AIRS Mid Tropospheric CO_2 Product

Recent Developments

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AIRS Science Team Meeting

Greenbelt, MD

Nov 3 - 5, 2010

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Jet Propulsion Laboratory
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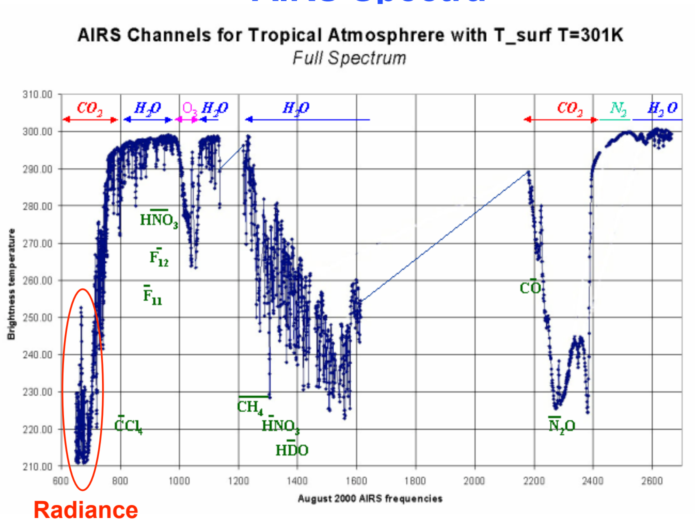
Atmospheric Infrared Sounder

The Atmospheric Infrared Sounder on NASA's EOS Aqua Spacecraft

- AIRS Characteristics
- Launched: May 4, 2002
- Orbit: 705 km, 1:30pm, Sun Synch
- IFOV : 1.1° x 0.6°
  (13.5 km x 7.4 km)
- Scan Range: ±49.5°
- Full Aperture OBC Blackbody, ε > 0.998
- Full Aperture Space View
- Solid State Grating Spectrometer
  - IR Spectral Range:
    3.74-4.61 µm, 6.2-8.22 µm,
    8.8-15.4 µm
  - IR Spectral Resolution:
    ≈ 1200 (λ/Δλ)
  - # IR Channels: 2378 IR
- VIS Channels: 4
- Mass: 177Kg,
  Power: 256 Watts,
  Life: 5 years (7 years goal)
- Currently: 8 years of data and AIRS is expected to remain operational for the lifetime of the Aqua spacecraft

AIRS

AIRS Spectra



Radiance regime for CO_2 retrievals

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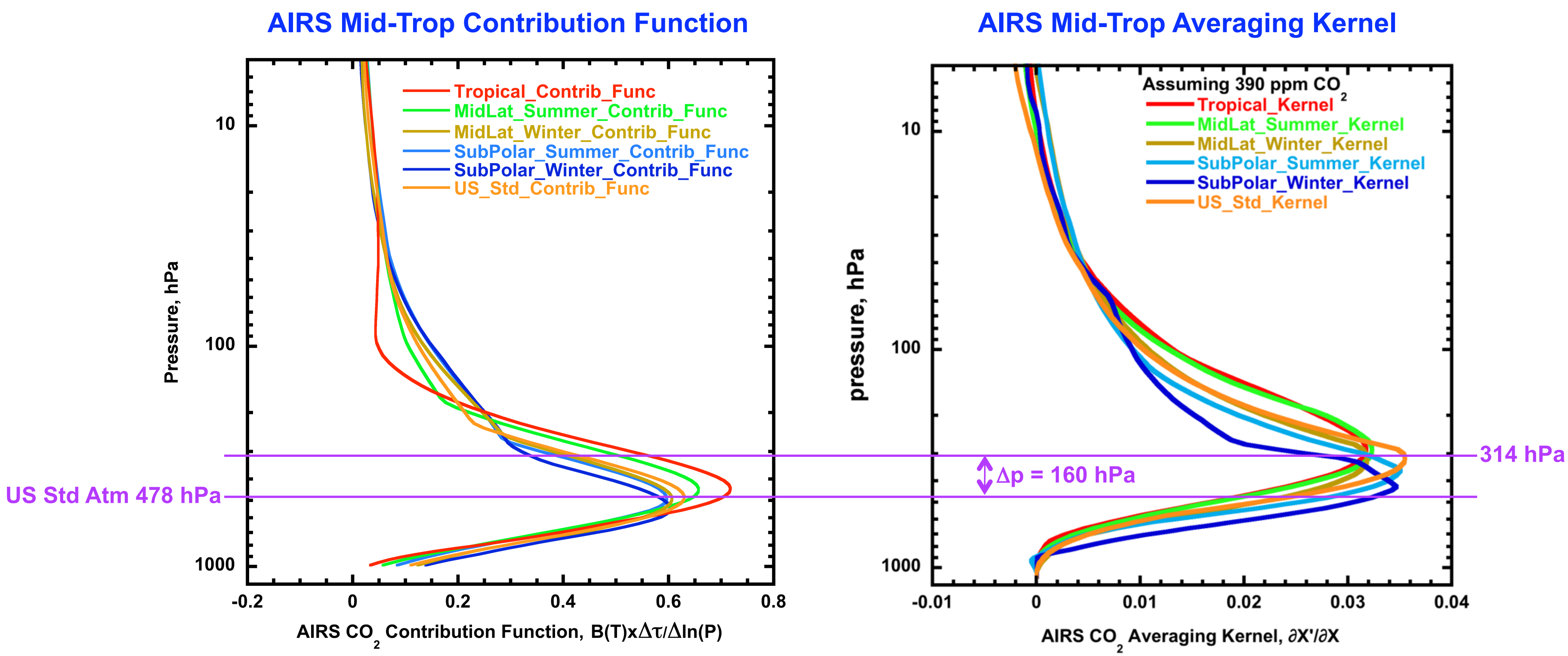
AIRS Mid-Tropospheric CO_2 Product Contribution Function vs Averaging Kernel



- **The AIRS Mid-Tropospheric Contribution Function is a measure of the contribution of an atmospheric layer to the TOA radiance used in the AIRS CO_2 retrieval**
- **The AIRS Mid-Tropospheric Averaging Kernel is a measure of the sensitivity of the AIRS CO_2 retrieval to a change in CO_2 concentration in an atmospheric layer**

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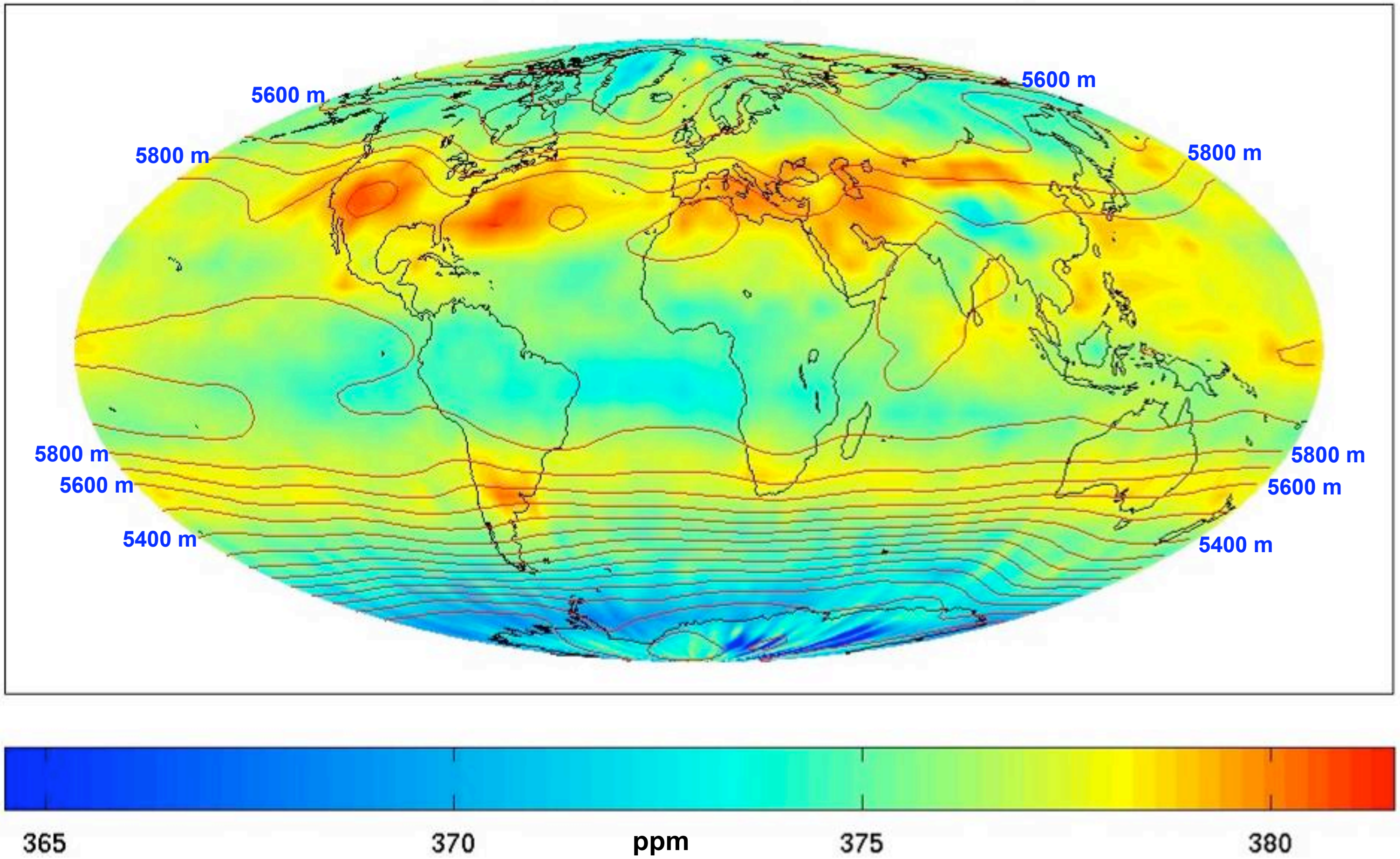
AIRS Data Show
CO_2 is not well mixed in Mid-Troposphere

July 2003 AIRS mid trop CO_2 (5° smoothing) with 500 hPa gph contours



CO_2 is <u>NOT</u> Well Mixed in the mid-troposphere

- **Driven by synoptic-scale phenomena (polar/subtropical jet streams)**
- **Complexity of the Southern Hemisphere not present in models**
- **AIRS mid-trop data will facilitate modeling of vertical & horizontal transport**

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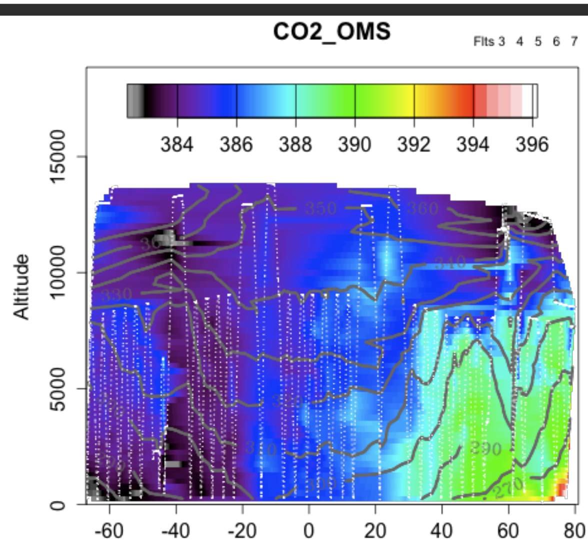
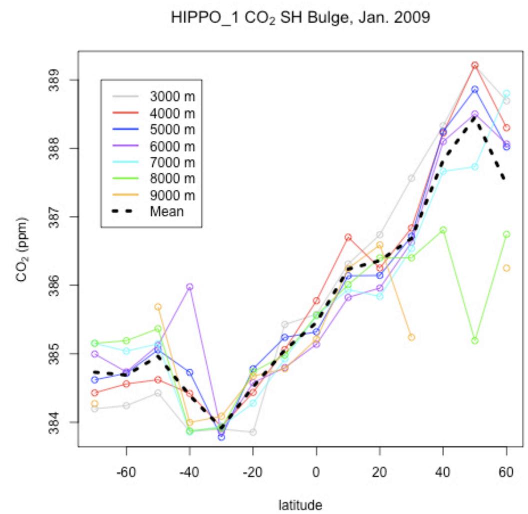
HIPPO In-Situ Observation of Seasonally-Variable Enhanced CO_2 in the Southern Hemisphere

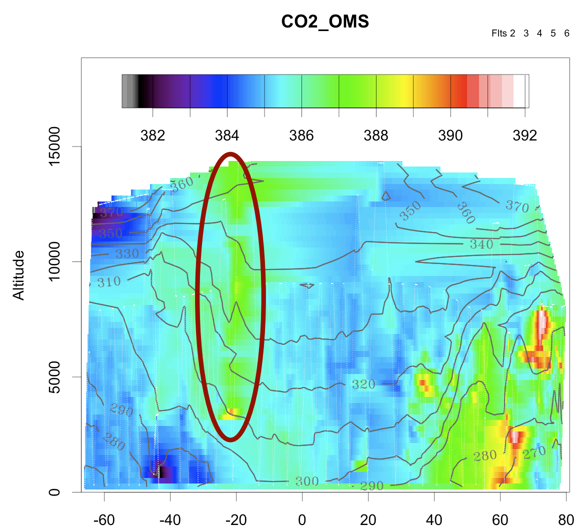


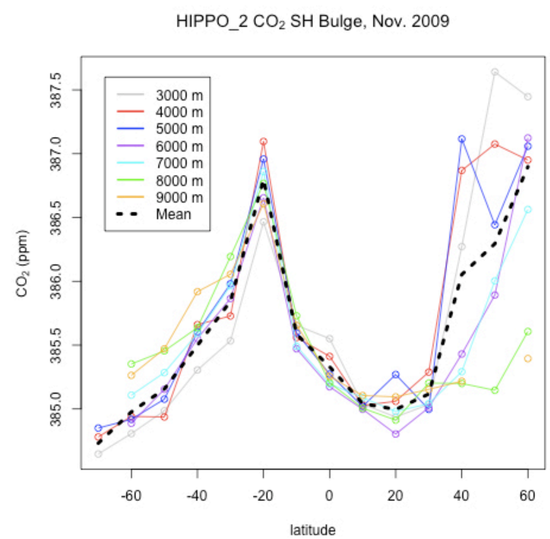


HIPPO_1

Xsects along the Dateline

Jan 2009





HIPPO_2

Xsects along the Dateline

Nov 2009

Enhanced CO_2 in SH does not reach surface

Steve Wofsy - Harvard

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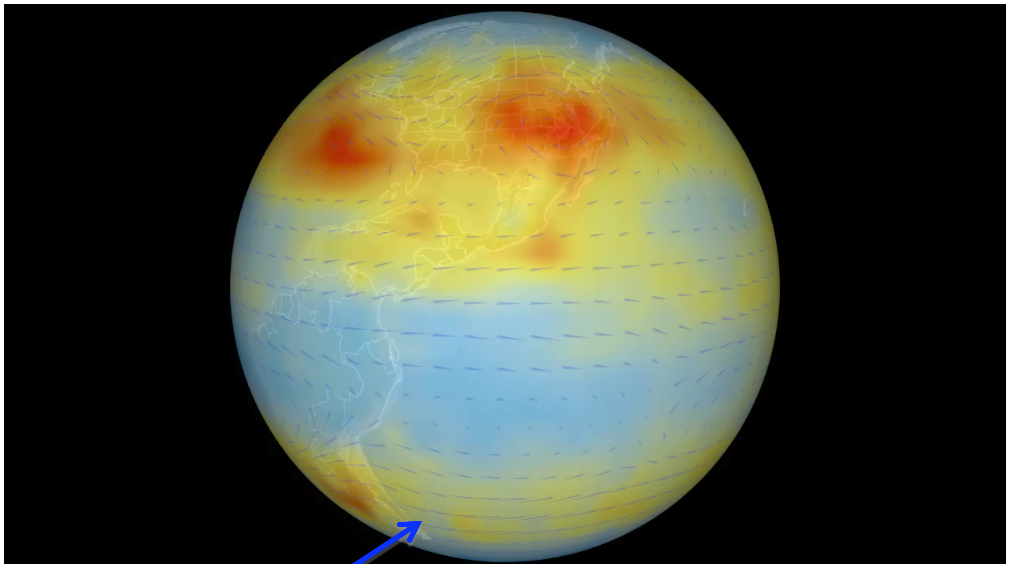
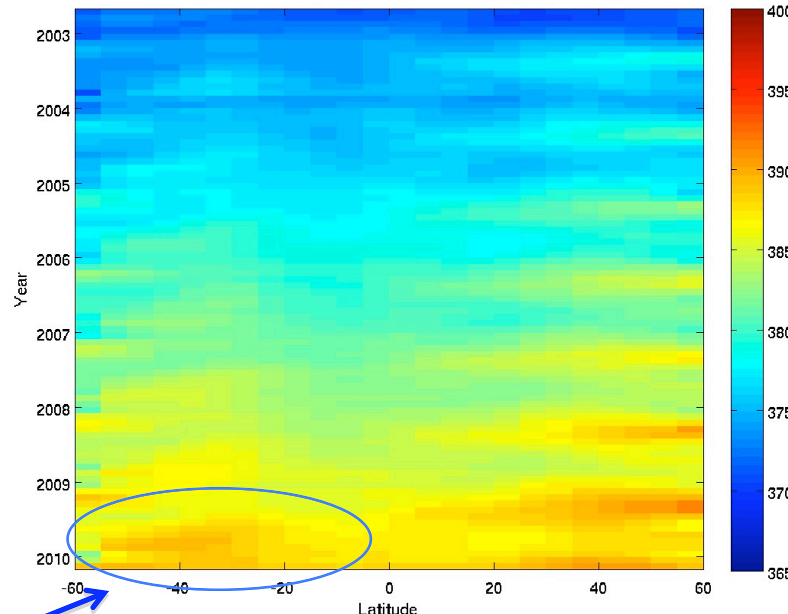
AIRS Data Show a Seasonally-Variable Belt of Enhanced CO_2 in the Southern Hemisphere

July 2003

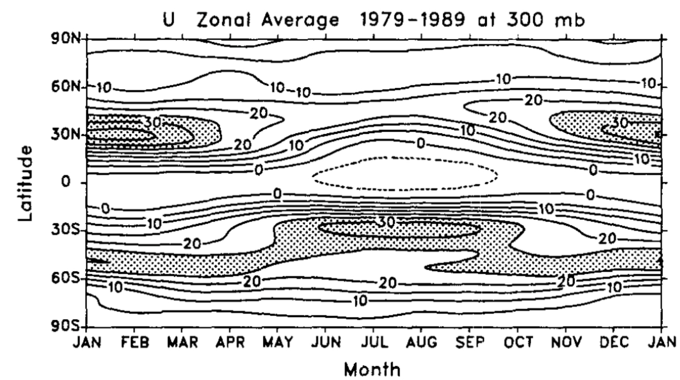


Hovmoller Diagram of AIRS CO2 Zonal Averages



Belt of CO_2 in SH
Appears in May
Strongest in July/August
Fades in November
(2002 to present)

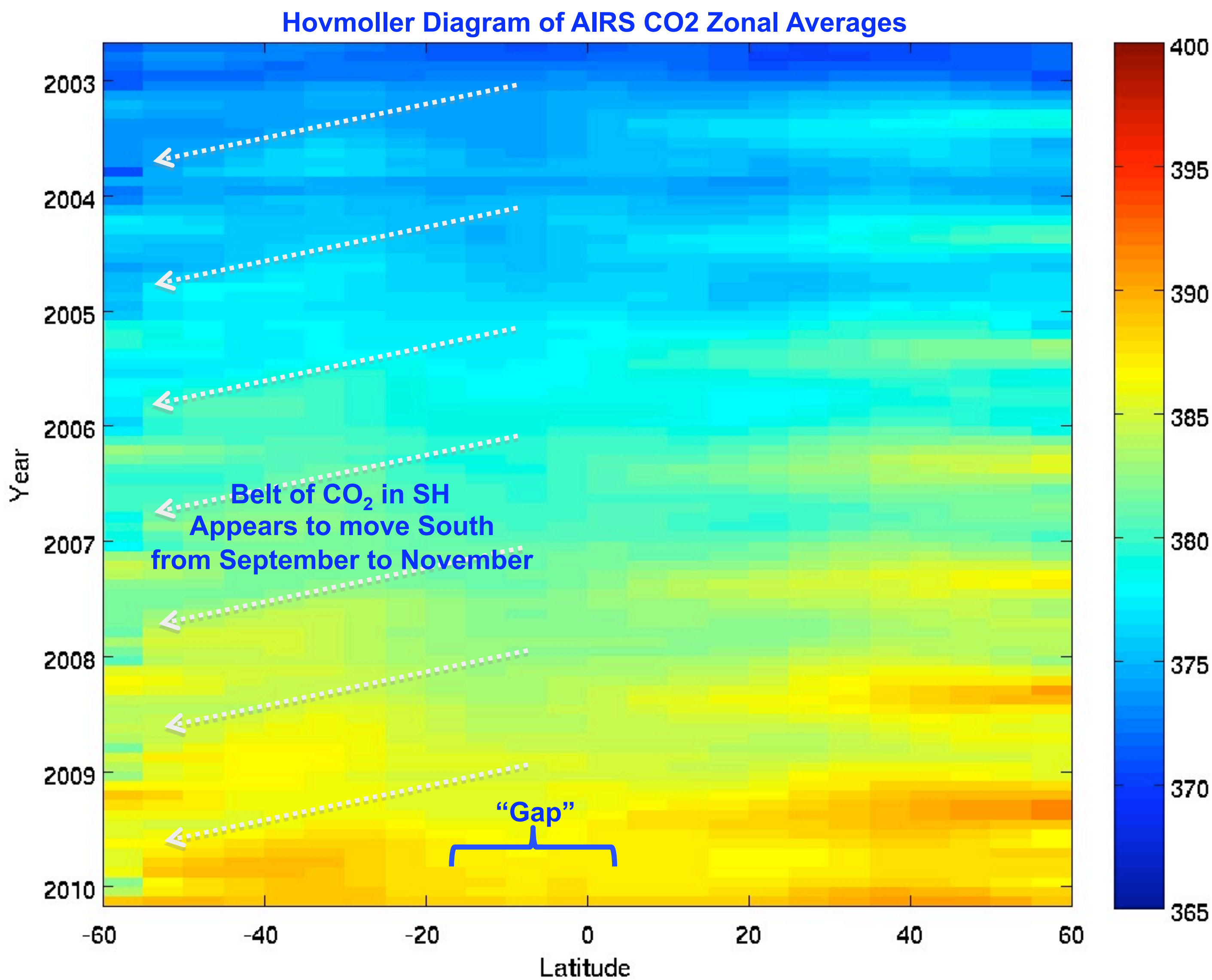
Belt of CO_2 in SH
Appears to move southward
September to November



Trenberth, K.E. (1991), Storm Tracks In the Southern Hemisphere, JAS, 48, 2159-2178

Complexity of the Southern Hemisphere Carbon Cycle
- Calls for Expanded Validation Efforts and Analysis

Complex SH CO_2 Dynamics and Elusive Connection Between Northern and Southern Hemisphere



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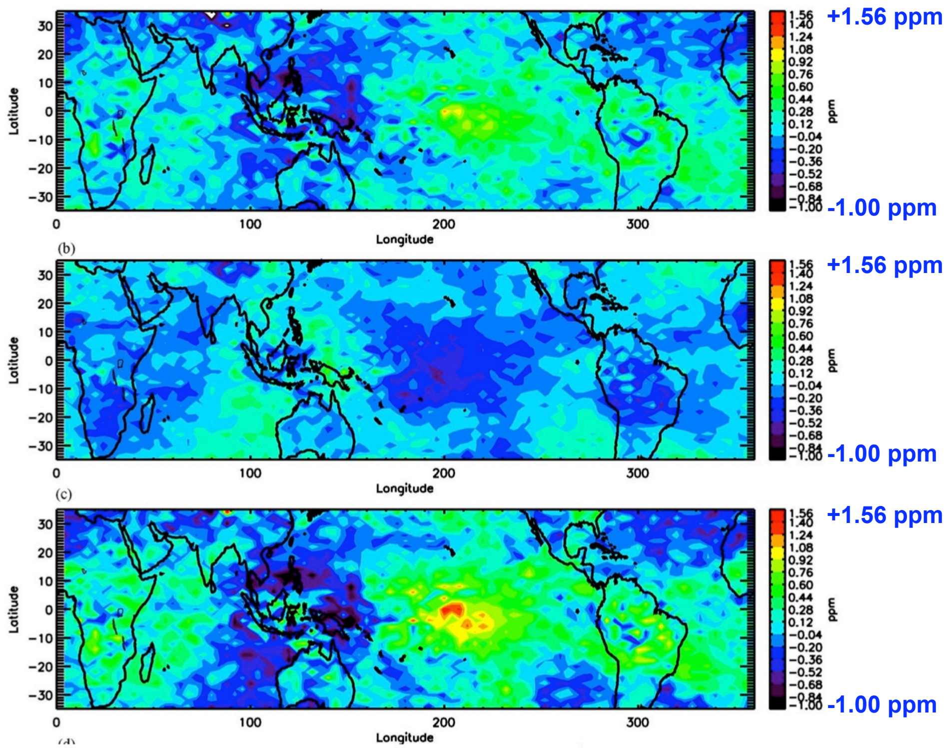
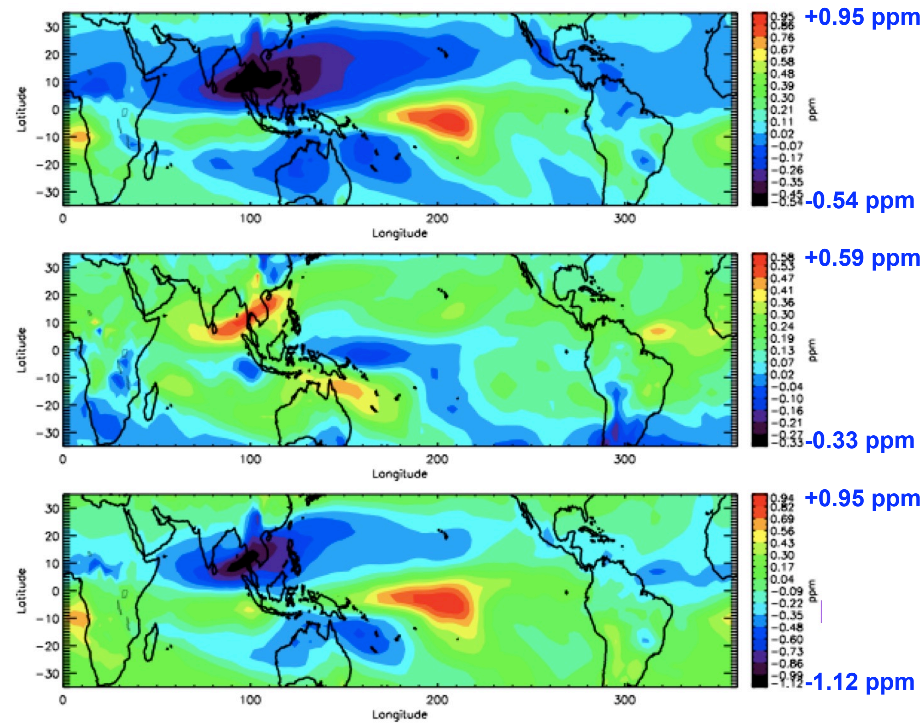
UofH/JPL Study Finds Influences of El Niño in Mid-Tropospheric CO_2 Levels observed by AIRS Agrees with Walker Circulation





TOP: AIRS detrended and deseasonalized CO_2 anomaly averaged for 11 El Nino months (high CO_2 in Central Pacific)

MIDDLE: AIRS detrended and deseasonalized CO_2 anomaly averaged for 17 La Nina months (low CO_2 in Central Pacific)

BOTTOM: AIRS CO_2 anomaly difference (El Nino – La Nina) (Consistent with change in Walker Circulation)

TOP: MOZART-2 CO_2 anomaly during El Nino

MIDDLE: MOZART-2 CO_2 anomaly during La Nina

BOTTOM: MOZART-2 CO_2 Difference (El Nino – La Nina) (signal is smaller than observed by AIRS)

Jiang, X., M. T. Chahine, E. T. Olsen, L. L. Chen, and Y. L. Yung (2010), Interannual variability of mid-tropospheric CO2 from Atmospheric Infrared Sounder, Geophys. Res. Lett., 37, L13801, doi:10.1029/2010GL042823

NOTE: MOZART-2 results are preliminary. The boundary condition is a climatology and does not include interannual variability

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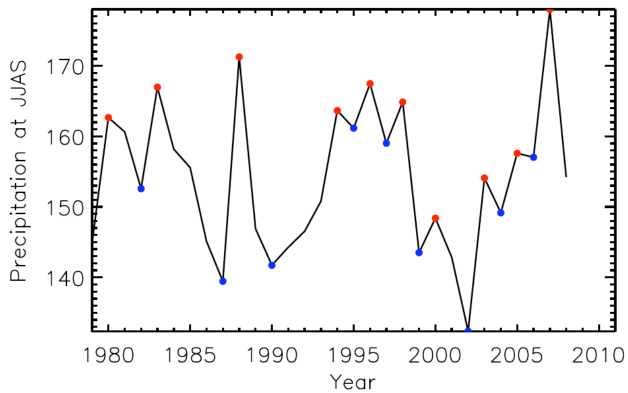
Tropospheric Bienneal Oscillation Influences Mid-Tropospheric CO_2 Concentration over Indonesia

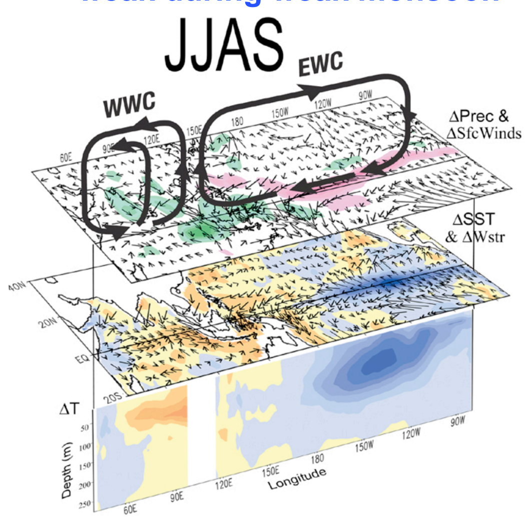
(Xun Jiang – University of Houston)

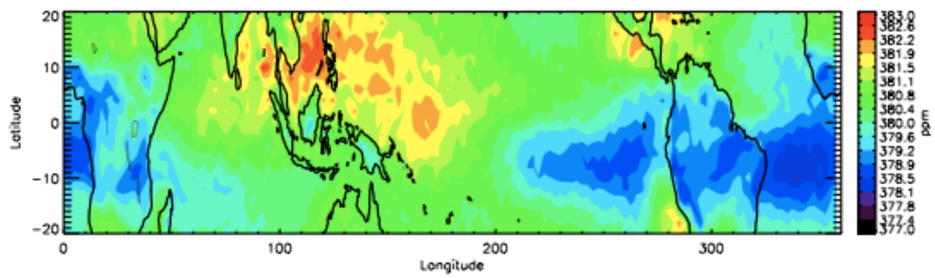
Indian Monsonal Precipitation (JJAS)

• = strong • = weak

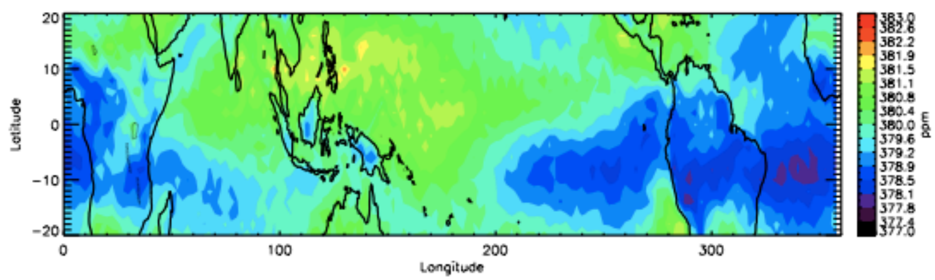


WWC = Western Walker Circulation strong during strong monsoon weak during weak monsoon

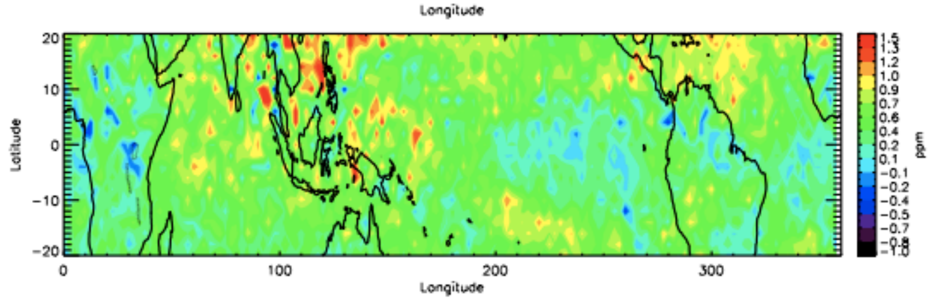




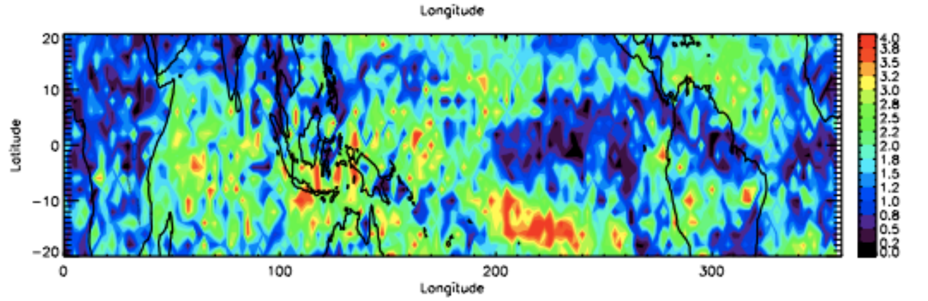
CO_2 Strong Monsoon (2003, 2005, 2007)



CO_2 Weak Monsoon (2004, 2006, 2008)



ΔCO_2 Strong – Weak Monsoon



T-value

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AIRS CO_2 Validation is a Continuing Endevour

Aircraft Profiles are Best Available Validation

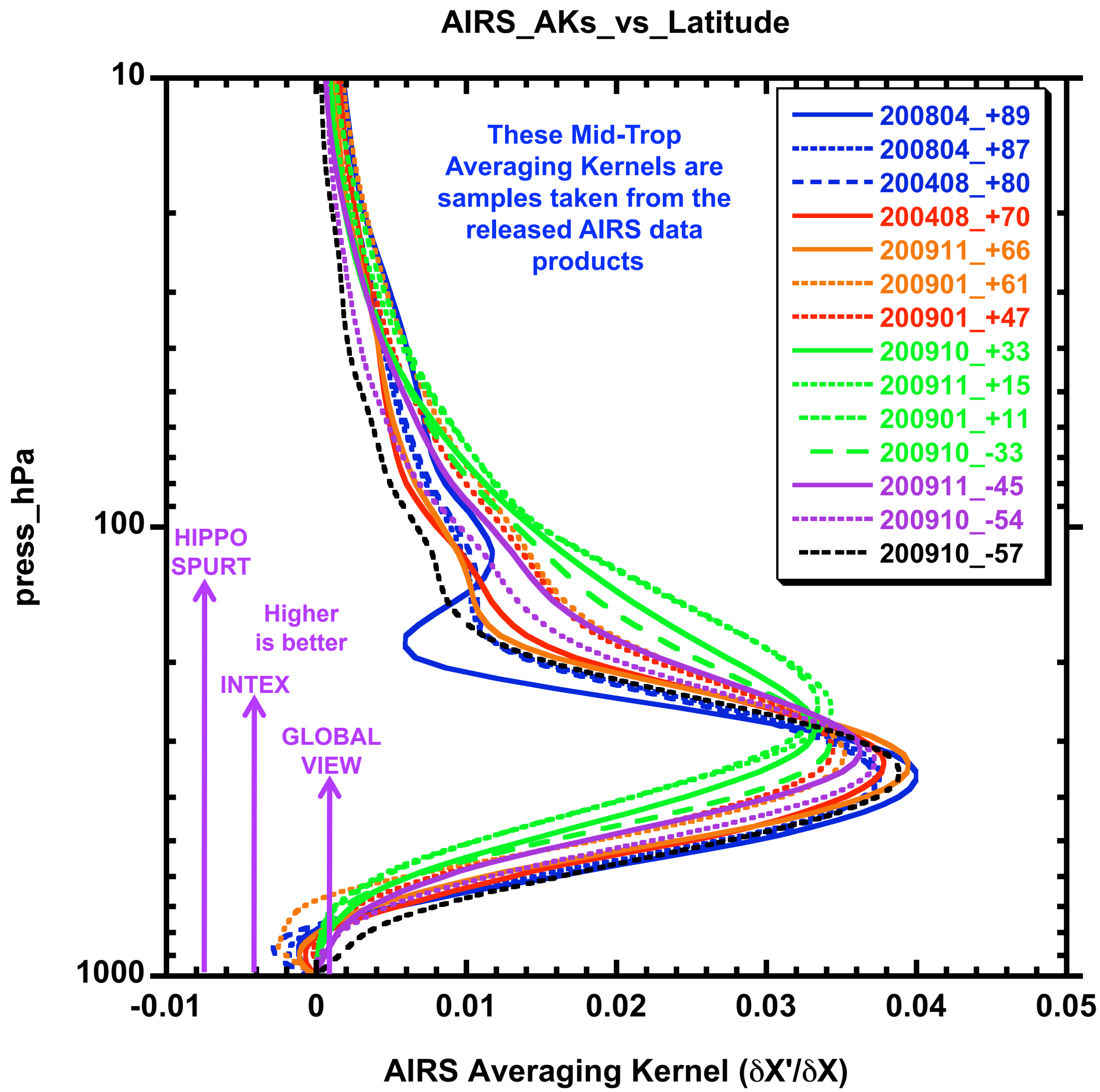
- Convolve the aircraft profiles with the AIRS sensitivity functions to arrive at a single number to compare to the AIRS result.

- HIPPO flights in January 2009:
- Ice Bridge flights Oct/Nov 2009:
  - Maximum Altitude: 14.5 km
  - Pressure Range: 1000 to 130 hPa

- SPURT flights in April 2003:
  - Maximum Altitude: 13.7 km
  - Pressure Range: 850 to 140 hPa

- INTEX-NA flights in July 2004:
  - Maximum Altitude: 10.7 km
  - Pressure Range: 850 to 240 hPa

- GLOBALVIEW flights (multi-year, many):
  - Maximum Altitude: 8 km (usually 6 km)
  - Pressure Range: surface to 360 hPa



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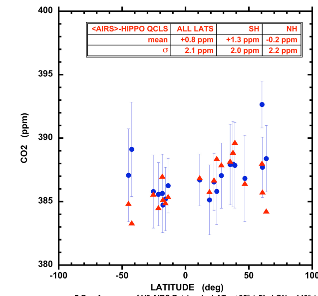
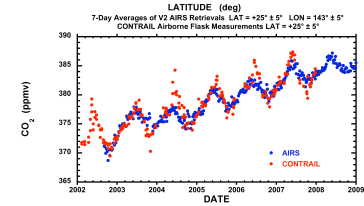
Continuing Validation and Comparisons with In Situ Measurements

- Aircraft profiles of CO_2 concentration to 120 hPa
  ➔ Direct validation of satellite retrievals because a column weighted value can be computed from measured profile for direct comparison to satellite



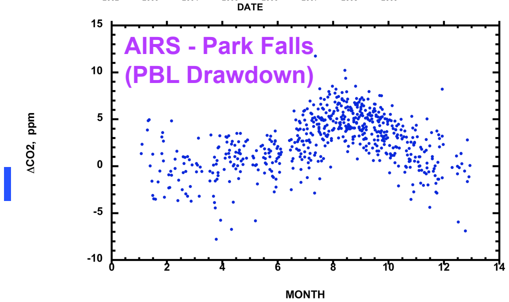
HIPPO and collocated AIRS

- CONTRAIL CO_2 samples at altitudes 10.5 km to 12.5 km
  ➔ Validate amplitude, phase of seasonal variations and interannual trends as function of latitude

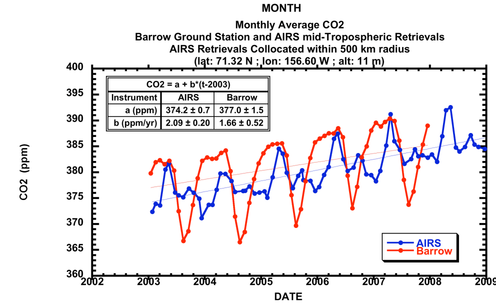


CONTRAIL and collocated AIRS

- TCCON daytime cloud-free column average CO_2
  ➔ Validate phase of seasonal variations and interannual trends; allows estimation of drawdown in PBL

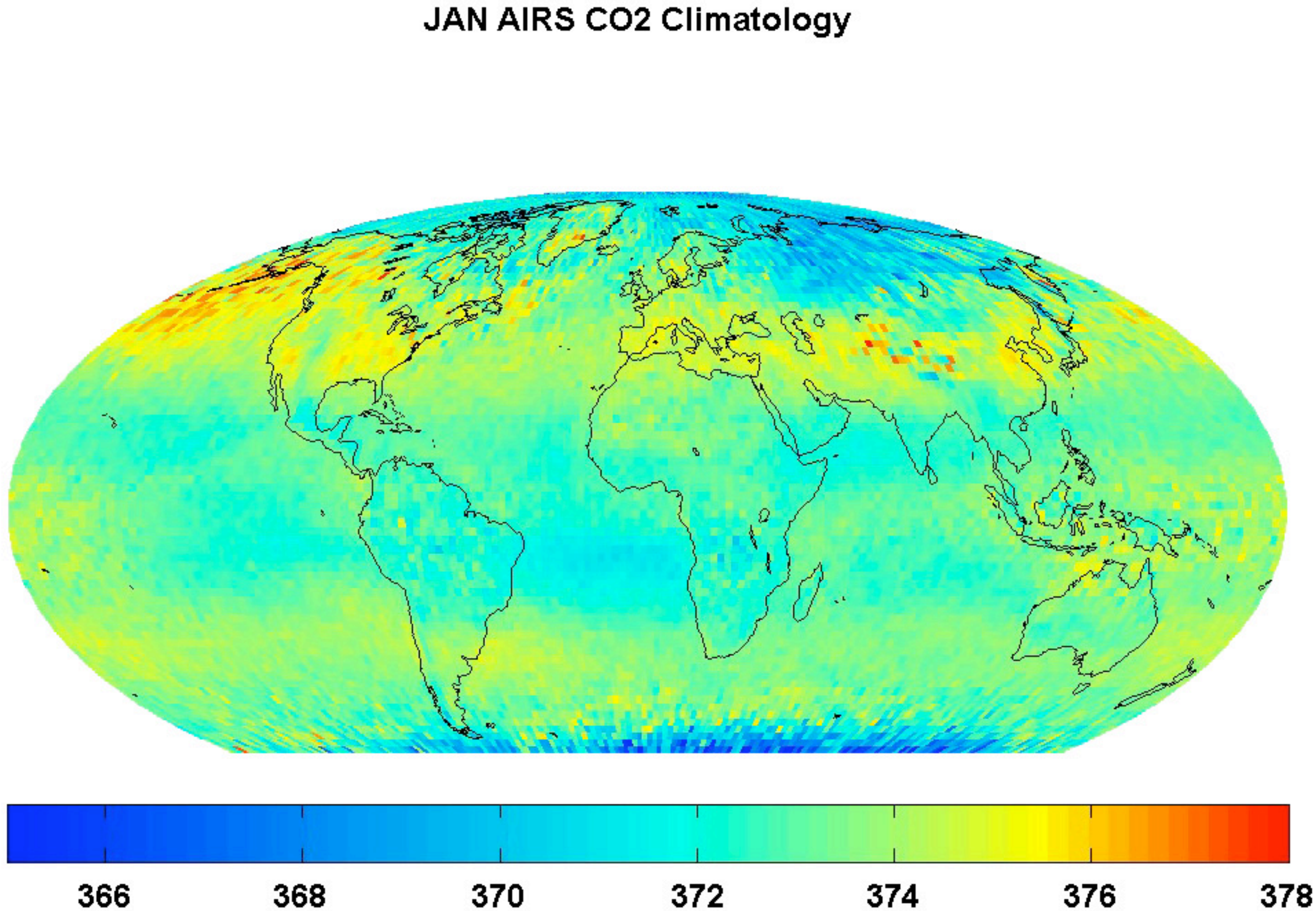


- Surface stations
  ➔ Estimate differences between free troposphere and planetary boundary layer; compare interannual trends



60°S-90°N RMS agreement is within 2 ppm

Monthly Global Climatology of Mid-Tropospheric CO_2



Monthly Average Data binned at 2°x2° spanning January 2003 to December 2009 detrended at 2.07 ppm/yr, then individual months (all Jans, all Febs, etc) averaged for the time span: September 2002 to February 2010 (to be added to the CO_2 products already available to the broad community)

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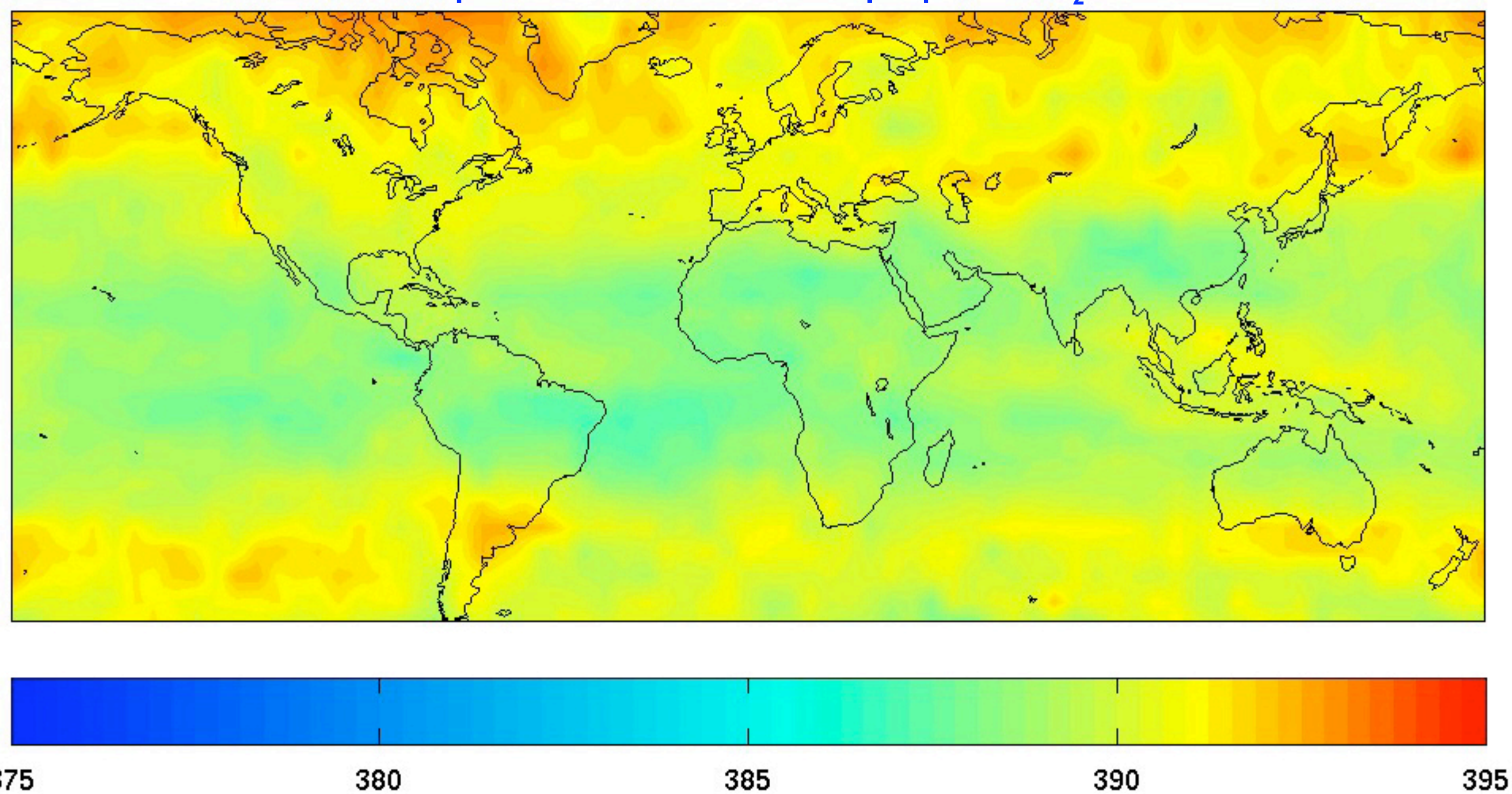
Links to Release of AIRS CO2 Data Products Located on URL http://airs.jpl.nasa.gov/AIRS_CO2_Data

AIRS Level 2 and Level 3 Mid-Tropospheric CO2 Data Release
Currently Available: September 2002 - September 2010
Latitude Range: 60°S to 90°N

September 2010 AIRS Mid-Tropospheric CO_2



Level 2

- includes averaging kernels
- nadir resolution: 100km x 100km

Level 3

- spatial grid: 2° x 2.5° (lat x lon)
- time periods: 1dy,8dy,calendar month

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phone: 818-354-7604