Evaluation of AIRS and IASI Trace Gases using *in situ* measurements from START08

Jasna Pittman, Laura Pan (NCAR)
Jennifer Wei, Eric Maddy, Chris Barnet (NOAA)
Bill Irion (JPL)

Atmospheric Sounding Science Team Meeting
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MOTIVATION

- Evaluate tracer measurements from AIRS and IASI
  - Plans to have these measurements for ~20 years
    - Global and long-term studies
  - 4x daily coverage between the 2 instruments
- Exploit wide horizontal coverage of satellite instruments to provide large-scale context for aircraft measurements

OUTLINE

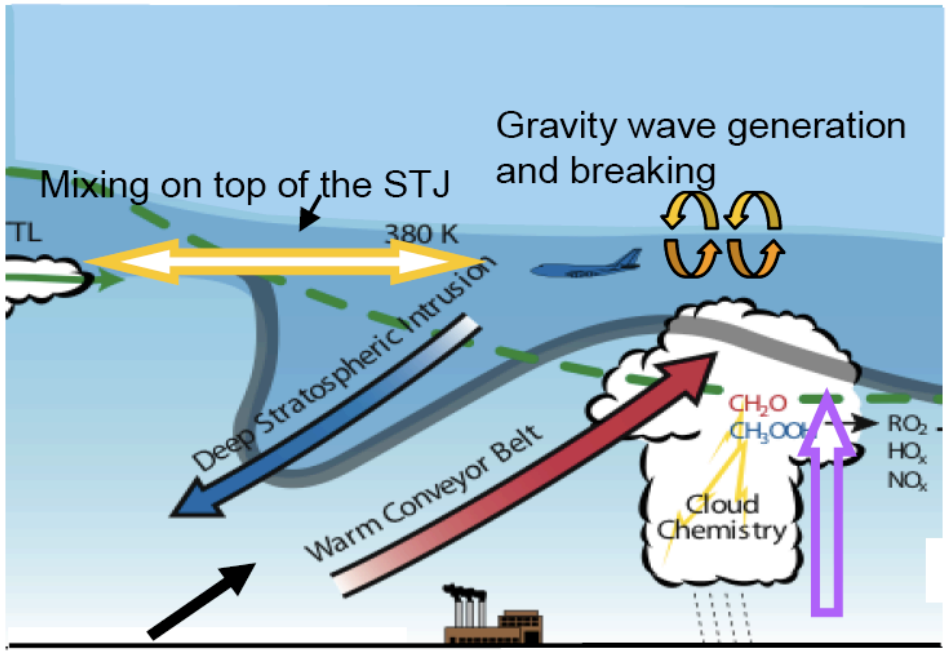
- Data description
- Aircraft – AIRS/IASI O_3
  - Vertical Profiles
    - Comparisons to Aura/MLS
  - Horizontal Variability
  - O_3-PV Analysis
- Aircraft – AIRS/IASI CO
    - Comparisons to MOPITT

Stratosphere-Troposphere Analysis of Regional Transport Experiment (START08)

and

HIAPER Pole-to-Pole Observations of Atmospheric Tracers (Pre-HIPPO)

April – June, 2008



Science Goals:

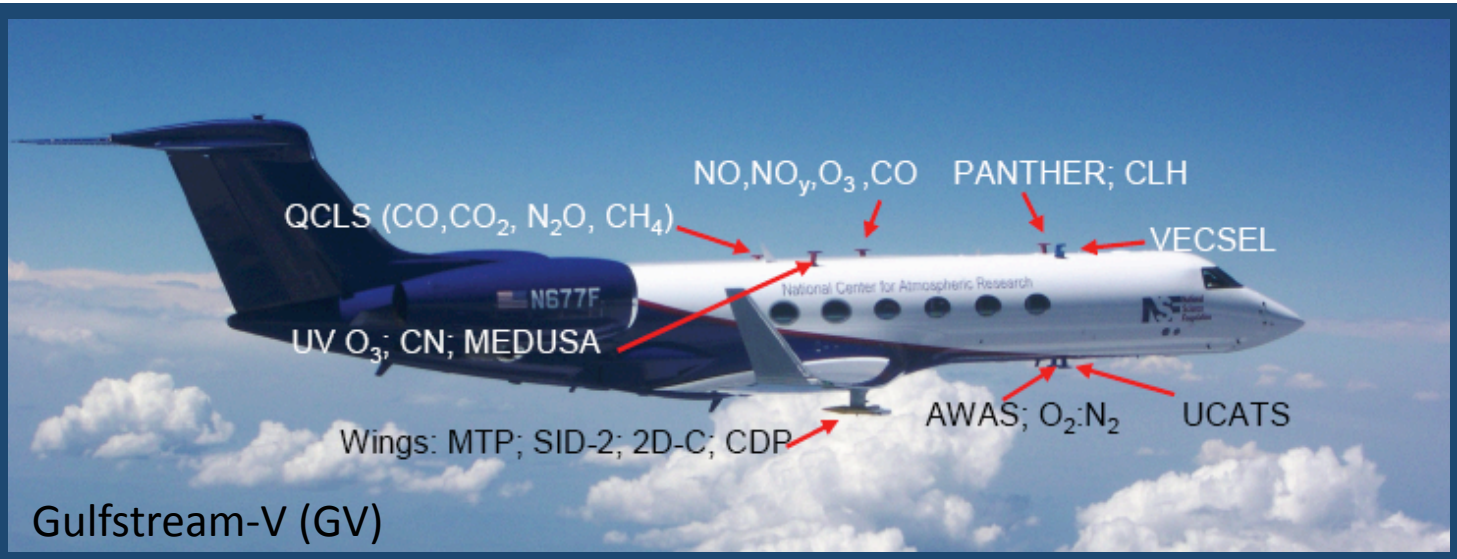
- Characterize the chemical and dynamical properties of the extratropical UT/LS

- Investigate the role of different transport pathways on the distribution of key chemical tracers in the UT/LS region

- Provide key measurement information to improve the coupling between chemistry and dynamics in chemistry-climate models

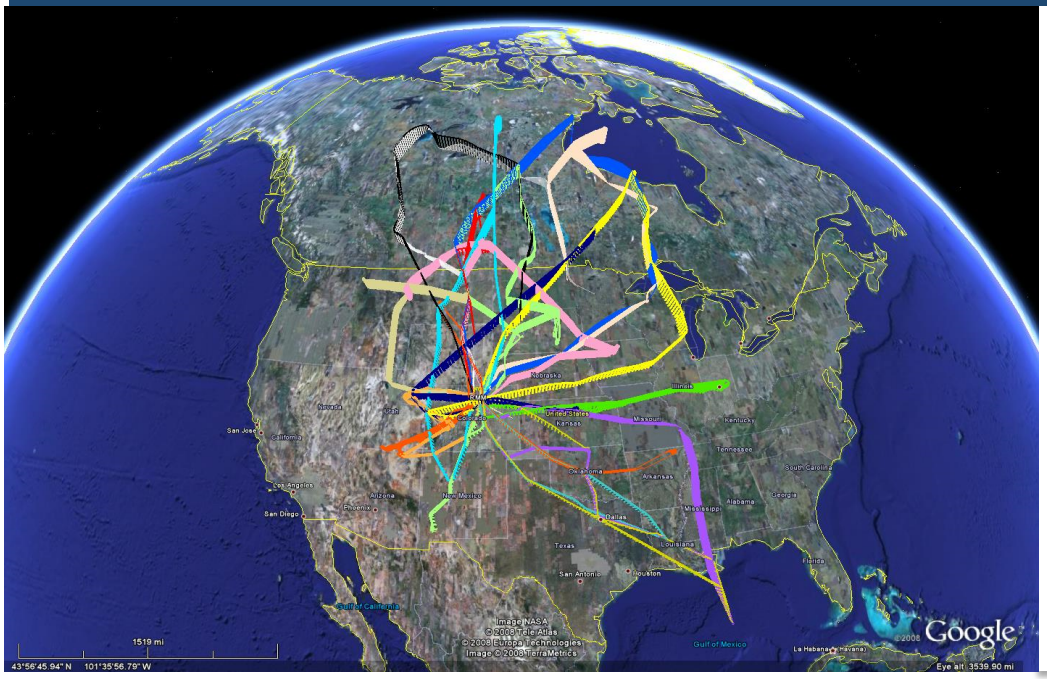
- Map the distribution of greenhouse gases to track seasonal changes in sources and sinks

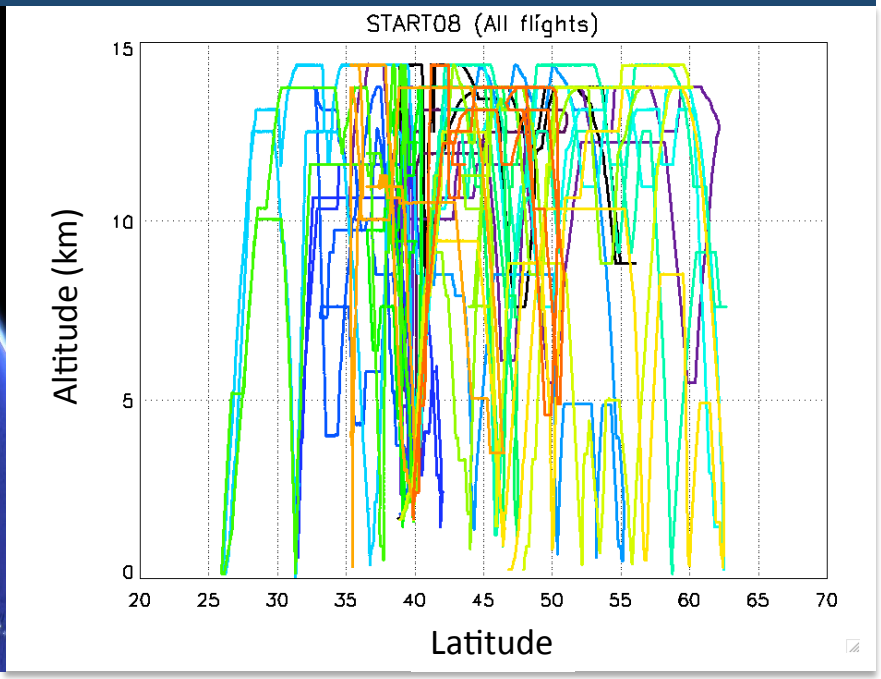
Participants:
-NCAR
-NOAA
-Univ. of CO
-Harvard Univ.
-Texas A&M Univ.
-Univ. of Miami

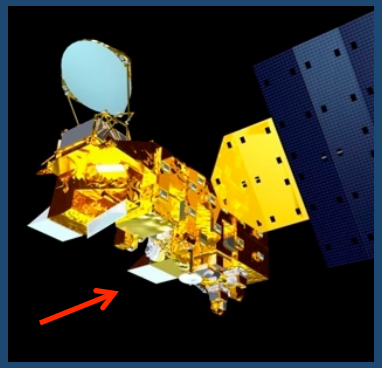


NSF/NCAR High-performance Instrumented Airborne Platform for Environmental Research (HIAPER)

18 Research Flights, 123 Flight Hours







AIRS

- 2,378 spectral bands in the IR (3.7 – 15.4 μm) and 4 in the Visible (0.4 – 1 μm)
- +/- 49.5 degree swath
- 9 FOV, 45 km horizontal resolution at L2
- Launch: May 2002
- PM Equator-crossing
- Aboard Aqua

IASI

- 8,461 spectral bands in the IR (3.7 – 15.4 μm)
- +/- 48.3 degree swath
- 4 FOV, 50 km horizontal resolution at L2
- Launch: October 2006
- AM Equator-crossing
- Aboard METOP-A (plans for METOP-B in 2010 and METOP-C in 2015)

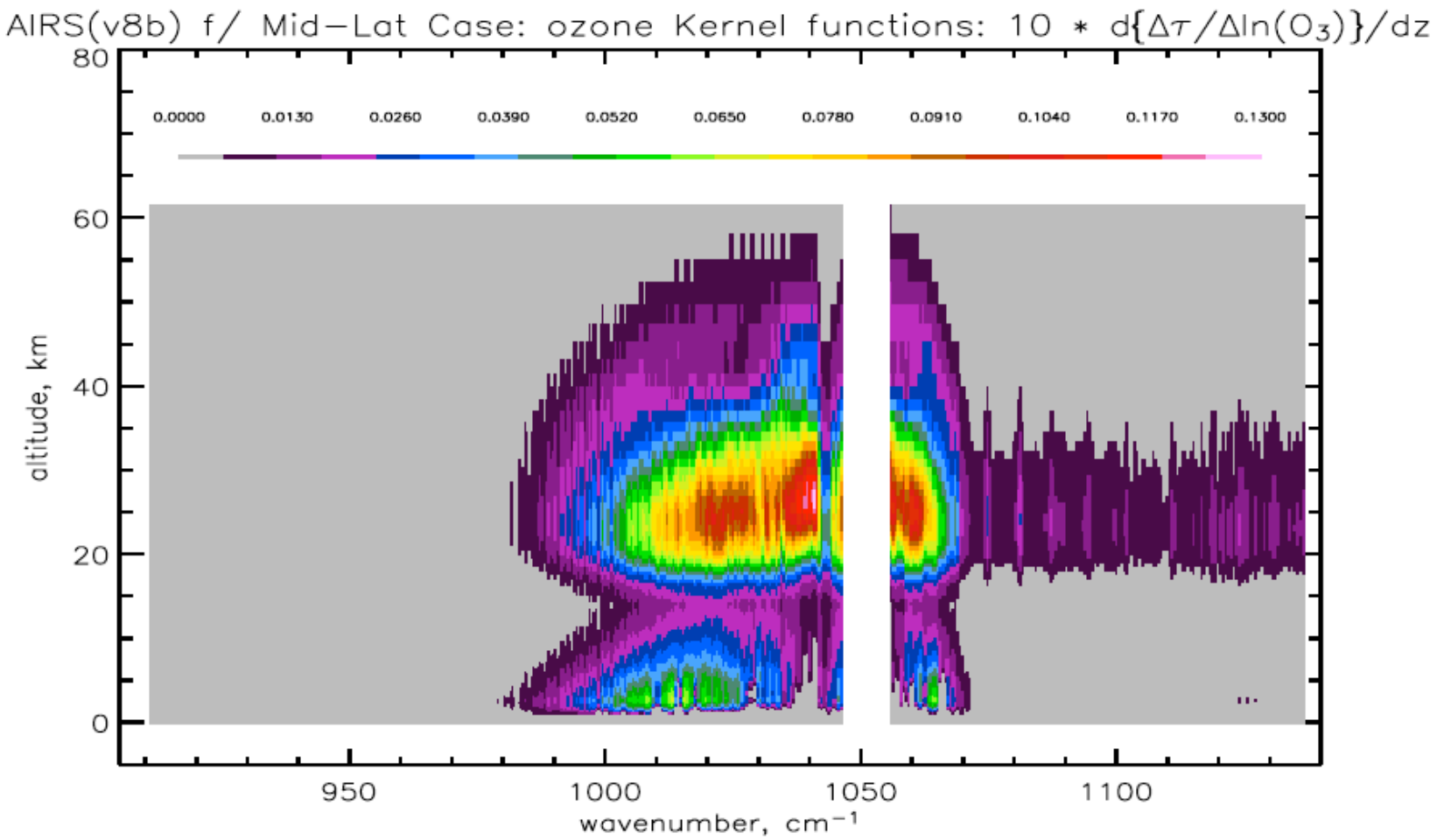
AIRS Information Content

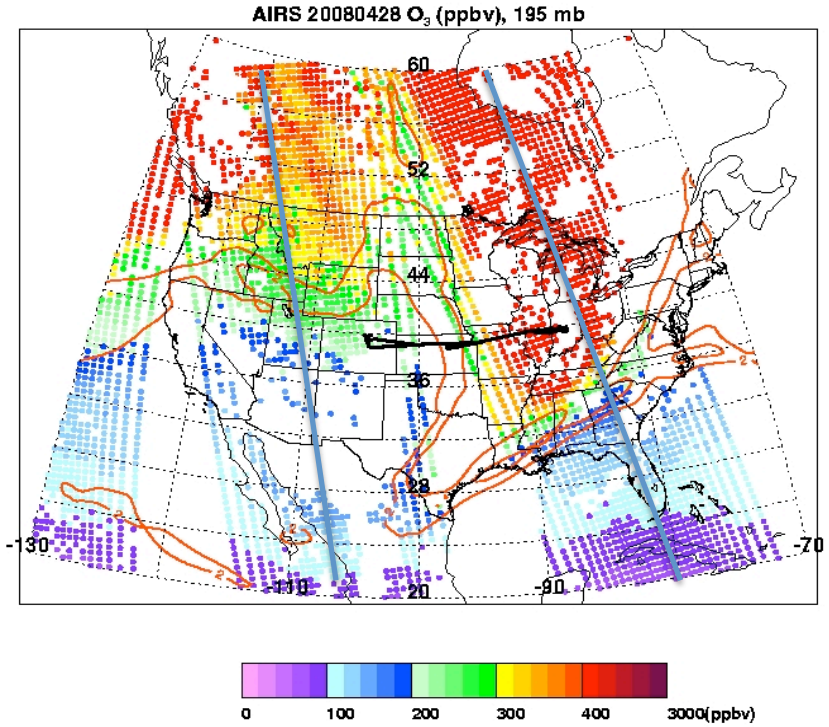
TABLE I
MEAN DEGREES OF FREEDOM AS CALCULATED FROM EQUATION 7 FOR VARIOUS ATMOSPHERES FOR VERSION 5

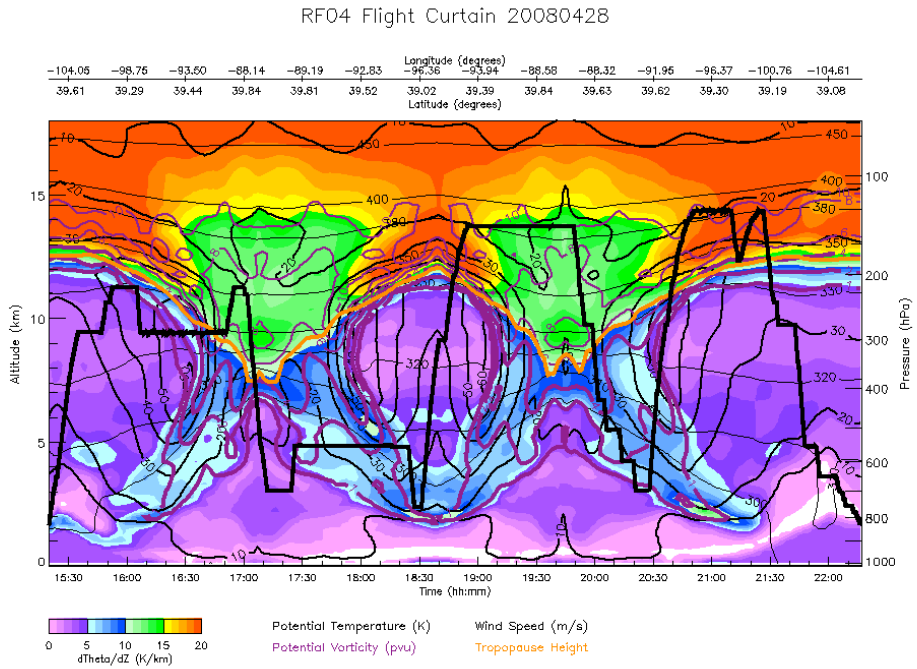
Retrieved Quantity	Tropical	Mid-latitude	Polar
T(p)	6.67	6.40	5.65
q(p)	4.46	3.85	2.89
O_3(p)	1.36	1.64	1.66
CO(p)	0.78	0.84	0.65
CH_4(p)	1.06	0.94	0.70

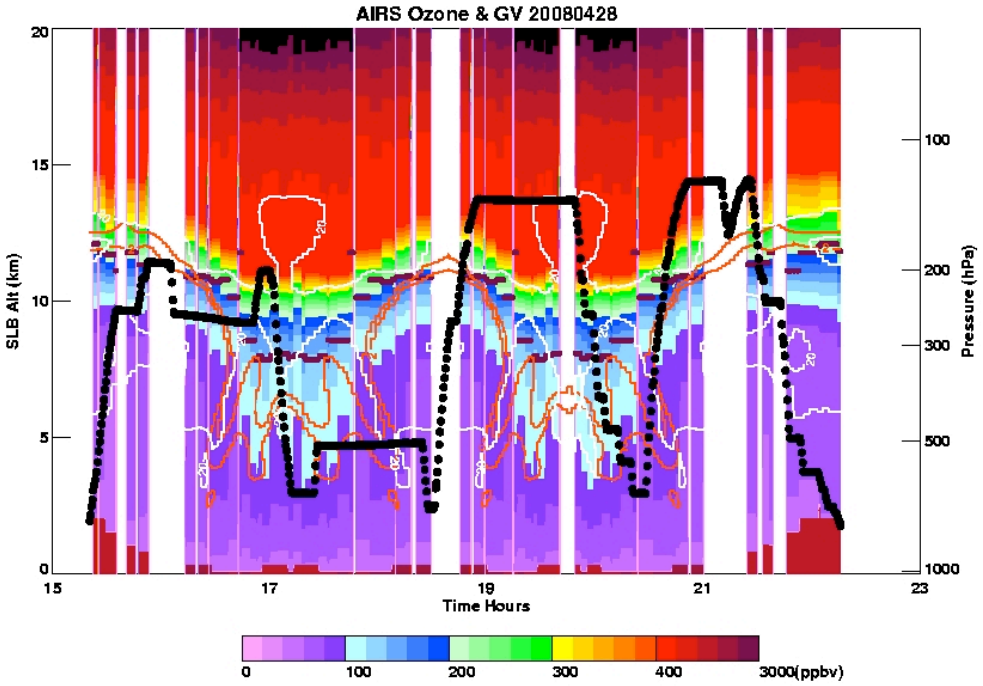
Maddy and Barnet, IEEE, 2008

AIRS O_3(p) KERNEL Functions: 910⟶ 1140 cm^{-1}




AIRS 20080428 O_3 (ppbv), 195 mb
60
52
44
36
28
20
-130
-110
-90
-70
0
100
200
300
400
3000(ppbv)


RF04 Flight Curtain 20080428
Longitude (degrees)
-104.05 -98.76 -93.60 -88.14 -89.19 -92.83 -96.36 -93.94 -88.58 -88.32 -91.96 -96.37 -100.76 -104.61
39.61 39.29 39.44 39.84 39.81 39.52 39.02 39.39 39.84 39.63 39.62 39.30 39.19 39.08
Latitude (degrees)
Altitude (km)
Pressure (hPa)
Time (hh:mm)
15:30 16:00 16:30 17:00 17:30 18:00 18:30 19:00 19:30 20:00 20:30 21:00 21:30 22:00
0 5 10 15 20
dTheta/dZ (K/km)
Potential Temperature (K)
Potential Vorticity (pvu)
Wind Speed (m/s)
Tropopause Height


AIRS Ozone & GV 20080428
SLB Alt (km)
Pressure (hPa)
Time Hours
15 17 19 21 23
0
100
200
300
400
3000(ppbv)

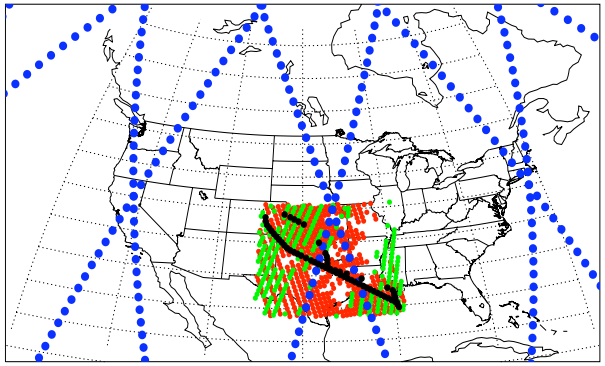
Vertical Profiles:

How good do AIRS and IASI capture Troposphere-Stratosphere Transition in Ozone?

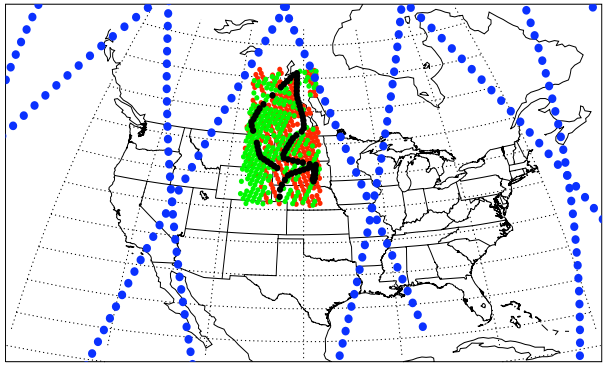
Ozone Comparisons:

GV, AIRS, IASI, MLS

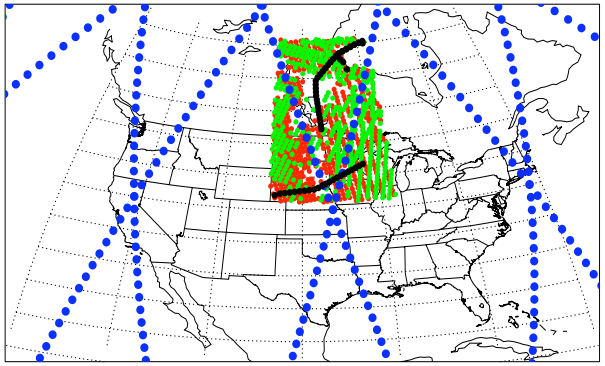
RF08

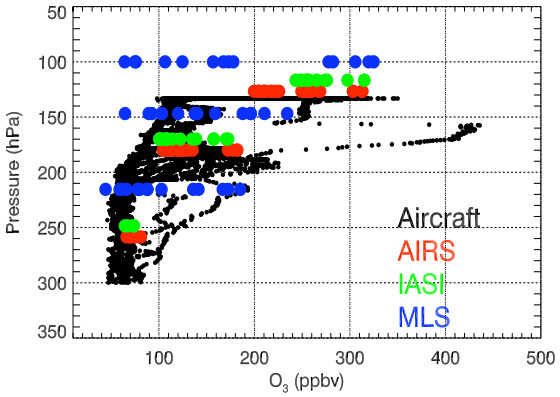


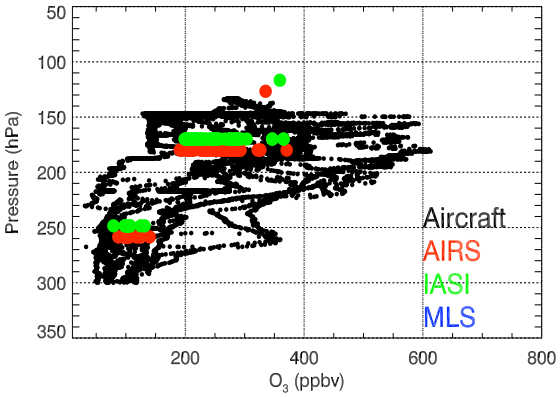
RF14

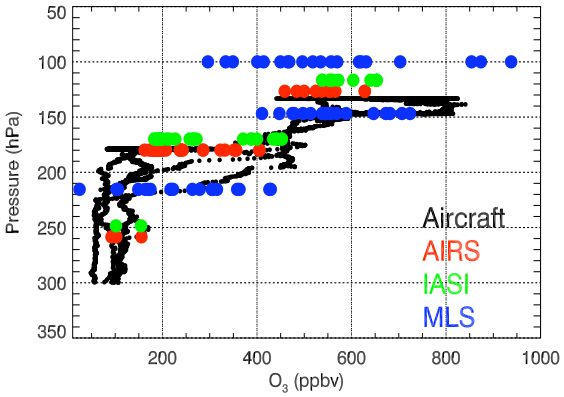


RF15

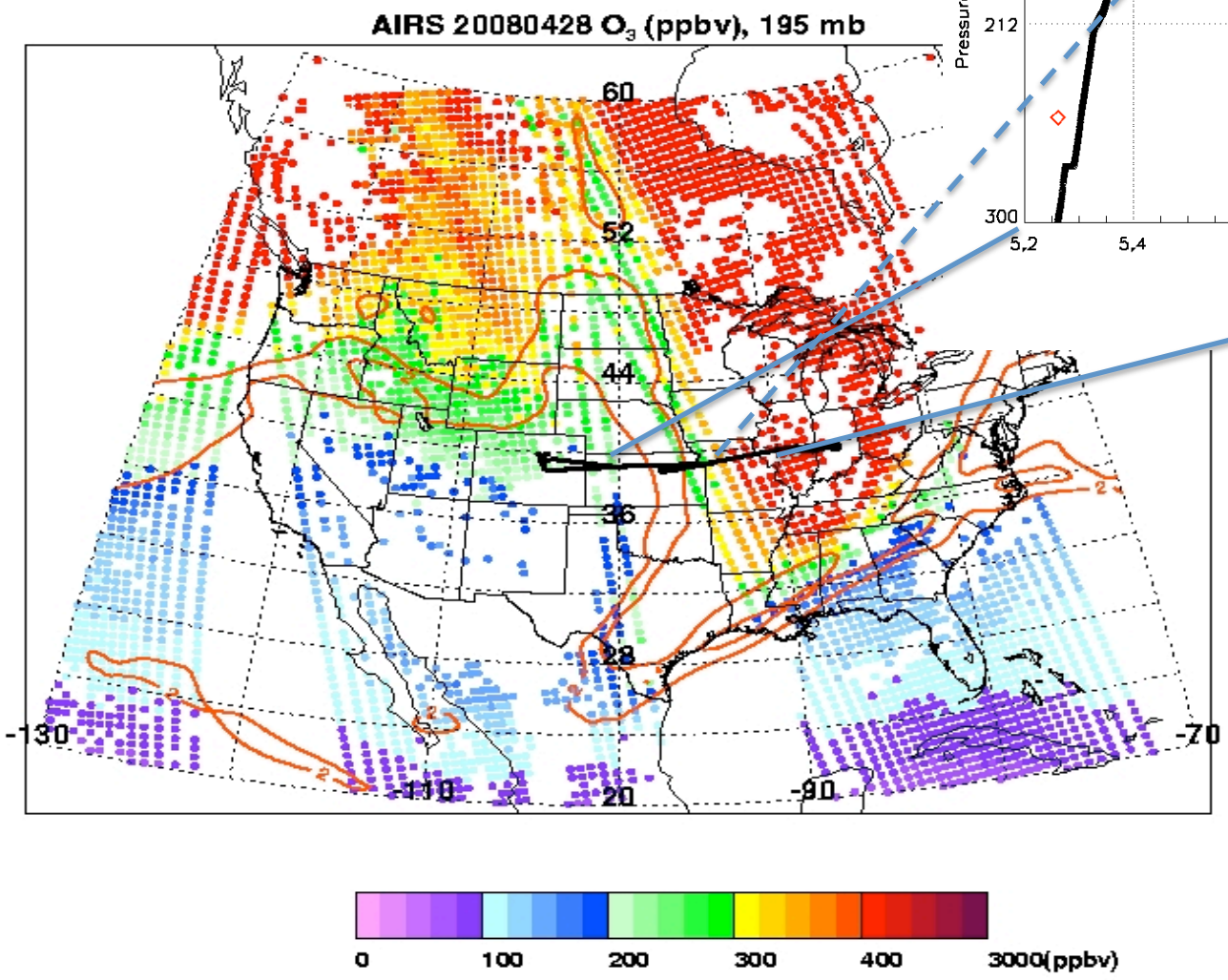


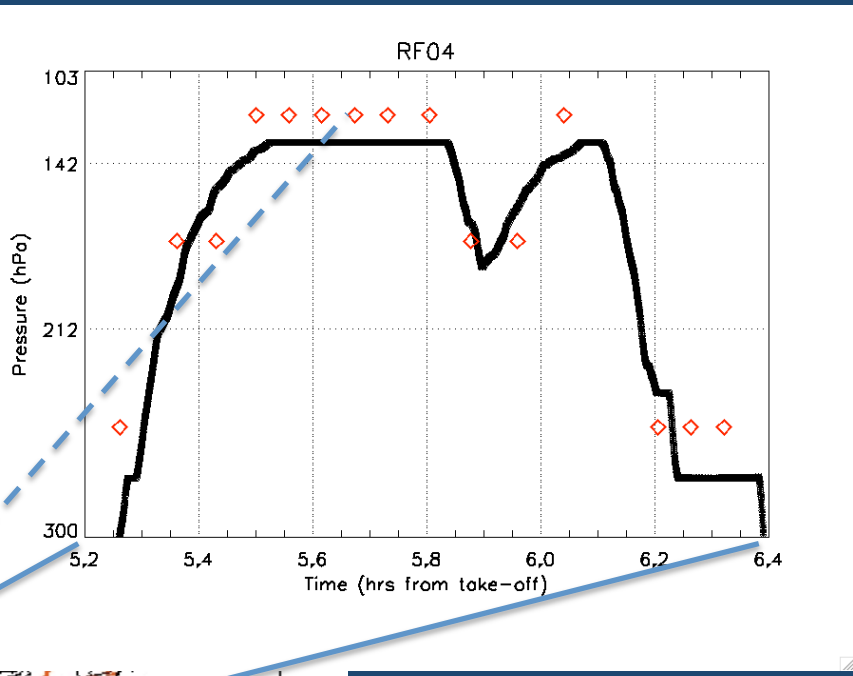


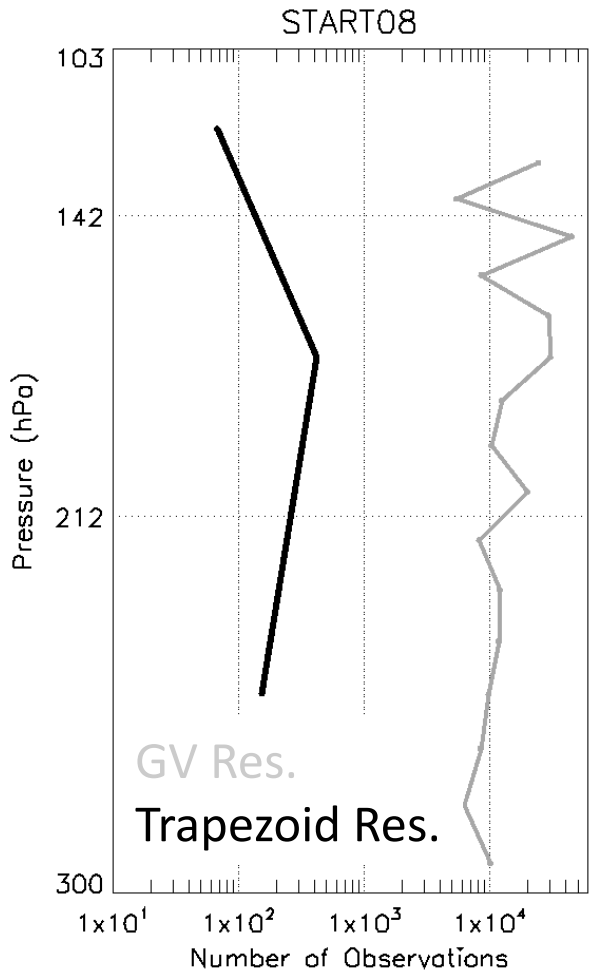


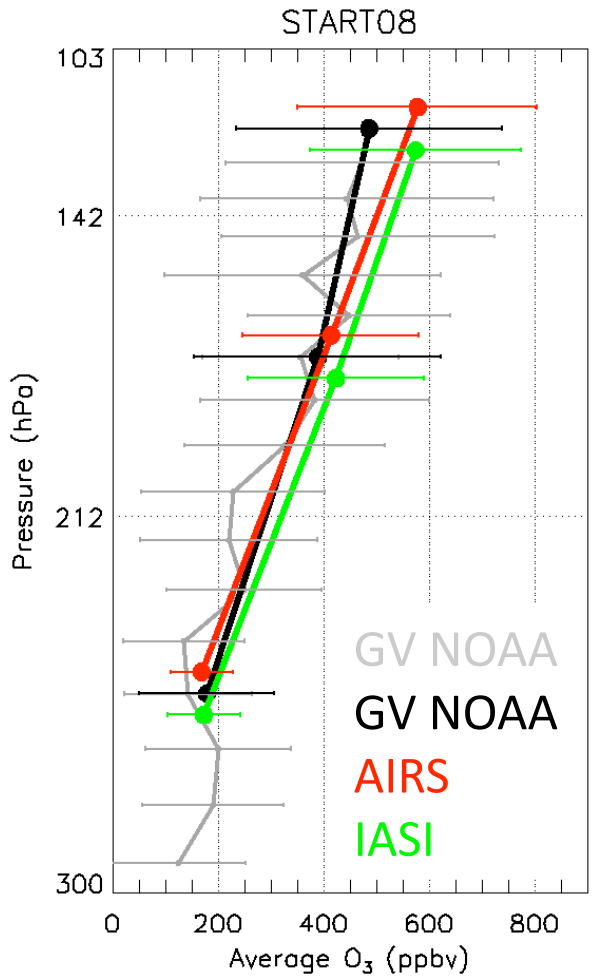


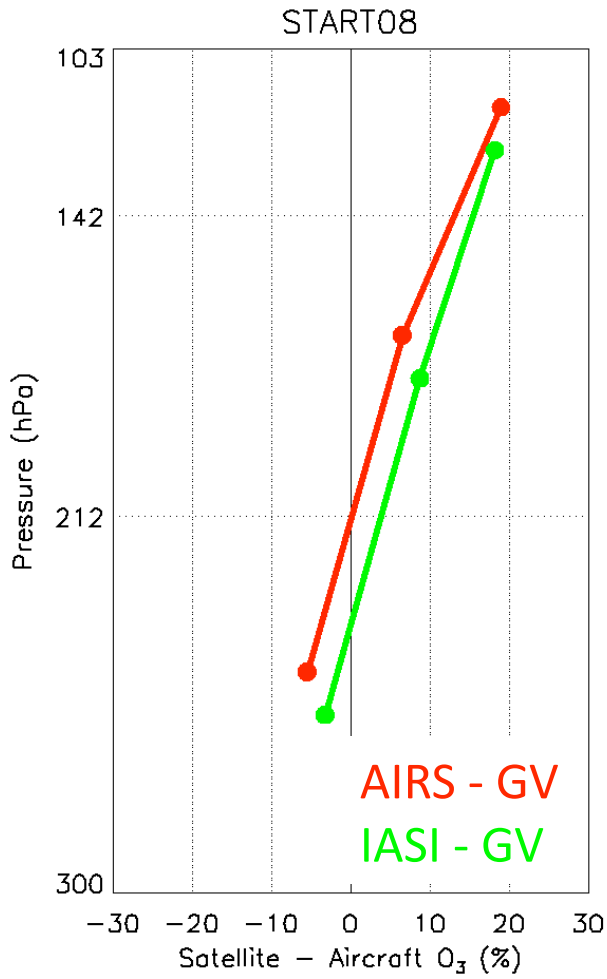
Three Trapezoids in the UT/LS region

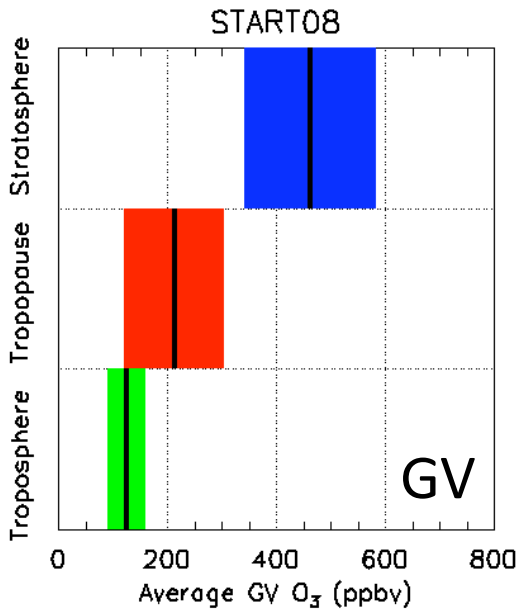


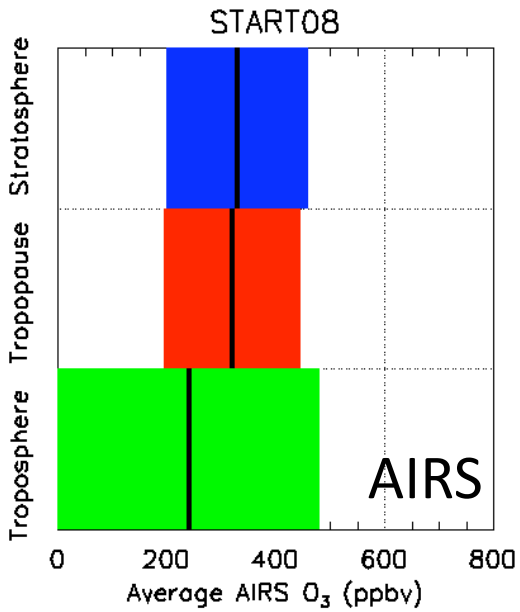


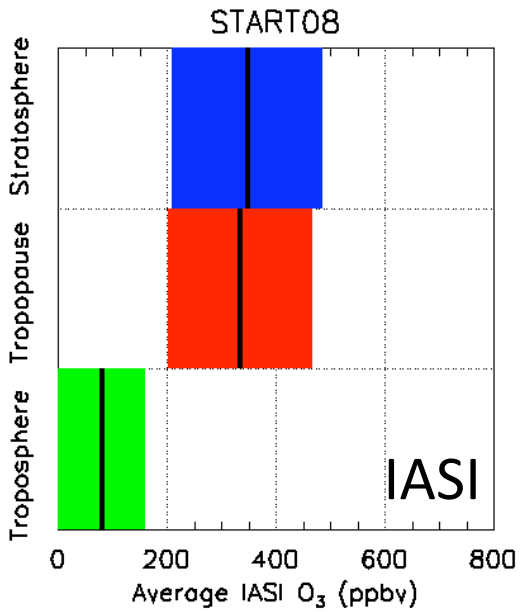

START08
103
142
212
300
Pressure (hPa)
1x10¹
1x10²
1x10³
1x10⁴
Number of Observations
GV Res.
Trapezoid Res.

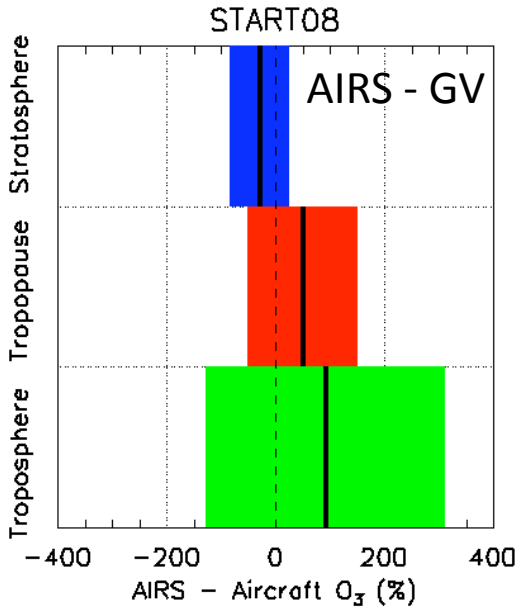

START08
103
142
212
300
Pressure (hPa)
0
200
400
600
800
Average O₃ (ppbv)
GV NOAA
GV NOAA
AIRS
IASI

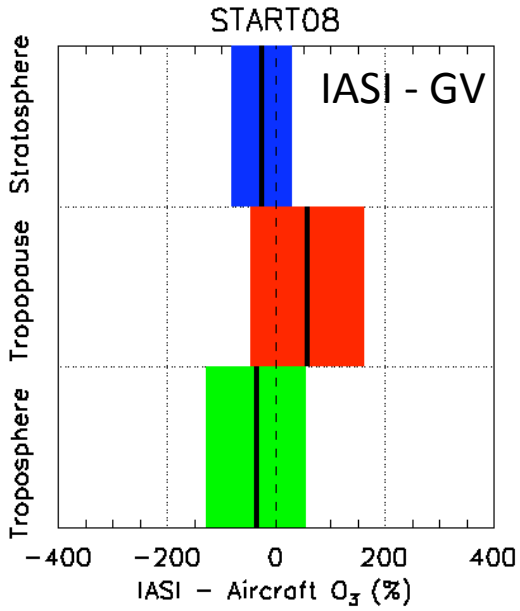

START08
103
142
212
300
Pressure (hPa)
−30
−20
−10
0
10
20
30
Satellite − Aircraft O₃ (%)
AIRS - GV
IASI - GV

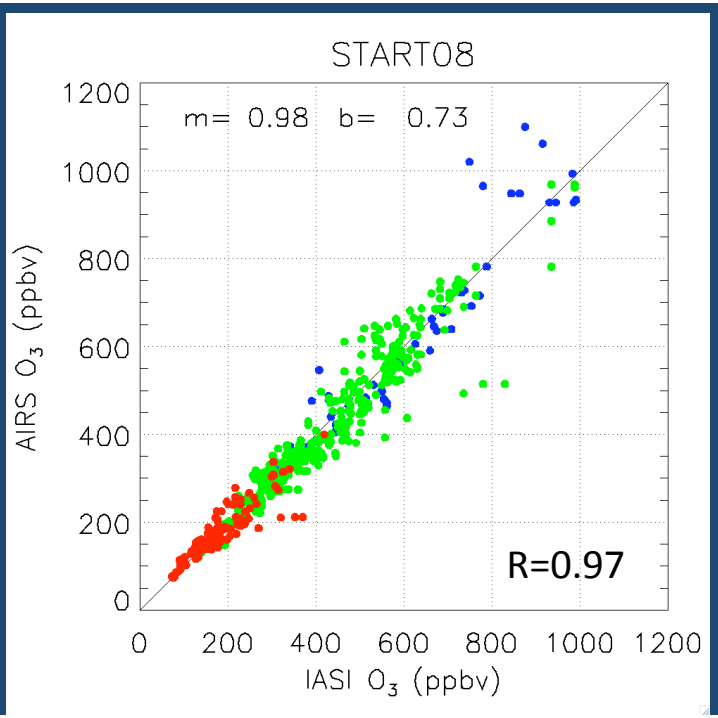

START08
Stratosphere
Tropopause
Troposphere
GV
0
200
400
600
800
Average GV O_3 (ppbv)


START08
Stratosphere
Tropopause
Troposphere
AIRS
0
200
400
600
800
Average AIRS O_3 (ppbv)

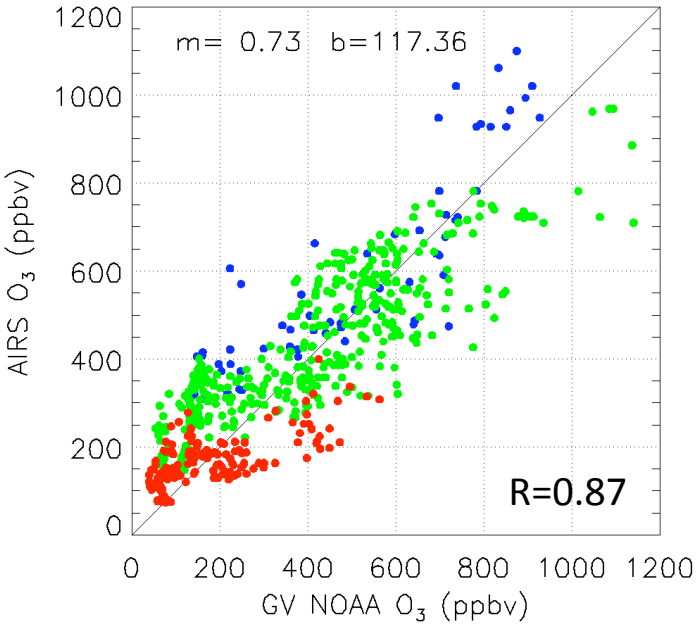

START08
Stratosphere
Tropopause
Troposphere
IASI
0
200
400
600
800
Average IASI O_3 (ppbv)

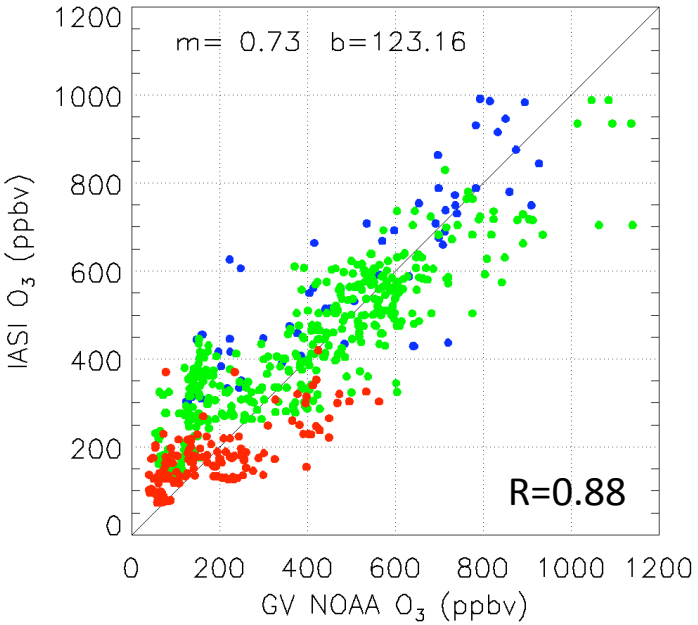

START08
Stratosphere
Tropopause
Troposphere
AIRS - GV
−400
−200
0
200
400
AIRS − Aircraft O_3 (%)


START08
Stratosphere
Tropopause
Troposphere
IASI - GV
−400
−200
0
200
400
IASI − Aircraft O_3 (%)



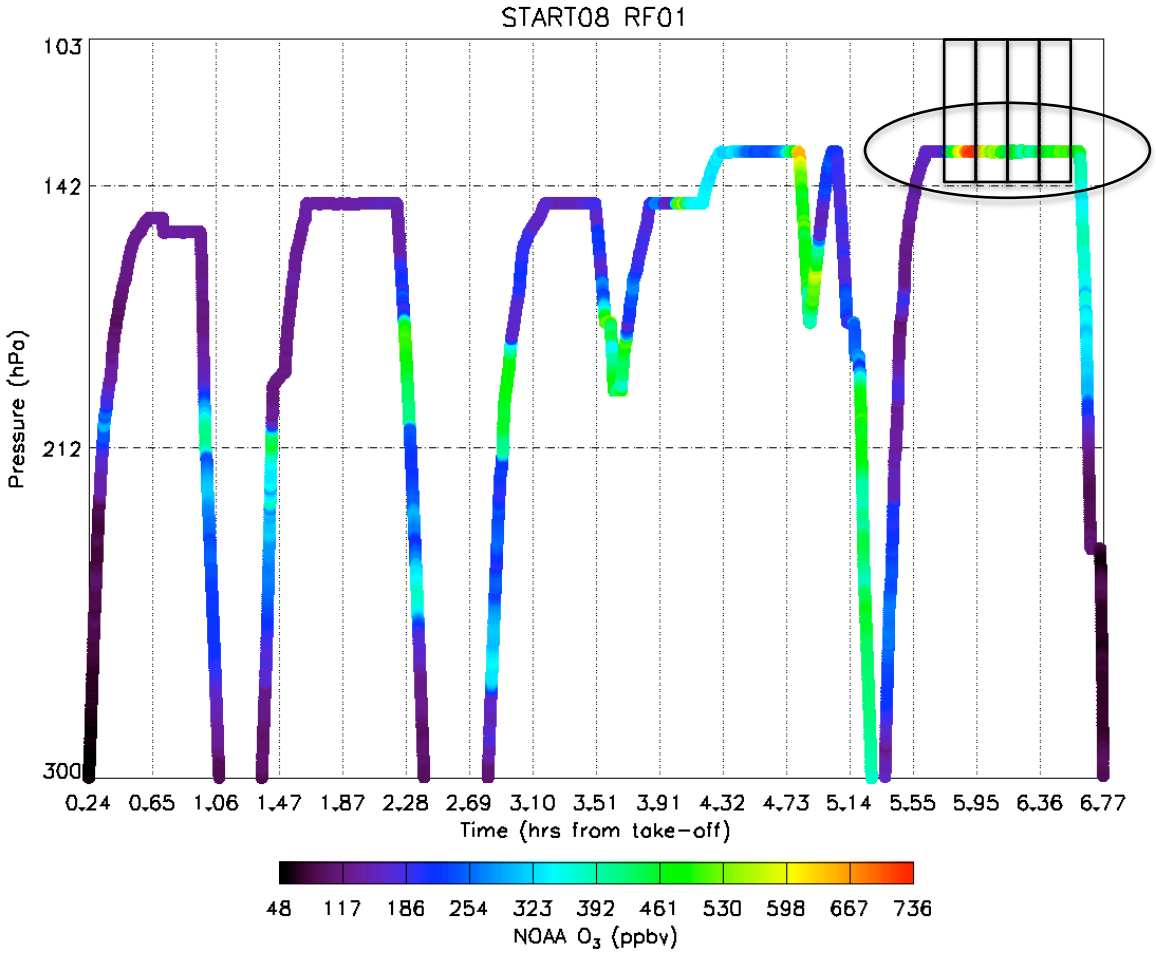
103 – 142 hPa
142 – 212 hPa
212 – 300 hPa

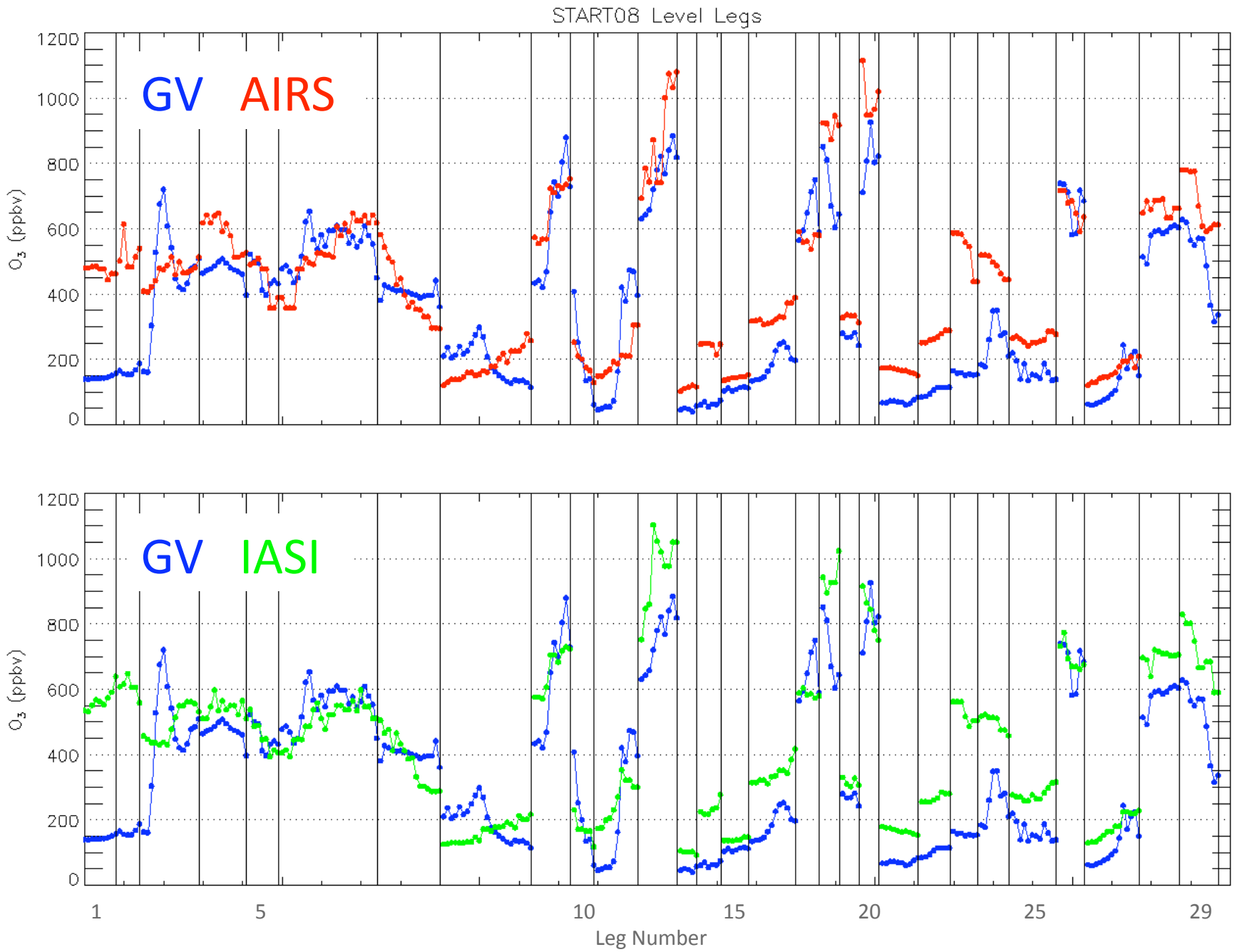


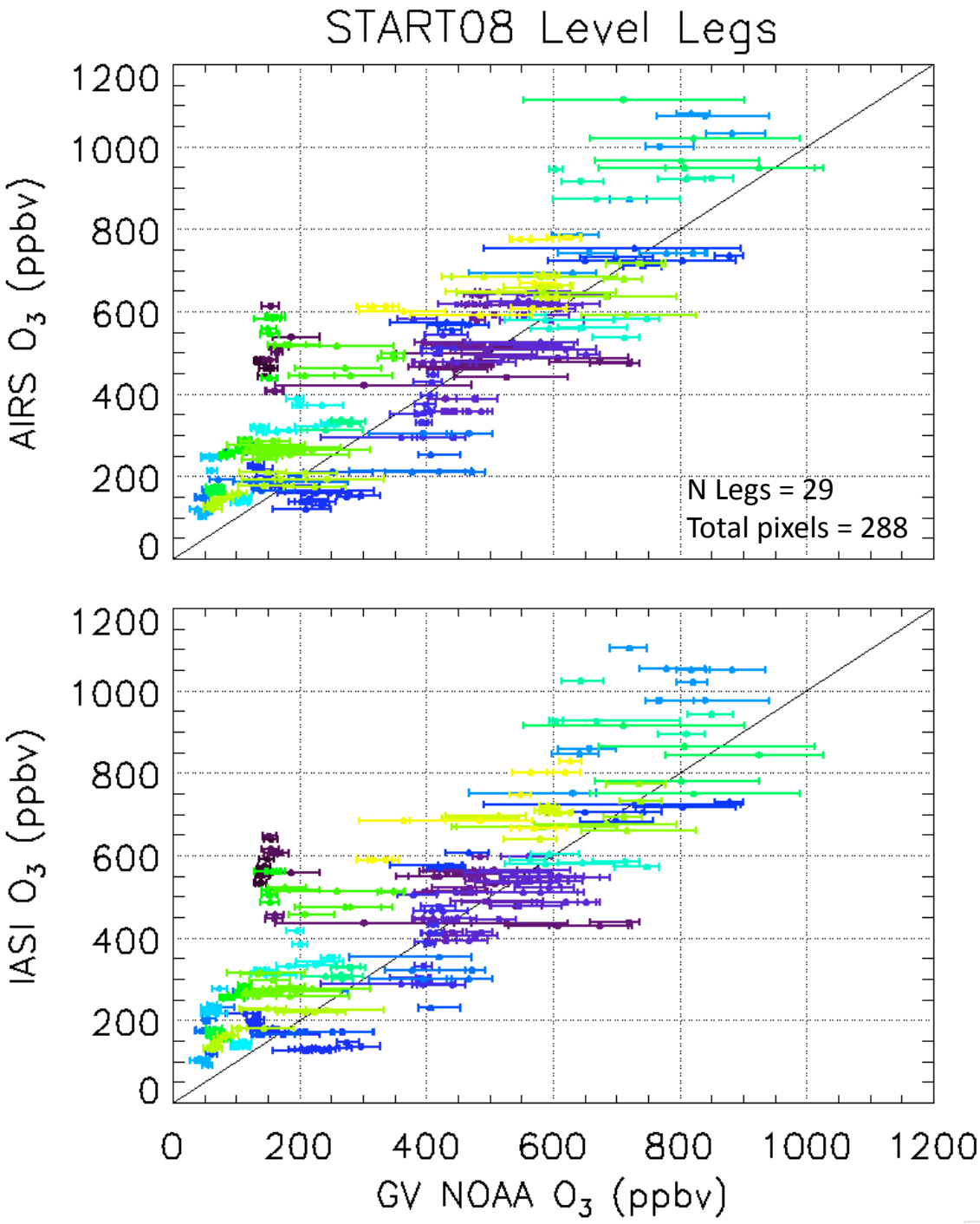


Horizontal Variability:

How good do AIRS and IASI capture Ozone gradients in the horizontal?

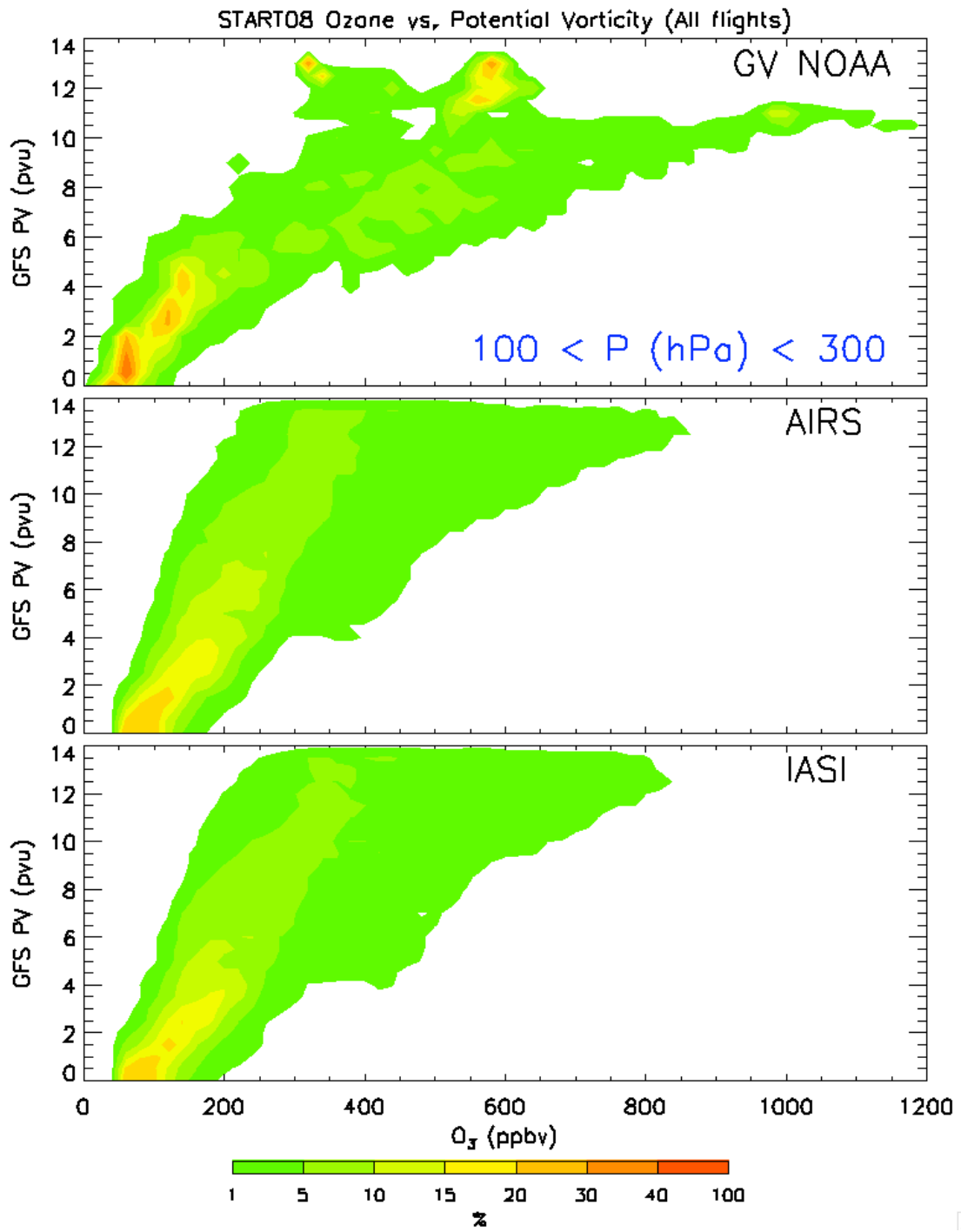

START08 RF01
103
142
212
300
Pressure (hPa)
0.24 0.65 1.06 1.47 1.87 2.28 2.69 3.10 3.51 3.91 4.32 4.73 5.14 5.55 5.95 6.36 6.77
Time (hrs from take-off)
48 117 186 254 323 392 461 530 598 667 736
NOAA O_3 (ppbv)


START08 Level Legs
GV AIRS
GV IASI
O_3 (ppbv)
0
200
400
600
800
1000
1200
1
5
10
15
20
25
29
Leg Number


START08 Level Legs
AIRS O_3 (ppbv)
IASI O_3 (ppbv)
GV NOAA O_3 (ppbv)
0
200
400
600
800
1000
1200
N Legs = 29
Total pixels = 288

Ozone – PV Analysis:

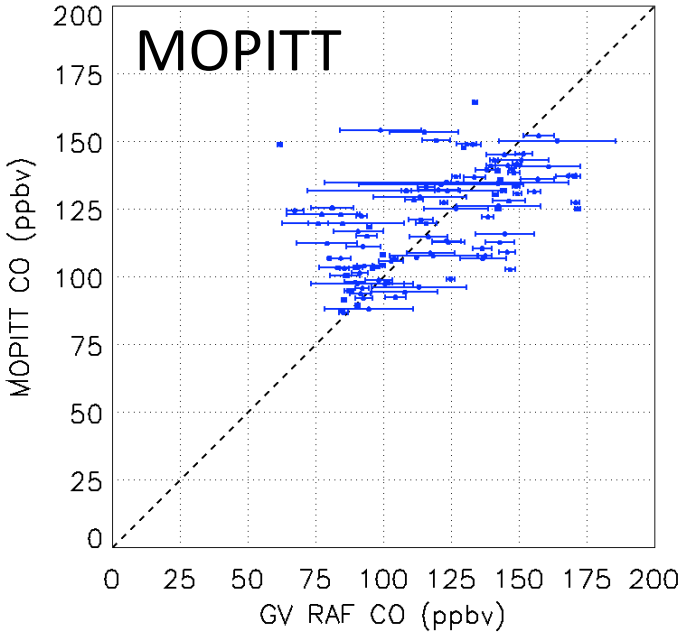
A valuable application for the AIRS and IASI datasets

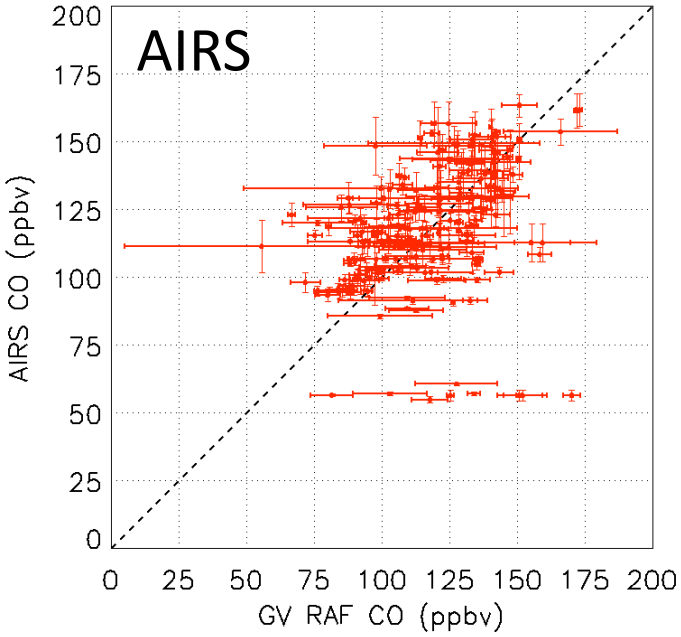

START08 Ozone vs, Potential Vorticity (All flights)
GV NOAA
100 < P (hPa) < 300
AIRS
IASI
GFS PV (pvu)
0
2
4
6
8
10
12
14
0
200
400
600
800
1000
1200
O_3 (ppbv)
1
5
10
15
20
30
40
100
%

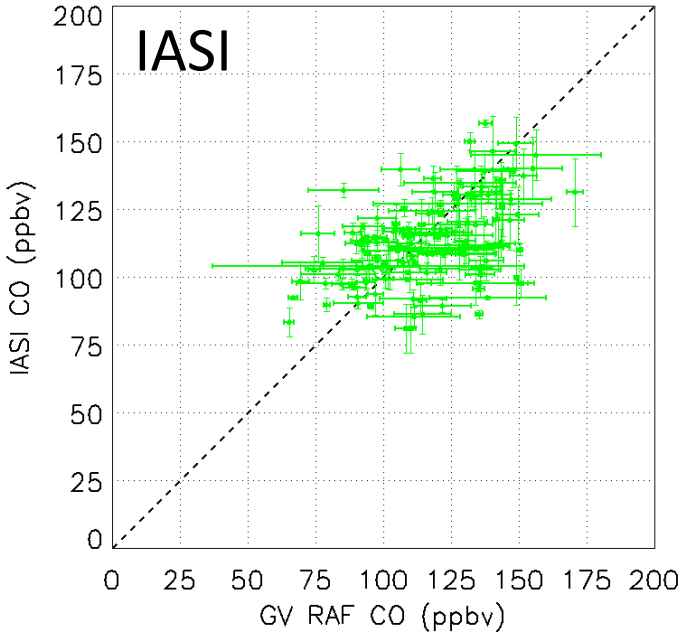
CO

(400-600 mb)

Satellite vs GV







Conclusions

- AIRS and IASI provide *daily* observations with wide horizontal coverage, which allow for a better dynamical and chemical characterization of the UT/LS
- AIRS and IASI show agreement with GV in: large-scale O_3 features, horizontal gradients in O_3, and large-scale CO variability
- AIRS and IASI show comparable performance to satellite instruments with well-established data characterization