WACCM Studies at CU-Boulder

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NCAR

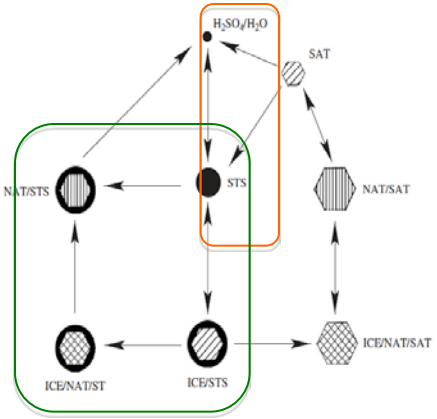
Most Topics are Ph.D. Theses

- Toon
  - Aerosols in WACCM/CARMA
  - Polar Stratospheric Clouds
  - Paleoclimate Studies
- Harvey
  - Mesospheric Transport
  - Stratopause and Mesopause Climatologies and Mesospheric Inversion Layers
  - Cold Air Outbreaks
- Randall
  - Energetic Particle Precipitation
  - Vertical Coupling via NO_x Transport
  - Polar Mesospheric Clouds
  - Arctic Ozone Loss

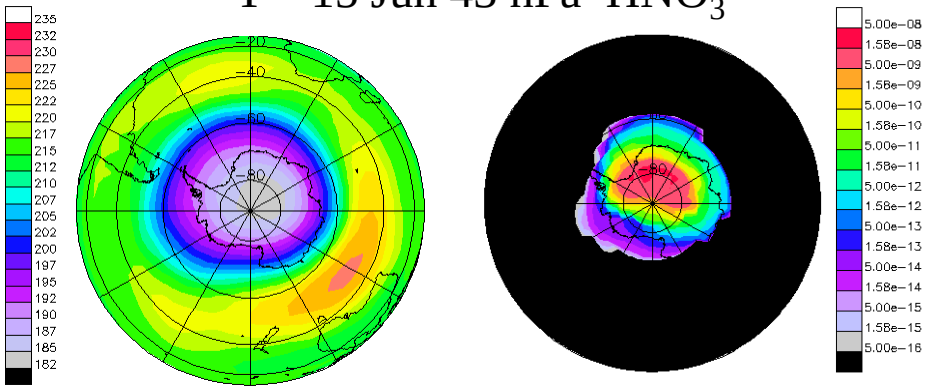
Polar Stratospheric Clouds

Thesis Work of Yunqian Zhu; Advisor: Dr. Brian Toon

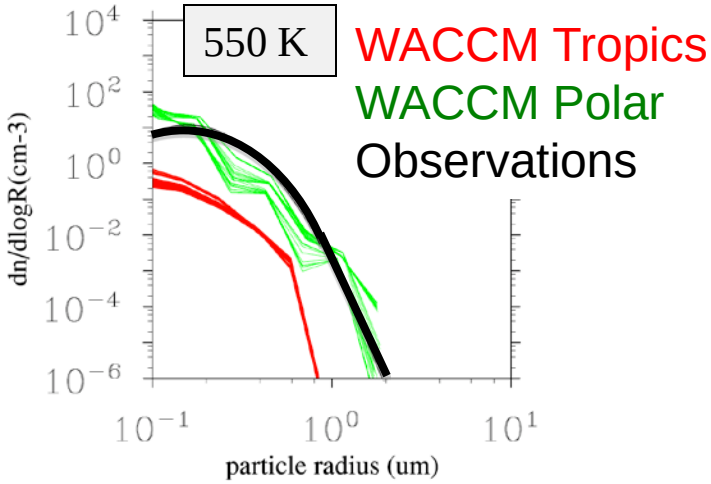
(1) Build STS-PSC microphysics model and conduct initial testing.
(2) Add nucleation/freezing processes into the model (i.e. NAT and ice particles).
(3) Comparison with MOZART parameterization results; CALIPSO data.



T 15 Jun 43 hPa HNO_3



The magnitude of condensed HNO_3 is ~10 ppbv. The area covered by PSCs is where it is cold.



WACCM polar particle size distribution agrees with obs.

A deep Paleoclimate GCM starting from WACCM/CARMA

Thesis Work of Eric Wolf; Advisor: Dr. Brian Toon

CARMA Microphysics:

fractal hydrocarbon haze particles

(Wolf & Toon, 2010)

Radiative Transfer:

new corrrelated-K distribution RT with H_2O, CO_2, CH_4, NH_3

(validation in progress)

Deep Paleo GCM

Clouds:

Include haze particles as CCN

(to be completed in 2011)

Chemistry:

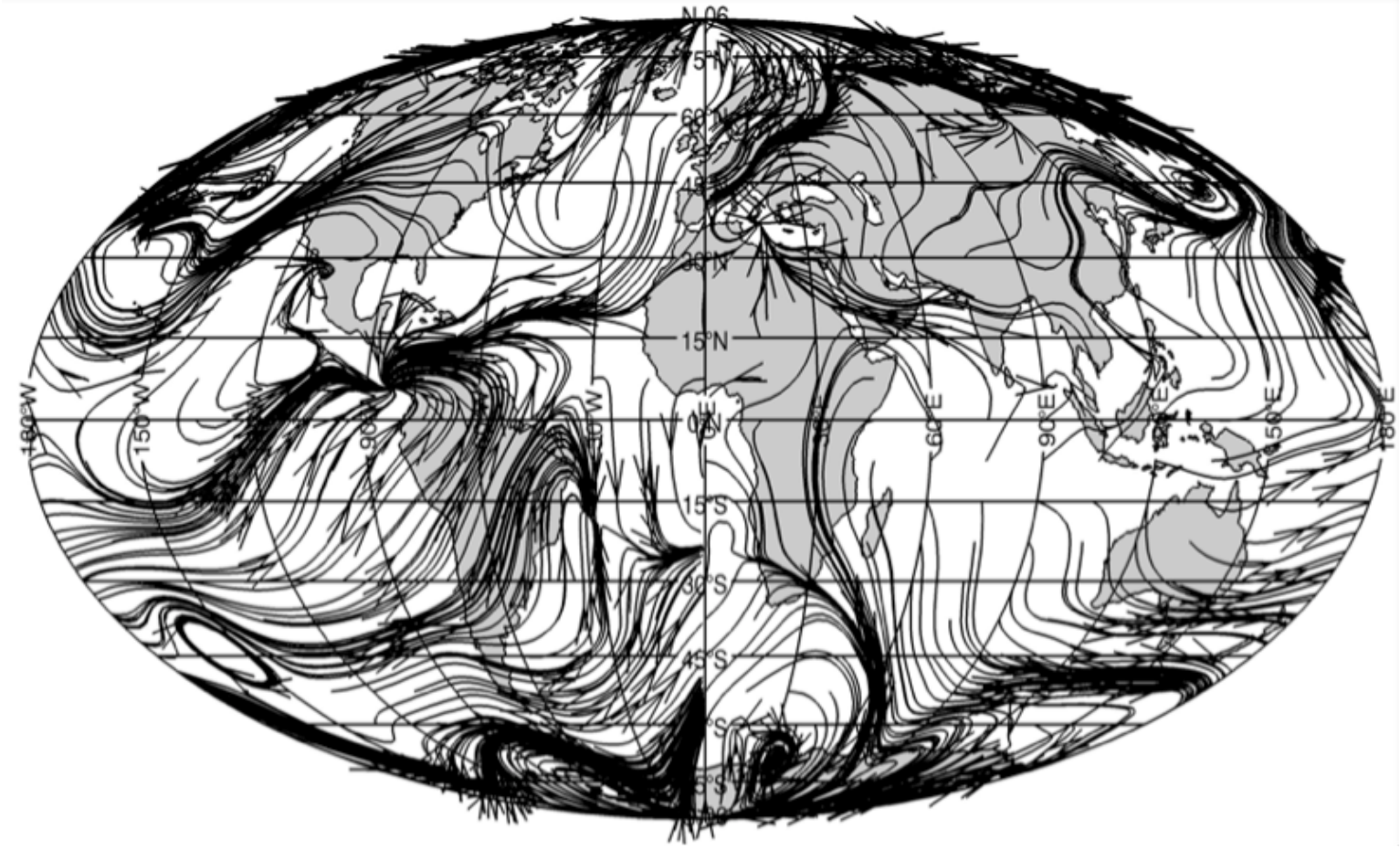
Incorporate chemistry for a reducing atmosphere

(to be completed in 2012)

Adapt WACCM/CARMA into a deep paleoclimate GCM and investigate the faint young Sun problem. The Sun 3B years ago was only ~80% as luminous as today, yet we have geologic evidence for a warm planet. WACCM will include cloud and ice feedbacks that are critical to climate.

Mesospheric Transport

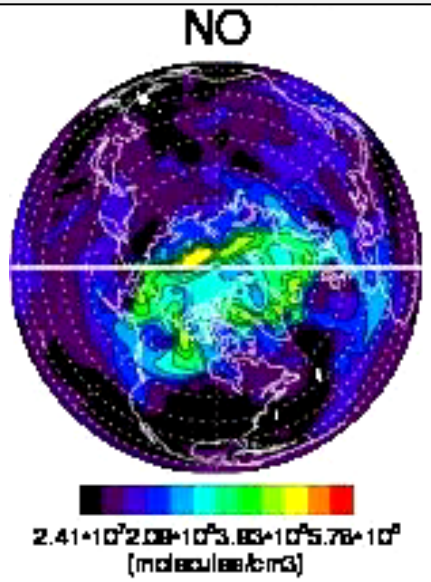
V. Lynn Harvey

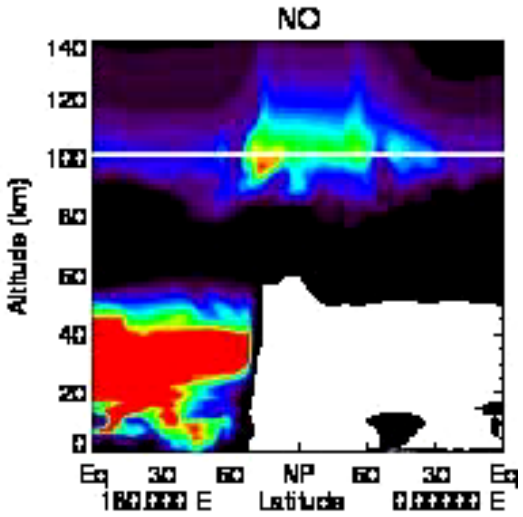


Streamlines on 1 January at 90 km. Daily horizontal flow field is complex, zonally asymmetric, and highly variable in space and time

1-day evolution of NO and latitude of origin

NO



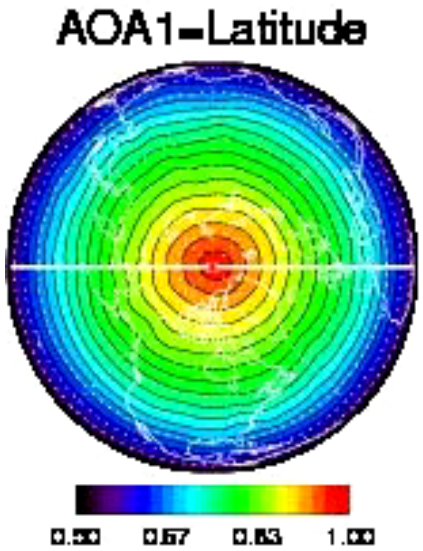


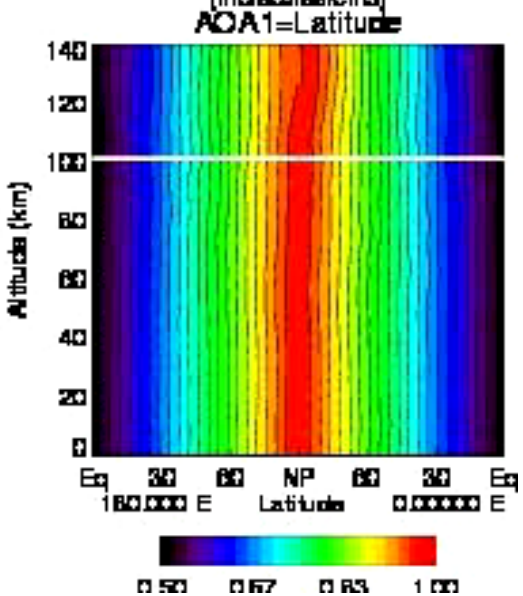
30-minute timestep
1 Jan, 100 km

0.0 hours

Cross-polar curtains
along DL and GM

Latitude

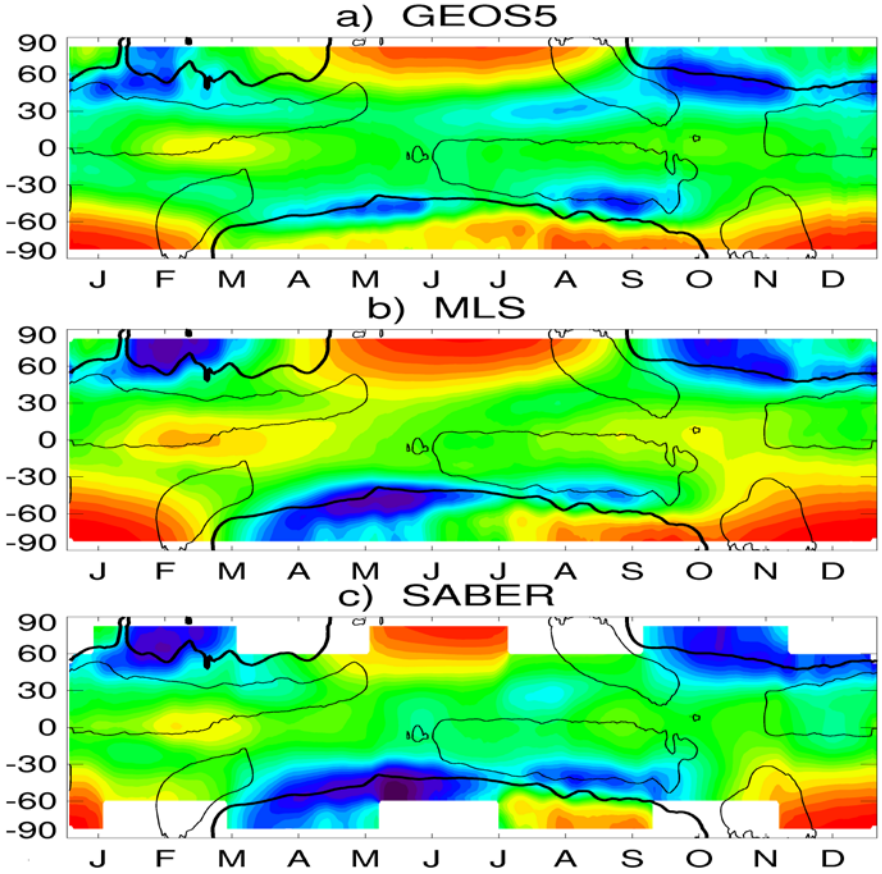




Stratopause, Mesopause, and MILs

Thesis Work of Jeff France; Advisor: Dr. V. Lynn Harvey

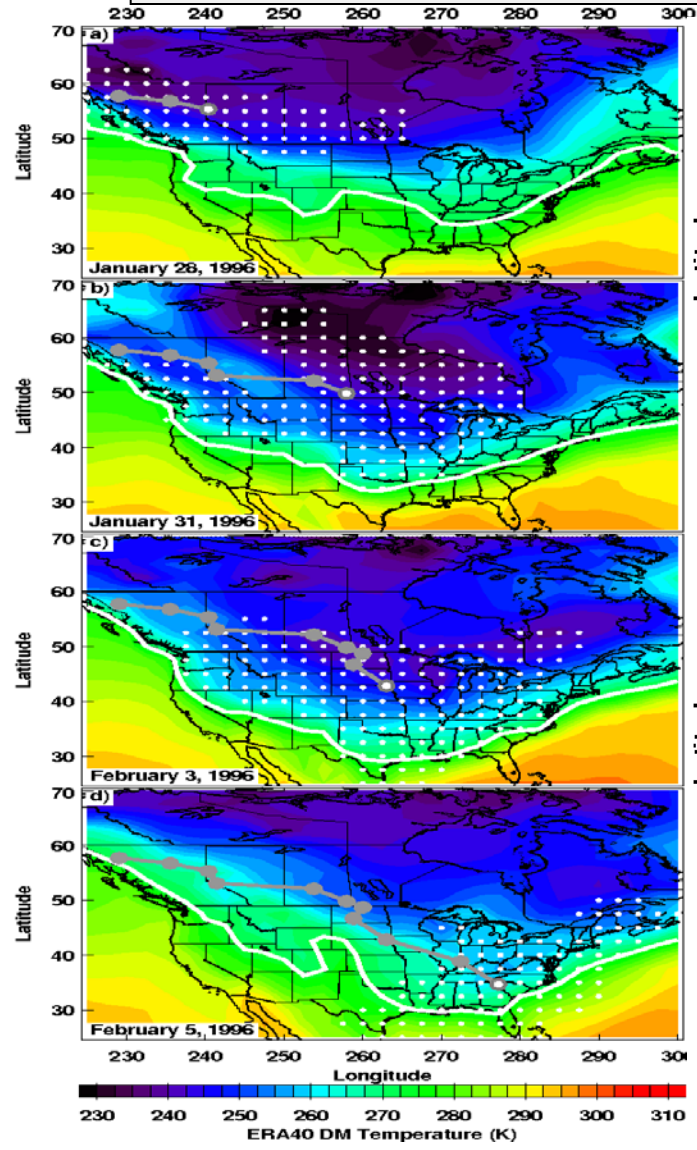
Stratopause Temperature

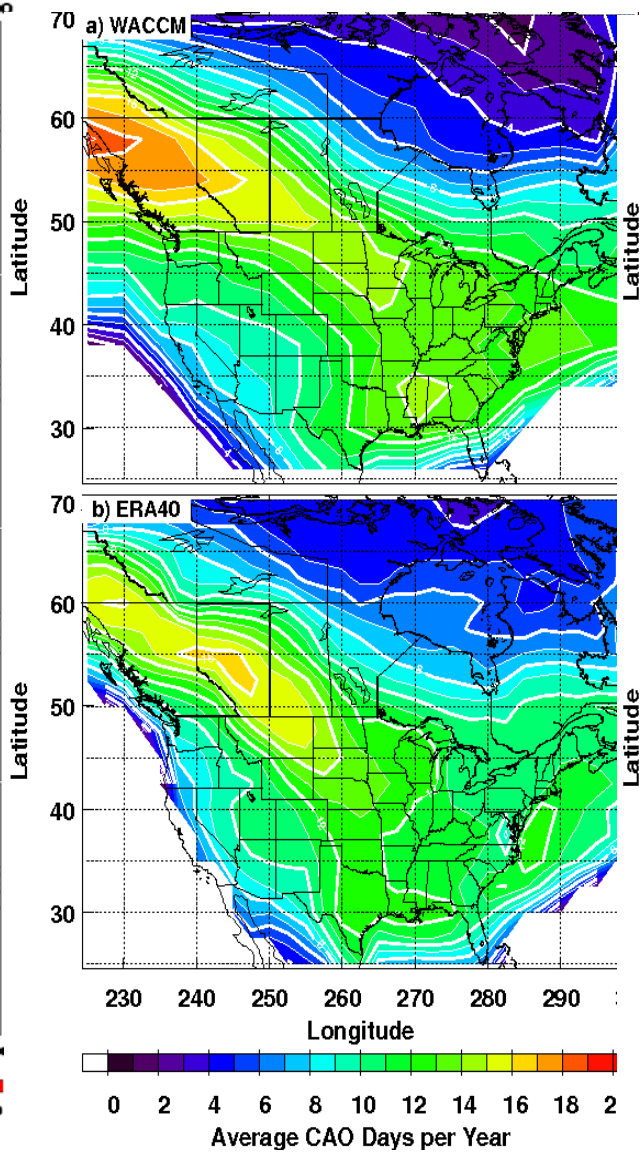


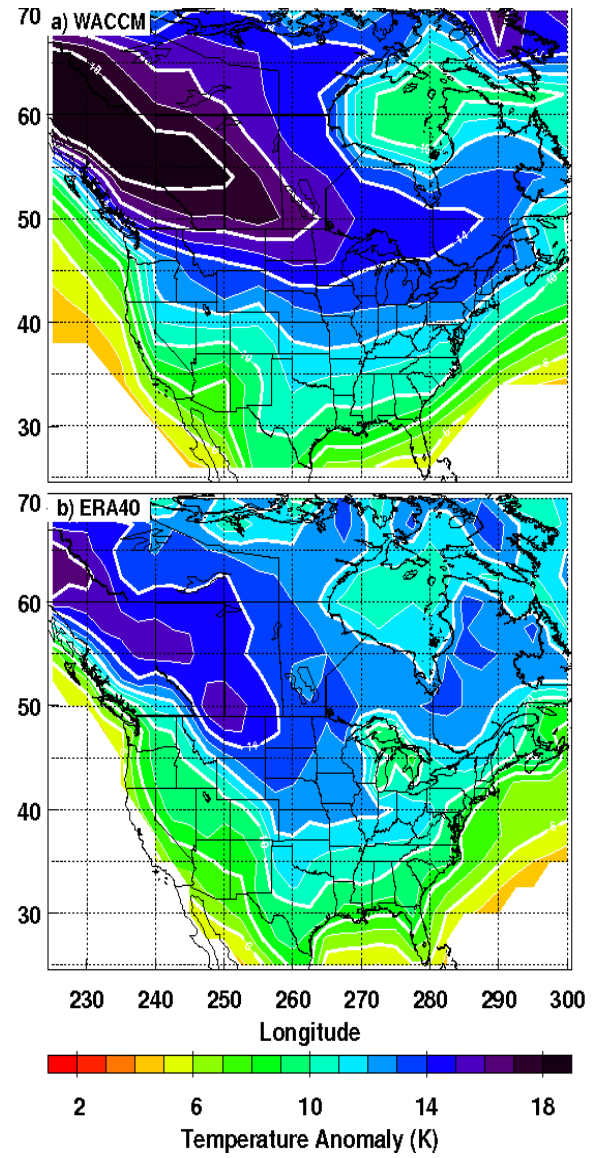
1) Compare WACCM stratopause and mesopause height an temperature to observations.
2) Document WACCM Mesospheric Inversion Layers (MILs).
3) Explore the effects of planetary and gravity waves on the formation and geographical distribution of MILs.

Cold Air Outbreaks

Thesis Work of Donavan Wheeler; Advisor: Dr. V. Lynn Harvey





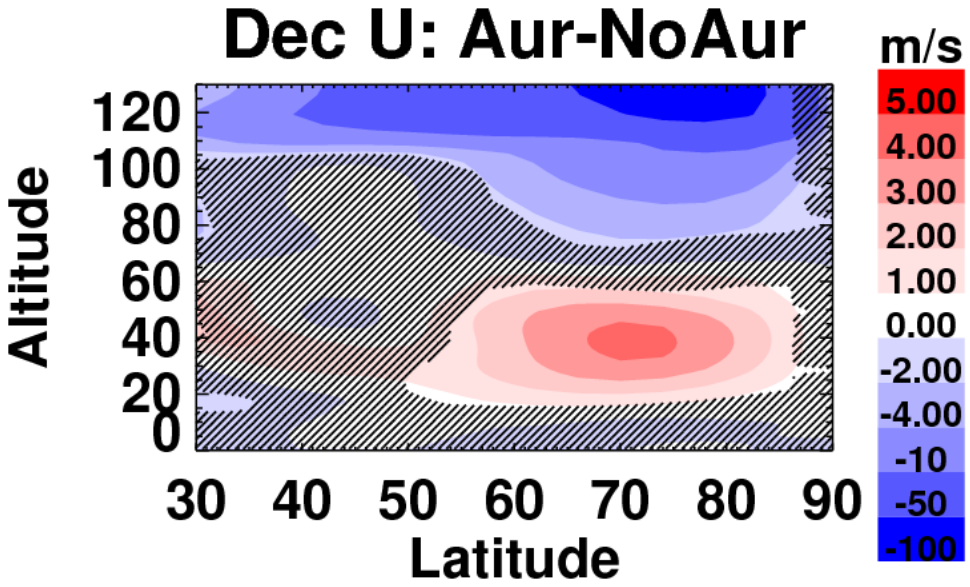


What is the effect of EPP on the stratosphere?

Cora Randall, Xiaohua Fang, Lynn Harvey, Laura Holt,
Charles Jackman, Mike Mills, Dan Marsh, Ethan Peck

Compare WACCM run with minimal EPP to run with moderately high auroral EPP

Run	F10.7	Kp (Ap)	# Years
No EPP (No Aur)	210	.667 (3)	87
Aurora	210	4 (27)	55



Most impressive result:
~15% increase in zonal mean zonal wind near 35-40 km in winter

Change NO_x->O_3->T->U

Vertical Coupling via NO_x Transport

Thesis Work of Laura Holt; Advisor: Dr. Cora Randall

- Explore the accuracy of WACCM stratospheric, mesospheric, and thermospheric meteorology.

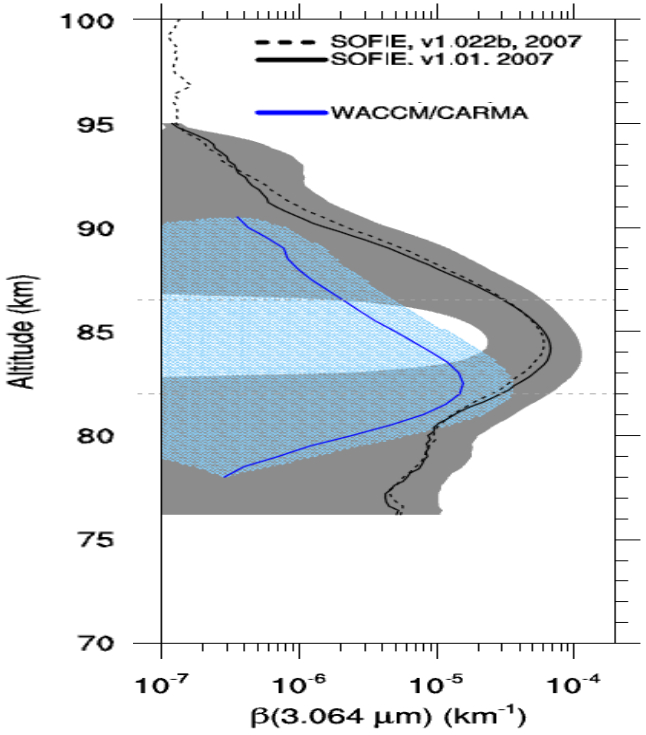
- Adjust tunable GW source function parameter to optimize both the stratopause and the mesopause.

- Quantify the interannual variability in the transport of EPP-NO_x to the stratosphere by analyzing SMLT meteorology in an ensemble of ~50 year WACCM simulations.

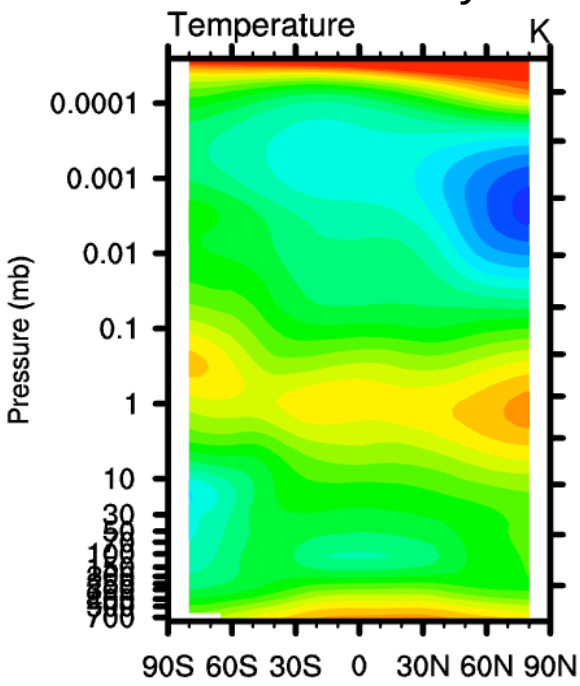
Polar Mesospheric Clouds

Thesis Work of Susanne Benze; Advisor: Dr. Cora Randall

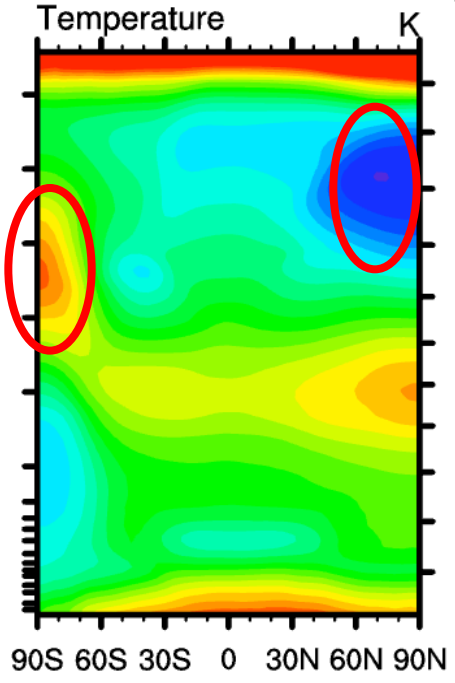
SH PMC extinction



CIRA86 July



WACCM/CARMA July



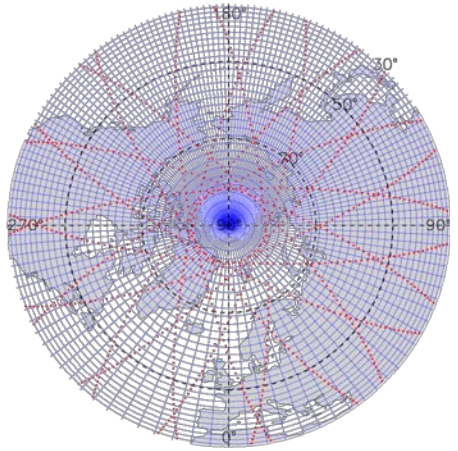
Build on work of Bardeen et al. [2010] by tuning the gravity wave parameterization to optimize both the polar summer mesopause and the polar winter stratopause temperature in multi-year WACCM simulations.

Arctic Ozone Loss

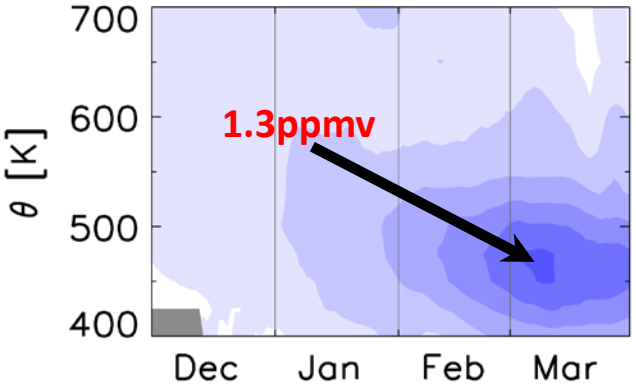
Thesis Work of Matthias Brakebusch; Advisor: Dr. Cora Randall

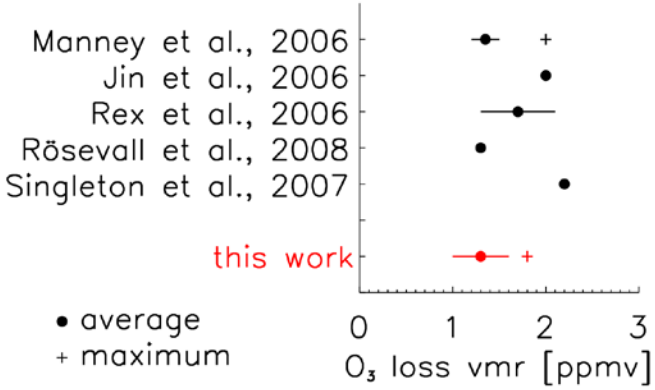
Initialize SD-WACCM with MLS O_3, N_2O, H_2O, HNO_3, and HCl.

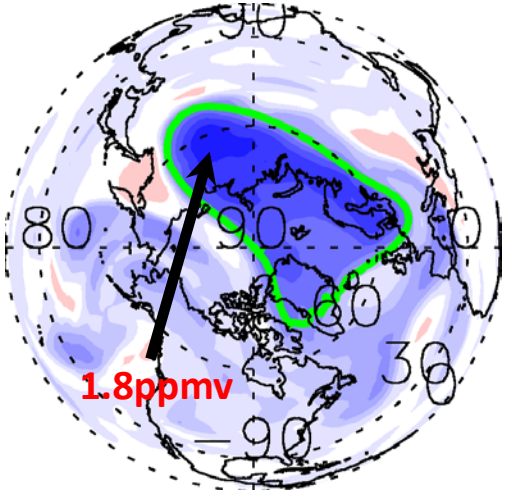
Use Passive Subtraction method to calculate vortex averaged ozone loss.



SD-WACCM ppO_3 – MLS O_3



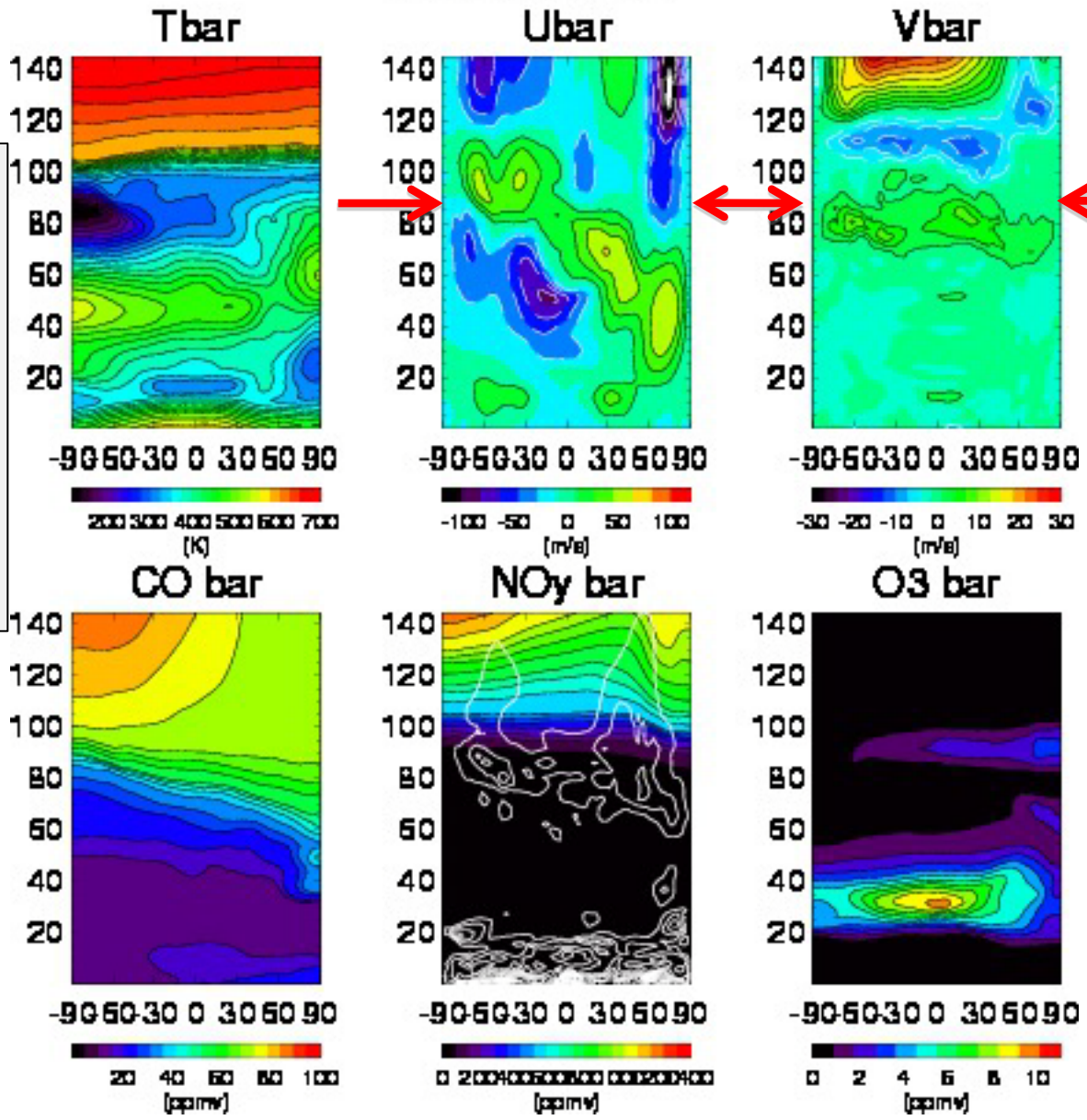




Thank You

1 Jan
Remainder of talk

WACCM Daily Zonal Means



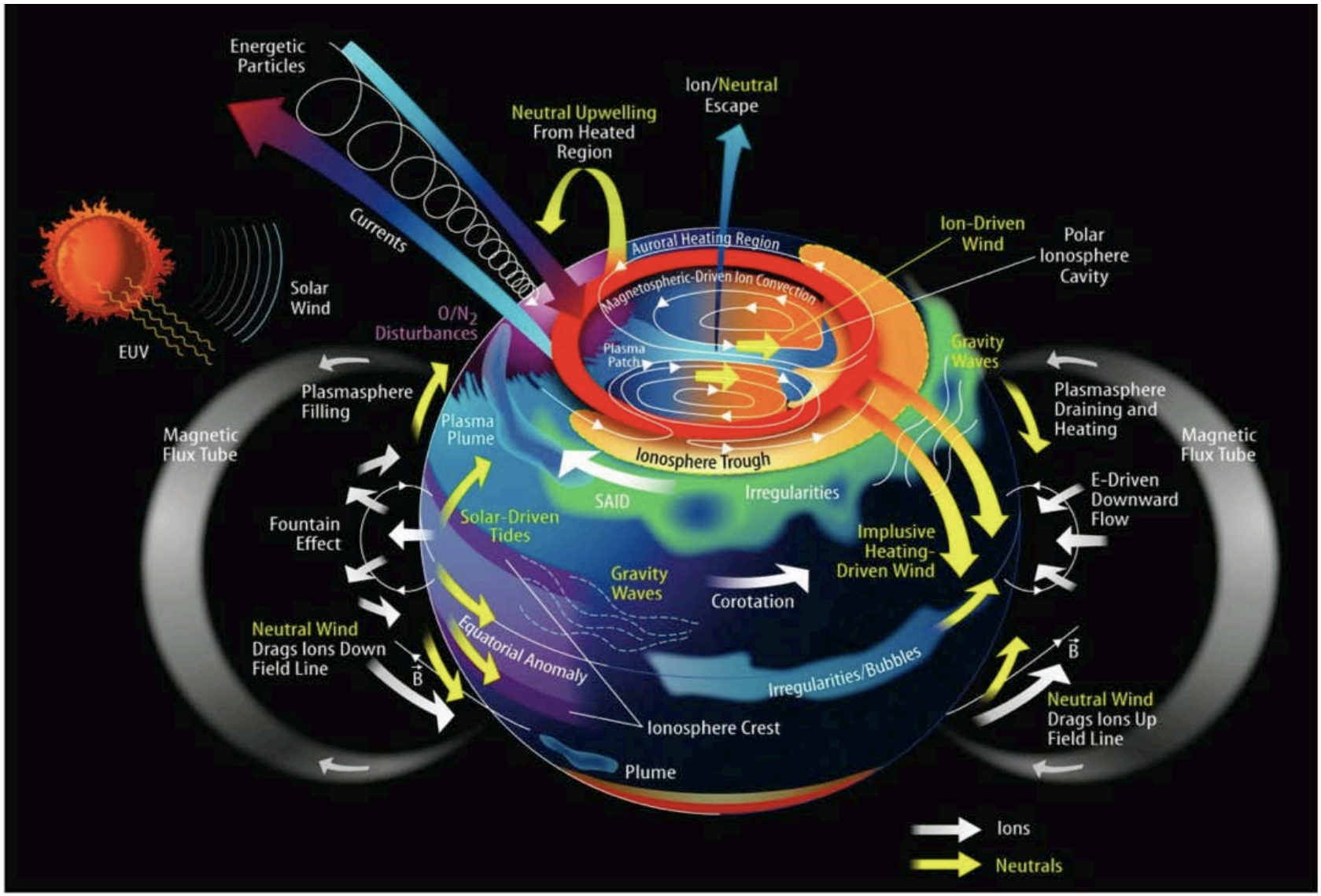
90 km

- Elevated polar winter stratopause
- Cold polar summer mesopause
- Arctic vortex 20-70 km
- Northward flow 70-90 km

- Descent of CO
- NOy
- O_3 primary, secondary, tertiary maxima

Next: Complexity

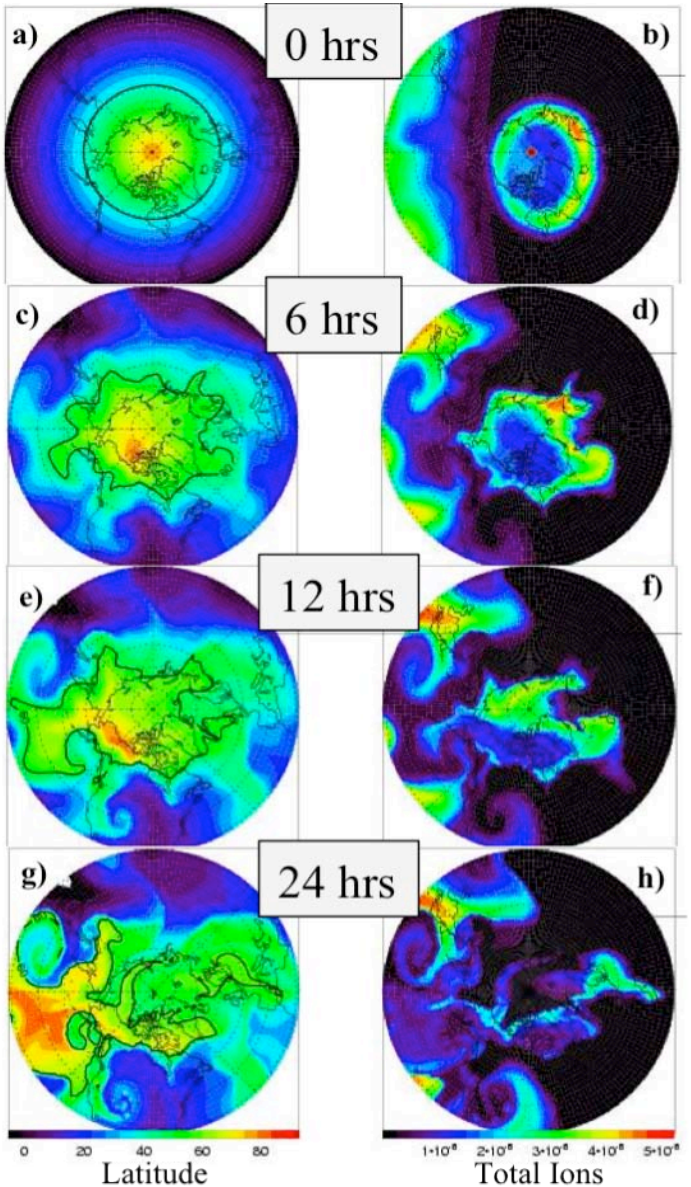
Ionosphere-Thermosphere Processes



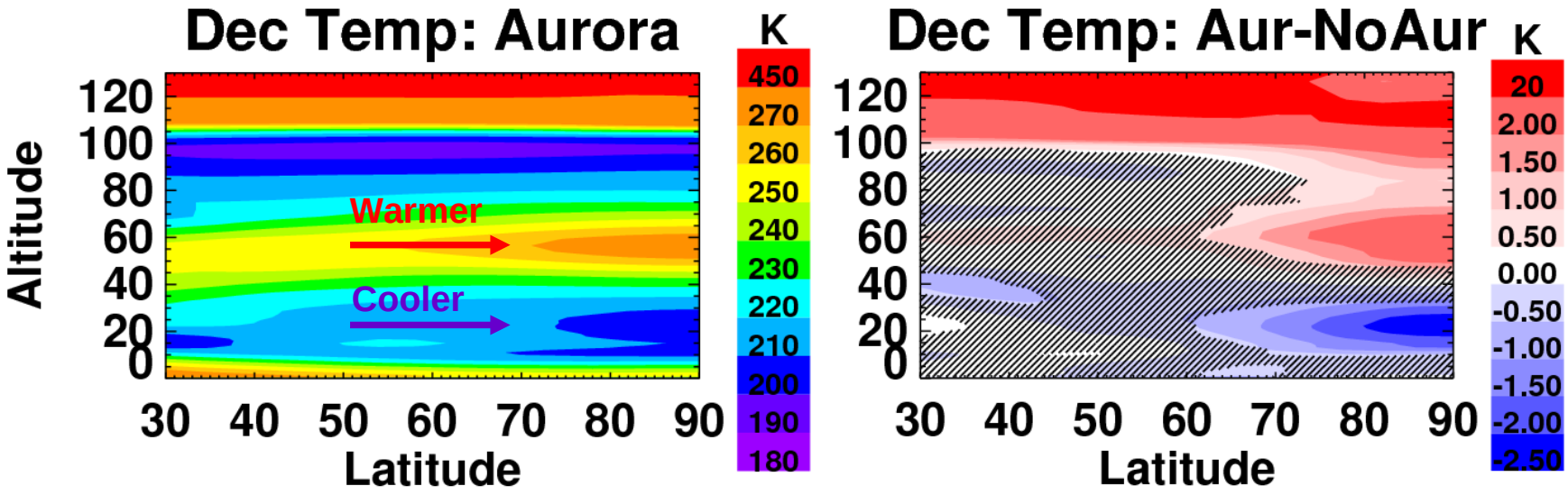
http://temoore.gsfc.nasa.gov/public/GSWG%20Site/152.html

1-day evolution of latitude of origin and the auroral oval

1 Jan at 100 km

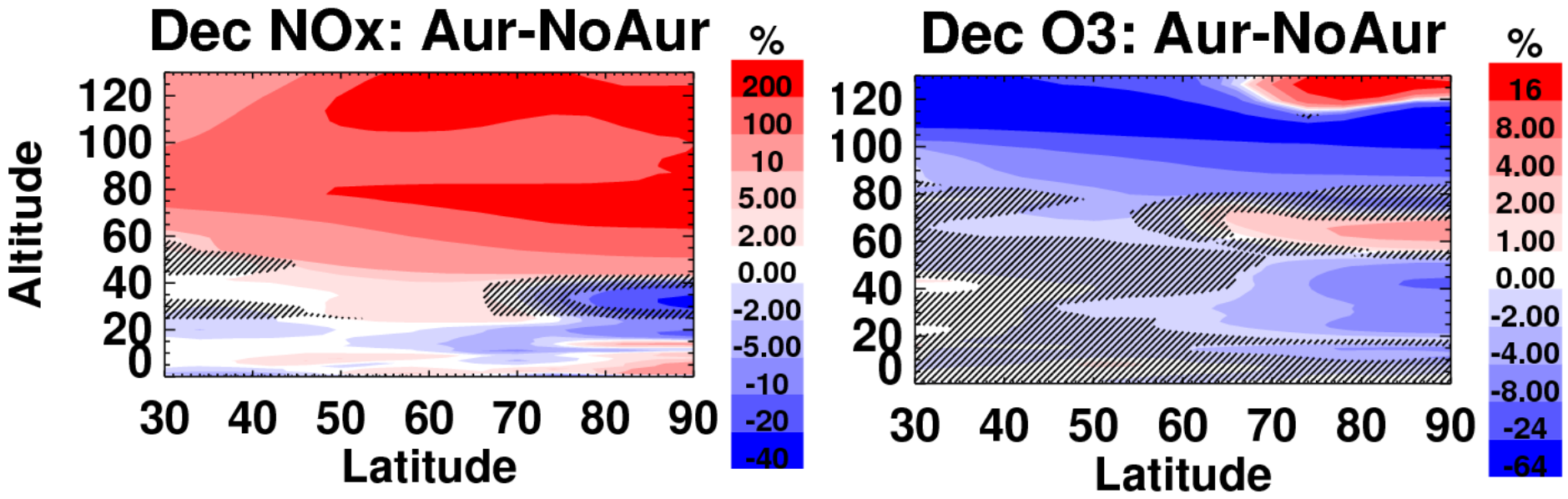


EPP-induced temperature changes are consistent with zonal mean zonal wind changes



- Warming of polar upper stratosphere and cooling of polar mid-lower stratosphere
- Consistent with stronger meridional temperature gradient and polar winter jet.

Are T & Wind effects caused by NO_x-induced O_3 depletion?



- Significant NO_x increases only down to ~40 km: Cannot explain most of the stratospheric O_3 loss.
- Picture appears to be more complicated than $NO_x \rightarrow O_3 \rightarrow T \rightarrow$ Wind
- If EPP-NO_x is the trigger, what is the mechanism?