Thermal IR and Model CO: Chicken and Egg problem or A symbiotic relationship?

Joanna Joiner

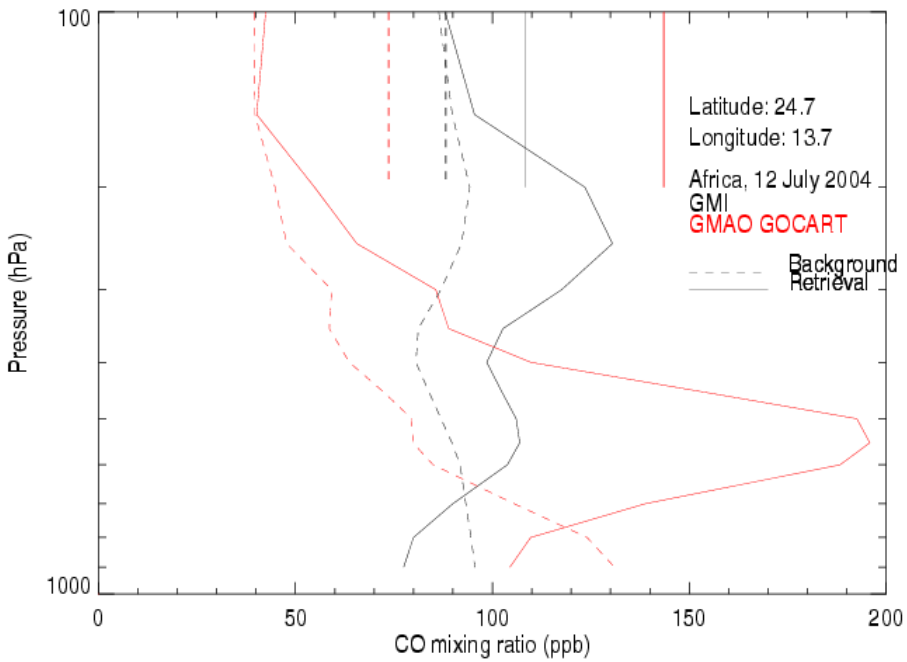
Outline

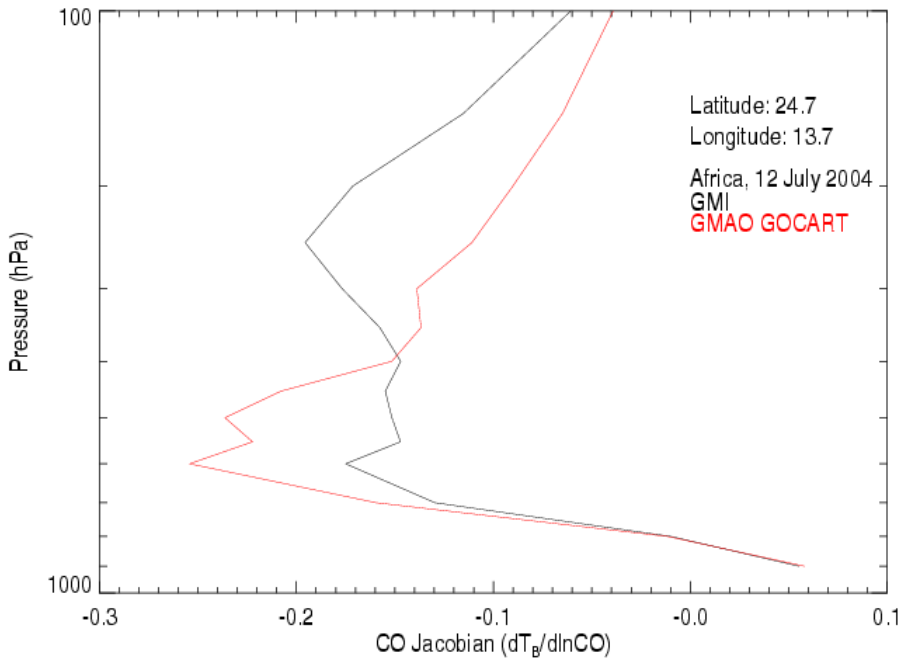
- Comparing model and thermal IR (AIRS/TES) satellite CO: The problem(s)
- Using the model as a transfer standard to compare different instruments, etc.
- Using MOZAIC data to investigate errors in vertical profile
- Examining convective influences: towards TC^4
- Summary

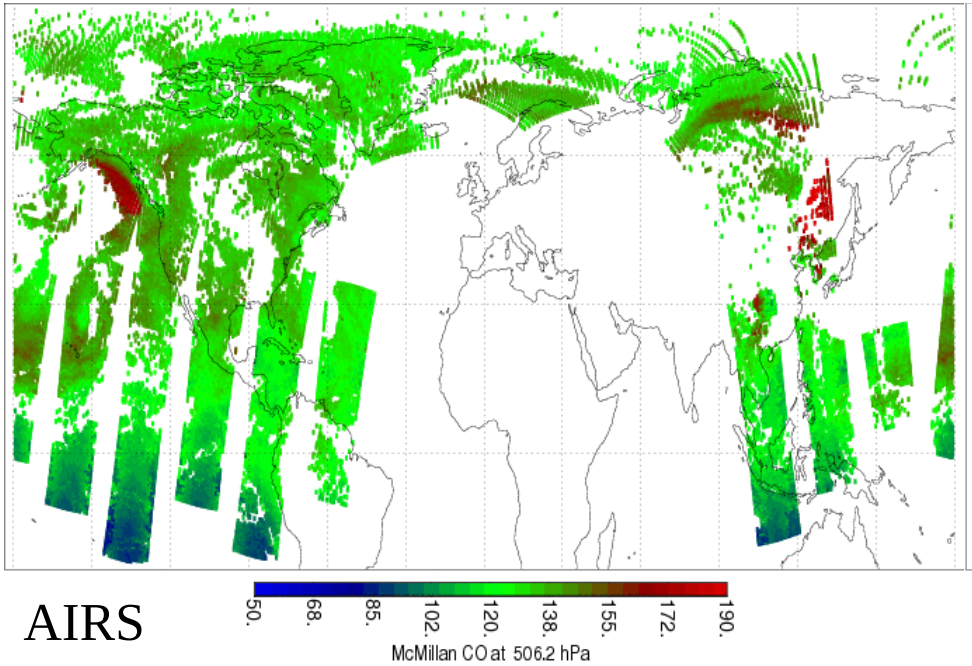
How do we compare satellite and model data?

- Apply averaging kernels
  - Pros: Decrease dependence on a-priori data
  - Cons: 1) In non-linear, information poor situations (CO from thermal IR), the real averaging kernel is not known! 2) Averaging kernel can smear profile, producing confusing results (important for ozone) 3) Not always easy to make maps
- Use radiances directly
  - Pros: Eliminates dependence on a-priori data
  - Cons: 1) More difficult to interpret (sensitivity changes across swath, have to translate brightness temperature to constituent concentration) 2) Computationally expensive, not user friendly
- Use 1DVAR retrievals/increments (model first guess)
  - Pros: 1) Decrease dependence on a-priori data 2) User friendly
  - Cons: 1) Errors in model profile can create errors in retrieval due to non-linearity 2) Can be computationally expensive

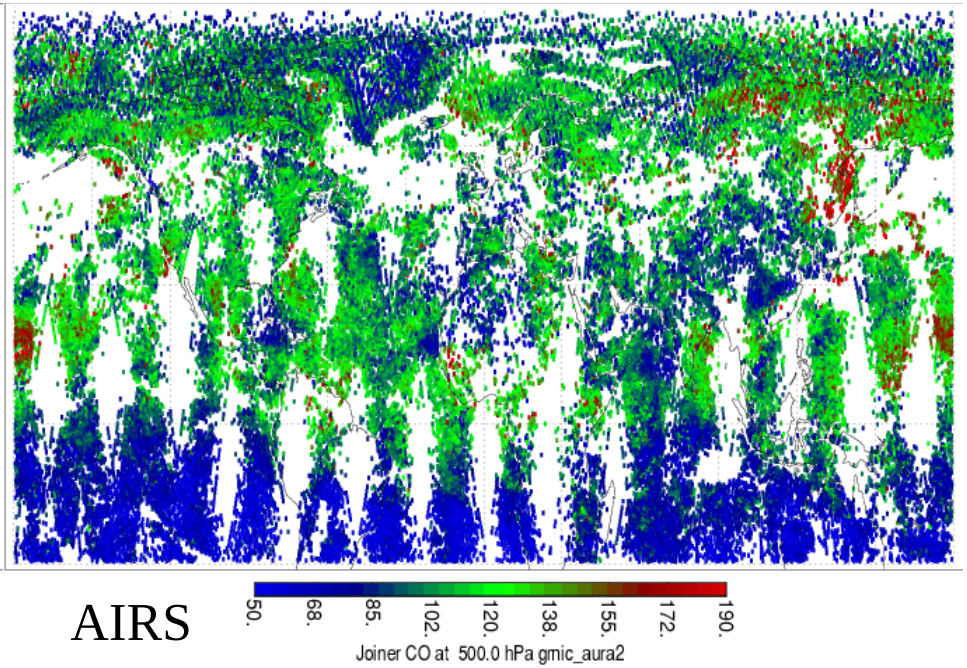
The problem: Thermal IR (AIRS/TES) is non-linear and contains only ~1 piece of information in vertical. This leads to large dependence on first guess profile, uncertainty in averaging kernel, potentially large errors if profile shape is misspecified



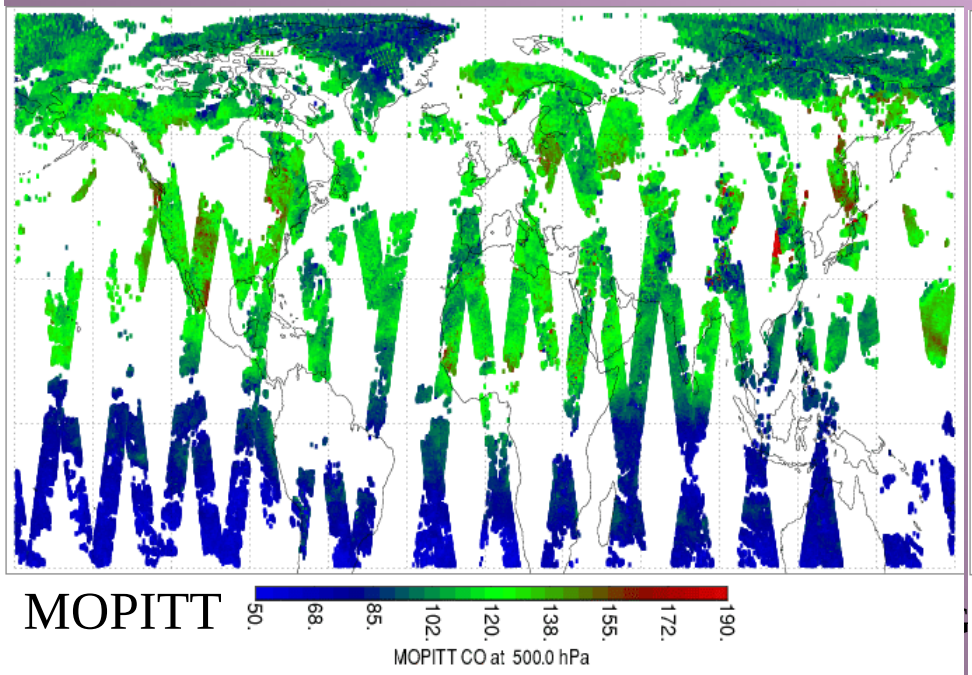




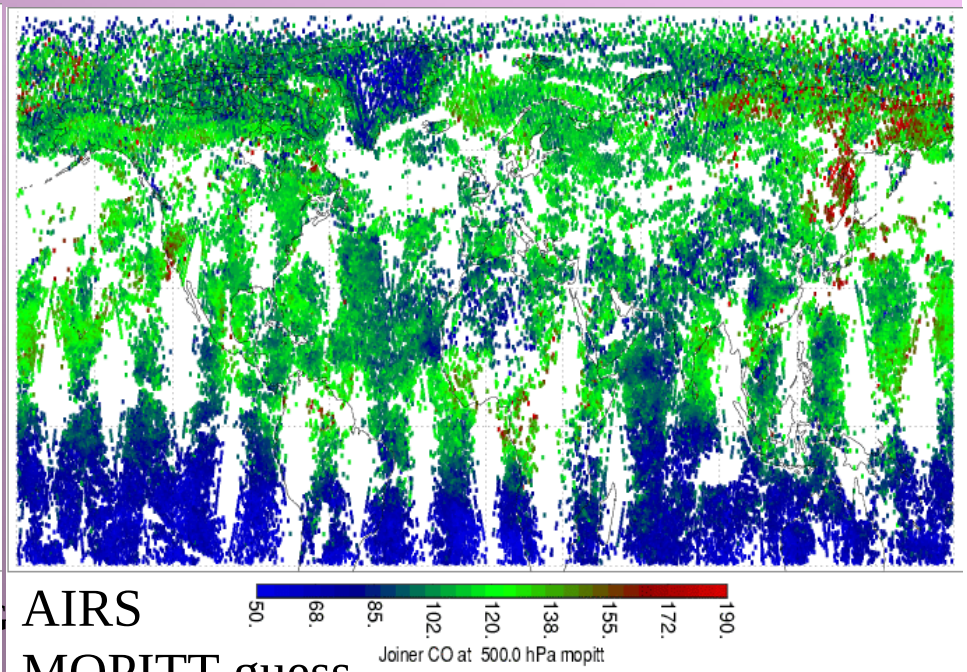
AIRS
Sci. Team (McMillan) INTEX, AVDC



AIRS
GMI guess May 1, 2006

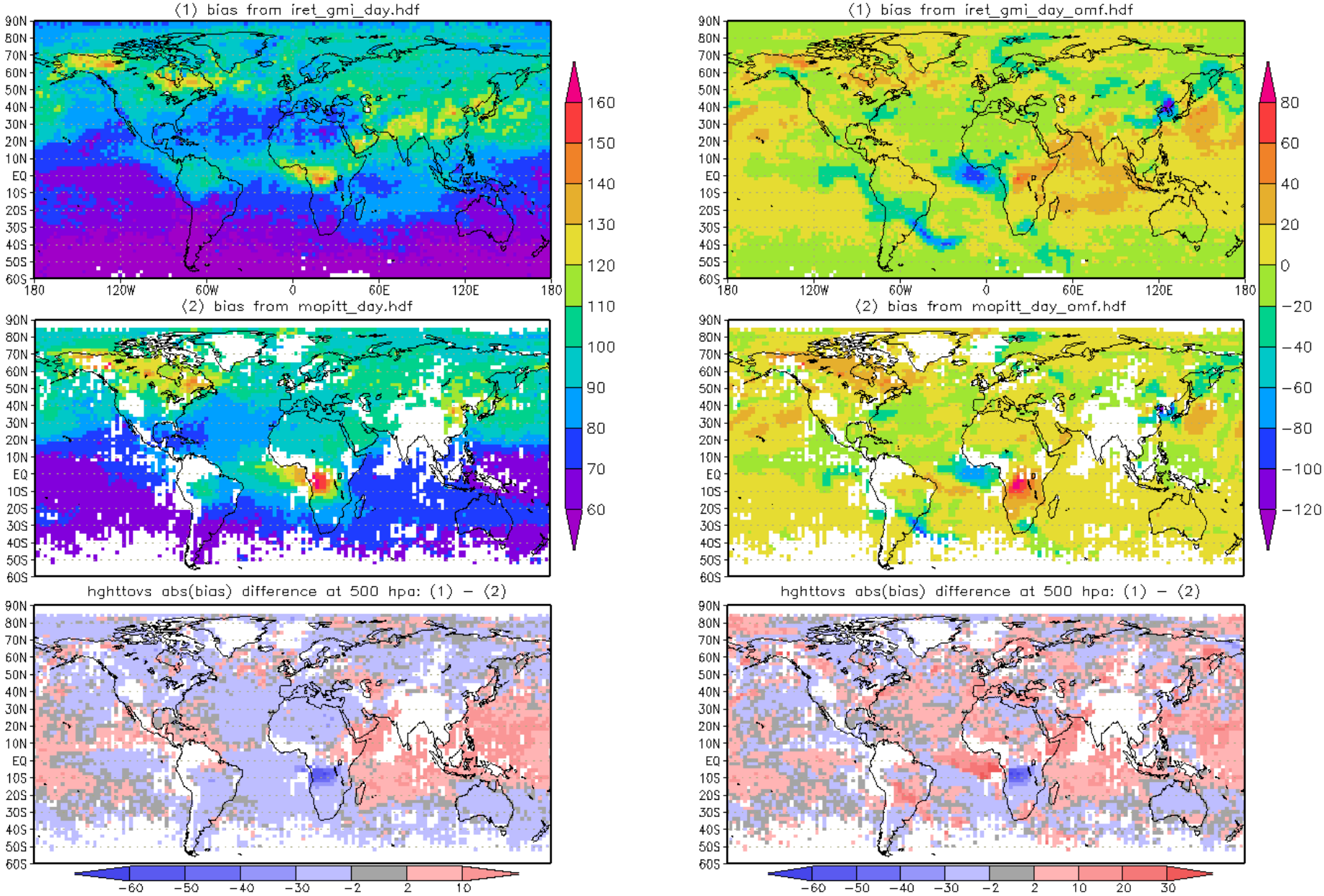


MOPITT

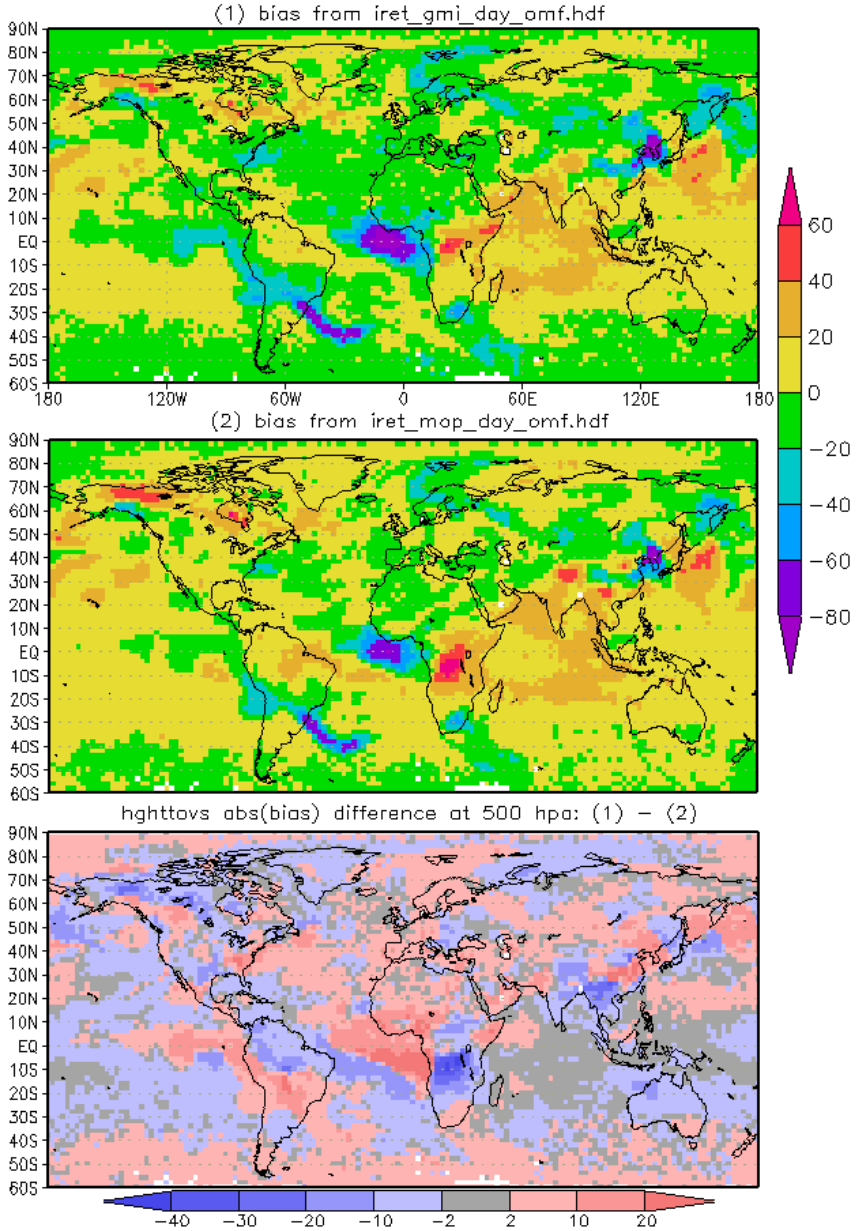


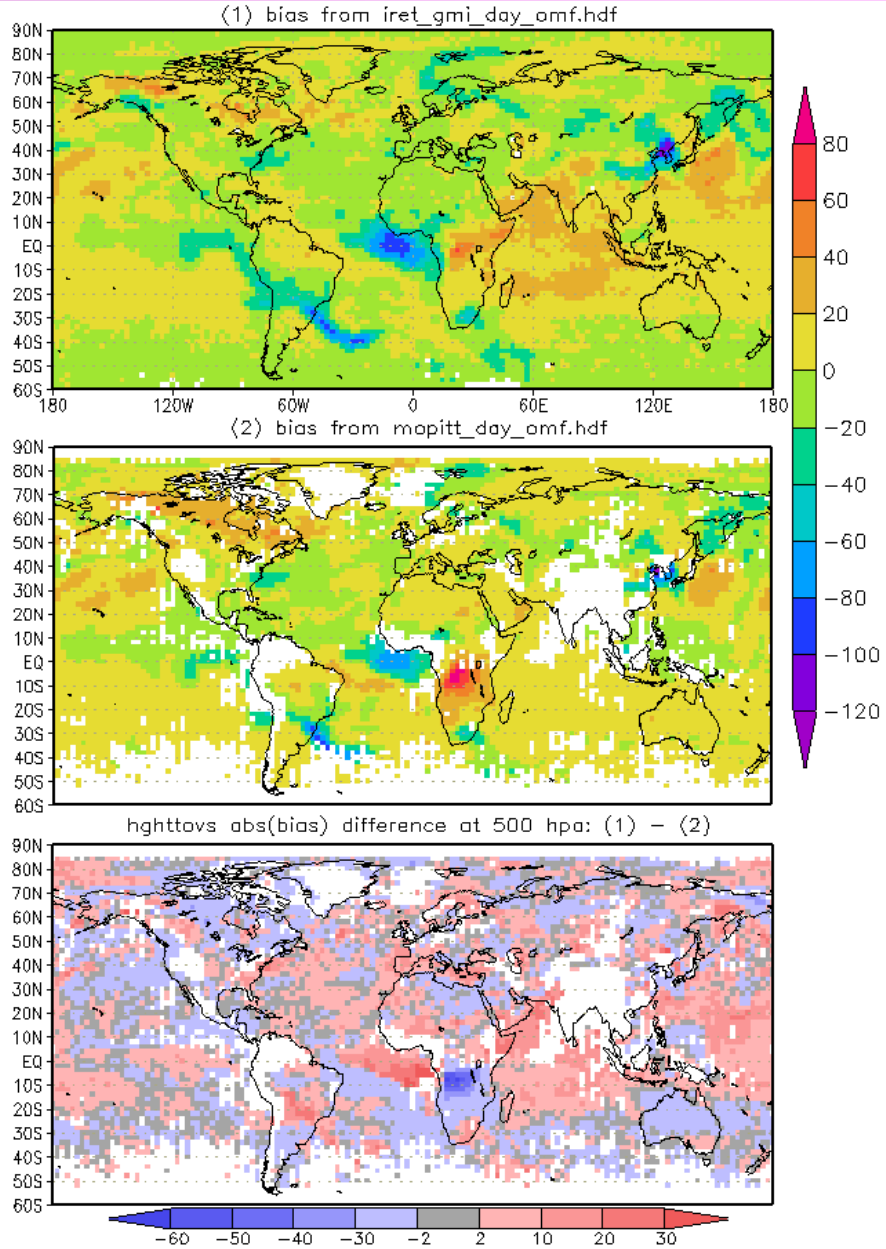
AIRS
MOPITT guess

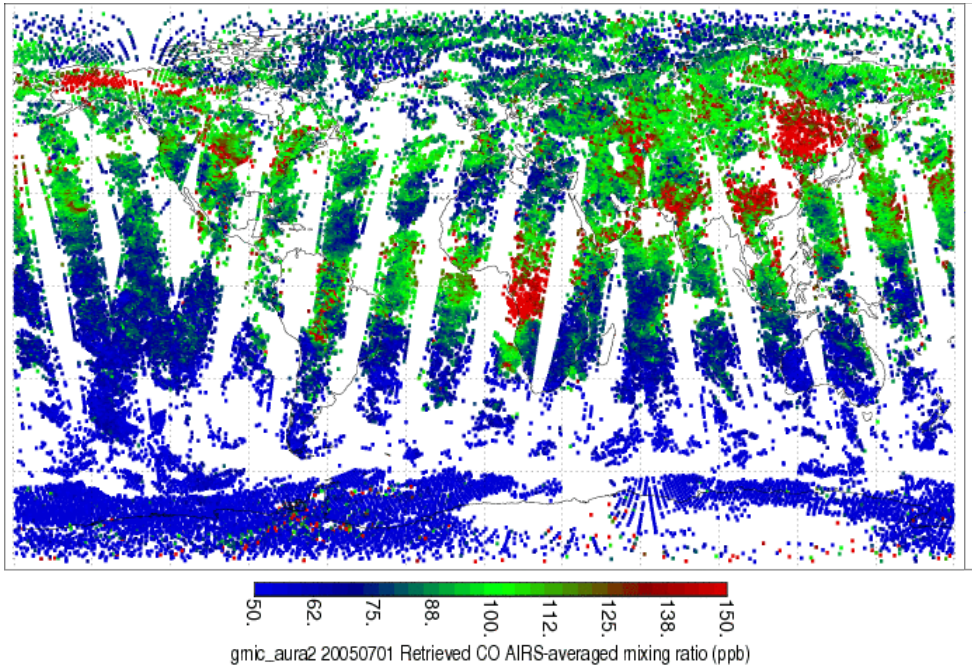
Model can be used as “transfer” standard to compare data sets from different instruments

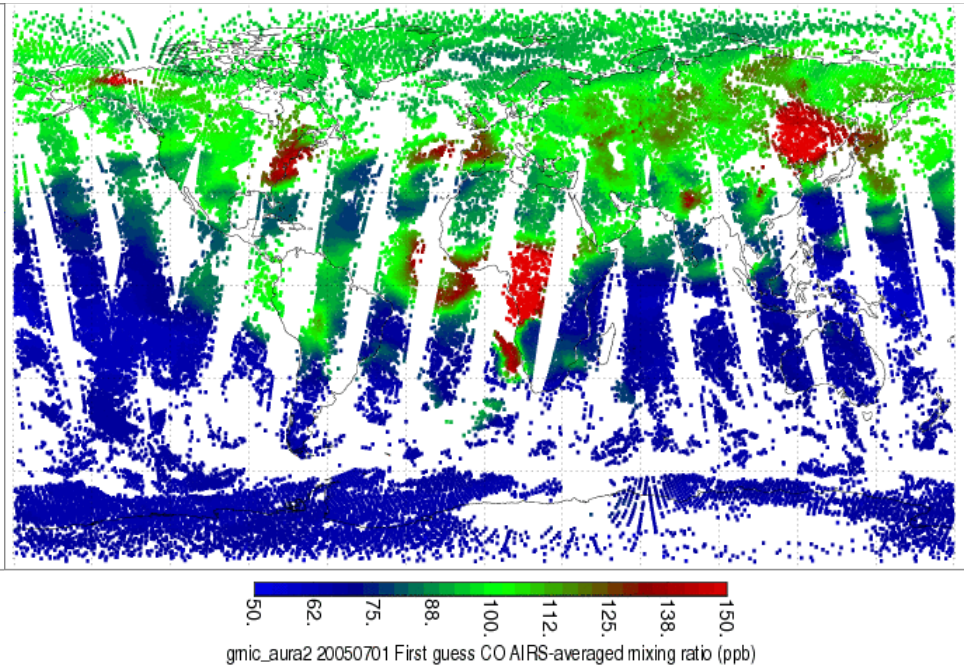


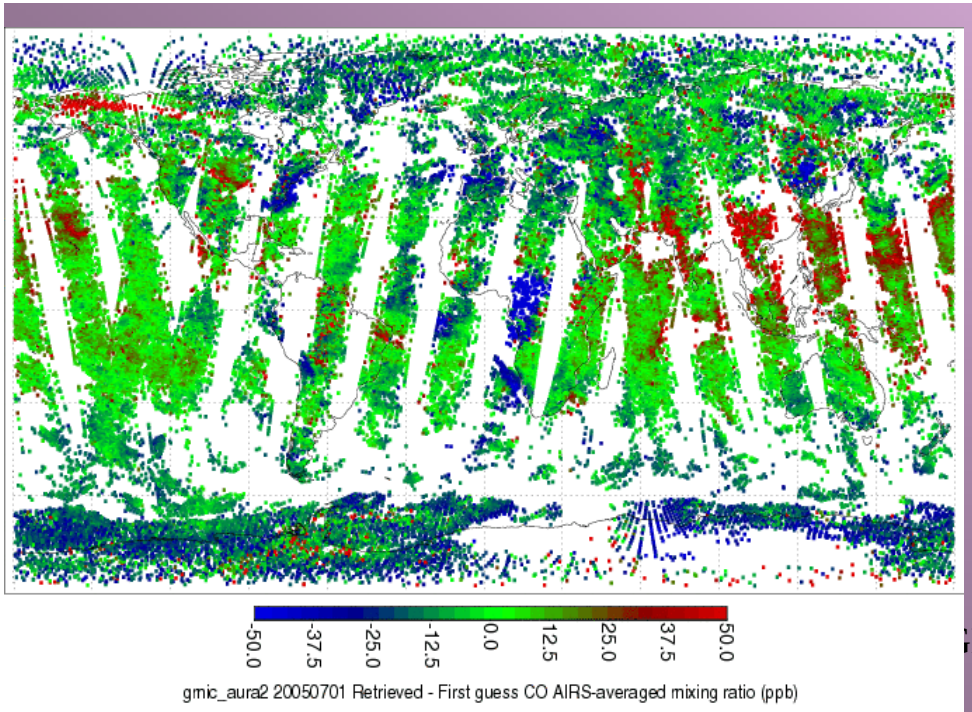
Most of differences come from first guess

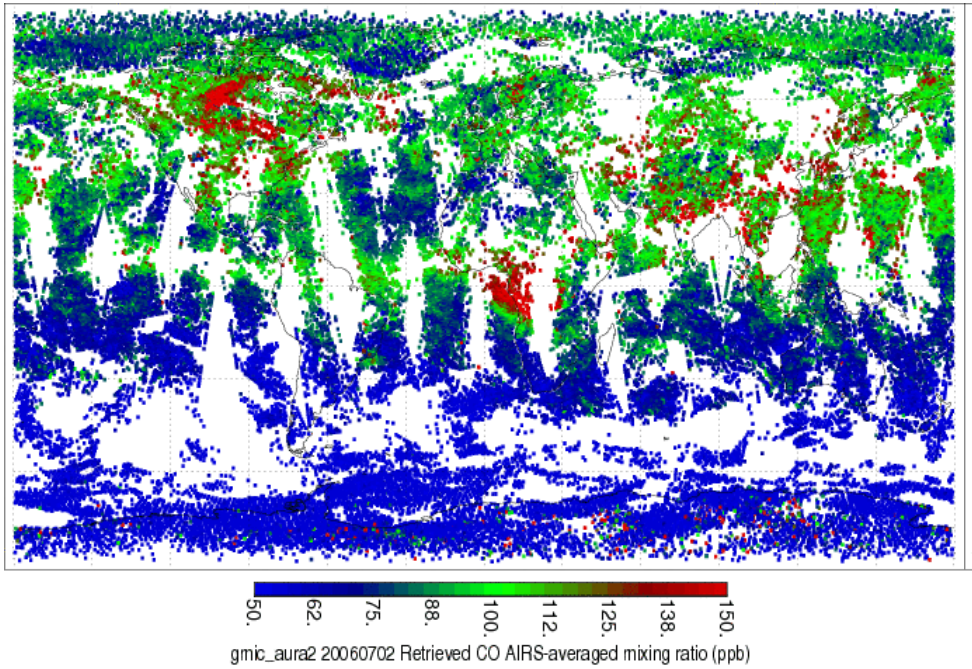


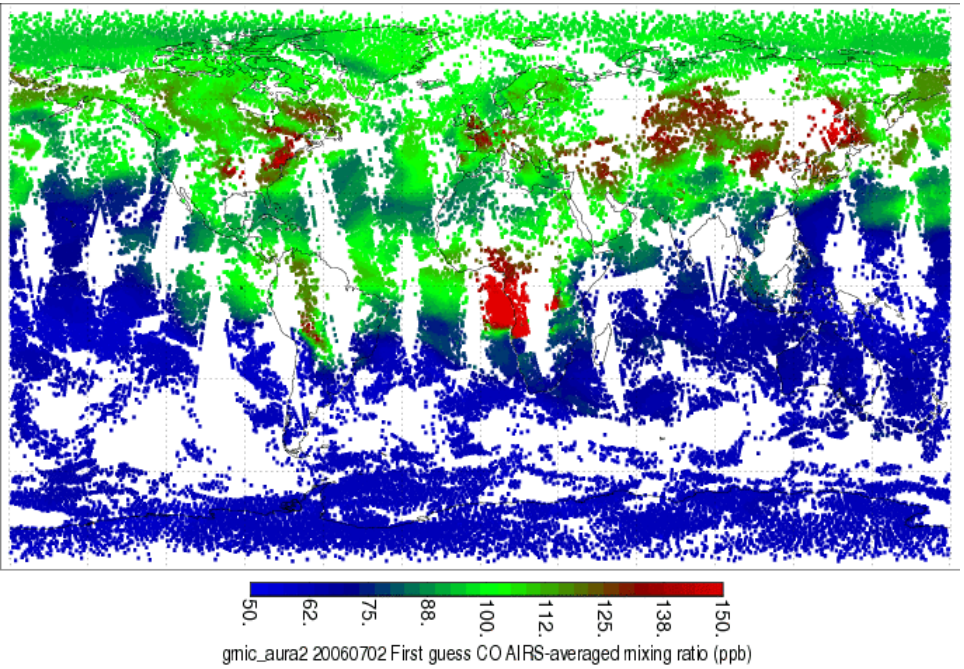


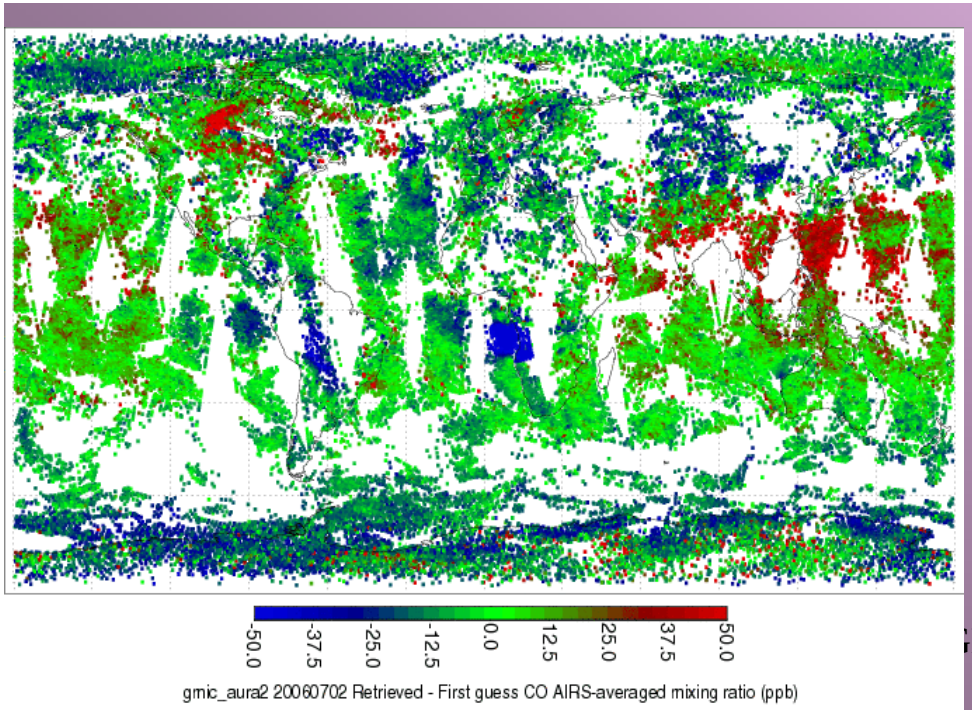

50.
62.
75.
88.
100.
112.
125.
138.
150.
gmic_aura2 20050701 Retrieved CO AIRS-averaged mixing ratio (ppb)


50.
62.
75.
88.
100.
112.
125.
138.
150.
gmic_aura2 20050701 First guess CO AIRS-averaged mixing ratio (ppb)

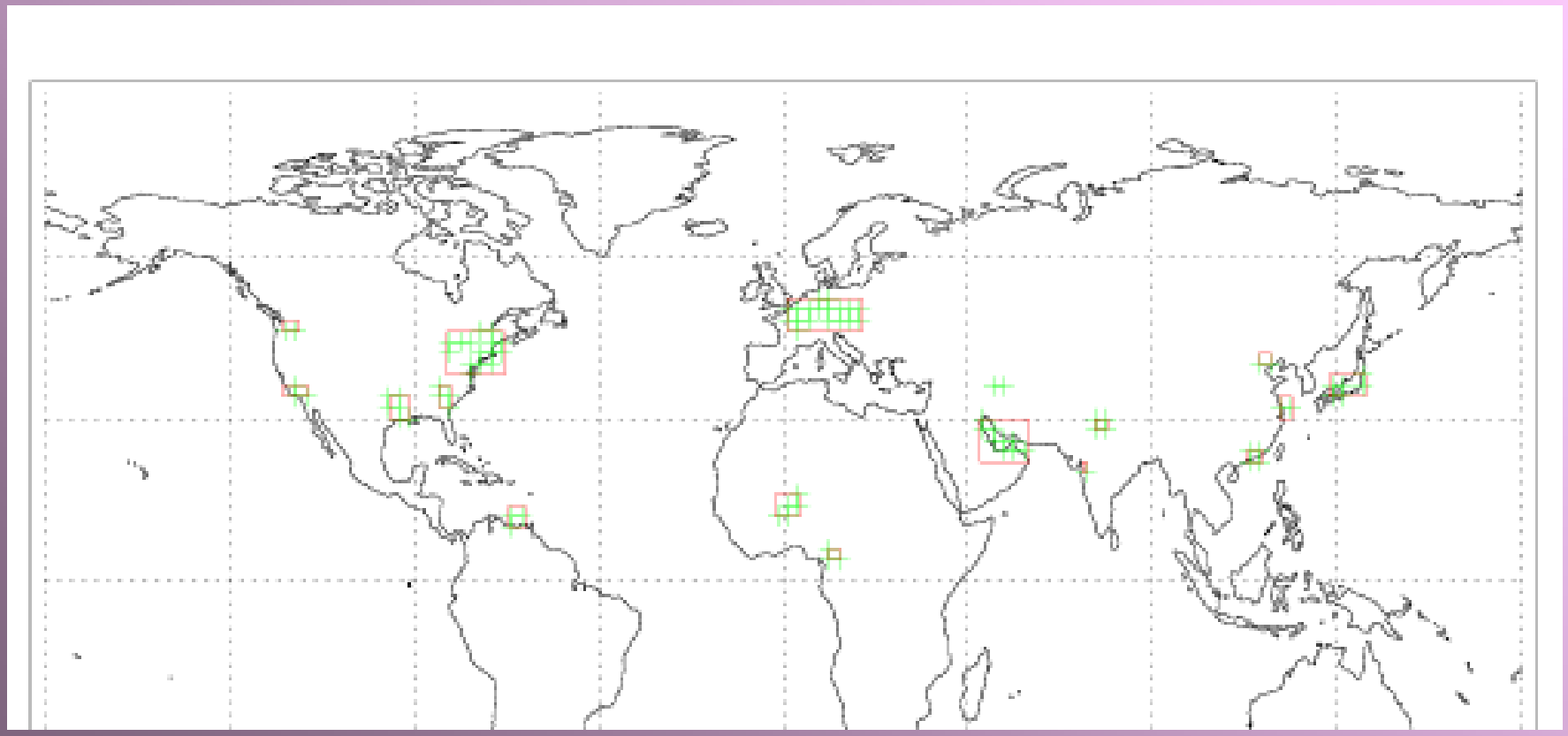

-50.0
-37.5
-25.0
-12.5
0.0
12.5
25.0
37.5
50.0
gmic_aura2 20050701 Retrieved - First guess CO AIRS-averaged mixing ratio (ppb)


50.
62.
75.
88.
100.
112.
125.
138.
150.
gmic_aura2 20060702 Retrieved CO AIRS-averaged mixing ratio (ppb)

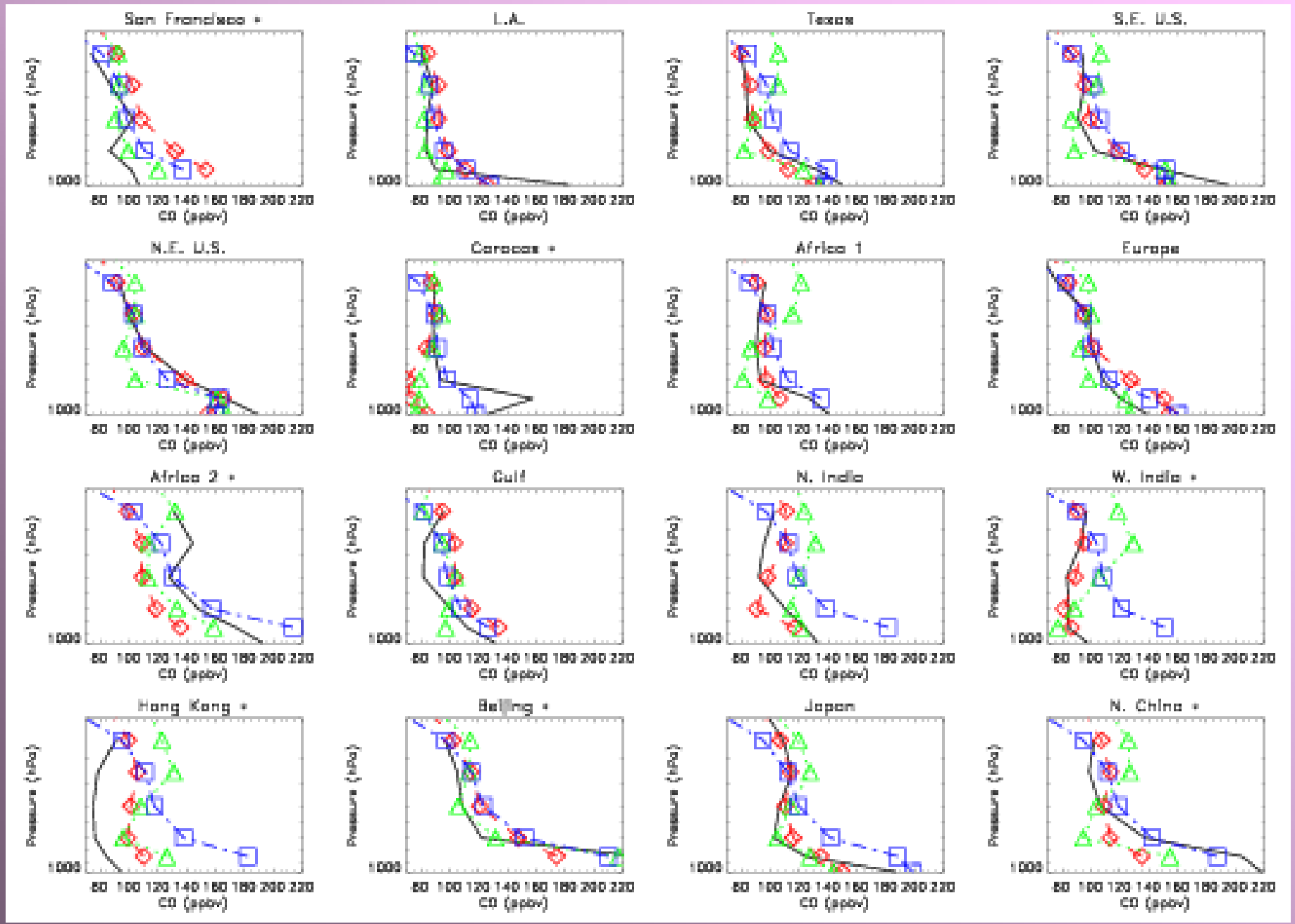

50.
62.
75.
88.
100.
112.
125.
138.
150.
gmic_aura2 20060702 First guess CO AIRS-averaged mixing ratio (ppb)


-50.0
-37.5
-25.0
-12.5
0.0
12.5
25.0
37.5
50.0
gmic_aura2 20060702 Retrieved - First guess CO AIRS-averaged mixing ratio (ppb)

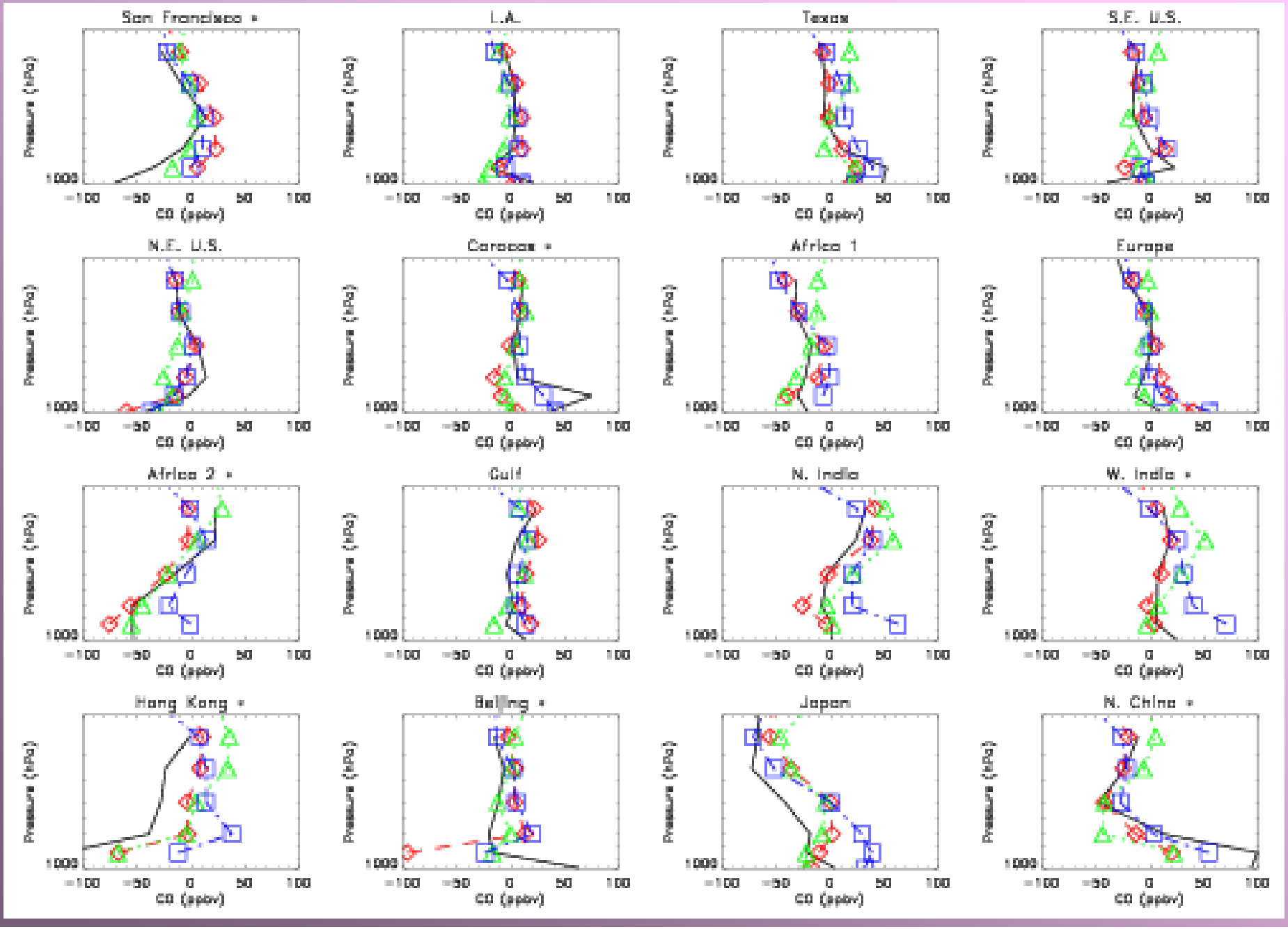
MOZAIC ascent/descent July 2004

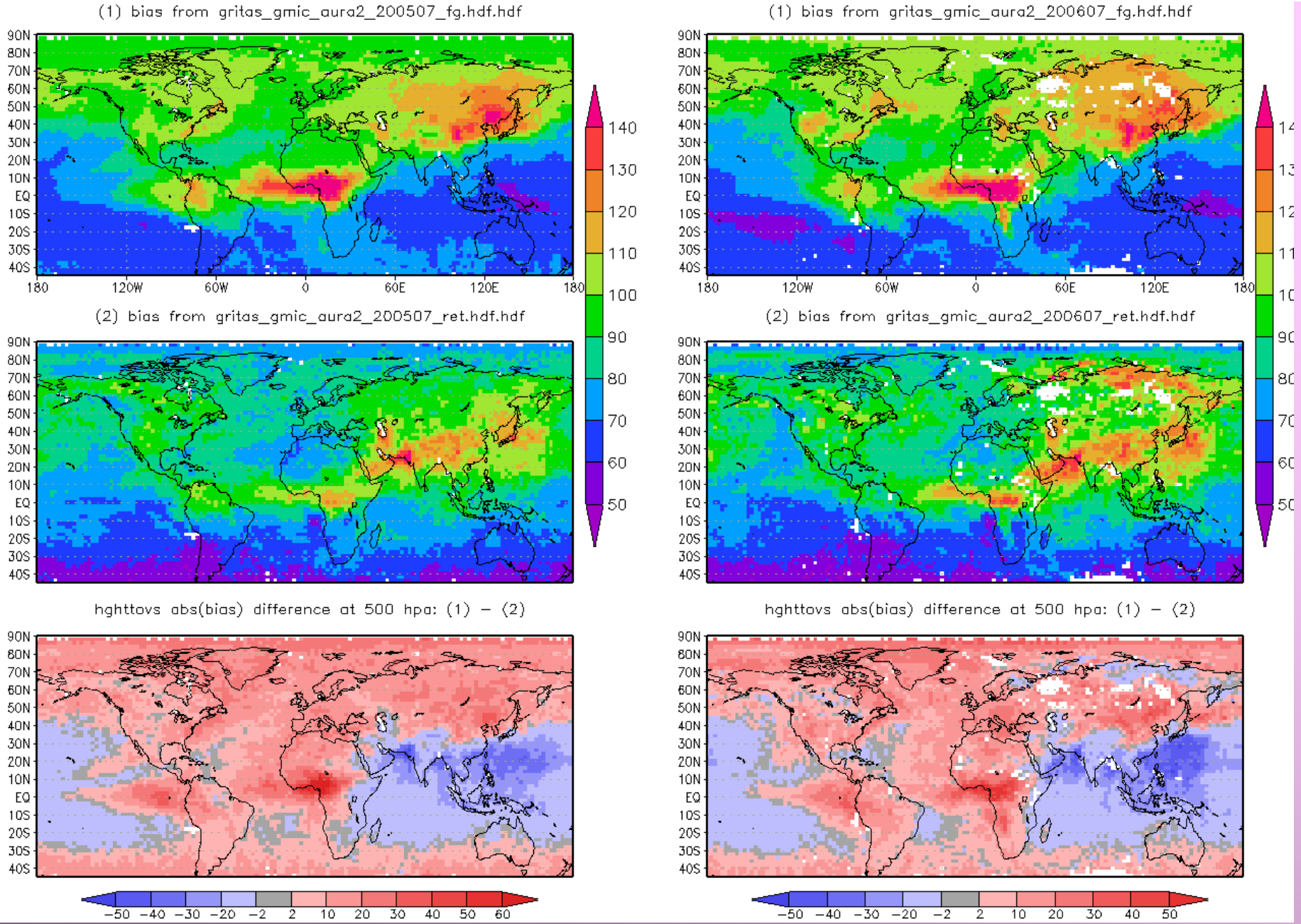


-: Mozaic; ◇ MOPITT; □ AIRS, MOPITT guess; △ AIRS, GMI guess

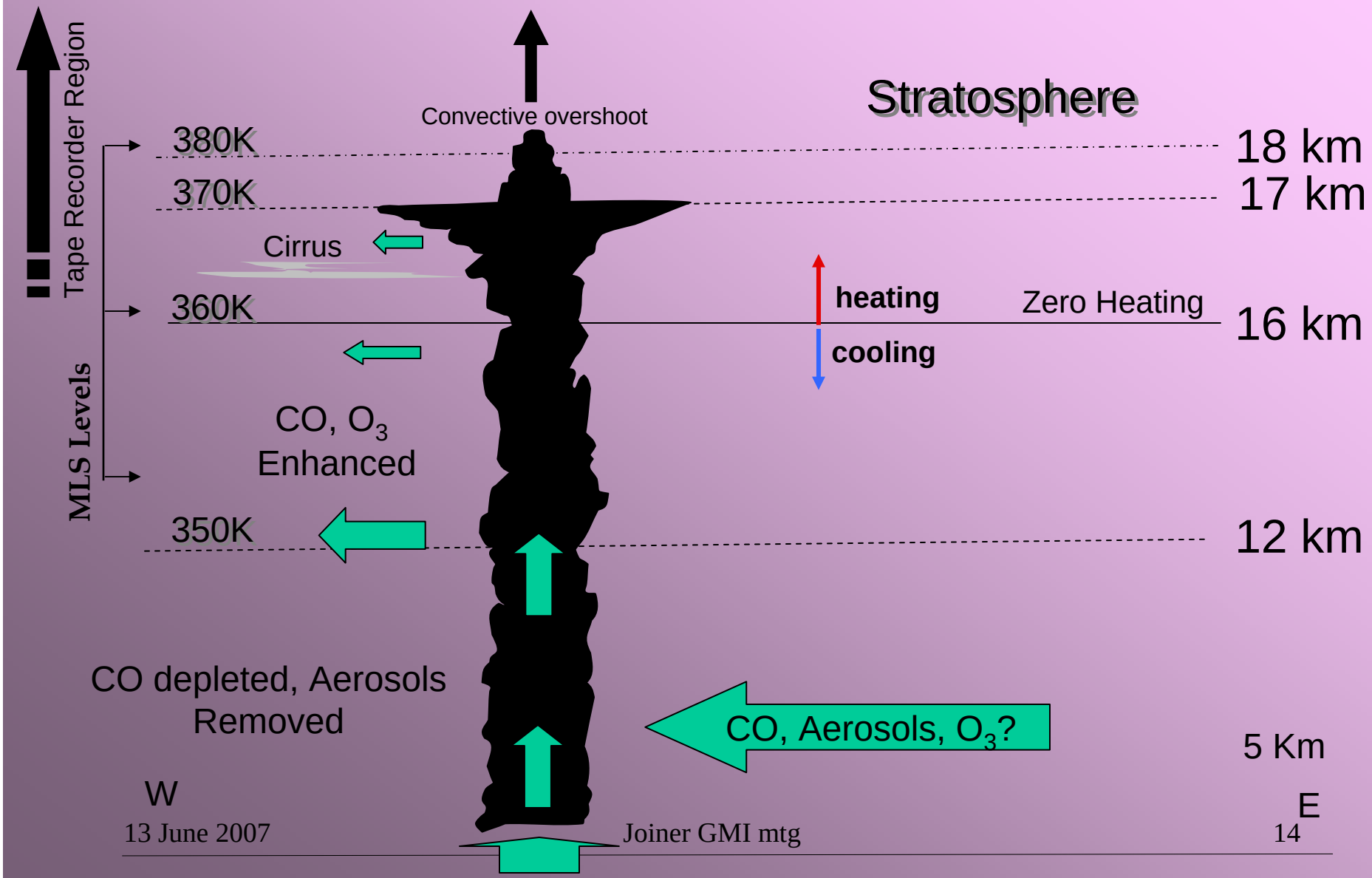


-: Mozaic; ◇ MOPITT; □ AIRS, MOPITT guess; △ AIRS, GMI guess



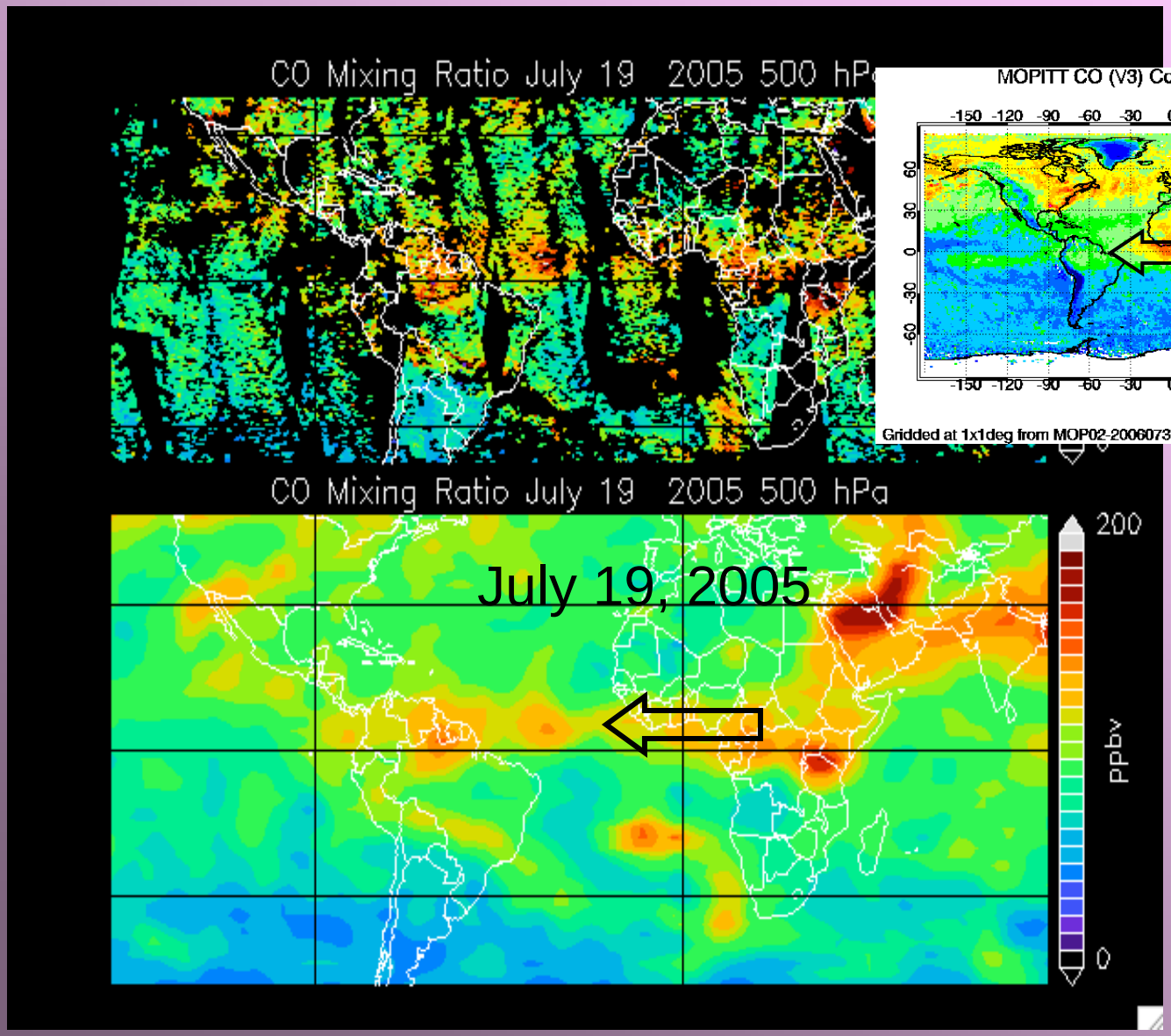

(1) bias from gritas_gmic_aura2_200507_fg.hdf.hdf
(1) bias from gritas_gmic_aura2_200607_fg.hdf.hdf
(2) bias from gritas_gmic_aura2_200507_ret.hdf.hdf
(2) bias from gritas_gmic_aura2_200607_ret.hdf.hdf
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
90N 80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S
180 120W 60W 0 60E 120E 180
140 130 120 110 100 90 80 70 60 50
−50 −40 −30 −20 −2 2 10 20 30 40 50 60
−50 −40 −30 −20 −2 2 10 20 30 40 50

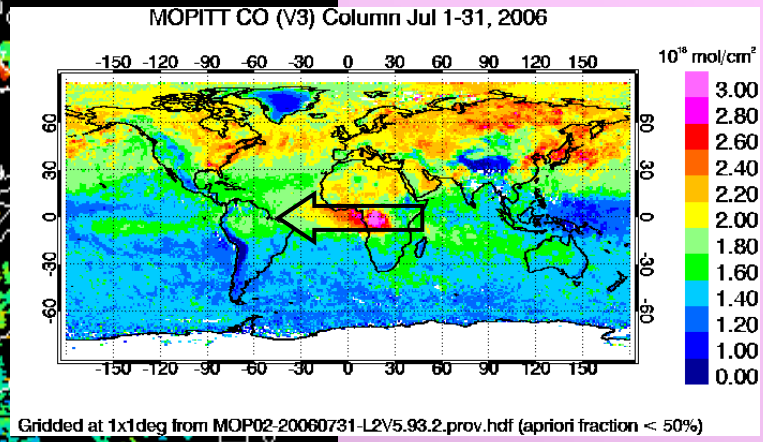
Convective Mixing and Transport Layer



After Gettleman and Forster, J. Met. Soc. Jpn.

Plumes from Africa

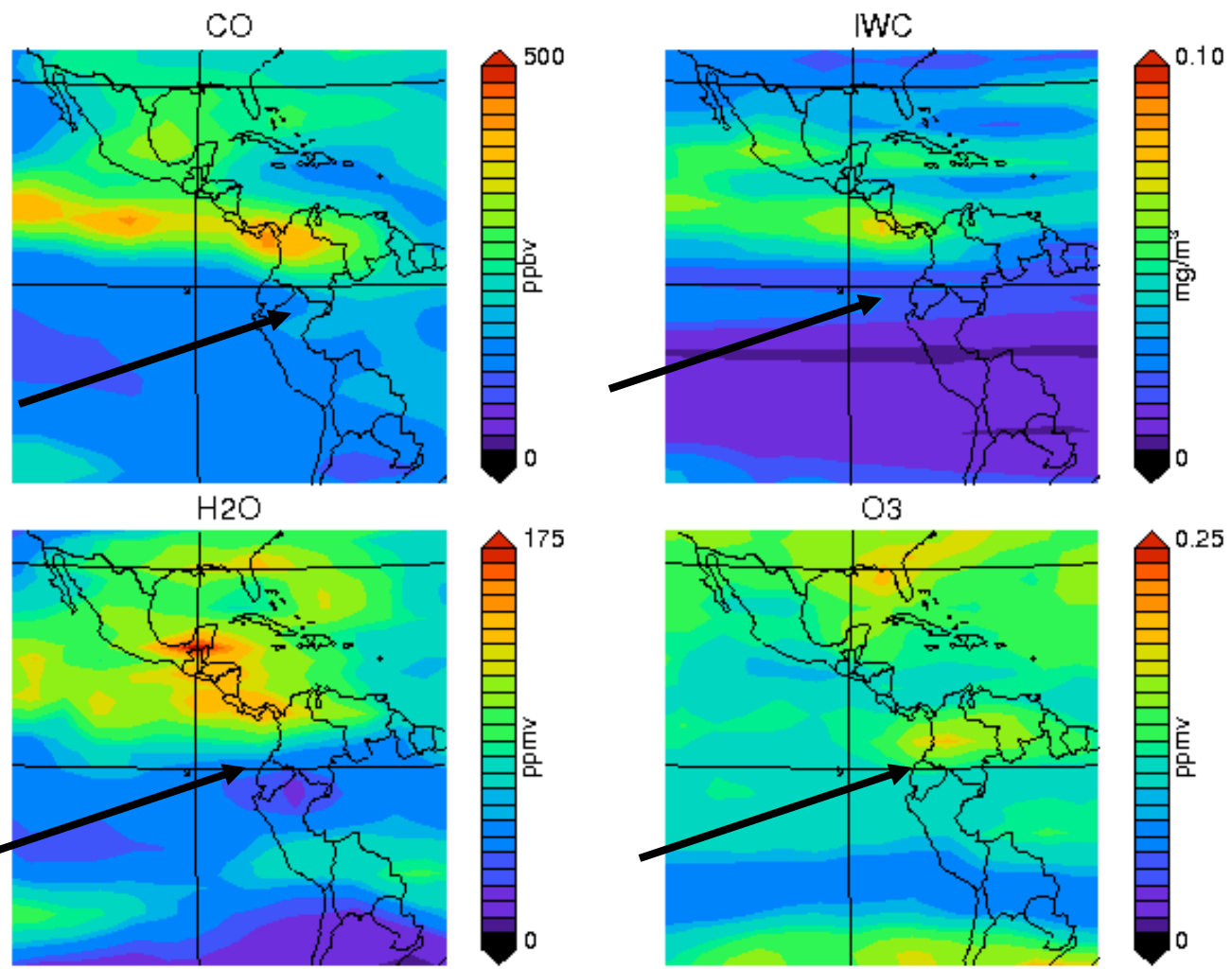


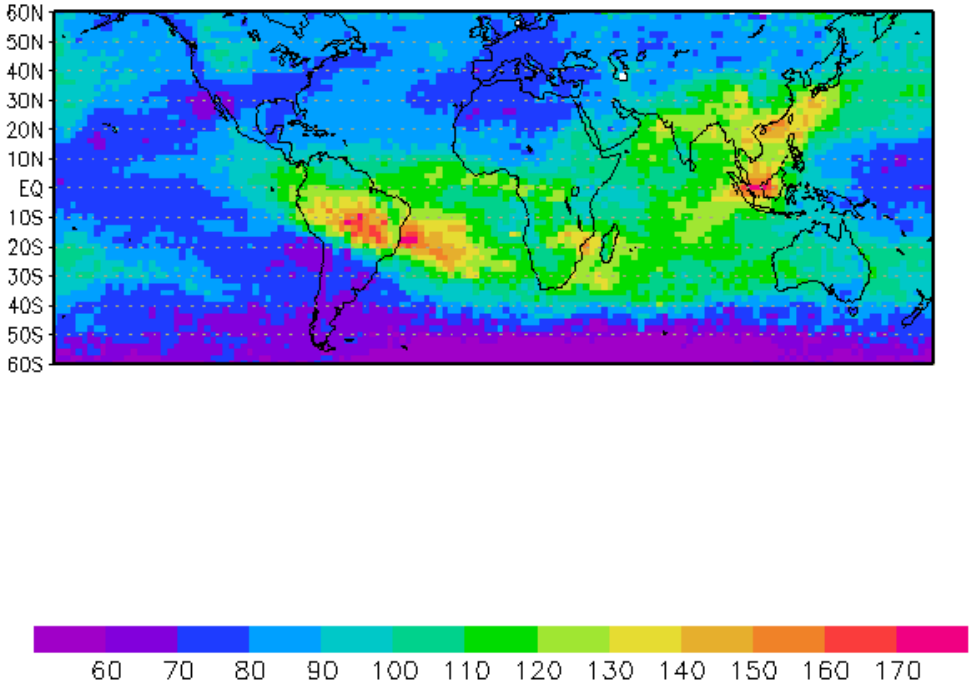


MLS 215 hPa (~10 km, 345K)

CO levels ~350 ppbv but MLS is high biased

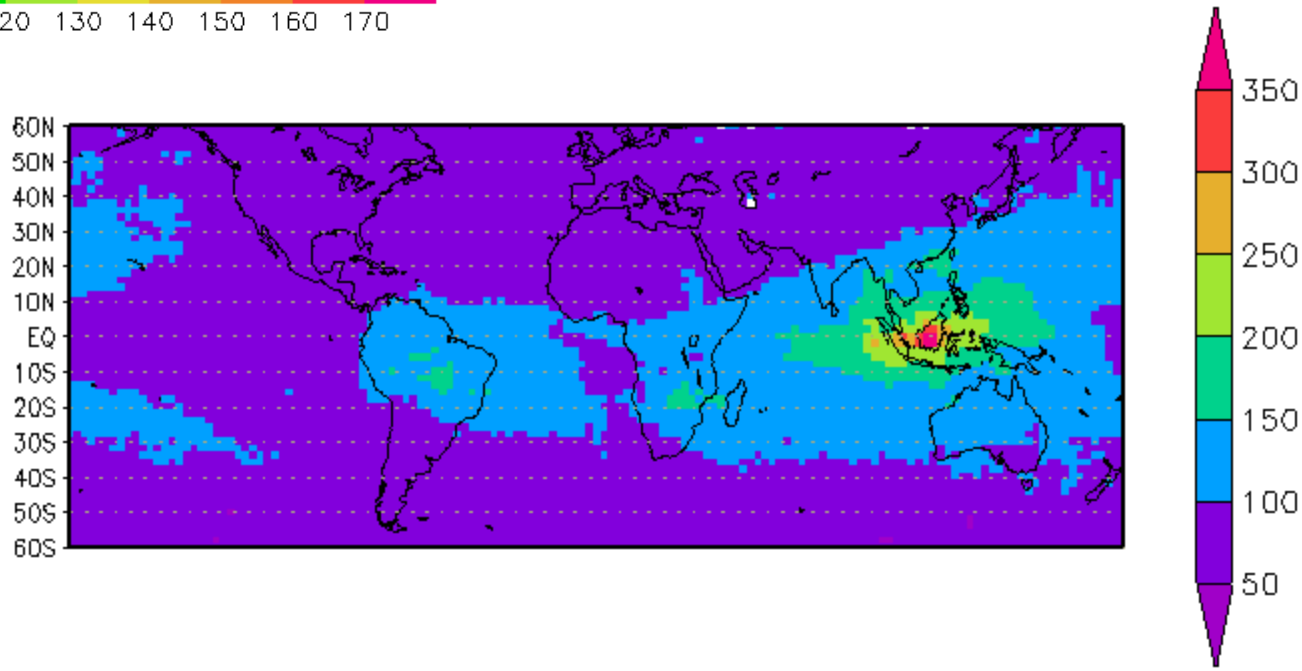
Convective moistening



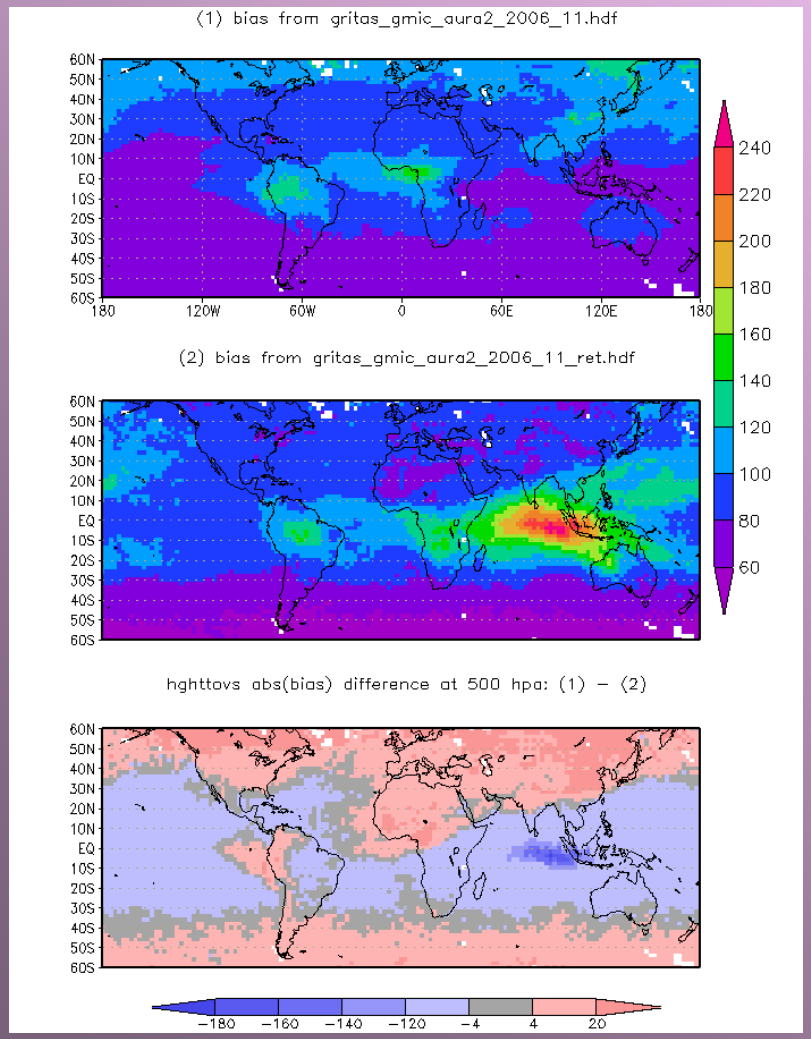


AIRS 500 hPa Sept. 2006

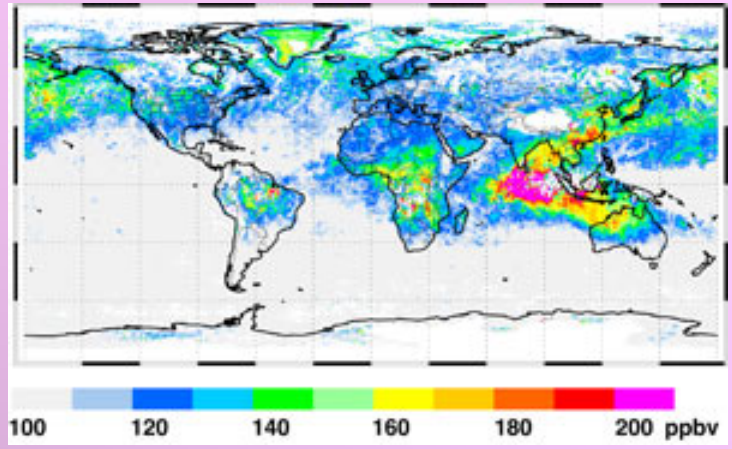
AIRS 500 hPa
Oct. 2006

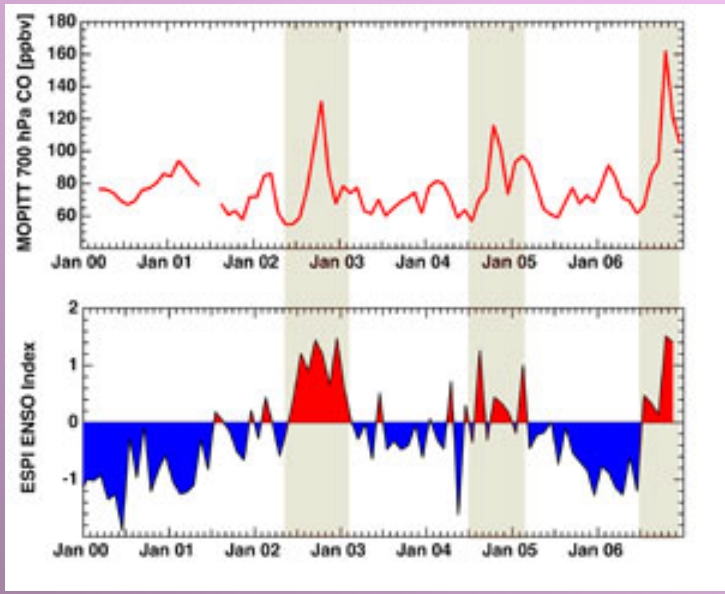


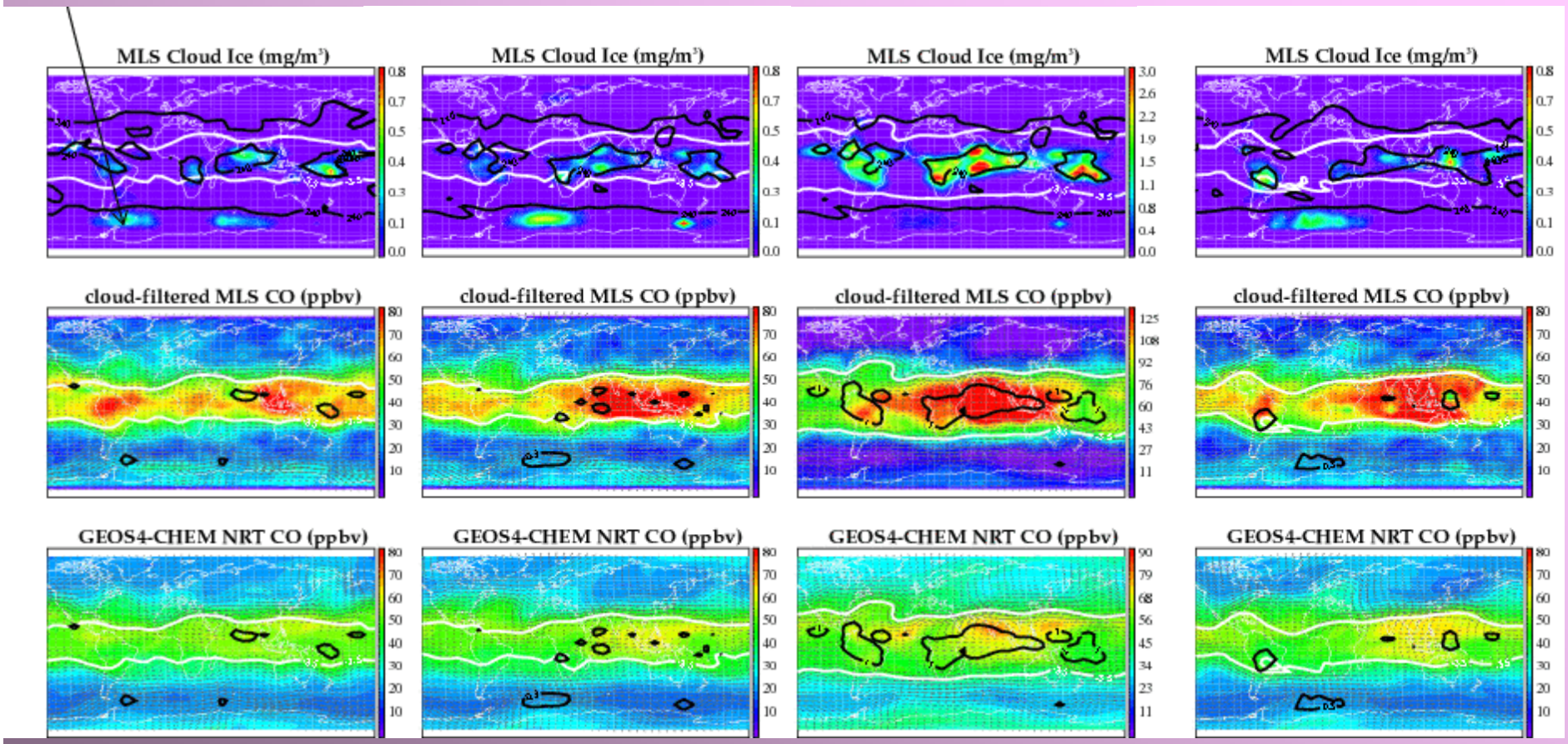
Nov. 2006 500 hPa
Top: GMI, Middle: AIRS
Bottom: Difference



MOPITT Nov. 2006



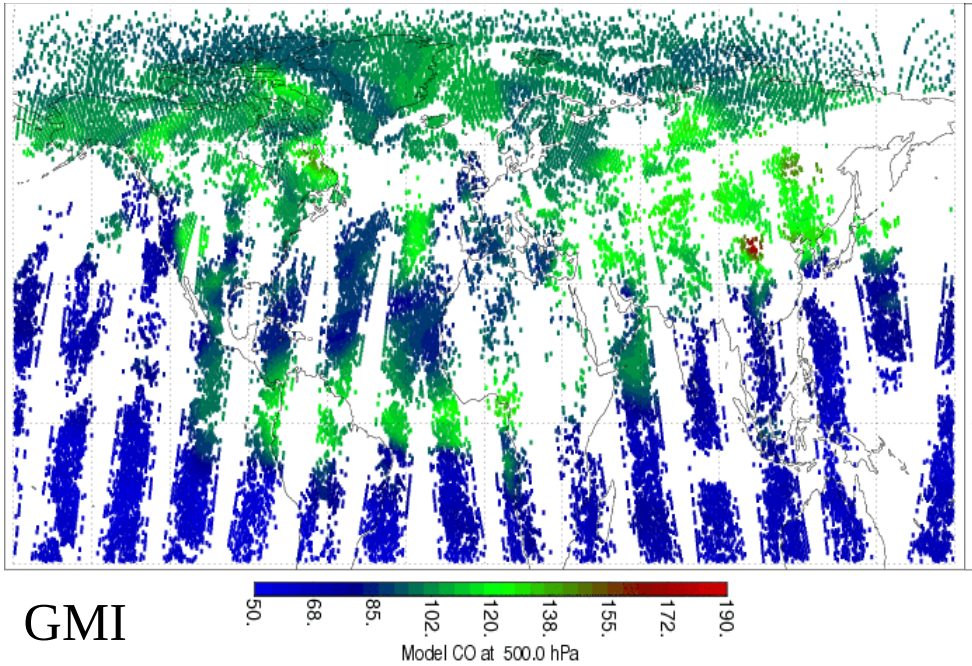




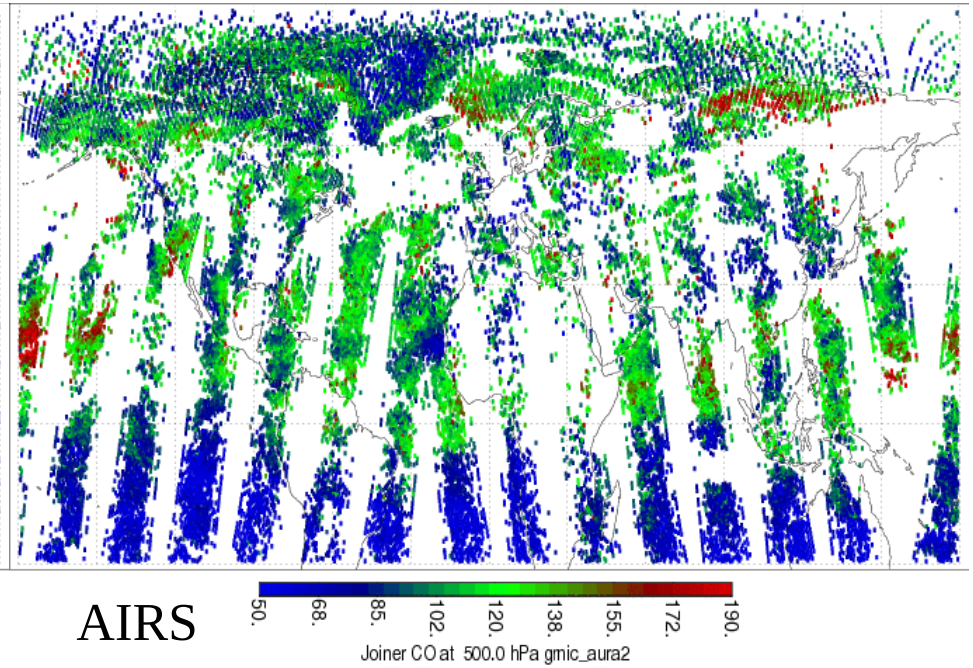
Nov. 12-18, 100hPa Nov. 19-25 100hPa Nov. 19-25 147 hPa Nov. 26-Dec.2 100 hPa

Summary

- Averaging kernel approach breaks down in non-linear, information-limited cases: Elevated CO in thermal IR
- Have daily AIRS retrievals: Feb 2004-Dec 2006 using GMI Aura first guess, on GSFC Code 613.3 cluster, available on request (near-real-time retrievals available on request)
- MOPITT compares well with MOZAIC profiles
- BB and S. Asia sources need to be improved in GMI. Excessive vertical transport in NH, tropical BB regions.
- Thermal IR good for evaluating individual processes: Future work will compare GMI CO with different meteorological forcing (forecast vs averaged DAS)
- Still a lot of room for improvement in both model and satellite free-tropospheric CO from thermal IR; iterative, incremental improvements in both are sought

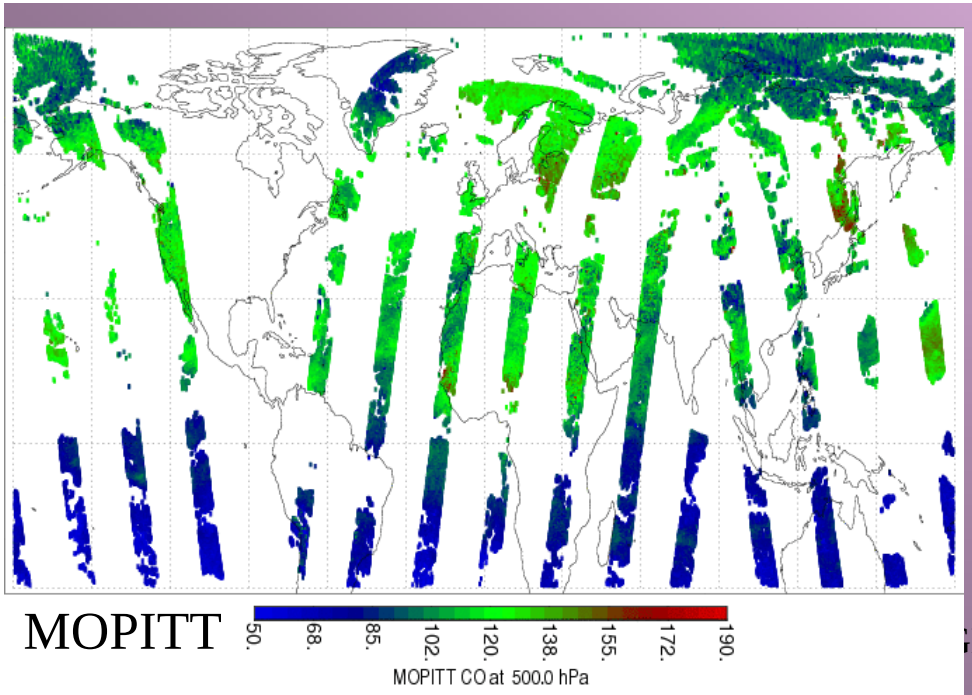


GMI

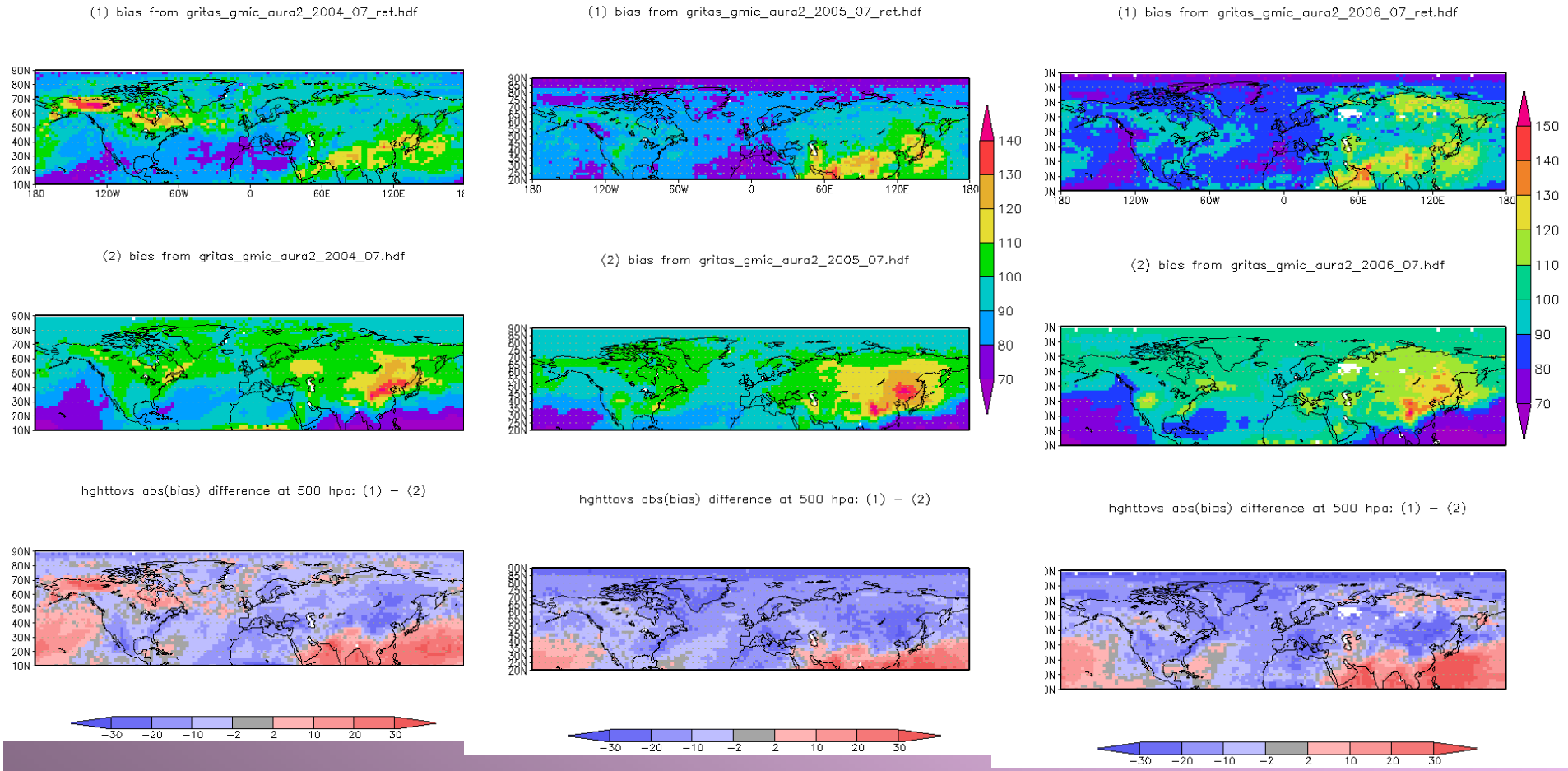


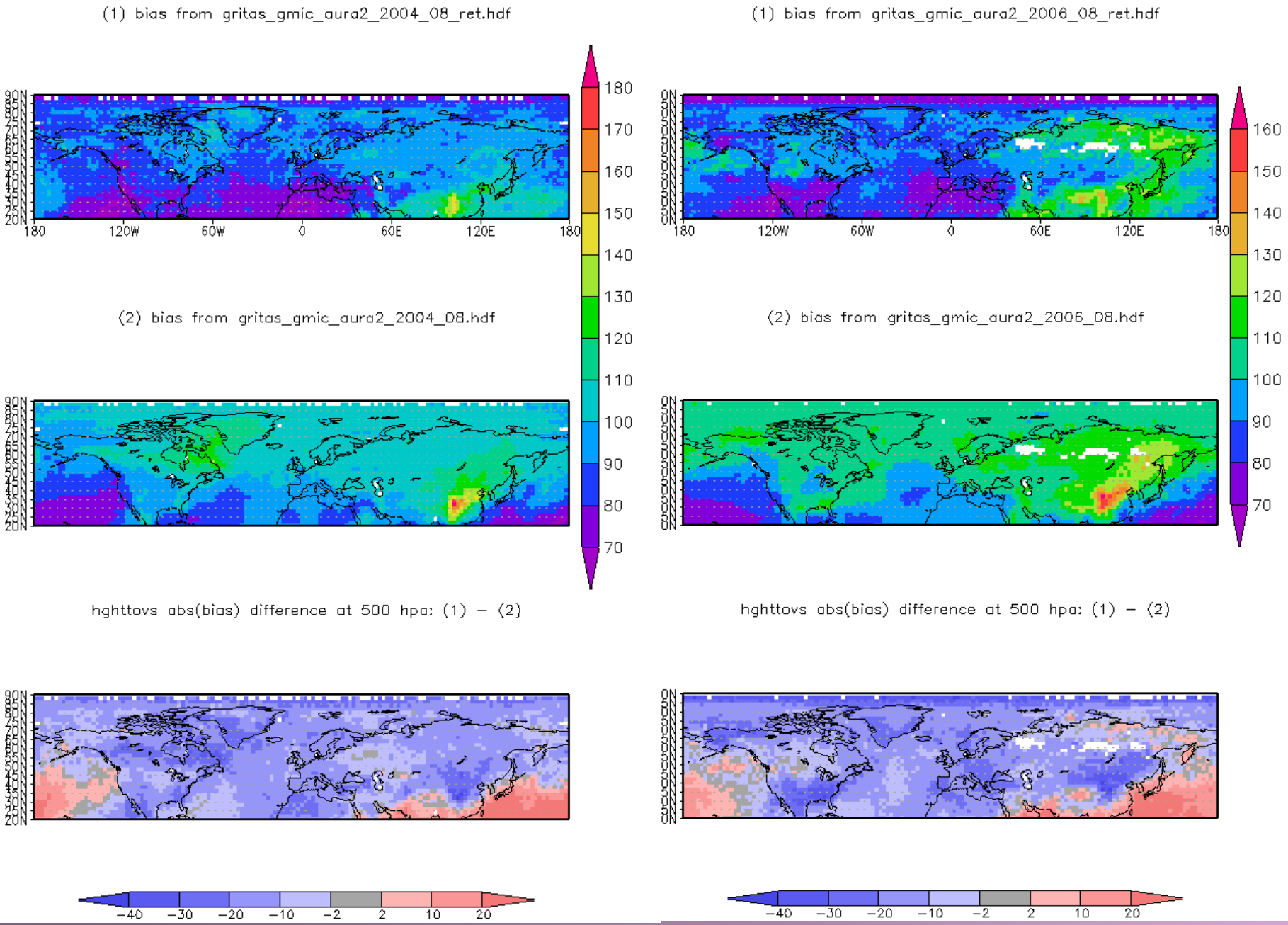
AIRS

GMI guess May 1, 2006

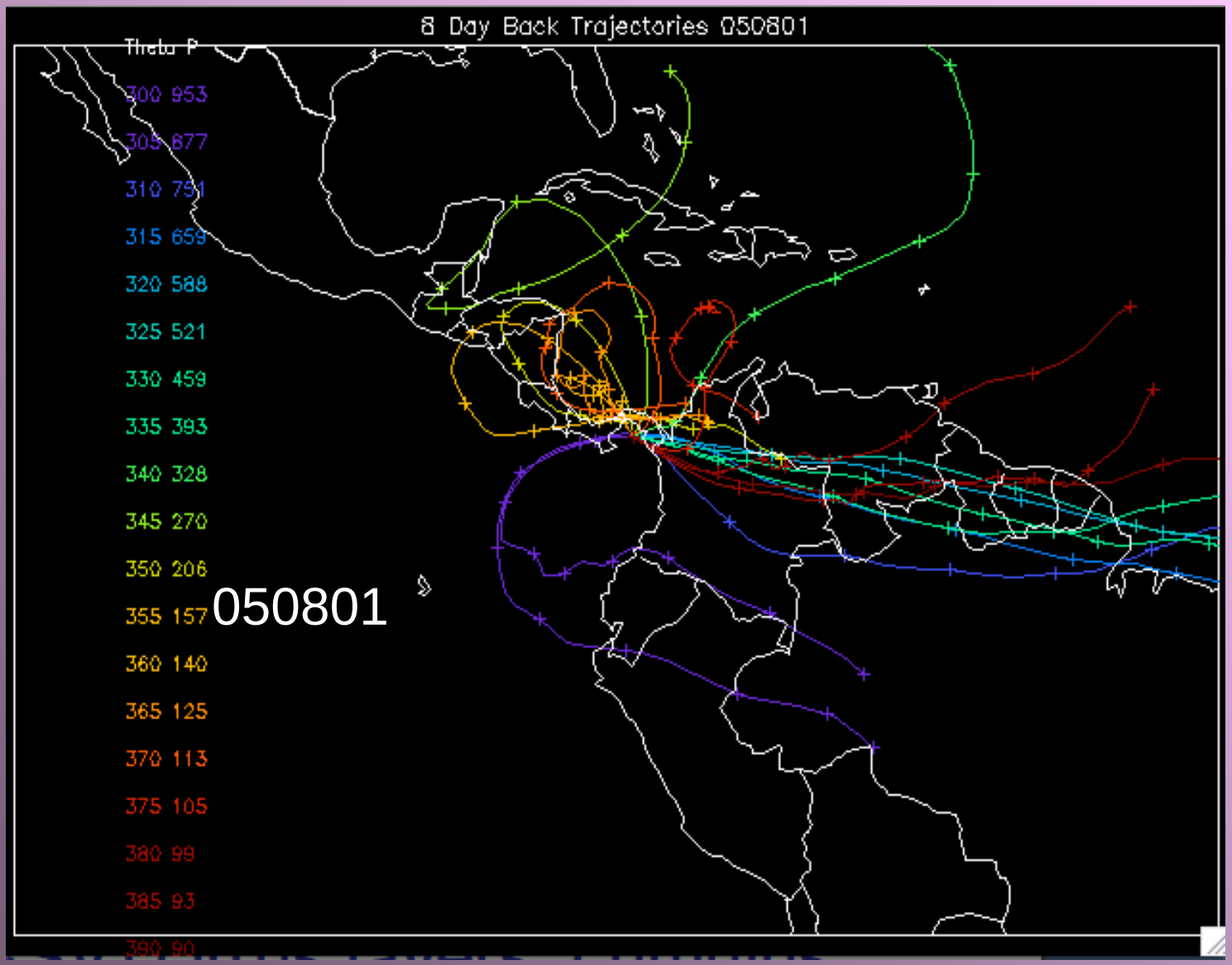


MOPITT


(1) bias from gritas_gmic_aura2_2004_07_ret.hdf
(1) bias from gritas_gmic_aura2_2005_07_ret.hdf
(1) bias from gritas_gmic_aura2_2006_07_ret.hdf
(2) bias from gritas_gmic_aura2_2004_07.hdf
(2) bias from gritas_gmic_aura2_2005_07.hdf
(2) bias from gritas_gmic_aura2_2006_07.hdf
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
90N 80N 70N 60N 50N 40N 30N 20N 10N
180 120W 60W 0 60E 120E 180
70 80 90 100 110 120 130 140
150
−30 −20 −10 −2 2 10 20 30


(1) bias from gritas_gmic_aura2_2004_08_ret.hdf
(1) bias from gritas_gmic_aura2_2006_08_ret.hdf
(2) bias from gritas_gmic_aura2_2004_08.hdf
(2) bias from gritas_gmic_aura2_2006_08.hdf
hghttovs abs(bias) difference at 500 hpa: (1) – (2)
hghttovs abs(bias) difference at 500 hpa: (1) – (2)
180 170 160 150 140 130 120 110 100 90 80 70
160 150 140 130 120 110 100 90 80 70
180 120W 60W 0 60E 120E 180
−40 −30 −20 −10 −2 2 10 20

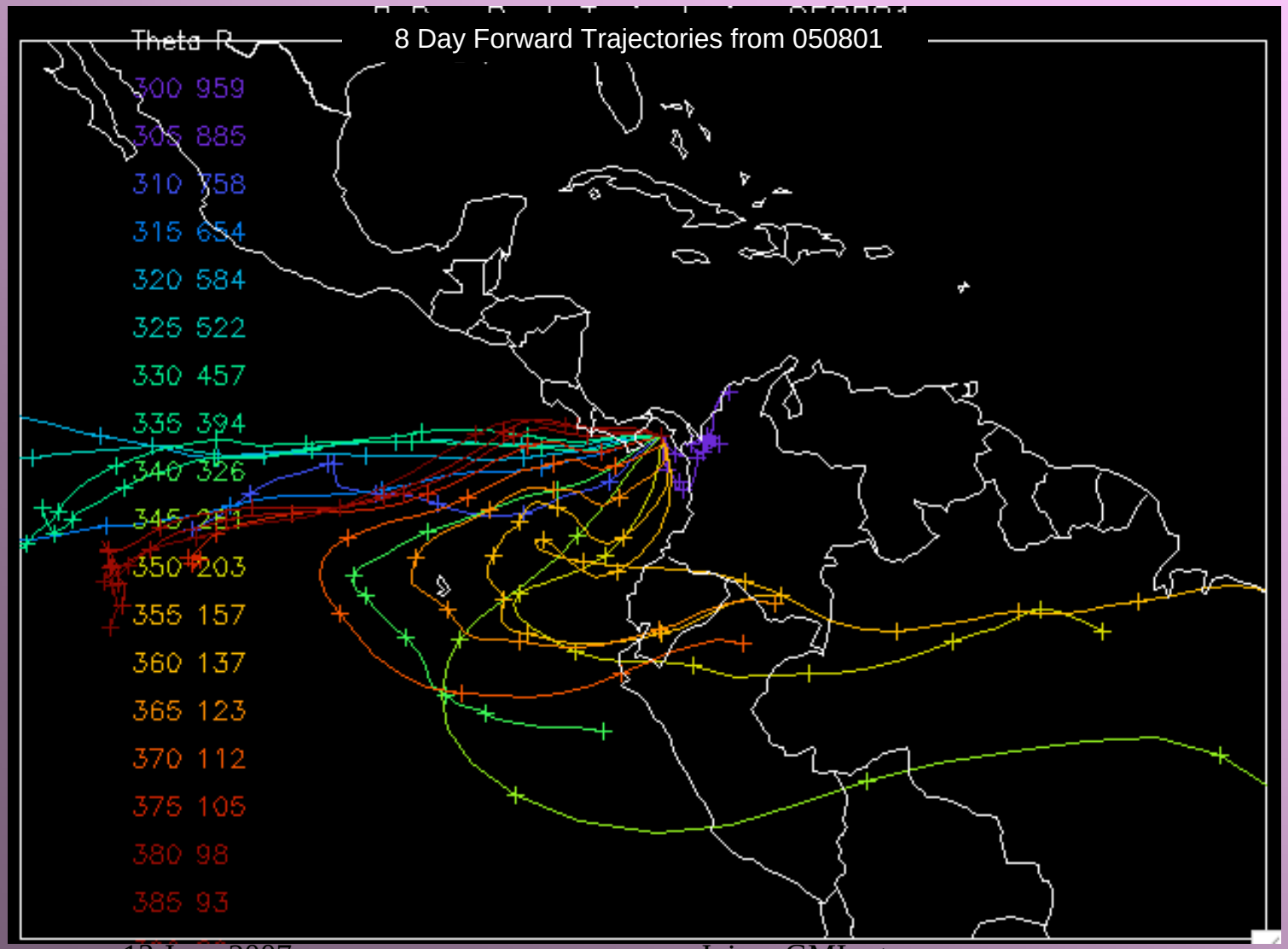
Where does the air come from?



8 day back trajectories:

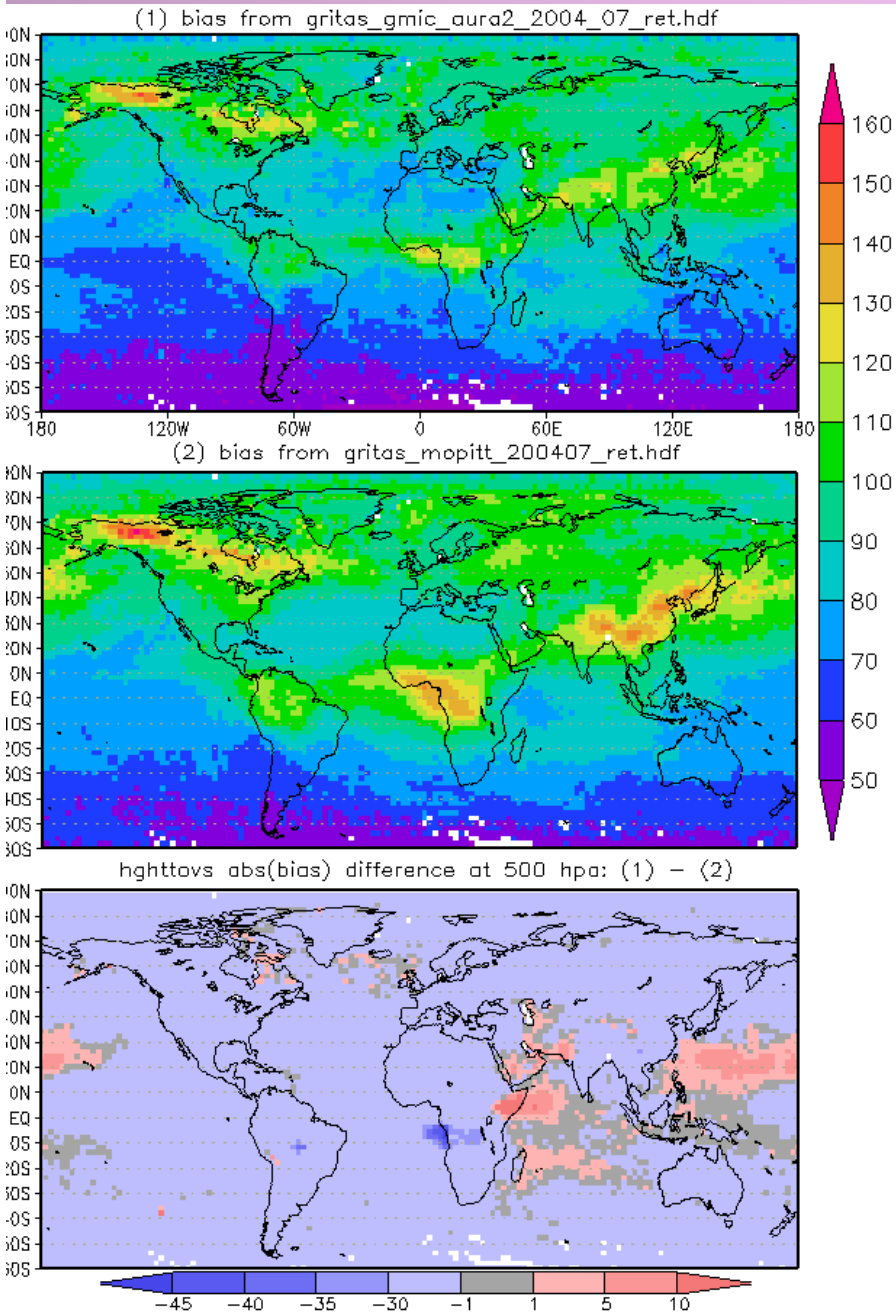
- Air near ~600 - 400 hPa is coming from the South Atlantic
- Low altitude air comes from the south east burning regions (Aug.)
- Higher altitude air wanders in from the north east - east

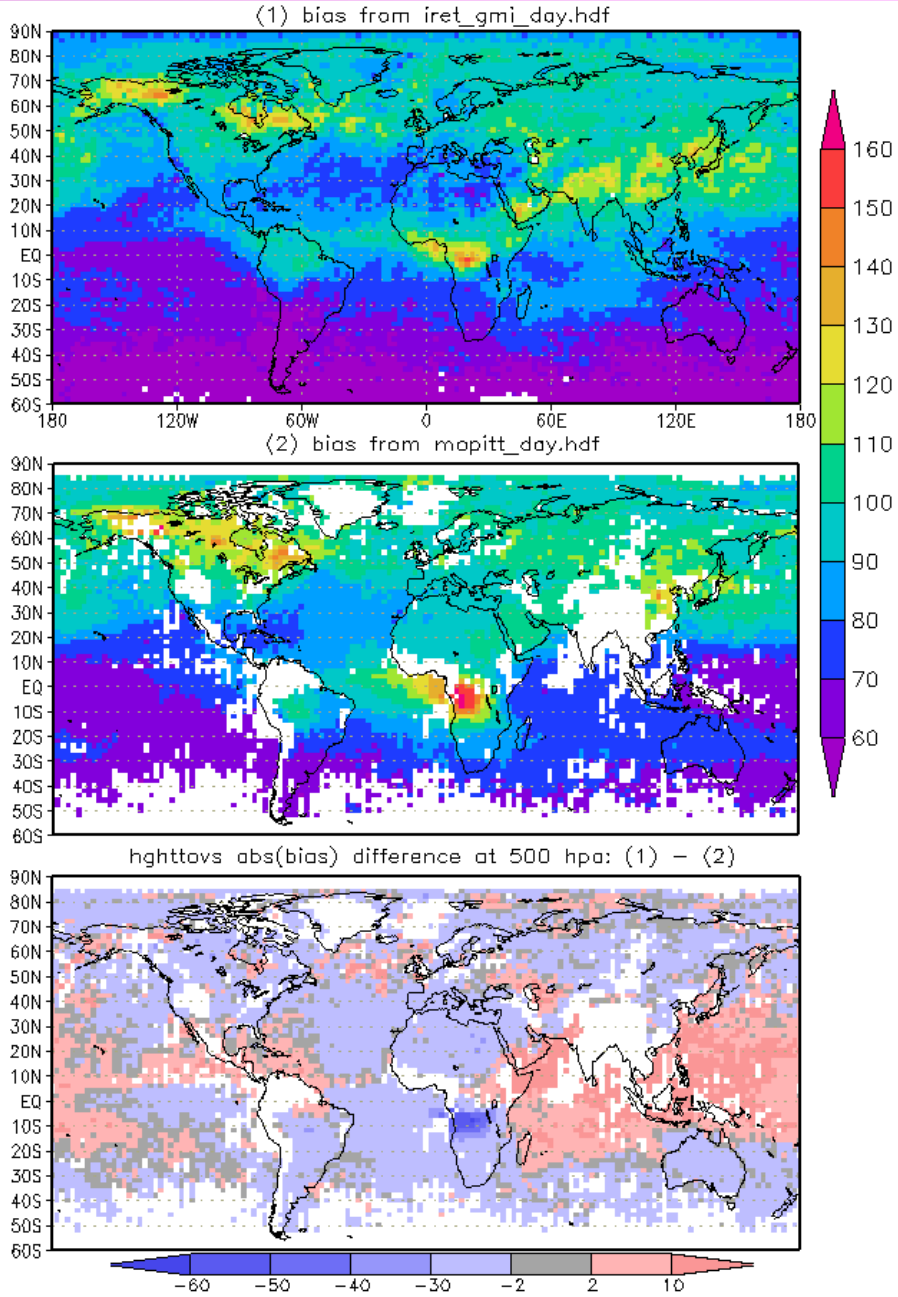
Where does the air go?

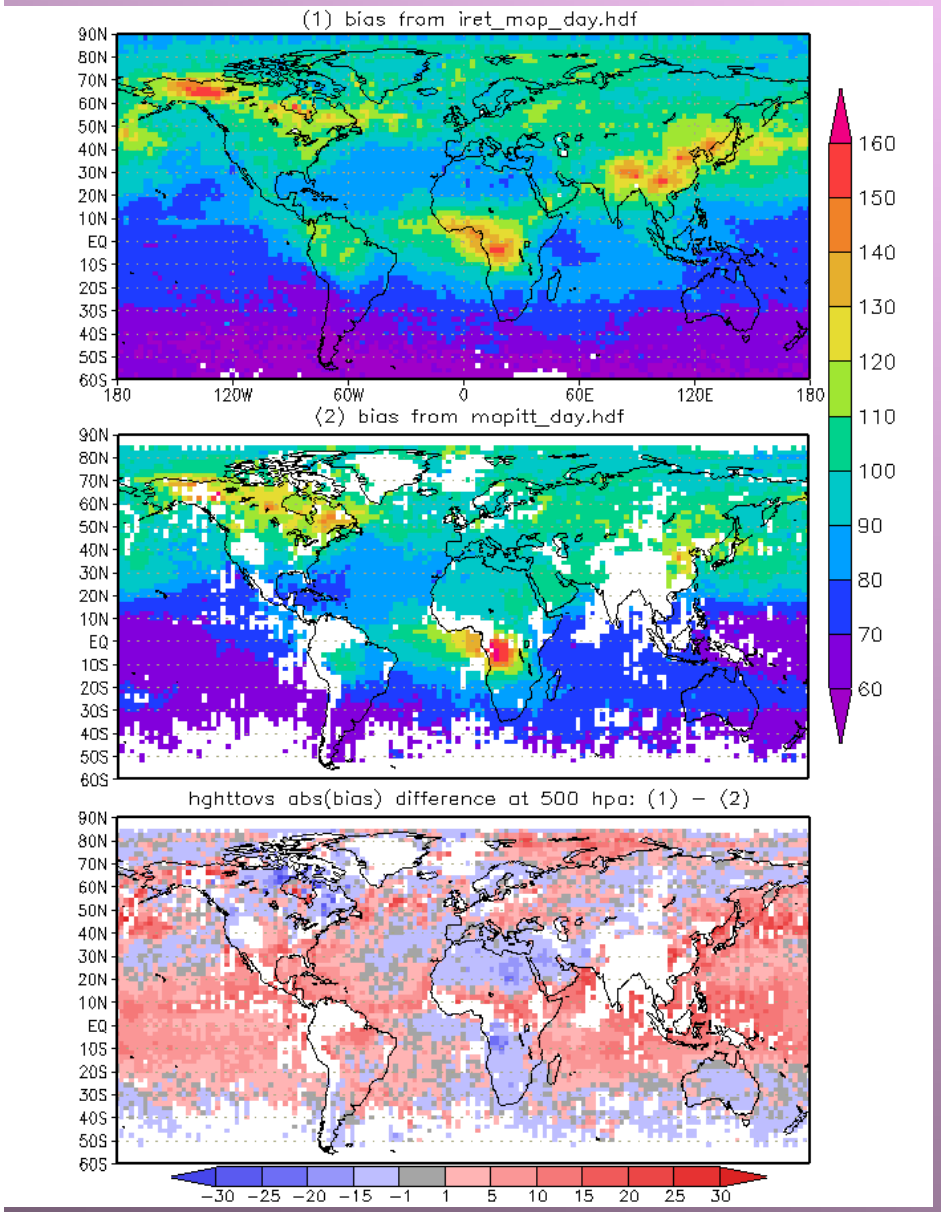


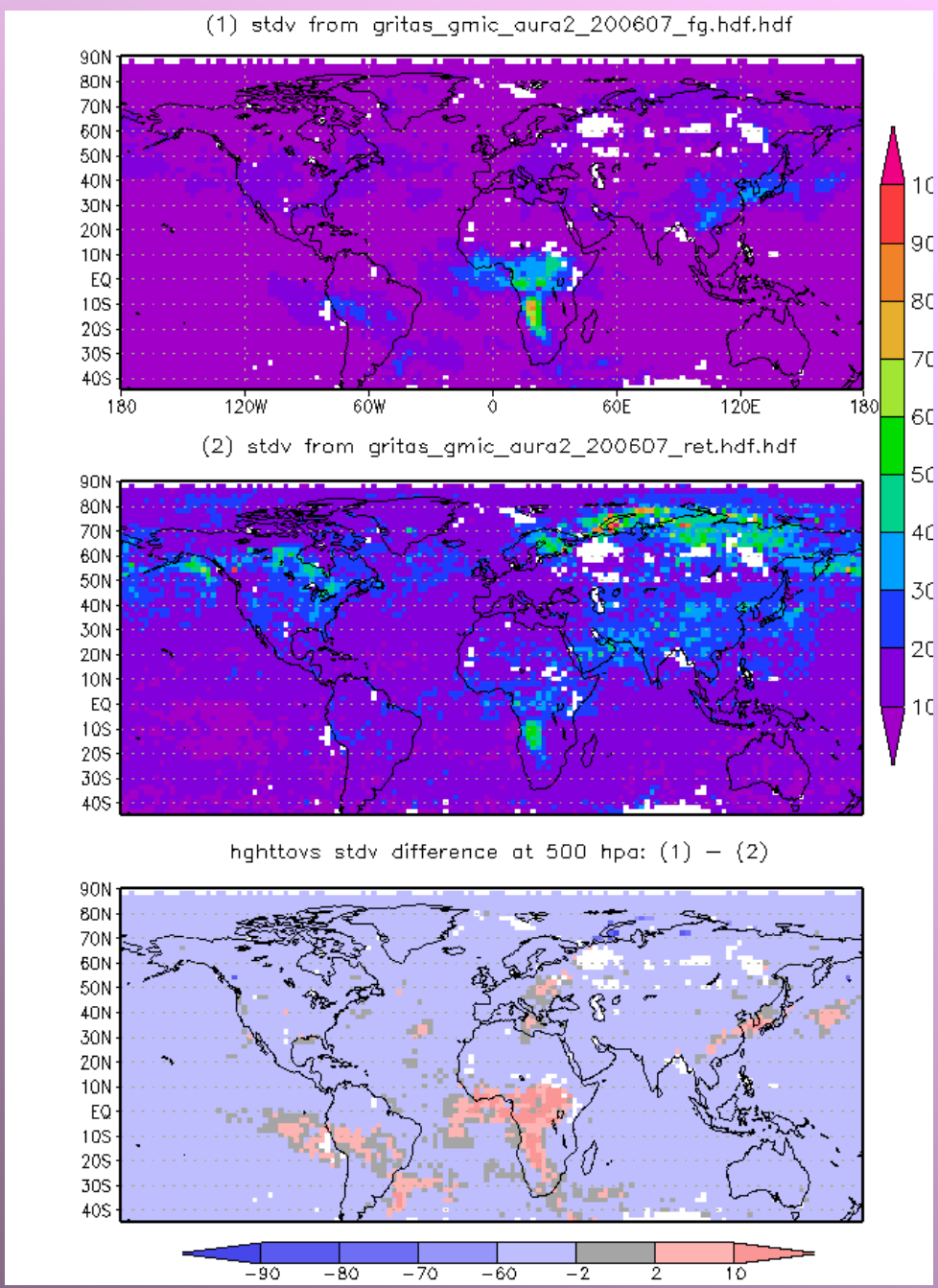
8 day forward trajectories:

- Air near ~600 - 400 hPa is goes to the West Pacific Atlantic
- Low altitude air stops
- Higher altitude heads west


(1) bias from gritas_gmic_aura2_2004_07_ret.hdf
(2) bias from gritas_mopitt_200407_ret.hdf
hghttovs abs(bias) difference at 500 hpa: (1) – (2)
180 120W 60W 0 60E 120E 180
160 150 140 130 120 110 100 90 80 70 60 50
−45 −40 −35 −30 −1 1 5 10


(1) bias from iret_gmi_day.hdf
(2) bias from mopitt_day.hdf
hghttovs abs(bias) difference at 500 hpa: (1) – (2)
90N 80N 70N 60N 50N 40N 30N 20N 10N EQ 10S 20S 30S 40S 50S 60S
180 120W 60W 0 60E 120E 180
160 150 140 130 120 110 100 90 80 70 60
−60 −50 −40 −30 −2 2 10


(1) bias from iret_mop_day.hdf
(2) bias from mopitt_day.hdf
hghttovs abs(bias) difference at 500 hpa: (1) − (2)
90N
80N
70N
60N
50N
40N
30N
20N
10N
EQ
10S
20S
30S
40S
50S
60S
180
120W
60W
0
60E
120E
180
160
150
140
130
120
110
100
90
80
70
60
−30 −25 −20 −15 −1 1 5 10 15 20 25 30


(1) stdv from gritas_gmic_aura2_200607_fg.hdf.hdf
(2) stdv from gritas_gmic_aura2_200607_ret.hdf.hdf
hghttovs stdv difference at 500 hpa: (1) – (2)
90N
80N
70N
60N
50N
40N
30N
20N
10N
EQ
10S
20S
30S
40S
180
120W
60W
0
60E
120E
180
-90
-80
-70
-60
-2
2
10