WACCM and WACCM/CARMA studies at CU LASP: June 2009 Update

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NCAR

WACCM, CAM & CARMA at LASP

Talk outline:

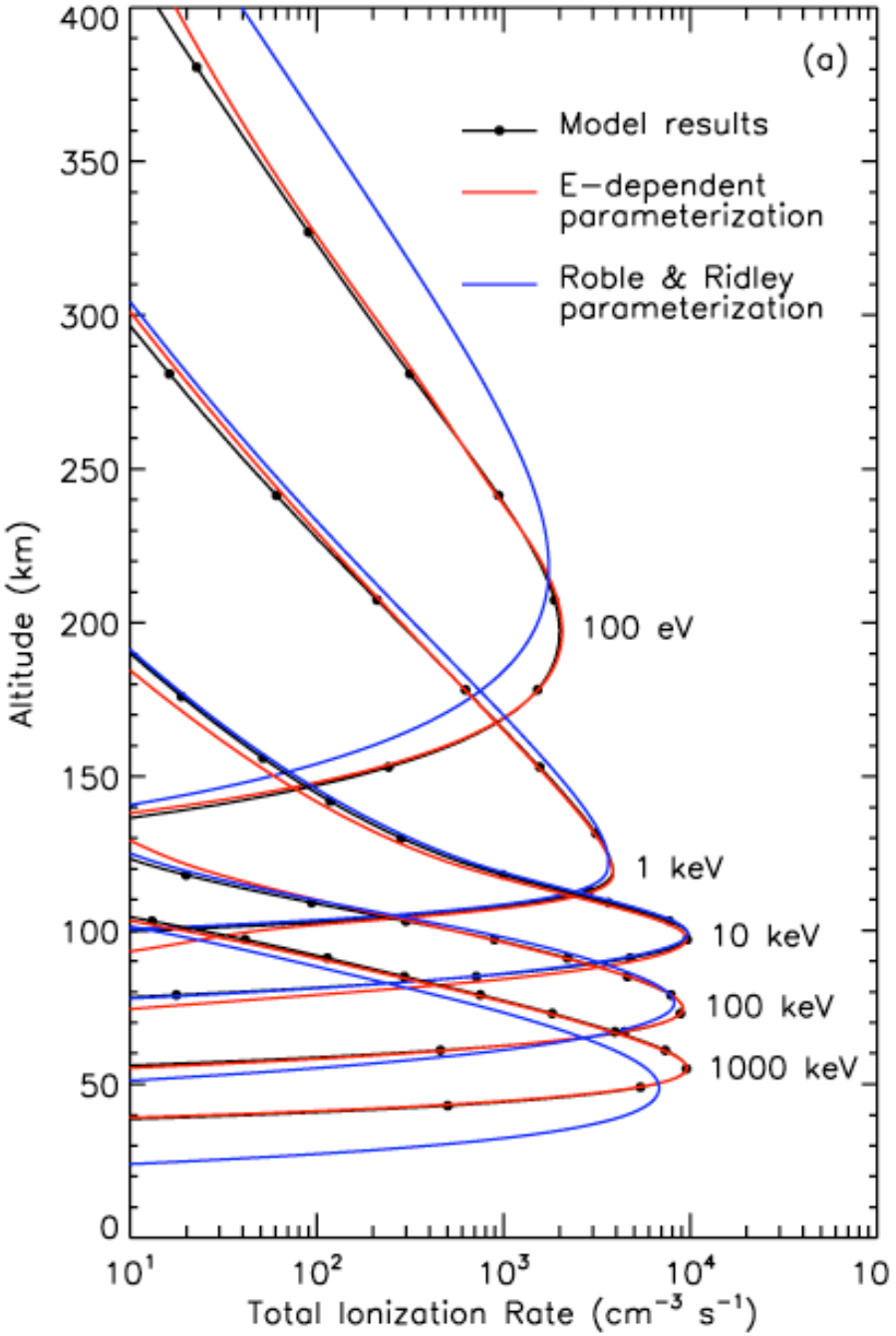
- WACCM
  - Energetic particle precipitation
  - Stratospheric warmings
  - Elevated stratopause (~80 km!)
- WACCM/CARMA
  - Mesospheric sulfate as PMC nuclei
  - Stratospheric background aerosol

Additional ongoing studies:

- WACCM
  - Interhemispheric coupling of PMCs
  - Polar vortex dynamics
  - Cold air outbreaks
  - Comparisons to SABER & MLS
- WACCM/CARMA
  - Geoengineering
  - Sulfate nucleation
  - Early Earth hazes
- CAM/CARMA
  - Tropospheric dust
  - Sea salt aerosol
  - Titan
  - Mars
  - Subvisible cirrus

WACCM Chemistry & Dynamics

Energetic particle precipitation
Stratospheric warmings
Elevated stratopause (~80 km!)

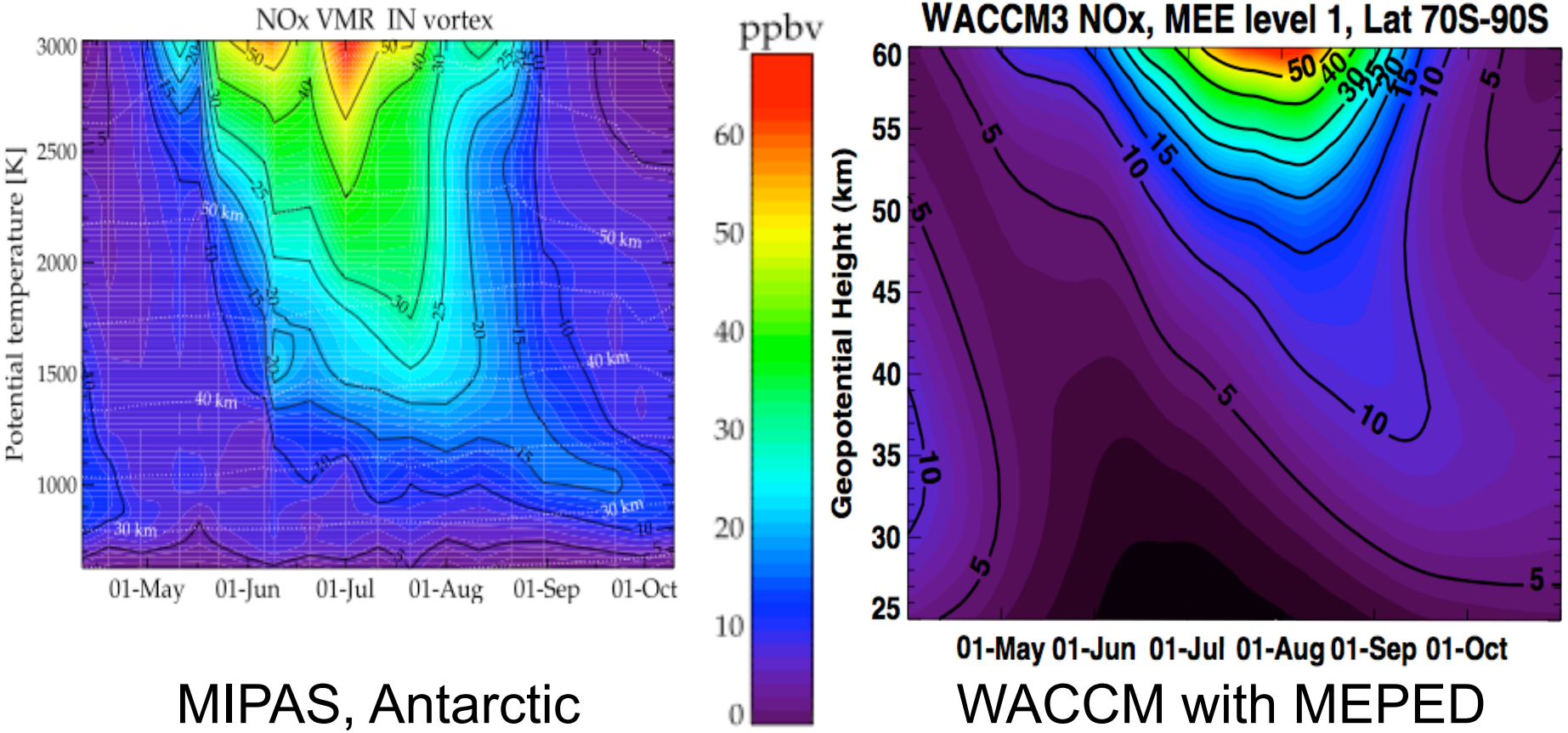


Energetic particle precipitation

- Ionization: $N_2 \rightarrow NO_x$
- Auroral electrons
  - 1 - 30 kev
- Add medium-energy electrons (MEE)
  - 30 kev - 2.5 Mev
  - new parameterization
  - goal: get in WACCM trunk

Figure from Fang *et al.*, JGR, 2008.

NO_x descent with medium-energy electron precipitation

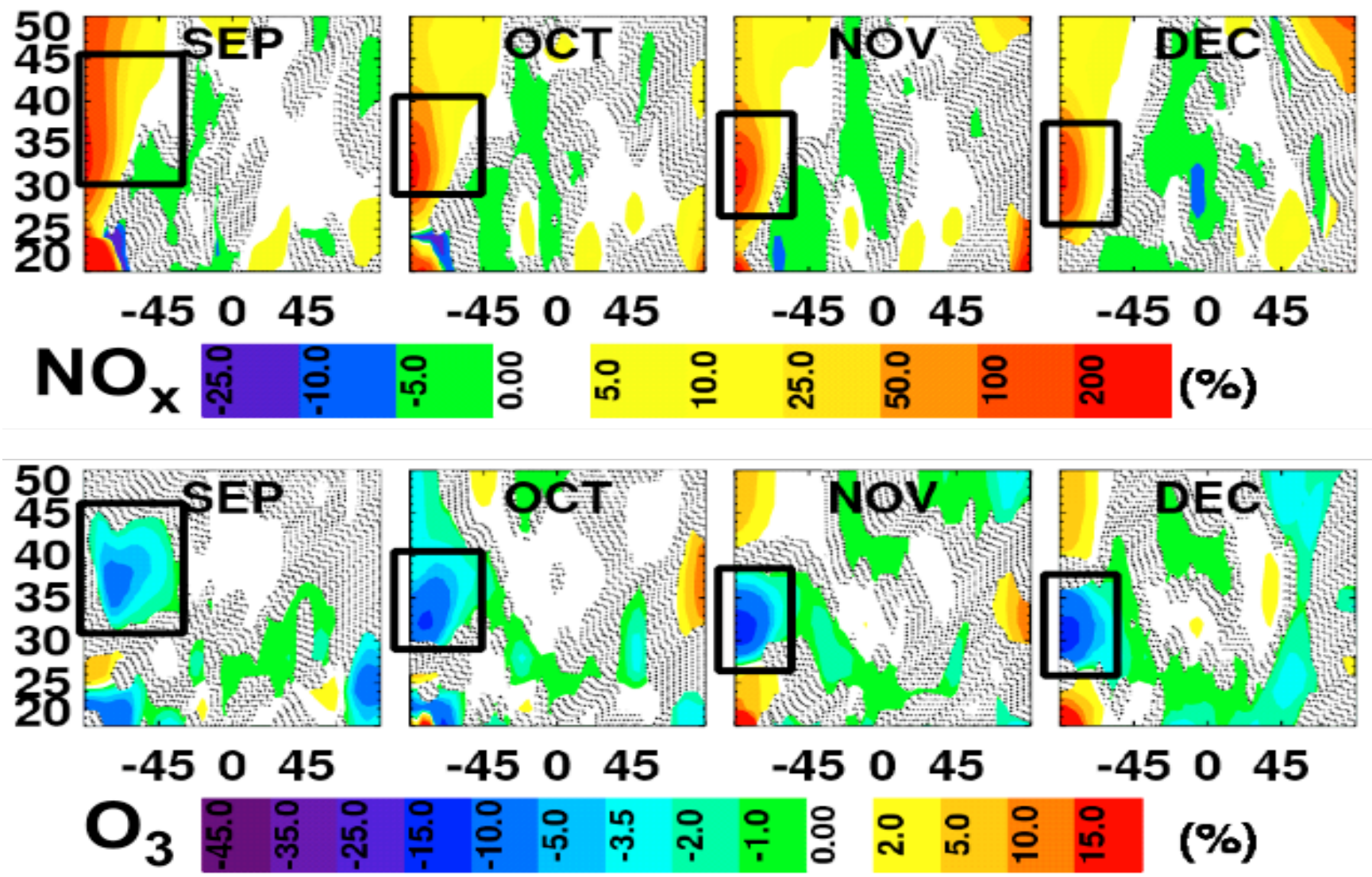


MIPAS, Antarctic Winter 2003

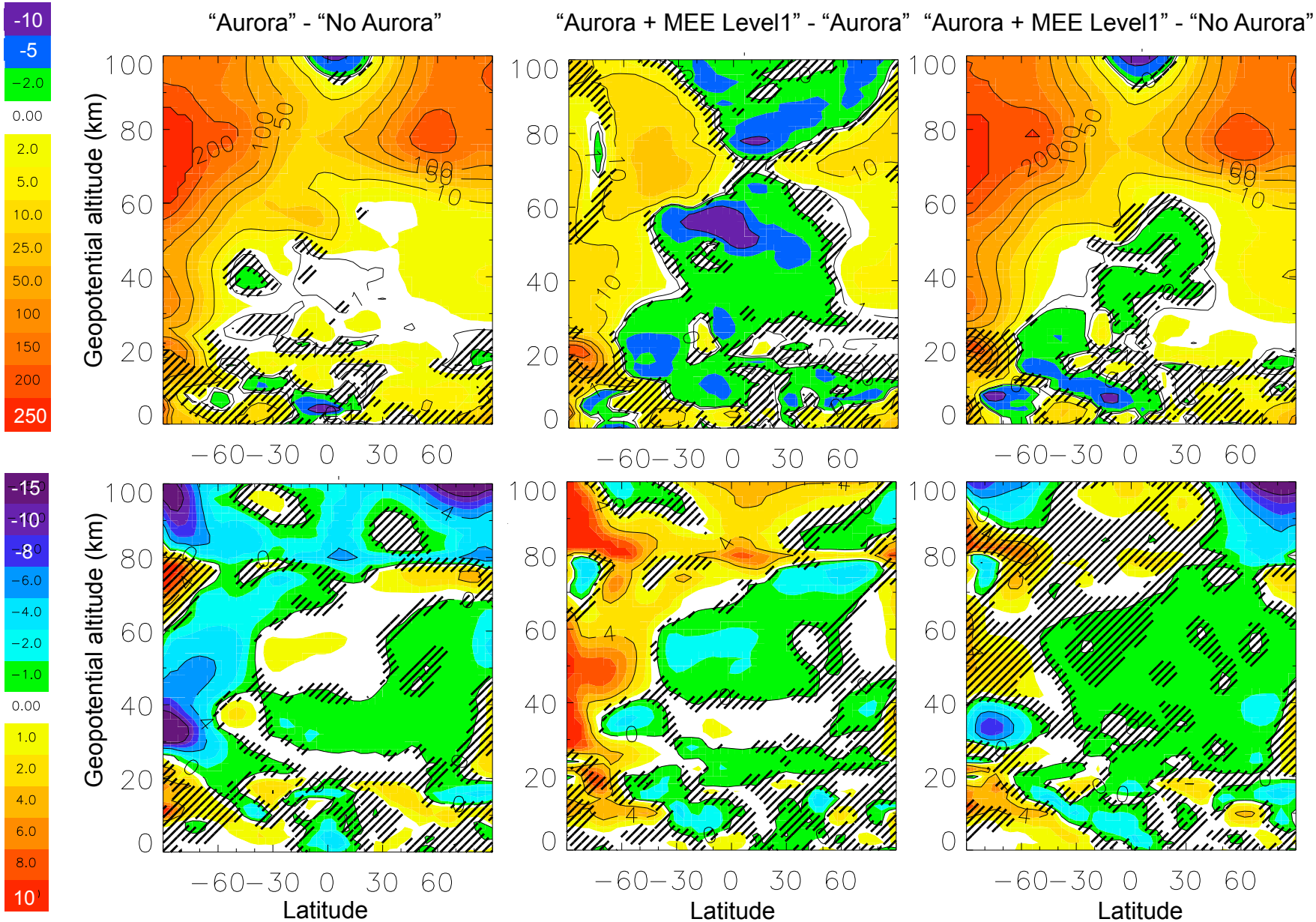
WACCM with MEPED activity level 1

Courtesy of C. Randall

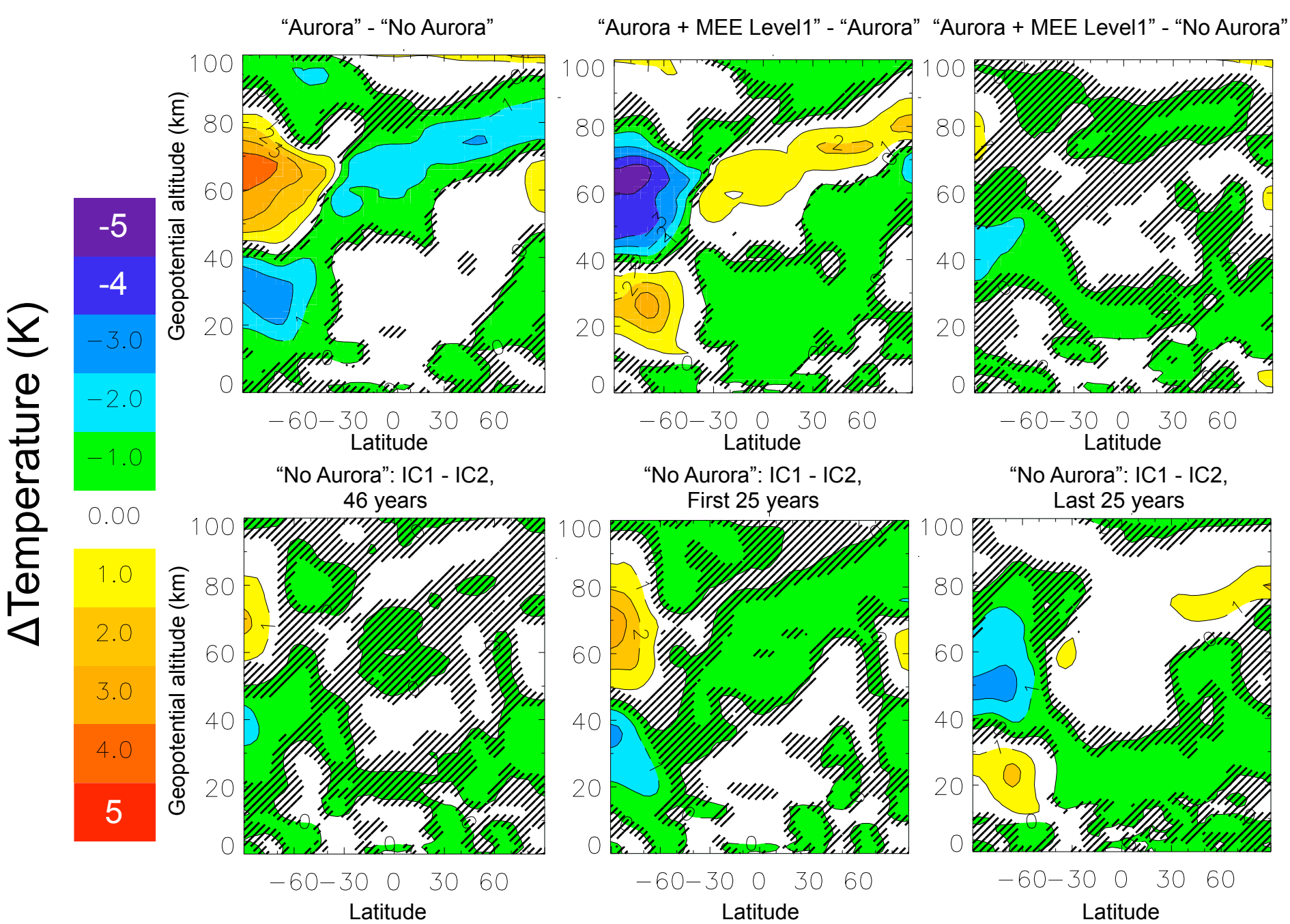
Medium-energy electrons induce O_3 depletion



Average changes over the last 20 years of 25-year runs are shown.
Non-shaded regions are statistically significant to >2σ. Courtesy of C. Randall.

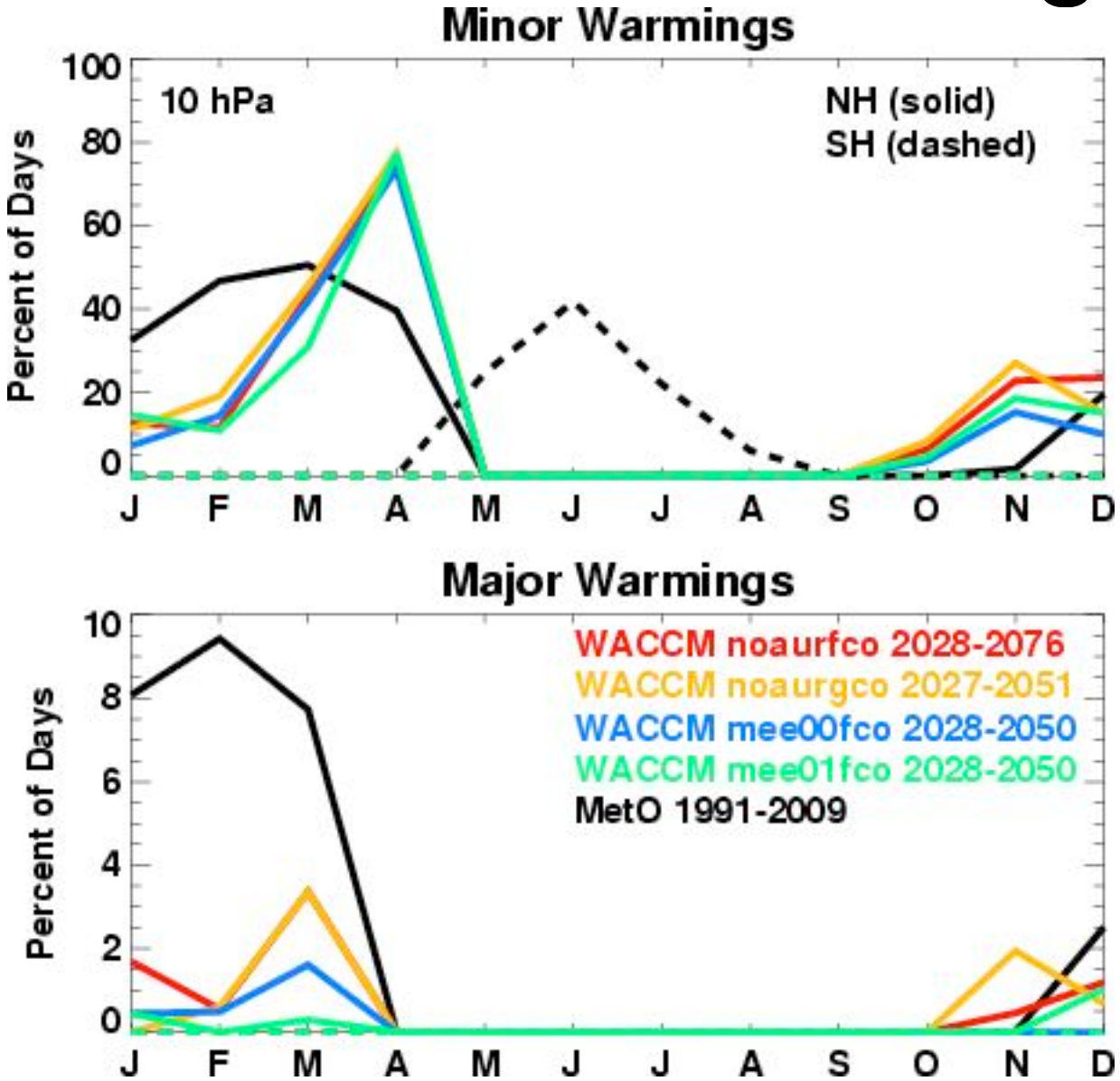


Average changes over the last 20 Septembers of 25-year runs are shown. Non-shaded regions are statistically significant to >2σ. Plots by X. Fang.



Average changes in September. Non-shaded regions are significant to >2σ. Plots by X. Fang

10 hPa Strat Warming Diagnostics

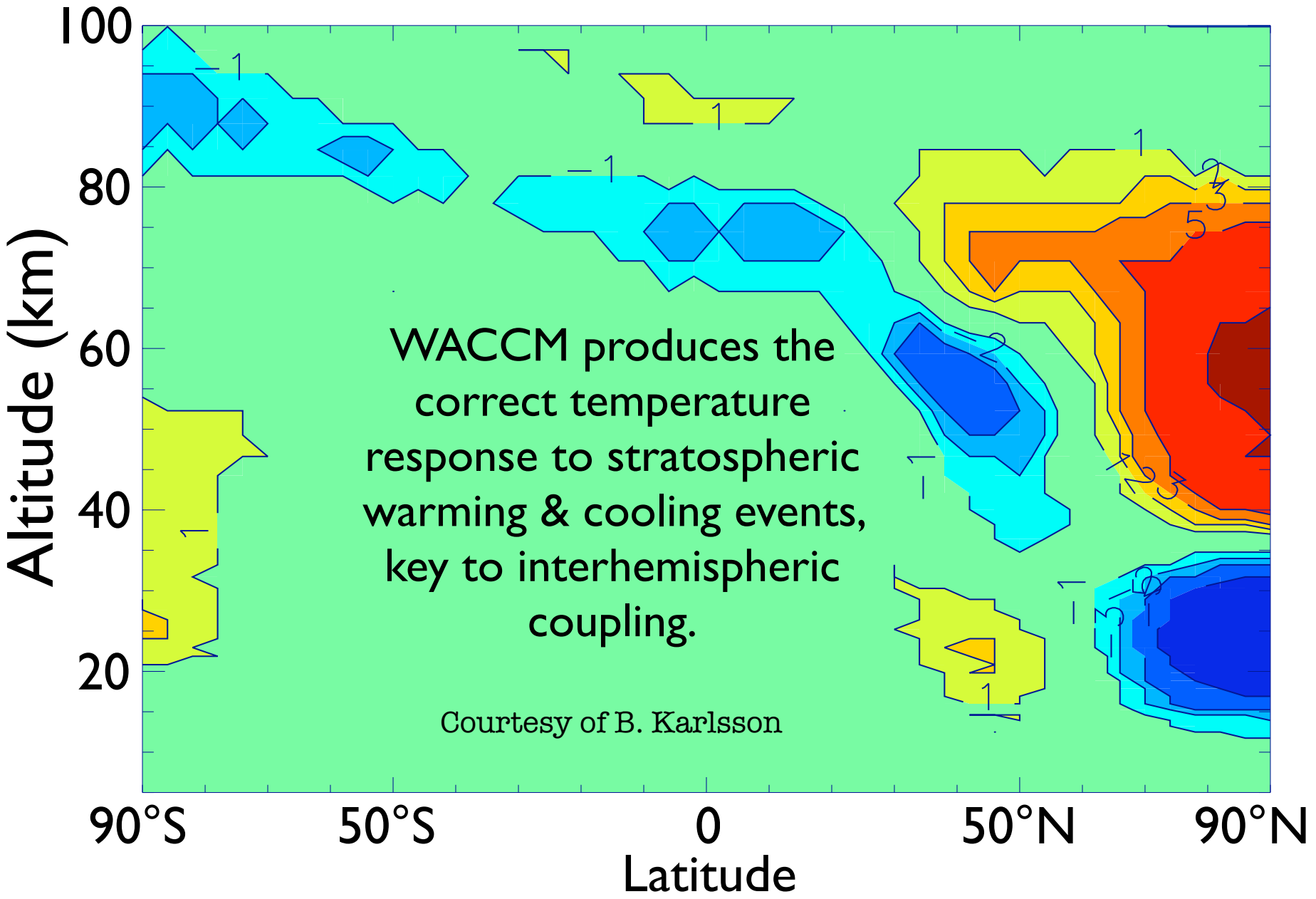


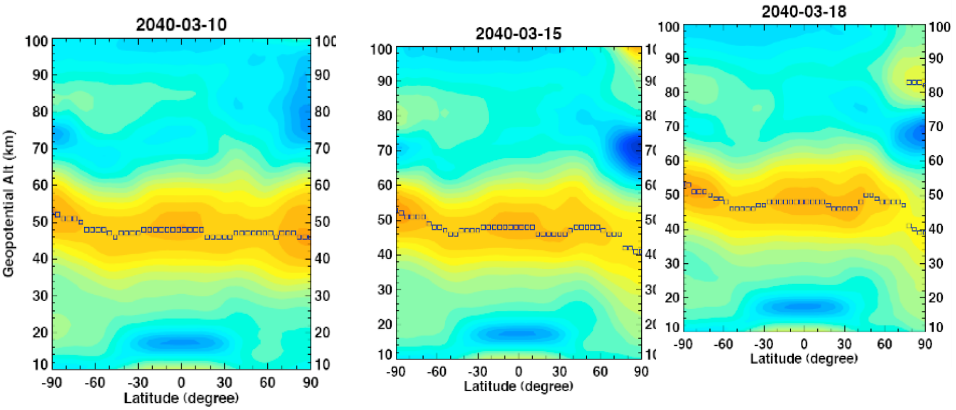
WACCM simulates fewer major and minor warmings than the analyses, except in April (final warming), and in October/ November (new result).

No variation between runs seen in May-September.

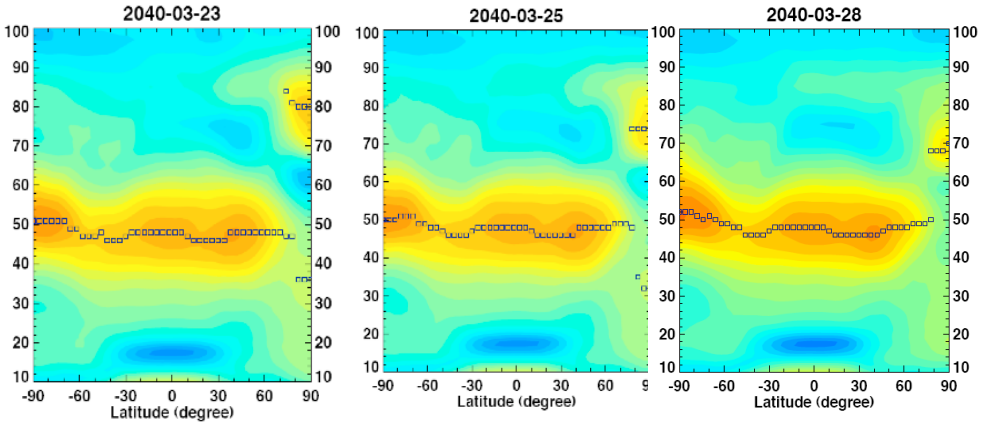
Courtesy of L. Harvey

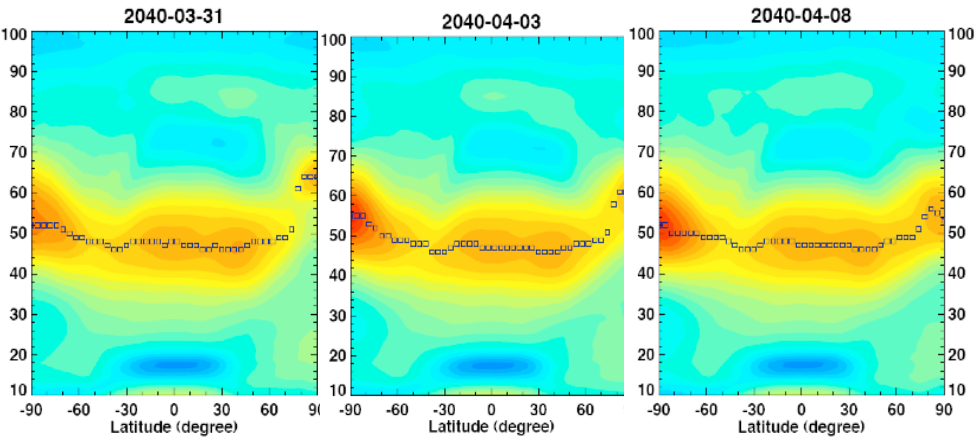
Temperature anomaly (K) for intra-seasonal strat cooling events

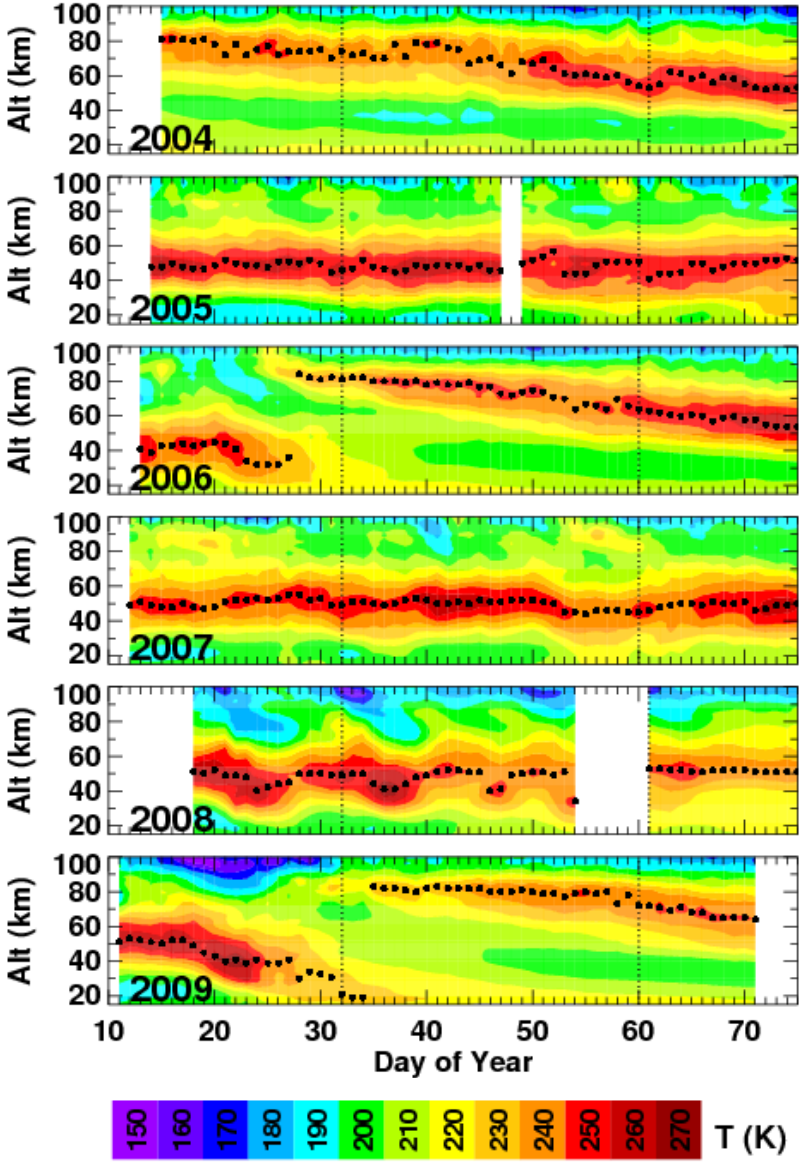




Courtesy of J. France







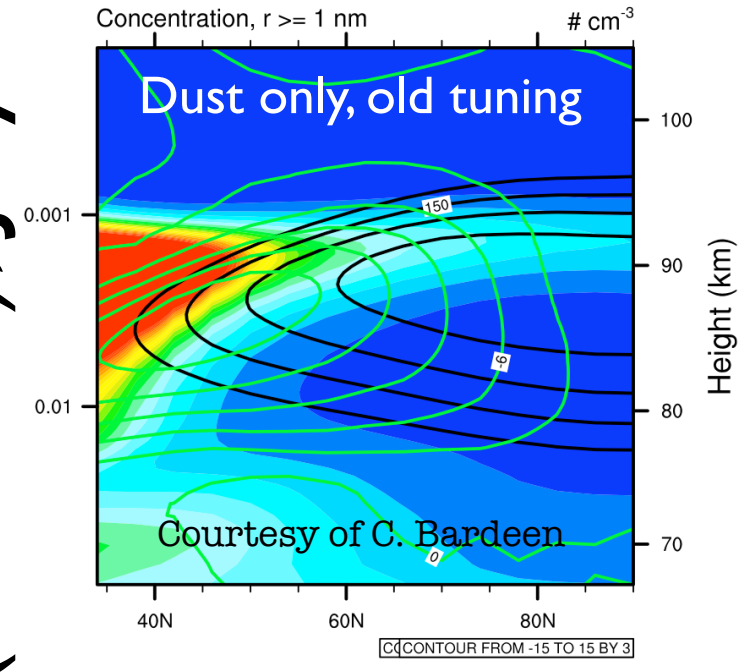
SABER zonal average temperatures from 75-80ºN from 10 Jan through 15 Mar in the years given in each panel. Vertical dotted lines denote 1 Feb and 1 Mar. Black dots denote the stratopause, defined as the maximum temperature from 15-100 km. White regions indicate missing data.

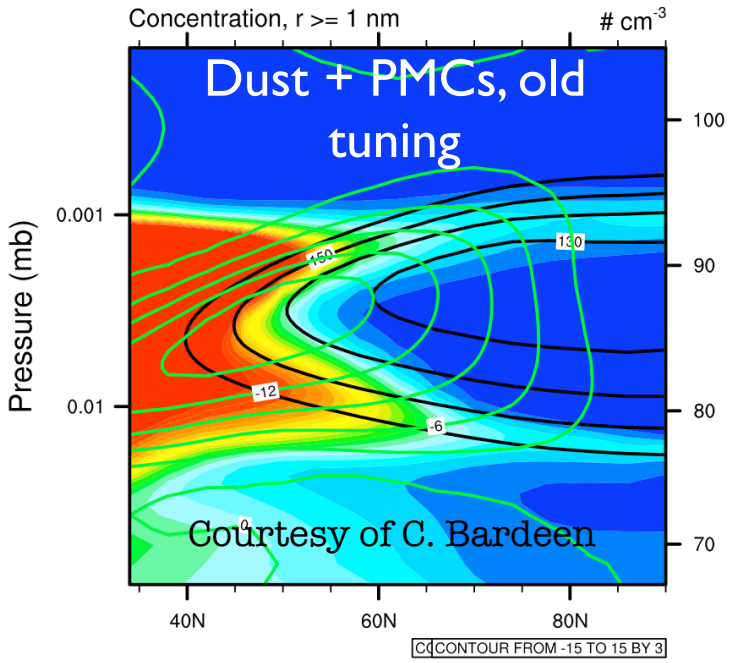
Courtesy of C. Randall

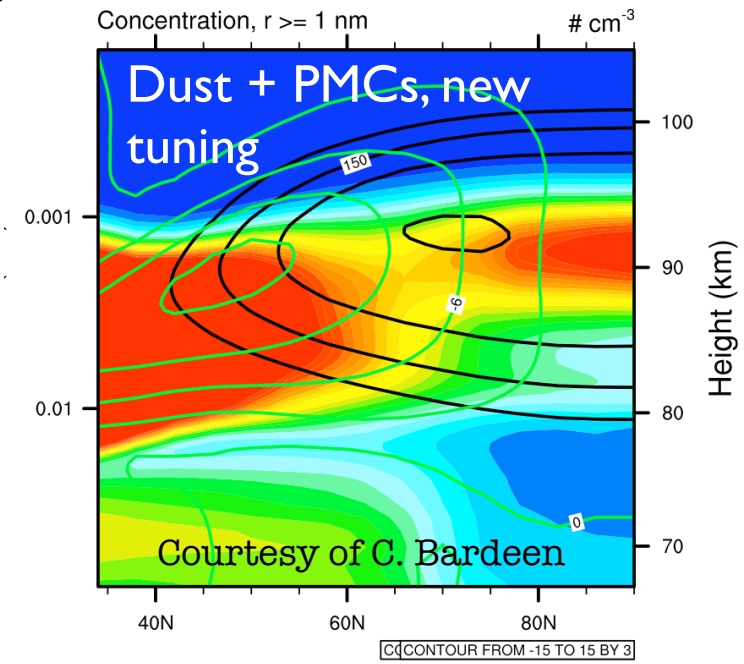
Sulfate aerosol in WACCM/CARMA

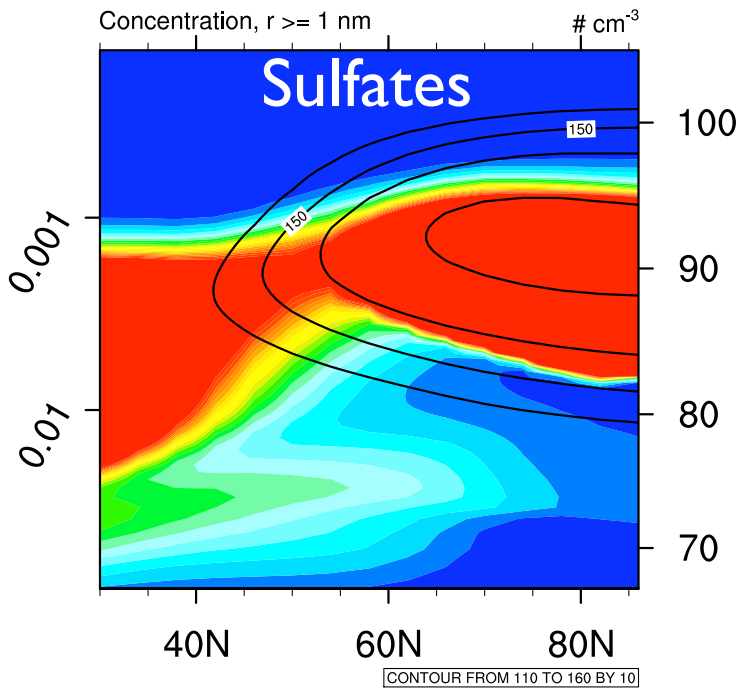
Mesospheric sulfate as PMC nuclei
Stratospheric background aerosol

PMC nuclei (r>1 nm), July

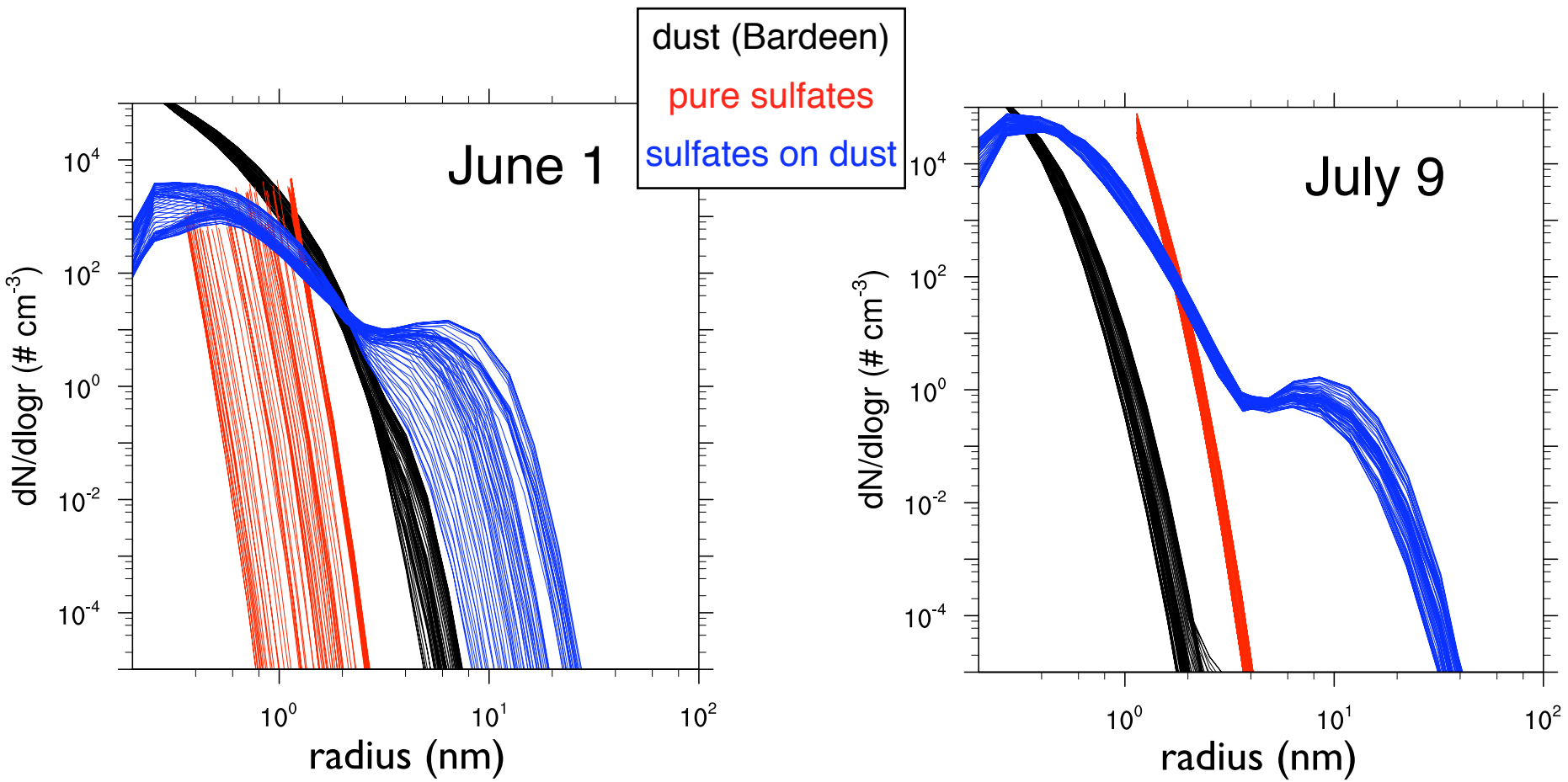








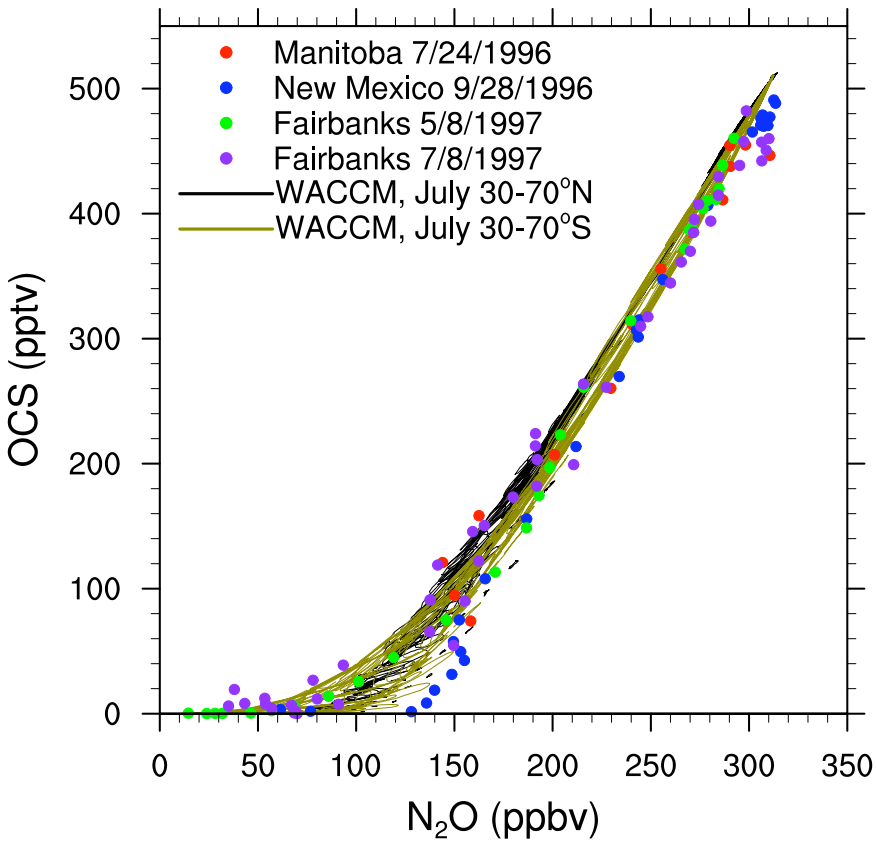
Size Distributions, 78°N, 86.5 km



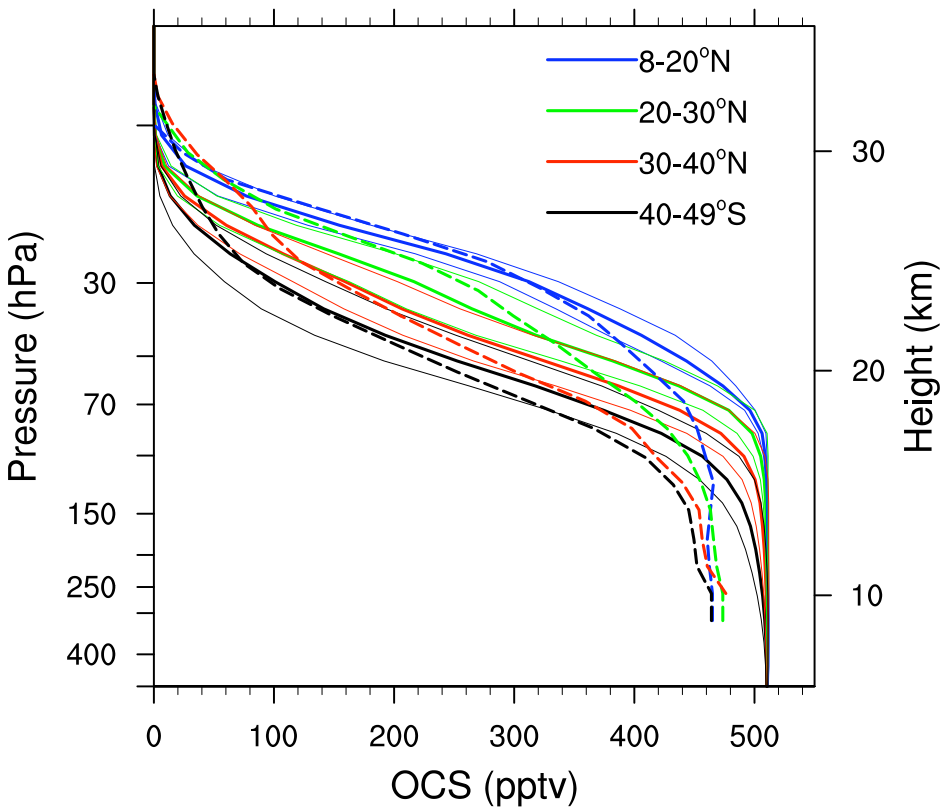
Dust particles are swept away from the pole during the nucleation season, while sulfates grow.

Carbonyl Sulfide (OCS)

WACCM vs. MkIV balloon data (G. Toon)



WACCM (solid) vs. SPARC report (dashed)



SO_2

2D Model

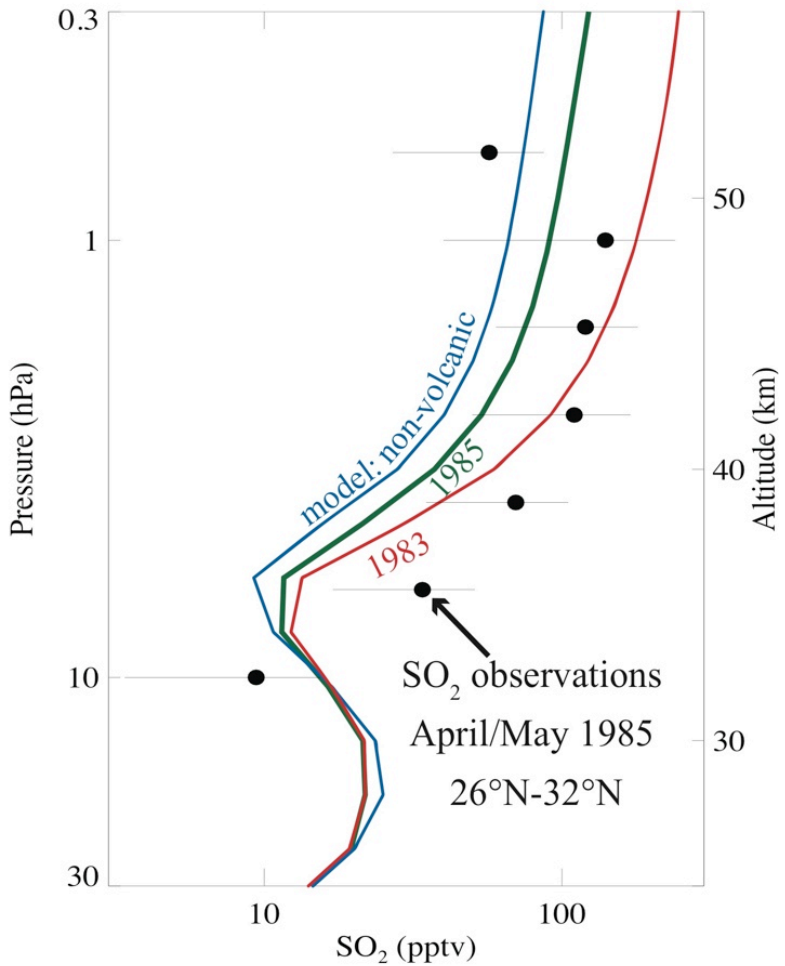
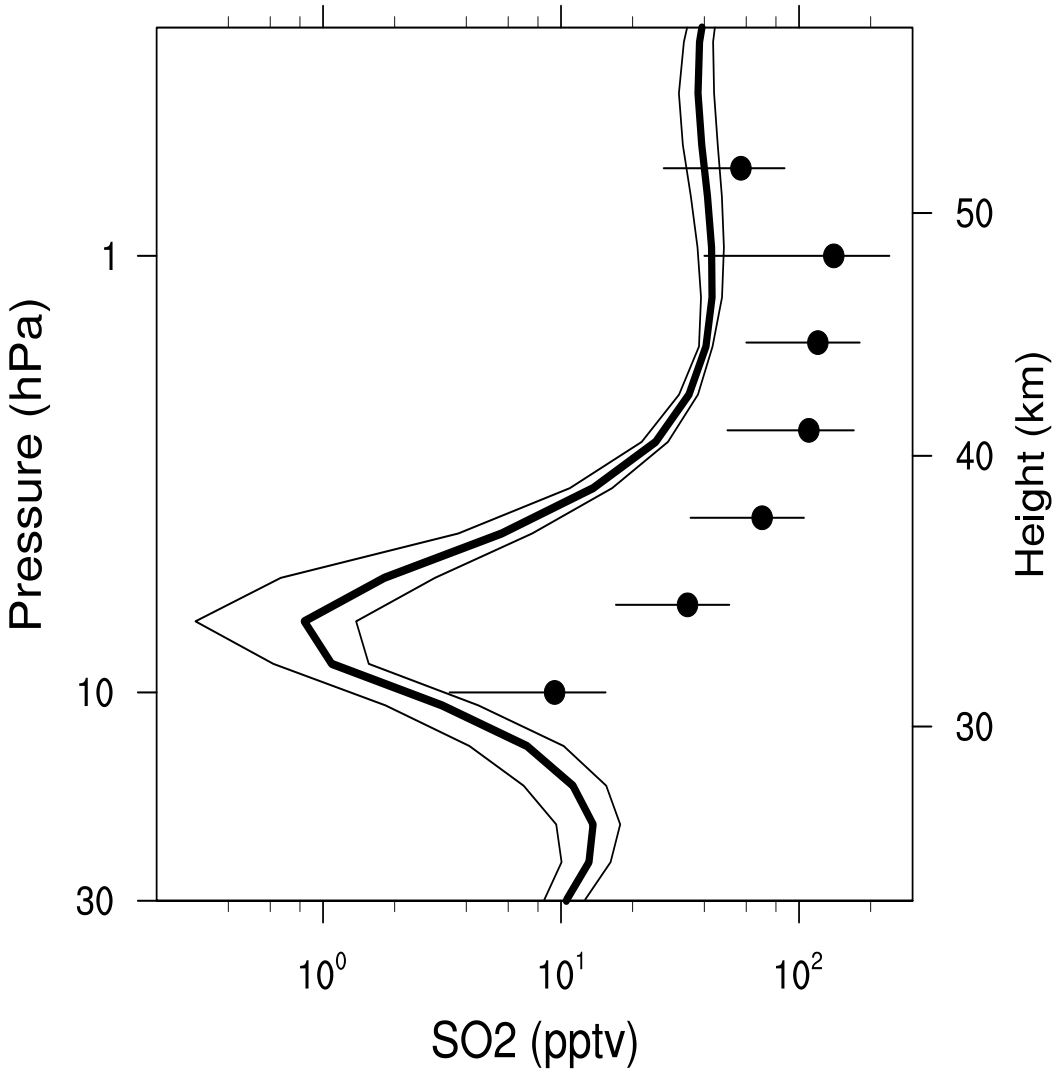
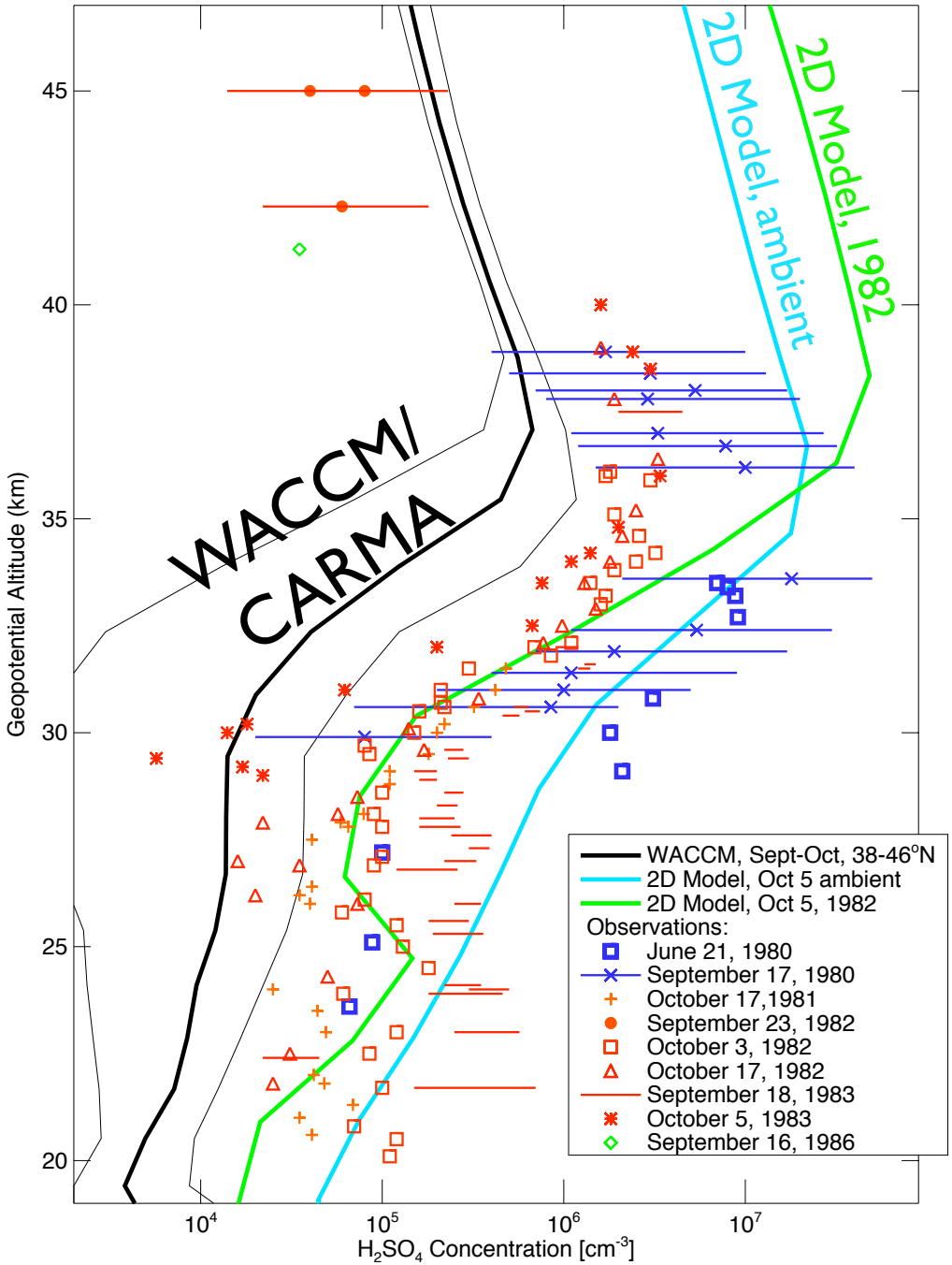


Figure 3 from Mills *et al.* [2005b]

WACCM, mesospheric tuning

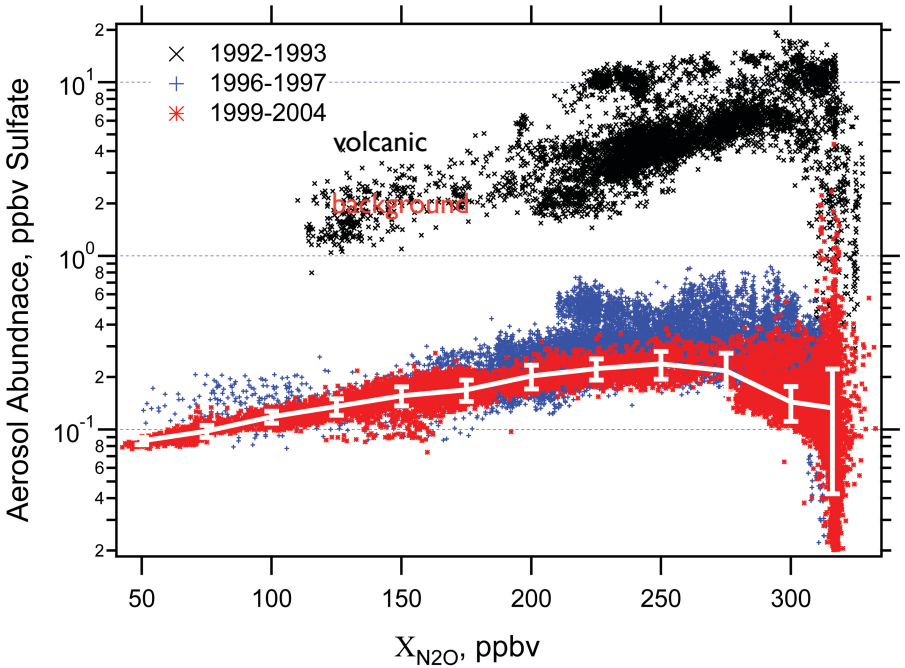




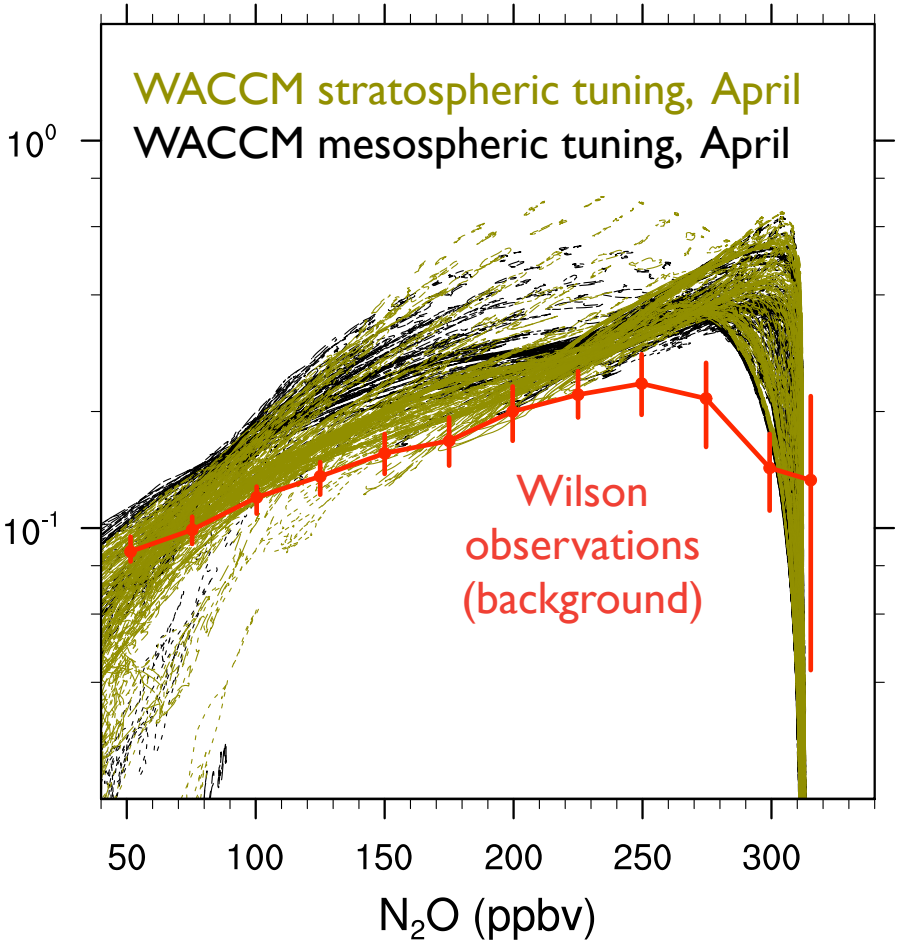
H_2SO_4 concentration

Too much sulfate in lower stratosphere drawing down H_2SO_4 vapor?

Sulfate vs. N_2O



Wilson et al. (ACP, 2008)
aircraft observations



Tropospheric SO_2: 150-300 pptv in WACCM
Observations: 10-150 pptv

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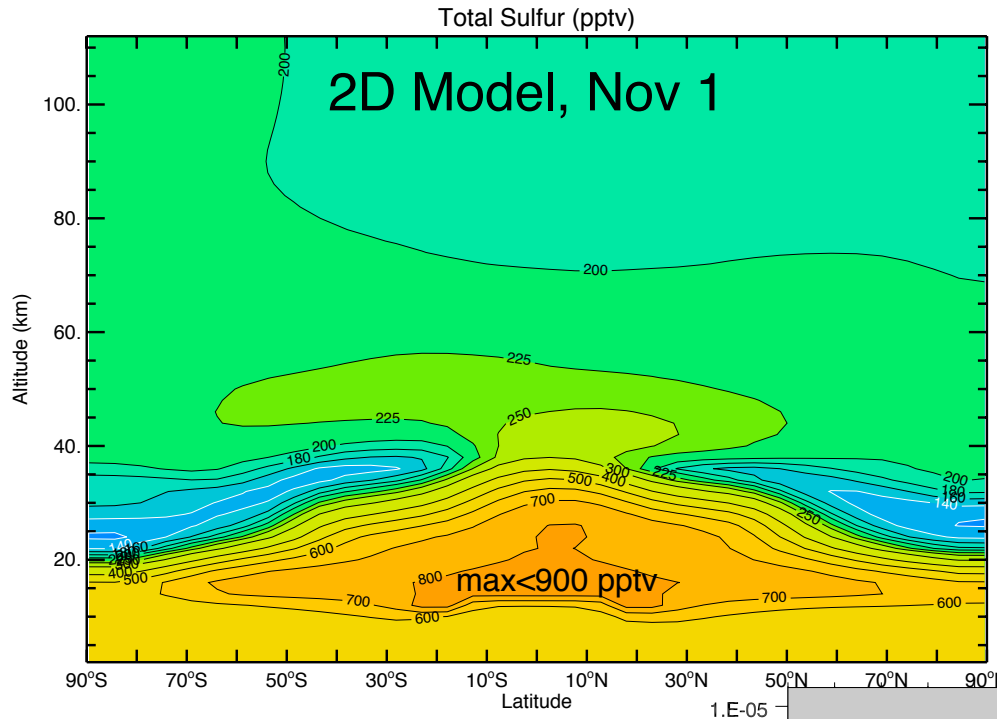
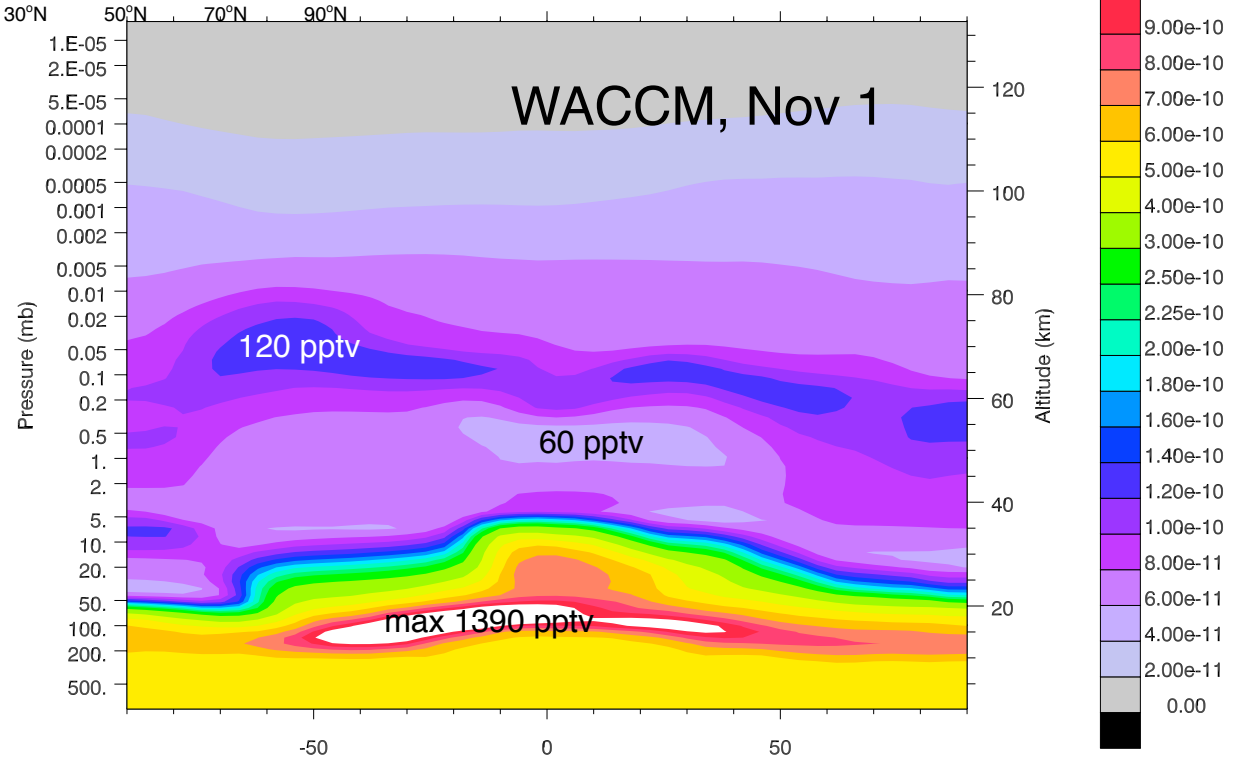
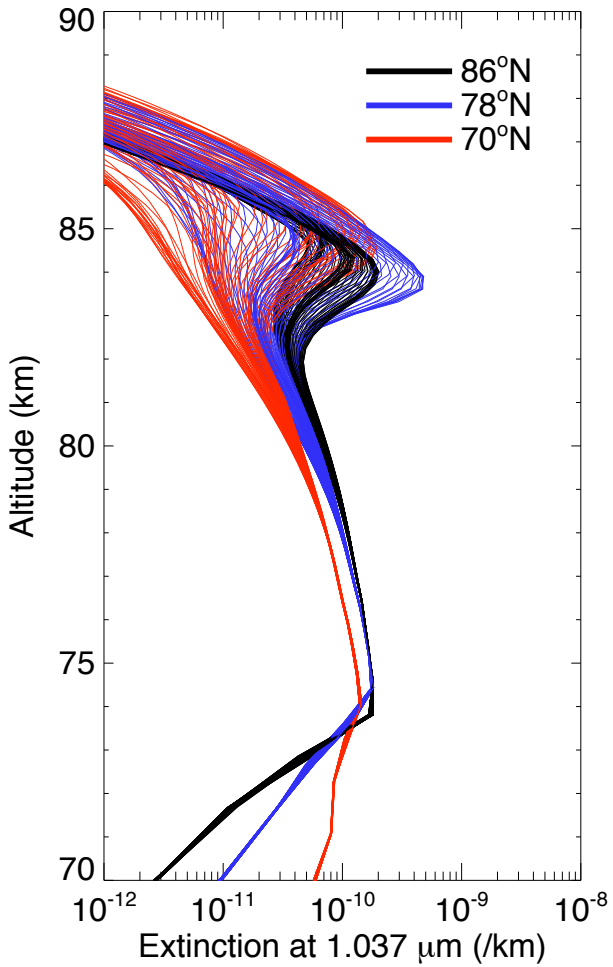
Total Sulfur (pptv)

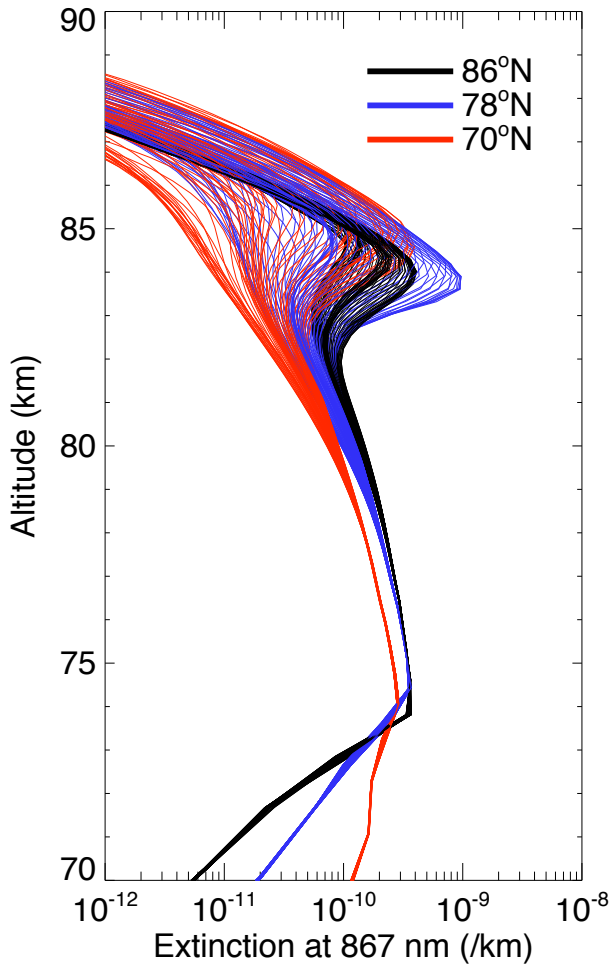


Is too much aerosol in lower stratosphere causing too much sedimentation?



Sulfate Extinction





Extinctions calculated for dust (assumed $Mg_{0.4}Fe_{0.6}SiO_3$) coated with sulfates fall below the SOFIE detection threshold (10^{-8} km^{-1}) at SOFIE wavelengths.

H_2SO_4 equilibrium mixing ratio