HIRDLS Observations of Mixing of Tropospheric Air Into The Lower Stratosphere (HIRDLS - the secret's out!)

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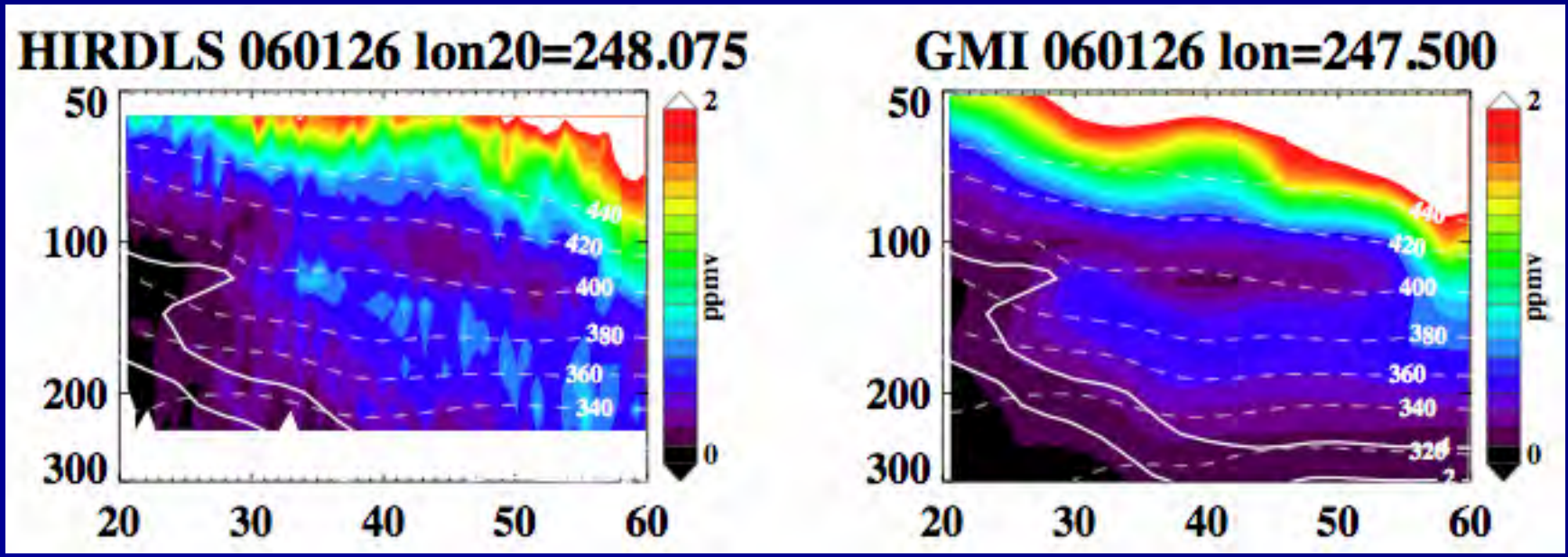
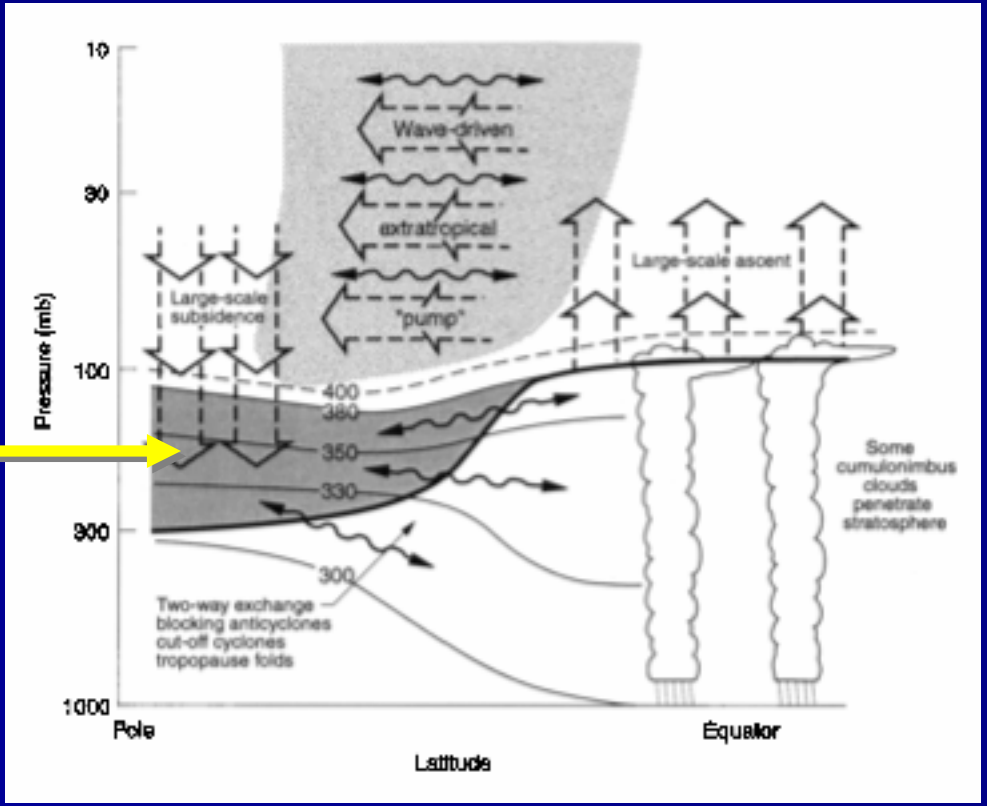
Inspiration!



LMS and General Circulation

Lowermost Stratosphere (LMS)



Holton et al., 1995

Prior Work

- Randel et al.1993 - CLAES N_2O and H_2O (1100 K)
- Trepte et al. 1993 - dispersion of Pinatubo aerosol
- Waugh et al. 1996- isentropic contour advection (425K)

- Limited satellite observations at this altitude
- Limited information (theory or observed) about the vertical extent of transport.
- Net impact (reversibility?)

Quasi-Horizontal Poleward Transport

425 K
(Just above LMS)

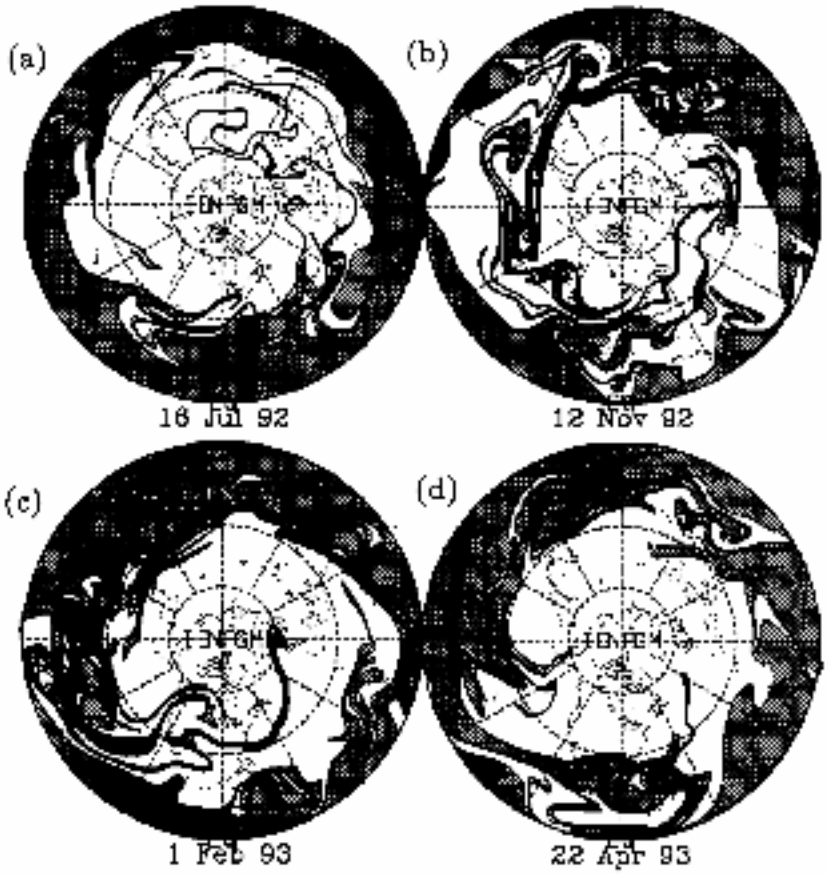


Figure 11. As in Figure 2, except for the 425 K surface. Calculations were started 15 days before (a) July 16, 1992, (b) November 12, 1992, (c) February 1, 1993, and (d) April 22, 1993.

Waugh, 1996 (Isentropic Contour Advection)

- Rossby wave breaking transports air polewards
- Rossby wave propagation is blocked by easterlies
- Studies suggest transport in relatively thin layers

HIRDLS and GMI

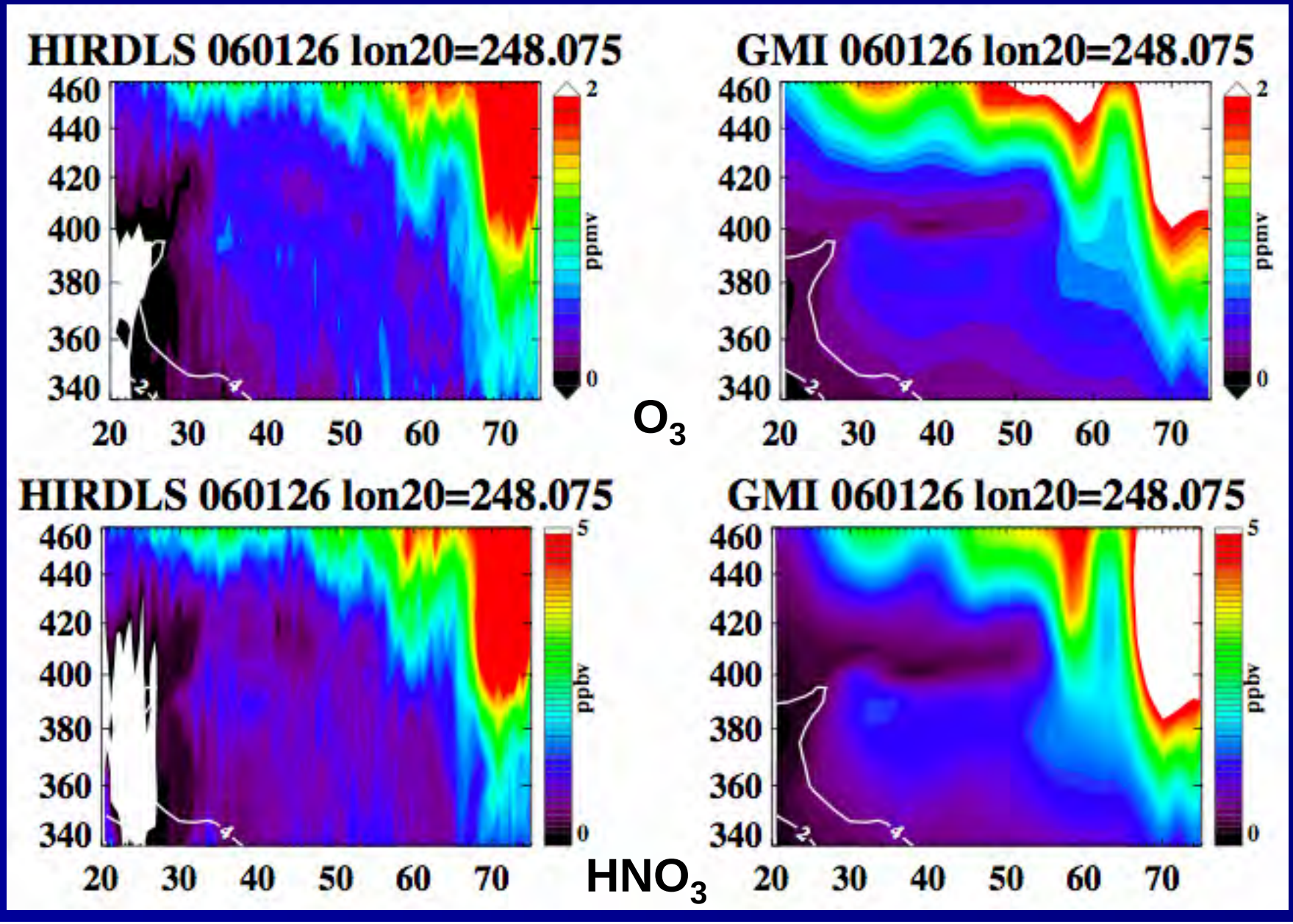
HIRDLS:

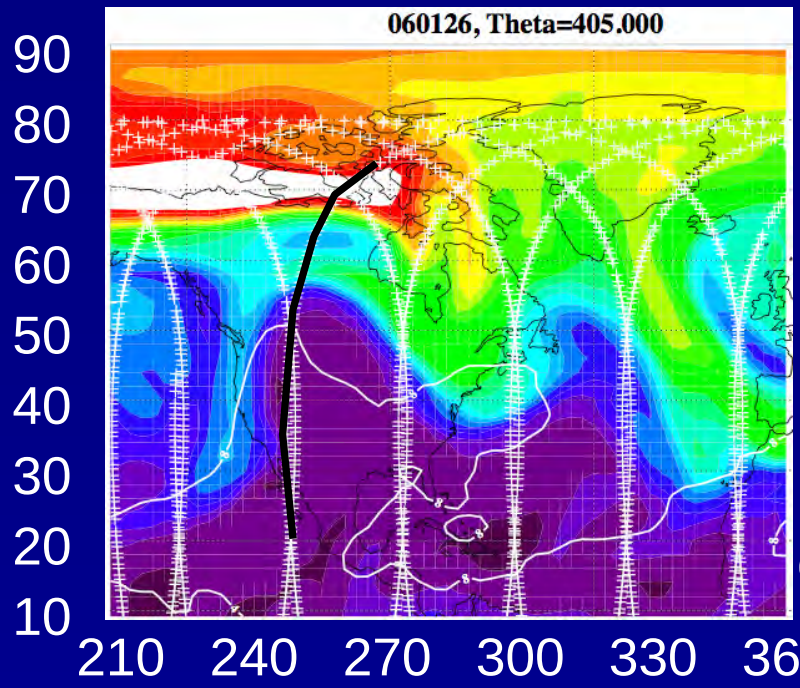
- Vertical profiles; ~ 1 km vertical resolution
- ~65 km along-track resolution
- ~ 14 orbits/day
- Currently available: O_3, HNO_3, temperature, cloud top pressure

GMI Combo:

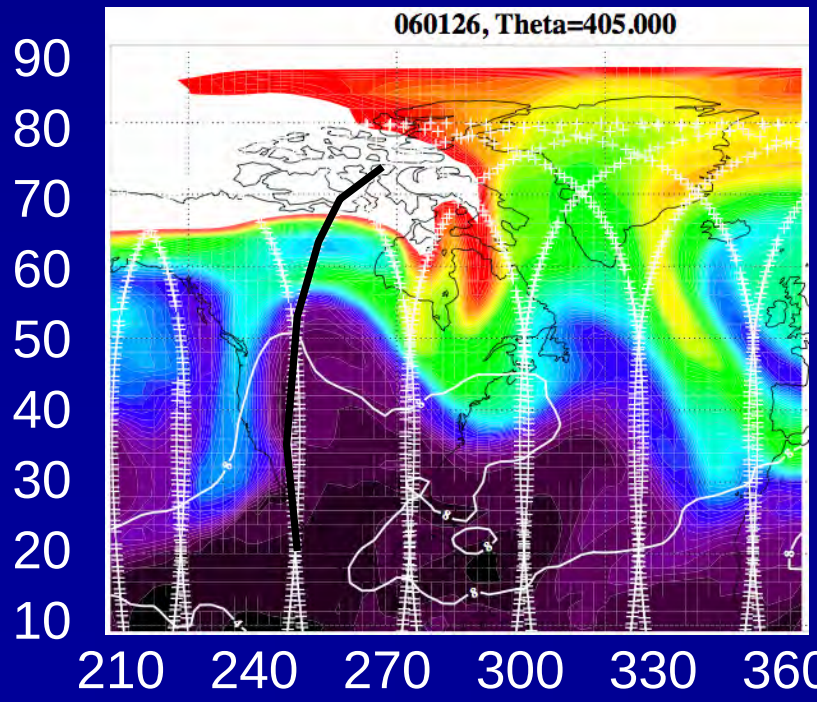
- Both stratospheric and tropospheric chemistry
- GEOS-4 DAS (time-averaged)
- ~ 1 km vertical resolution in the UTLS
- 2° x 2.5° horizontal resolution

January 26, 2006





Ozone

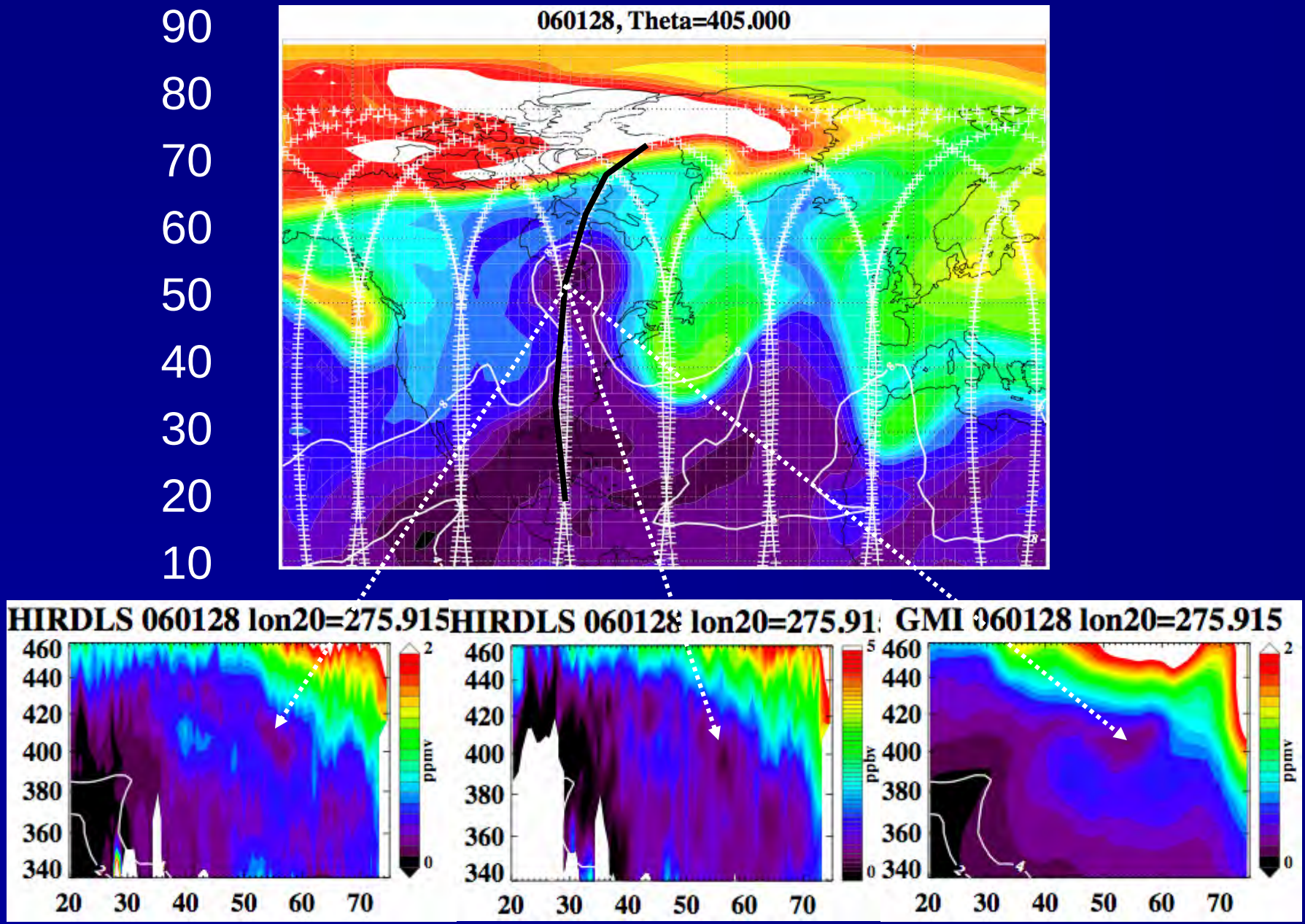


HNO_3

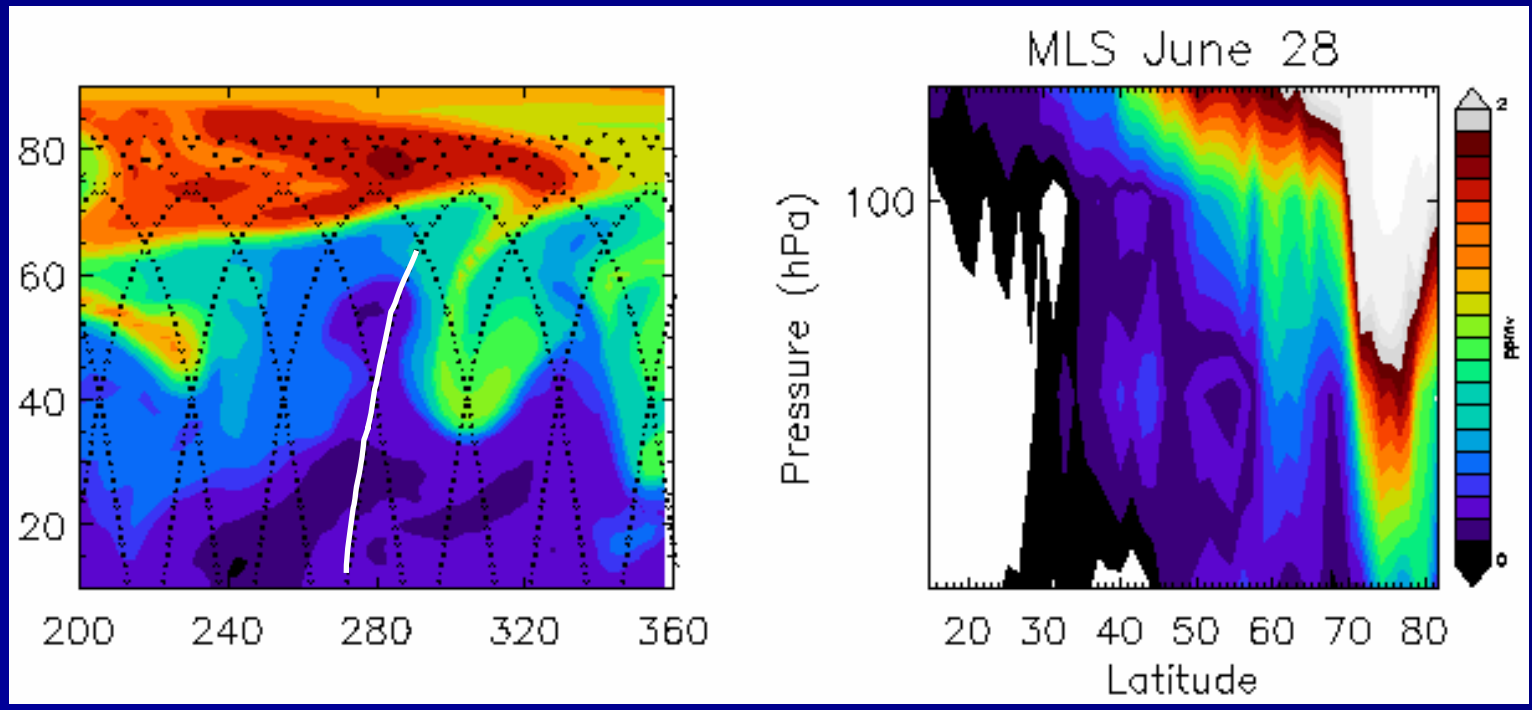
Ozone maps from the GMI simulation

- identify the HIRDLS orbit from the previous slide
- initiation of transport of low ozone air from the tropics

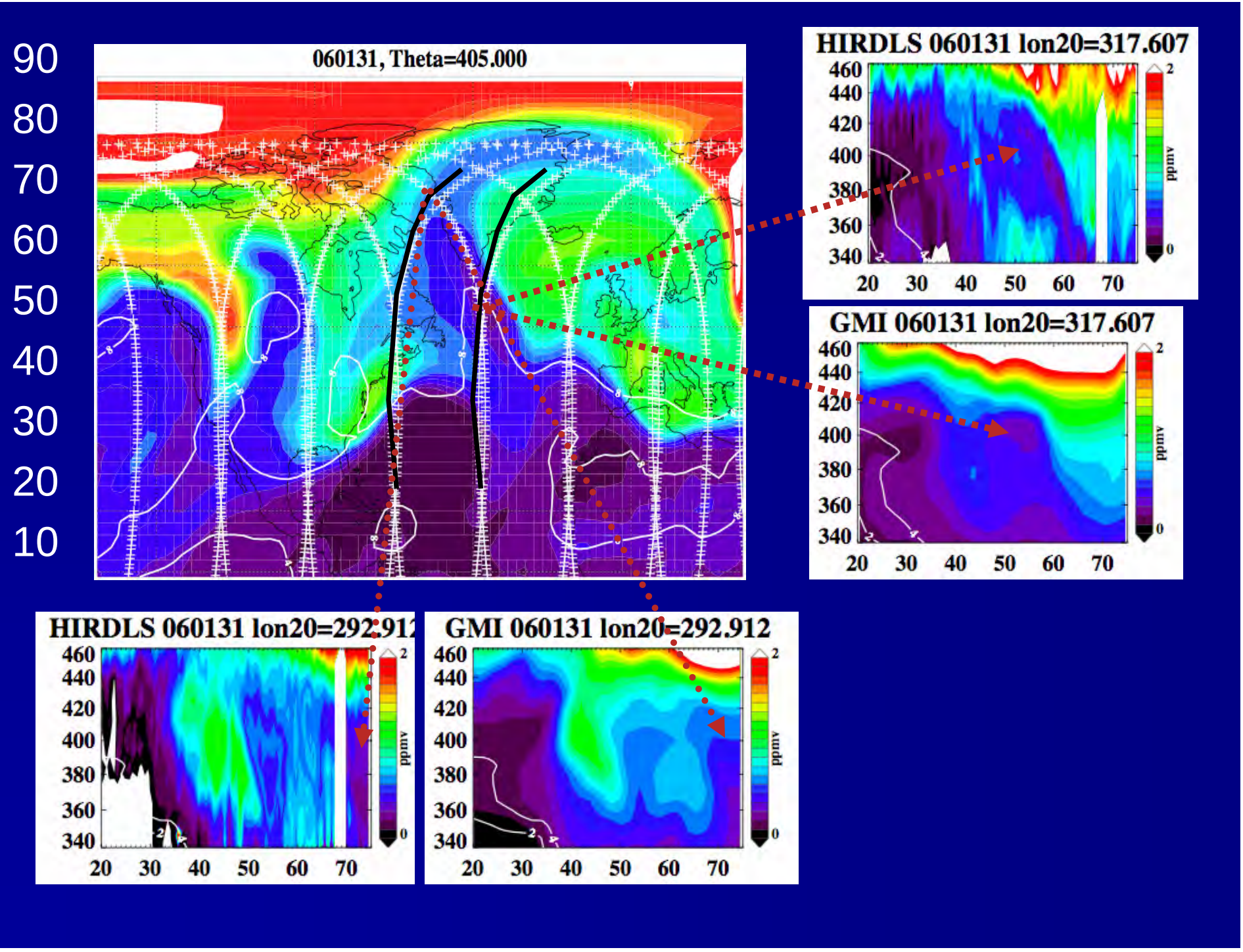
June 28, 2008 - Two days later

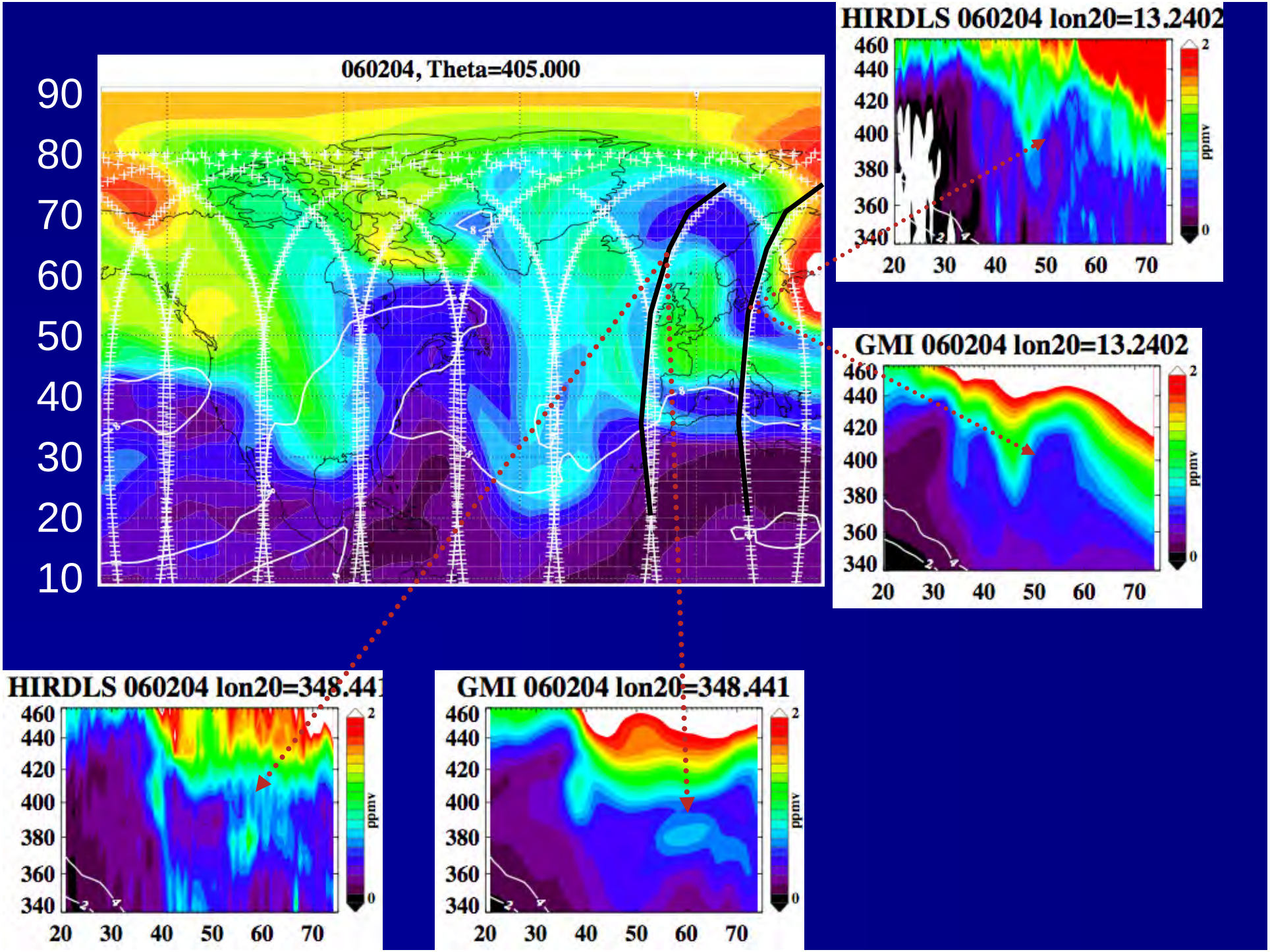


What's the view from MLS?



(there are events of greater vertical scale that are seen by both MLS and HIRDLS)


90
80
70
60
50
40
30
20
10
060131, Theta=405.000
HIRDLS 060131 lon20=317.607
GMI 060131 lon20=317.607
HIRDLS 060131 lon20=292.912
GMI 060131 lon20=292.912
460
440
420
400
380
360
340
20
30
40
50
60
70
ppmv
2
0


060204, Theta=405.000
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HIRDLS 060204 lon20=13.2402
GMI 060204 lon20=13.2402
HIRDLS 060204 lon20=348.441
GMI 060204 lon20=348.441
460
440
420
400
380
360
340
20
30
40
50
60
70
ppmv
2
0

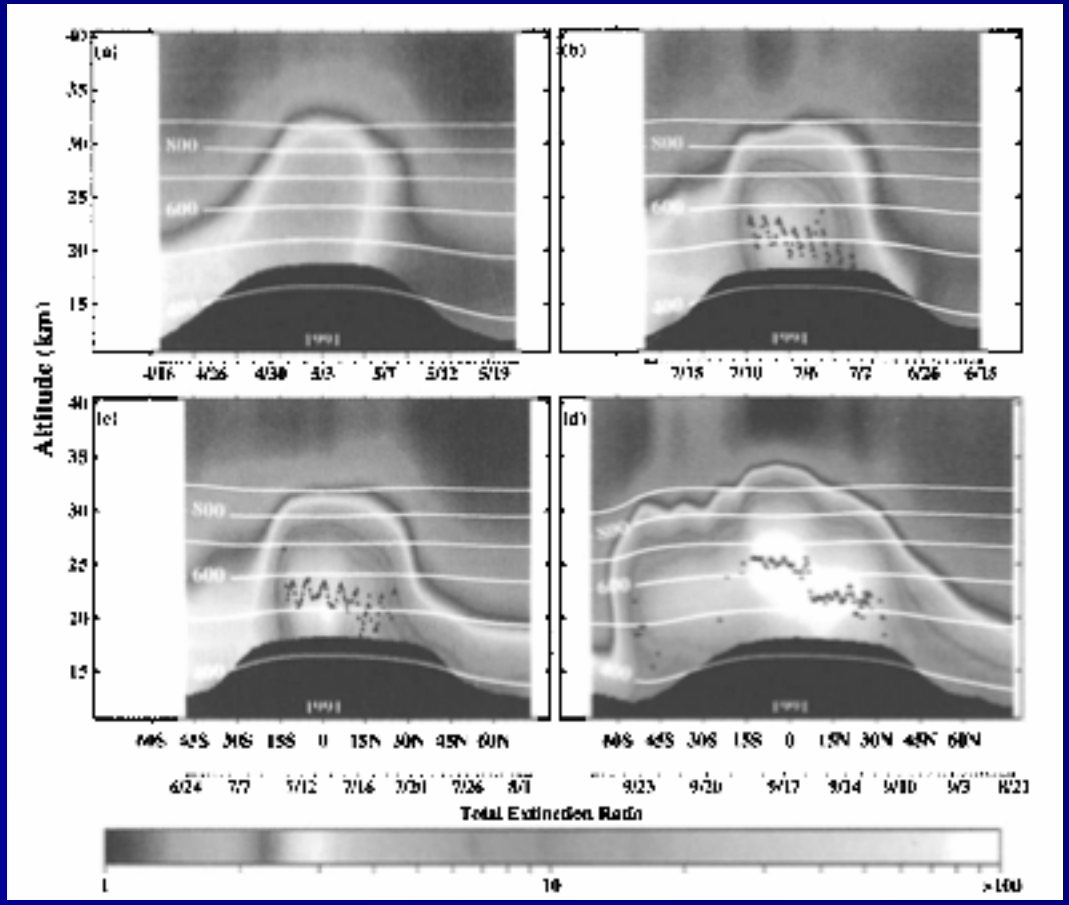
Conclusion

- GMI Combo GEOS-4 DAS fields and HIRDLS are remarkable similar!
- Isentropic poleward advection thin layers of tropical lower stratospheric
- Events are common and ~ 1 km thick (HIRDLS best)
- Much of the air returns to lower latitudes but some diabatic descent and PV changes suggest that it is not entirely reversible. Decreasing mixing ratios in the model suggest mixing.
- Up to 5-10% of zonal band is tropical air for this single event.
- Next Steps:
  - quantify the source of tropospheric character air in the lowermost stratosphere.
  - Seasonal cycle of these intrusions determined from HIRDLS data?

Pinatubo Aerosol Dispersion

April 15
To
May 25

June 23
To
Aug. 8



June 14
To
July 26

Aug. 20
To
Sept. 30

Trepte et al., 1993

Eruption: June 14-15, 1991