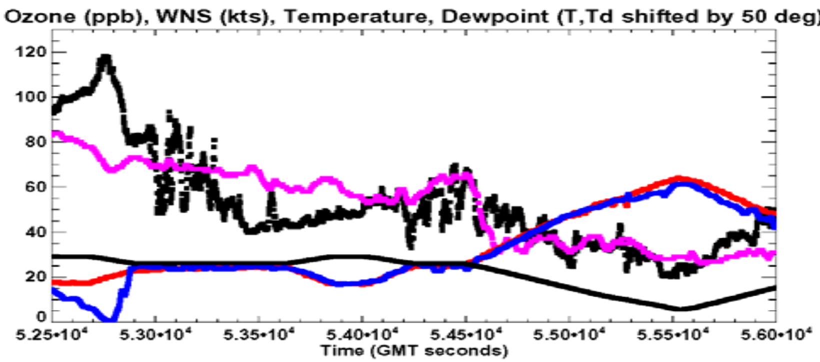
Langley In Situ Fast-Response Ozone Measurements (FASTOZ)



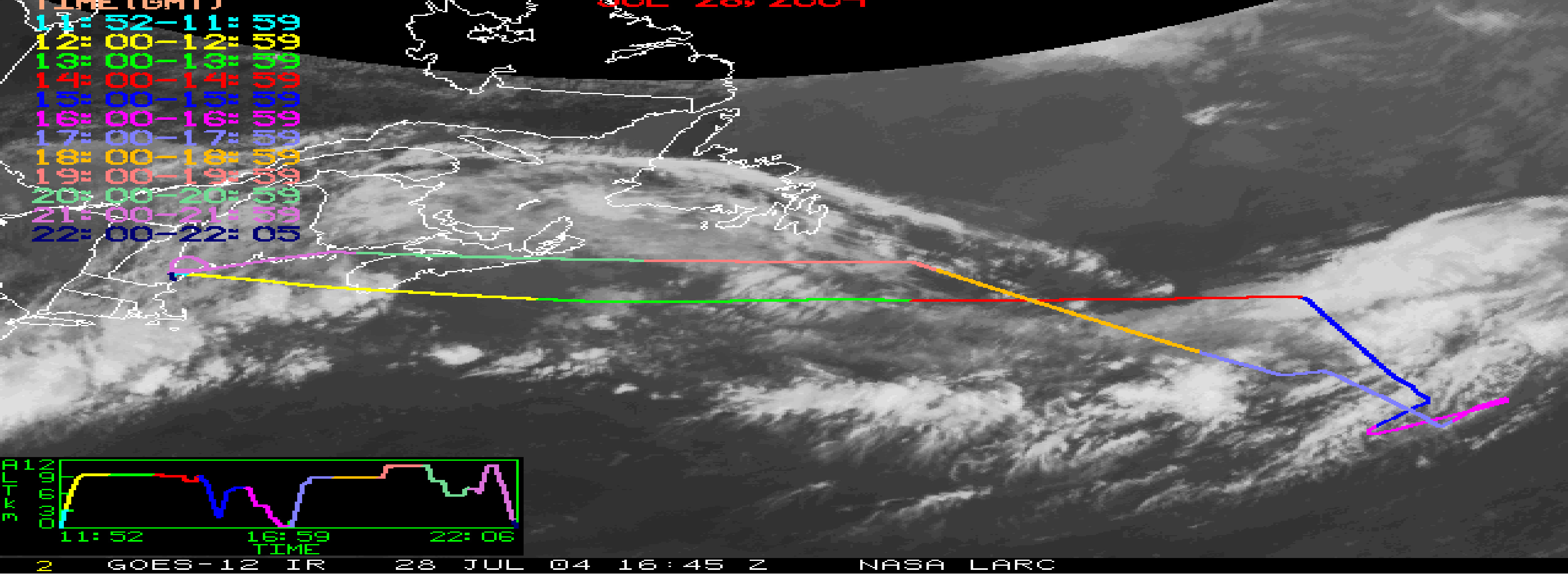
Melody Avery, James Plant, Charles Hudgins

Ozone Instrument Specifications (INTEX Phase A – DC-8)

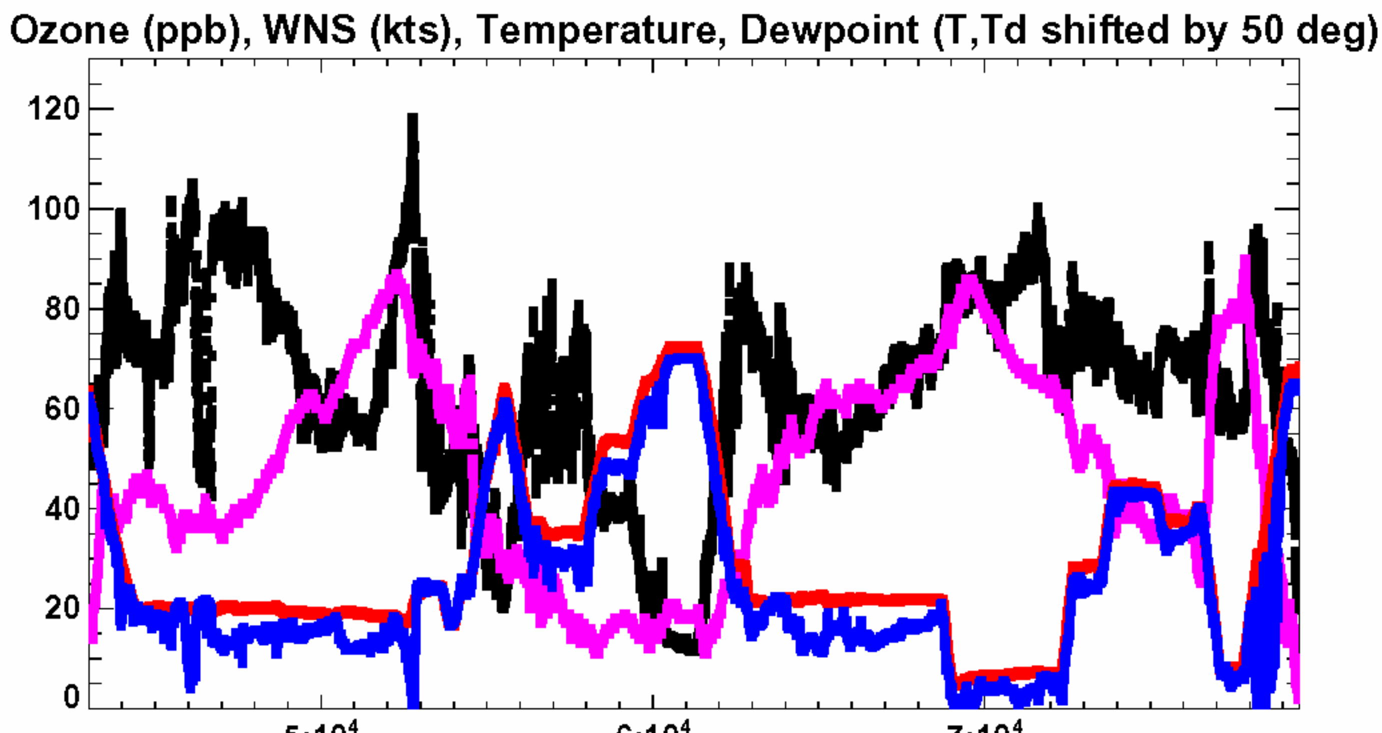
- Technique: Chemluminescent reaction of ozone with nitric oxide
- Dynamic Range: 0.6 - 1600 ppb
- Accuracy: 5% or 2 ppb
- Precision: 2% or 0.6 ppb
- Response: 2-3 Hz; recorded at 6 Hz, reported at 1 Hz, faster data on request
- Spatial Resolution: <10 m vertical (aircraft spiral), 200 m horizontal (at 400 kts)

In situ Ozone INTEX Calibration Statistics

- Slope = 46.187 ppb/volt; offset = 178 ppt; (disregard the offset – smaller than the LOD).
- 1 sigma “noise” is 0.33% measured value at top of range; 1 sigma slope = 0.66%
- Largest residual error = 1.3% at ~400 ppb
- Water vapor correction multiplier 1+0.000007965*wvmr(j) (wvmr(j)=Glenn Diskin’s DLH water vapor mixing ratio.



11:52-11:59
12:00-12:59
13:00-13:59
14:00-14:59
15:00-15:59
16:00-16:59
17:00-17:59
18:00-18:59
19:00-19:59
20:00-20:59
21:00-21:59
22:00-22:05
ALT km
12
9
6
3
0
11:52
16:59
22:06
TIME
2 GOES-12 IR 28 JUL 04 16:45 Z NASA LARC

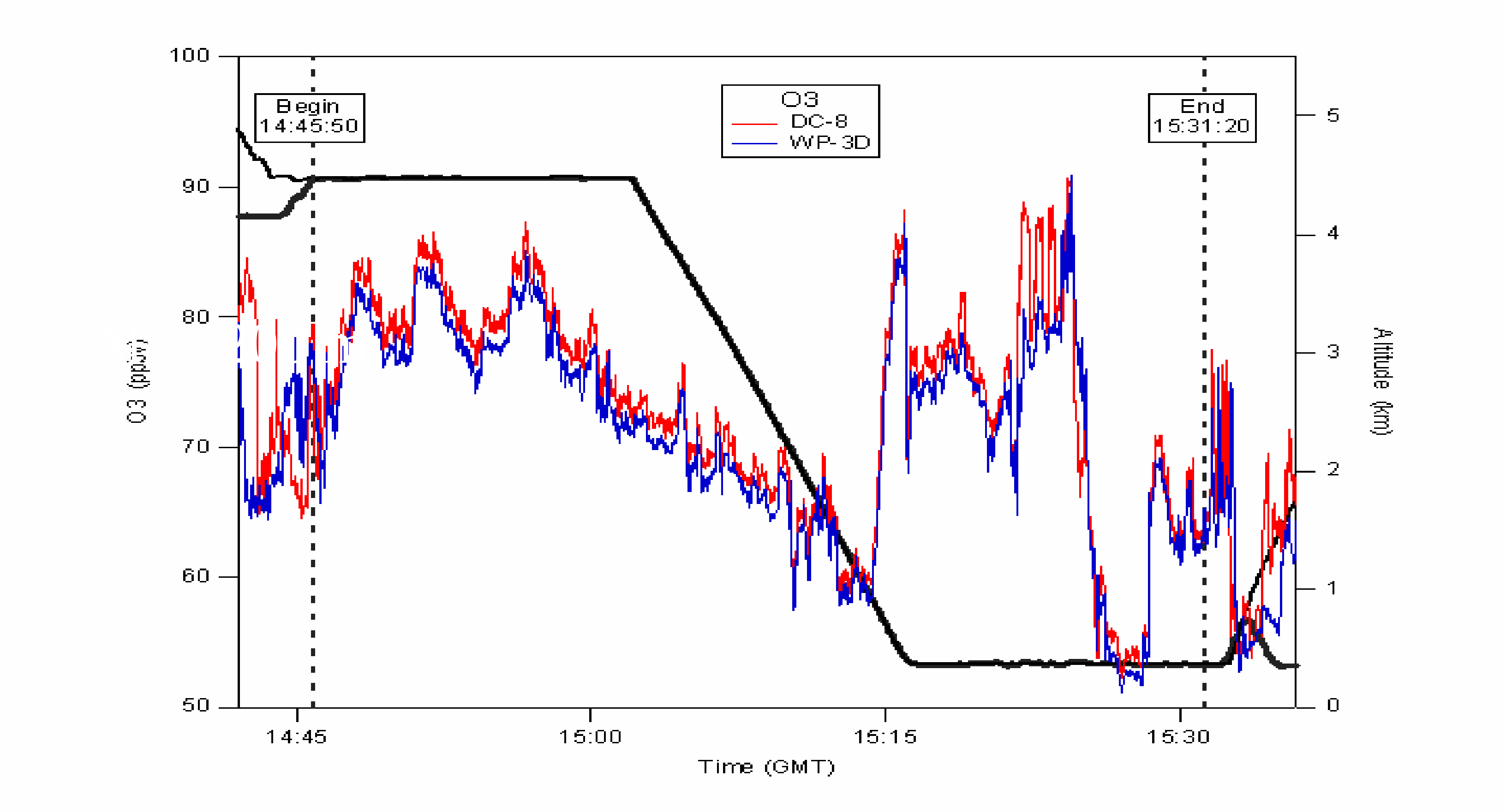


Ozone (ppb), WNS (kts), Temperature, Dewpoint (T,Td shifted by 50 deg)
120
100
80
60
40
20
0

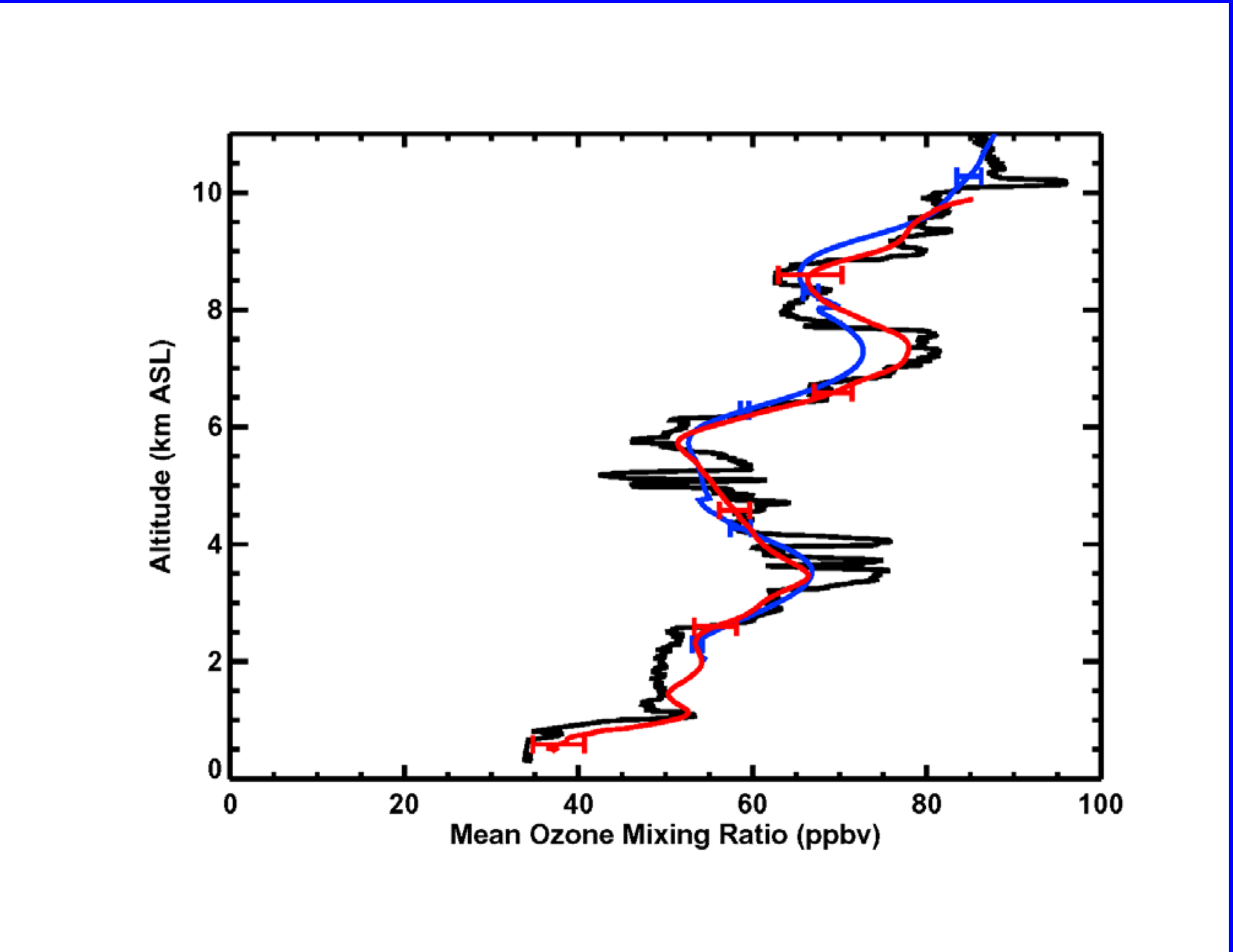
AVE Science Question we hope to answer with FASTOZ data:

- What is the horizontal and vertical variability of ozone in the lower stratosphere, tropopause, and middle to upper troposphere?
- What is the impact of sub-model grid scale processes on inhomogeneity and on ozone profiles retrieved from AURA instruments?
- Can geophysical synoptic-scale markers be used to locate areas with relatively large inhomogeneity?

In situ ozone data from the NASA DC-8 (red) and the NOAA P3-B (Tom Ryerson, NOAA Aeronomy Lab - blue) at 1 second time resolution, measured while the two planes flew side-by-side on July 22, 2004 during INTEX-A. The excellent correlation of measurements from two different airplanes at this resolution suggests that both instruments have a true 1-Hz response time to atmospheric ozone fluctuations.



In situ ozone (black) and DIAL lidar ozone (Edward Browell, LaRC, blue – zenith, red – nadir) profile measurements during an INTEX-A TERRA under flight at 15 Z on August 11, 2004.



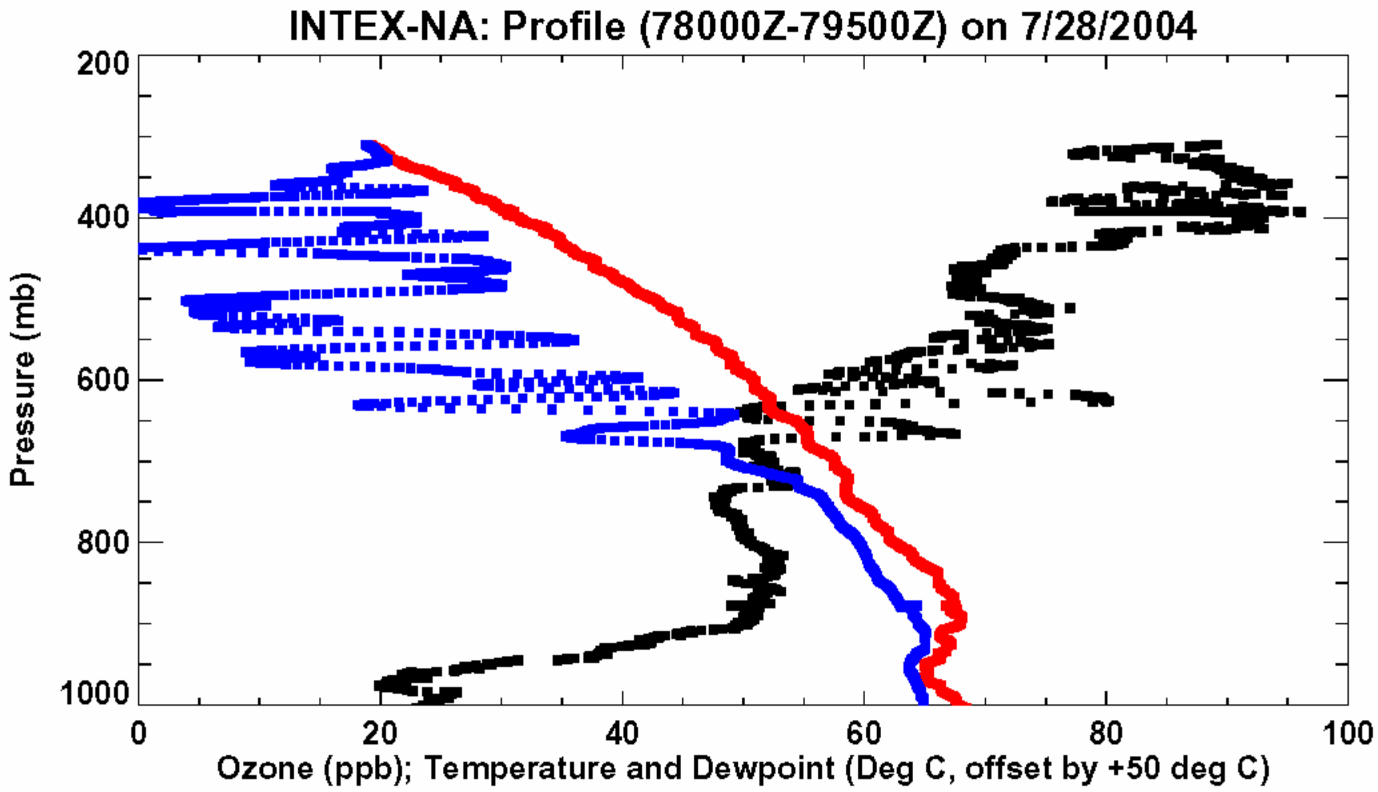
Δv = 600m

Δv = 300m,

Δh = 36 km

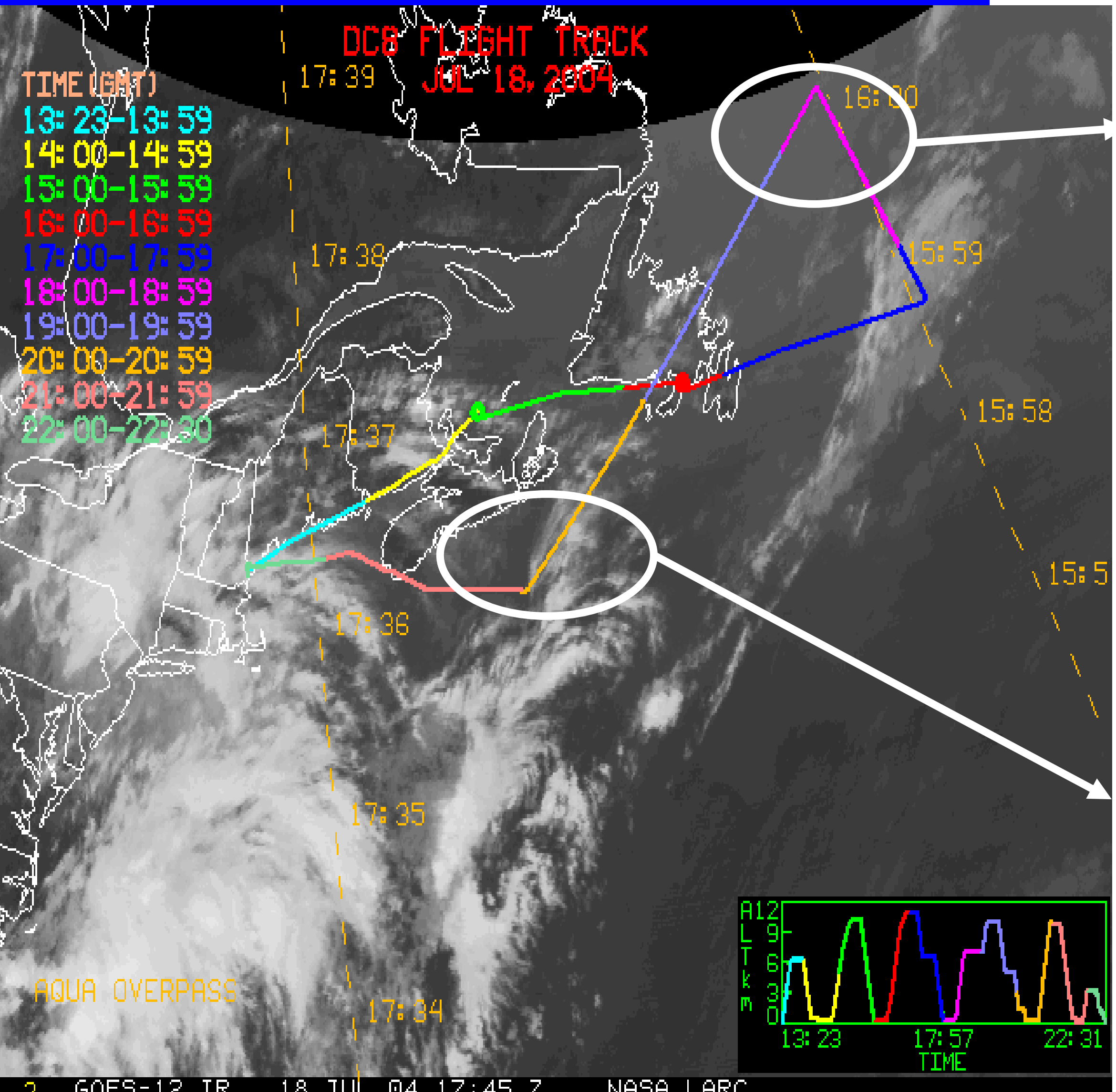
Δv = 15 m,

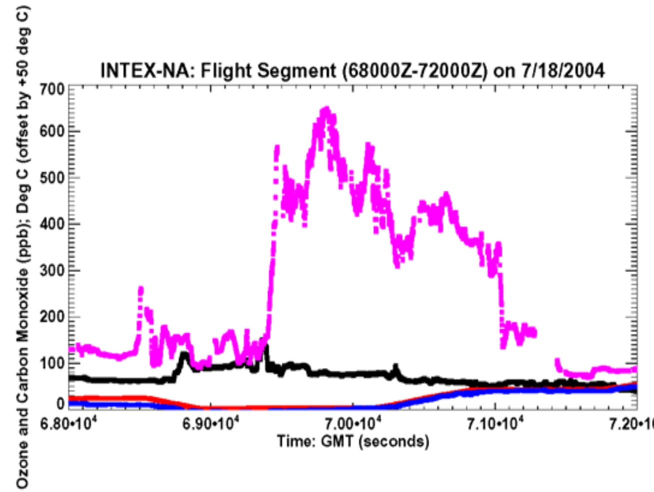
Δh = 225 m

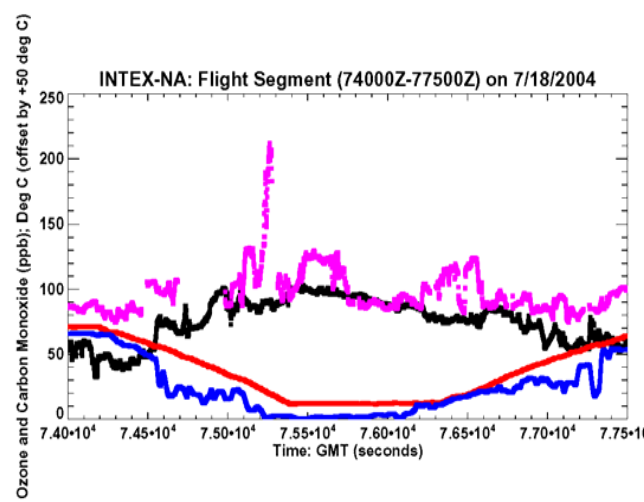

INTEX-NA: Profile (78000Z-79500Z) on 7/28/2004
Pressure (mb)
200
400
600
800
1000
0
20
40
60
80
100
Ozone (ppb); Temperature and Dewpoint (Deg C, offset by +50 deg C)

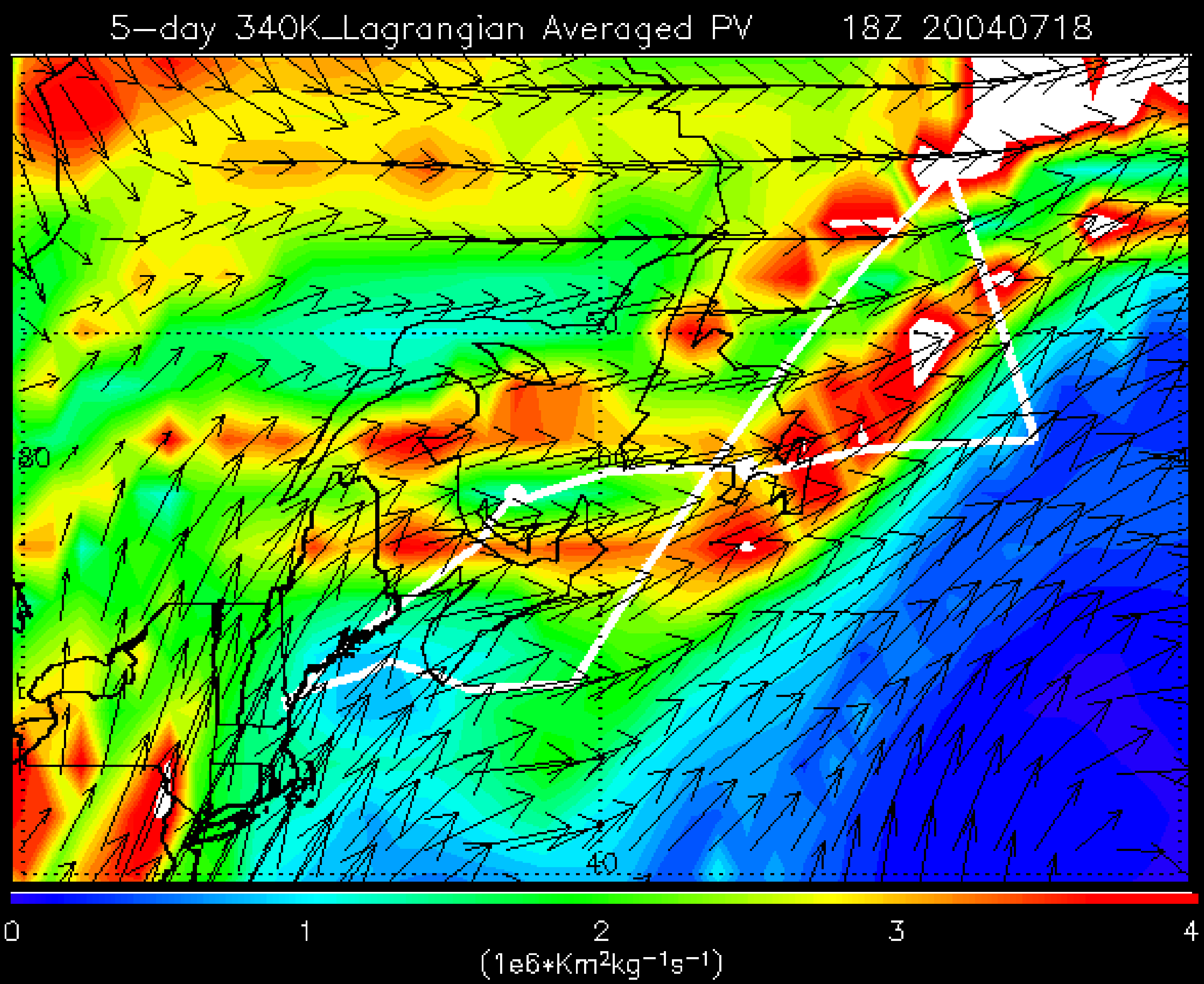
Flight 9 on July 18, 2004: DC-8 In Situ Ozone, CO, Dewpoint and T data

Sachse, Avery, Barrick








5-day 340K_Lagrangian Averaged PV
18Z 20040718
50
60
40
0
1
2
3
4
(1e6*Km²kg⁻¹s⁻¹)

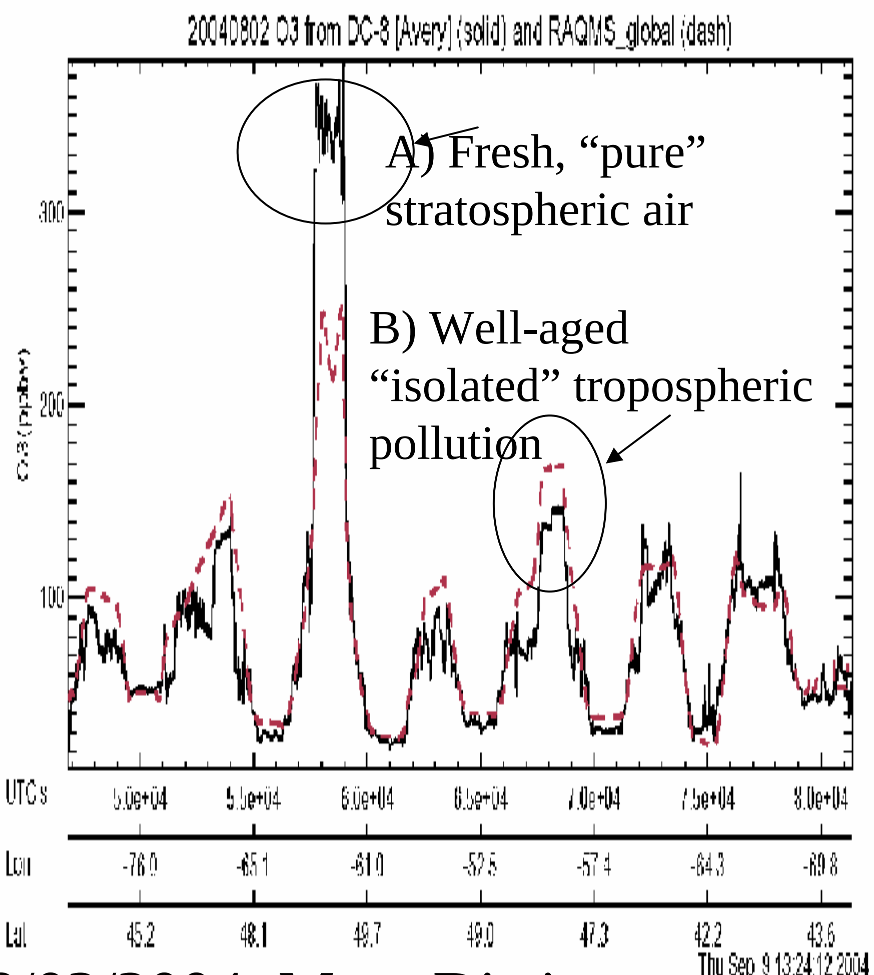
The Upper Troposphere During INTEX-A: a Combination of Stratospheric and Tropospheric Influences

Question: How much **of the ozone we observe in the Upper Troposphere (above 500 hPa) is produced by photochemistry (anthropogenic) or from Strat.-Trop. exchange (natural) ?**

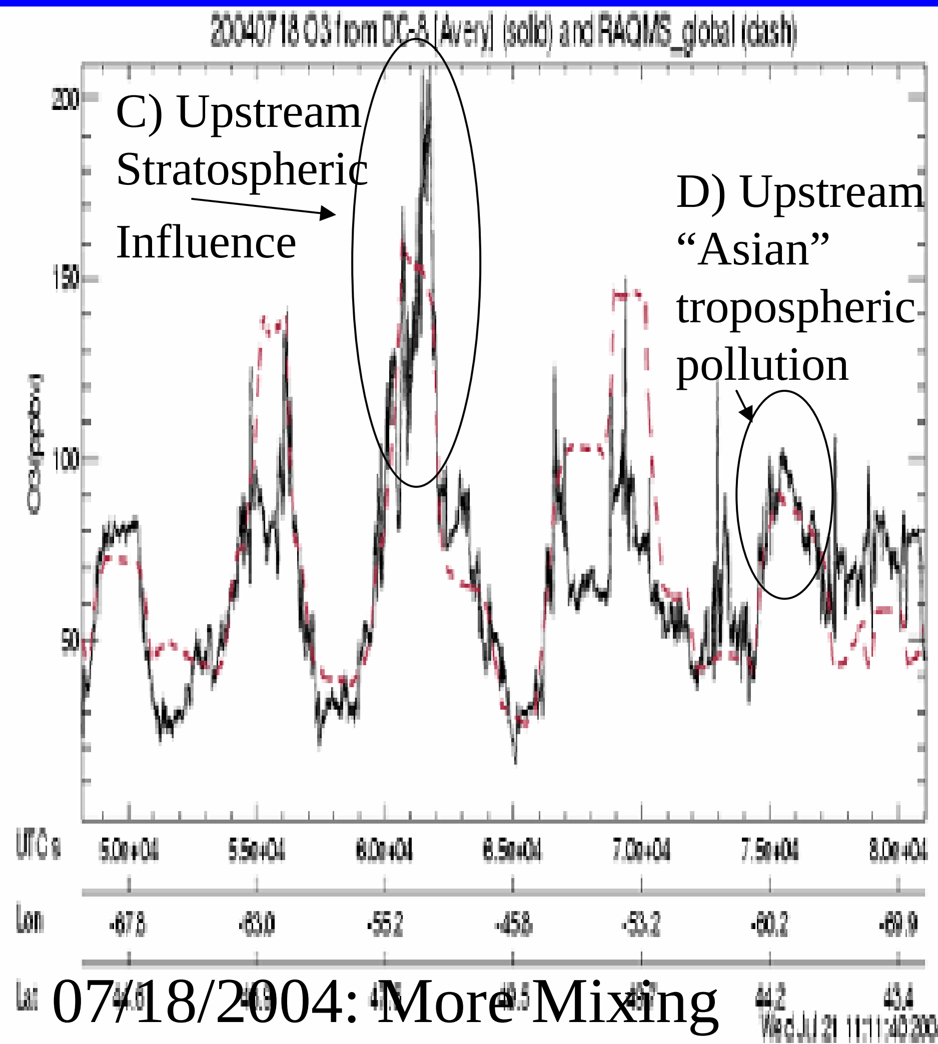
What we need to know to answer the “big” question:

- How do we tell the difference between Strat. and Trop. air?
- How “fresh” are the contributions from each source?
- How much mixing has taken place between them?
- Is there any unusual chemistry going on at the interfaces between stratospheric and tropospheric filaments?

In Situ Ozone Time Series: Data From 4 DC-8 Flight Segments at 250 hPa

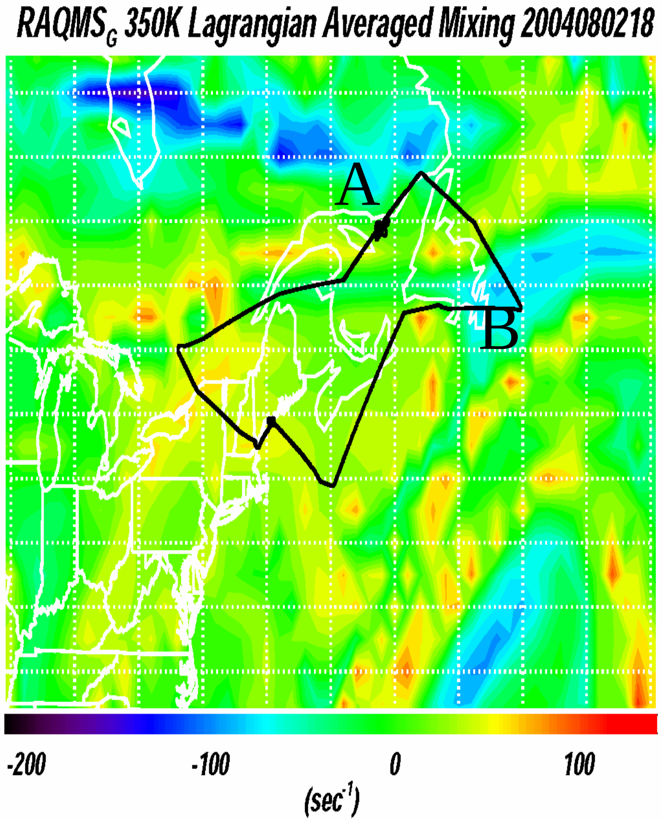


08/02/2004: More Distinct

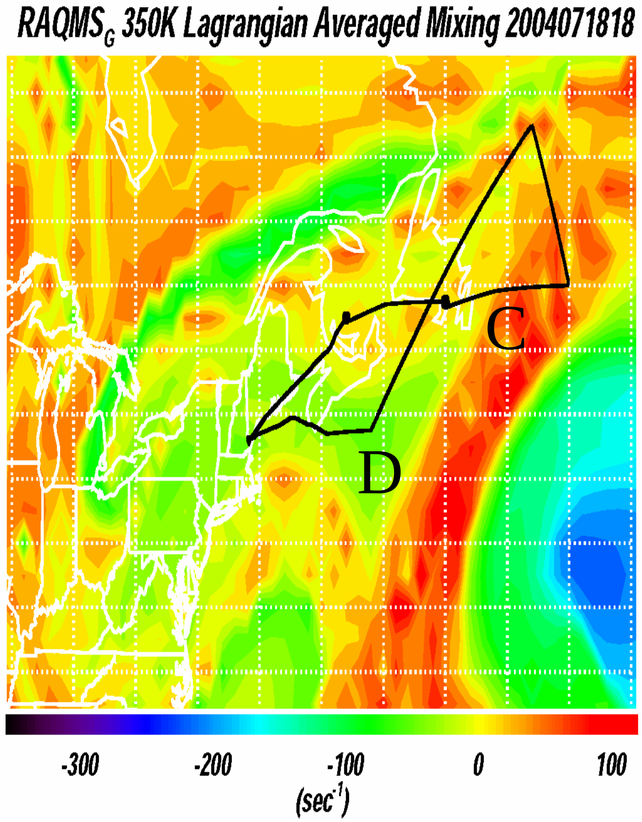


07/18/2004: More Mixing

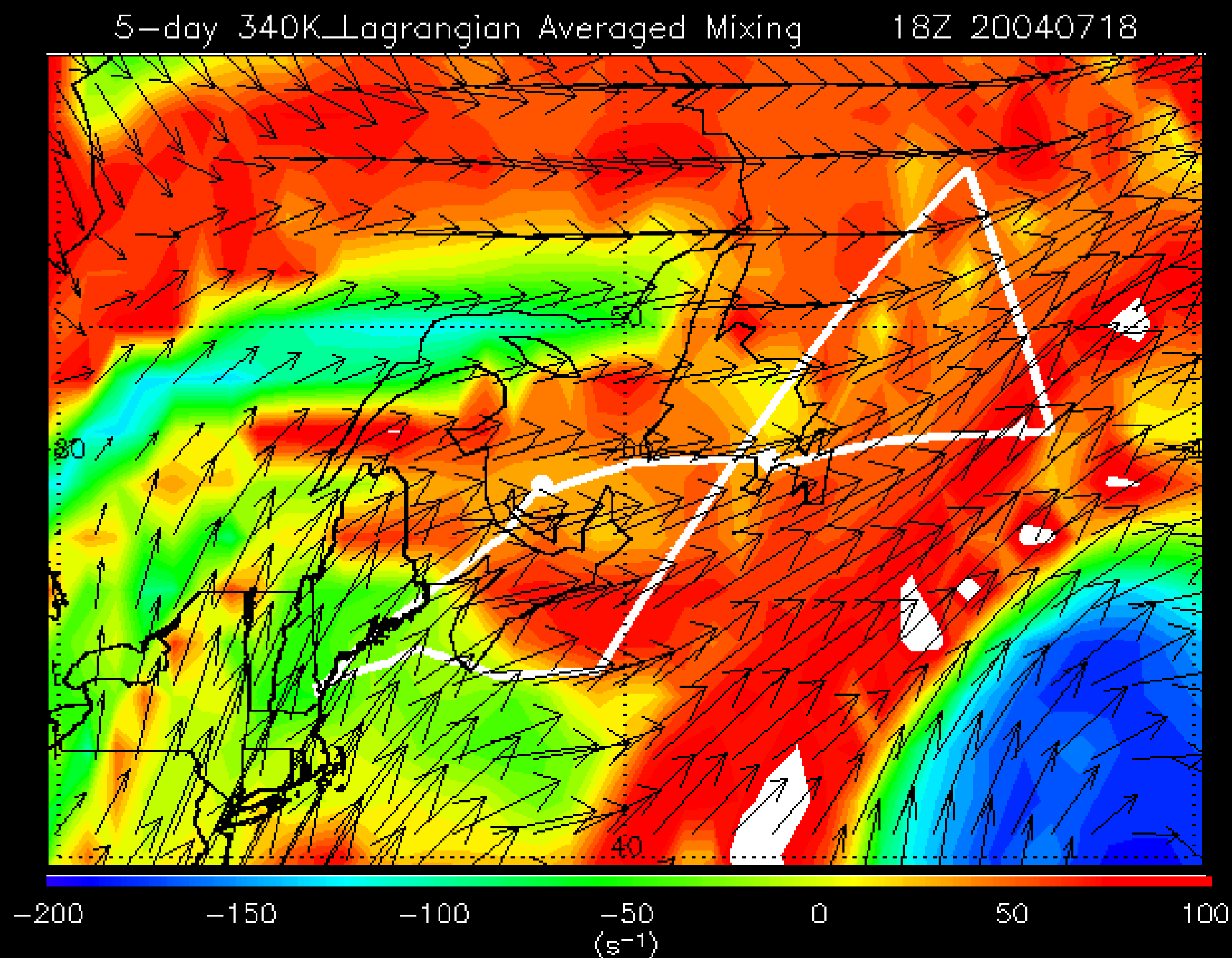
Mixing Diagnostic from the Langley RAQMS, Averaged over Five-Day Back Trajectories



More distinct (blue, mixing neg.)



More mixing (red, mixing pos.)

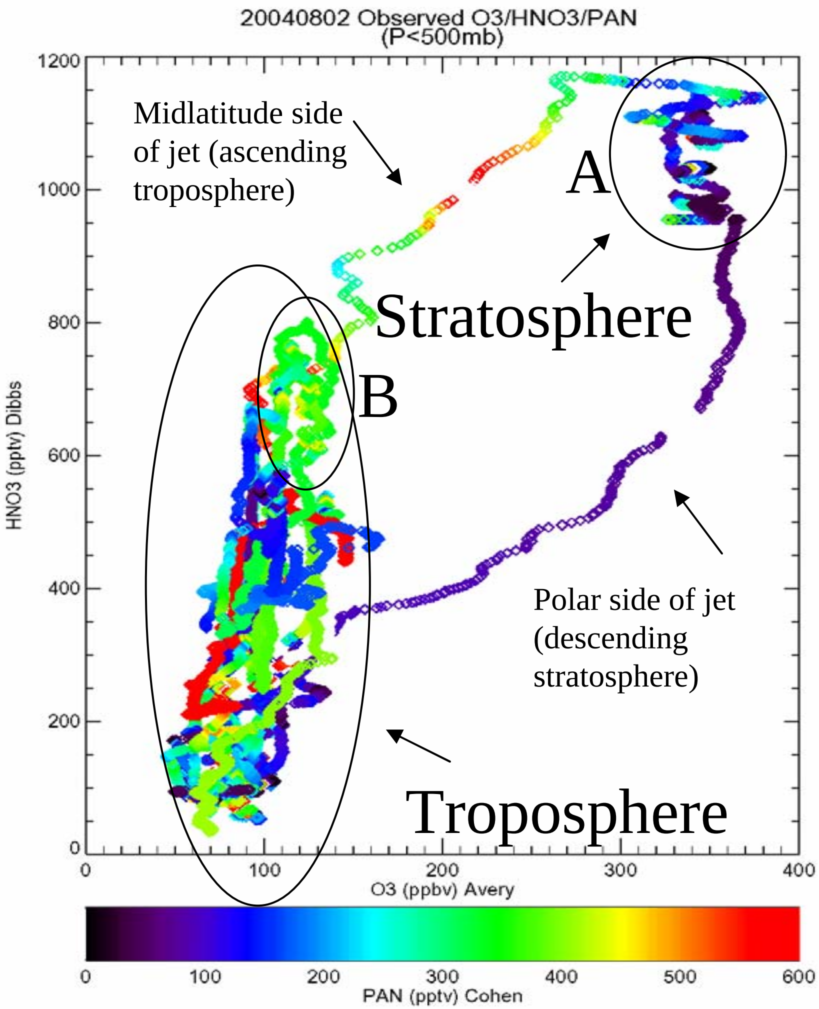


5-day 340K Lagrangian Averaged Mixing 18Z 20040718
60
40
−200
−150
−100
−50
0
50
100
(s^{-1})

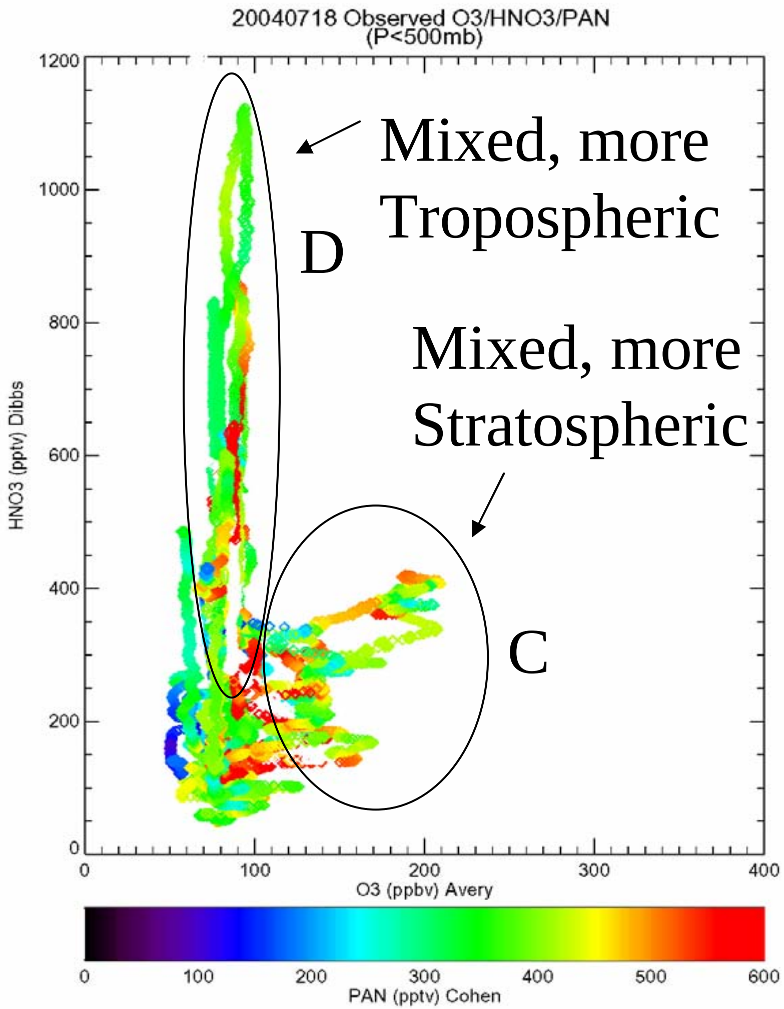
Nitric Acid – Ozone Correlations, Colored by PAN:

- Large stratospheric source for Ozone, Nitric Acid (soluble)
- PAN is a long-lived Upper Tropospheric Pollutant

Distinct :



Well-Mixed and Aged :



Summary:

- Ozone instrument functioned well during INTEX-A

- Max ozone = 447 ppb (stratospheric), Min ozone ~ 11 ppb (cold marine boundary layer – fish ate it?)

- Upper troposphere appears to be a complex mixture of stratospheric and internationally polluted tropospheric air with fire signature (in ozone?)

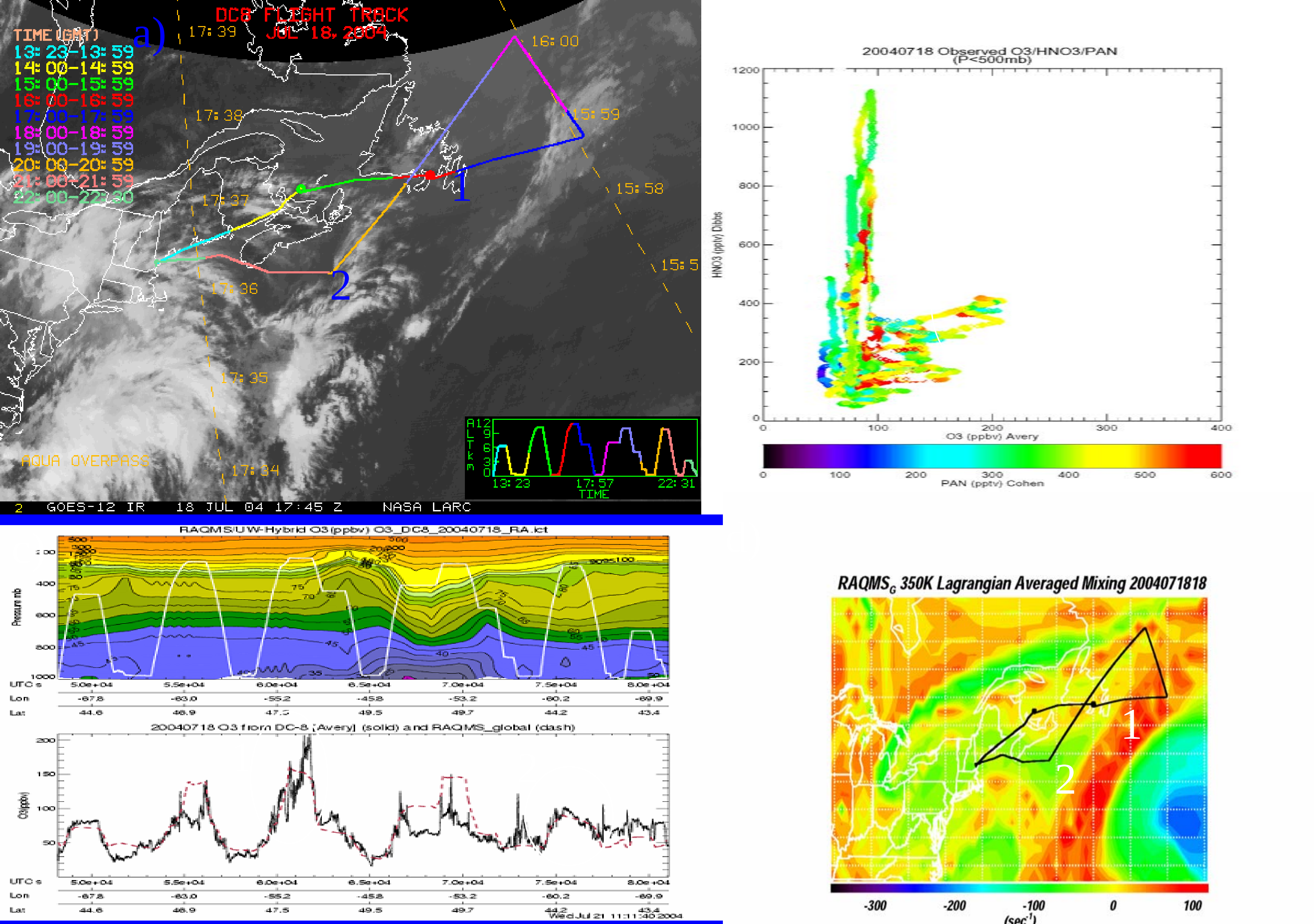
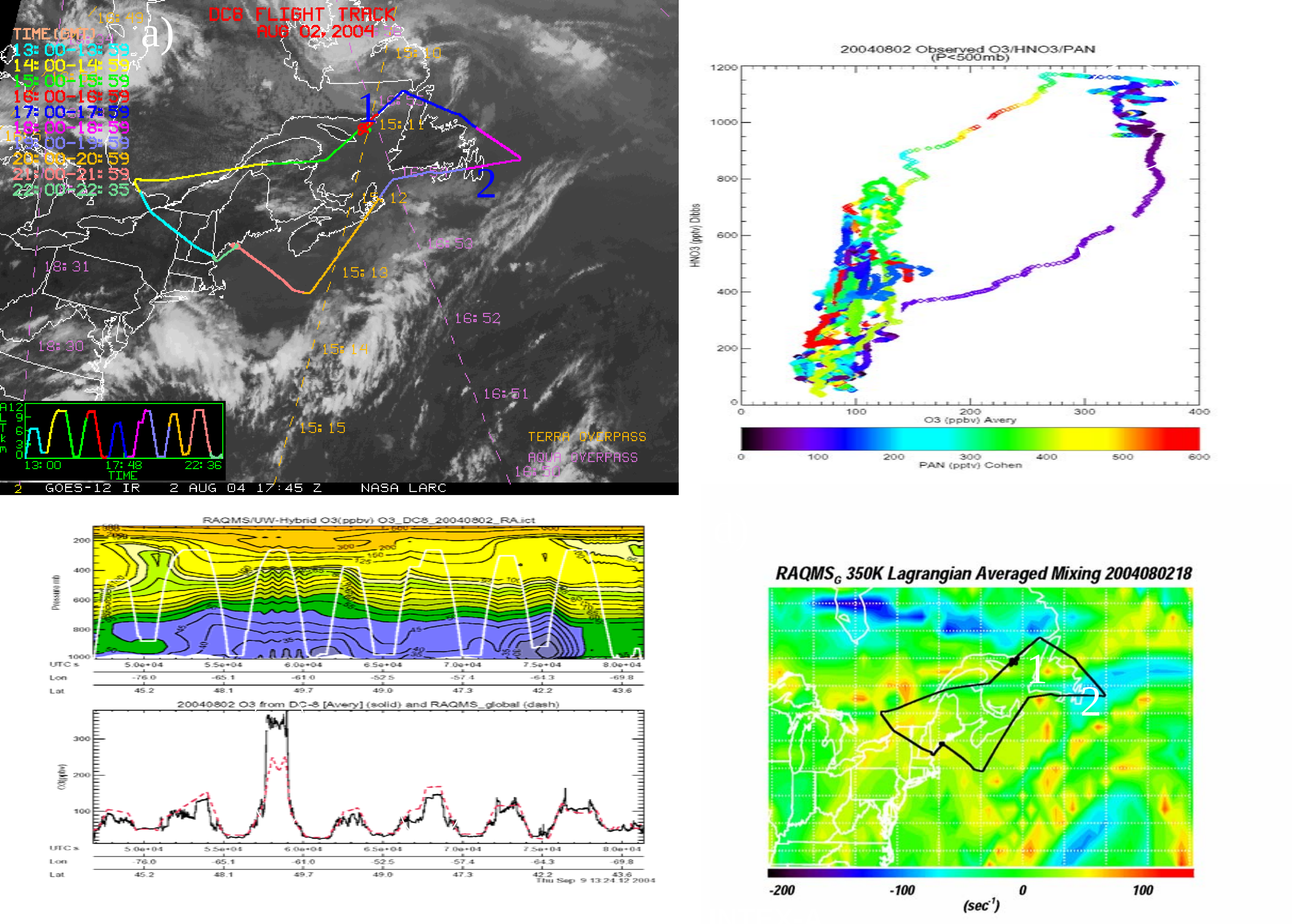


Figure 3: DC-8 Flight on July 18, 2004 during INT



DC8 FLIGHT TRACK
AUG 02,2004
a)
TIME(GMT)
13:00-13:59
14:00-14:59
15:00-15:59
16:00-16:59
17:00-17:59
18:00-18:59
19:00-19:59
20:00-20:59
21:00-21:59
22:00-22:35
1
2
15:10
15:11
15:12
15:13
15:14
15:15
16:53
16:52
16:51
16:50
18:31
18:30
TERRA OVERPASS
AQUA OVERPASS
ALT km
13:00
17:48
22:36
TIME
GOES-12 IR 2 AUG 04 17:45 Z NASA LARC
20040802 Observed O3/HNO3/PAN
(P<500mb)
HNO3 (pptv) Dibbs
O3 (ppbv) Avery
PAN (pptv) Cohen
RAQMS/UW-Hybrid O3(ppbv) O3_DC8_20040802_RA.ict
Pressure mb
UTC s
Lon
Lat
20040802 O3 from DC-8 [Avery] (solid) and RAQMS_global (dash)
O3(ppbv)
Thu Sep 9 13:24:12 2004
RAQMS$_G$ 350K Lagrangian Averaged Mixing 2004080218
(sec^{-1})