Impacts of Solar Irradiance and Auroral EPP in WACCM

Presented by,
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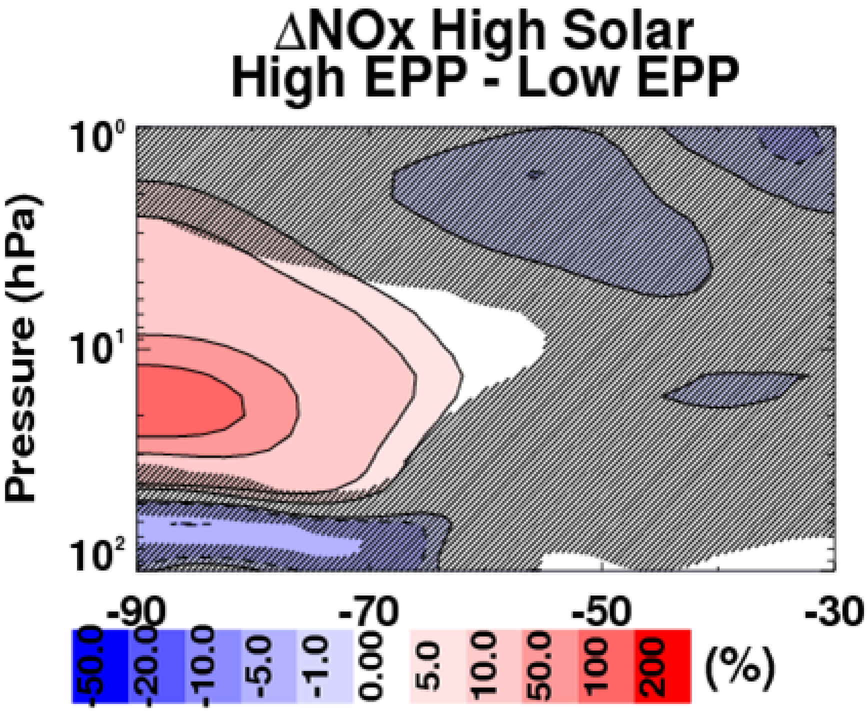
WACCM Simulations

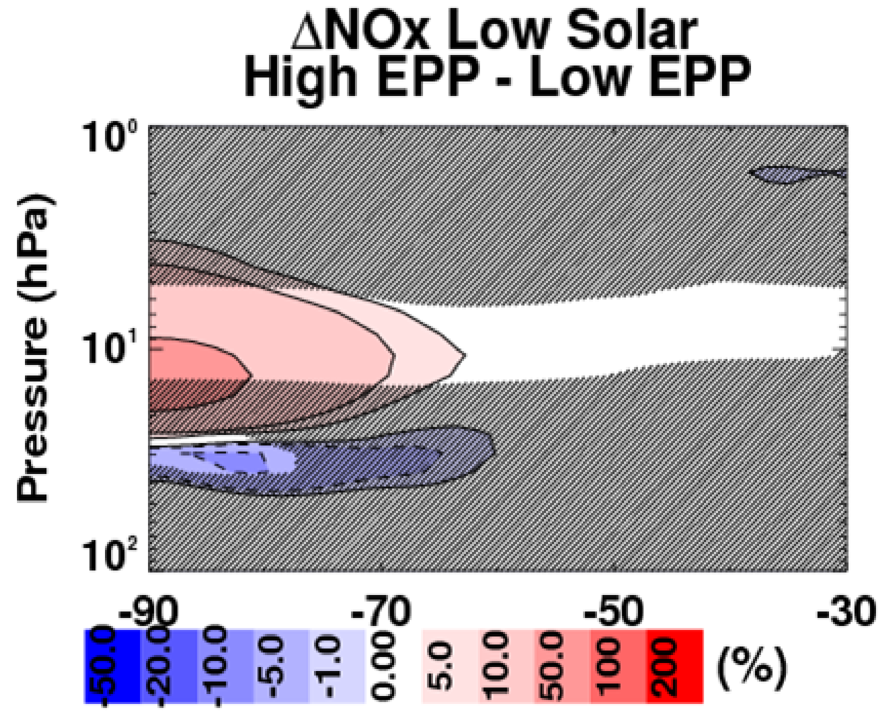
- CESM1.0.3
- FW Compset
- 1.9x2.5 degree horizontal resolution.

Name	Run Length (spinup)	Solar Flux f10.7	Ap Index	Auroral EPP
Low EPP Low Solar	42 years (2 years)	72	3	Low
High EPP Low Solar	42 years (2 years)	72	27	High
Low EPP High Solar	42 years (2 years)	210	3	Low
High EPP High Solar	42 years (2 years)	210	27	High

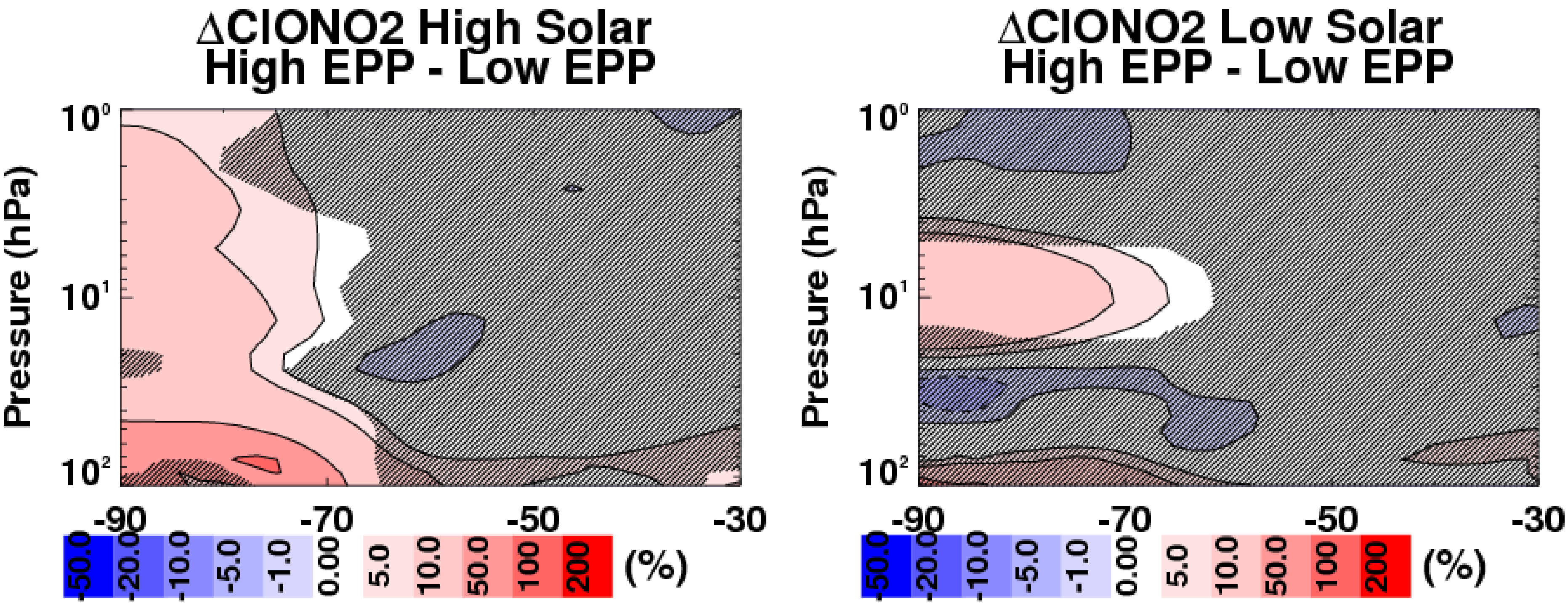
WACCM Simulation Comparisons

High EPP–Low EPP (December)

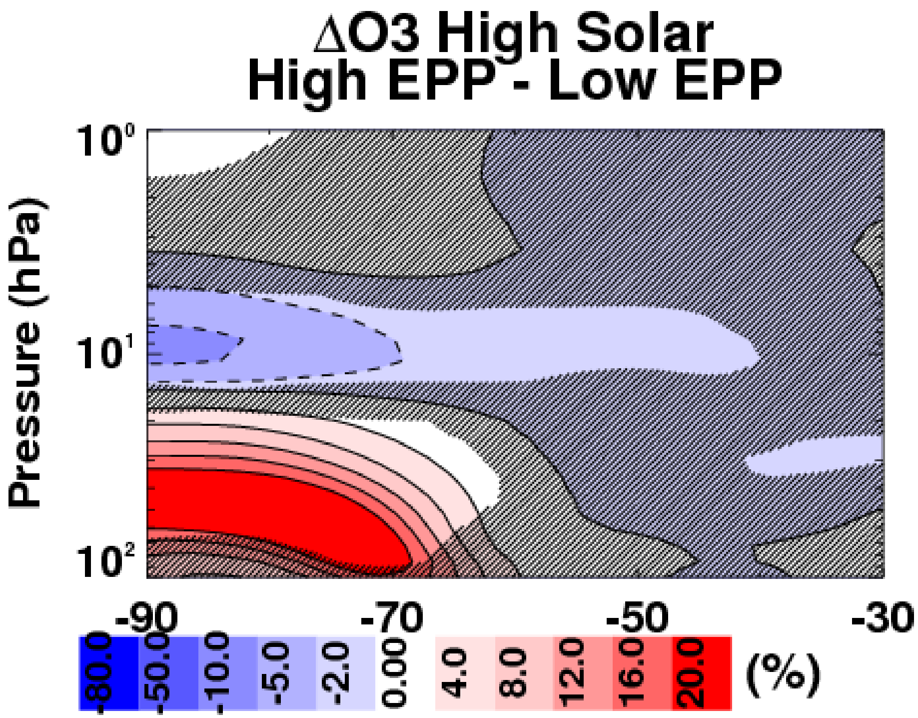


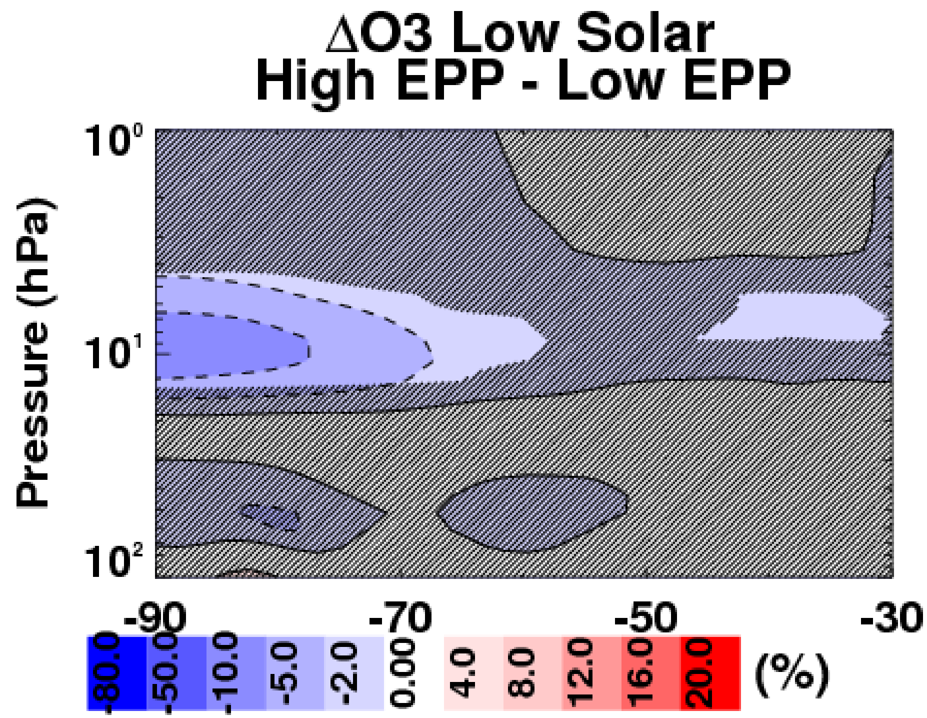


High EPP–Low EPP (December)

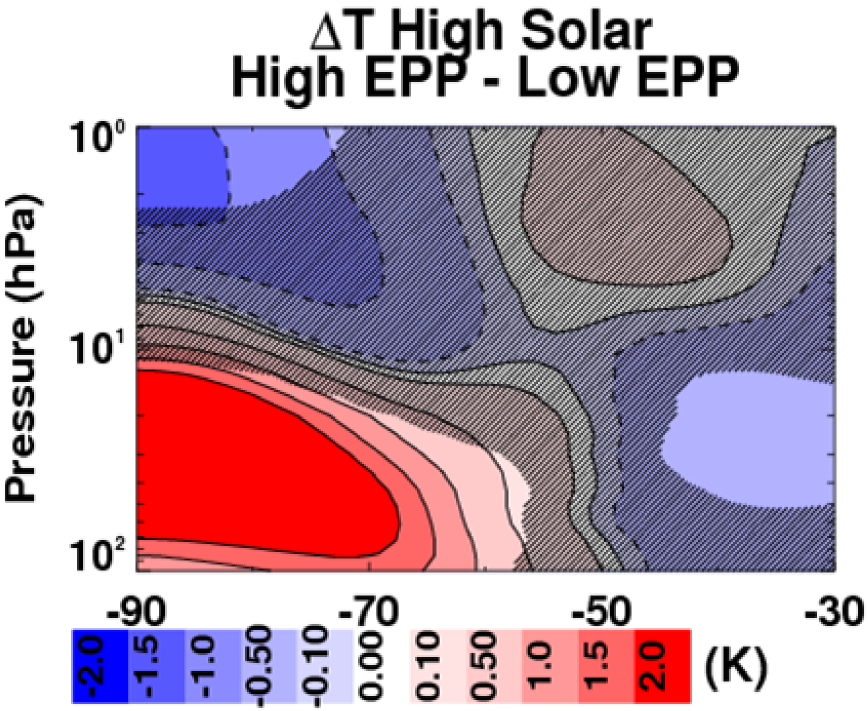


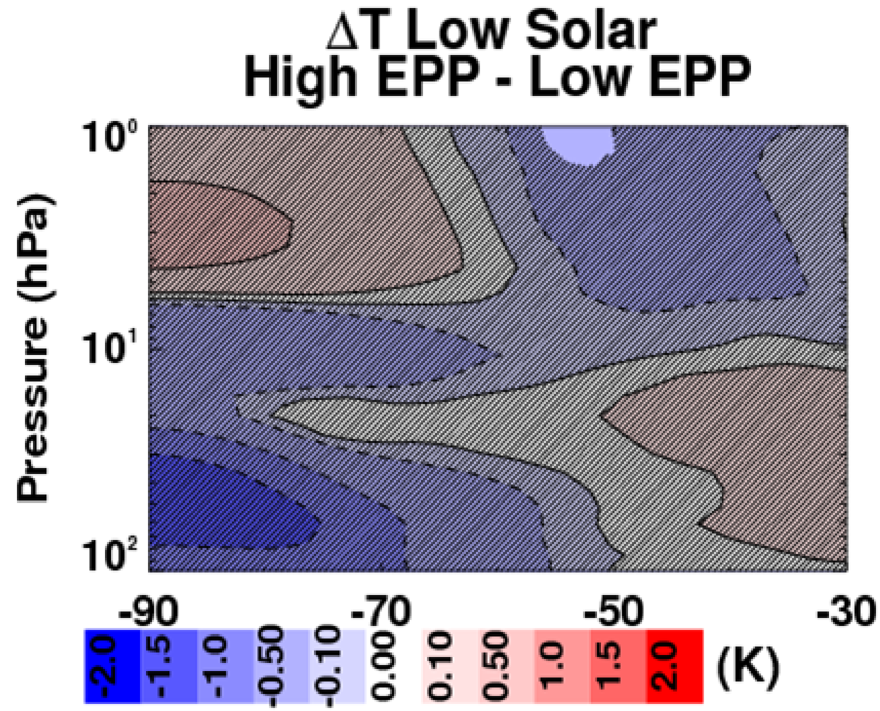
High EPP–Low EPP (December)



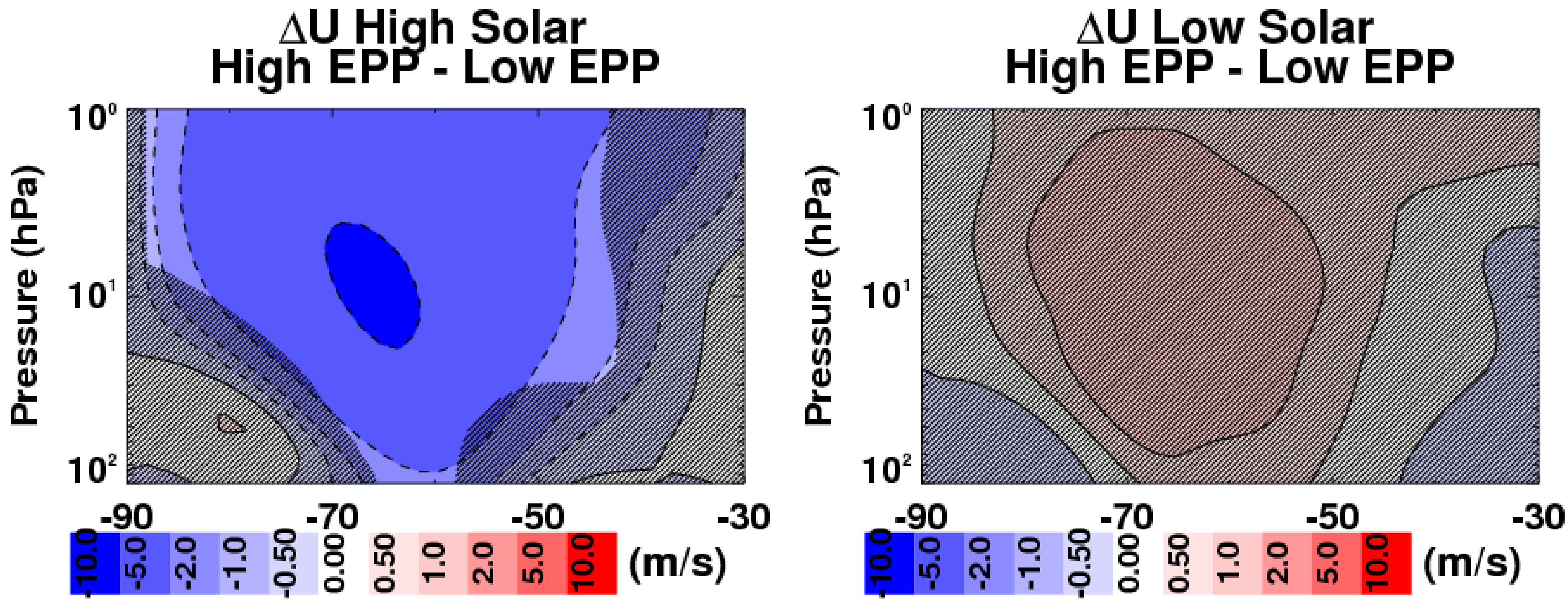


High EPP–Low EPP (December)



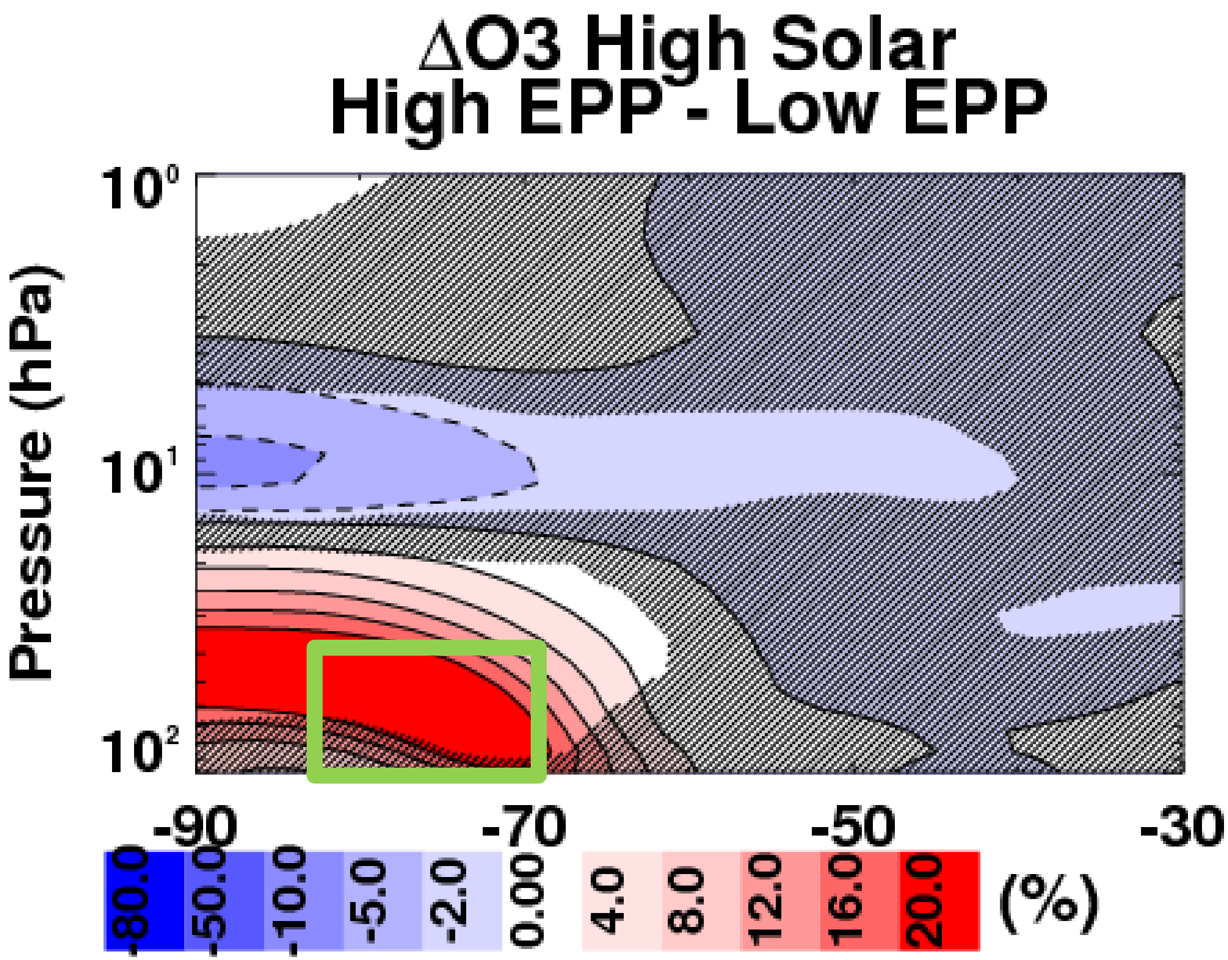


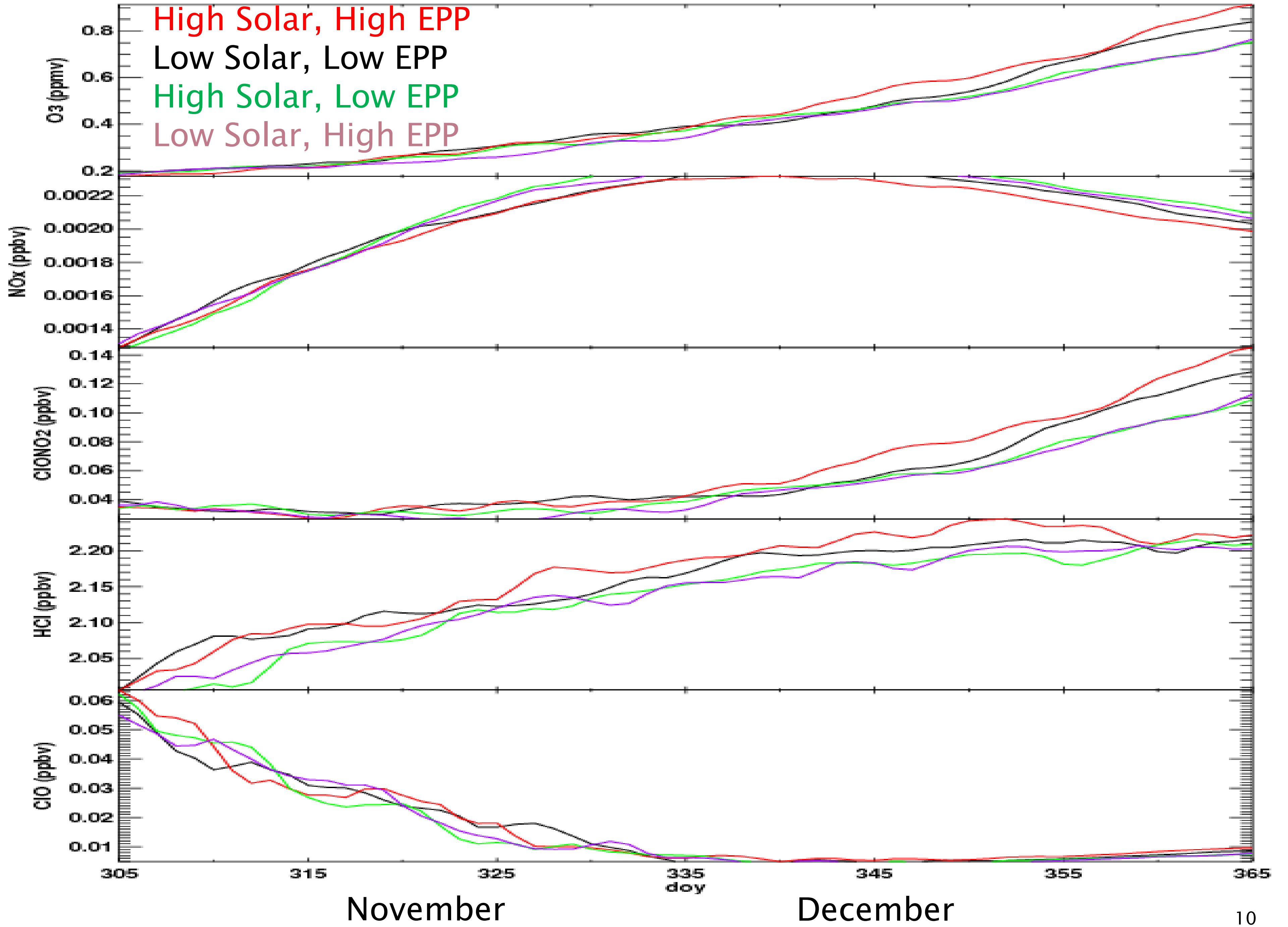
High EPP–Low EPP (December)



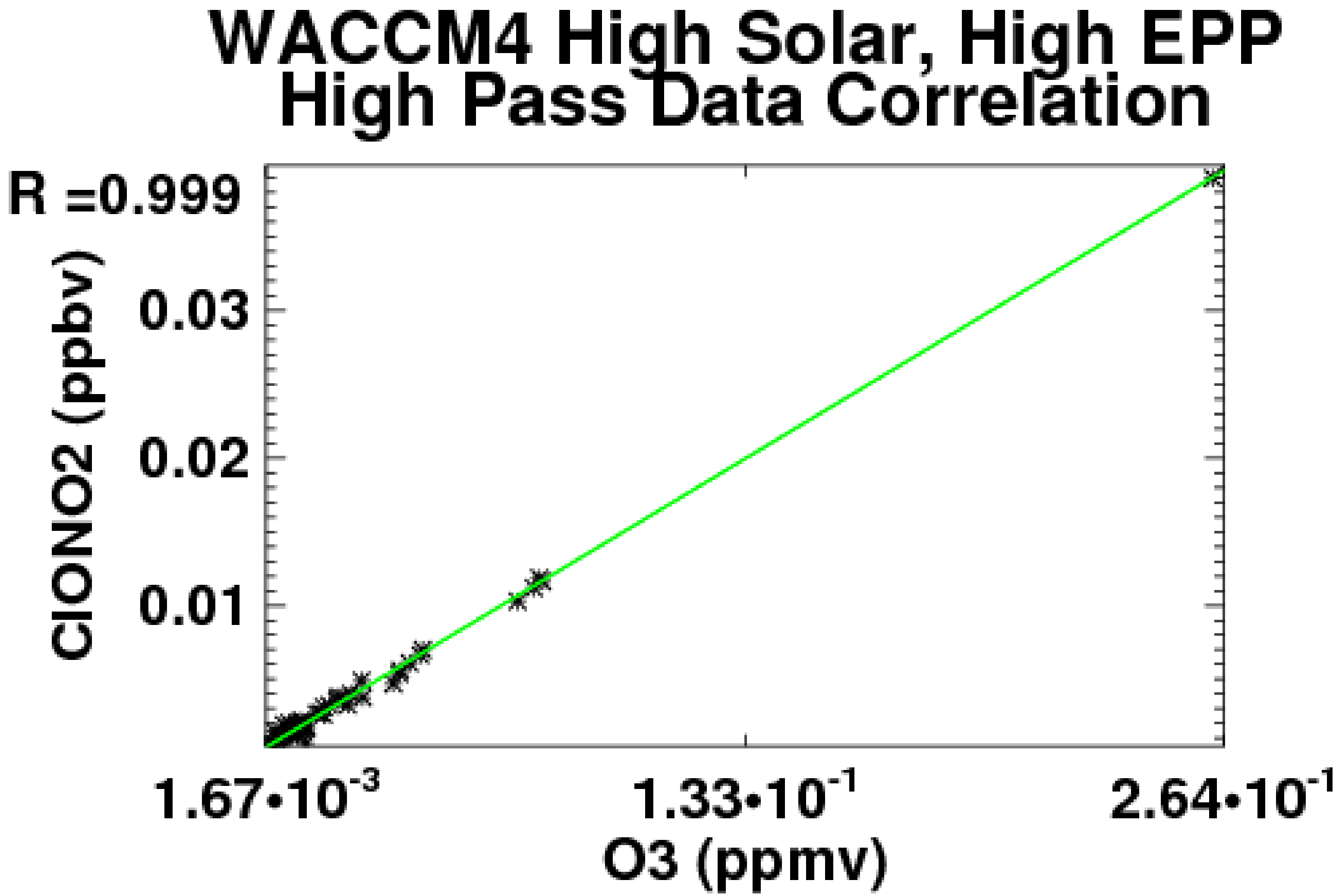
Binning Data

- Bin average daily data:
  - 80S–70S latitude
  - 50–100 hPa




High Solar, High EPP
Low Solar, Low EPP
High Solar, Low EPP
Low Solar, High EPP
O3 (ppmv)
NOx (ppbv)
ClONO2 (ppbv)
HCl (ppbv)
ClO (ppbv)
doy
November
December

High Pass Filtered Data Extreme Correlation



EPP and Solar Irradiance to O3 Mechanism

EPP-NO_x descends through atmosphere.

$NO_2 + ClO \rightarrow ClONO_2$

ClO

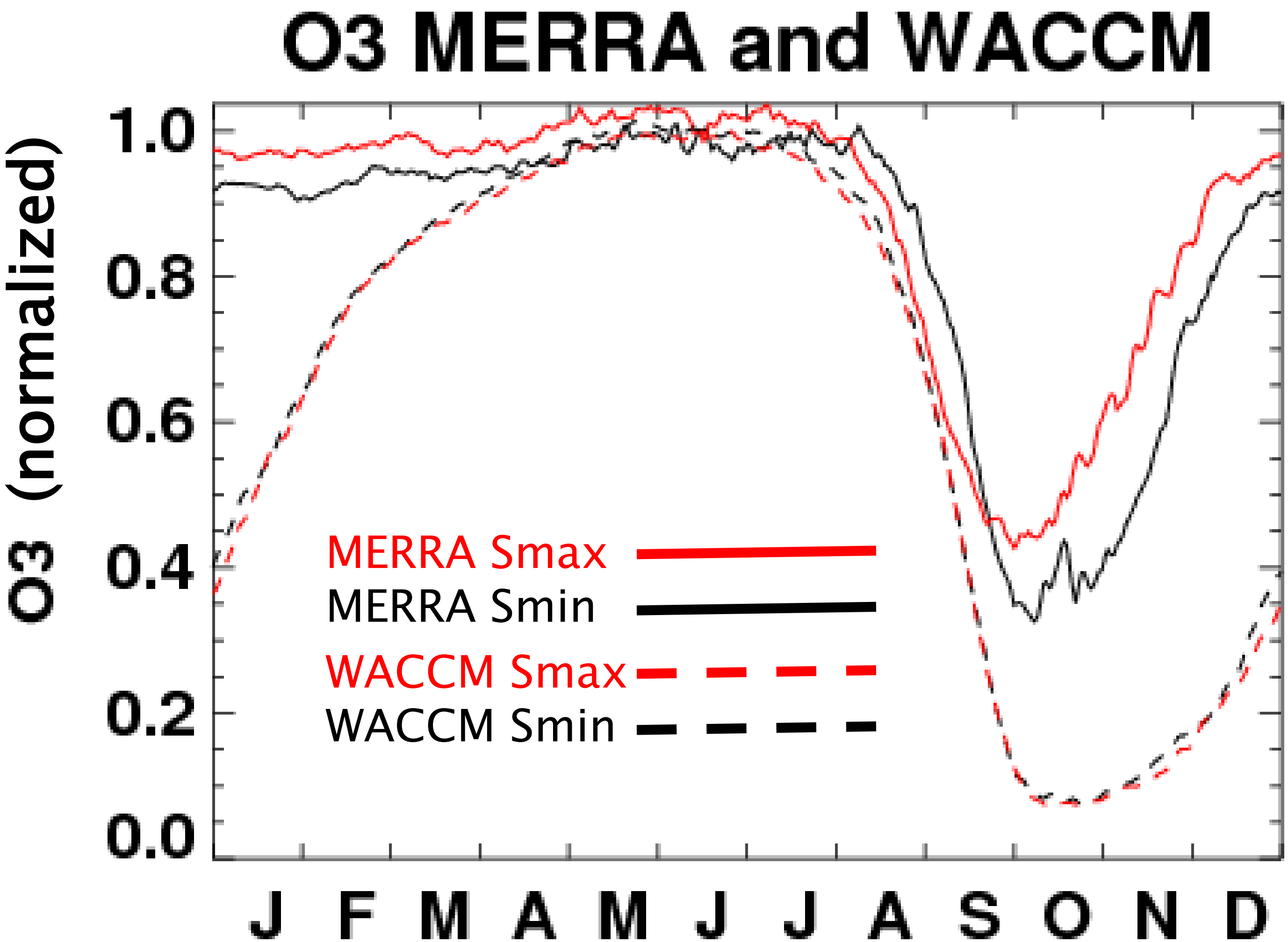
O_3

Less O_3 destruction.

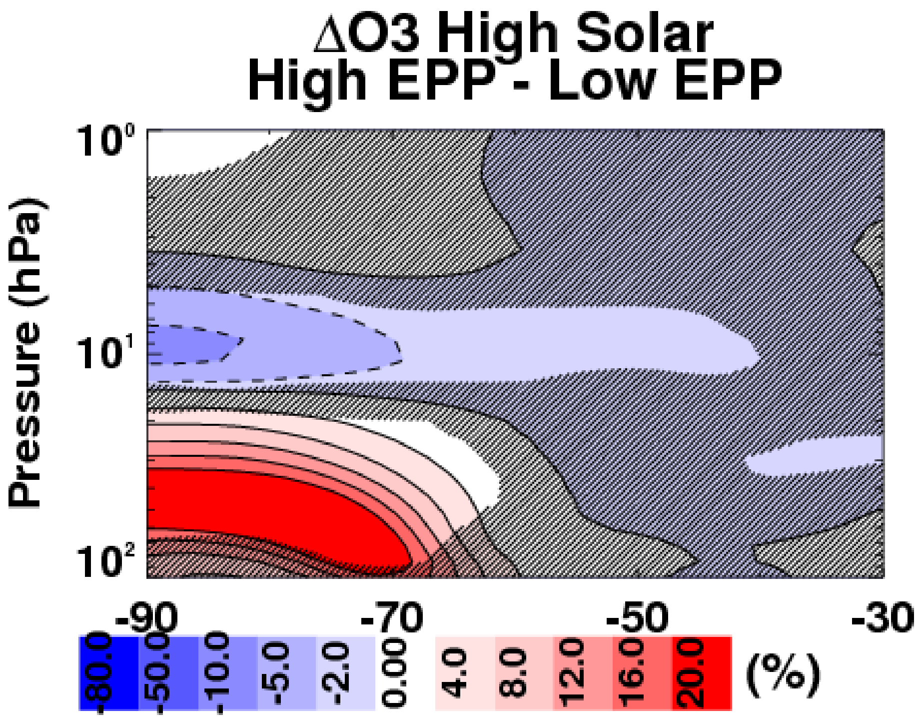
The “real” world.

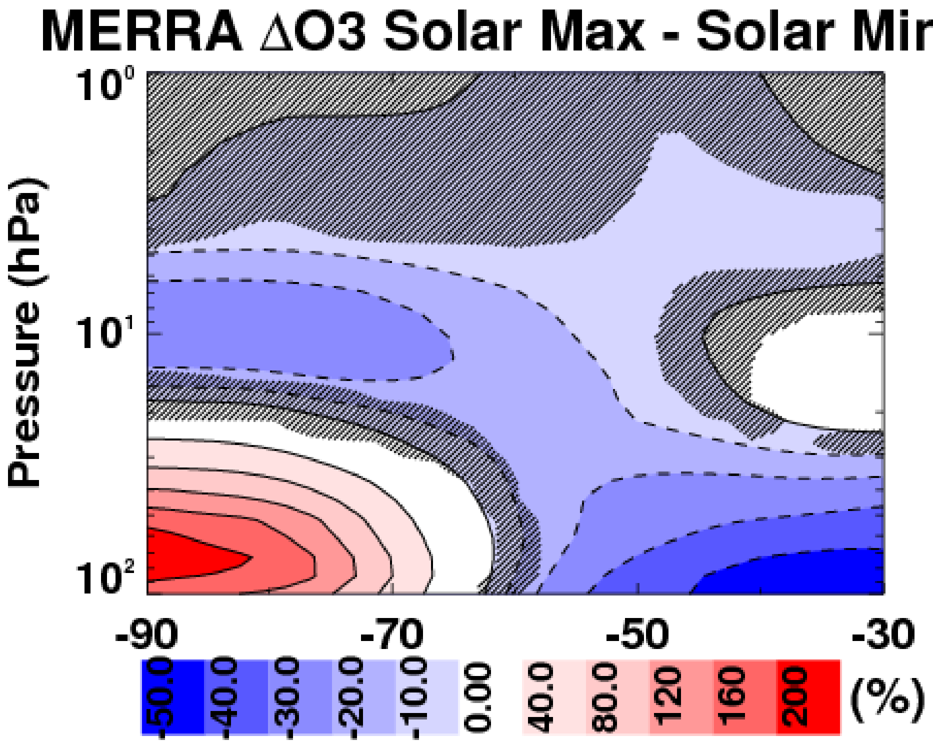
- Results are compared to NASA Modern-ERa Retrospective Analysis (MERRA).
- MERRA dataset goes back to 1979.
- Split into 2 datasets:
  - Solar Maximum: Take peak solar max years and surrounding years (+/- 1 year). (8 years total)
  - Solar Minimum: Same as solar maximum but for solar minimum. (9 years total).
- These results are preliminary! (I plan on investigating more robust cutoffs for separation of MERRA data.)

WACCM and MERRA



WACCM (Dec) MERRA (Oct)





Conclusions

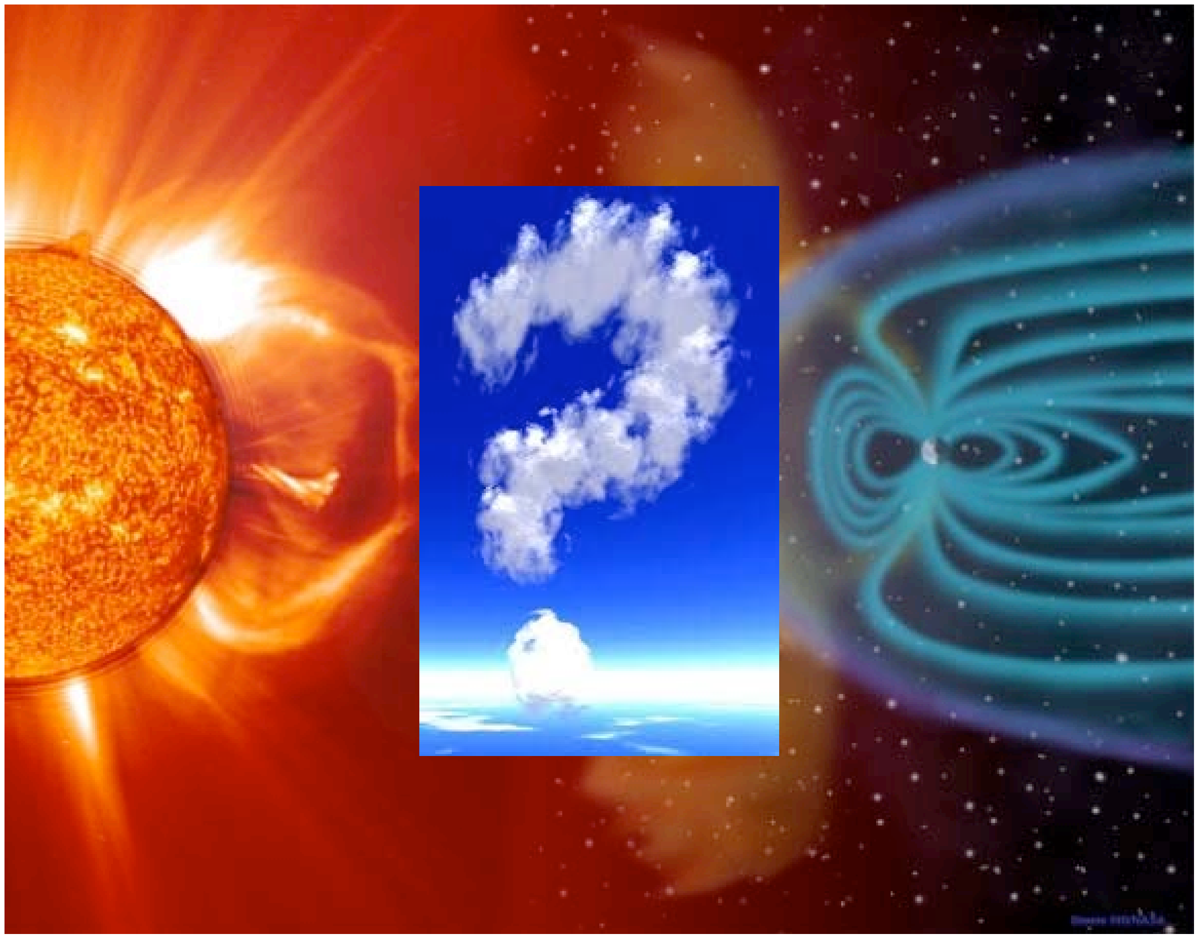
- WACCM and MERRA show significant changes in annual O_3 recovery caused by solar cycle (EPP and Solar irradiance).
- In the lower stratosphere, WACCM O_3 changes (20% increase) are smaller than MERRA (200% increase) and occur at different times (early December for WACCM, late October for MERRA).
  - This can be explained by persisting vortex (known issue) in WACCM.
- Results suggest that EPP and Solar irradiance changes associated with the solar cycle can create large differences in annual SH polar O_3 recovery.

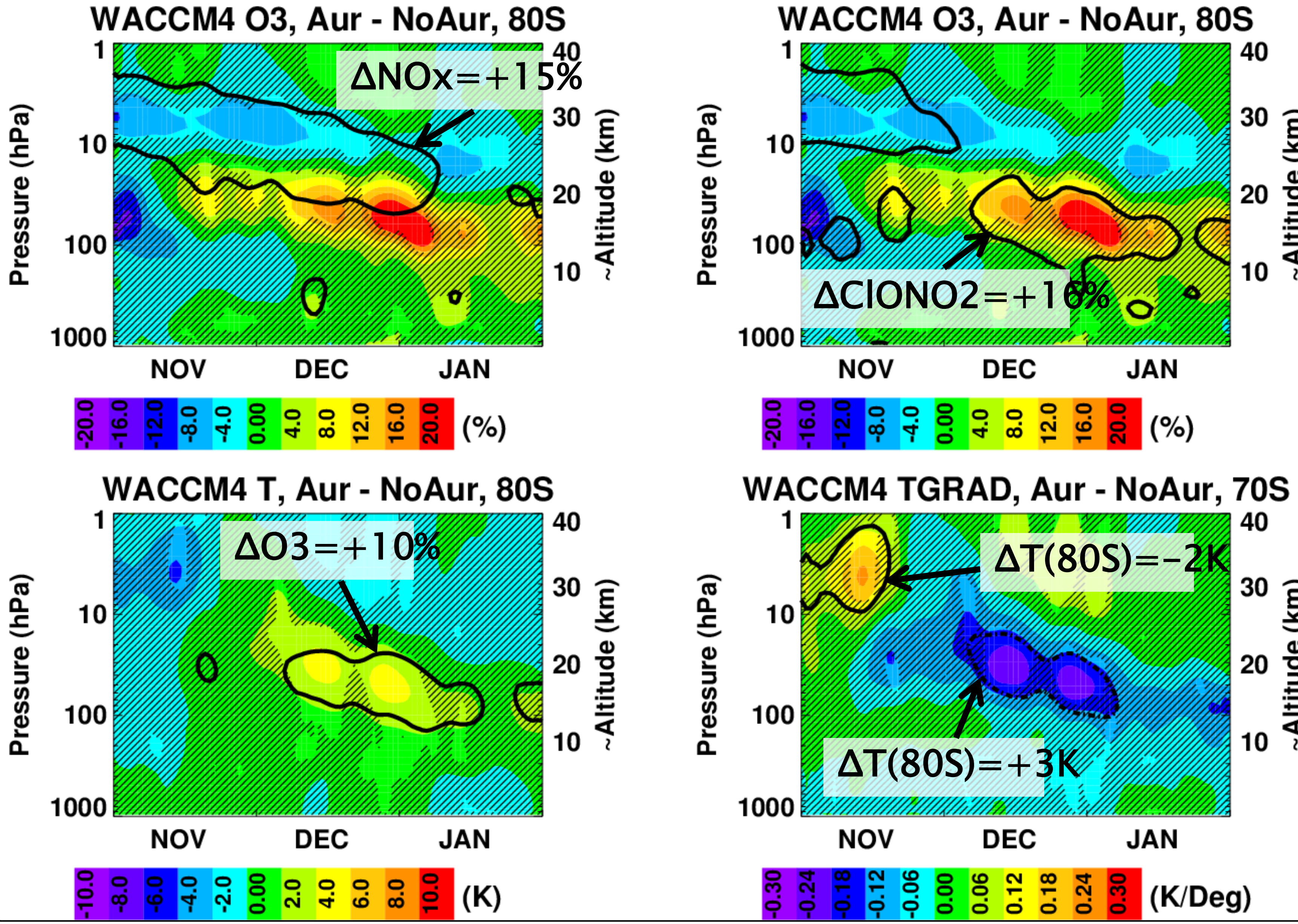
What's Next?

- Look for MERRA signal directly in satellite data.
  - Likely will use the Michaelson Interferometer for Passive Atmospheric Sounding (MIPAS) instrument on board ENVISAT.
  - This will allow analysis of mechanism as well, since MIPAS observes O_3 and $ClONO_2$.
- Include other types of EPP.

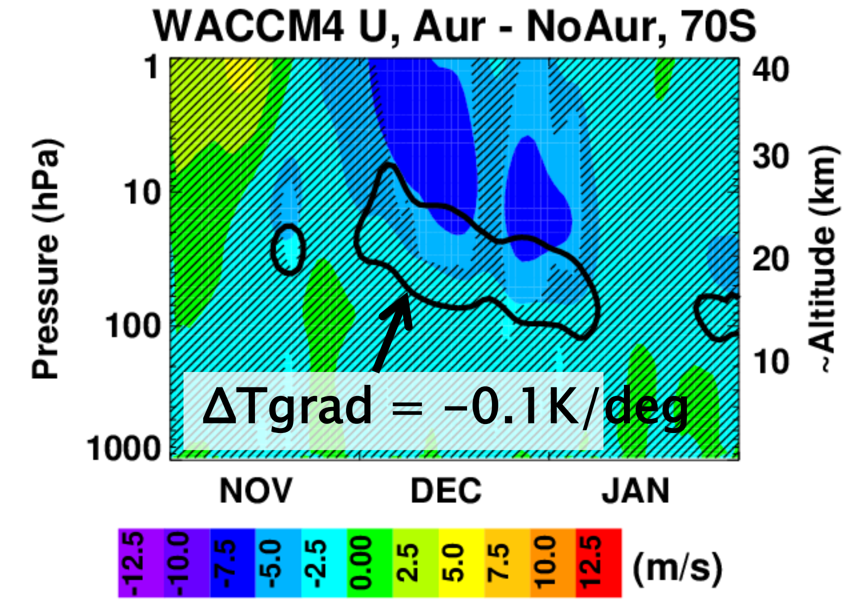
Thank You!

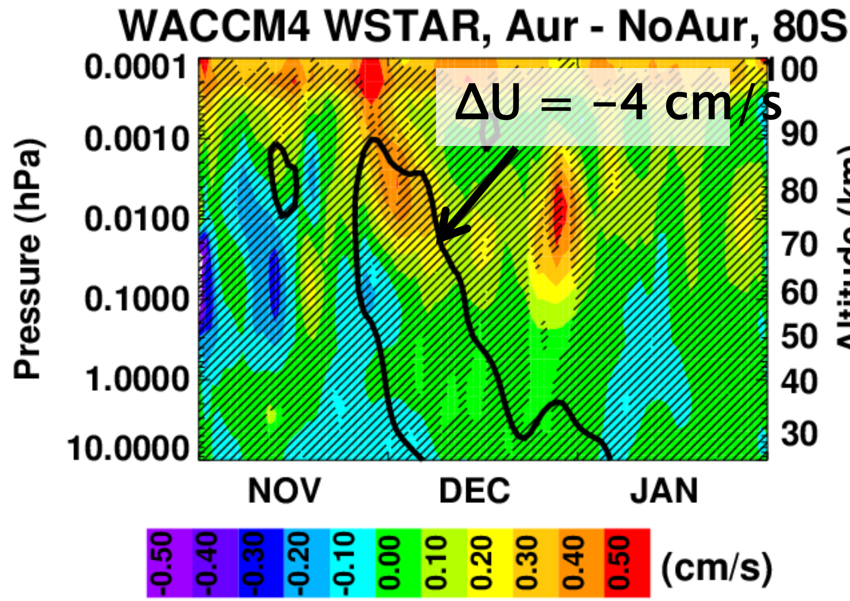
Questions

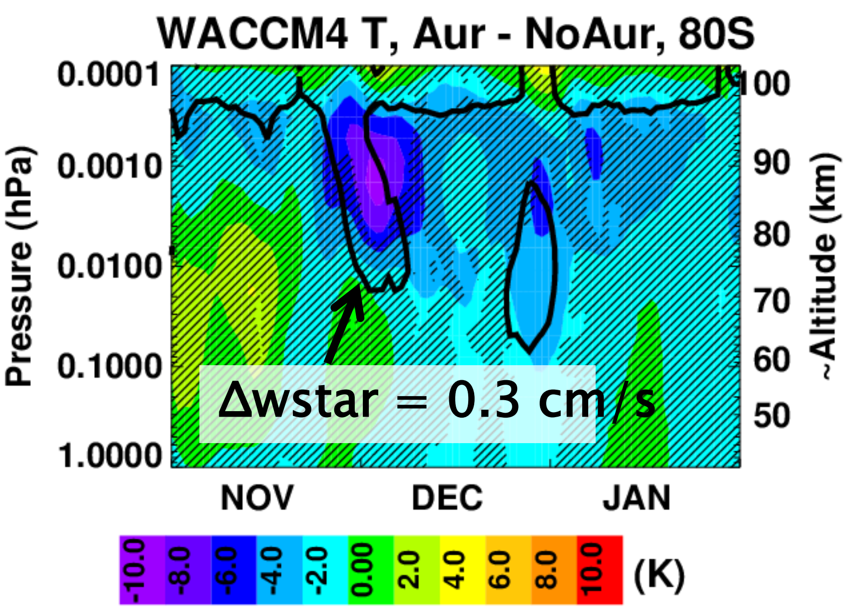




Upper left: Increased EPP-NOx causes O3 depletion and increased ClONO2. Upper right: Increased ClONO2 mitigates O3 loss. Lower left: Increased O3 causes temperature to increase. Lower right: Change in polar T leads to change in latitudinal T gradient at 70S.



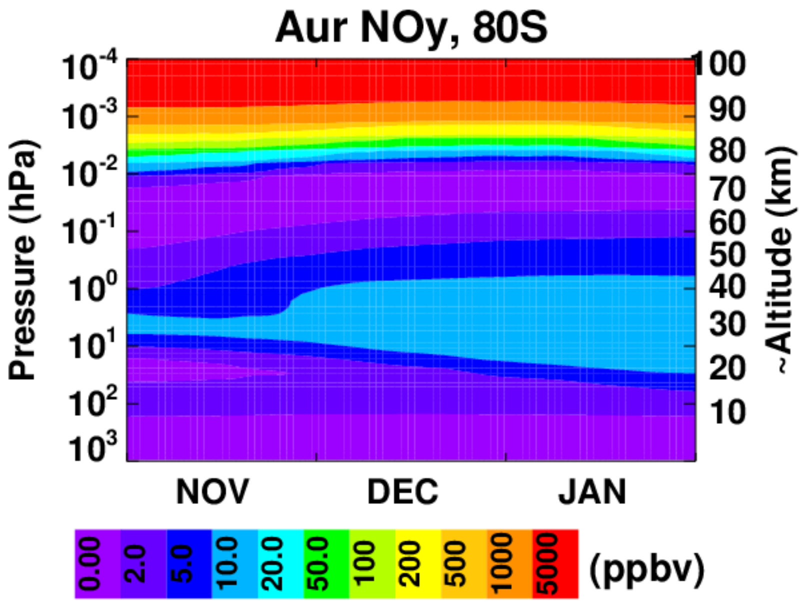


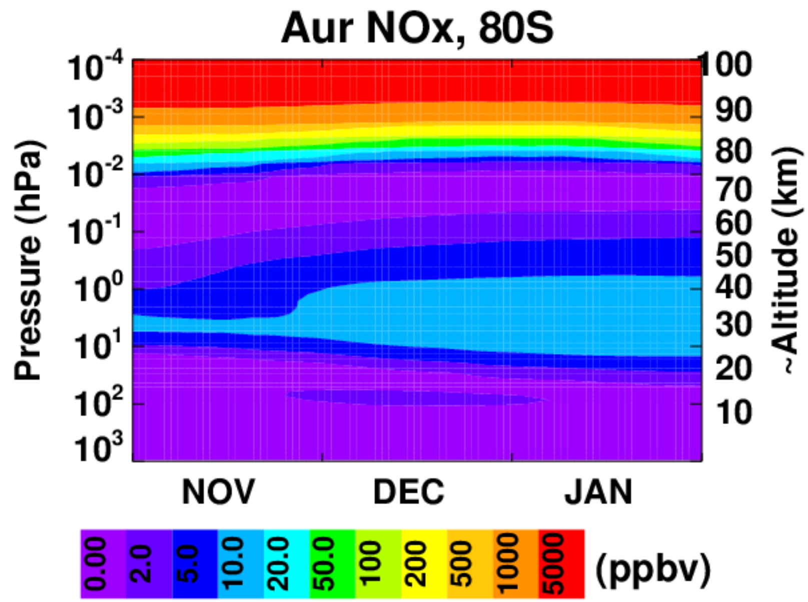


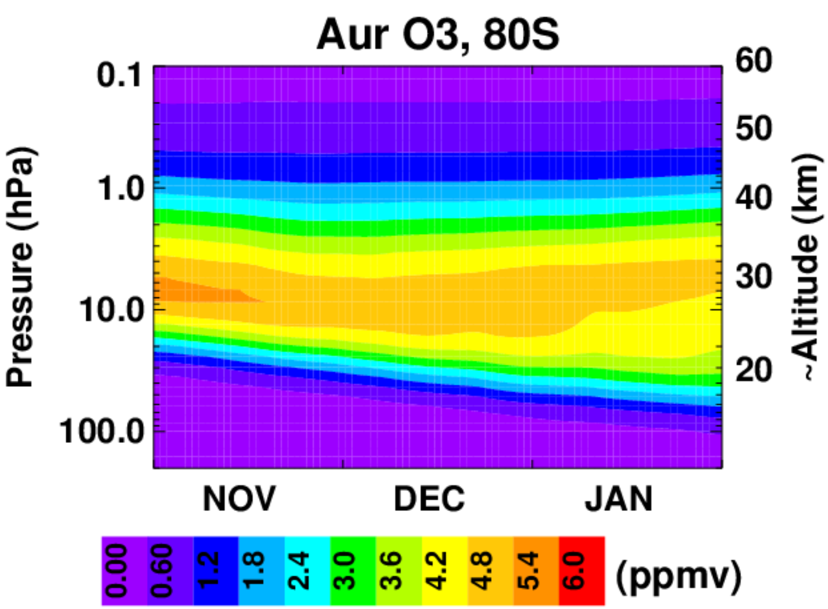
Upper left: Changing latitudinal gradient in T causes U at 70S above to become more negative (easterly/summer) .

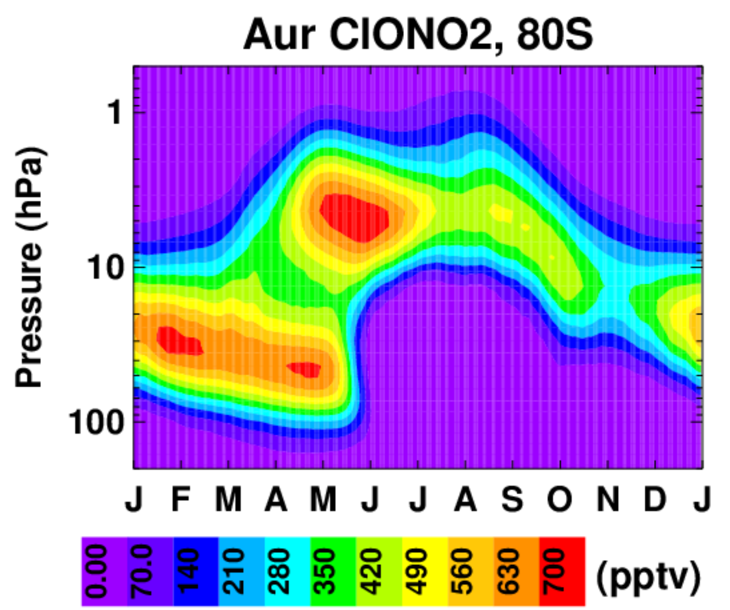
Upper right: Changing U at 70S affects GW filtering so that wbar* above, at 80S, is increased (i.e., stratospheric zonal wind more summer-like, leading to more ascent in the mesosphere) .

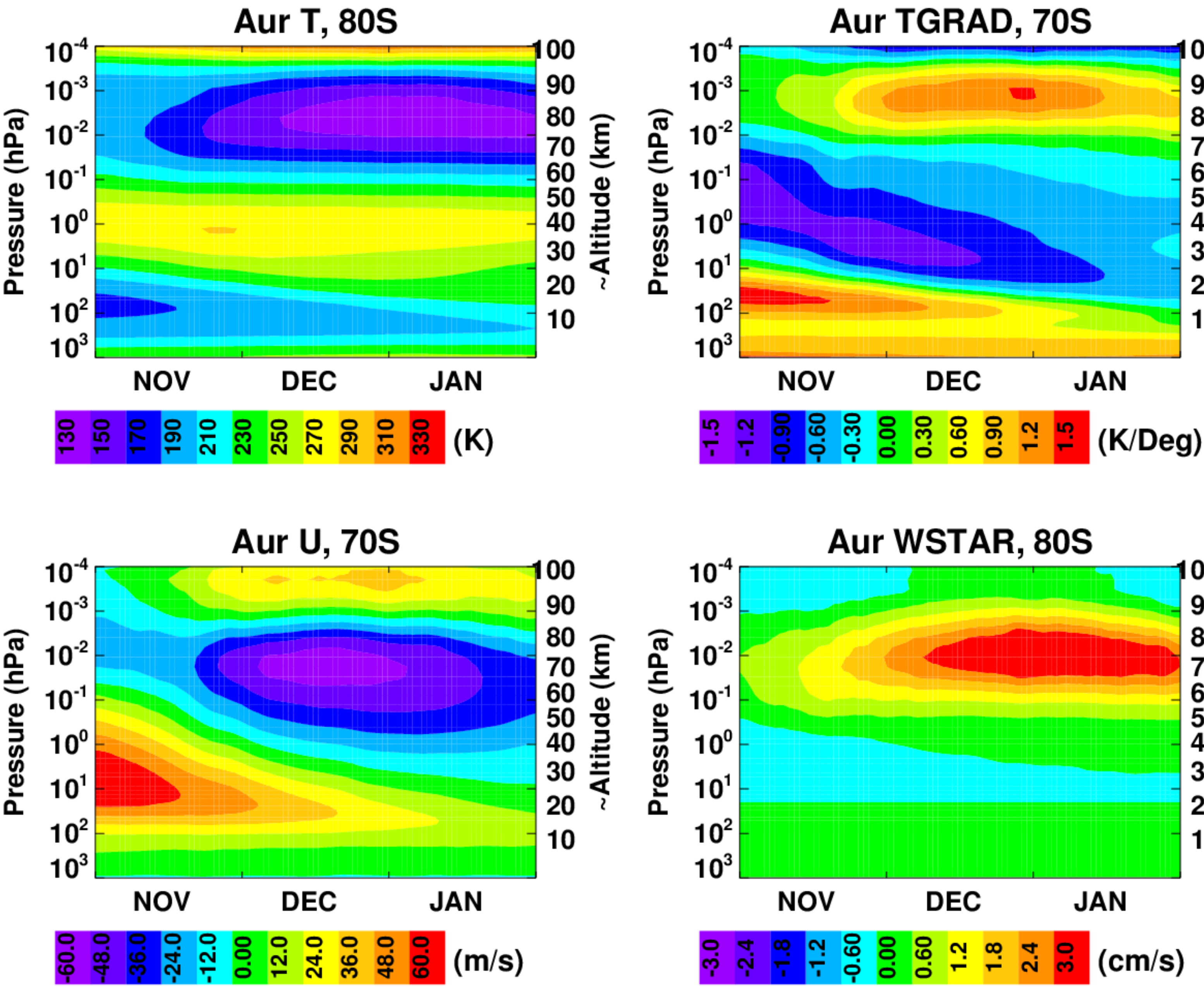
Lower left: Increase in wbar* leads to mesospheric cooling at 80S.

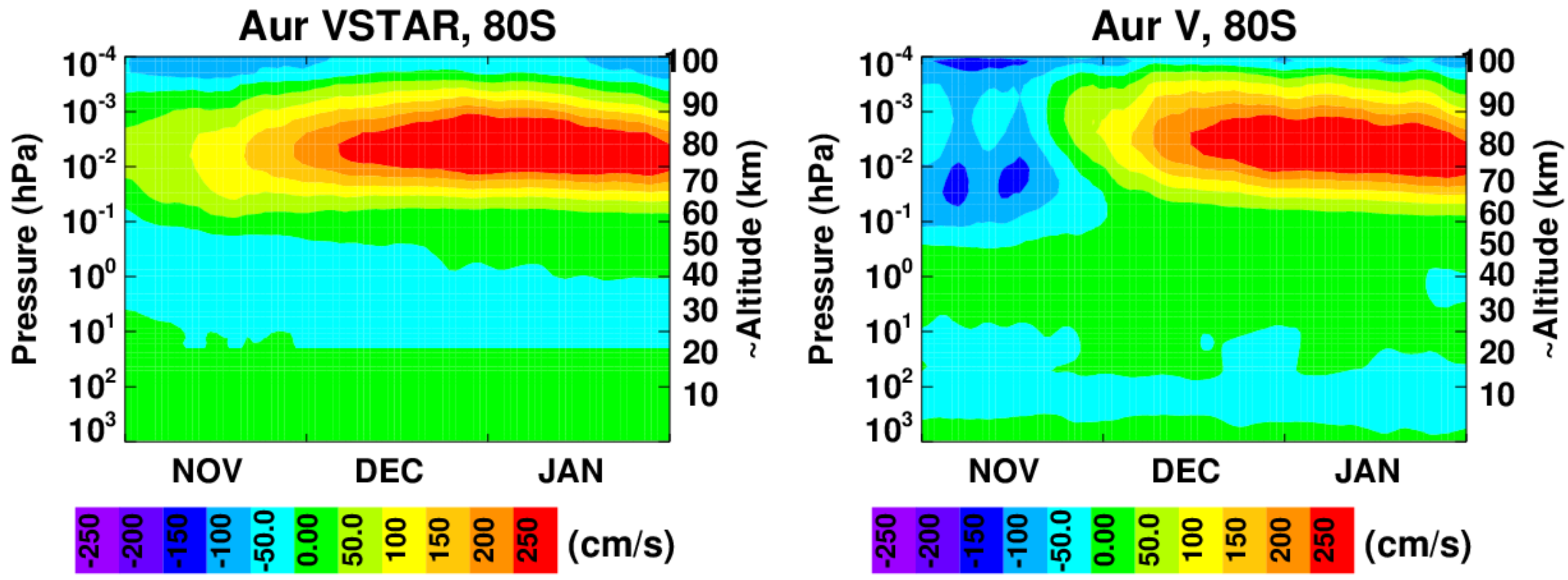

Aur NOy, 80S
Pressure (hPa)
10-4 10-3 10-2 10-1 100 101 102 103
100 90 80 70 60 50 40 30 20 10
~Altitude (km)
NOV DEC JAN
0.00 2.0 5.0 10.0 20.0 50.0 100 200 500 1000 5000
(ppbv)


Aur NOx, 80S
Pressure (hPa)
10-4 10-3 10-2 10-1 100 101 102 103
100 90 80 70 60 50 40 30 20 10
~Altitude (km)
NOV DEC JAN
0.00 2.0 5.0 10.0 20.0 50.0 100 200 500 1000 5000
(ppbv)


Aur O3, 80S
Pressure (hPa)
0.1 1.0 10.0 100.0
60 50 40 30 20
~Altitude (km)
NOV DEC JAN
0.00 0.60 1.2 1.8 2.4 3.0 3.6 4.2 4.8 5.4 6.0
(ppmv)


Aur ClONO2, 80S
Pressure (hPa)
1 10 100
J F M A M J J A S O N D J
0.00 70.0 140 210 280 350 420 490 560 630 700
(pptv)


Aur T, 80S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
130 150 170 190 210 230 250 270 290 310 330
(K)
Aur TGRAD, 70S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
-1.5 -1.2 -0.90 -0.60 -0.30 0.00 0.30 0.60 0.90 1.2 1.5
(K/Deg)
Aur U, 70S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
-60.0 -48.0 -36.0 -24.0 -12.0 0.00 12.0 24.0 36.0 48.0 60.0
(m/s)
Aur WSTAR, 80S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
-3.0 -2.4 -1.8 -1.2 -0.60 0.00 0.60 1.2 1.8 2.4 3.0
(cm/s)


Aur VSTAR, 80S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
(cm/s)
Aur V, 80S
Pressure (hPa)
~Altitude (km)
NOV
DEC
JAN
(cm/s)