GMI Stratospheric Studies

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1. Ozone Depletion Potential Simulations
2. Experimenting with NO_y loss rate (J-NO)
3. Estimating Arctic Ozone loss in 2011

GMI Stratospheric Studies
Ozone Depletion Potential Simulations

Lifetime estimates of ODSs have not changed since 1998, but atmospheric models have changed dramatically since that time (e.g., improvements in tropical isolation and age of air). Douglass et al. (2007) showed that simulations that produce realistic mean age of air have longer lifetimes that use by WMO to project future evolution of source gases.

We have performed a series of perturbation experiments with the GMI Combo CTM using meteorological fields from the GEOS5-GCM with source gas boundary conditions for 2000. Transport characteristics of the GEOS5-GCM were evaluated in the CCMVal Report and were shown to have realistic mean age of air, tropical isolation, and overall stratospheric circulation. The simulations are run at 2°x2.5^{o} latitude by longitude with 72 vertical levels and a lid near 0.01 hPa.

A 10-yr baseline simulation was run to achieve steady state. Using the final year of the baseline simulation, **a series of perturbation experiments were performed for CFC-11, CFC12, CH3Cl3, HCFC22, CCl4, CFC113, CH4, and N2O to calculate lifetimes and ODPs**. Each experiment perturbed one species by an amount that resulted in a ~0.5-1% ozone change. Simulations were run for 10 years.

GMI Stratospheric Studies
Ozone Depletion Potential Simulations

Lifetimes (yrs) from baseline run

Species	GMI-2000	WMO 2007
F11	65	45
F12	106	100
CH3CCl3	7.5	5.0
HCFC22	17	12
CCl4	59*	26
CFC113	93	85
CH4	13.5	--
N2O	121	114

*GMI does not have the requisite ocean sink for CCl4.

$$ODP_i = \frac{\text{Global O3 loss due to unit mass emission of } ODS_i}{\text{Global O3 loss due to unit mass emission of F11}}$$

ODPs from Perturbation Runs*

Species	GMI-2000	Rel Frac Release Factor	Semi-Empirical	Montreal Protocol
F11	1.0	1.0	1.0	1.0
F12	0.80	0.6	1.0	1.0
CH3CCl3	0.13	1.08	0.12	0.1
HCFC22	0.04	0.35	0.05	0.055
CCl4	1.1	1.06	0.73	1.1
CFC113	0.73	0.75	1.0	0.8
CH4	0.00	--	--	--
N2O	0.011	--	--	--

*Comparisons made with Table 8-1 from WMO 2007.

GMI Stratospheric Studies
Testing J-NO scaled by 0.6

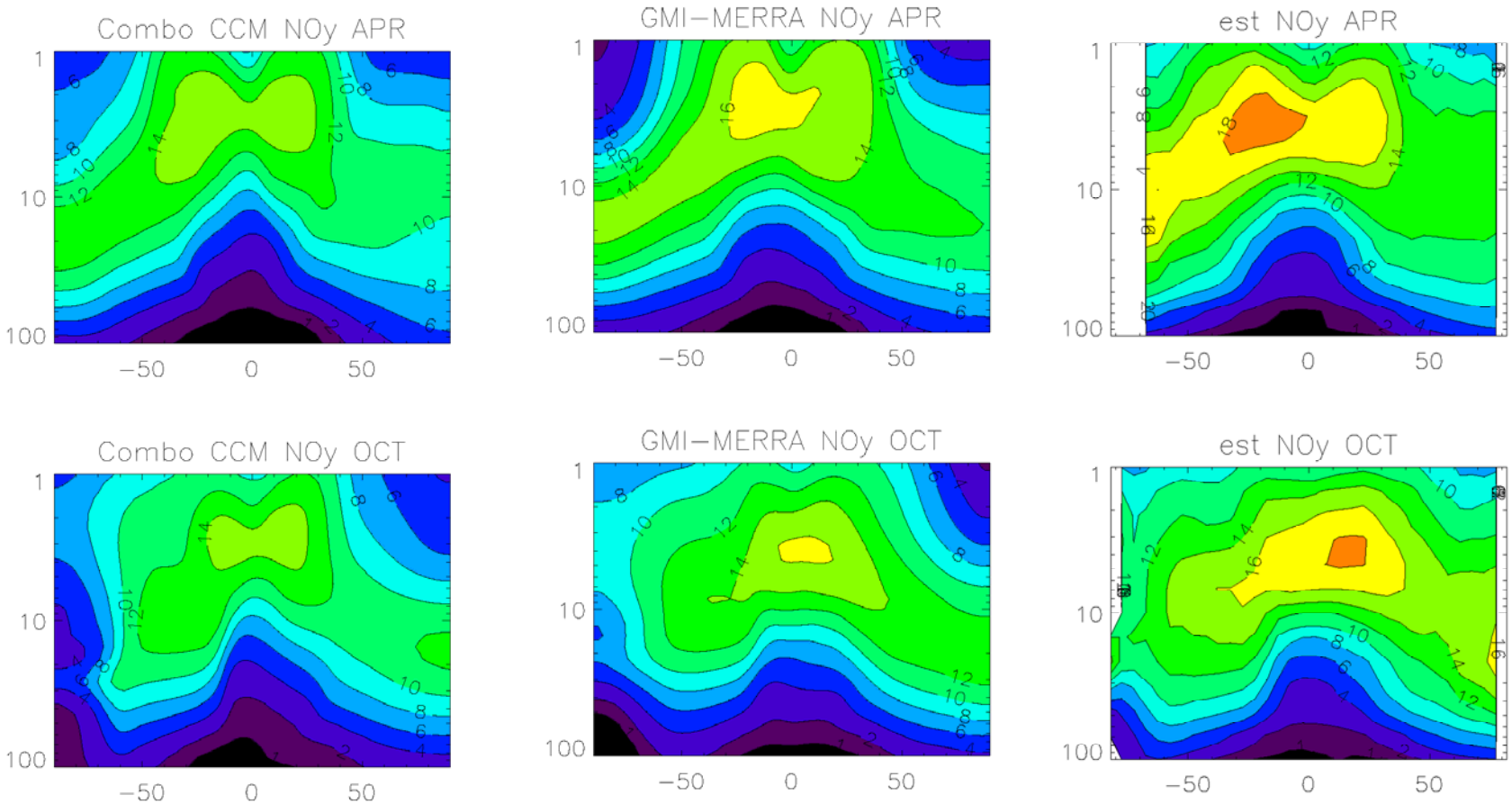
The GMI Combo model and the Combo-GEOS CCM (which uses FAST-JX) both have apparently low NO_y in the upper stratosphere.

Michael Prather recently suggested that J-NO, responsible for NO_y losses, maybe be too large. He recommended reducing it by 0.6.

We have run 3 years of the Combo model with MERRA met fields (2004-2006) to test the effects of reduced J-NO.

I've created an NO_y climatology by combining the Grooss and Russell (2005) HALOE NO_x (sunset) climatology with a 6-yr averaged MLS HNO_3 data set. This accounts for at least 95% of NO_Y for most of the stratosphere, except 10-30 hPa where $ClNO_3$ is important (accounts for only 90-95% there).

GMI Stratospheric Studies
Testing J-NO scaled by 0.6



GEOS-CCM

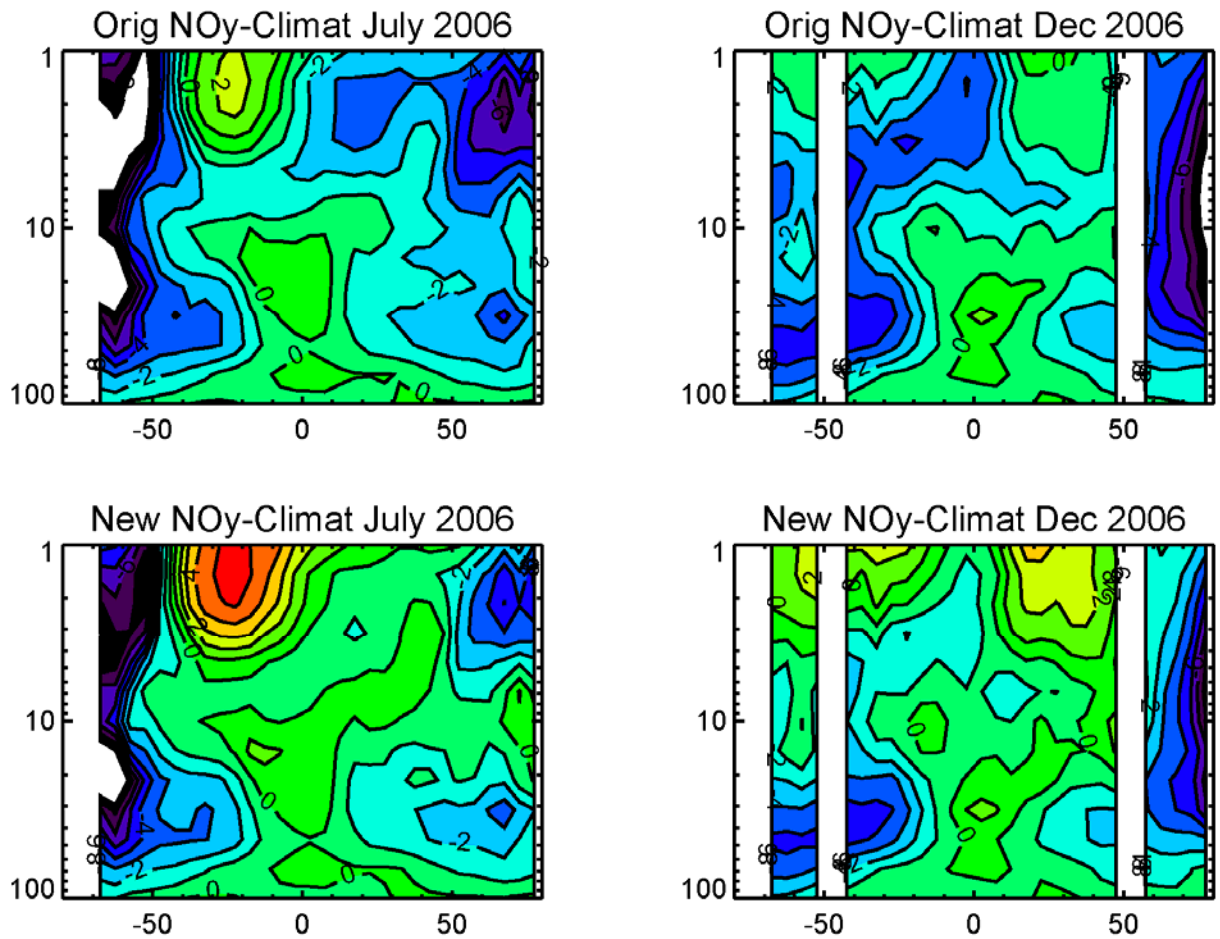
GMI-CTM

Obs Noy (NOx+HNO3)

GMI Stratospheric Studies
Testing J-NO scaled by 0.6

Original

New J-NO

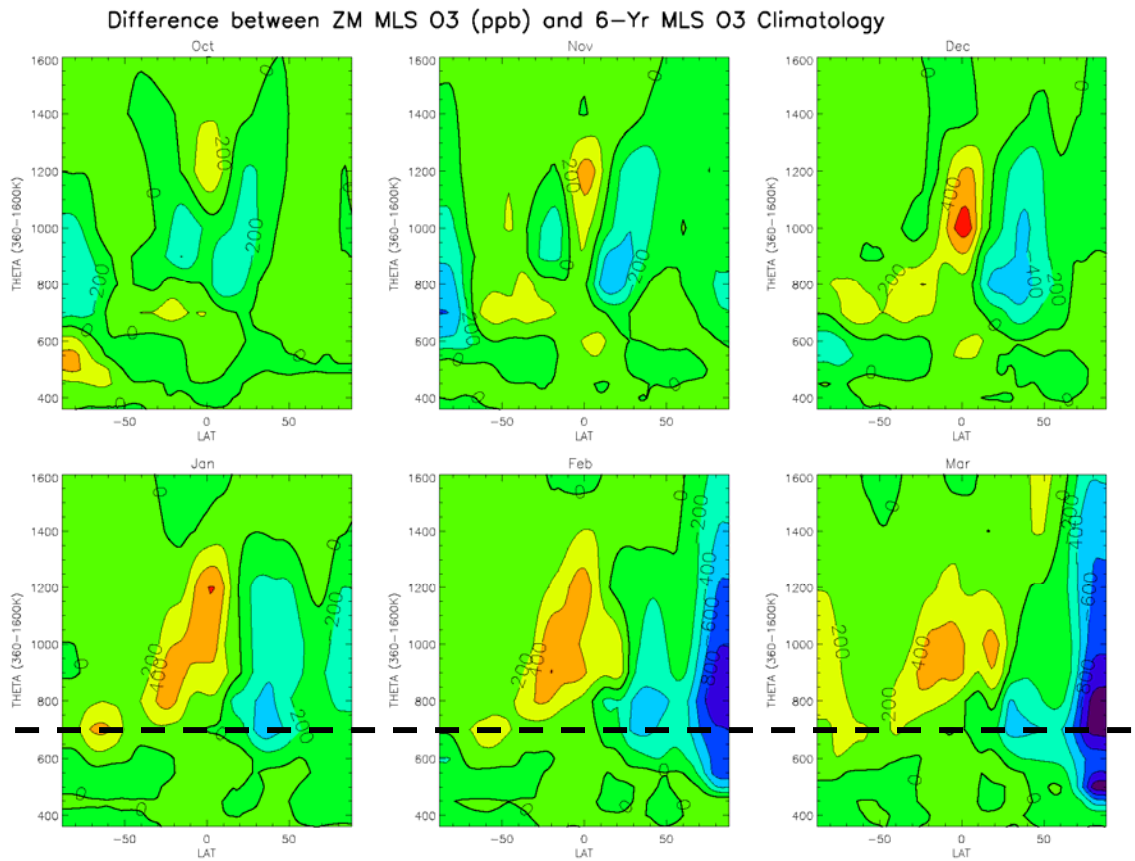


Model - 'Obs' nearly 3 years into the test run. NO_x +HNO_3 Only.

Better? Overall, yes. May need another 3 years to see the full effect.

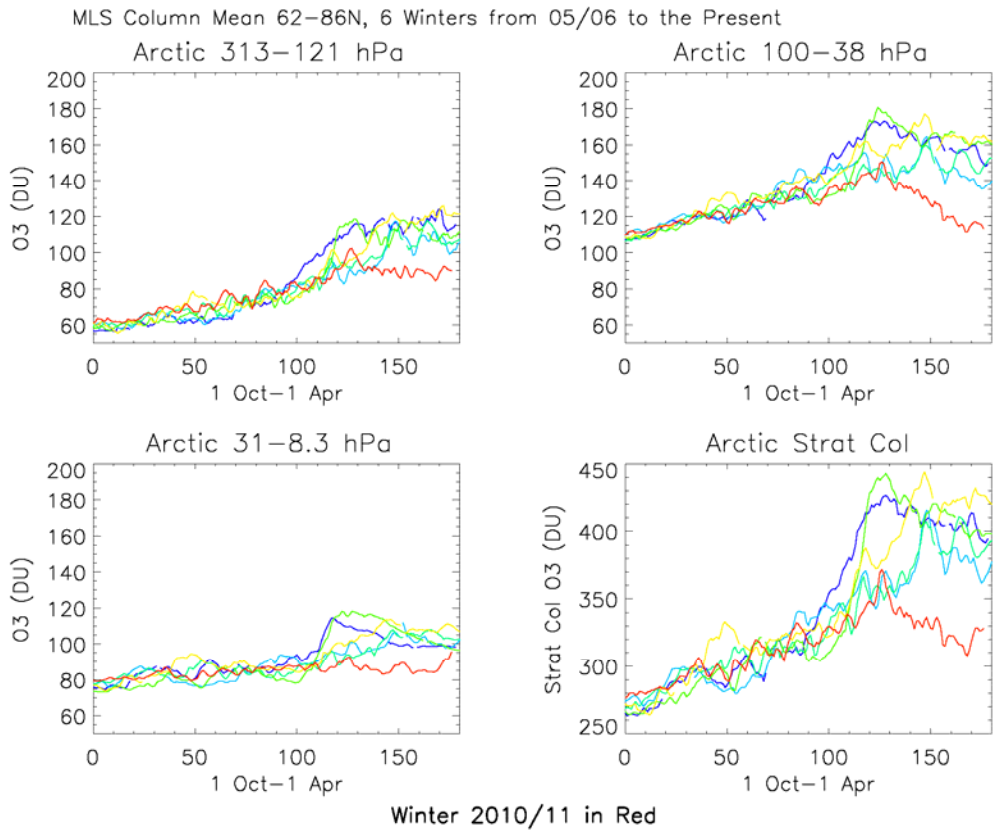
GMI Stratospheric Studies
Estimating Arctic O_3 losses in 2011

Why are O3 columns <u>above</u> the region of PSC losses so low in 2011?



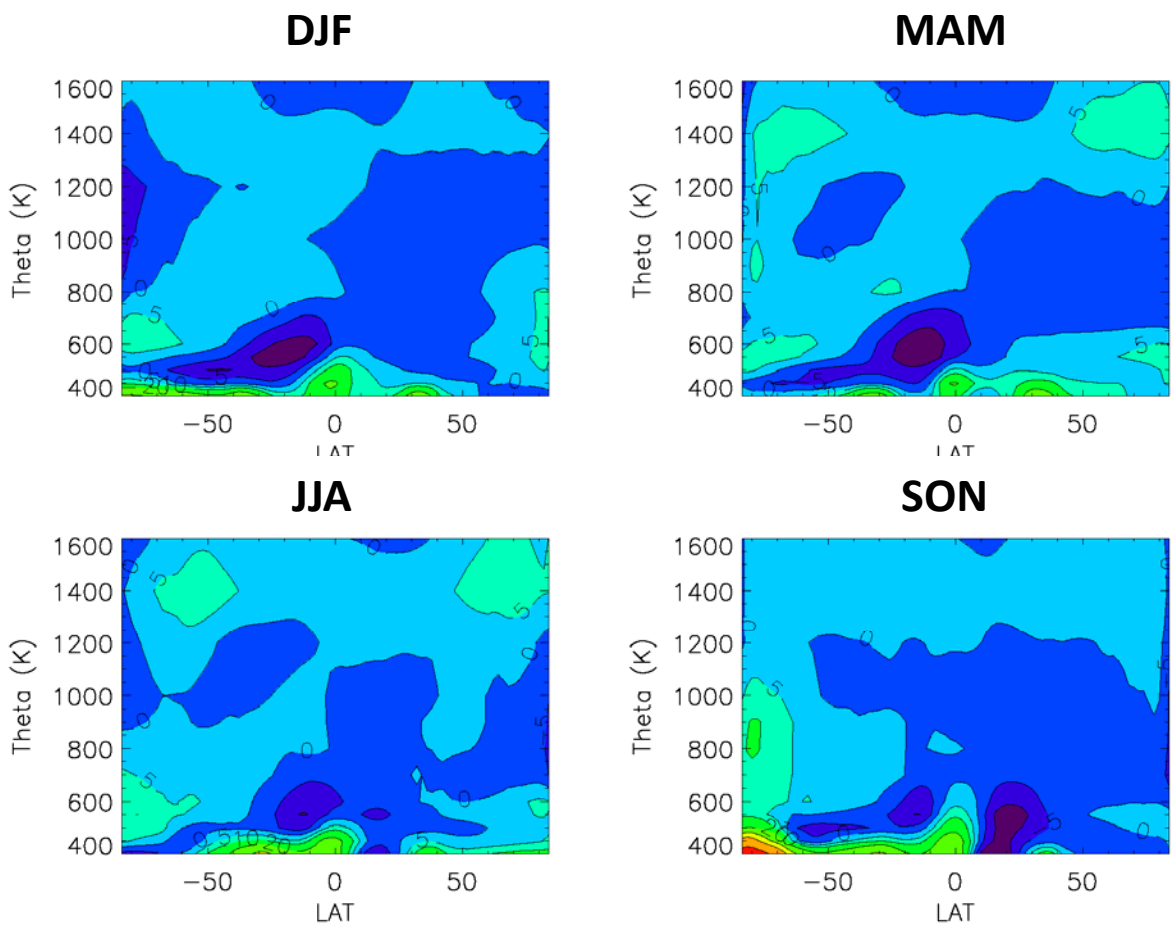
Max. level of PSC activity (~700K)

Manish tanah? (Why is year different from all other years?)
Here are 6-month time series from Aura MLS -6 fall/winter seasons, starting with fall 2005 (dark blue) and ending with fall 2010 (red)



Seasonal mean stratospheric O_3 Percentage Difference, GMI_MERRA-MLS, averaged over 6 yrs (Sep 2004-Aug 2010)

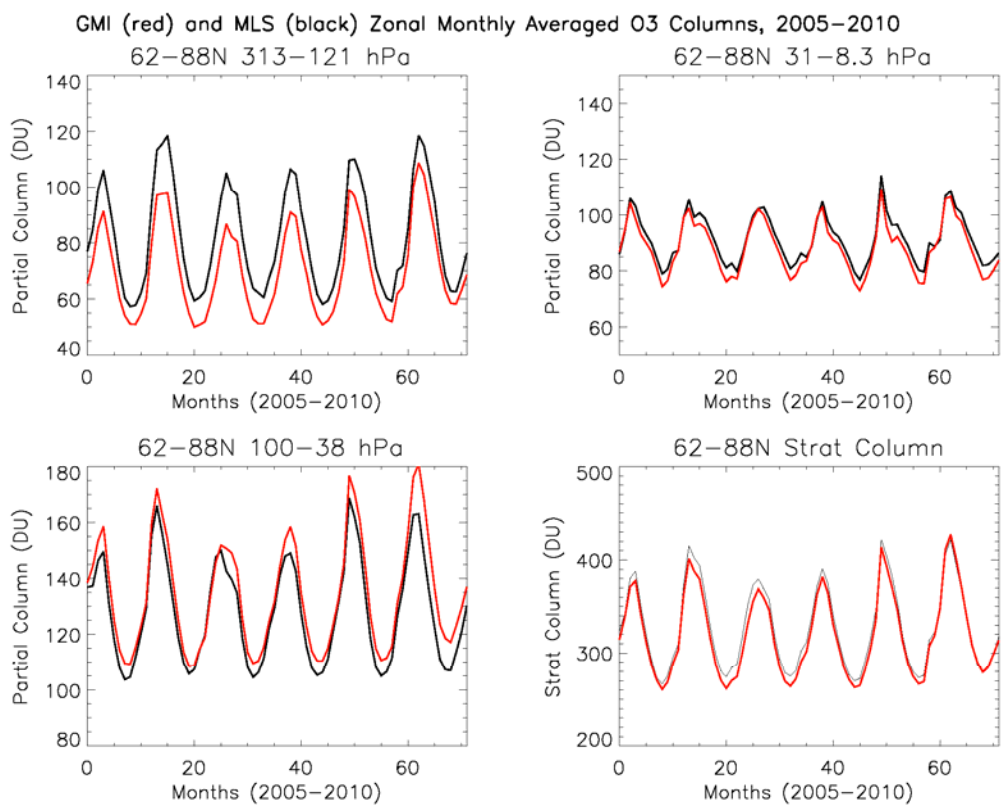
Each interval is 5%



Zonal monthly mean Arctic O3 columns for 6 years.
The stratospheric column agreement is better than 3%.

MLS (black)

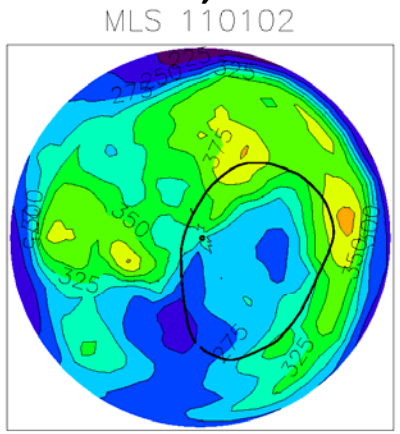
GMI (red)

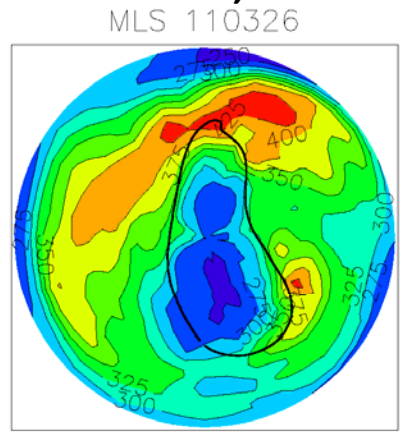


MLS and GMI Strat O3 columns, Jan 2 and Mar 26, 2011.
Black curve is the vortex edge on the 500K surface.

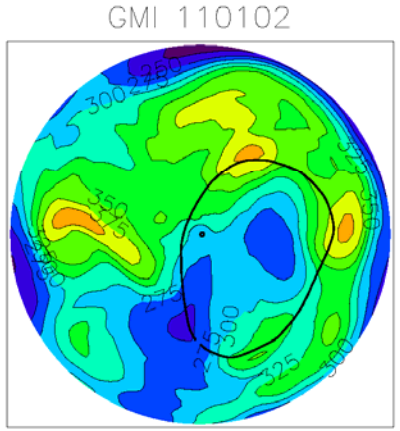
Jan. 2, 2011 | **March 26, 2011**

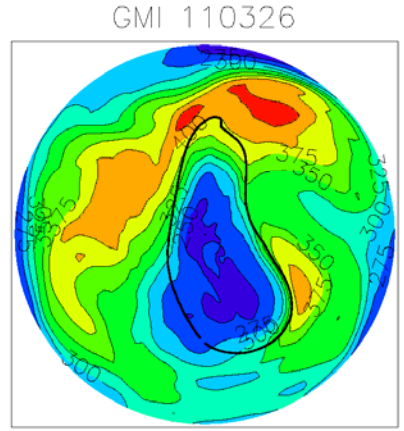
MLS



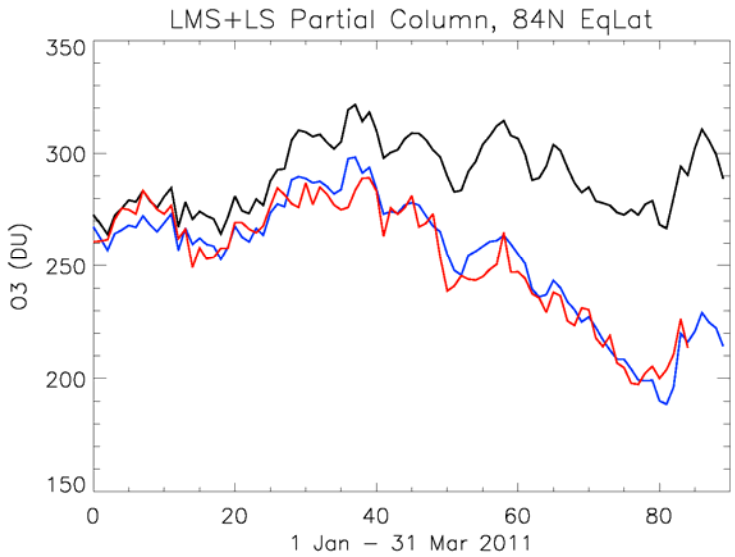


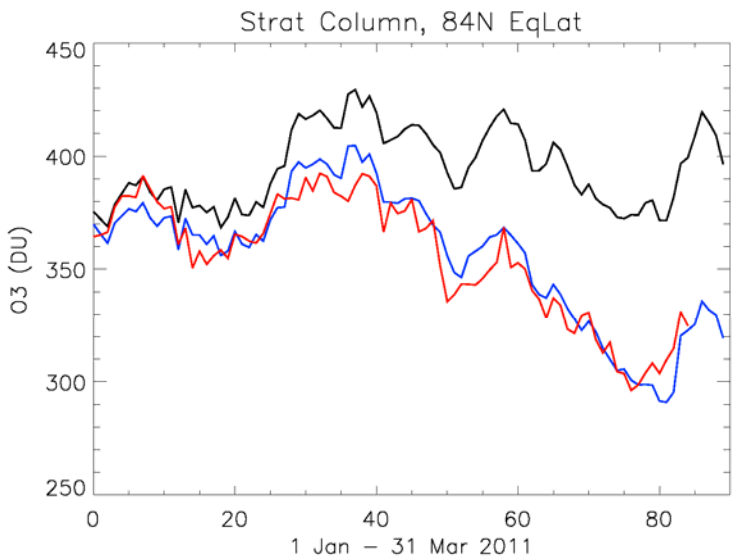
GMI





MLS RED, MERRA BLUE, 'NO_HET' BLACK





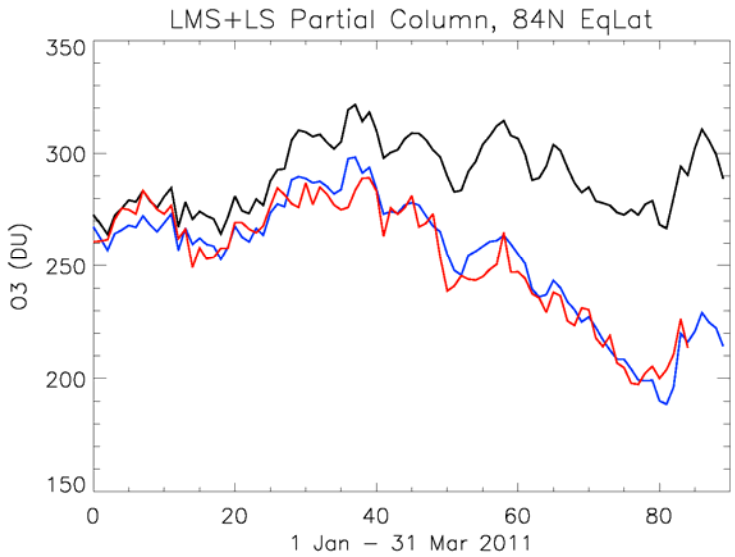
1 Jan – 31 Mar 2011

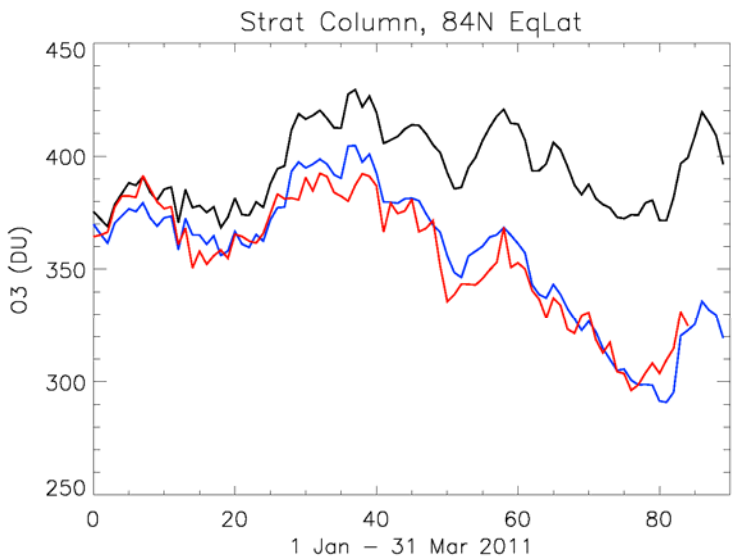
These time series show the 313-38 hPa and total strat columns from 1 Jan-31 Mar 2011. MLS and GMI O3 on pressure levels were first converted to equivalent latitude, then columns were calculated. These are time series at 84N equivalent latitude, well inside the vortex at all dates.

Red curve is MLS data.
Blue curve is MERRA. VERY close agreement.

Black curve is GMI with heterogeneous reactions turned off. The difference between the black and blue curves is the column amount of chemical O3 loss at 84N. **Maximum column loss inside the vortex is about 80 DU.**

MLS RED, MERRA BLUE, 'NO_HET' BLACK





1 Jan – 31 Mar 2011

Seems like a great result but we know from comparison with MLS N_2O that descent deep inside the model vortex is not strong enough in early winter.

(May be related to the O3 biases in the LS and LMS.)

We are concerned the cause is the large (3°) polar cap in the advection core. It averages all tracer values within the cap.

How to get around this? Run Replay which has a newer advection core than GMI and smaller cap.