WACCM Studies of the Polar Middle Atmosphere

Cora Randall, Lynn Harvey, Bodil Karlsson

Susanne Benze, Matthias Brakebusch, Laura Holt, Ethan Peck

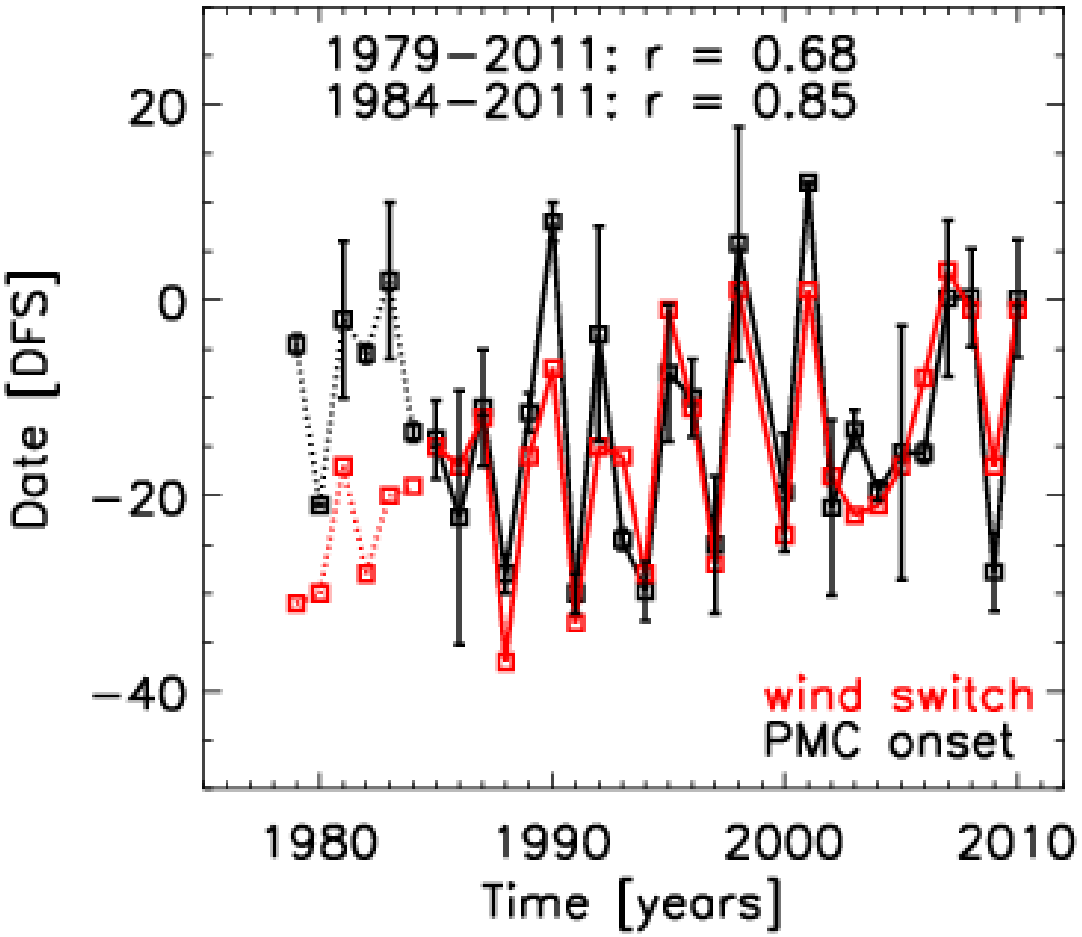
Chuck Bardeen, Rolando Garcia, Doug Kinnison, Dan Marsh, Mike Mills, Anne Smith, Simone Tilmes

Outline

- Polar Mesospheric Cloud Season Onset
- Polar Stratospheric Ozone Loss
- Energetic Particle Precipitation
- WACCM Dynamics

Polar Mesospheric Cloud Season Onset

(Susanne Benze)



SH PMC season onset correlates with timing of SH stratospheric winter-to-summer wind switch

Benze et al., JGR, in review 2012.

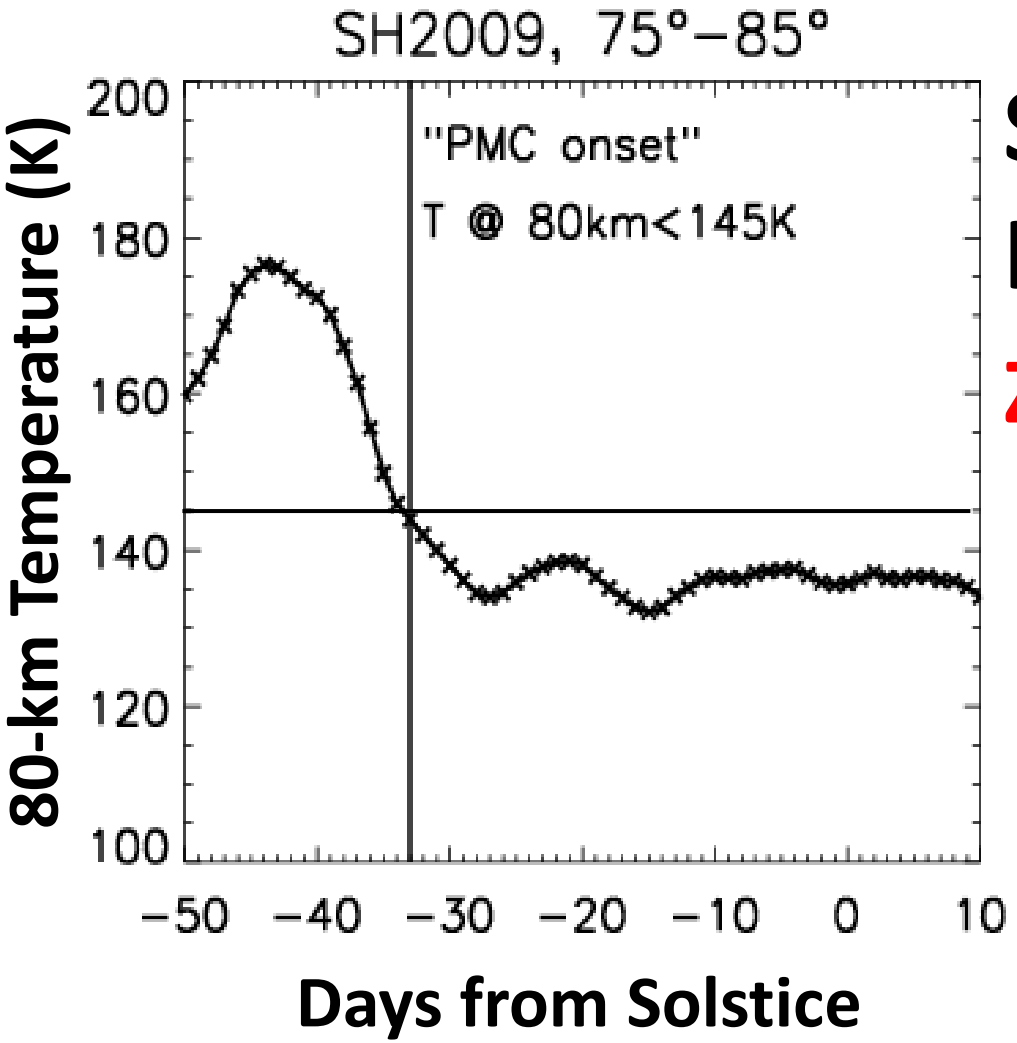
See also Karlsson et al. [2011], Gumbel & Karlsson [2011], and Smith et al. [2010].

Mechanism

	Winter	Summer
Zonal wind	Eastward	Westward
GW drag	Westward	Eastward
Meridional circulation	Poleward	Equatorward
Vertical motion	Downwelling	Upwelling
Departure from radiative equilibrium in mesosphere	Warming	Cooling
PMCs	No	Yes

What does WACCM say?

SD-WACCM 2001-2010 Diagnostics

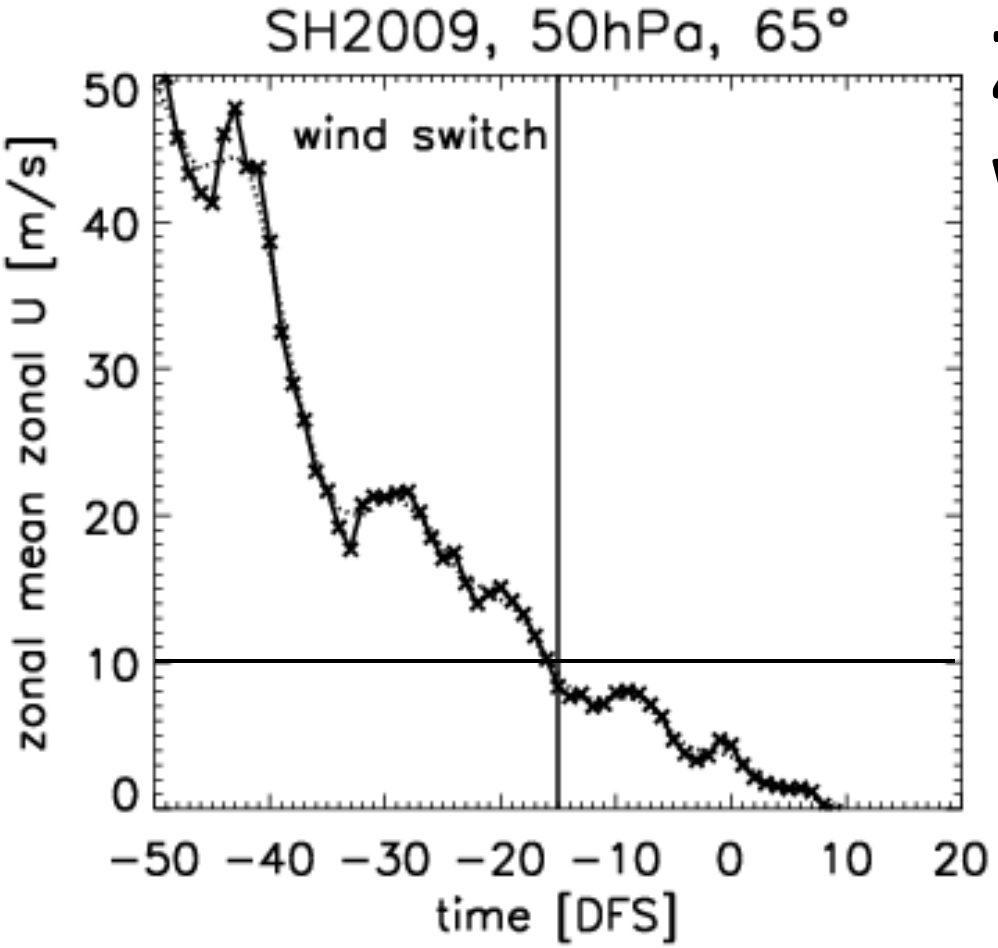


SH PMC Onset Indicator:

Zonal mean T < 145 K

- 80 km
- 75°-85° S Latitude
- 5-day avg

SD-WACCM 2001-2010 Diagnostics

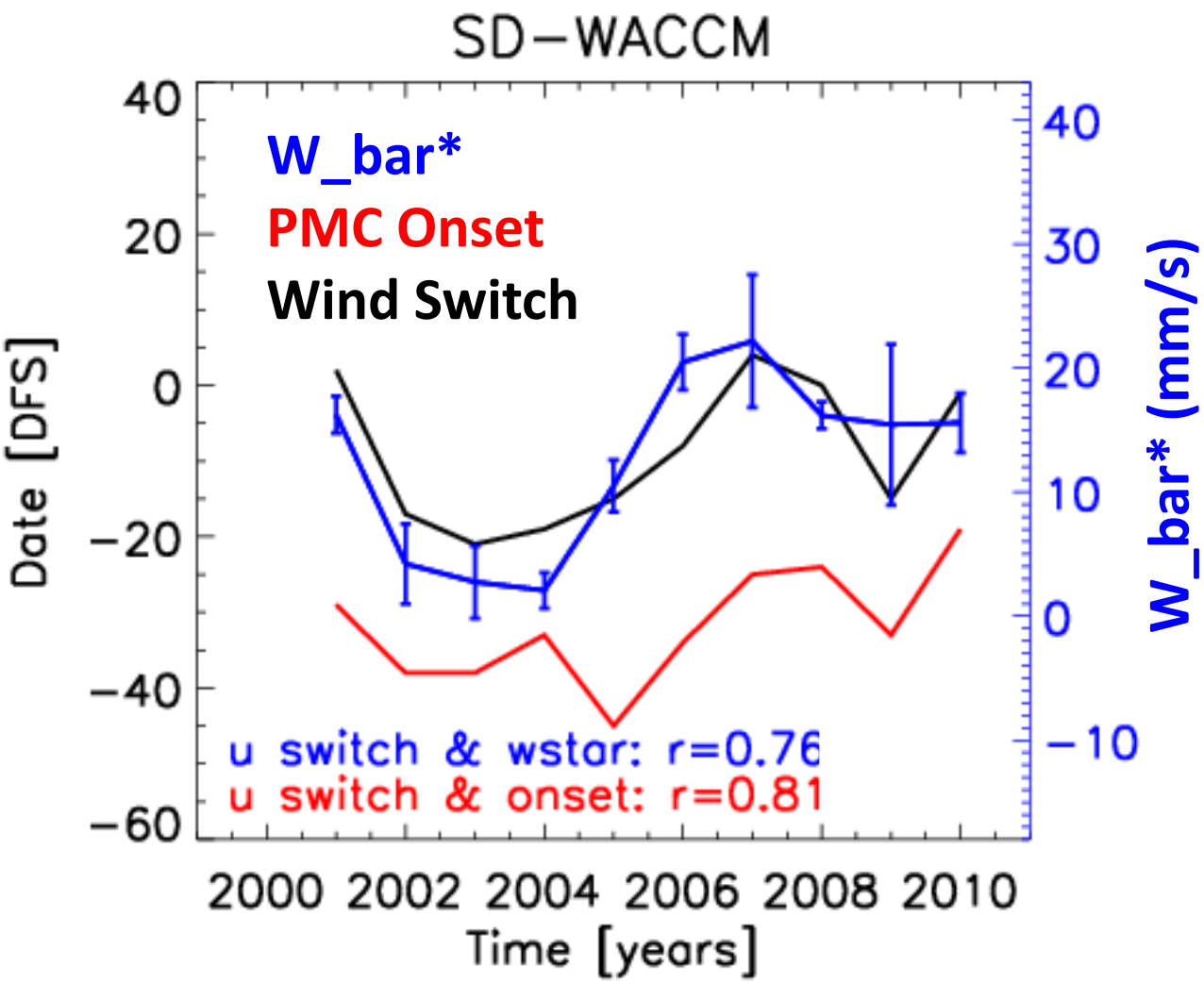


Zonal Mean Zonal Wind "Switch":

U_{bar} < 10 m/s

- 50 hPa
- 65° S Latitude
- 5-day avg

SD-WACCM consistent with Obs



Stratospheric wind change correlates with upwelling and polar 80-km temperature.

$$\overline{U}\ (strat)$$

$$\downarrow \quad \text{GW Filtering}$$

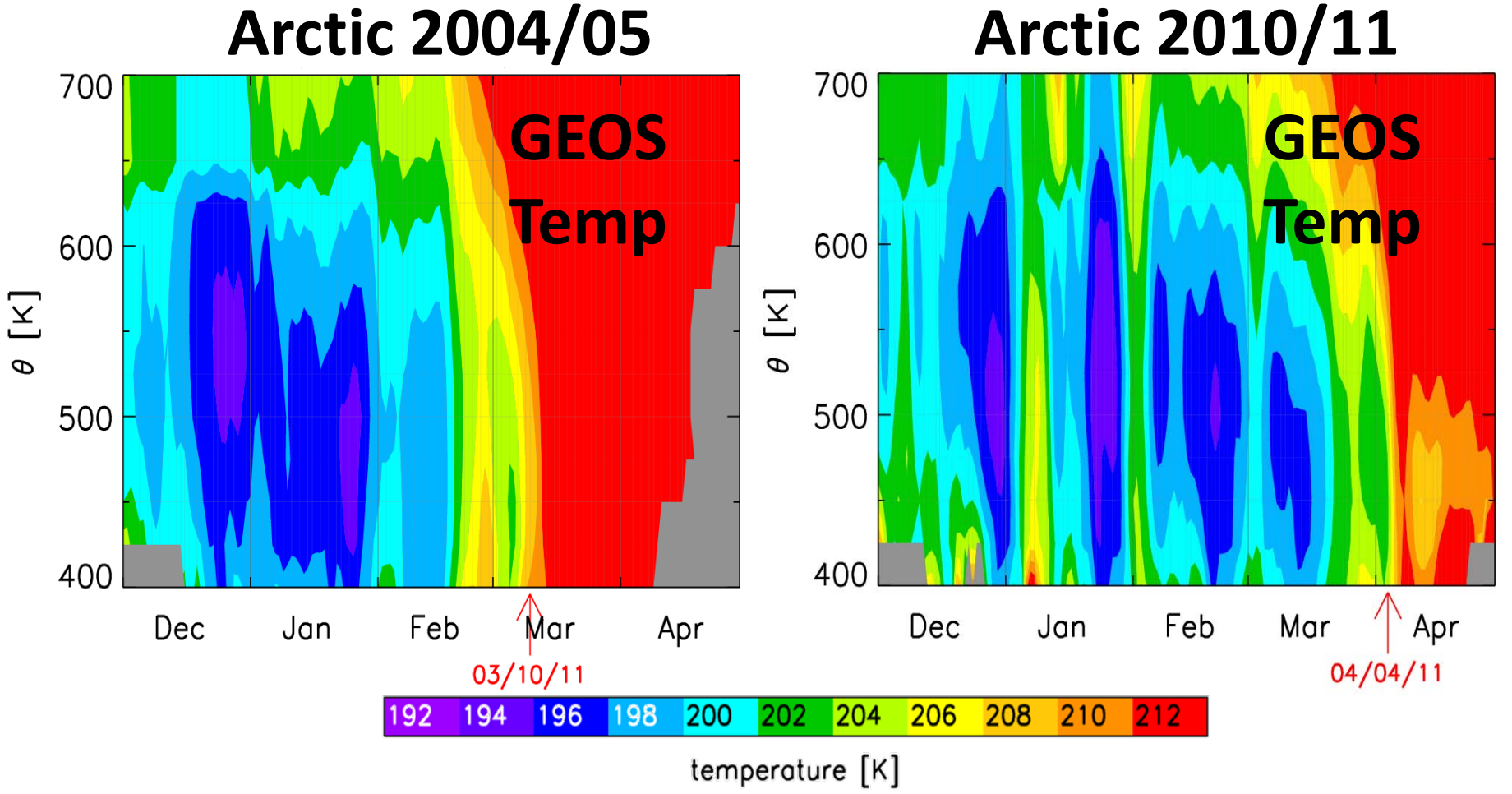
$$\overline{W}^{*}\ (80\,km)$$

$$\downarrow$$

$$T\ (80\,km)$$

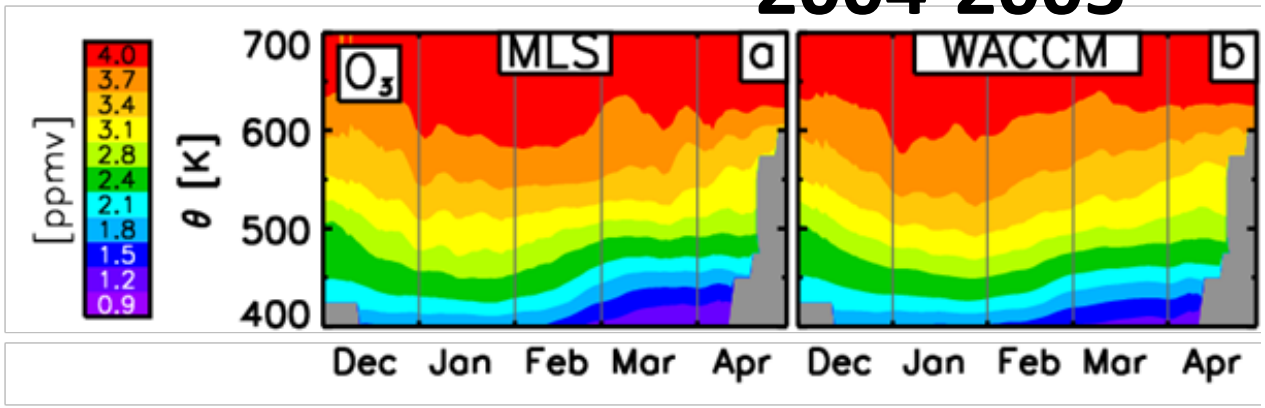
Arctic Ozone Loss

(Matthias Brakebusch)

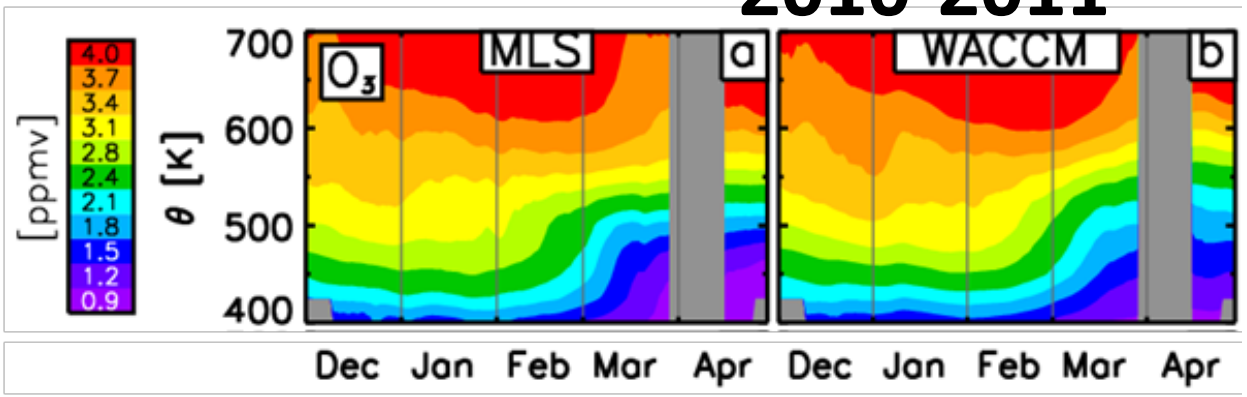


SD-WACCM vs. MLS Vortex Ozone

2004-2005



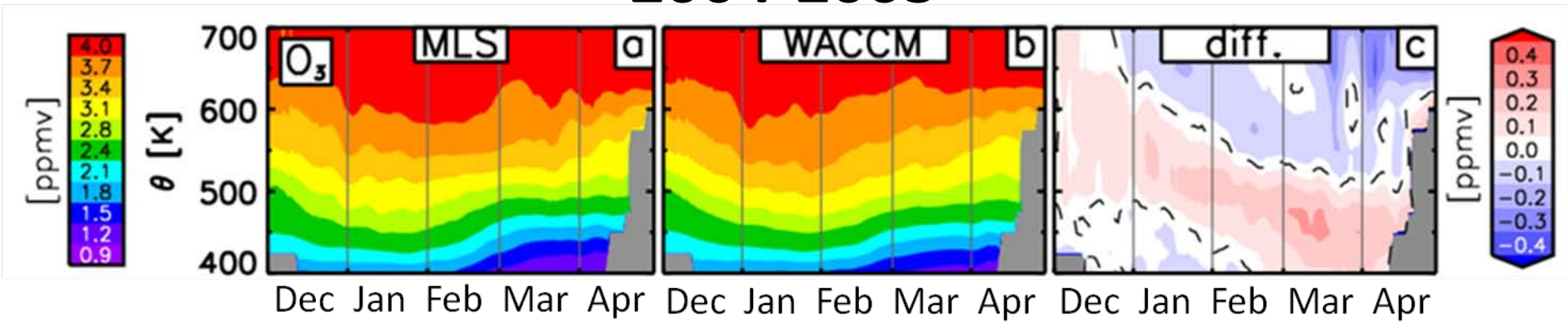
2010-2011



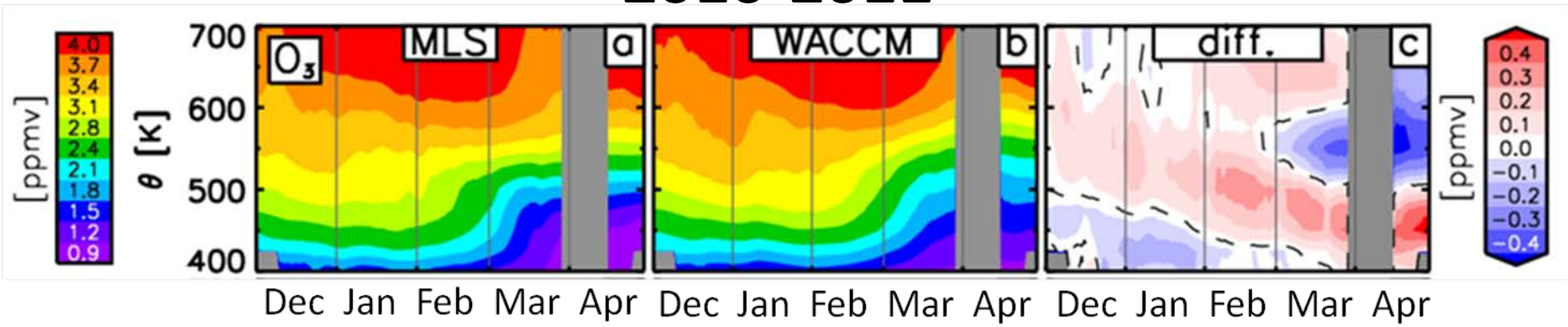
Qualitative agreement is excellent both years.

SD-WACCM vs. MLS Vortex Ozone

2004-2005



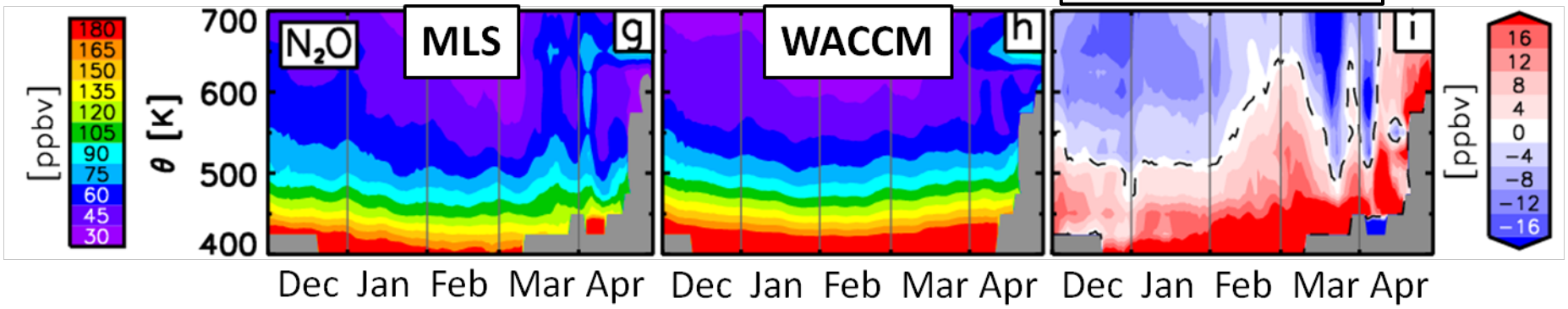
2010-2011



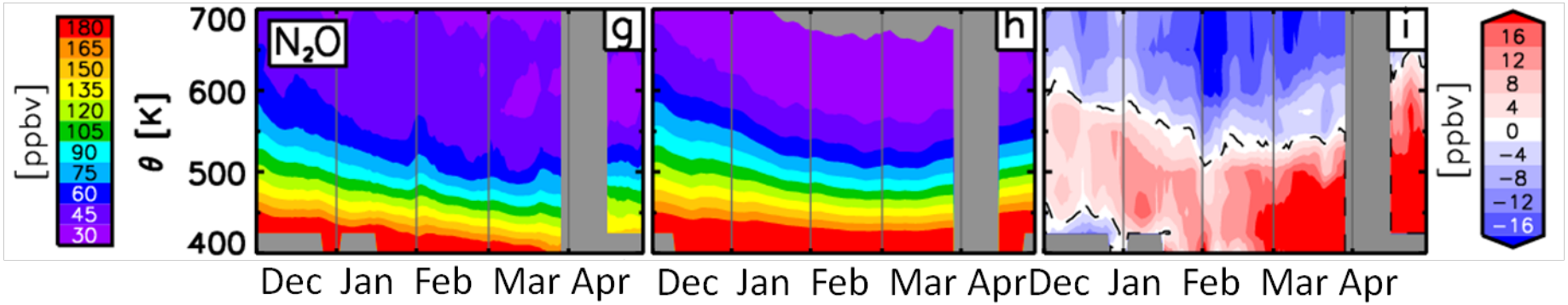
WACCM overestimates O_3 in main loss region
Caused by errors in transport and chemistry

SD-WACCM vs. MLS Vortex N_2O

2004-2005



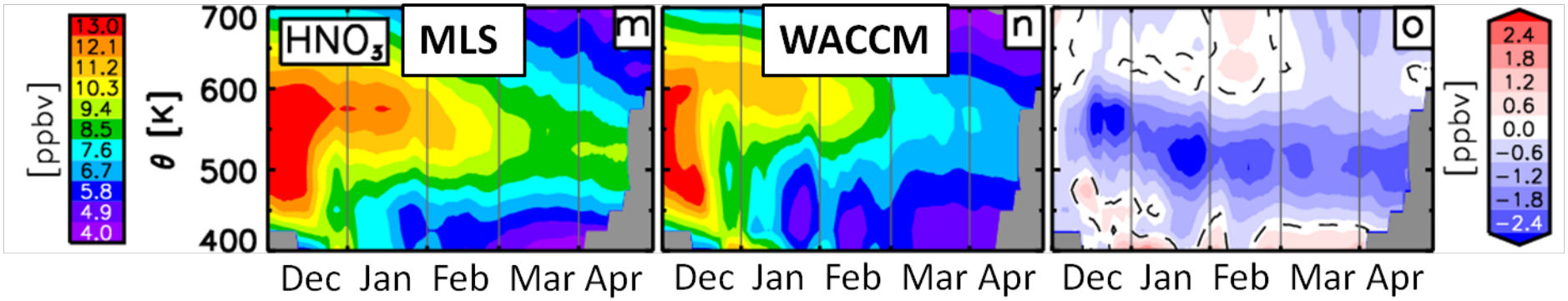
2010-2011



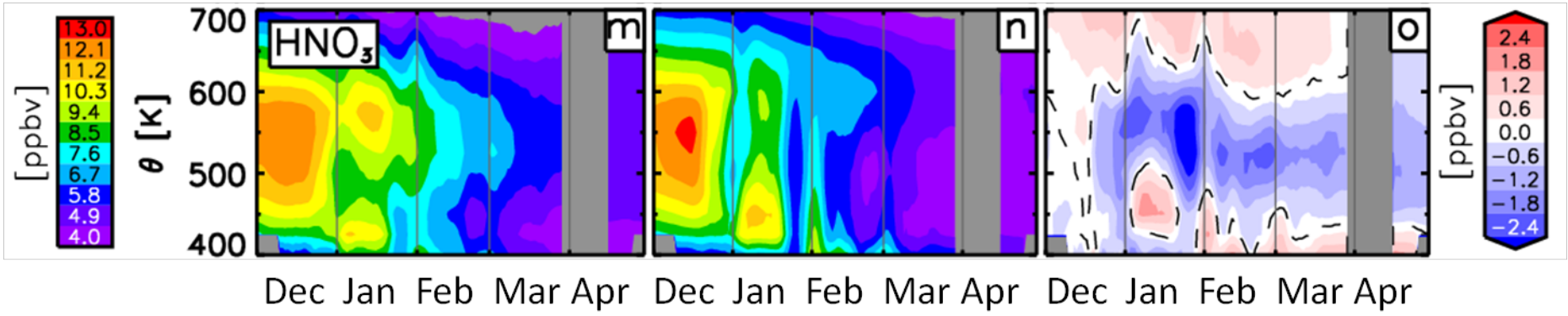
Similar patterns in the differences both years
Errors in descent and mixing

SD-WACCM vs. MLS Vortex HNO_3

2004-2005



2010-2011

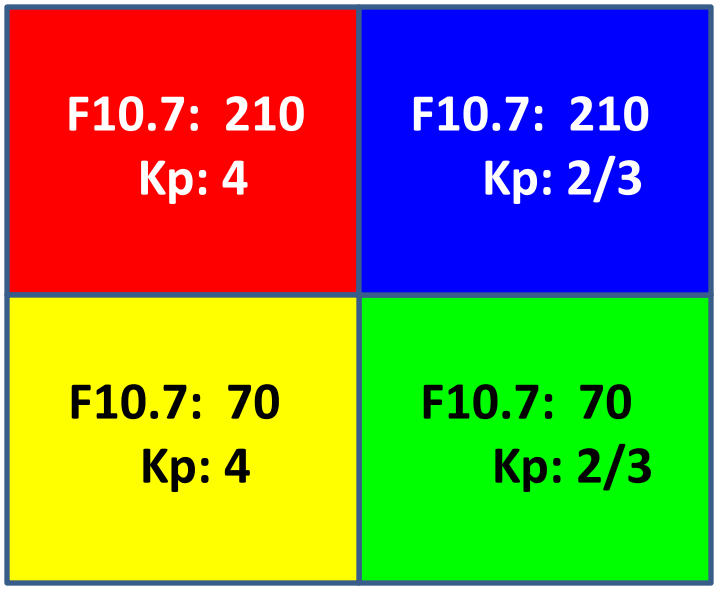


Too much denitrification both years

This does *not* mean more O_3 loss (Cl-limited)

Energetic Particle Precipitation (EPP)

(Ethan Peck)



Free-Running WACCM

Constant Year Repeating

Year 2000 SST/GHG/Halogens

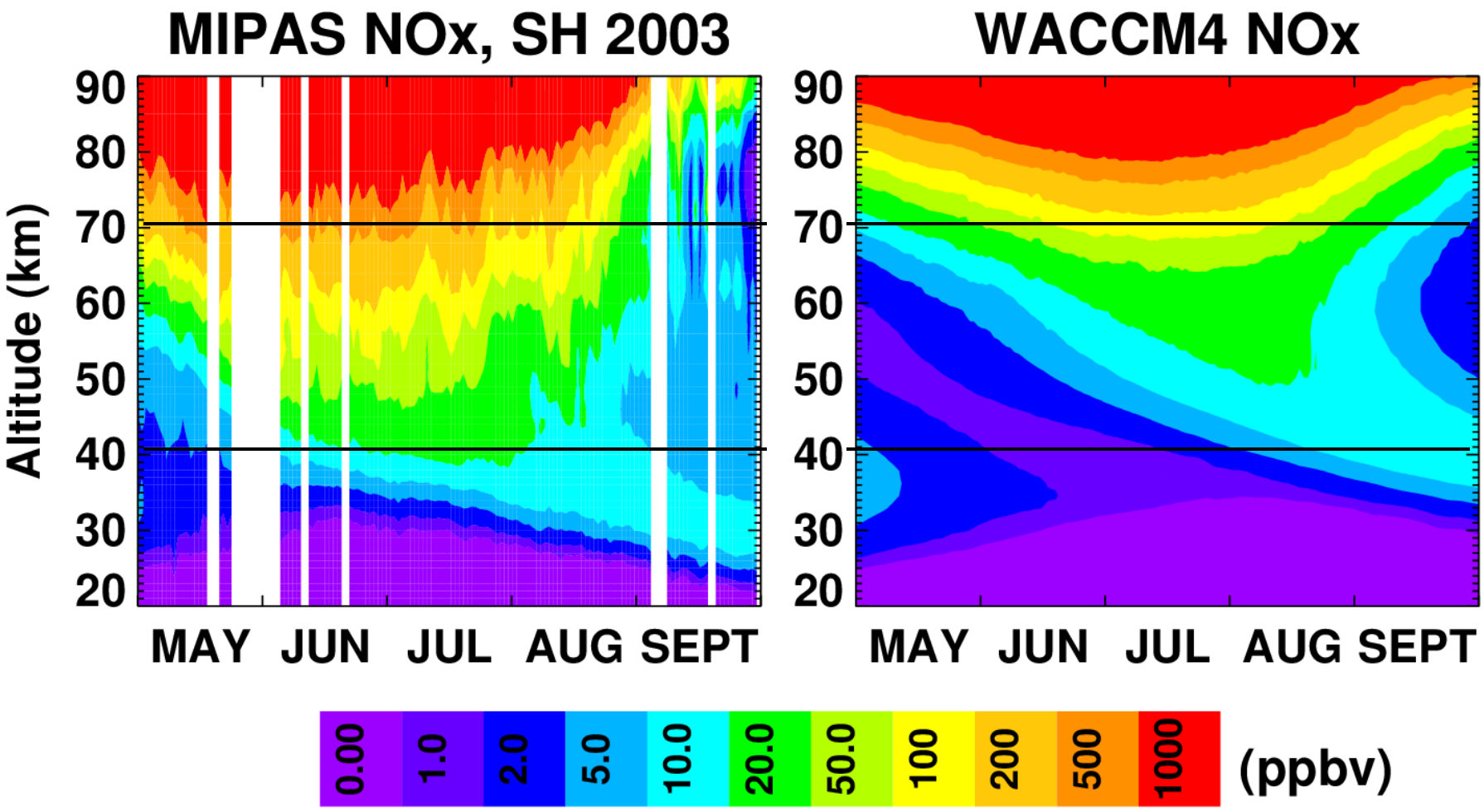
Auroral Electrons only

Next:

Specified Dynamics WACCM Extreme Event Simulation

>> Impose 2003 Halloween storms (protons + auroral electrons) on ~1 January 2004

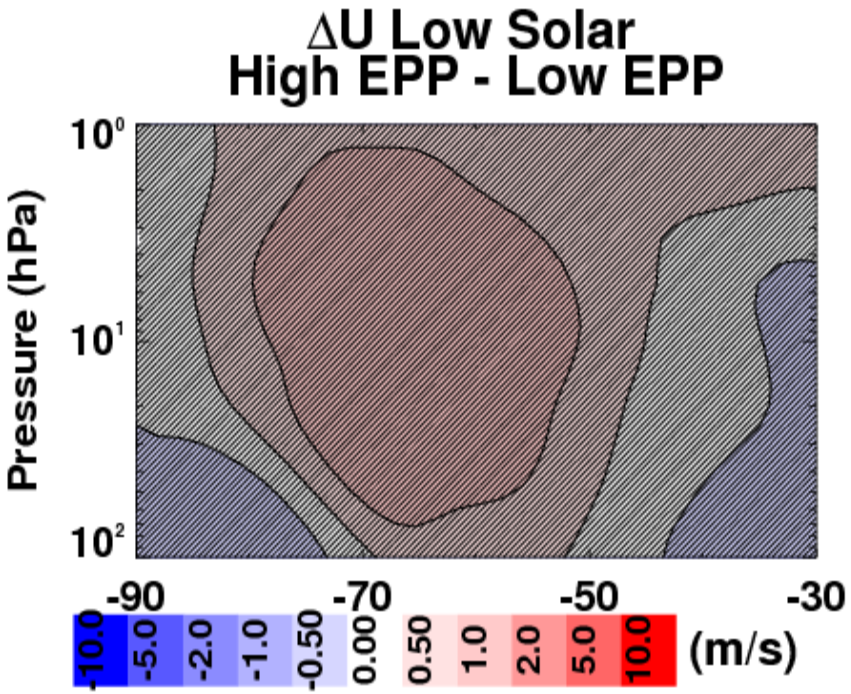
WACCM SH NOx is reasonable

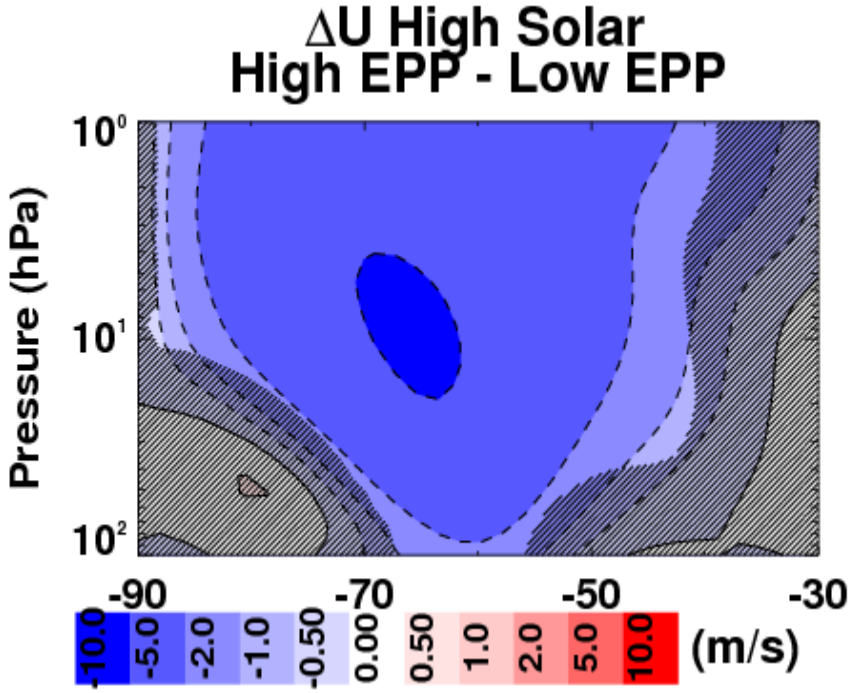


(Poleward of 70S)

Significant shift in Ubar from EPP

(Poleward of 70S in December)

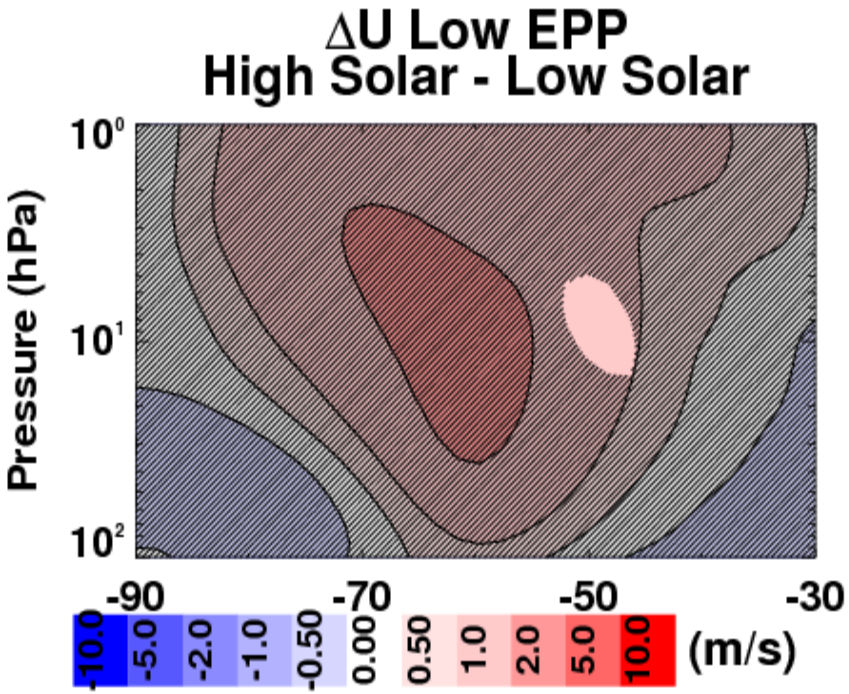


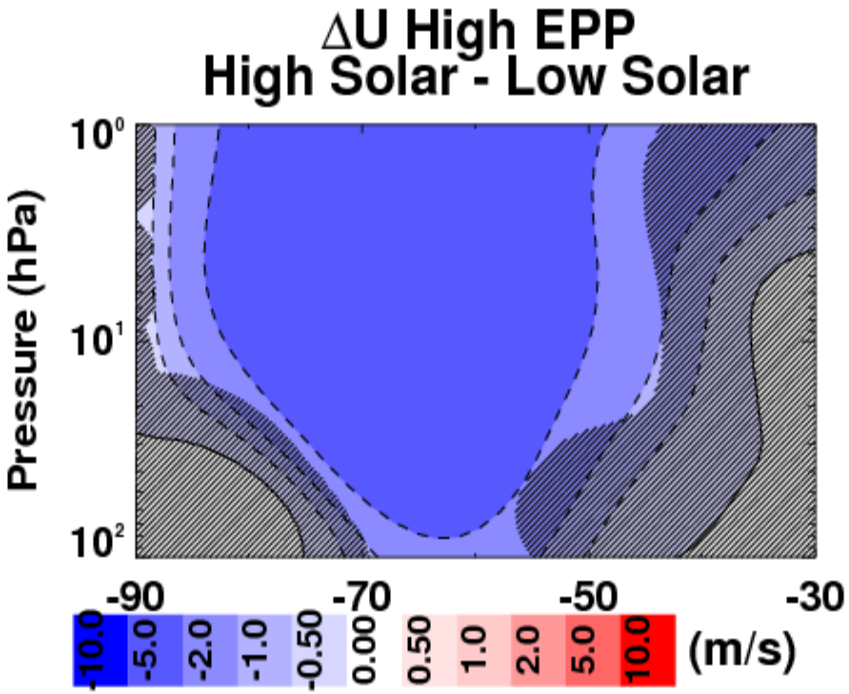


but only for high irradiance

Significant shift in Ubar from Sun

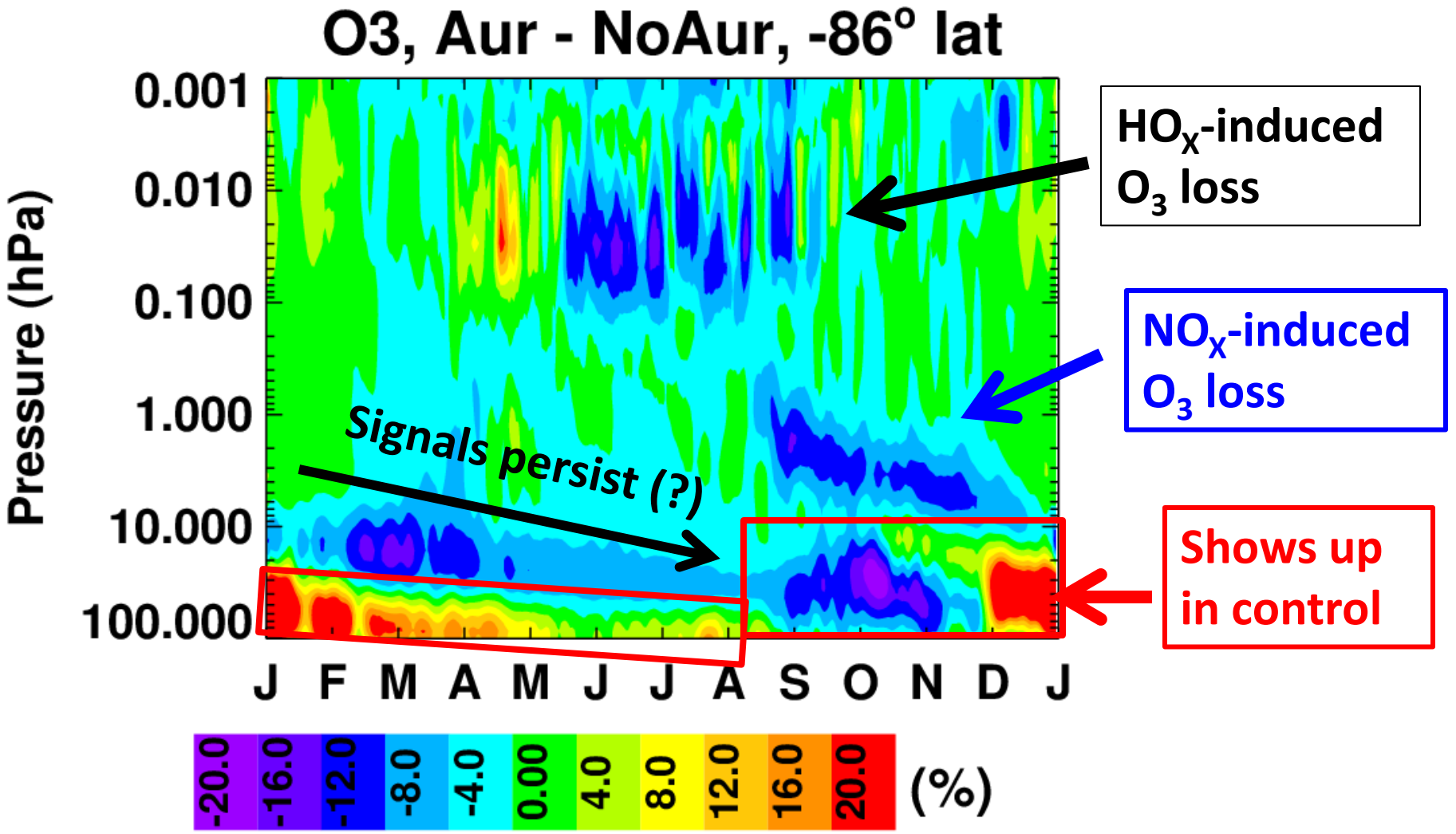
(Poleward of 70S in December)





but only for high EPP

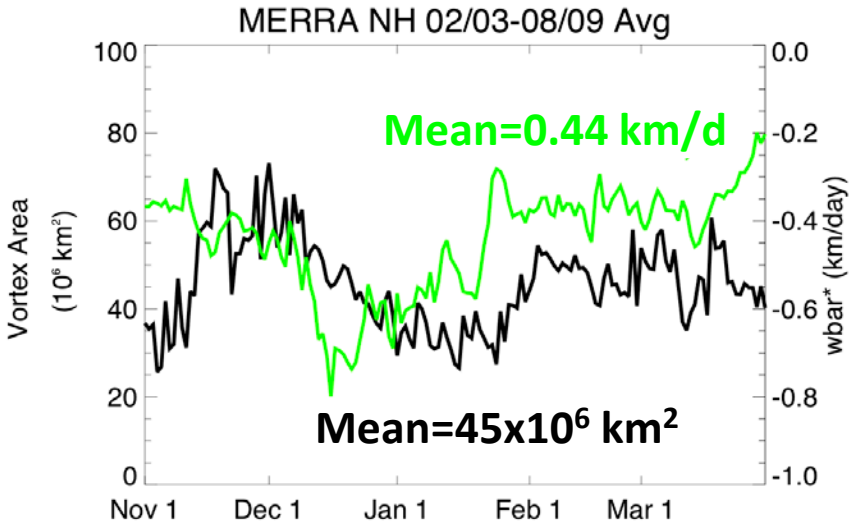
EPP Effects on SH Ozone

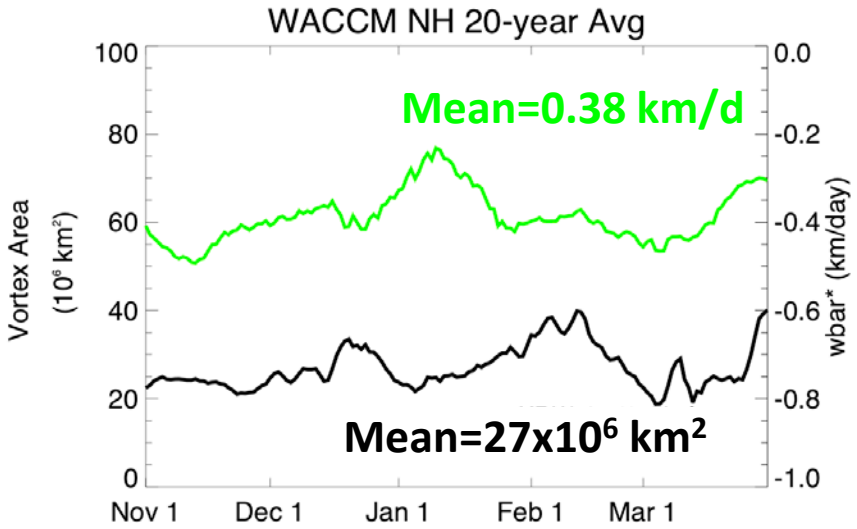


WACCM Dynamics & Transport

(Laura Holt)

Free-running WACCM W_Bar* & Vortex Area at 2000 K in Arctic vs. MERRA from 2003-2008





– MERRA vortex nearly twice as large

– Is there consistent relationship between w_bar* & vortex?

Some Considerations

– What is the best diagnostic for WACCM MLT meteorology?

– Can we use SD-WACCM to constrain the evaluation of MLT parameters?

– What is the best diagnostic for mixing (distinguish from descent)?

– How valid are simple statistical significance tests for free-running WACCM in polar regions?

– Is there a problem with constant, repetitive forcing?

– How should we evaluate (fix?) the persistent SH vortex?

Thanks very much!!