Aircraft/Satellite comparisons from the HIPPO and GloPac campaigns

Karen Rosenlof[1] and Eric Ray[2]
[1]NOAA ESRL CSD
[2]CIRES, University of Colorado
Boulder, CO

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Instruments compared with HIPPO

AIRS (Atmospheric Infrared Sounder)

Hyperspectral infrared instrument on EOS Aqua

~ 1 km vertical, 13.5 km horizontal resolution (at nadir)

elevant measurements: T, CO_2, H_2O, O_3, CO, CH_4 (troposphere)

MLS (Microwave Limb Sounder) on EOS Aura

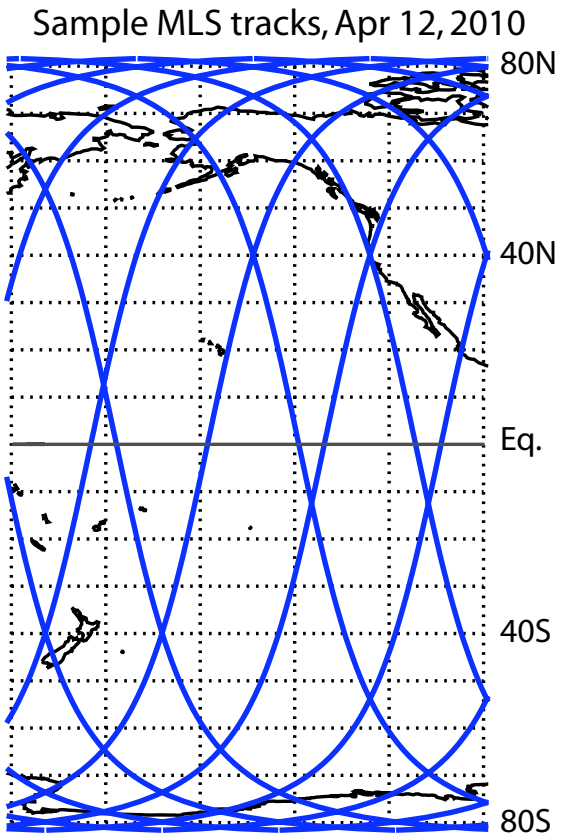
On EOS AURA. Measures microwave thermal emission from the limb resolution varies with altitude and species, ~3 km X 250-500 km horizontal, and 2-6 km vertical (best accuracy in the stratosphere, but does extend into the upper troposphere for some species) relevant measurements, H_2O, CO, O_3 (upper troposphere); does have stratospheric N_2O.

Other possibilities:

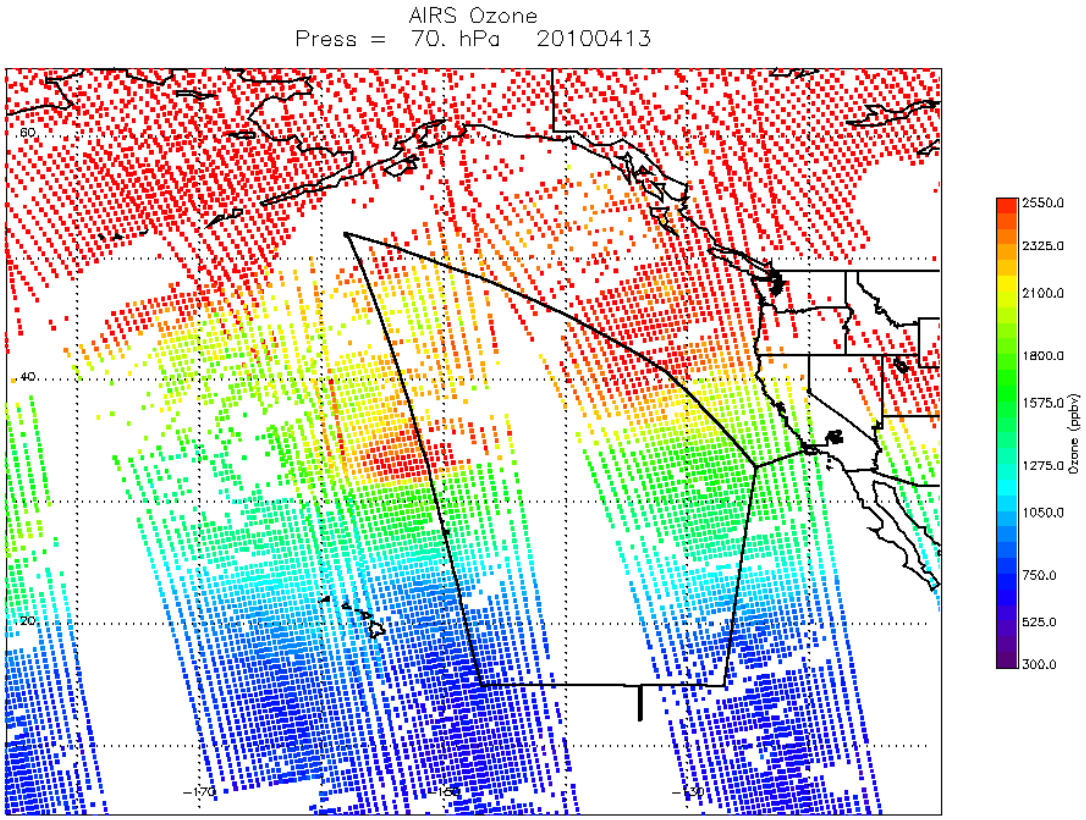
IASI, TES, OMI, GOMOS, SCIAMACHY, HIRDLS, MOPITT, DMSP instruments (SSM/I, SSM/T2), Operational polar orbiters (IASI, AMSU-A, GOME-2, TOMS), GPS limb measurements (COSMIC), ACE

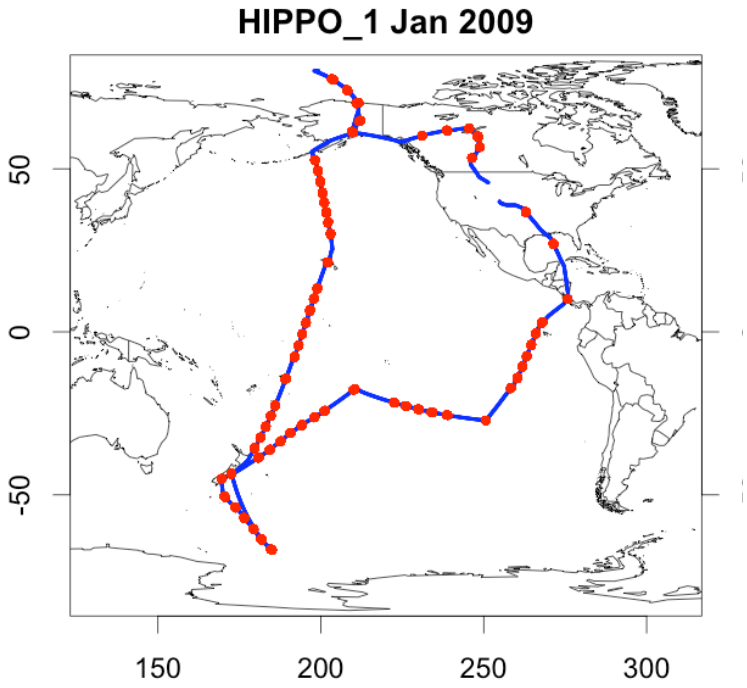
HIPPO flights were not planned with satellite validation in mind. However, AIRS has extensive spatial sampling (in an A-train orbit, ~2AM/2PM local time) that reasonably close coincidences are quite possible. MLS has sparser sampling, but comparisons are still possible.

MLS coverage example



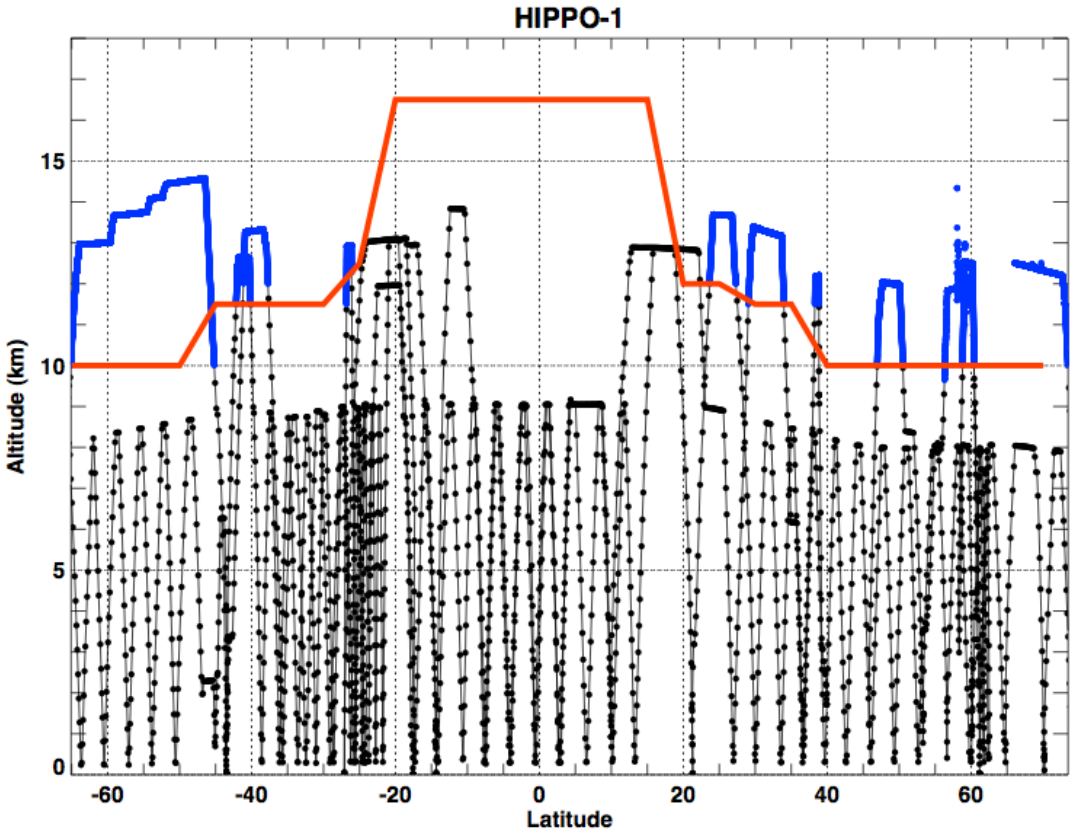
AIRS coverage example





Example of HIPPO vertical coverage: shows there is some coverage in the lower stratosphere and upper troposphere, so can make MLS comparisons.

Lowest useful level for MLS is typically either 215 or 315 mb; this varies with species measured. These (along with 146 mb) are levels that are not well validated...so HIPPO measurements should prove to be valuable.



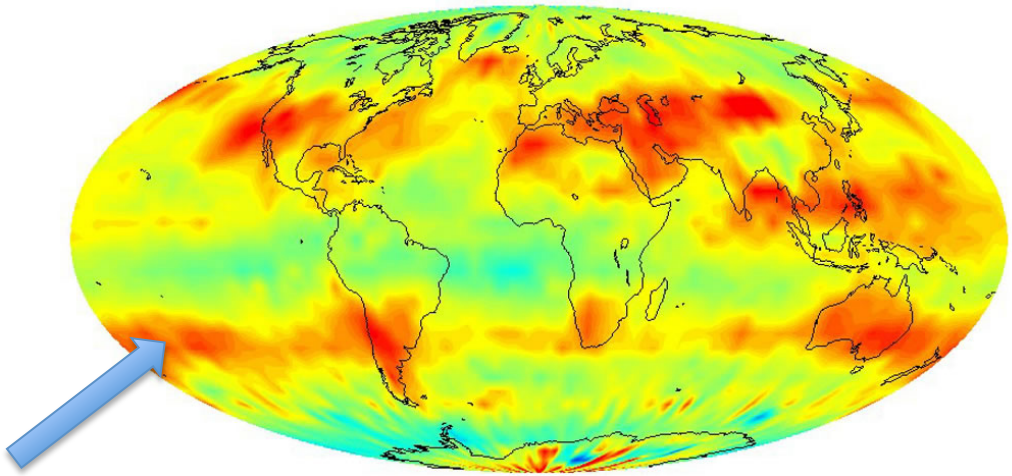
Species we have done detailed HIPPO/AIRS comparisons with are:
O_3, H_2O, CO, CH_4, CO_2, and Temperature

I'll show a few comparisons with MLS for HIPPO-3:
Specifically O_3 H_2O and CO

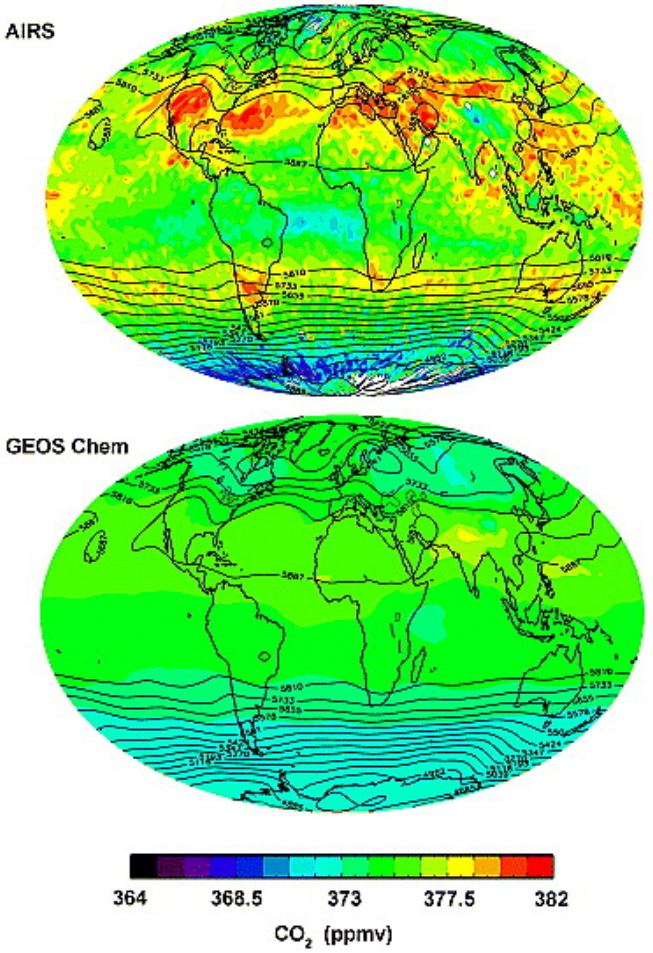
What makes HIPPO extremely useful for satellite comparisons is the abundance of profiles.

Such comparisons are a means of adding value to both the satellite and aircraft data...improves confidence in satellite data via comparison to high quality measurements, thereby expanding the influence of the geographically limited aircraft data globally.

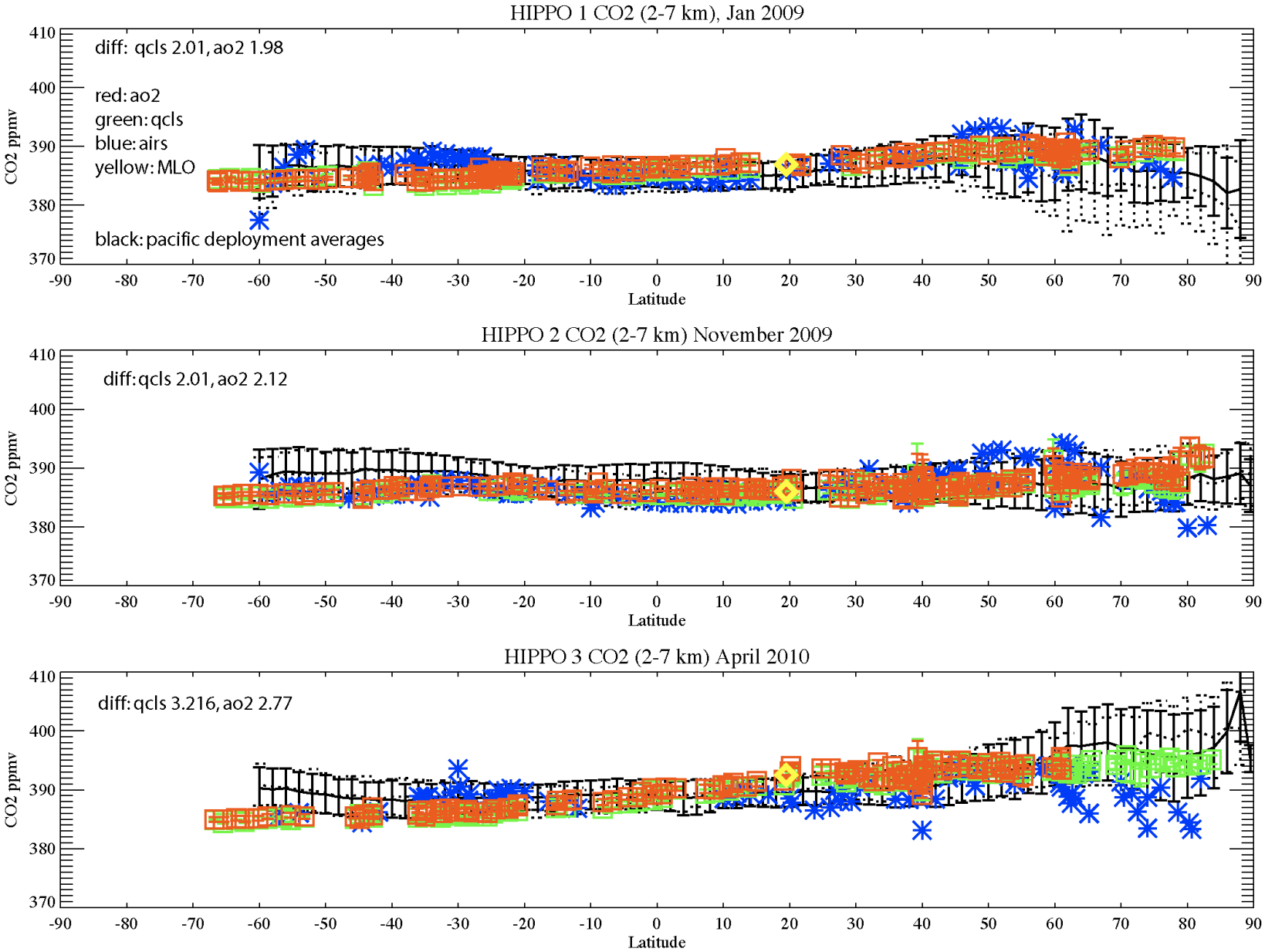
AIRS CO_2



AIRS July 2008 CO_2 (ppmv)



Chahine et al, 2008: discussed spatial patterns and attributed features to specific dynamical patterns....However, are these robust?

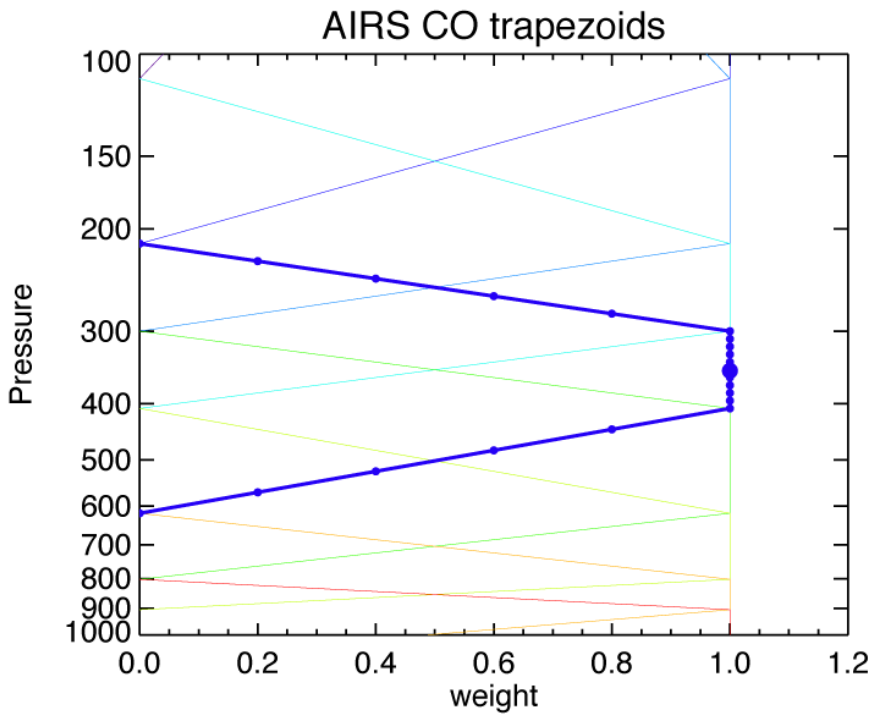


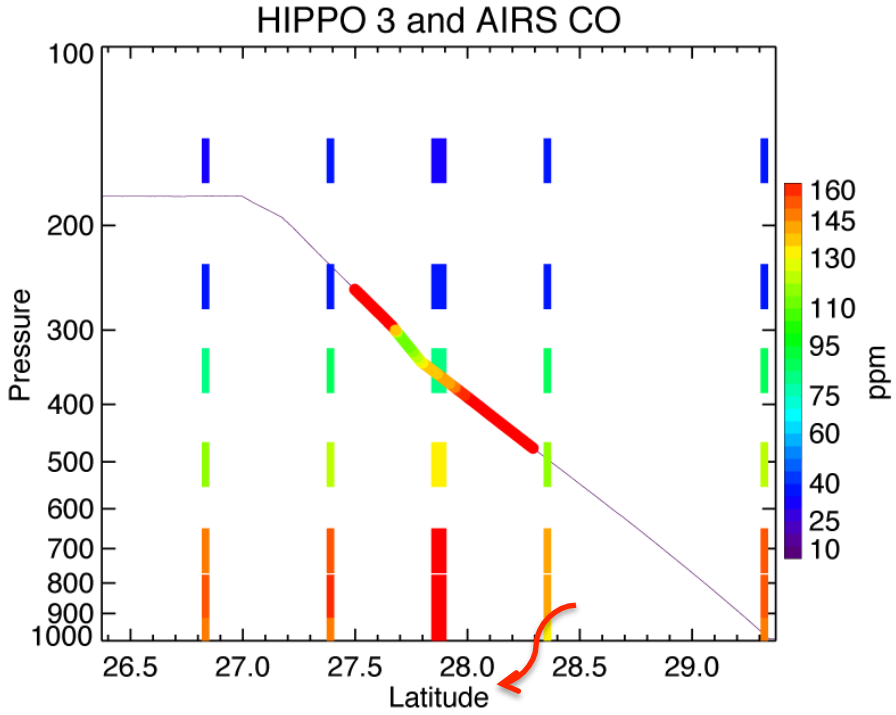
Note, AIRS takes a lot of averaging to beat down noise. Blue symbols are 3 day averages of points within 3º latitude and 5º longitude of the observation profile.

Tropics agree better than high latitudes.

AIRS species with multiple layers

To compare:



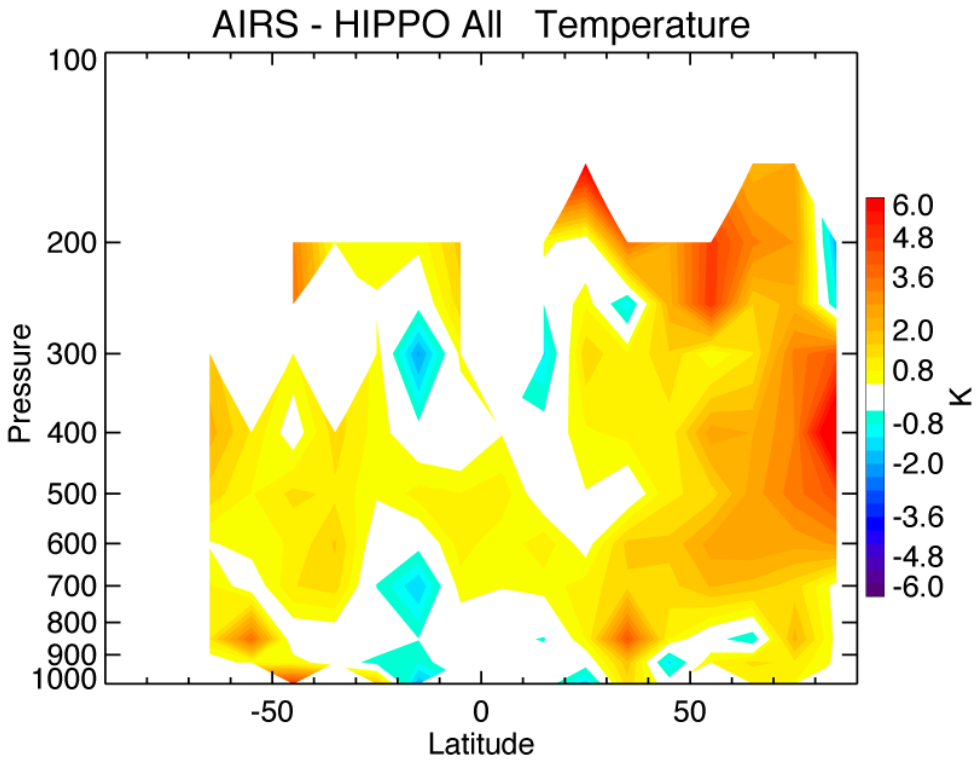


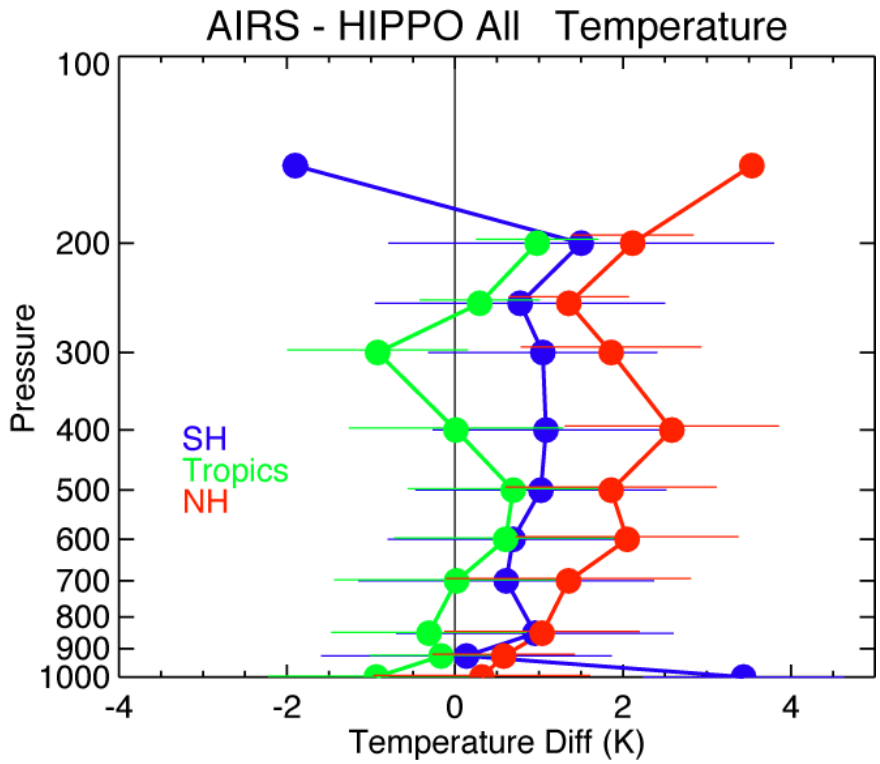
- Identify nearest AIRS profiles to HIPPO flight tracks (≈2500 for 3 missions).
- For each AIRS profile find HIPPO measurements within 50 km and 6 hours.
- For AIRS layer quantities we divide the layer into 10-20 finer layers and the layer difference is:

$$\Delta\chi = \sum_{z1}^{z2}\left(\left(\overline{\chi}_{AIRS}(z) - \overline{\chi}_{HIPPO}(z)\right) \times W_{AIRS}(z)\right)/(z2 - z1)$$

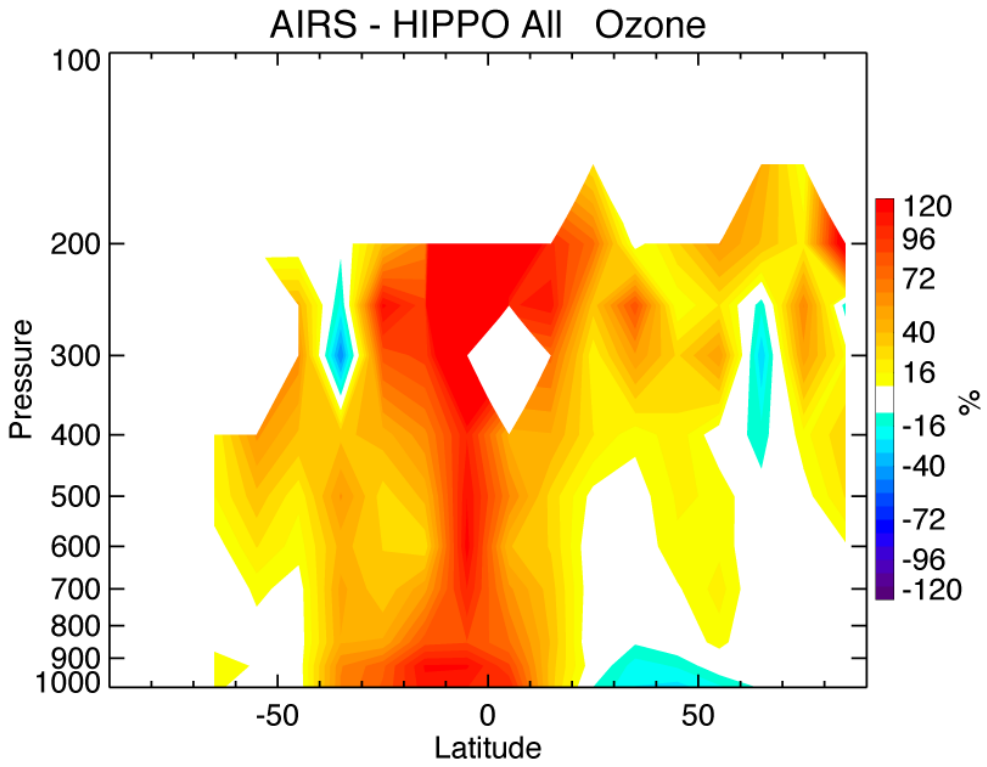
where z is the fine layer where HIPPO data is available and W is the layer weighting function.

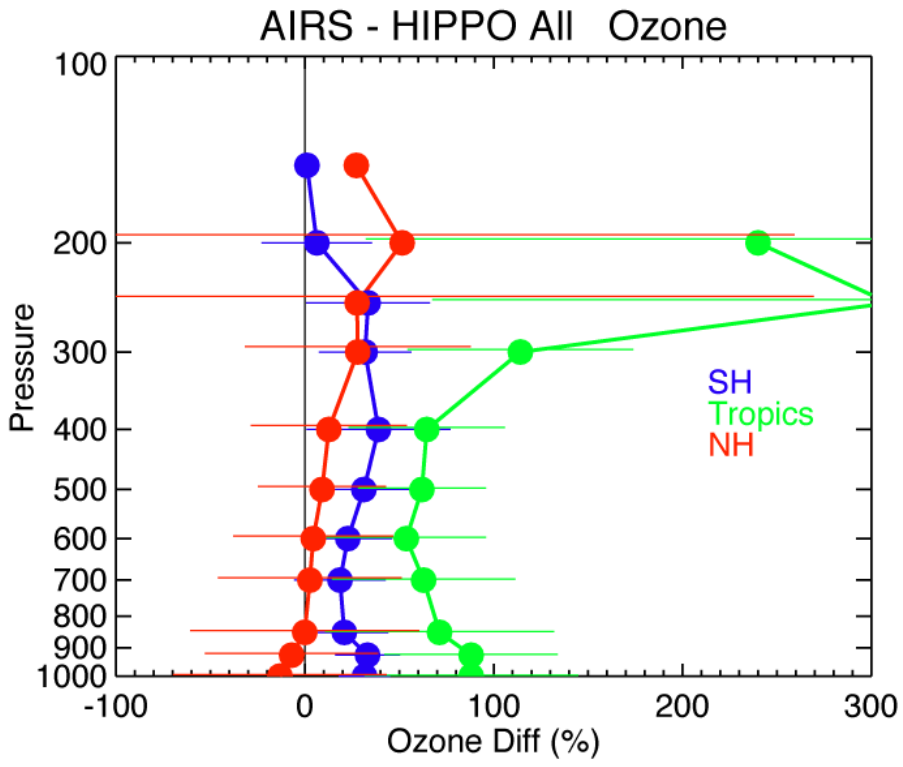
Temperature



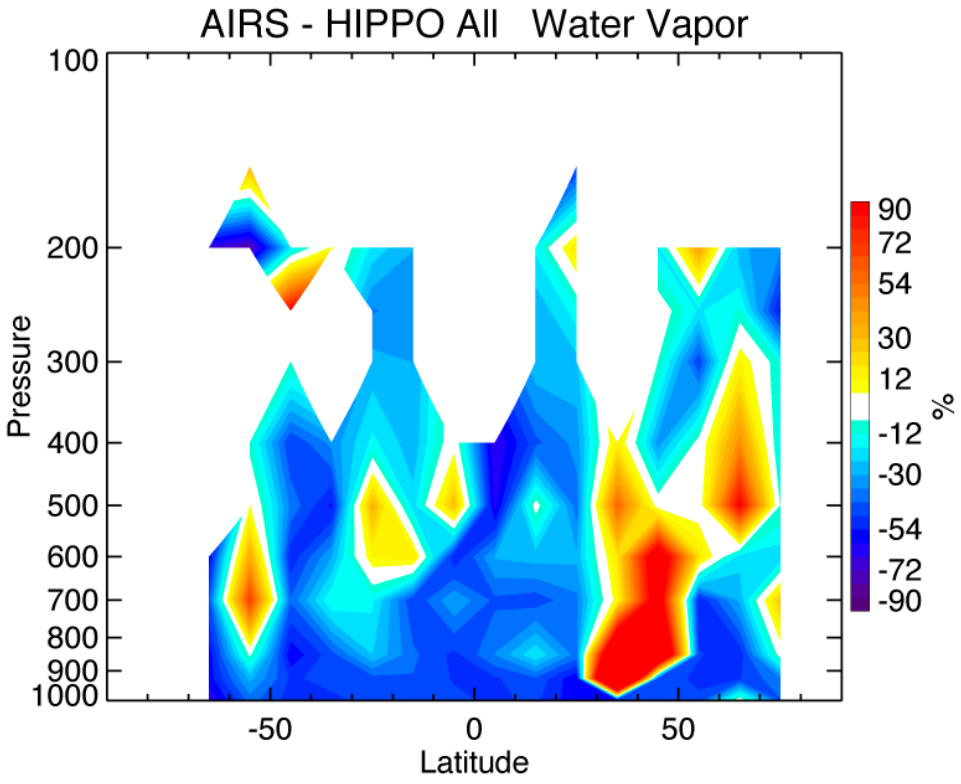


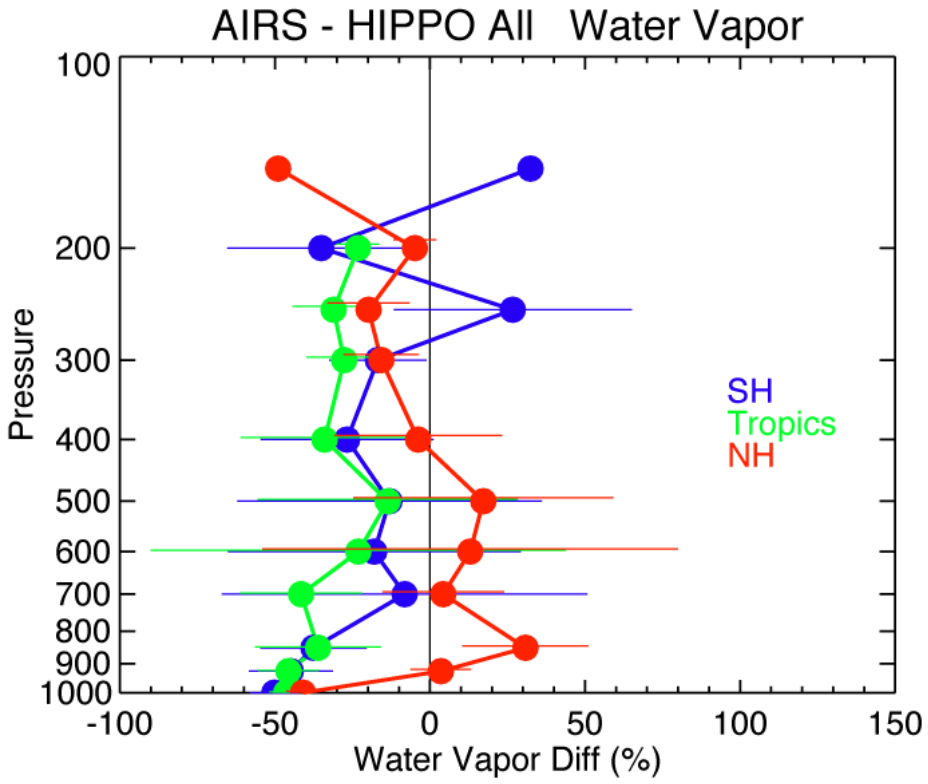
Ozone


AIRS - HIPPO All Ozone
Pressure
100
200
300
400
500
600
700
800
900
1000
-50
0
50
Latitude
120
96
72
40
16
-16
-40
-72
-96
-120
%

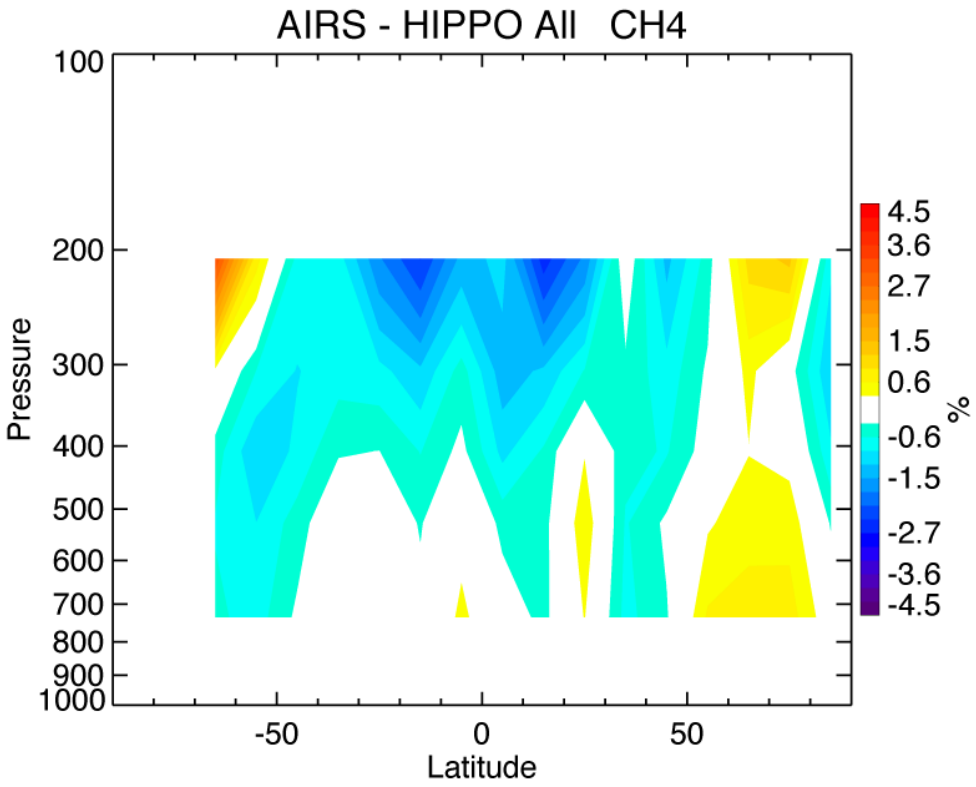

AIRS - HIPPO All Ozone
Pressure
100
200
300
400
500
600
700
800
900
1000
-100
0
100
200
300
Ozone Diff (%)
SH
Tropics
NH

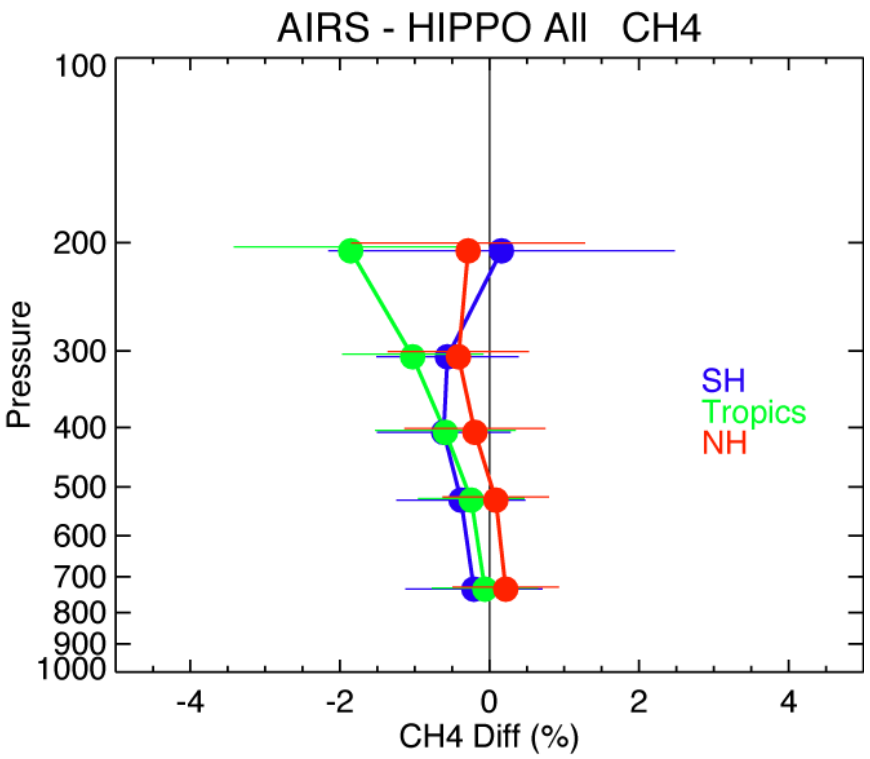
Water Vapor


AIRS - HIPPO All Water Vapor
Pressure
100
200
300
400
500
600
700
800
900
1000
-50
0
50
Latitude
90
72
54
30
12
-12
-30
-54
-72
-90
%

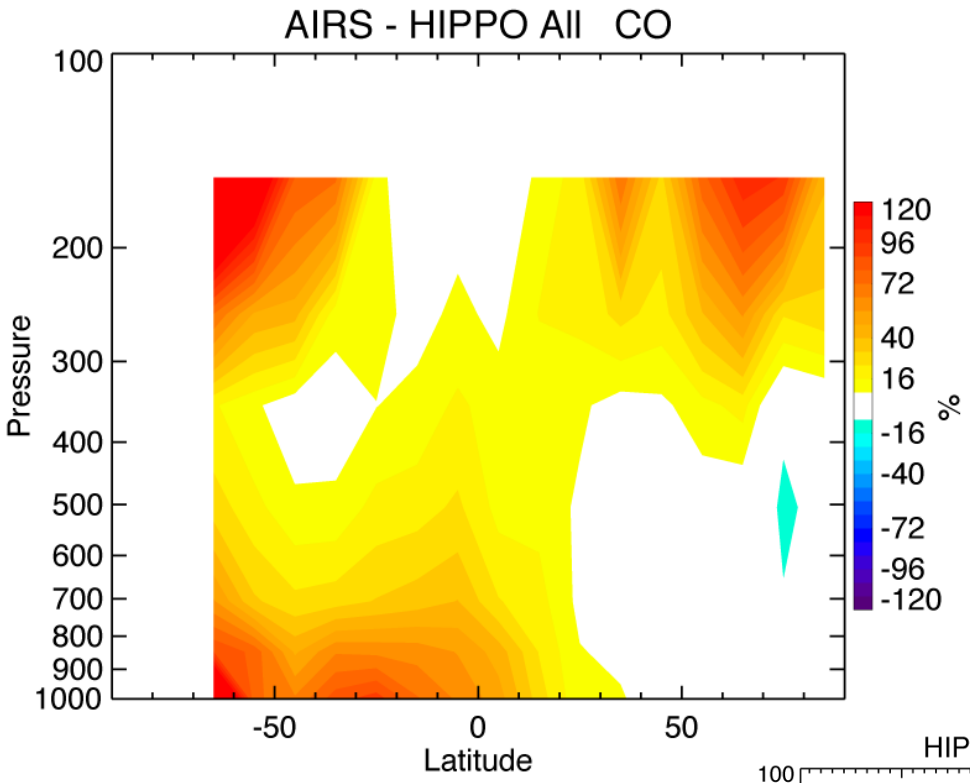

AIRS - HIPPO All Water Vapor
Pressure
100
200
300
400
500
600
700
800
900
1000
-100
-50
0
50
100
150
Water Vapor Diff (%)
SH
Tropics
NH

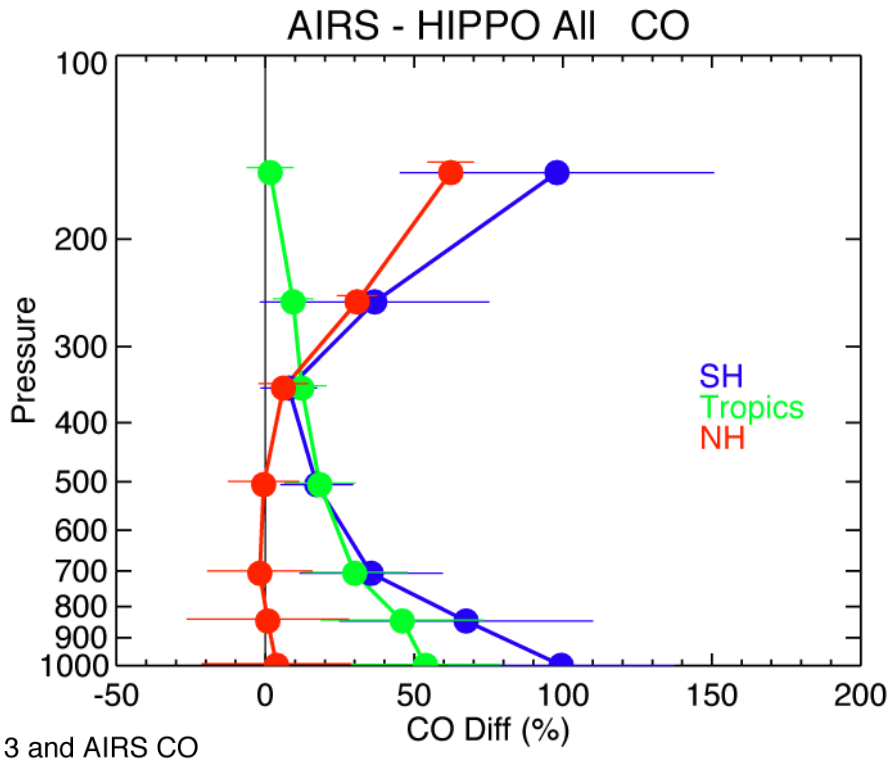
CH_4

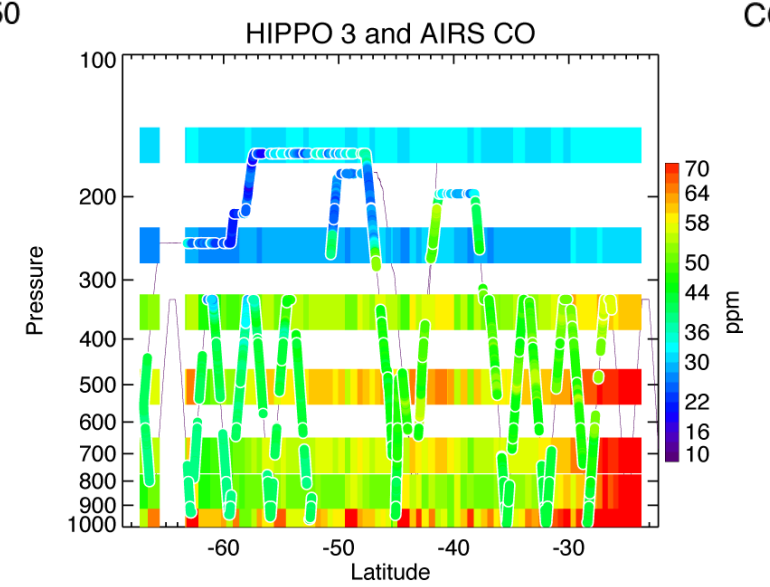

AIRS - HIPPO All CH4
Pressure
100
200
300
400
500
600
700
800
900
1000
-50
0
50
Latitude
4.5
3.6
2.7
1.5
0.6
-0.6
-1.5
-2.7
-3.6
-4.5
%


AIRS - HIPPO All CH4
Pressure
100
200
300
400
500
600
700
800
900
1000
-4
-2
0
2
4
CH4 Diff (%)
SH
Tropics
NH

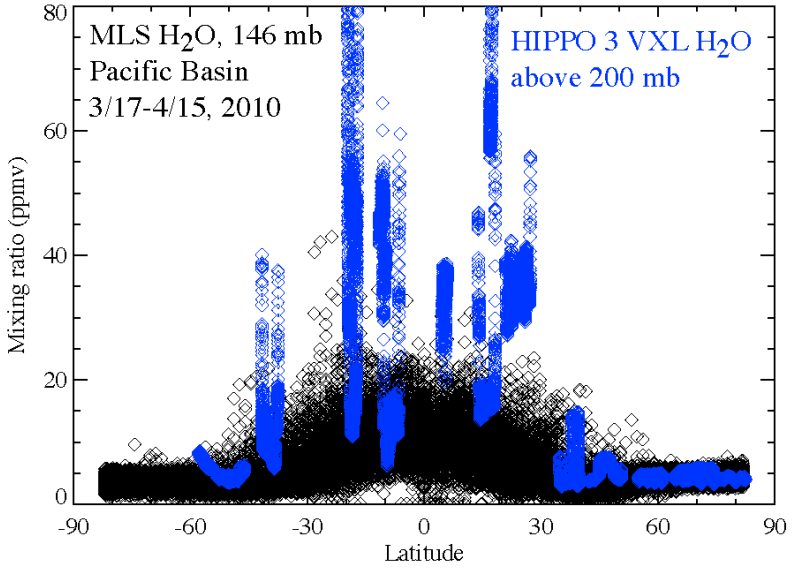
CO

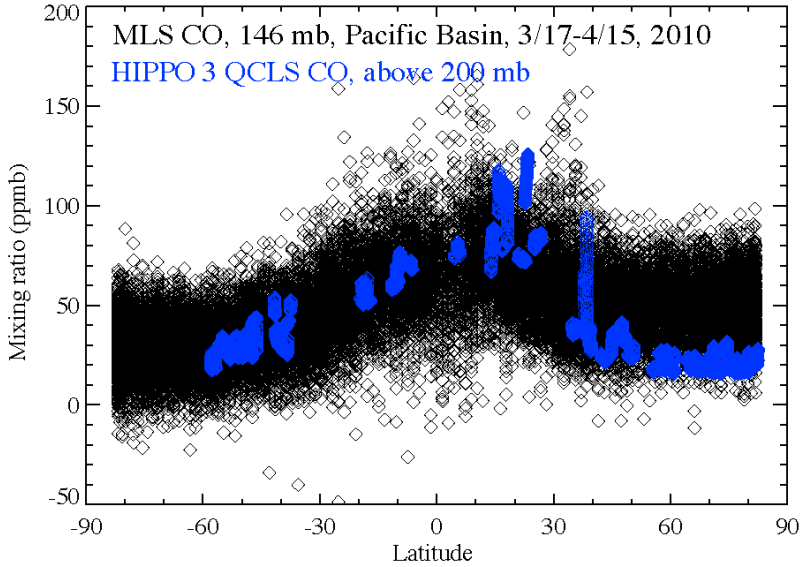

AIRS - HIPPO All CO
Pressure
Latitude
%
120
96
72
40
16
-16
-40
-72
-96
-120

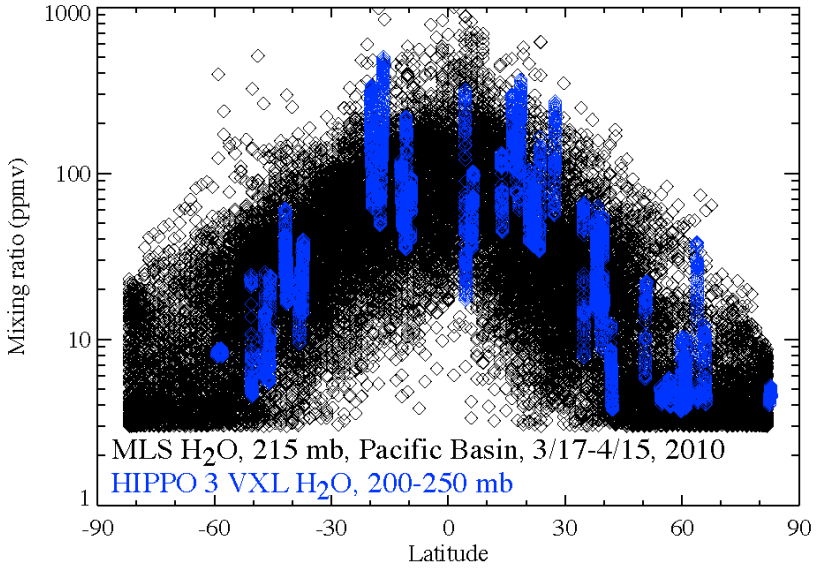

AIRS - HIPPO All CO
Pressure
CO Diff (%)
SH
Tropics
NH

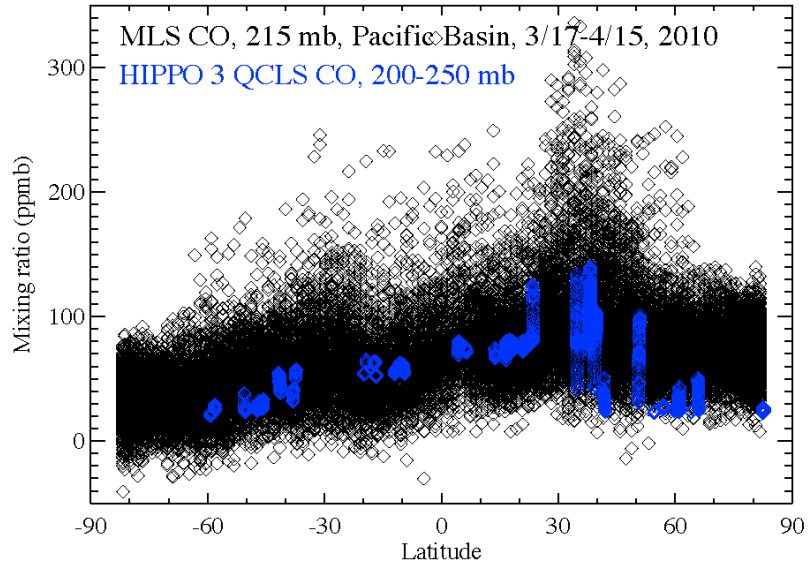

HIPPO 3 and AIRS CO
Pressure
Latitude
ppm
70
64
58
50
44
36
30
22
16
10

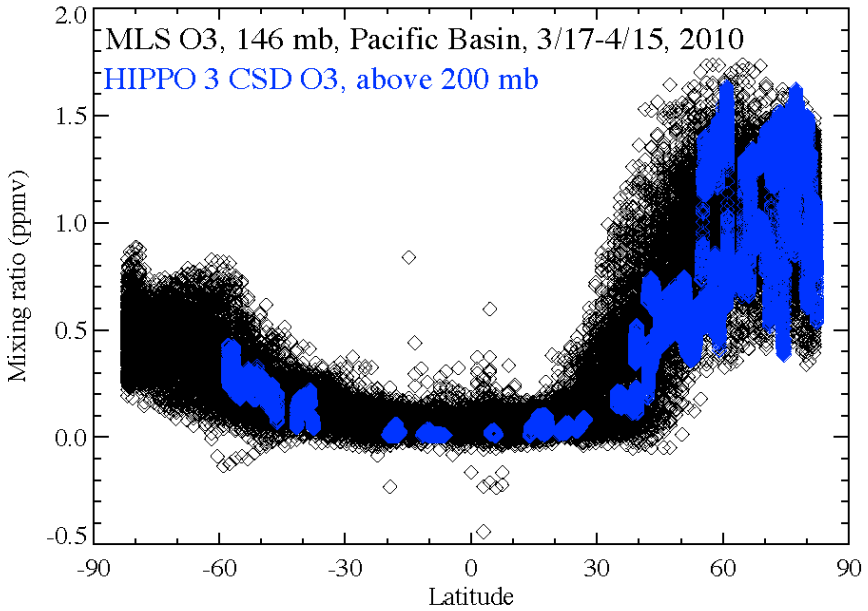
MLS comparisons

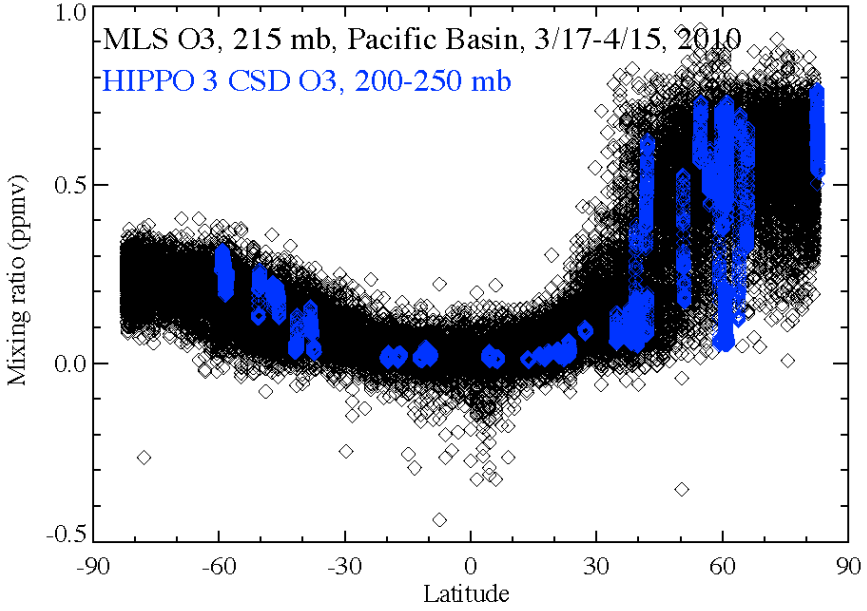









MLS O3, 146 mb, Pacific Basin, 3/17-4/15, 2010
HIPPO 3 CSD O3, above 200 mb
Mixing ratio (ppmv)
2.0
1.5
1.0
0.5
0.0
-0.5
-90
-60
-30
0
30
60
90
Latitude

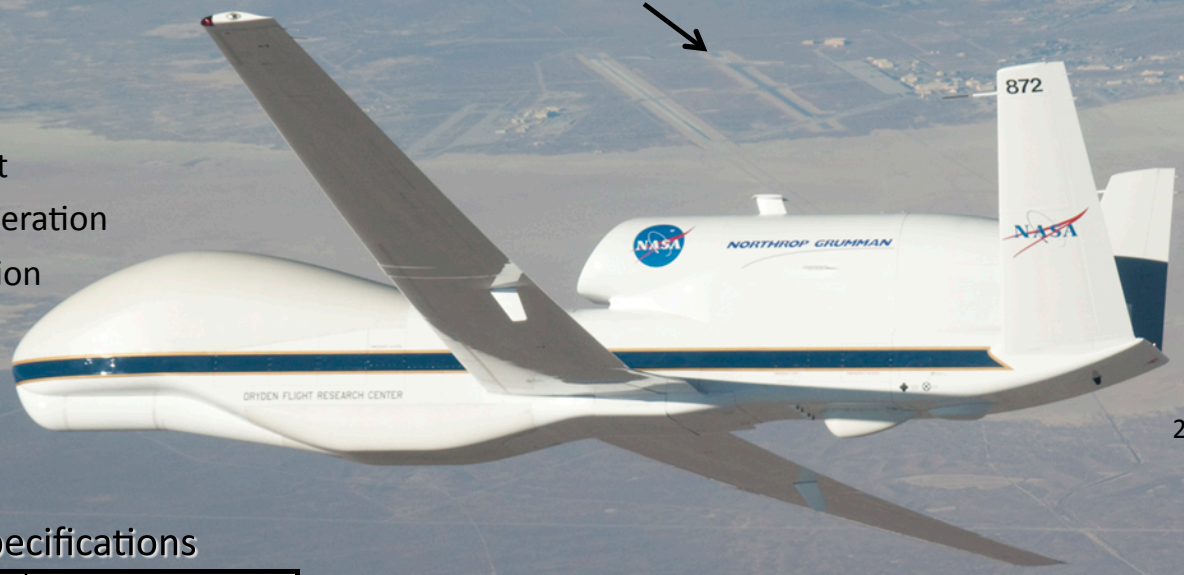

MLS O3, 215 mb, Pacific Basin, 3/17-4/15, 2010
HIPPO 3 CSD O3, 200-250 mb
Mixing ratio (ppmv)
1.0
0.5
0.0
-0.5
-90
-60
-30
0
30
60
90
Latitude

GloPac (Spring 2010)

Payload: ULH H_2O; NOAA O_3; UCATS N_2O, SF_6, CO, H_2, CH_4; DU NMASS, FCAS; DMT UHSAS, MMS P,T, winds; ACAM column O_3, NO_2; CPL cloud properties; MTP Temp profiles; HD-VIS camera

NASA Dryden Flight Research Center
Edwards, CA

UAS runway



Military development
Fully autonomous operation
Composite construction

25 October 2009
NASA DFRC

Performance Specifications

Endurance	> 30 hours
Range	>11,000 nmi
Service Ceiling	65,000 ft
Airspeed (55K+ ft)	335 KTAS
Payload	1,000-1,500 lb
Length	44 ft
Wingspan	116 ft

65,000 feet = 12.3 mi = 19.8 km = 56.5 hPa

First demonstration of the Global Hawk unmanned aircraft system (UAS) for NASA and NOAA Earth science research and applications

Global Hawk coordinated flights and satellite validation

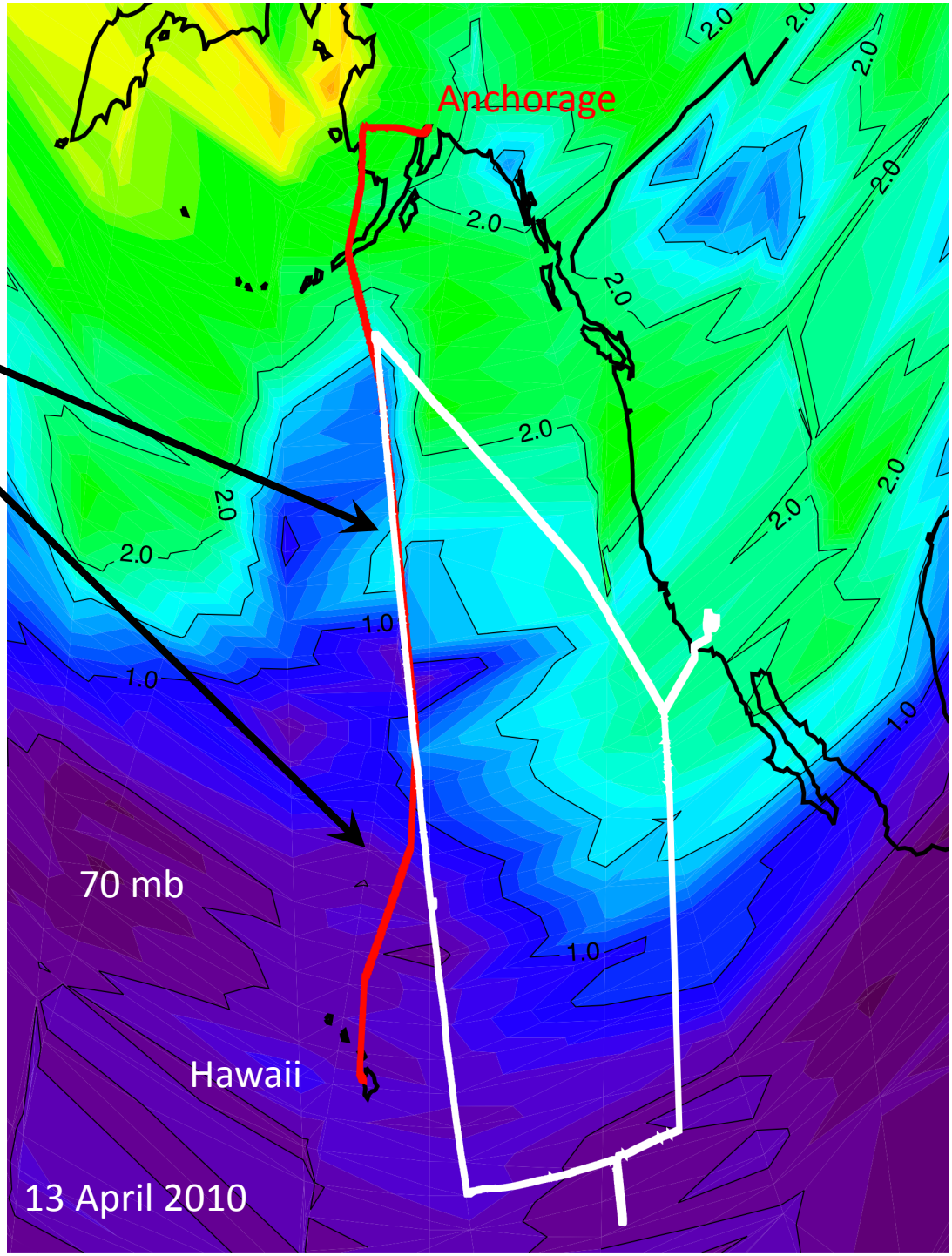
GloPac GH track

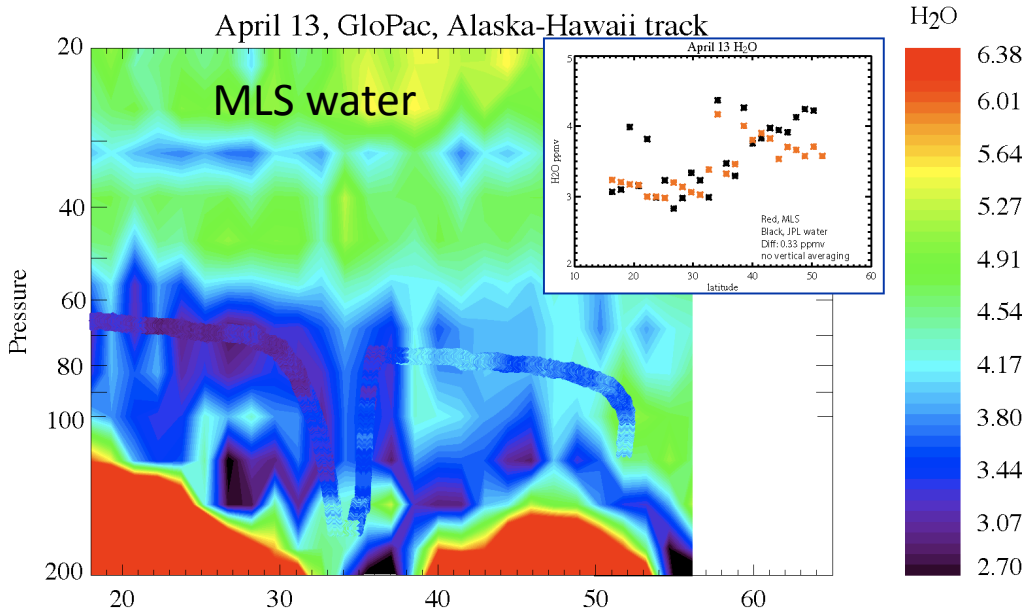
HIPPO NSF/NCAR GV

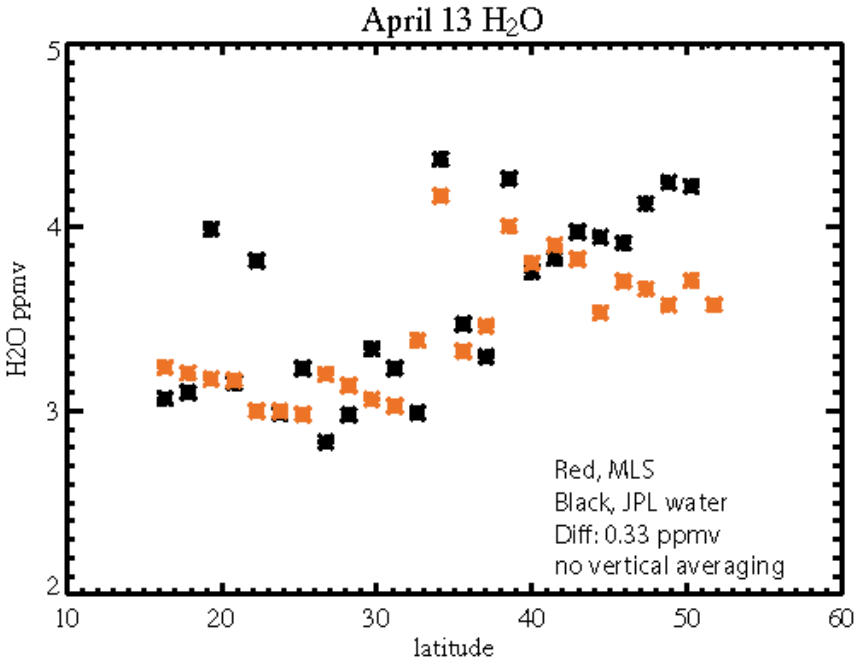
J. Schwarz

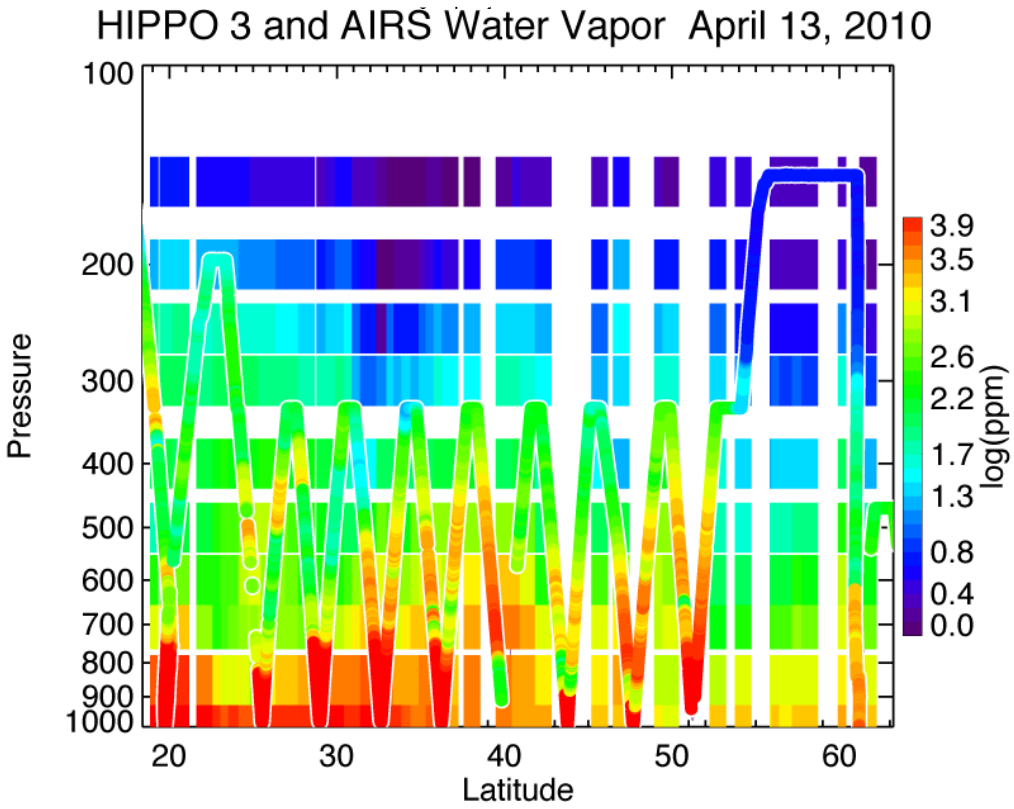
Aura satellite track follows the western side of the GloPac flight.

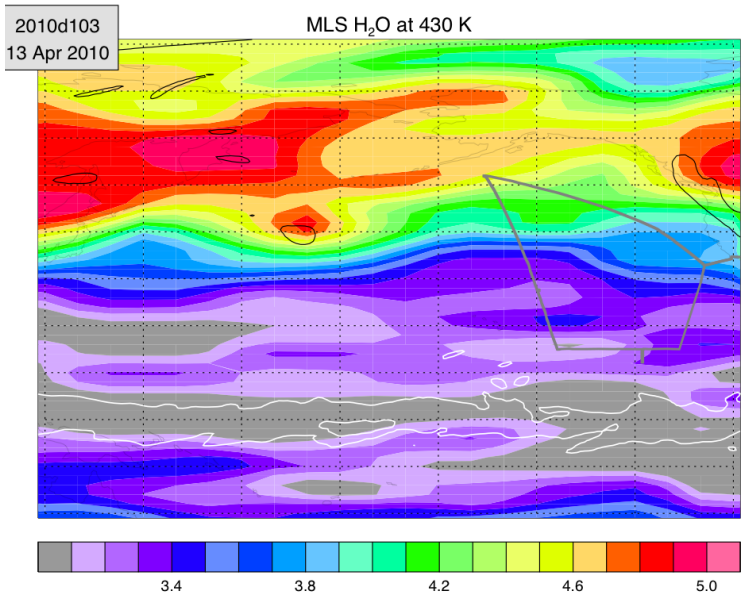
Ozone field from Aura Microwave Limb Sounder (MLS).

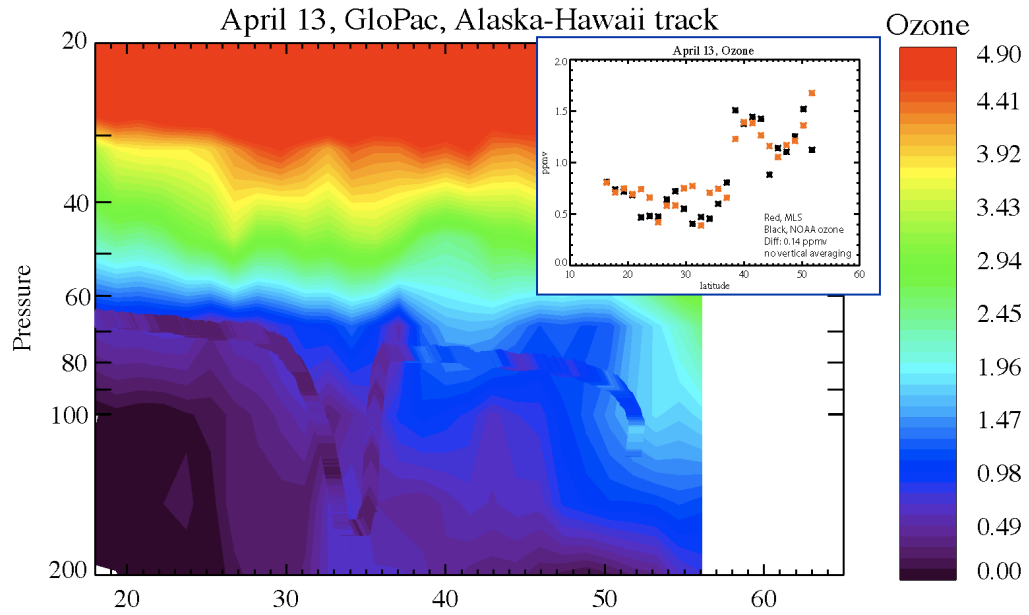


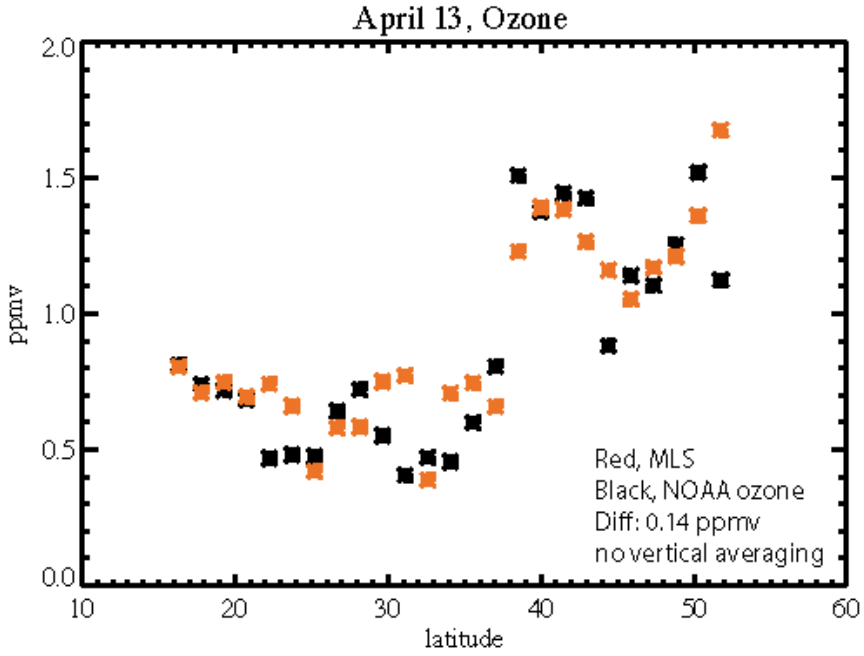

April 13, GloPac, Alaska-Hawaii track
MLS water
Pressure
20
40
60
80
100
200
20
30
40
50
60
H2O
6.38
6.01
5.64
5.27
4.91
4.54
4.17
3.80
3.44
3.07
2.70
April 13 H2O
H2O ppmv
Red, MLS
Black, JPL water
Diff: 0.33 ppmv
no vertical averaging
latitude

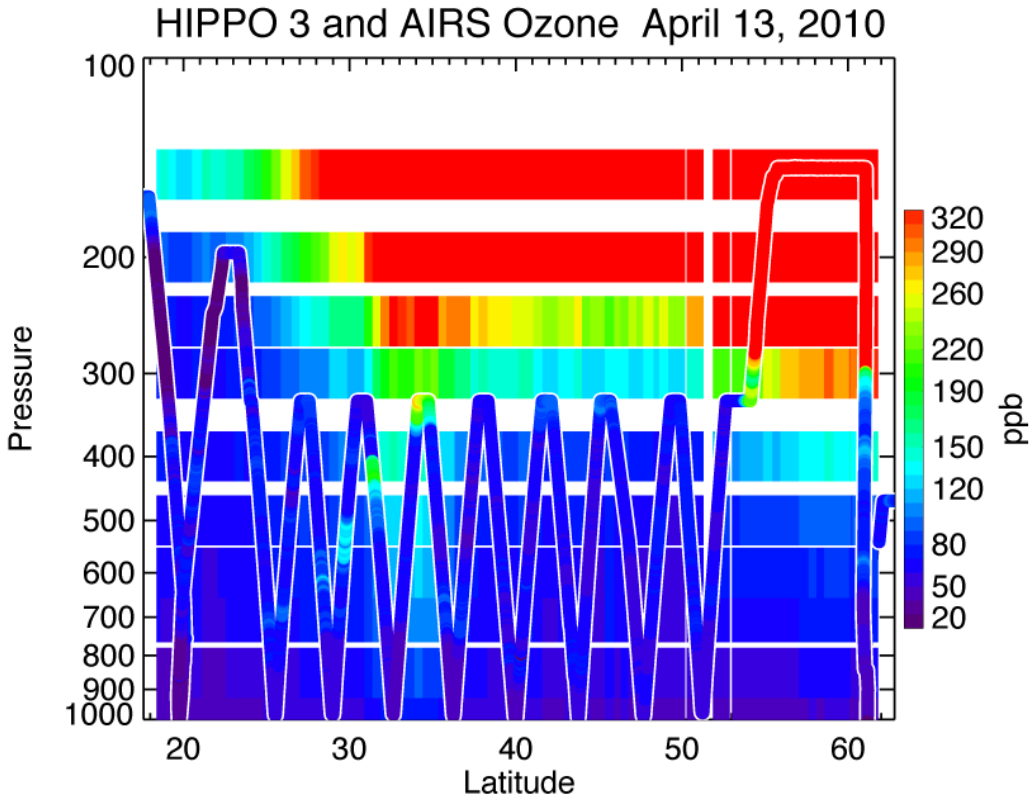

April 13 H2O
H2O ppmv
5
4
3
2
10
20
30
40
50
60
latitude
Red, MLS
Black, JPL water
Diff: 0.33 ppmv
no vertical averaging

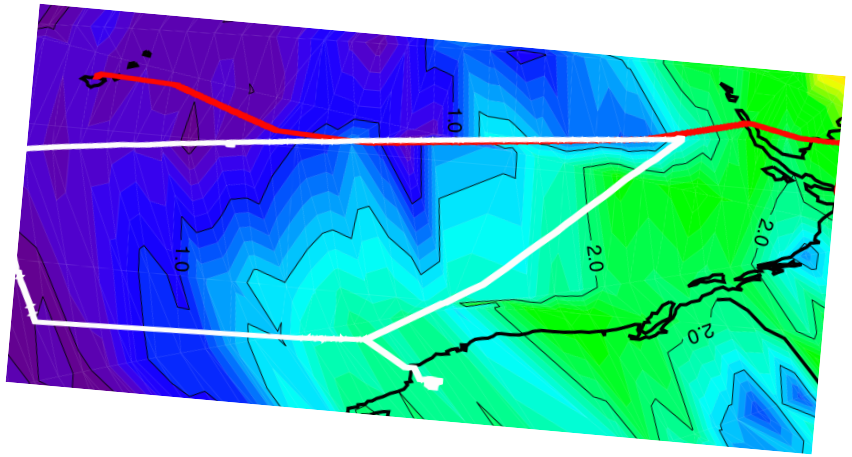

HIPPO 3 and AIRS Water Vapor April 13, 2010
Pressure
100
200
300
400
500
600
700
800
900
1000
20
30
40
50
60
Latitude
3.9
3.5
3.1
2.6
2.2
1.7
1.3
0.8
0.4
0.0
log(ppm)


2010d103
13 Apr 2010
MLS H2O at 430 K
3.4
3.8
4.2
4.6
5.0


April 13, GloPac, Alaska-Hawaii track
Ozone
4.90
4.41
3.92
3.43
2.94
2.45
1.96
1.47
0.98
0.49
0.00
Pressure
20
40
60
80
100
200
20
30
40
50
60
April 13, Ozone
Red, MLS
Black, NOAA ozone
Diff: 0.14 ppmv
no vertical averaging


April 13, Ozone
ppmv
2.0
1.5
1.0
0.5
0.0
10
20
30
40
50
60
latitude
Red, MLS
Black, NOAA ozone
Diff: 0.14 ppmv
no vertical averaging


HIPPO 3 and AIRS Ozone April 13, 2010
Pressure
100
200
300
400
500
600
700
800
900
1000
20
30
40
50
60
Latitude
320
290
260
220
190
150
120
80
50
20
ppb


1.0
2.0

Final Notes:

HIPPO provides a unique fine resolution data set covering the latitudinal extent of the Pacific for a number of species. These should prove useful for satellite comparisons.

AIRS:
CO_2 looks good in the tropics; bigger differences at high latitudes
CH_4 compared well globally
Temperature differences were less than 2 degrees C.
O_3 differences were largest in the tropics; good comparisons elsewhere.
H_2O differences were typically less than 40%.

MLS: have just started UT comparisons...overall latitudinal features compare well for HIPPO-3; we need to do formal matching and statistical comparisons.

Initial Glo-Pac comparisons also look good...will hopefully see more from Jim Elkins' group in the future. And also ACE comparisons with HIPPO data.