The Seasonal Atmospheric Carbopause

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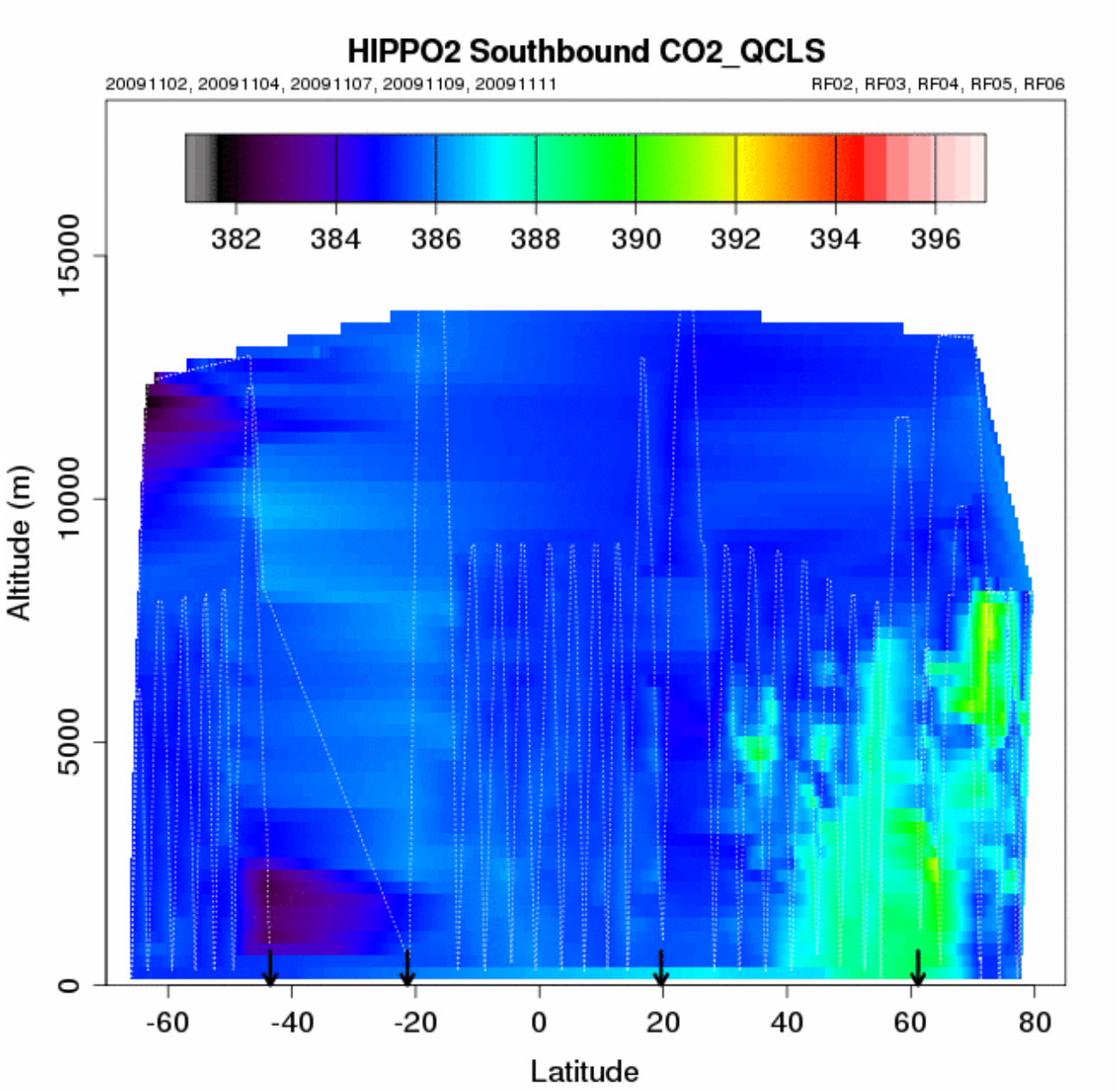
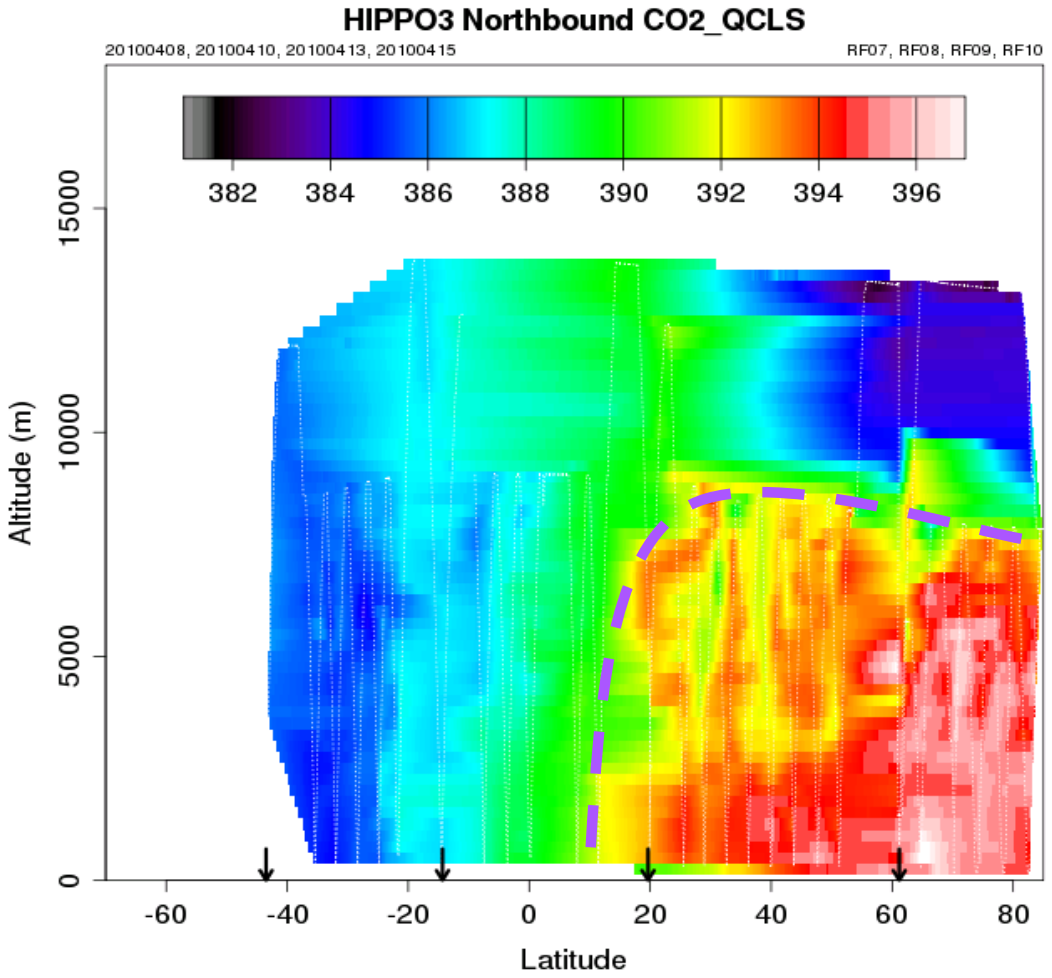
HIPPO Workshop 3/17/11


HIPPO2 Southbound CO2_QCLS
20091102, 20091104, 20091107, 20091109, 20091111
RF02, RF03, RF04, RF05, RF06
382
384
386
388
390
392
394
396
Altitude (m)
0
5000
10000
15000
-60
-40
-20
0
20
40
60
80
Latitude

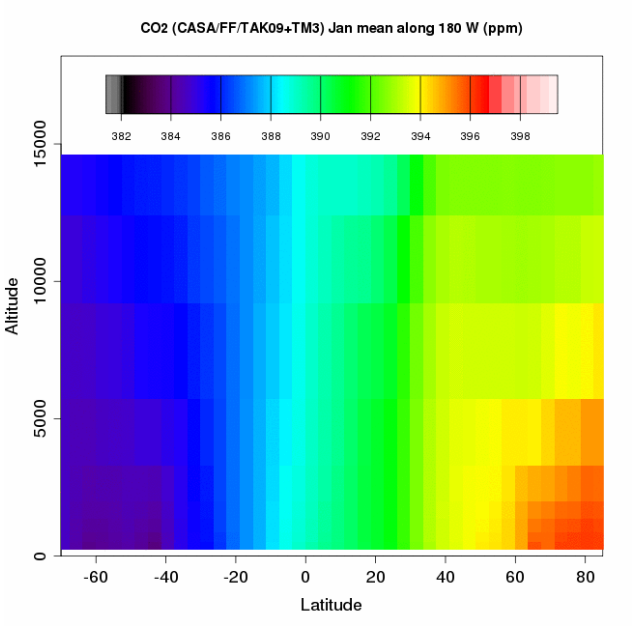
Preliminary definition: The boundary between that part of the atmosphere that is directly influenced by the seasonal component of northern CO_2 exchange, and that part which is not.



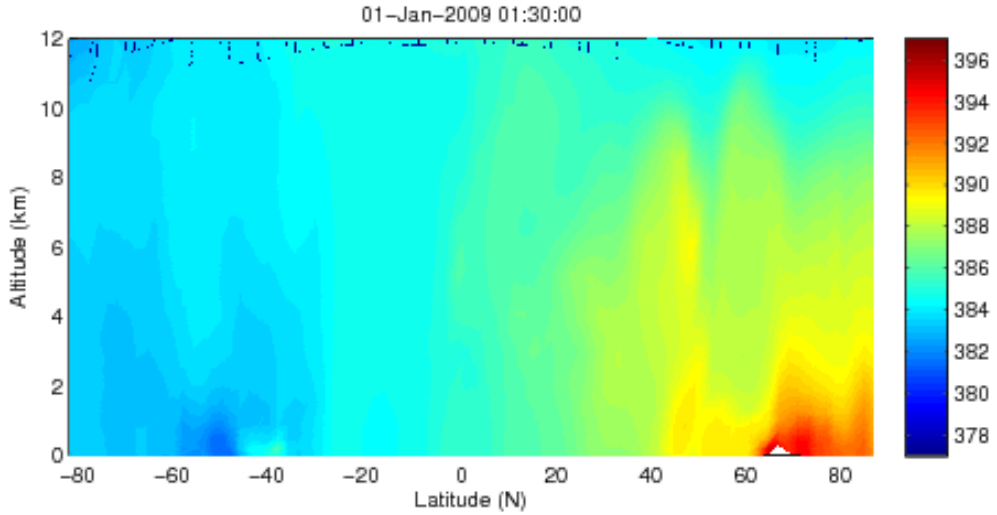
Point 1) The dominant feature in global atmospheric CO_2 distributions is the signal from seasonal exchange with northern biota

Point 2) If a transport model does not mix this exchange into the right atmospheric volume, it will infer incorrect CO_2 fluxes

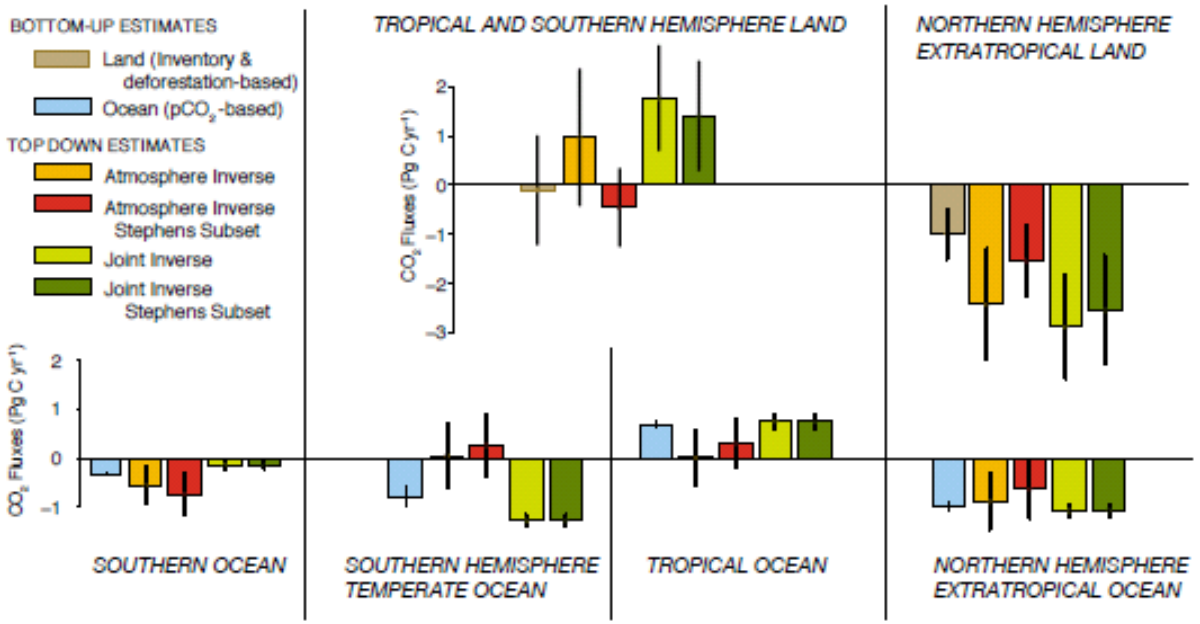
TM3 Monthly Means



NOAA CarbonTracker 3-Hourly

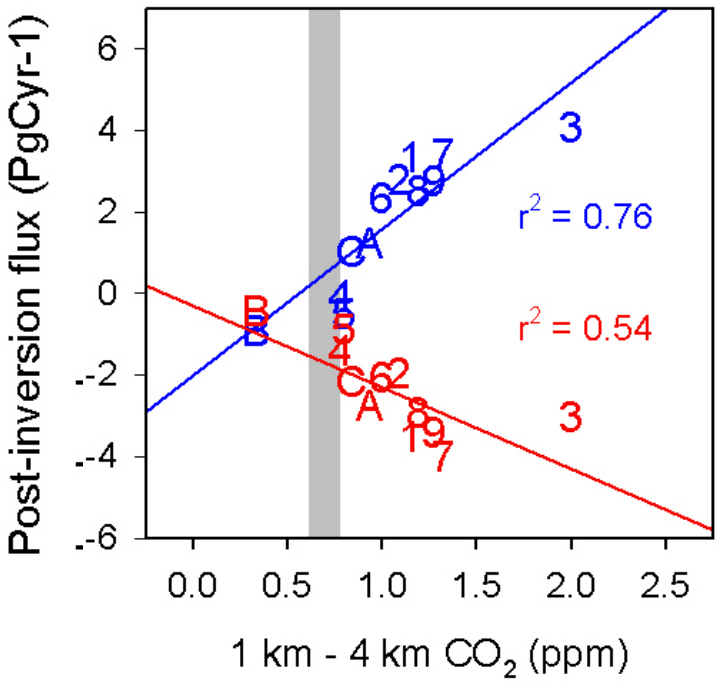


Zonal land flux uncertainties are still very large



[Sarmiento et al., BGS 2010]

Tropical Land and Northern Land fluxes plotted versus vertical CO_2 gradient

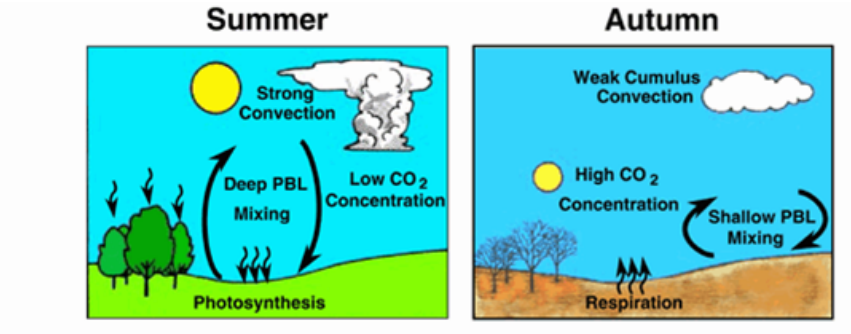


Model	Model Name
1	CSU
2	GCTM
3	UCB
4	UCI
5	JMA
6	MATCH.CCM3
7	MATCH.NCEP
8	MATCH.MACCM2
9	NIES
A	NIRE
B	TM2
C	TM3

Systematic trade off is related to vertical mixing biases in the models

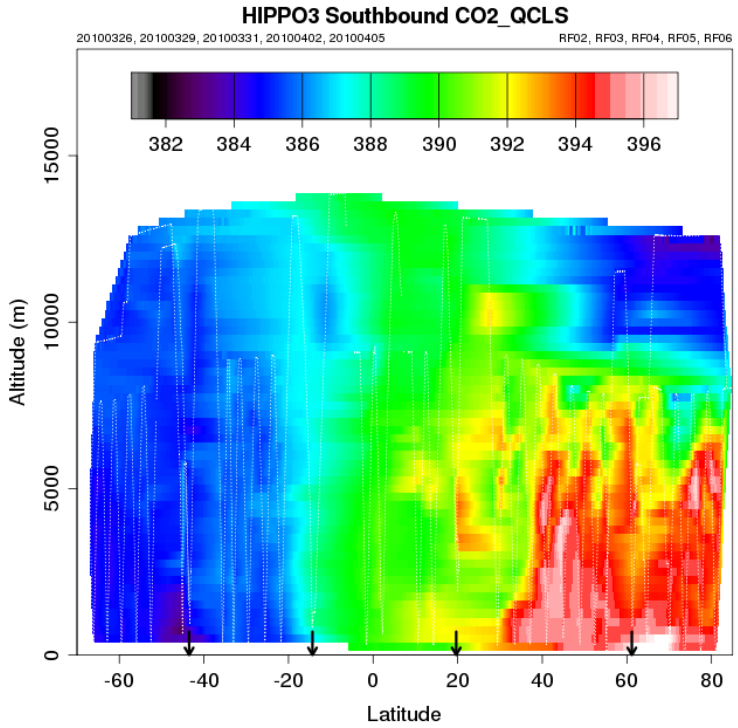
[Stephens et al., 2007]

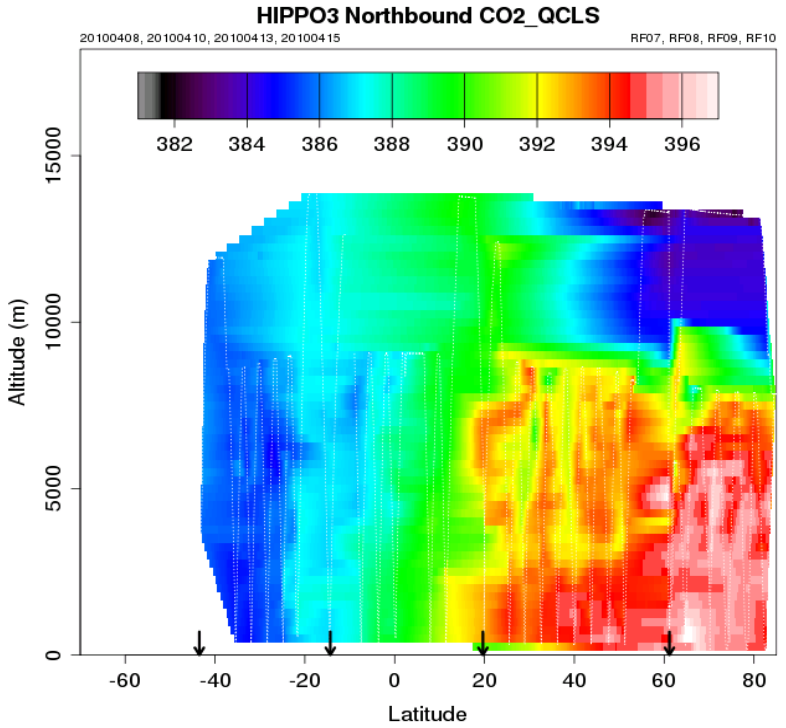
Observed value



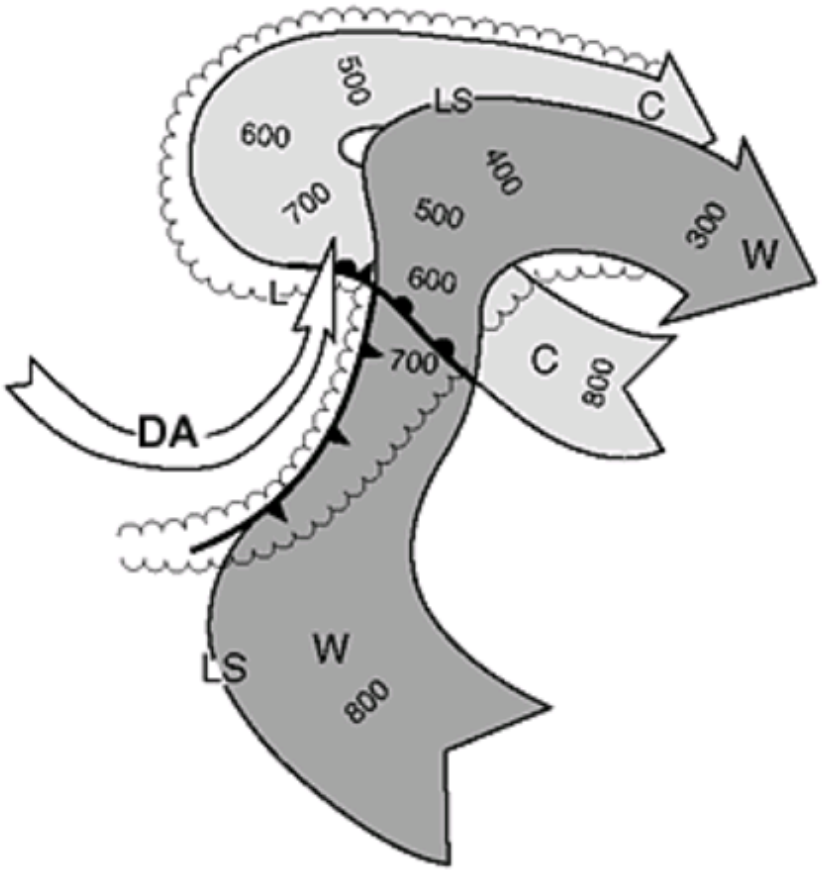
Point 3) Analysis of vertical gradients is a 1-dimensional view on a 3-dimensional problem

Point 4) Now that we have HIPPO data, we can improve this analysis to a 2-dimensional view

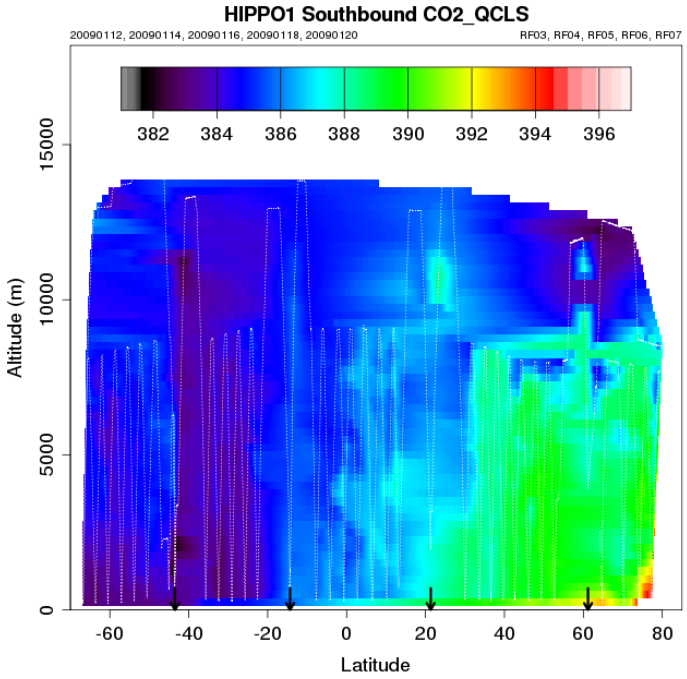


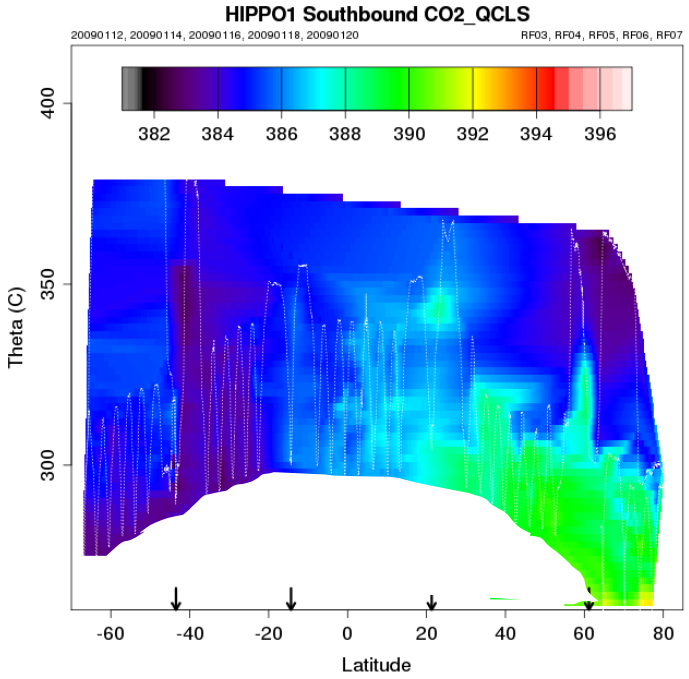


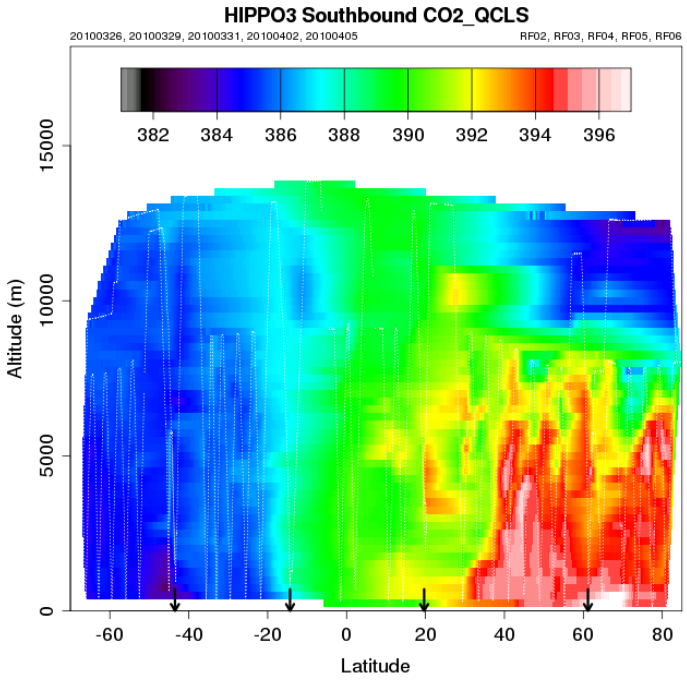
The Warm and Cold Conveyor Belts

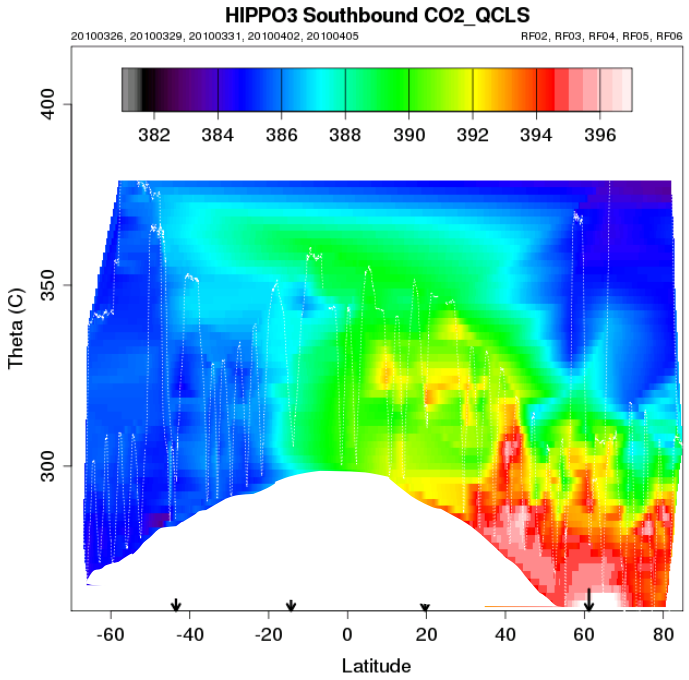


[Bader et al 1995, adapted from Carlson, 1980]

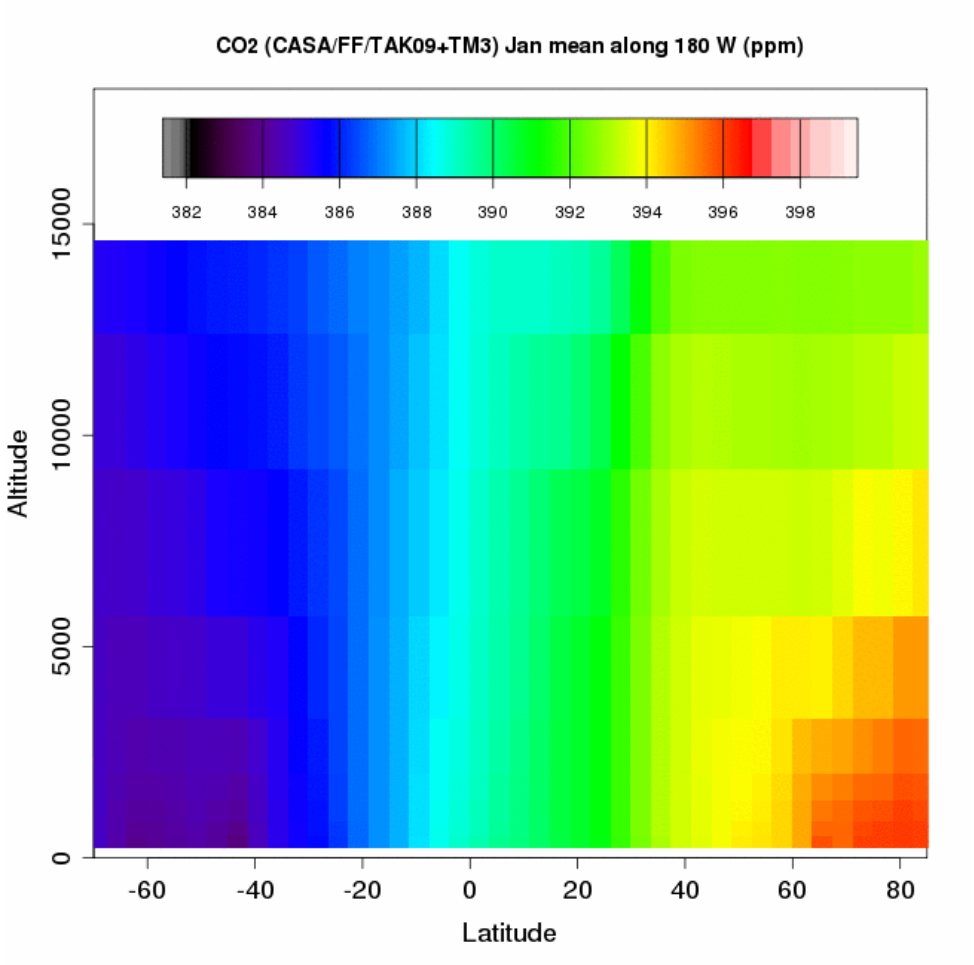

HIPPO1 Southbound CO2_QCLS
20090112, 20090114, 20090116, 20090118, 20090120
RF03, RF04, RF05, RF06, RF07
382 384 386 388 390 392 394 396
Altitude (m)
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

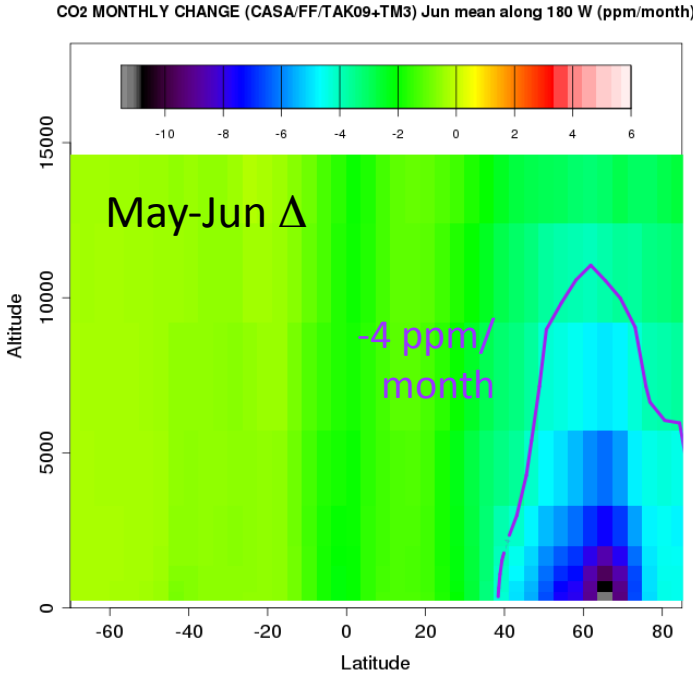

HIPPO1 Southbound CO2_QCLS
20090112, 20090114, 20090116, 20090118, 20090120
RF03, RF04, RF05, RF06, RF07
382 384 386 388 390 392 394 396
Theta (C)
300 350 400
-60 -40 -20 0 20 40 60 80
Latitude

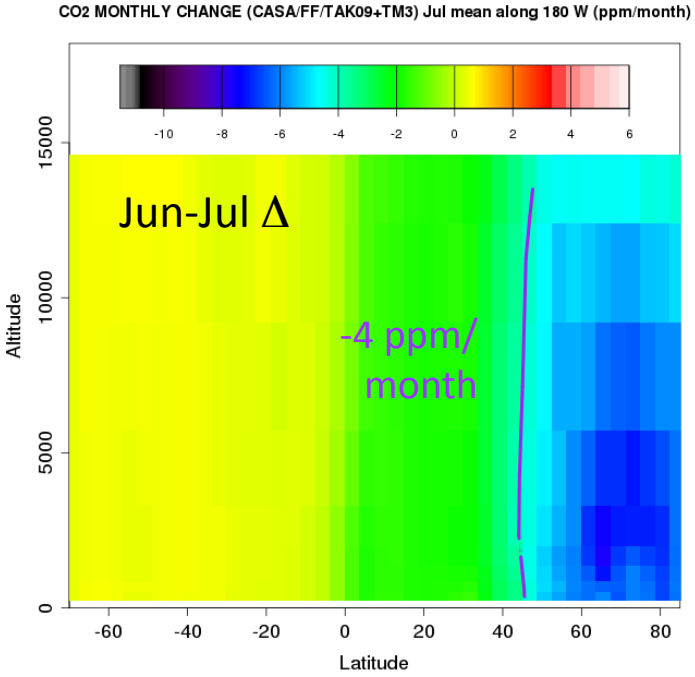

HIPPO3 Southbound CO2_QCLS
20100326, 20100329, 20100331, 20100402, 20100405
RF02, RF03, RF04, RF05, RF06
382 384 386 388 390 392 394 396
Altitude (m)
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

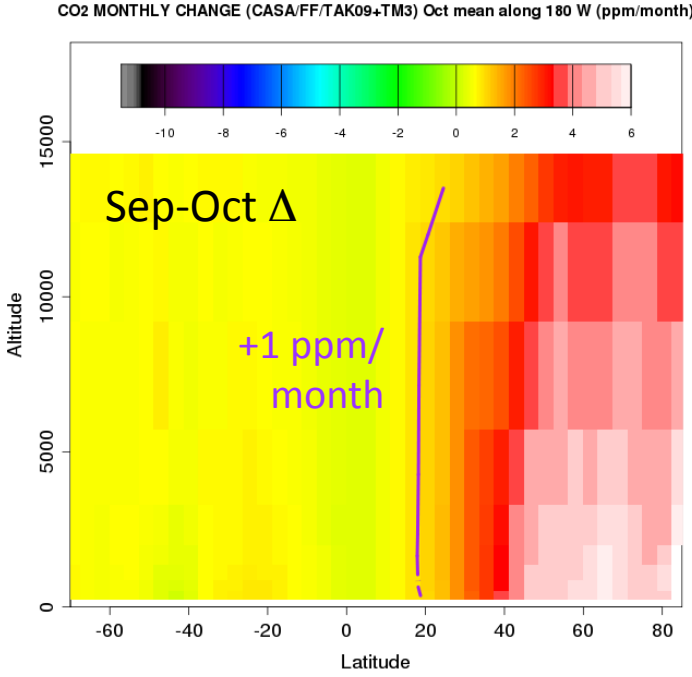

HIPPO3 Southbound CO2_QCLS
20100326, 20100329, 20100331, 20100402, 20100405
RF02, RF03, RF04, RF05, RF06
382 384 386 388 390 392 394 396
Theta (C)
300 350 400
-60 -40 -20 0 20 40 60 80
Latitude

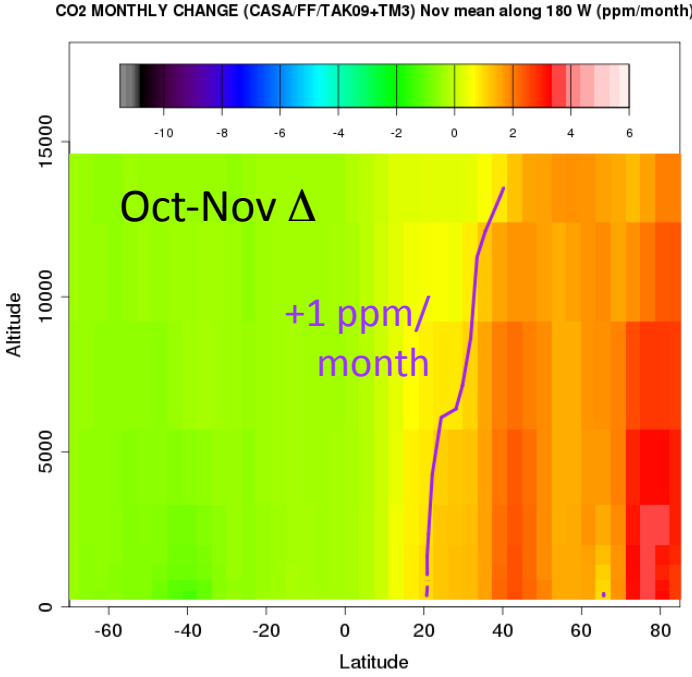
How can we measure the seasonal northern hemisphere mixing volume?

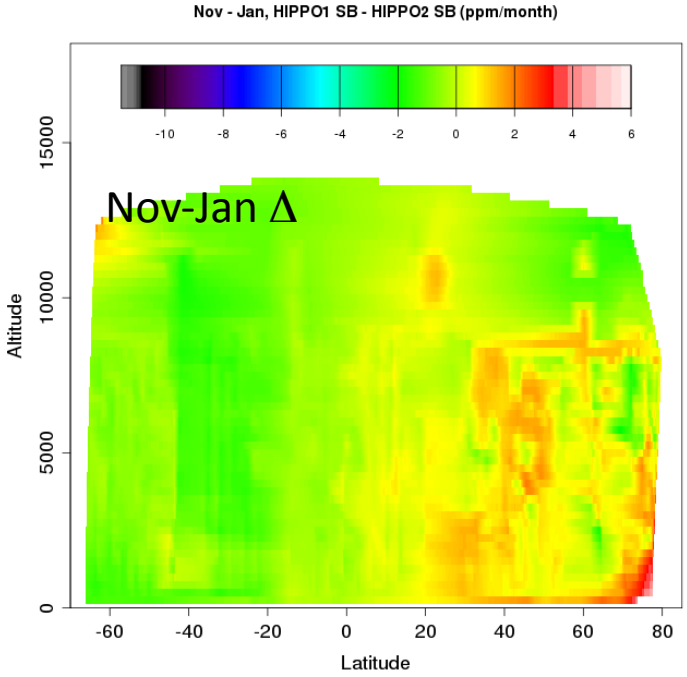


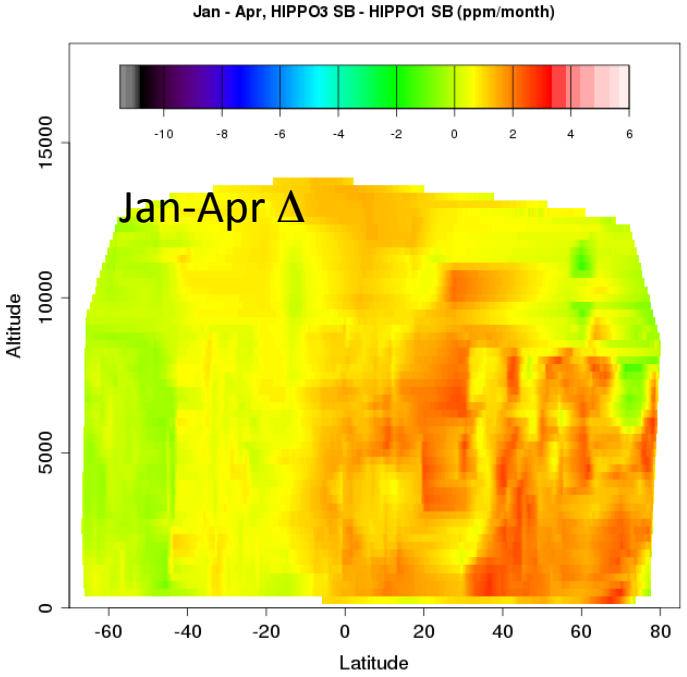

CO2 MONTHLY CHANGE (CASA/FF/TAK09+TM3) Jun mean along 180 W (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
May-Jun Δ
-4 ppm/ month
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

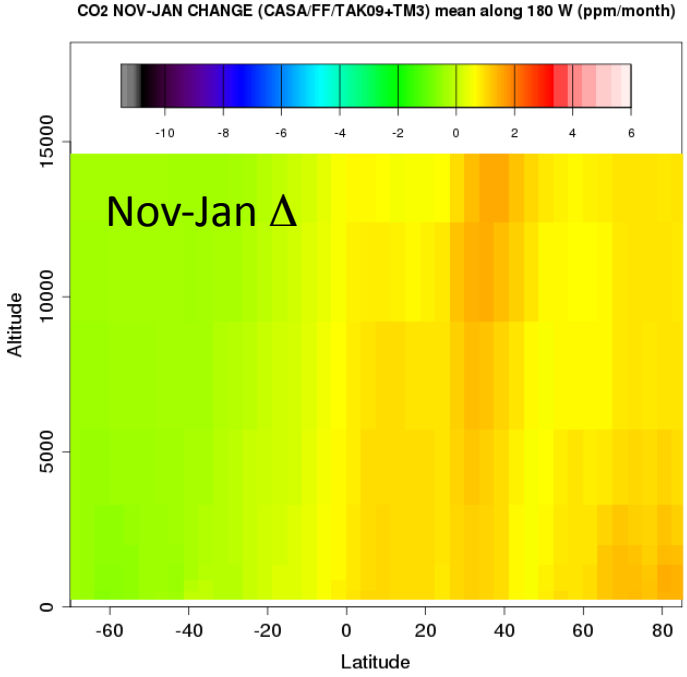

CO2 MONTHLY CHANGE (CASA/FF/TAK09+TM3) Jul mean along 180 W (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
Jun-Jul Δ
-4 ppm/ month
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

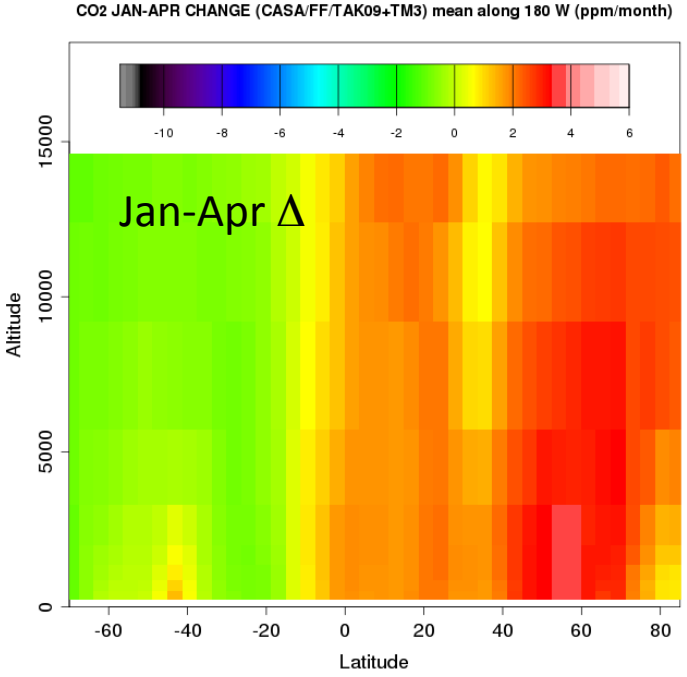

CO2 MONTHLY CHANGE (CASA/FF/TAK09+TM3) Oct mean along 180 W (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
Sep-Oct Δ
+1 ppm/ month
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude


CO2 MONTHLY CHANGE (CASA/FF/TAK09+TM3) Nov mean along 180 W (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
Oct-Nov Δ
+1 ppm/ month
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

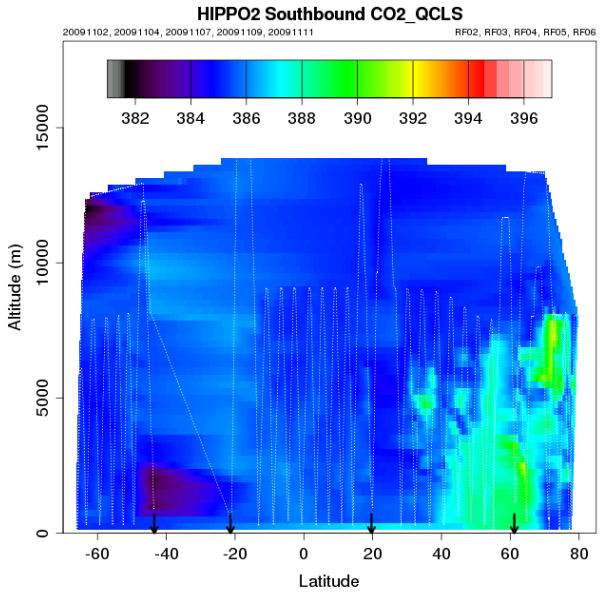

Nov - Jan, HIPPO1 SB - HIPPO2 SB (ppm/month)
Nov-Jan Δ
-10 -8 -6 -4 -2 0 2 4 6
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

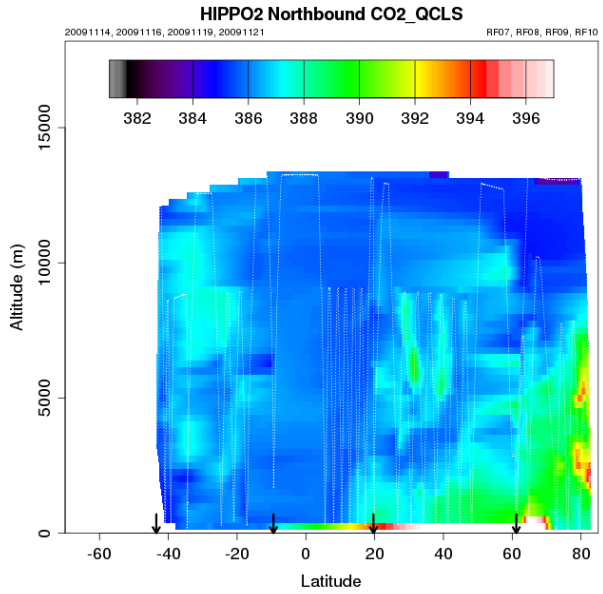

Jan - Apr, HIPPO3 SB - HIPPO1 SB (ppm/month)
Jan-Apr Δ
-10 -8 -6 -4 -2 0 2 4 6
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

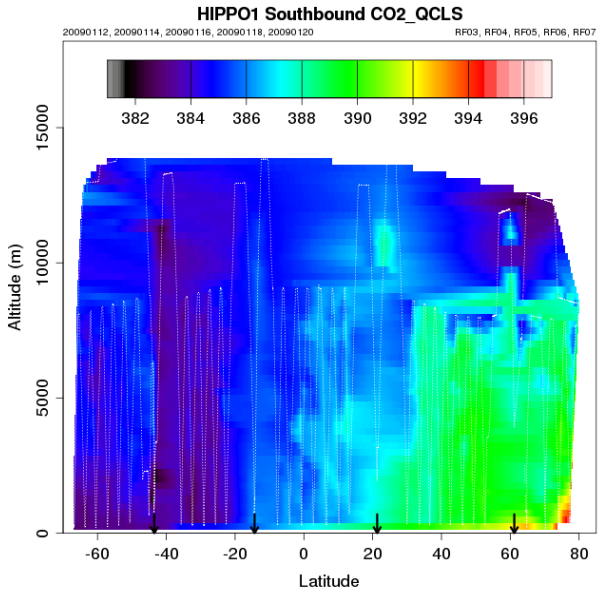

CO2 NOV-JAN CHANGE (CASA/FF/TAK09+TM3) mean along 180 W (ppm/month)
Nov-Jan Δ
-10 -8 -6 -4 -2 0 2 4 6
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

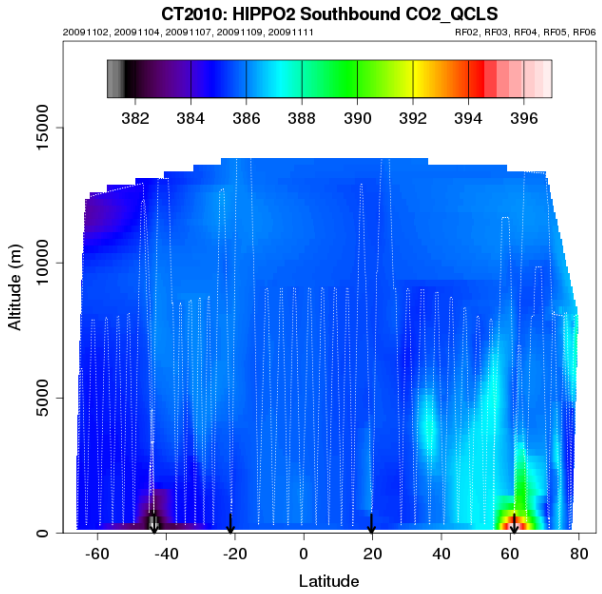

CO2 JAN-APR CHANGE (CASA/FF/TAK09+TM3) mean along 180 W (ppm/month)
Jan-Apr Δ
-10 -8 -6 -4 -2 0 2 4 6
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

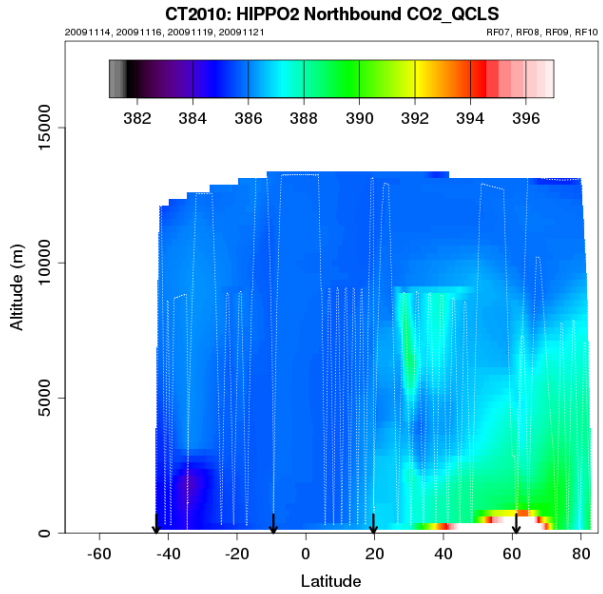
HIPPO 1 and 2 and NOAA CarbonTracker Comparisons

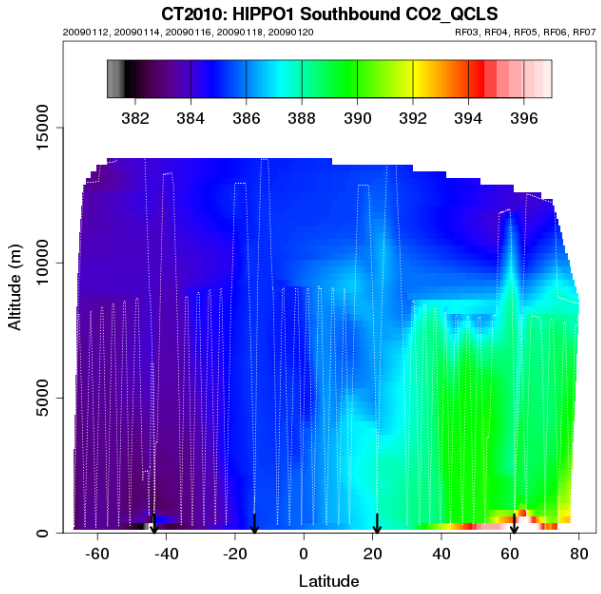


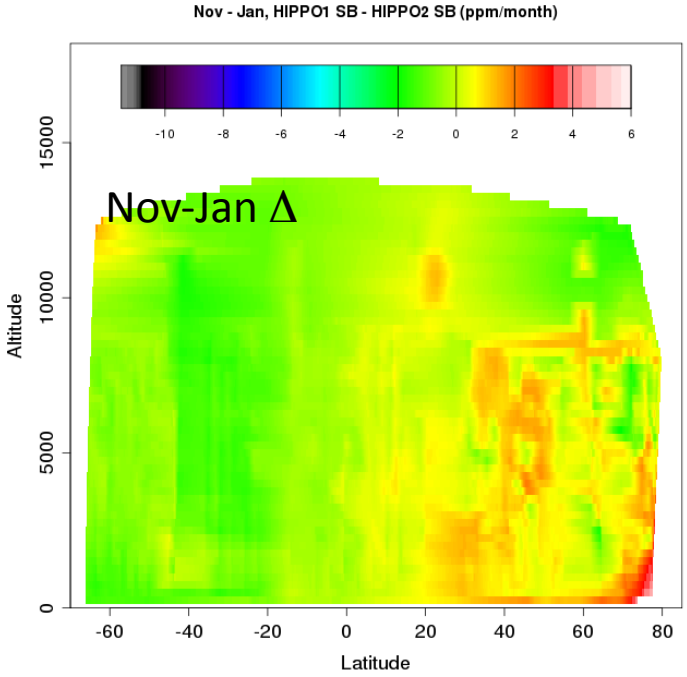


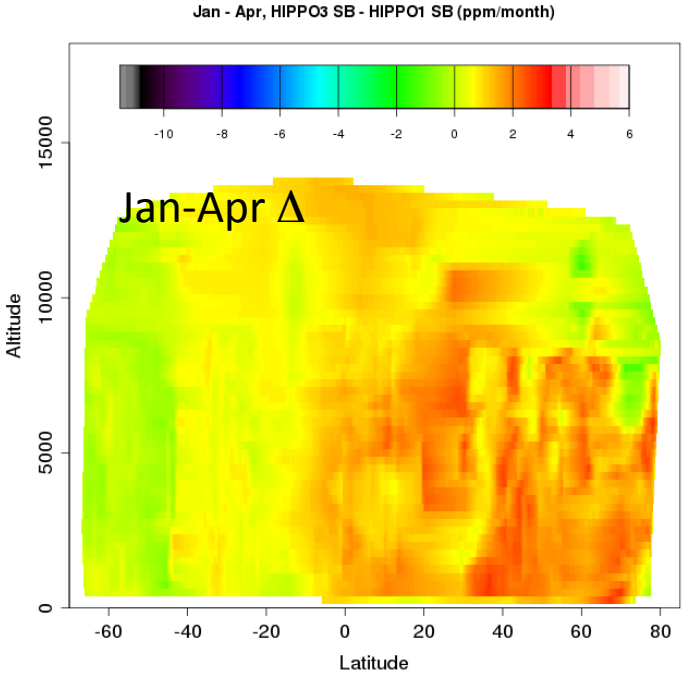


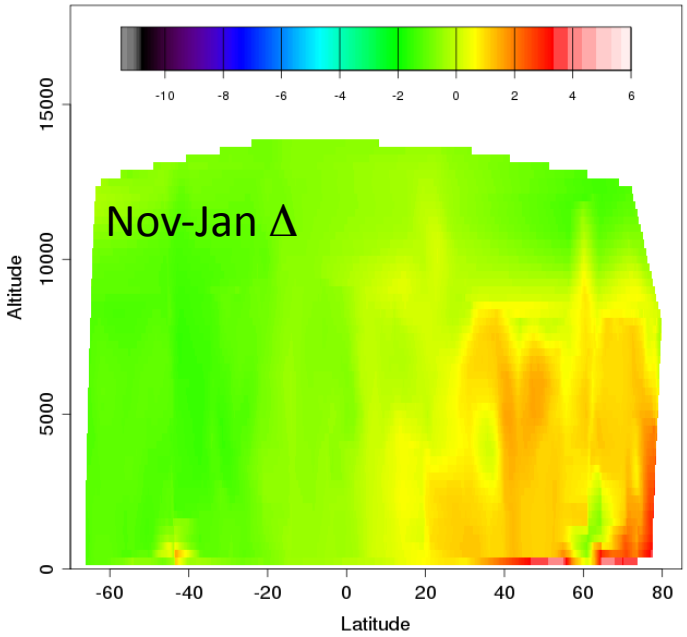







Nov - Jan, HIPPO1 SB - HIPPO2 SB (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
Nov-Jan Δ
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude


Jan - Apr, HIPPO3 SB - HIPPO1 SB (ppm/month)
-10 -8 -6 -4 -2 0 2 4 6
Jan-Apr Δ
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude


-10 -8 -6 -4 -2 0 2 4 6
Nov-Jan Δ
Altitude
0 5000 10000 15000
-60 -40 -20 0 20 40 60 80
Latitude

Conclusions:

- HIPPO data show promise for challenging hemispheric atmospheric model transport
- Winter CO_2 increases permeate entire Northern Hemisphere
- CarbonTracker (TM5) appears to match large scale patterns well, but with near-surface trapping
- Ongoing work:
  - Include other models
  - Develop quantitative measures