Transport Behavior of GEOS4-DAS & GEOS5-DAS in the GMI CTM and the GEOS5 "Replay" Mode

I. The GEOS5-DAS Transport Characteristics

- In the GMI CTM, how does GEOS5-DAS stratospheric transport compare to GEOS4-DAS?

II. Different ways to run Combo Chemistry simulations: GMI CTM and GEOS5-Replay

- What is 'Replay' Mode and how does its transport compare to the CTM?

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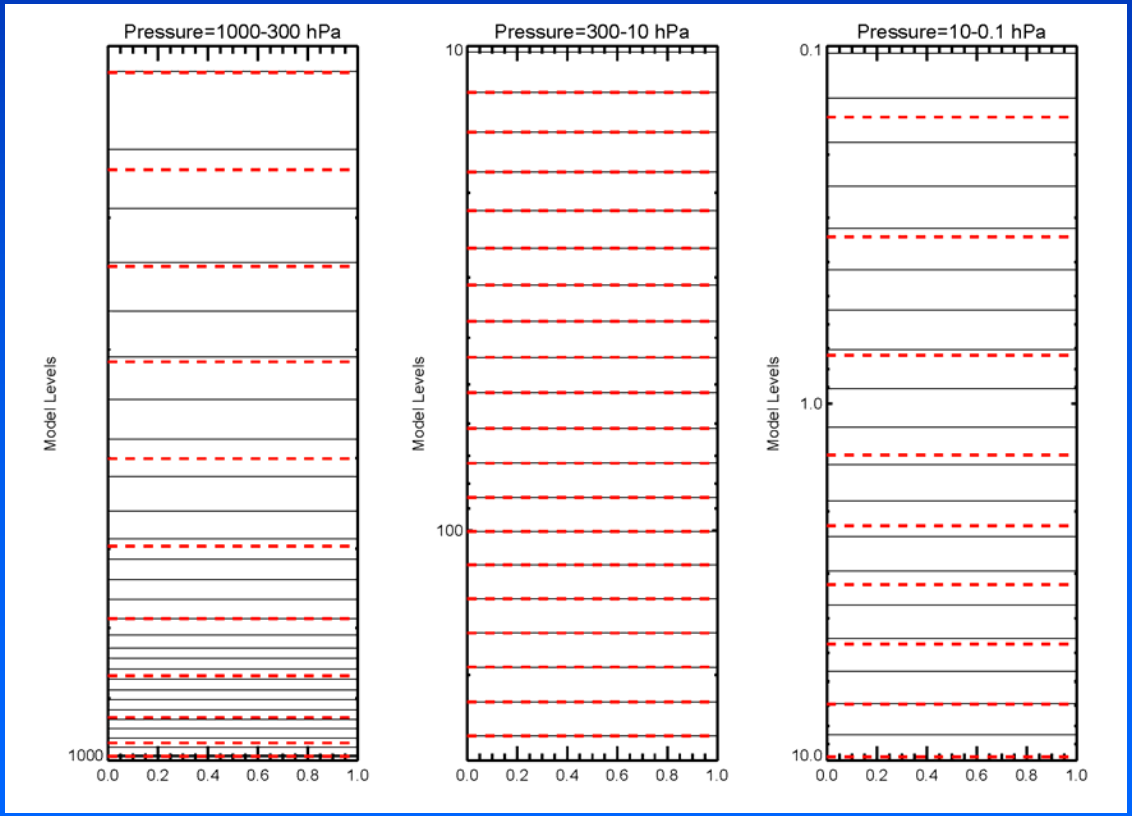
GMI Science Team Meeting, May 11, 2009

GEOS4-DAS:
Original: 1° x 1.25° x 55 levels
Regridded: 2° x 2.5° x 42 levels

GEOS5-DAS
Original: 0.5° x 2/3° x 72 levels
Regridded: 2° x 2.5° x 72 levels

Vertical Level Comparison

Troposphere	UT/LS	Upper Strat/Meso
1000-300 hPa	*300-10 hPa*	*10-0.1 hPa*



28 vs. 11	20 vs. 20	24 vs. 11

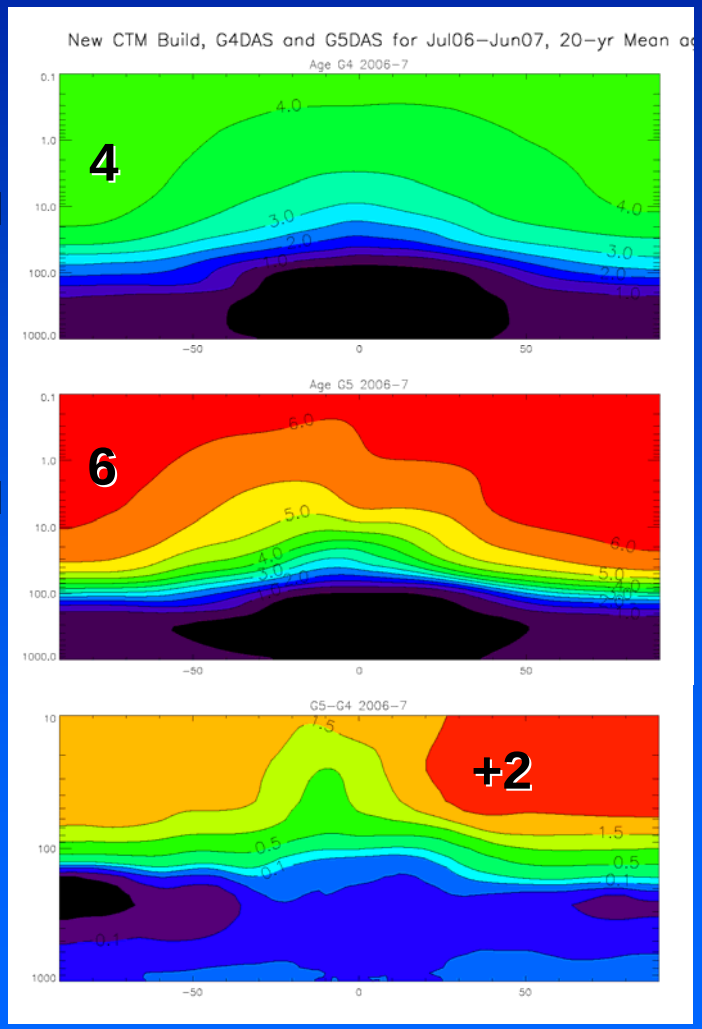
The most basic test of transport: Age Tracer Experiment

Mean Age of G4-GMI & G5-GMI and their difference (G5-G4)

G4-GMI

G5-GMI

G5-G4



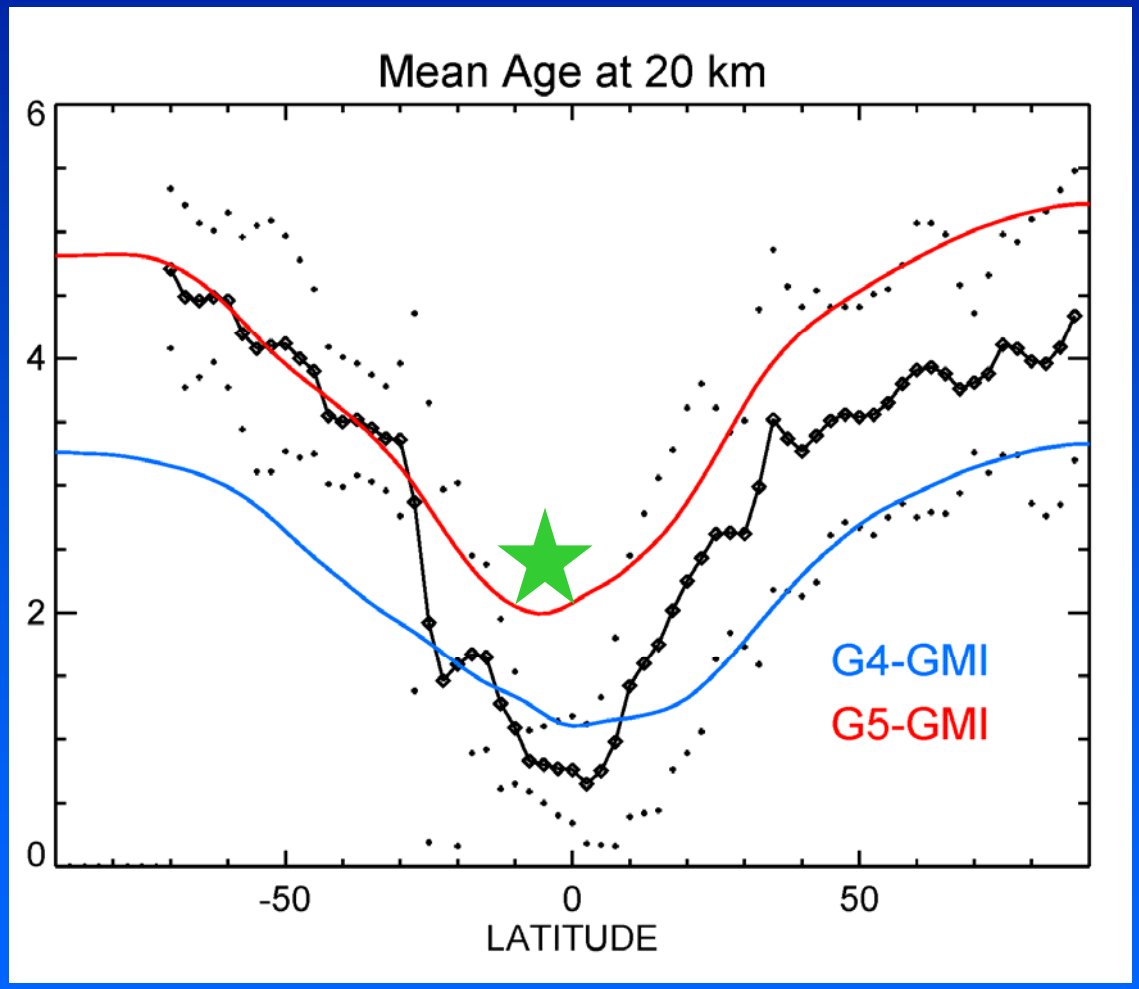
G5-GMI is much older than G4-GMI (*up to 2 years*!), and also much older than G5GCM (not shown). *This raised a red flag for me.*

We have verified that these differences are NOT caused by:

1) Changes in the CTM build
2) GMAO regridding routines used to reduce the horizontal resolution from 0.5x0.67 to 2x2.5.

Therefore, these age differences appear to be intrinsic differences in G4DAS and G5DAS meteorology.

Reality Check: Mean Age from aircraft CO_2 at 20 km

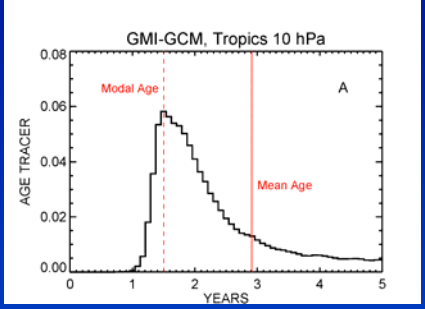


★ G5-GMI Tropical Mean Age is way too old

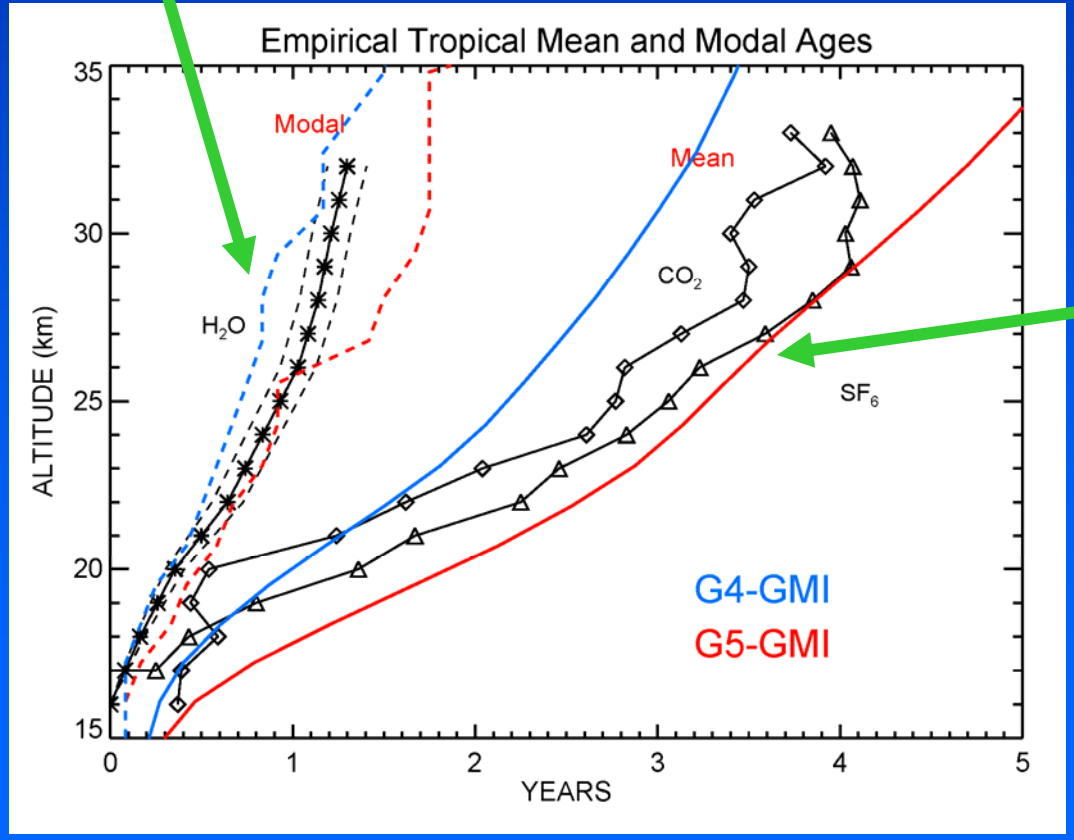
Subtropical Age gradients indicate strength of circulation – slightly slower in G5-GMI.

Gradients less steep than observed may mean the ascent is too fast.

Another Reality Check: Mean and Modal Age in the Tropics



Modal Age (ascent rate): Slower in G5, much slower than observed above 26 km.



Mean Age of G5 is older than observed and much older than G4 . This means G5 subtropical mixing is MUCH stronger than G4.

The G5 mean age at 20 km is too old because there is too much mixing of old, midlatitude air into the tropics. Above 26 km, air is too old in part due to slow ascent.

Comparisons with Observations: O_3 and N_2O

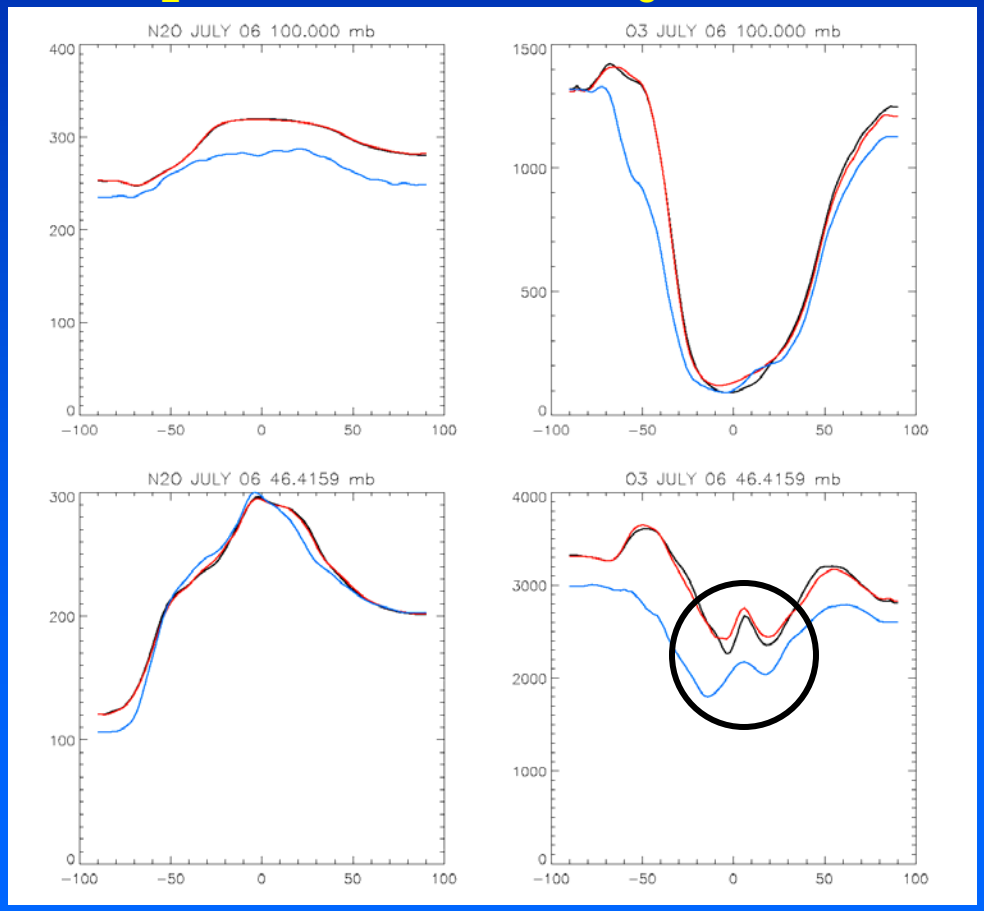
MLS (blue) and G4-GMI (black) and G5-GMI (red)

N_2O vs. Lat

O_3 vs. Lat

100 hPa

46 hPa



This is July 2006, 100 and 46 hPa.

G4 and G5 produce nearly identical results in the GMI CTM.

Both met fields show O_3 'bumps' at 46 (also 31 mb). Often much bigger than MLS.

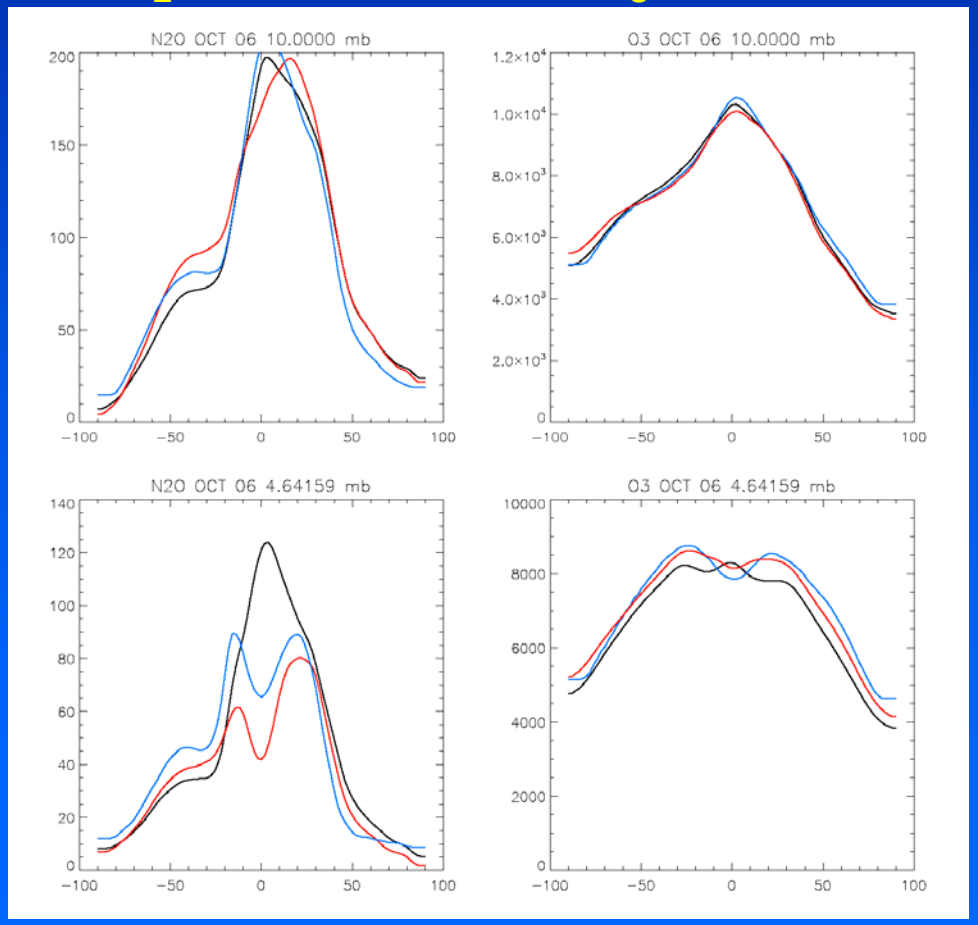
Comparisons with Observations: O_3 and N_2O

MLS (blue) and G4-GMI (black) and G5-GMI (red)

N_2O vs. Lat O_3 vs. Lat

10 hPa

4.6 hPa



This is Oct 2006, 10 and 4.6 hPa.

At 10 hPa there are slight differences, neither is obviously better than the other.

At 4.6 hPa, N_2O is much improved. The G5DAS is trying to capture real structure (SAO?). G5 O_3 is slightly better too. Maybe higher vertical resolution in G5 is helping.

II. A new kind of off-line simulation: GEOS5-Replay

What is GEOS5-Replay?

It's simulation tool built by the GMAO.

It has online chemistry (Combo) that interacts with the meteorology but the chemistry does not feedback on the meteorology.

It uses a forecast model (i.e. GCM) and reads in archived meteorological analyses from the GEOS5 assimilation.

The Replay model computes meteorological fields by deriving increments from the analyses to apply to the forecast. These are the met fields 'felt' by the chemistry.

Chemistry calculated online in Replay is able to 'react' to meteorology that is updated every 30 min, unlike in the CTM where met fields are updated every 3 or 6 hours.

How does a Combo-Replay simulation compare to a GMI-Combo-CTM simulation?

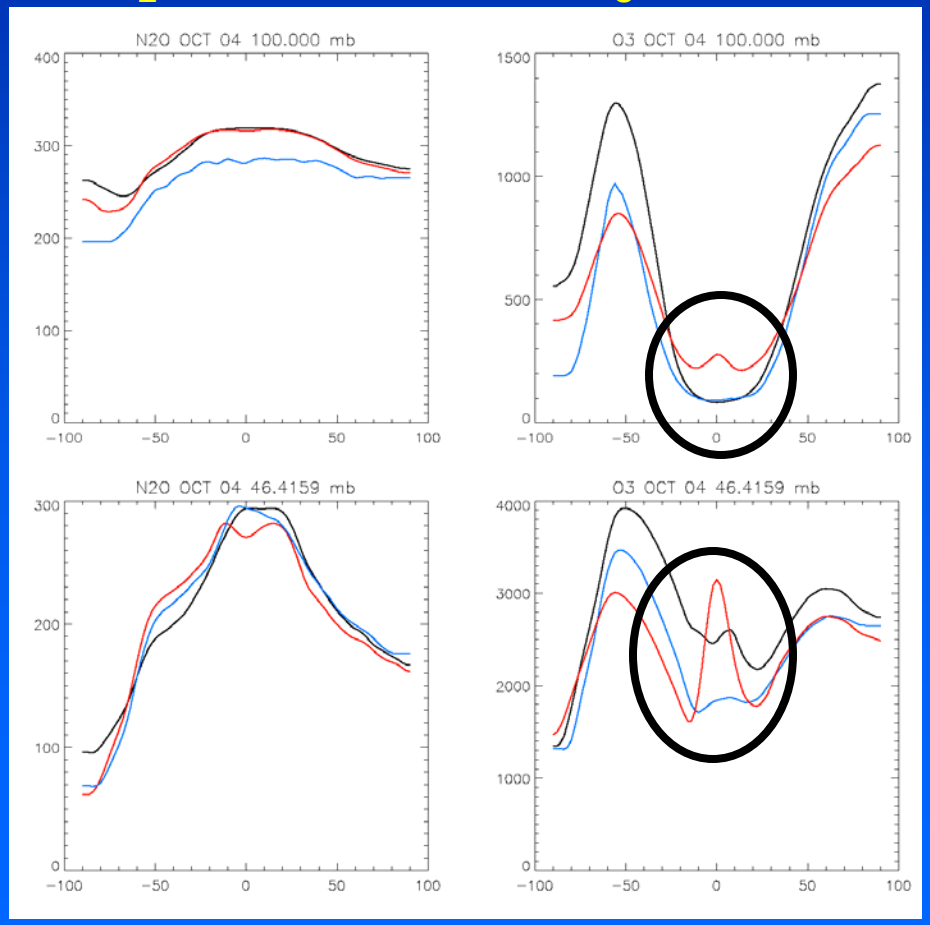
Comparisons with Observations: O_3 and N_2O

MLS (blue) and G4-GMI (black) and G5-Replay (red)

N_2O vs. Lat O_3 vs. Lat

100 hPa

46 hPa



This is Oct 2004, 100 and 46 hPa.

While the G4-GMI and MLS O_3 show a little bump in the tropics (46 hPa), the G5-Replay has a large one. This behavior can be seen in most months.

G5-Replay N_2O shows differences but no obvious pathologies.

Comparisons with Observations: O_3 and N_2O

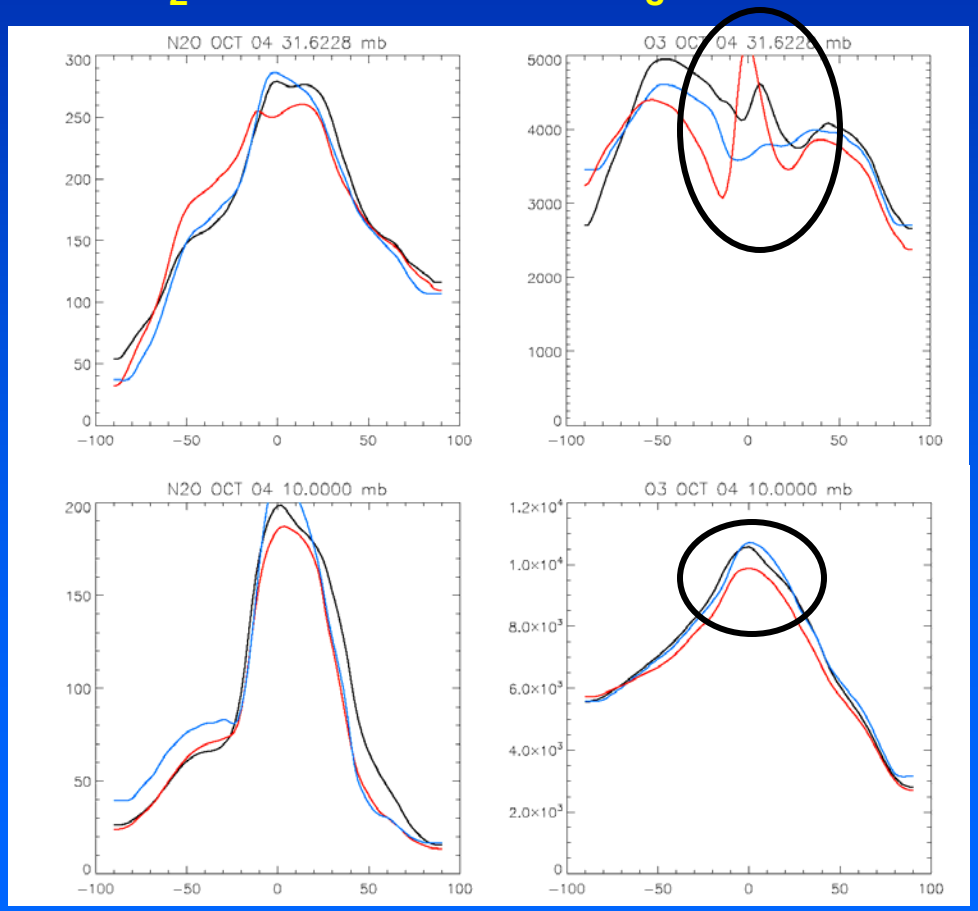
MLS (blue) and G4-GMI (black) and G5-Replay (red)

N_2O vs. Lat

O_3 vs. Lat

31 hPa

10 hPa



This is Oct 2004, 31 and 10 hPa.

As in the previous slide, MLS and G4-GMI O_3 show a little bump in the tropics (31 hPa), but the G5-Replay has a large one. Replay O_3 is low by ~1 ppm at 10 hPa.

At 31 hPa, G5-Replay N_2O looks less like MLS than G4-GMI. At both levels the G5-Replay is low in the tropics.

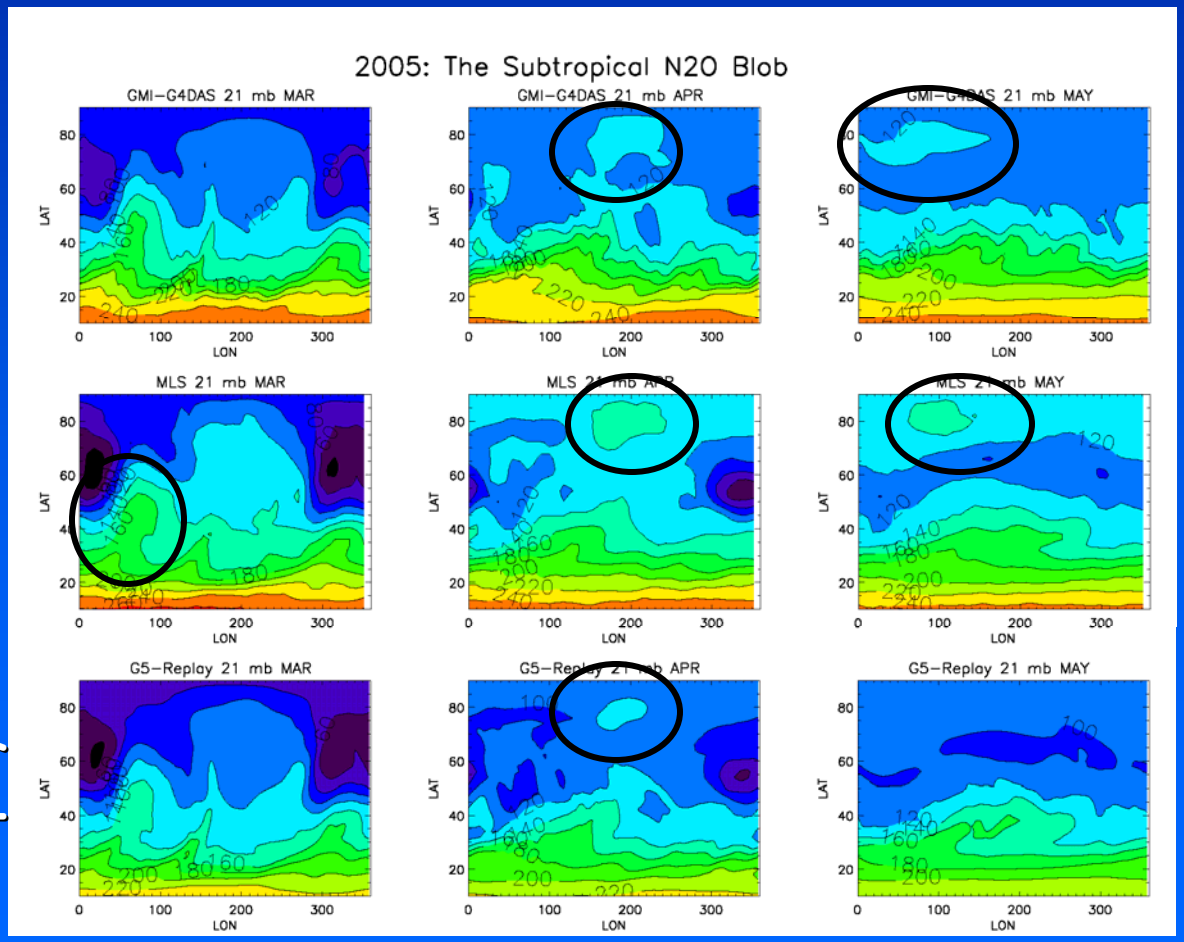
Another Reality Check: A large blob of subtropical air (high N_2O) split off from the subtropics in Mar 2005 and traveled to the pole. It remained there, undissipated, until August (according to MLS N_2O measurements).

21 mb: MAR, APR, and MAY

G4-GMI

MLS

Replay



There is only monthly mean output available (not ideal).

MLS shows persistant blob of high N_2O near the pole, even in the monthly mean.

G4-GMI at least still has a blob (it lasts til early July).

G5-replay shows no evidence of high N_2O near the pole by May.

What I conclude:

N_2O and O_3 in the G5-GMI hardly look different from G4-GMI, except that above 10 hPa, N_2O looks BETTER – probably due to higher vertical resolution.

BUT…the mean age and age spectra say that transport is quite different in G5-GMI! The comparisons with mean and modal age aren't good. There is too much mixing into the tropics. It's possible that a 1-yr combo simulation was not long enough to show these effects in a long-lived tracer (N_2O) in the LS.

GEOS5-Replay messes up tropical O_3. Replay transport does not look as good as the time-averaged GEOS5 met fields in the GMI CTM.

Replay transport in the extratropical stratosphere is more dissipative – the high N_2O blob transported from the subtropics doesn't persist nearly as long as it does in the G4-GMI CTM run.

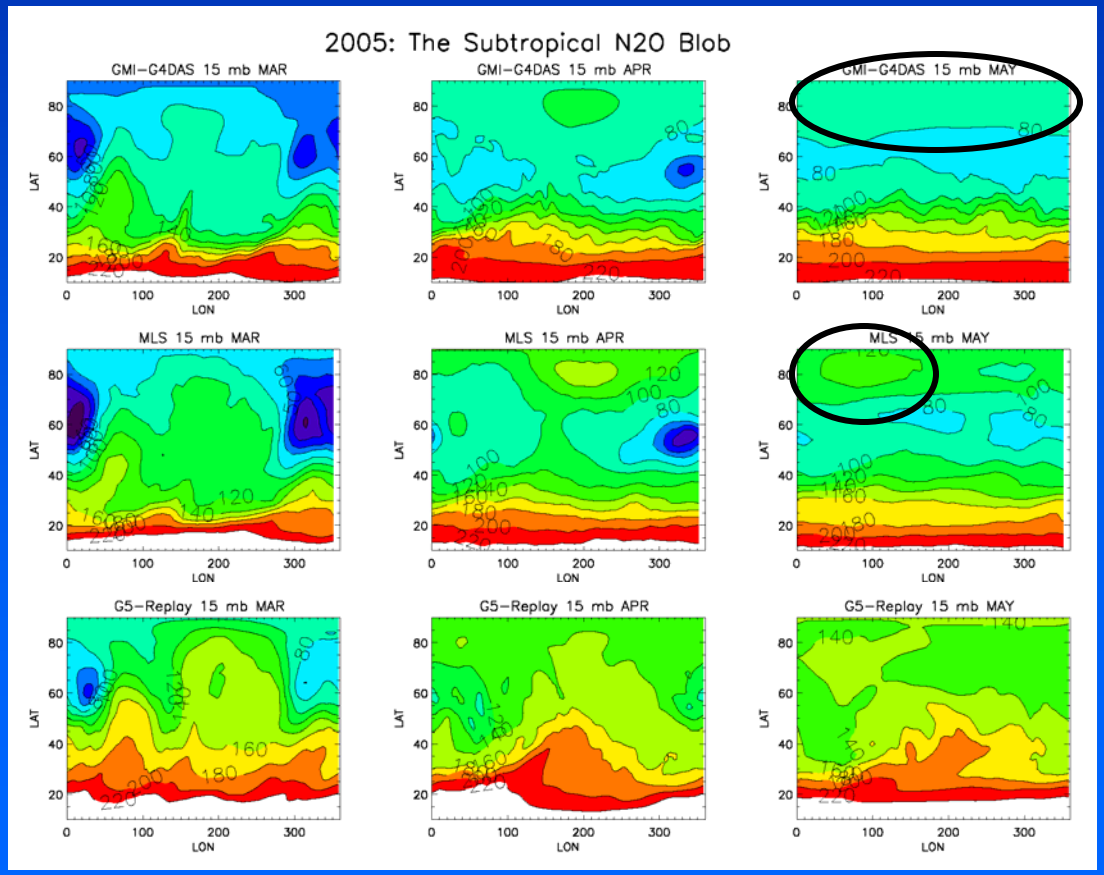
A large blob of subtropical air (high N2O) split off from the subtropics in Mar 2005 and traveled to the pole. It remained there, undissipated, until August (according to MLS N2O measurements).

15 mb: MAR, APR, and MAY

GMI-G4

MLS

Replay



There is only monthly mean output available (not ideal).

MLS shows persistant blob of high N2O near the pole, and a reversed gradient from 50-90N.

G4DAS also shows the reversed gradient.

G5-replay shows no evidence low N2O 40-60N with higher N2O 60-90N.