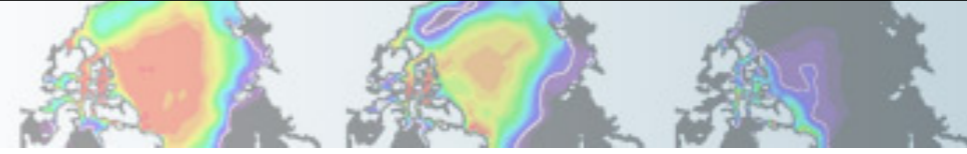
Pinatubo simulation: How much SO$_2$?

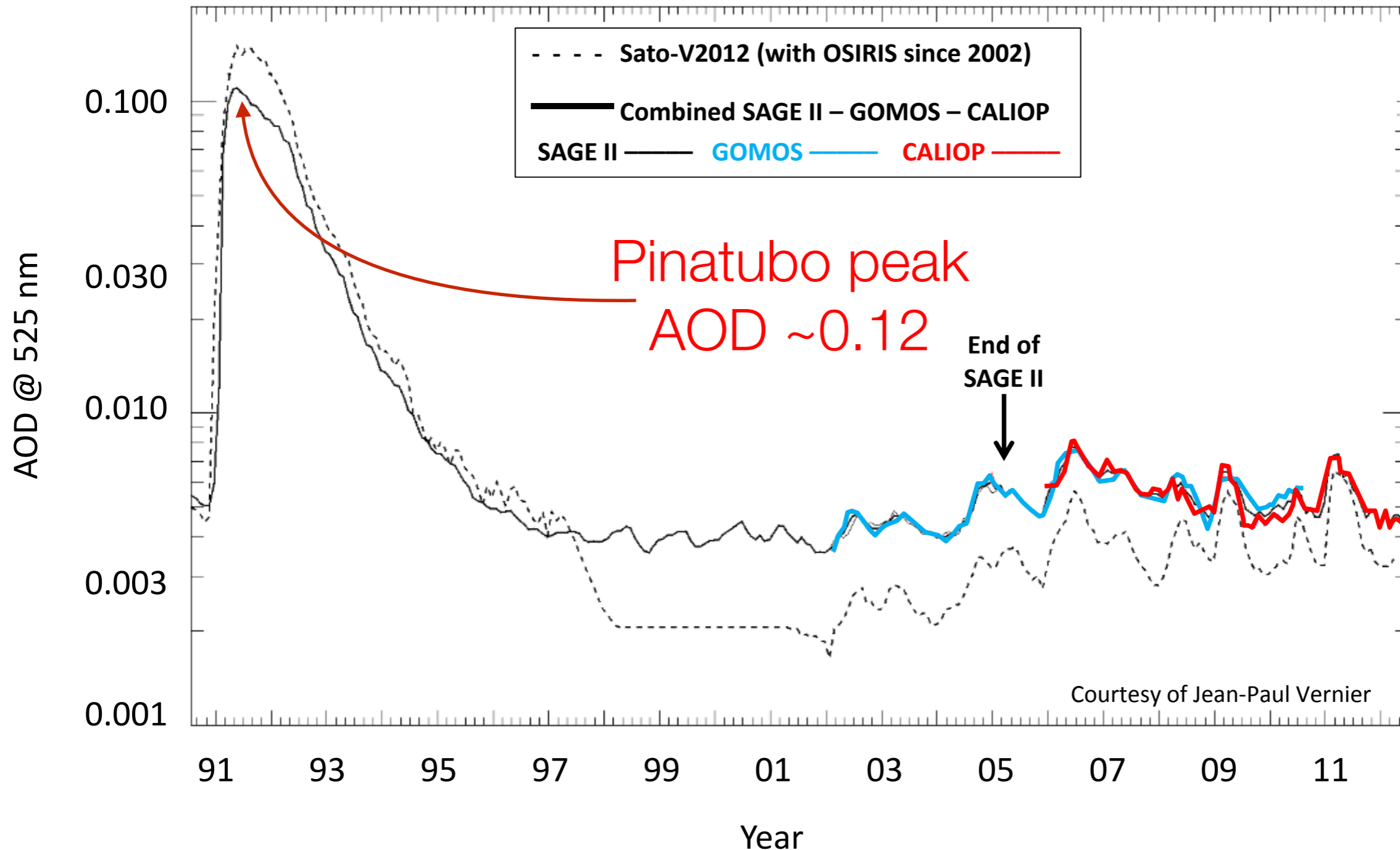Guo et al., 2004: 15-19 Tg   CCMI input data file: 9.7 Tg
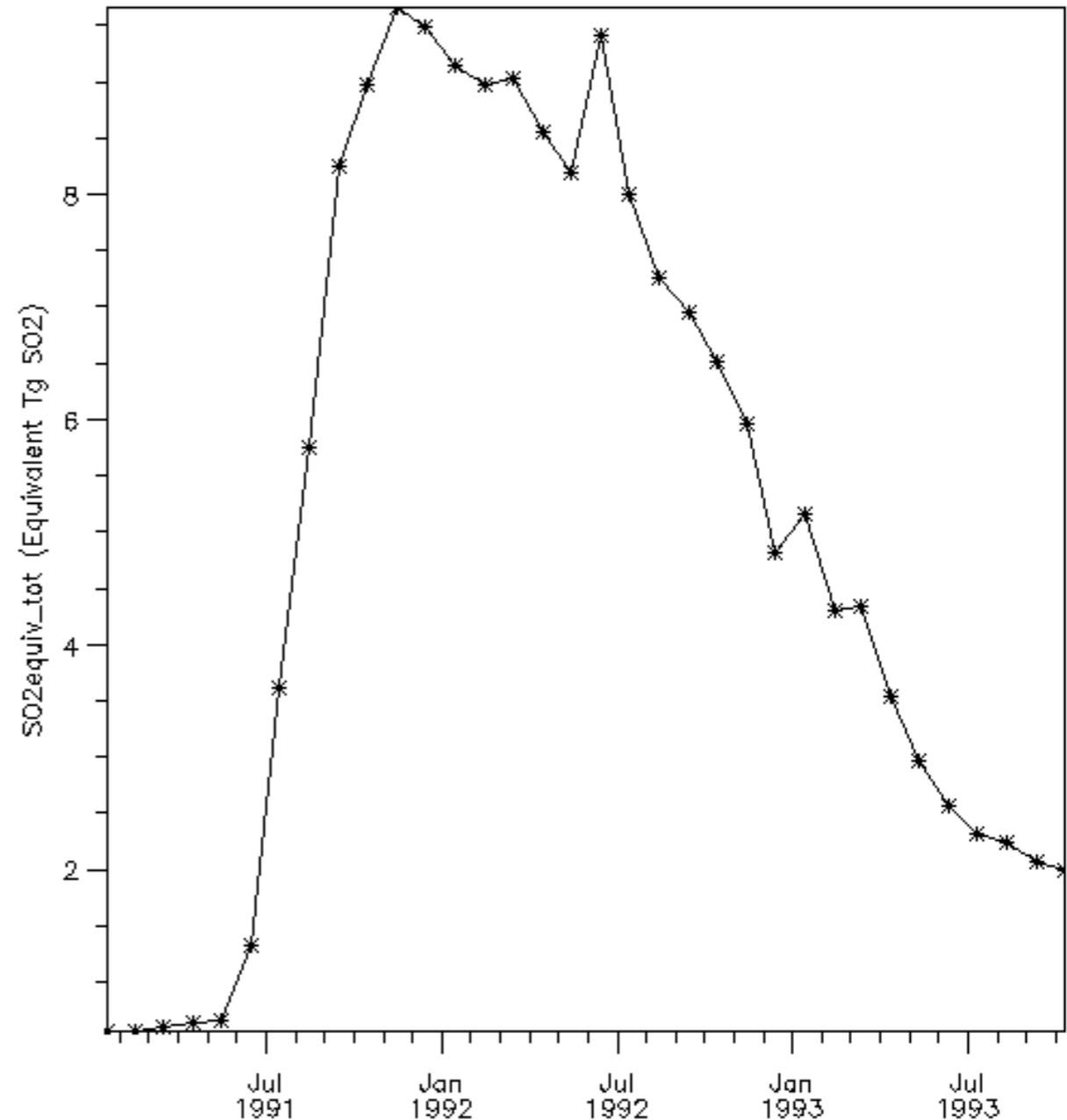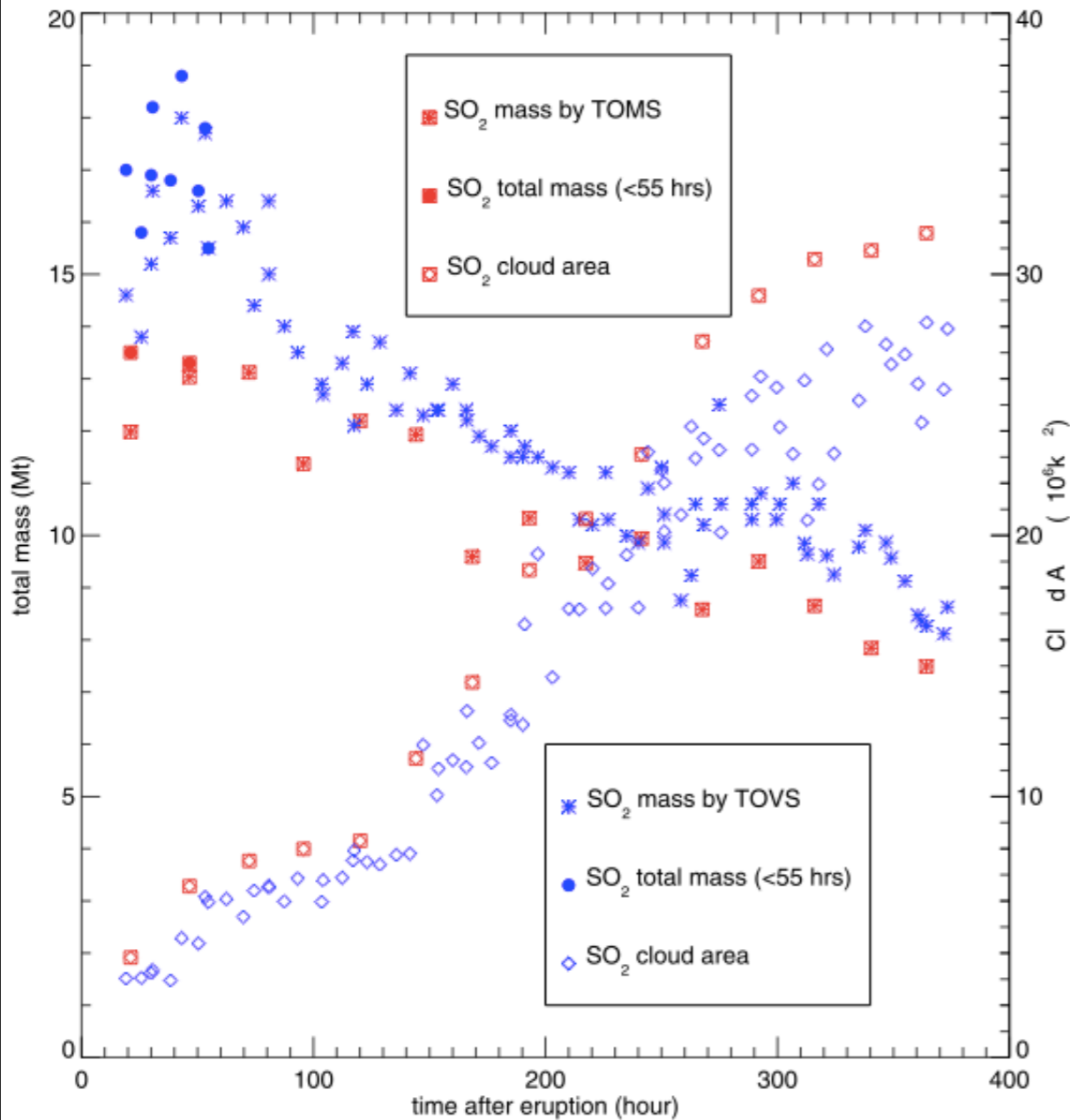
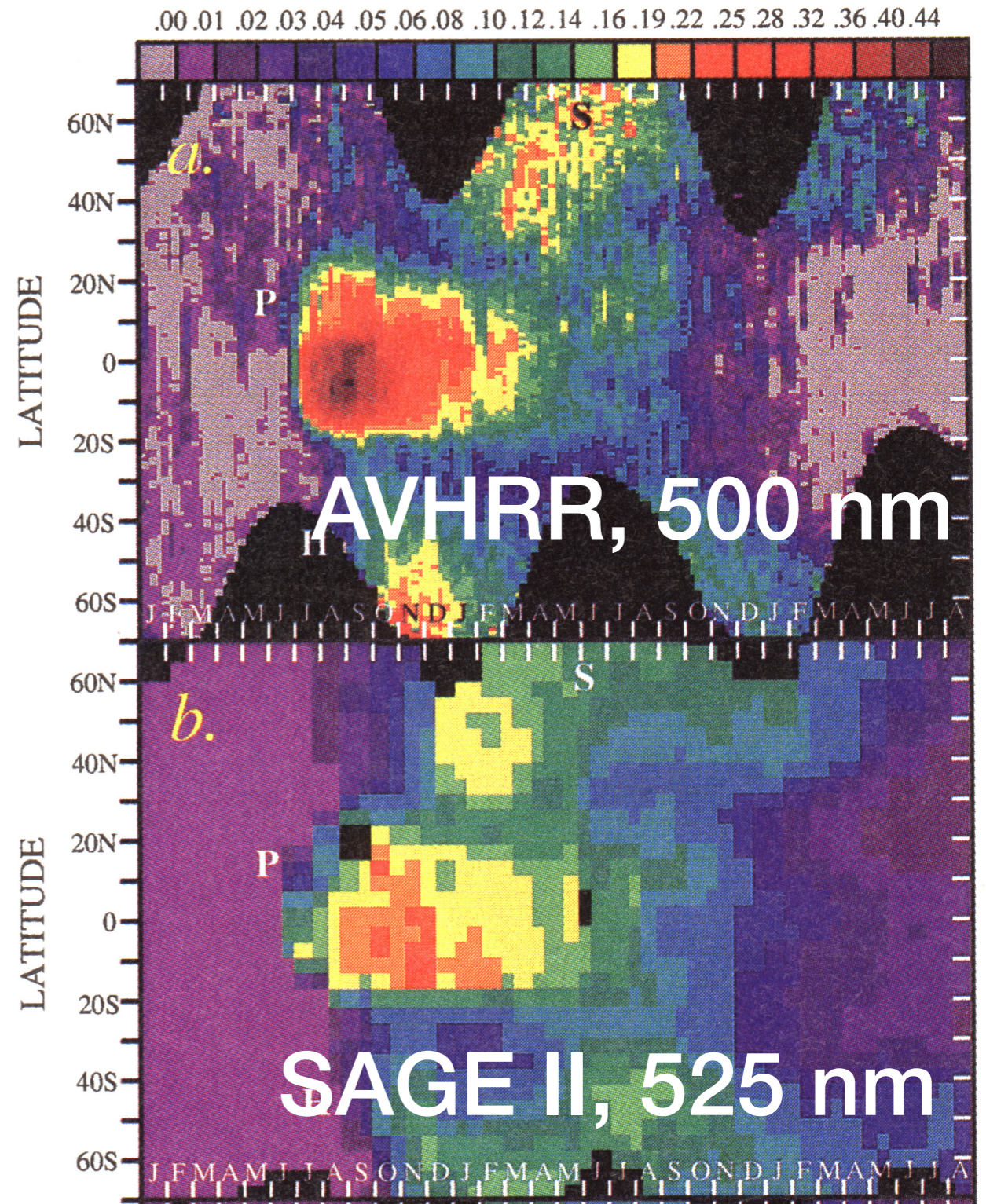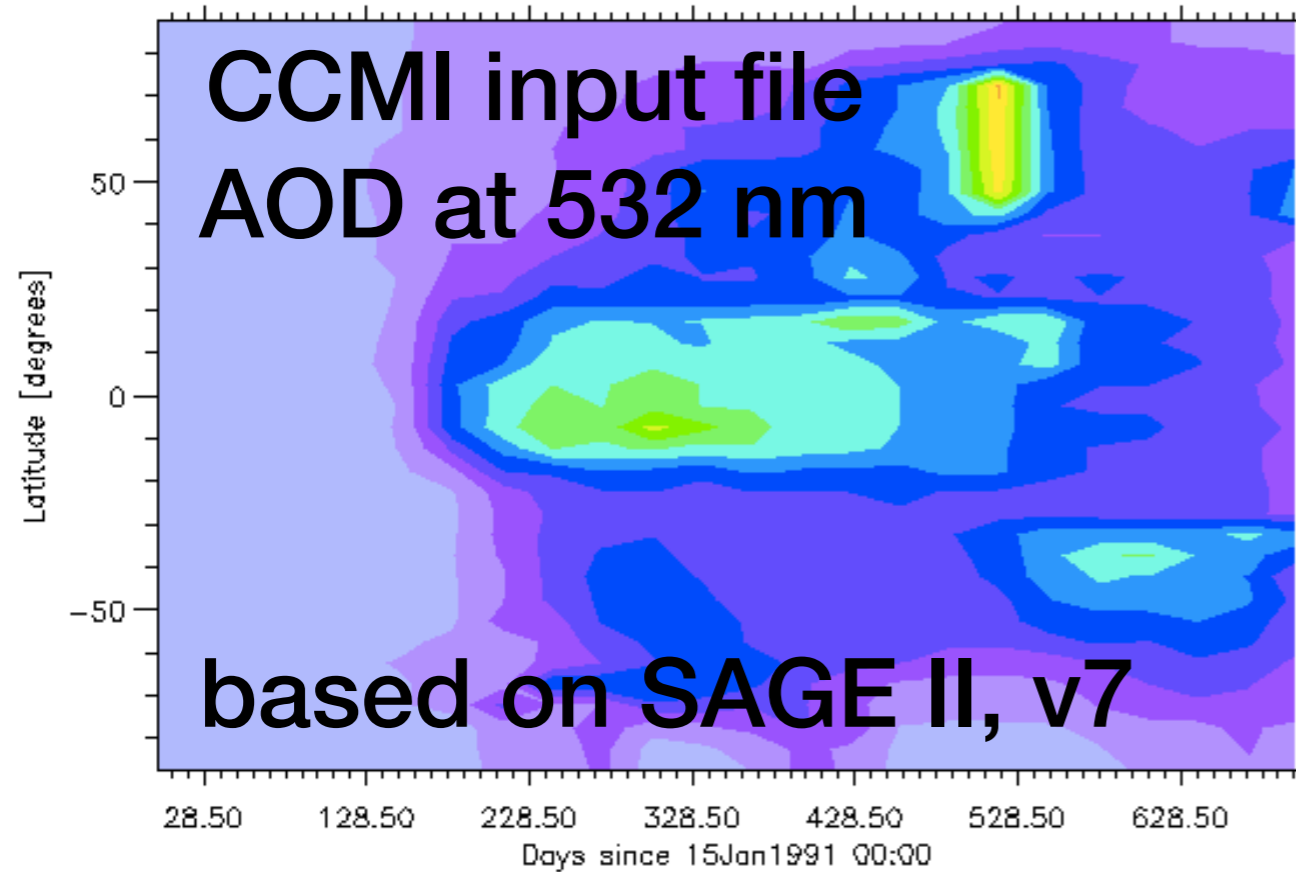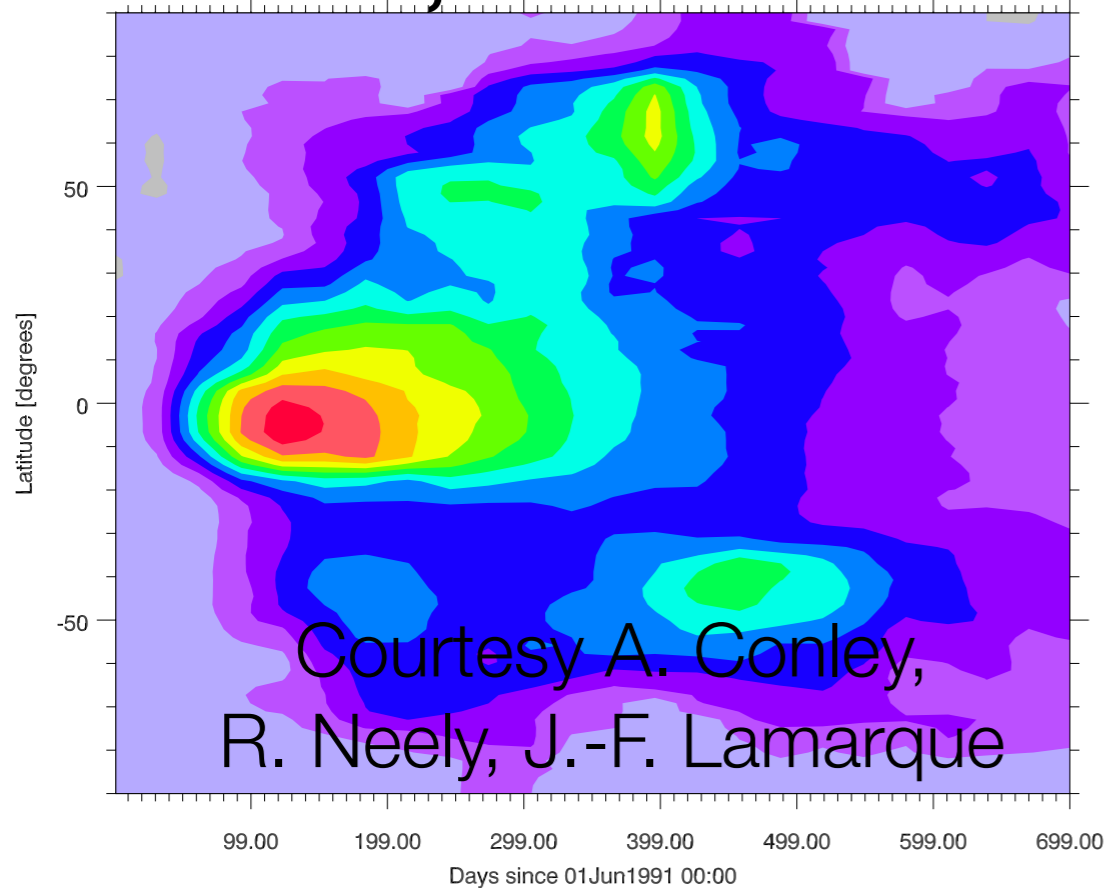# New long term record of stratospheric aerosol properties
(B.P. Luo, F. Arfeuille, J.P.Vernier, L.W. Thomason, T. Peter, CCMI Workshop, May 2013)

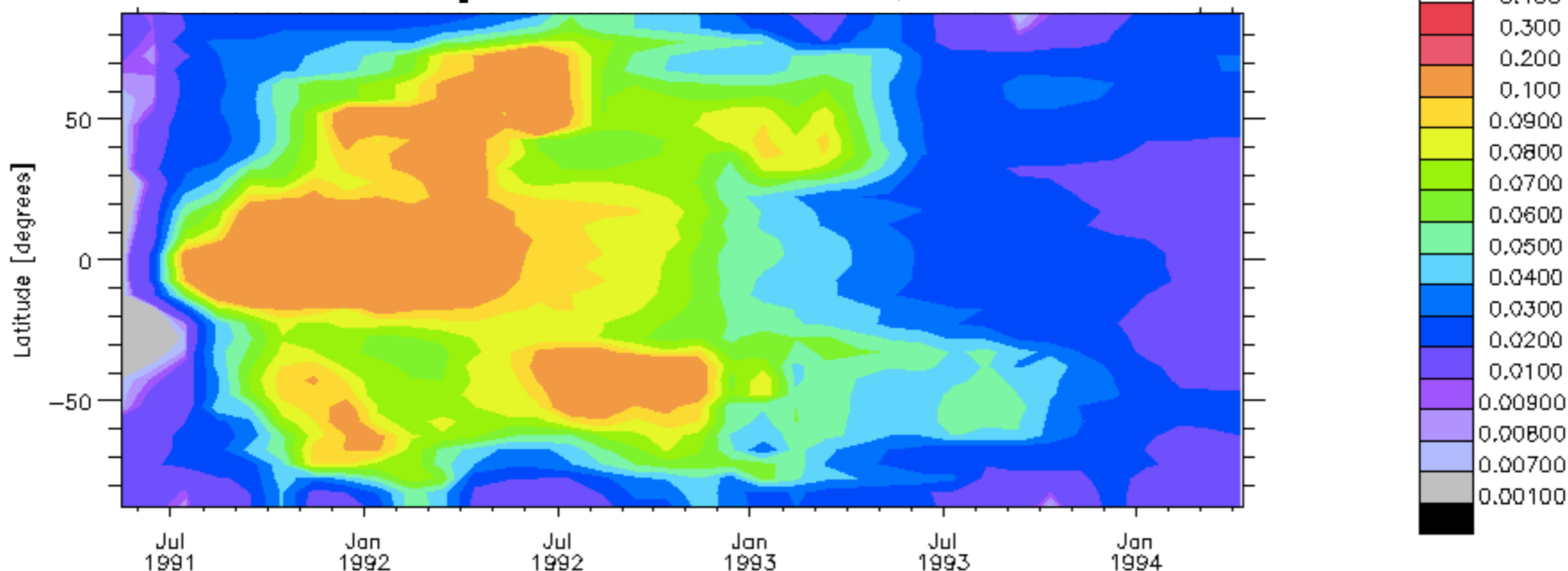**AOD 15-35 km 50°N-50°S**

Courtesy of Jean-Paul Vernier

- Overlap of instruments allows to test SAGE II – CALIPSO transition
- Important differences to Sato GISS data
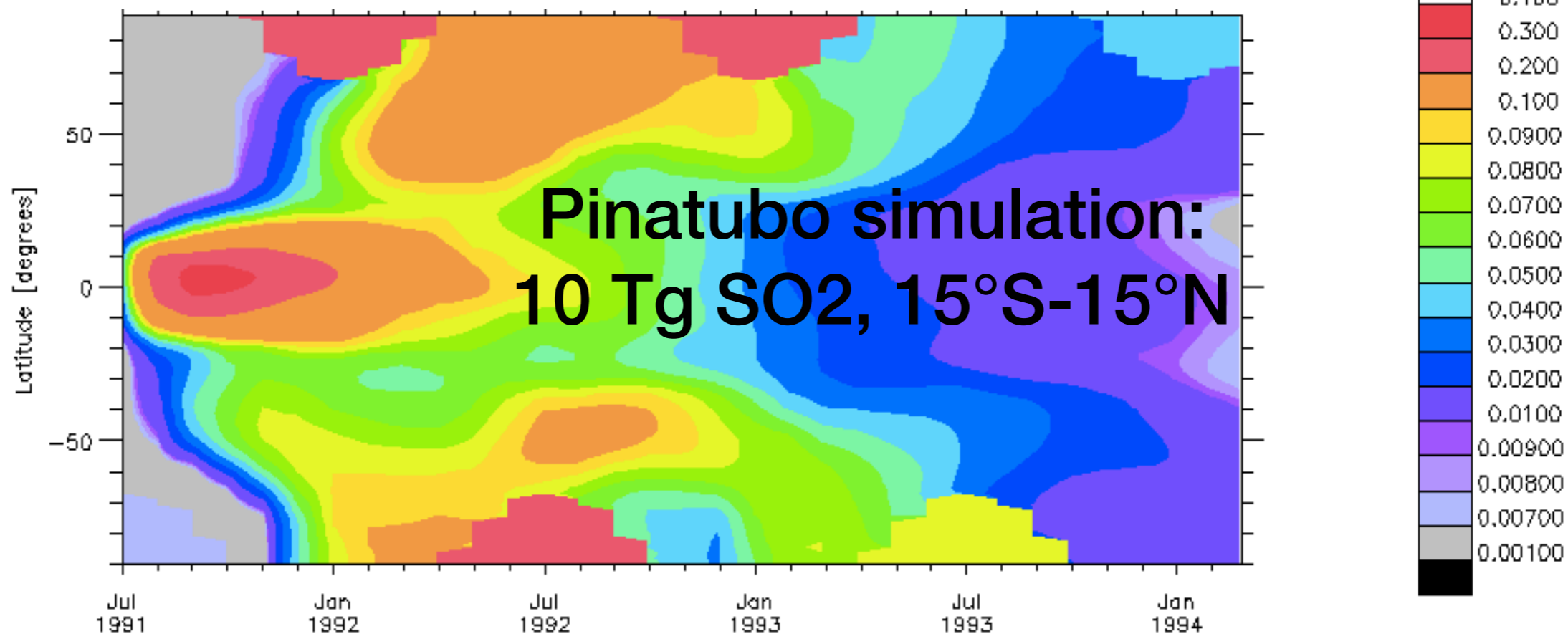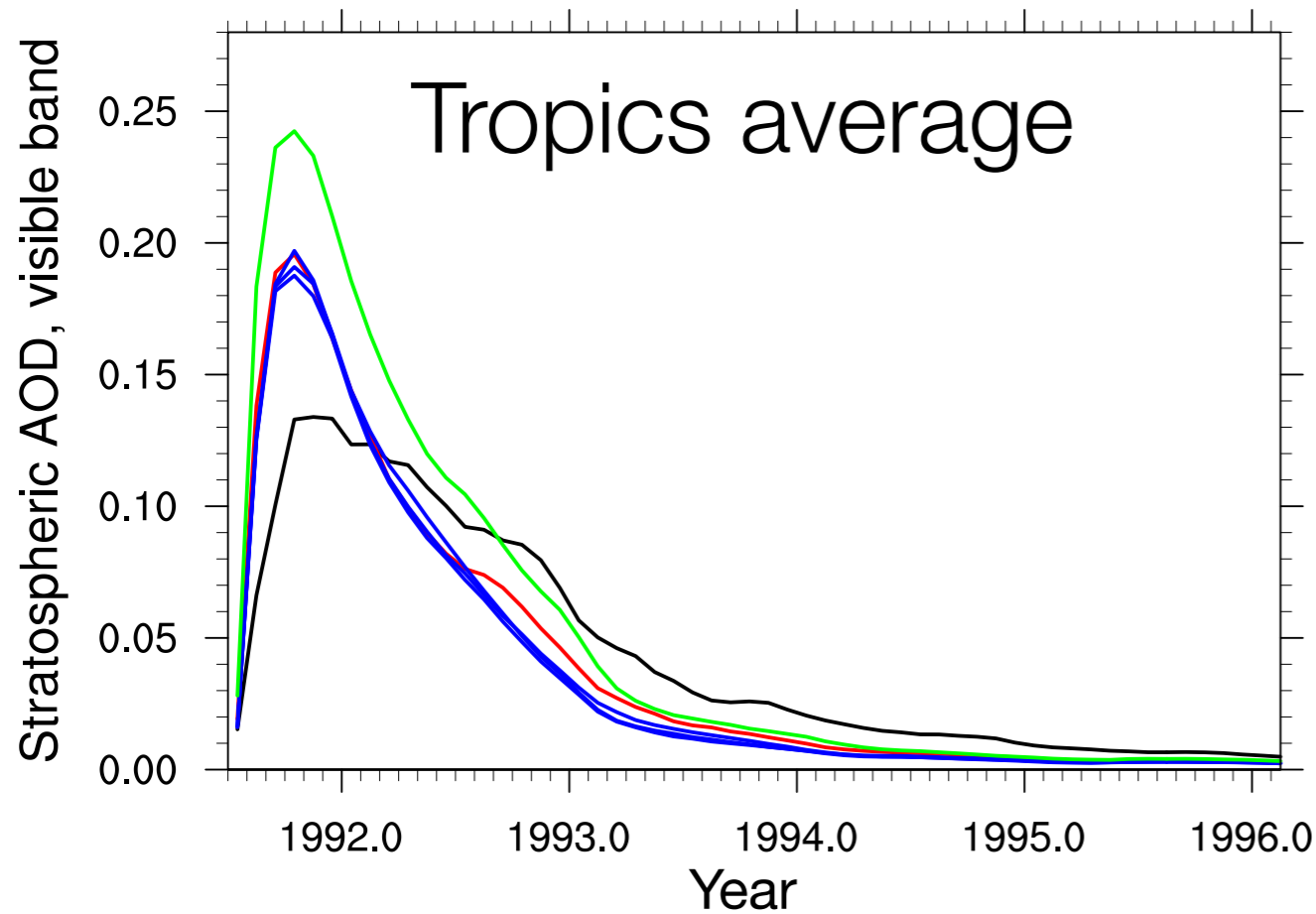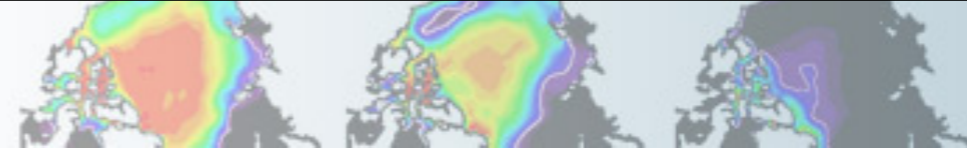
CCMI CESM output
AOD, visible band

Courtesy A. Conley,
R. Neely, J.-F. Lamarque

CCMI input file
AOD at 532 nm

based on SAGE II, v7

AVHRR, 500 nm

SAGE II, 525 nm

From Russell et al., 1996

CCMI Input File AOD, 532 nm

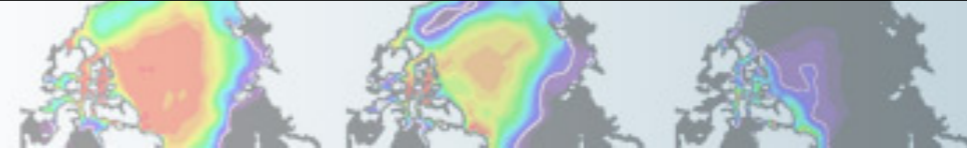# SD-WACCM5-MAM3 AOD, visible

Pinatubo simulation:
10 Tg SO2, 15°S-15°N

Community Earth System Model CESM

Pinatubo simulation:
10 Tg SO2, 15°S-15°N

CCMI input file
SD-WACCM5-MAM3
FR-WACCM5-MAM3
FR, wet radius

Tropics average

Northern extratropics

Southern extratropics
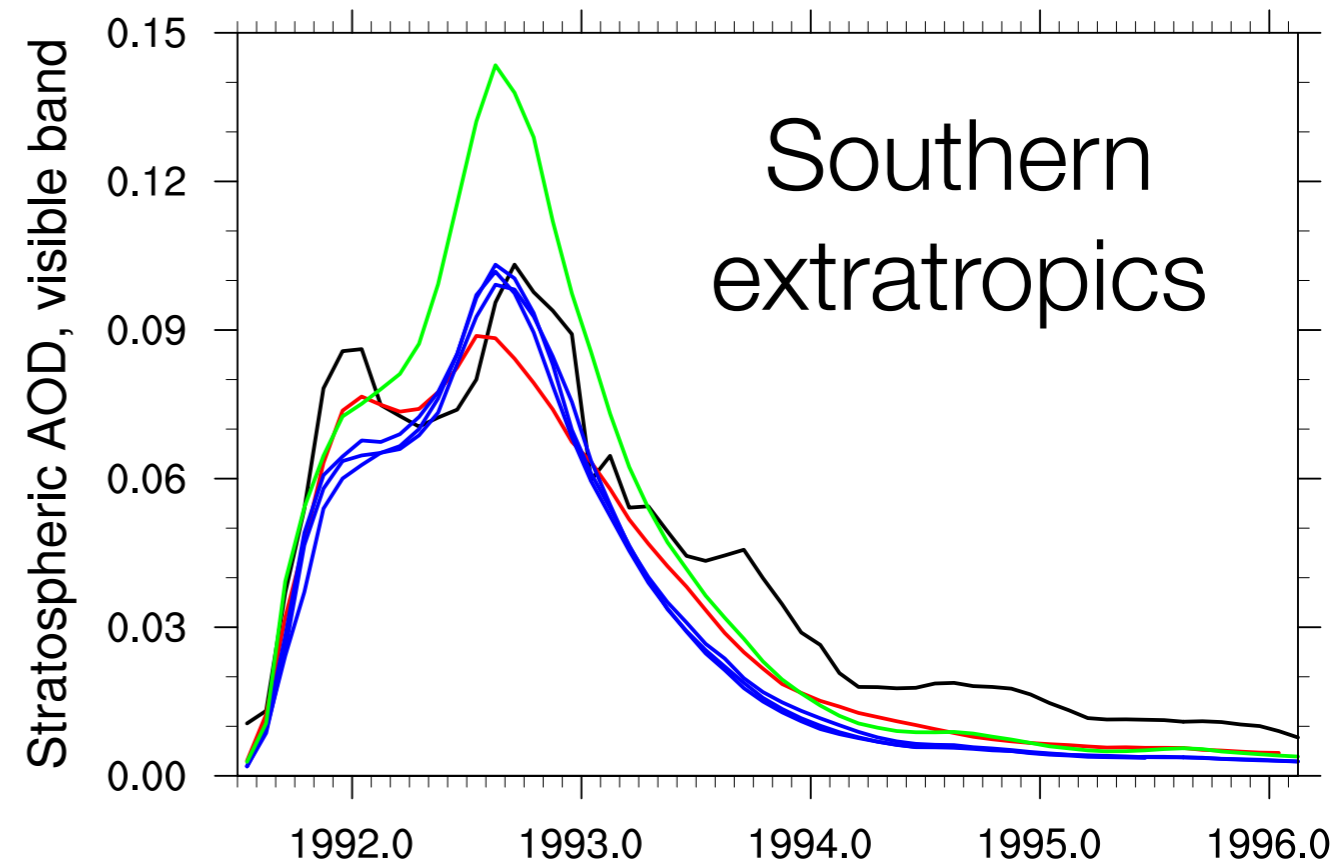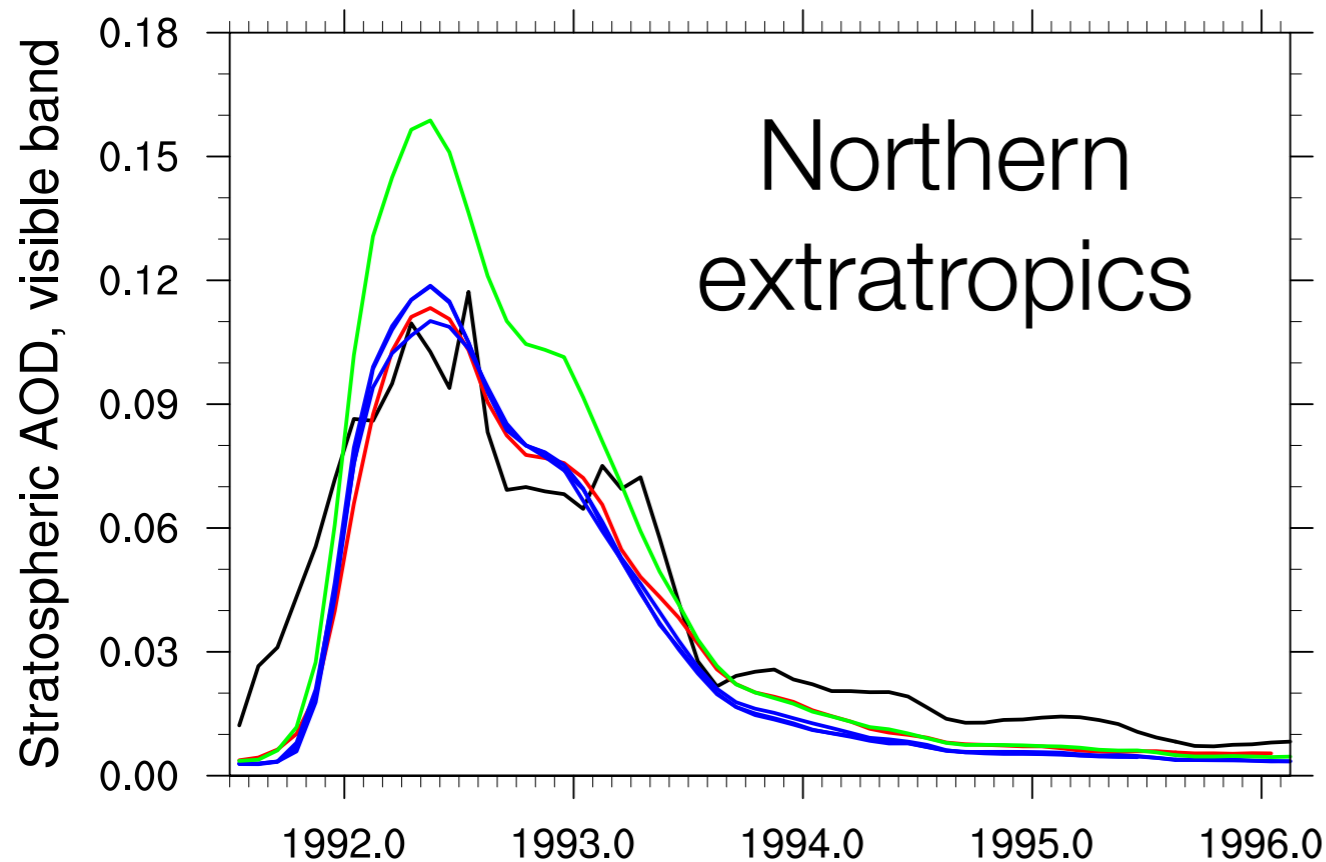
Stratospheric temperature anomalies

Surface, tropical average anomaly relative to June 1990 - May 1991 average

Surface temperature anomalies
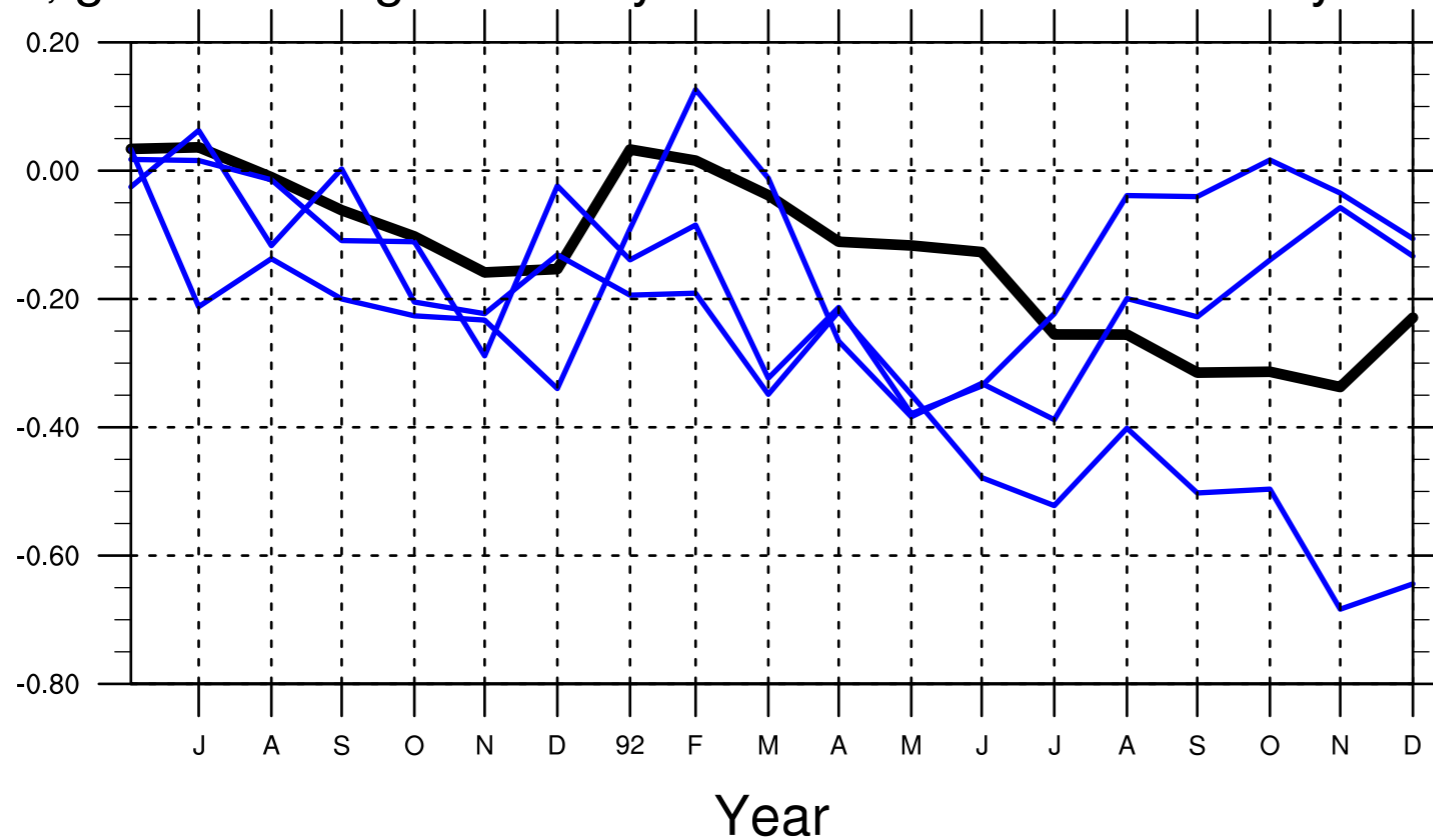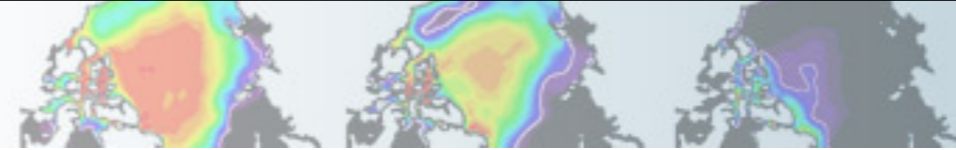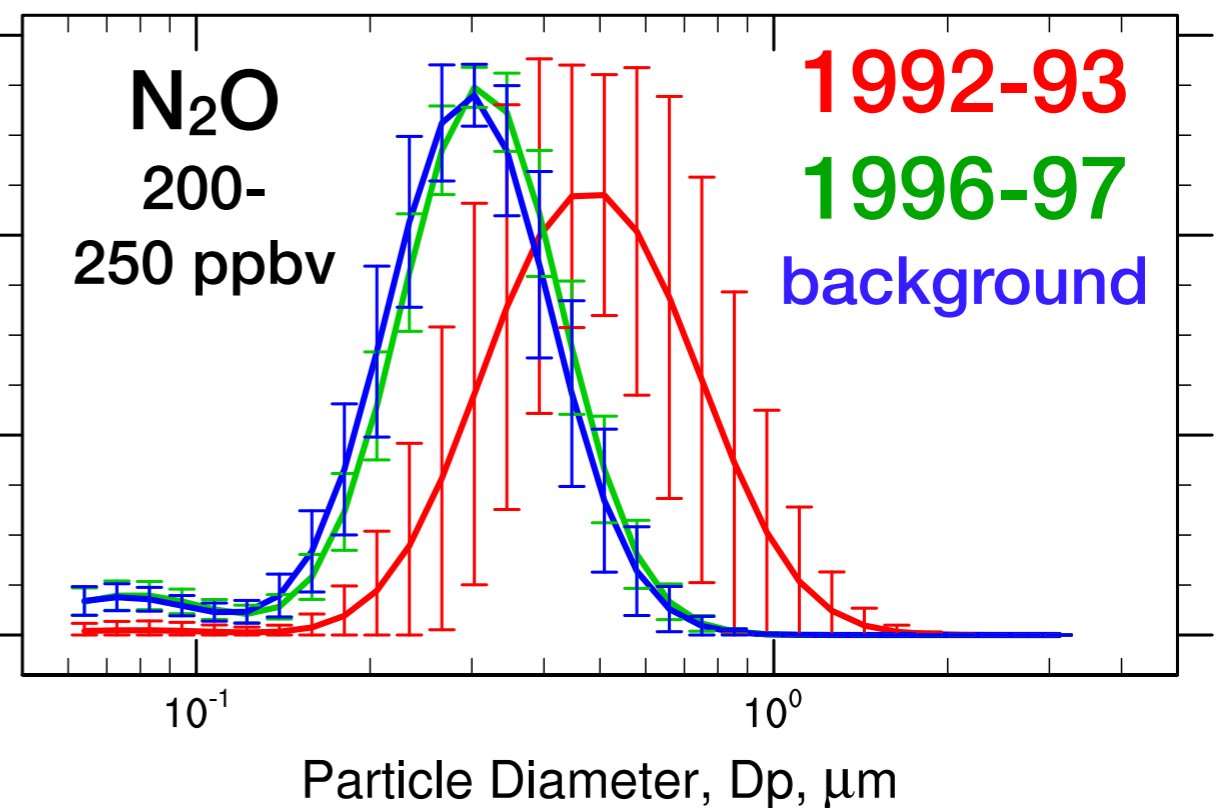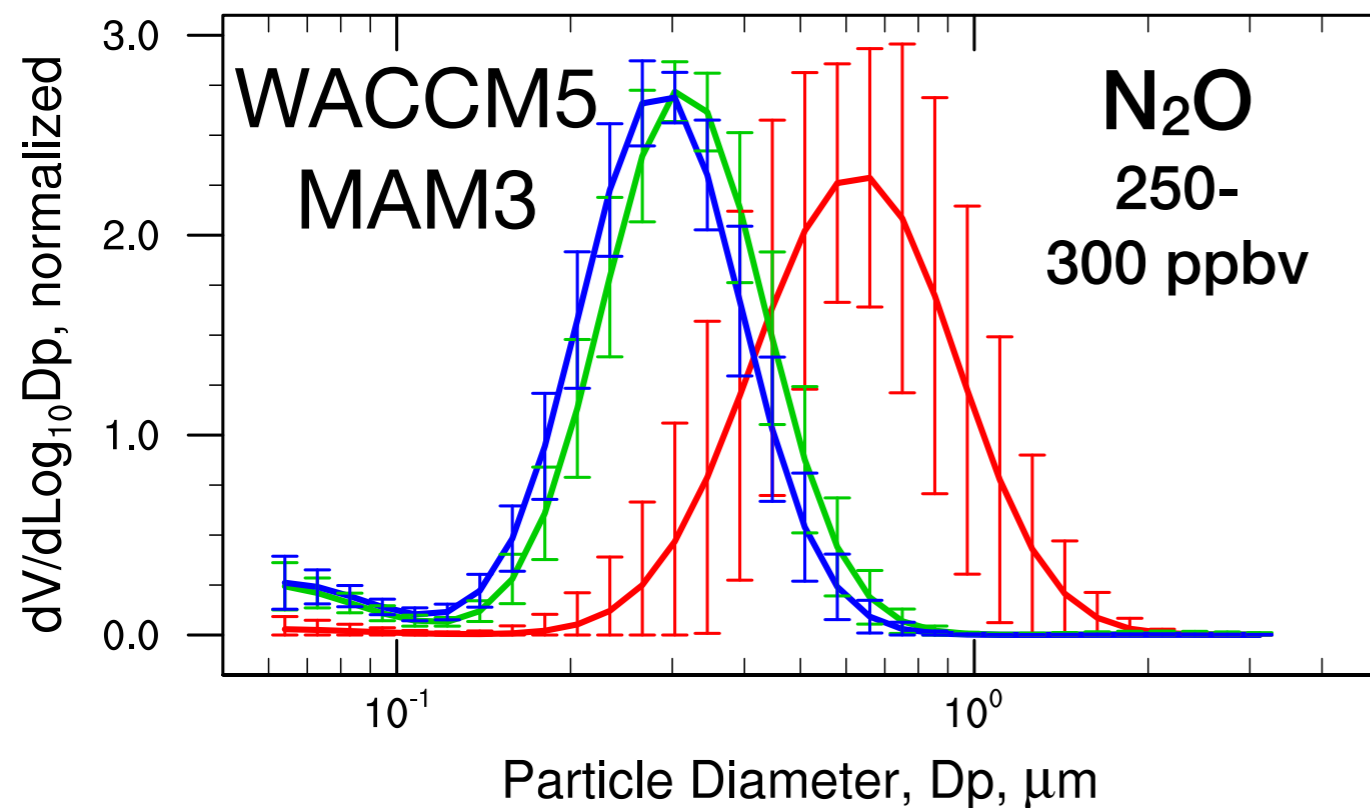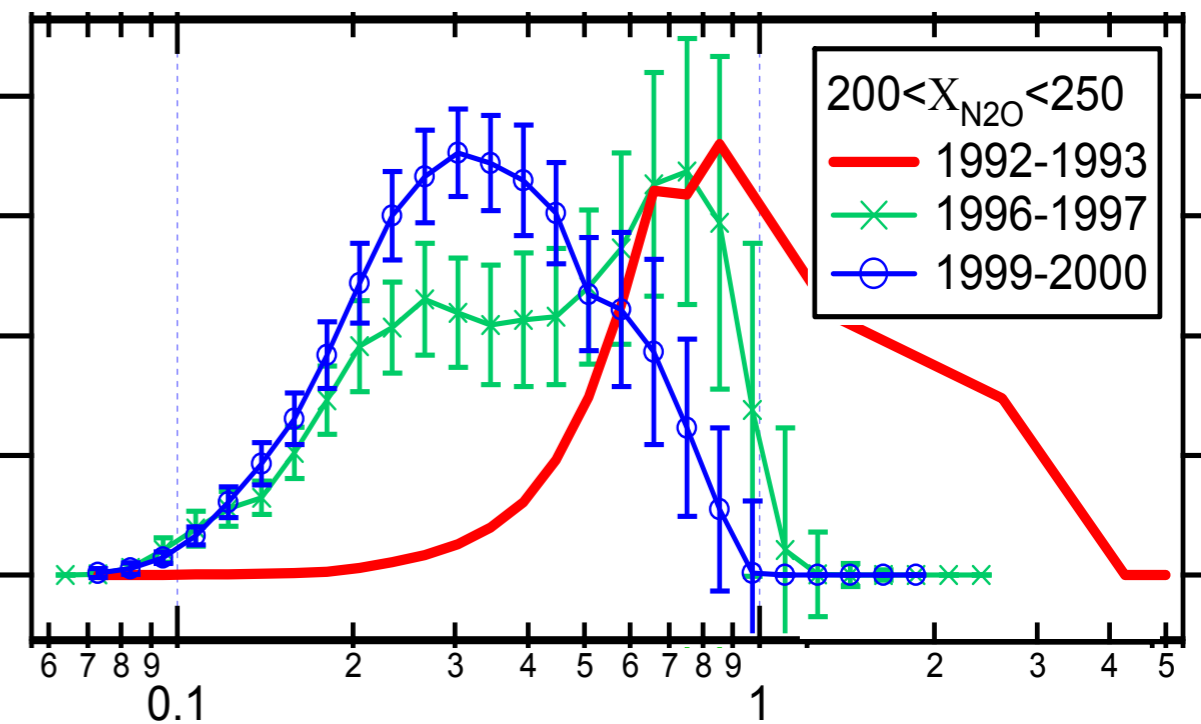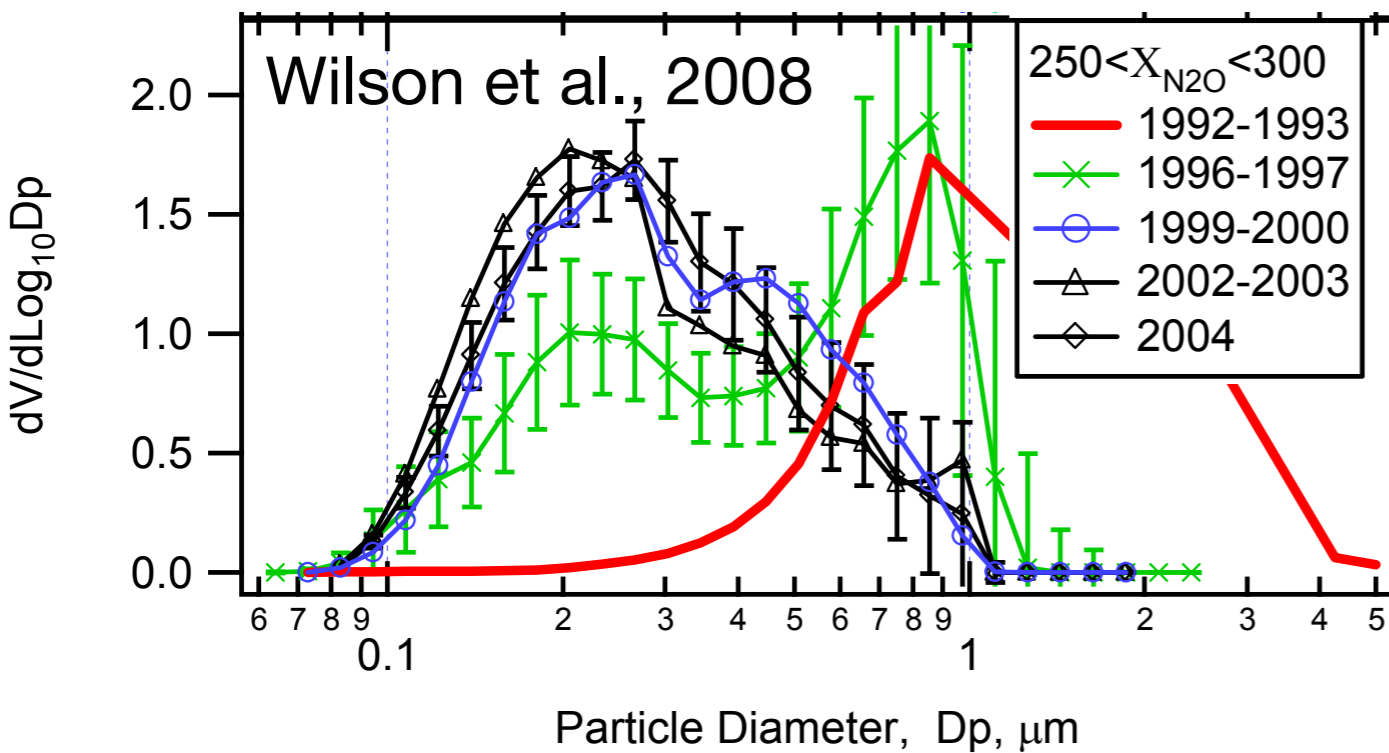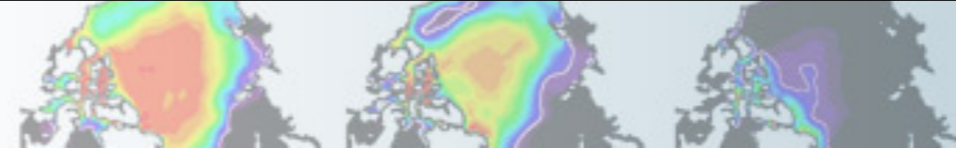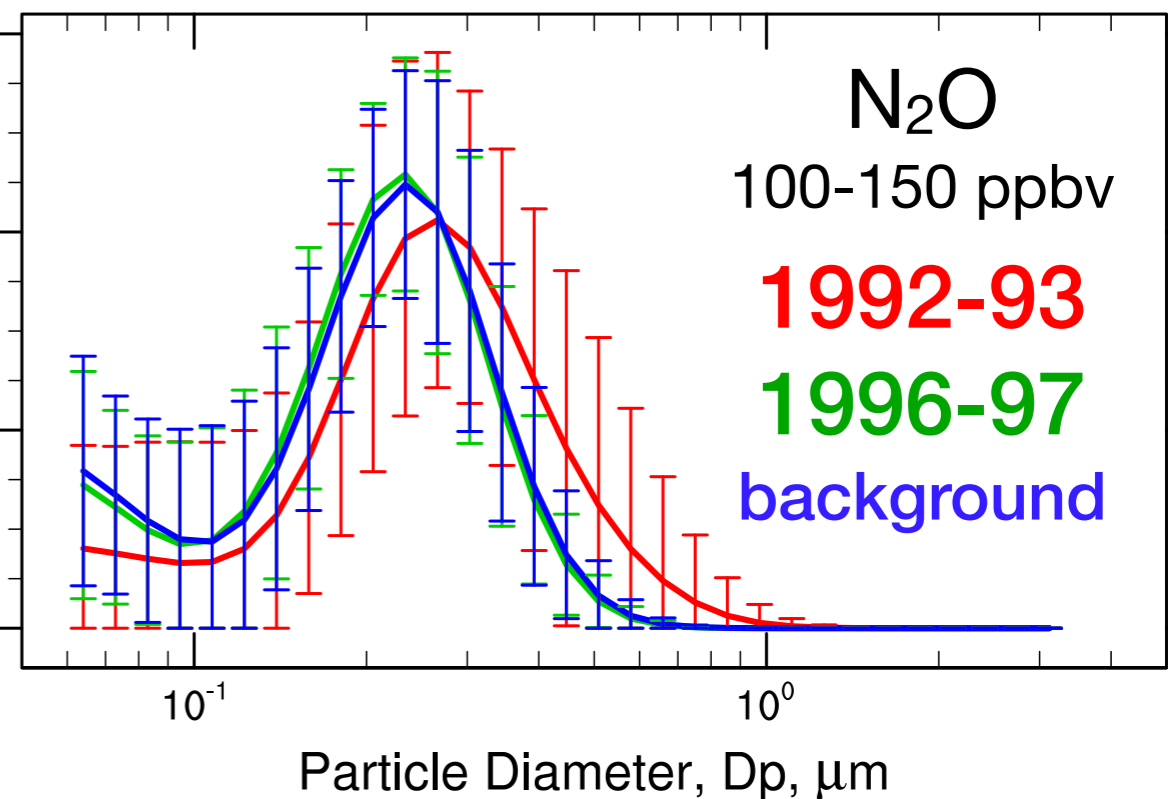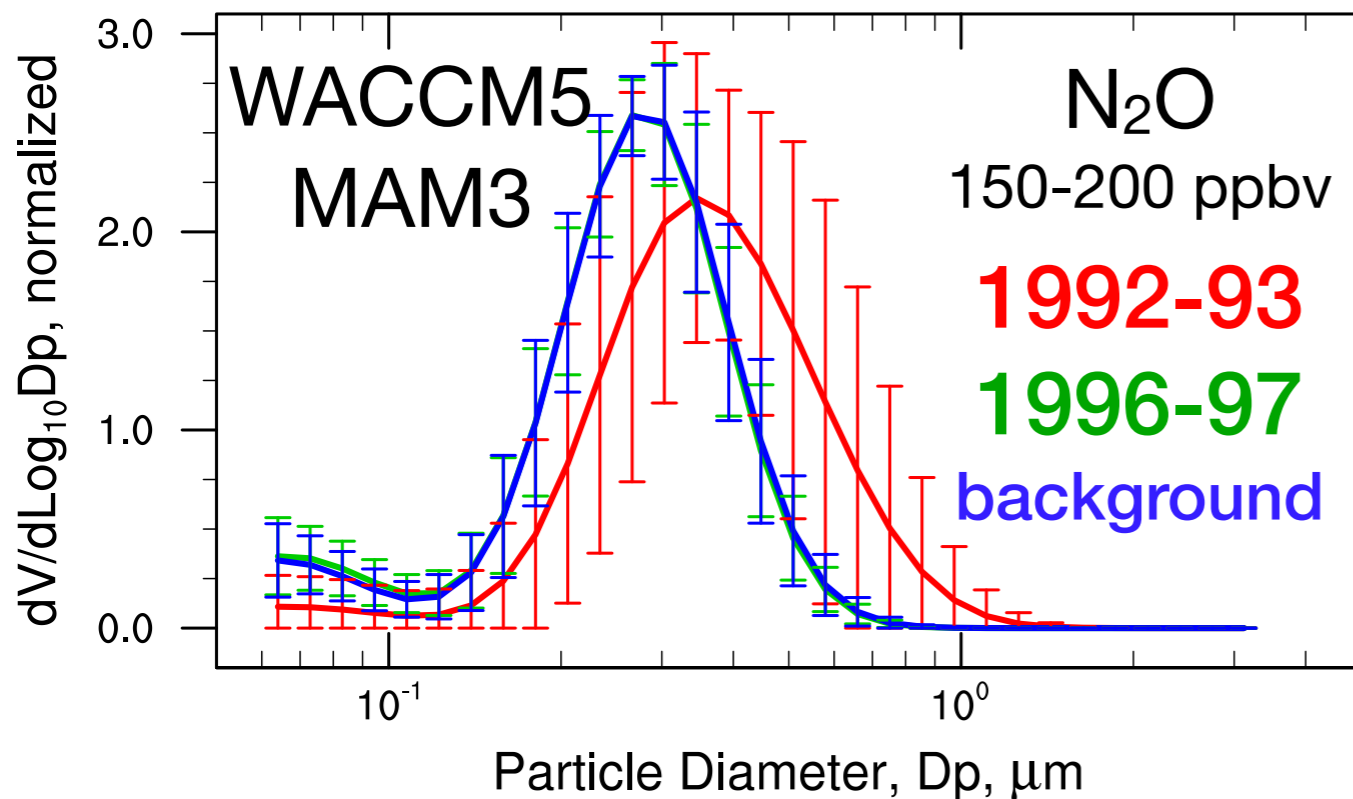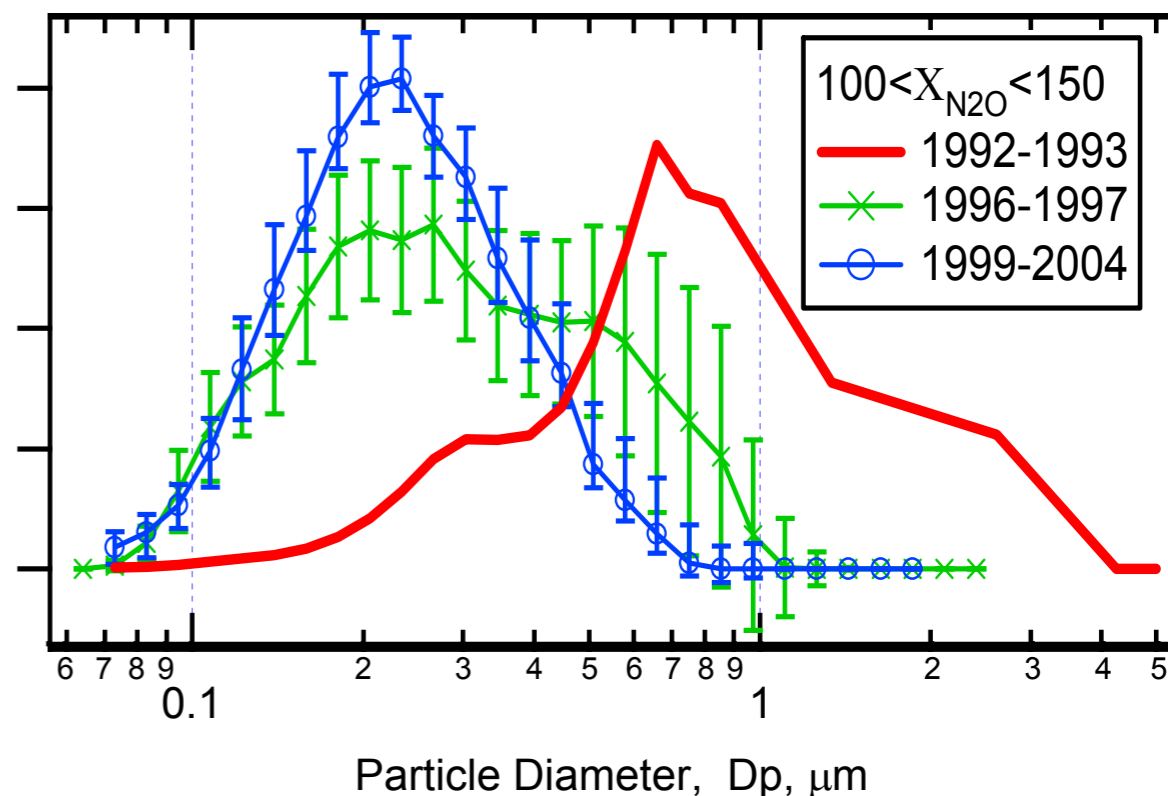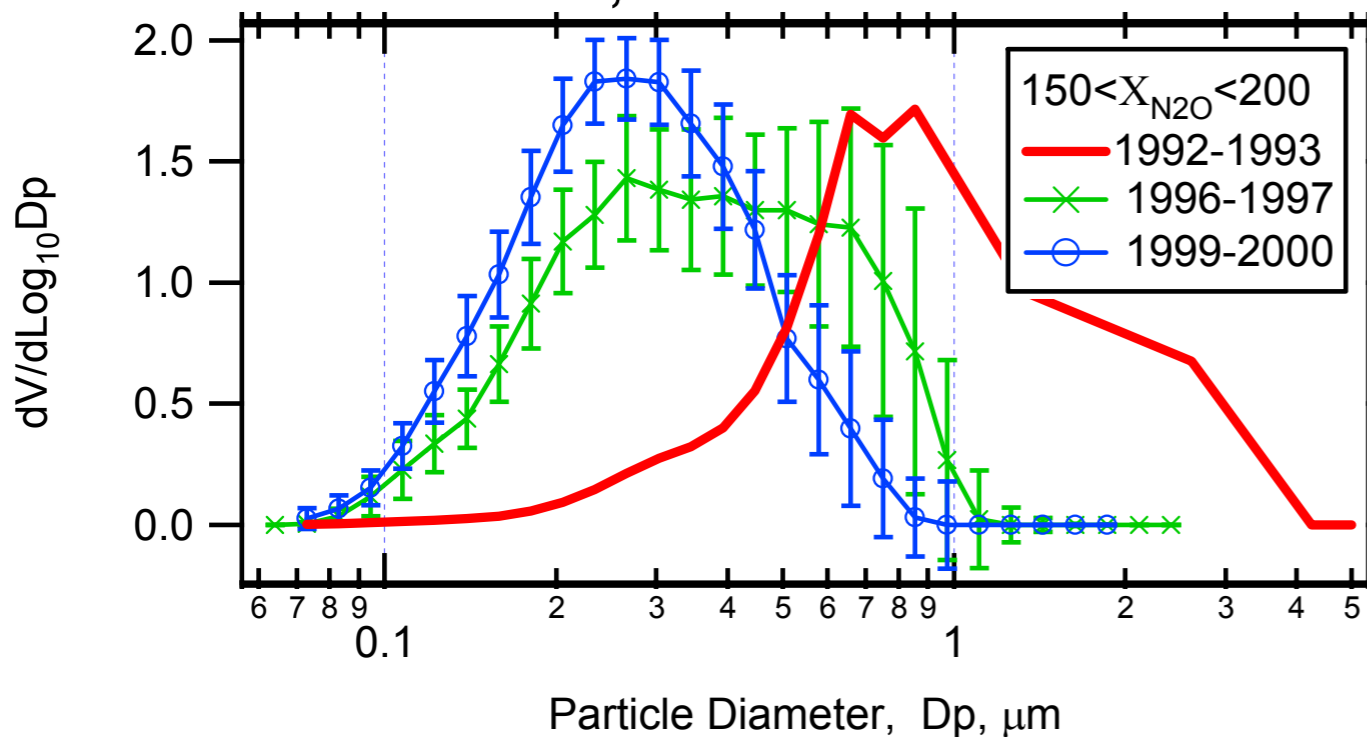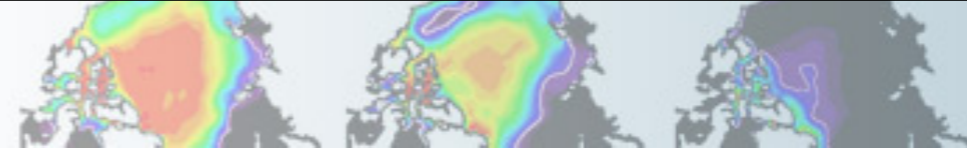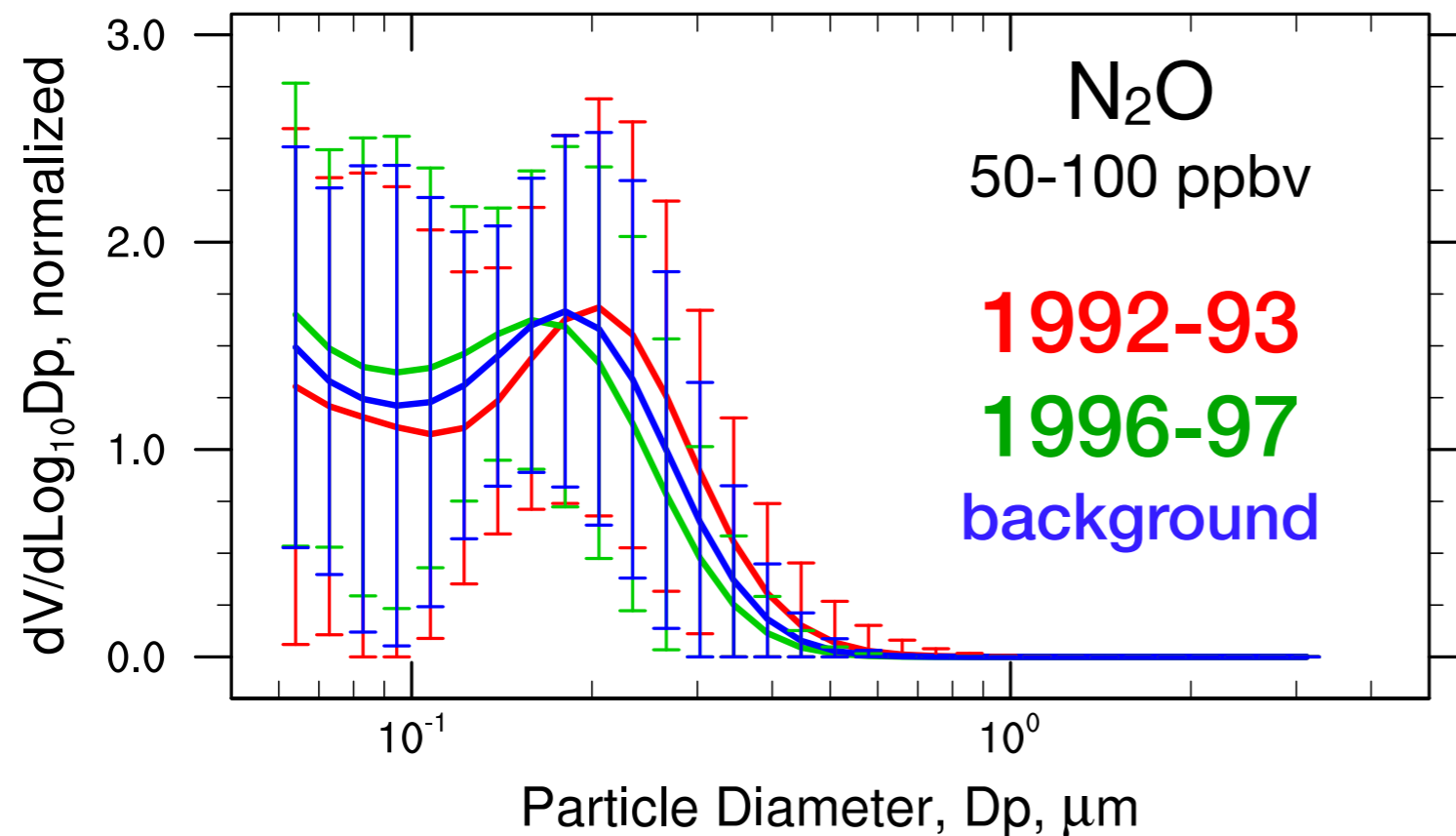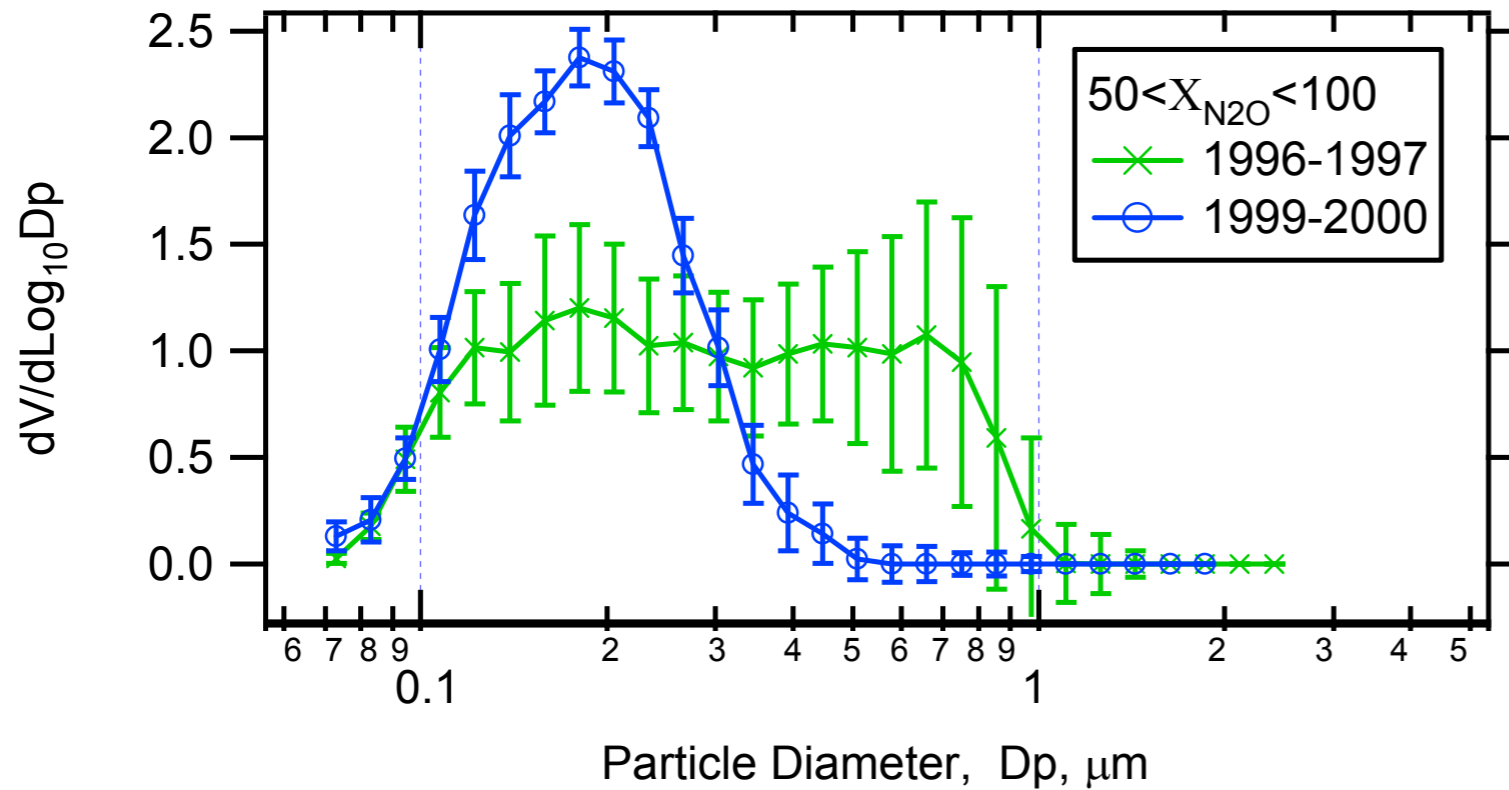
Volume size distributions compared to observations
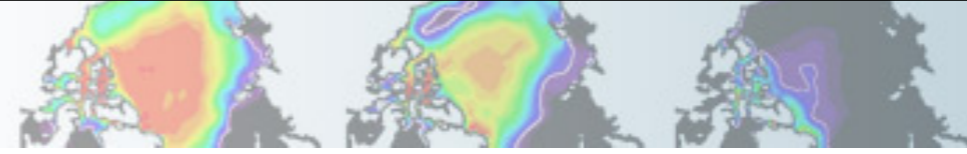
Volume size distributions compared to observations

Volume size distributions compared to observations

Outstanding issues

- Investigate lack of growth to coarse mode

- Evaporation does not allow aerosols to move to smaller modes

- Adjustment of mode widths

- Treatment of sulfate in MAM3 as ammonium sulfate

  - CAM5 scientific description: "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."

  - MAM-3: 98 μg of H_2SO_4(g) will produce 115 μg of the MAM3 sulfate species

  - Switch to MAM-7?

- Need for additional modes, i.e. nucleation mode?