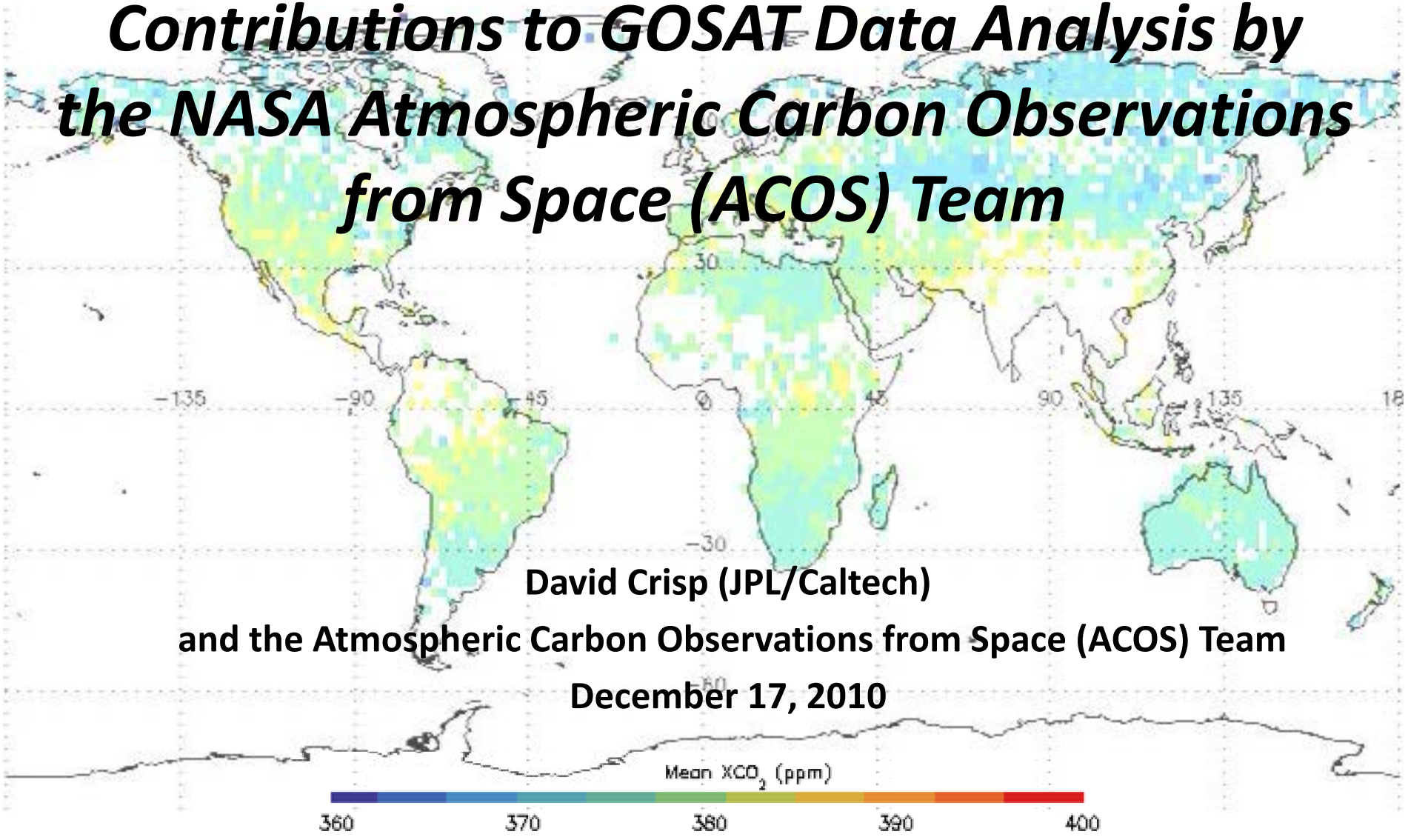
Contributions to GOSAT Data Analysis by the NASA Atmospheric Carbon Observations from Space (ACOS) Team



David Crisp (JPL/Caltech)

and the Atmospheric Carbon Observations from Space (ACOS) Team

December 17, 2010

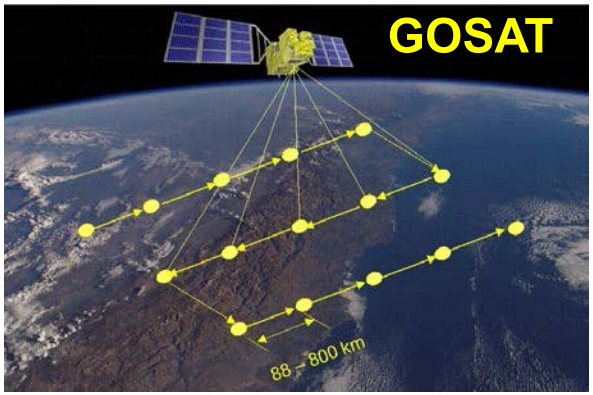
OCO and GOSAT Collaboration

The OCO and GOSAT teams formed a close partnership during the implementation phases of these 2missions to:

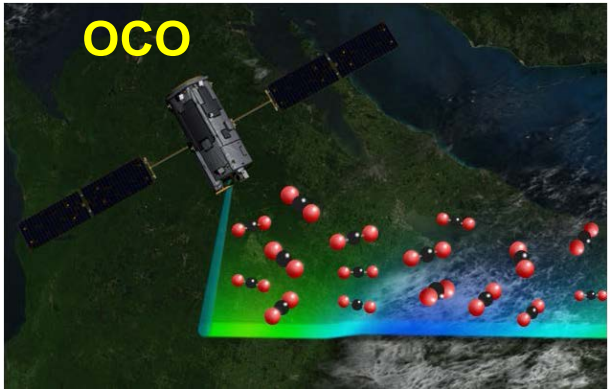
- Cross calibrate the OCO instrument and TANSO-FTS
- Cross validate OCO and GOSAT X_{CO2} retrievals against a common standard

The primary objectives of this partnership were to:

- Accelerate “learning curve” for this new data source
- Facilitate combining results from GOSAT and OCO to improve spatial and temporal coverage



3-day ground track repeat cycle resolves weather



Continuous high resolution measurements along track

The Launch of GOSAT and Loss of OCO

GOSAT launched successfully on 23 January 2009

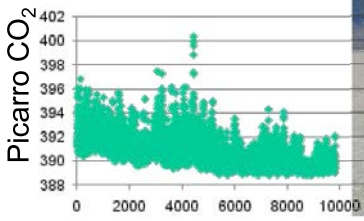
OCO was lost a month later when its launch system failed

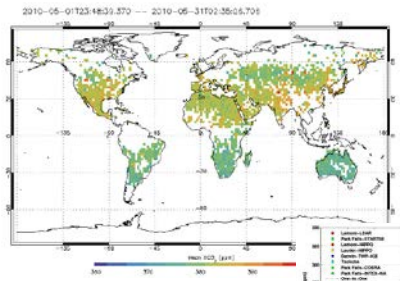
Working with the GOSAT Team

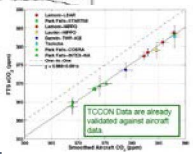
- Immediately after the loss of the OCO Mission, the GOSAT Project manager invited the OCO Team to participate in the GOSAT data analysis
- NASA reformulated the OCO team as the "Atmospheric Carbon Observations from Space" (ACOS) team
- This collaboration benefits the GOSAT team by:
  - Combining the ground based calibration and validation resources of both teams to maximize the accuracy of the GOSAT data
  - Combining the scientific expertise from both teams to accelerate our understanding of this new, space-based data source
- This collaboration benefits the NASA OCO by
  - Providing direct experience with the analysis of space based CO_2 measurements
  - Accelerating the delivery of precise CO_2 measurements from future NASA carbon dioxide monitoring missions

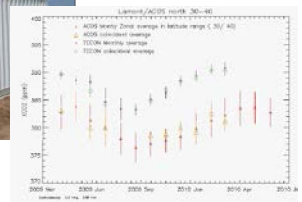
Elements of the ACOS/GOSAT Collaboration

- The ACOS team is collaborating closely with the GOSAT teams at JAXA and NIES to:
  - Conduct vicarious calibration campaigns in Railroad Valley, Nevada and analyze results of those campaigns
  - Retrieve X_{CO2} from GOSAT data
    - Model development, implementation, and testing
    - Data production and delivery
  - Validate GOSAT retrievals through comparisons of
    - GOSAT retrievals with TCCON measurements
    - 0ther validation standards (surface pressure, aircraft and ground-based CO_2 measurements

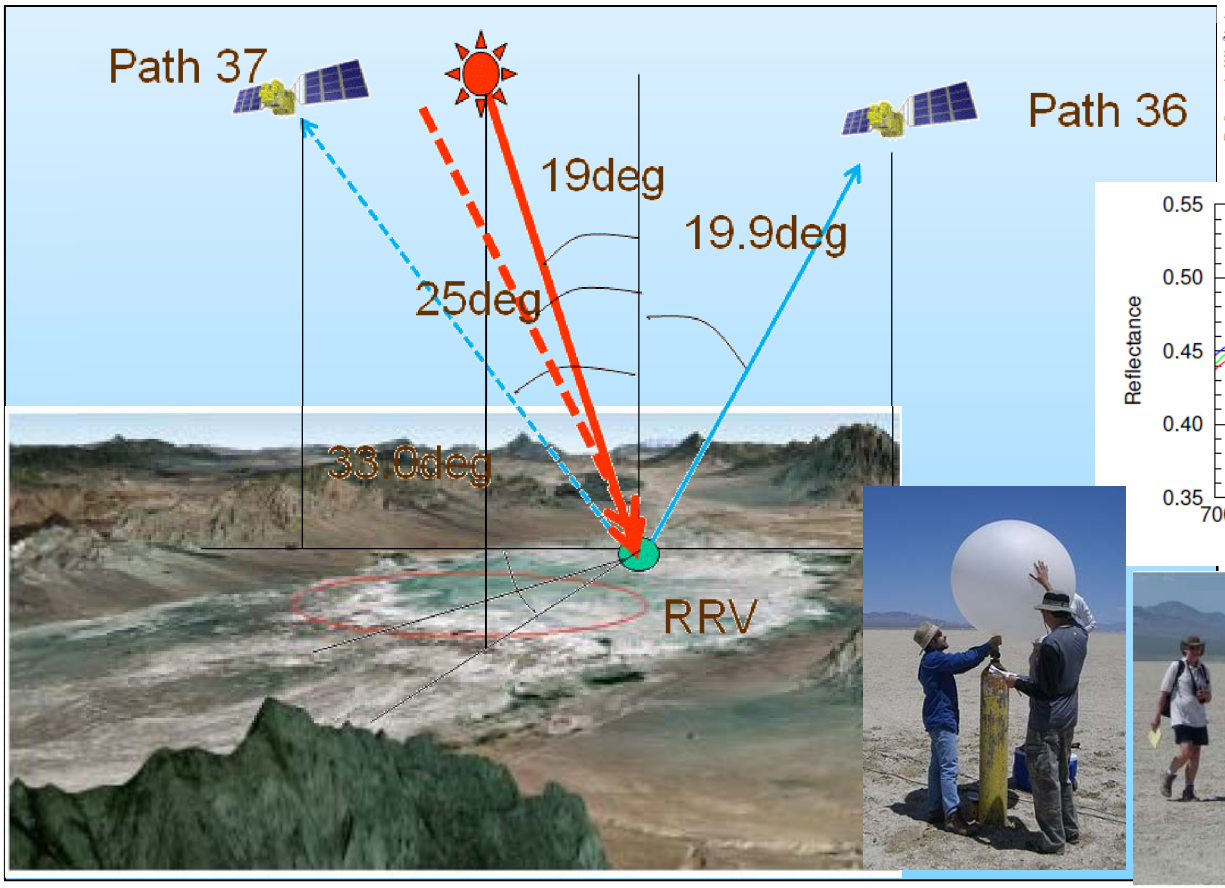


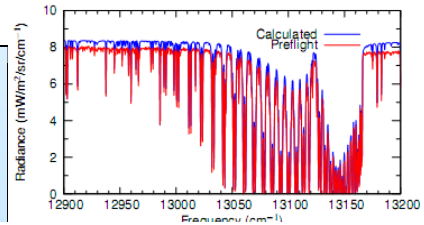


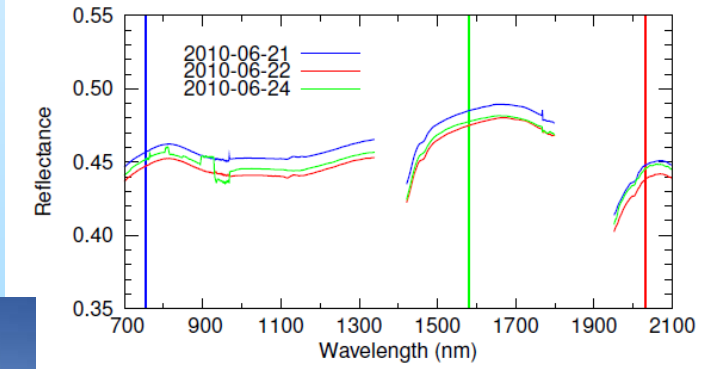




Ground Based Calibration Experiments: Vicarious Calibration in Railroad Valley, NV







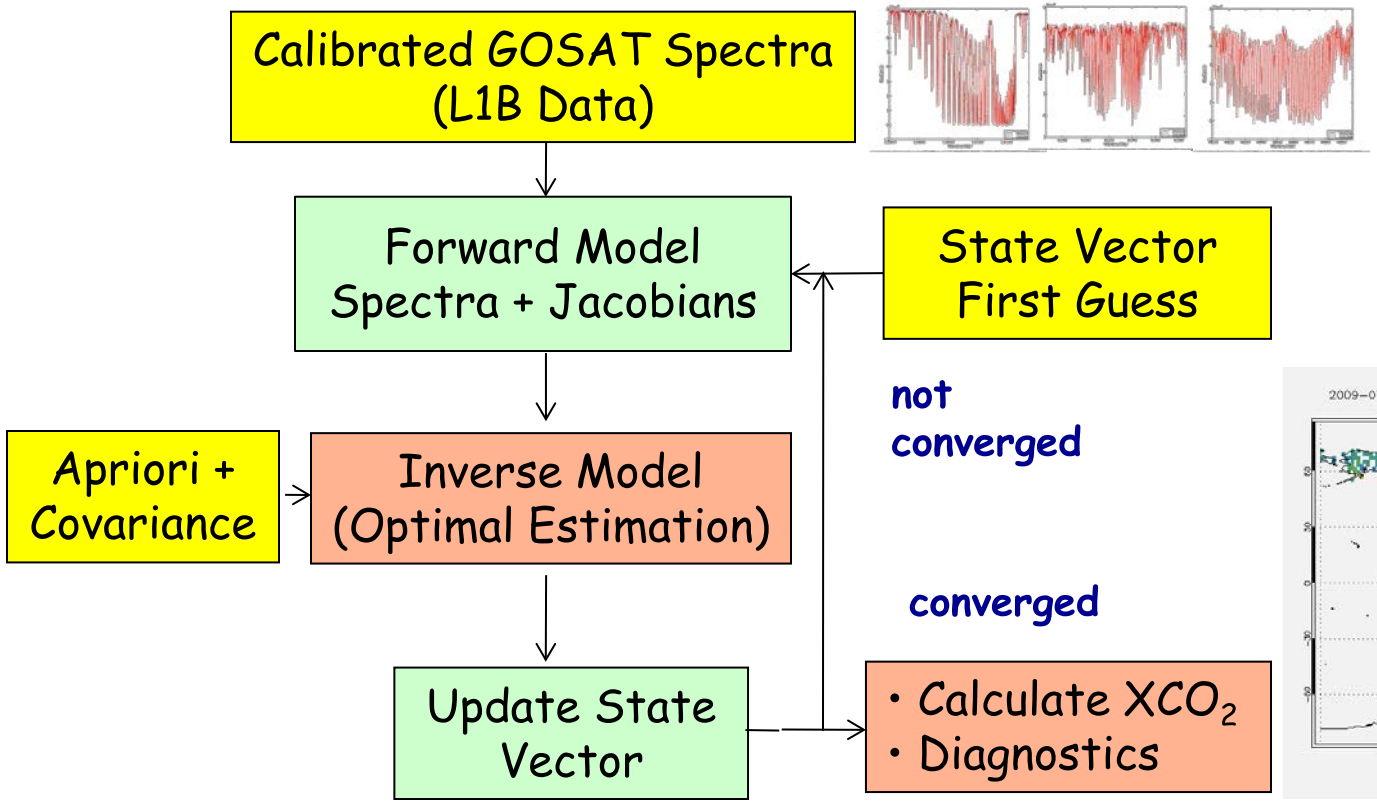
The NASA and GOSAT teams are collaborating to collect ground based and aircraft measurements over Railroad Valley, Nevada during GOSAT overflights to monitor the calibration of the GOSAT instruments

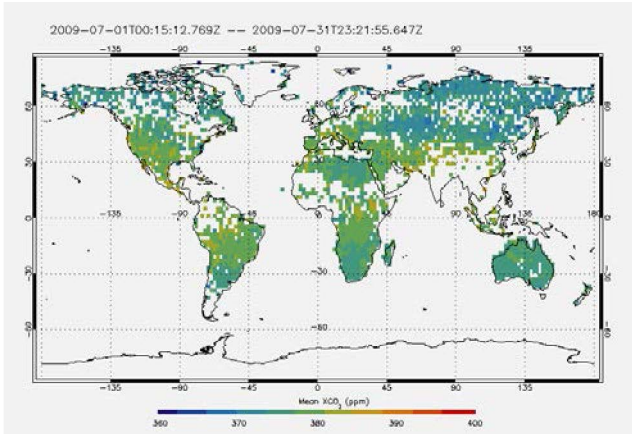
Retrieving X_{CO2} from GOSAT Data

The OCO Retrieval Algorithm was modified to retrieve X_{CO2} from GOSAT measurements

- "Full-physics" forward model
- Inverse model based on optimal estimation

State Vector
CO_2 profile (full)
H_2O profile (scale factor)
Temperature profile (offset)
Aerosol Profiles
Surface Pressure
Albedo (Mean, Slope)
Wavelength Shift (+ stretch)



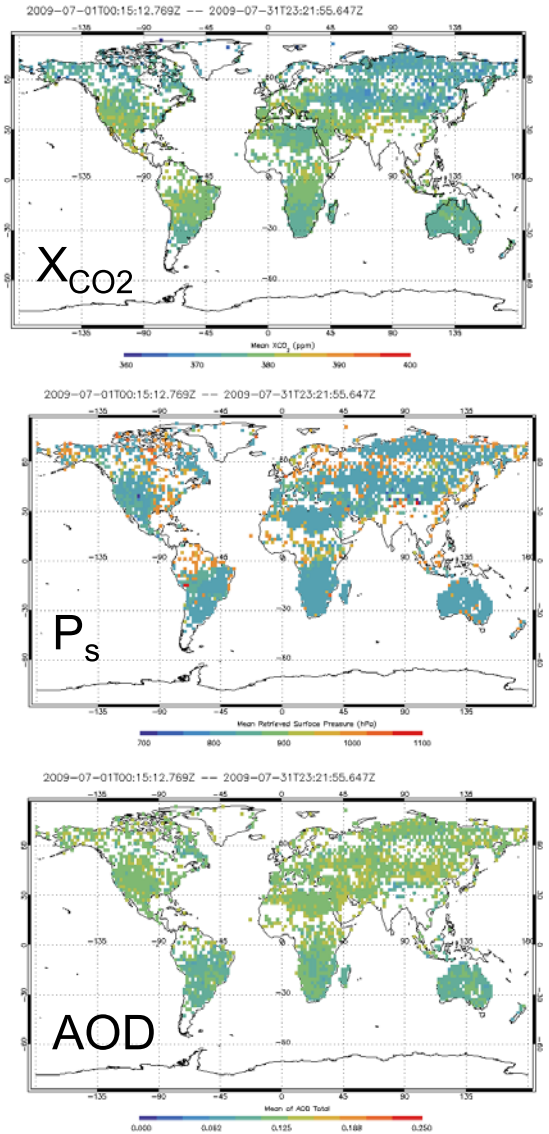


Preliminary Retrievals

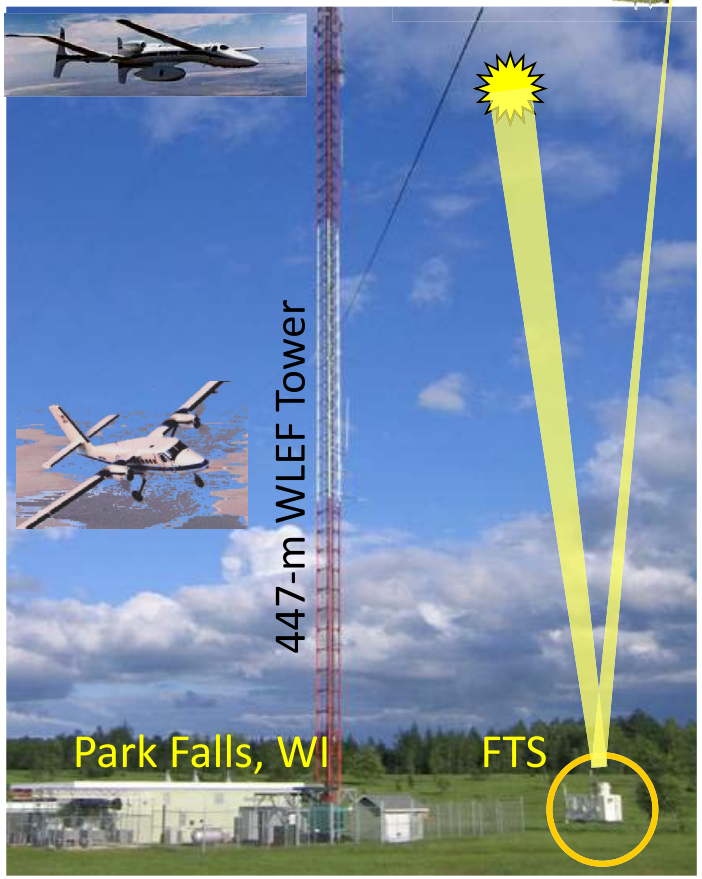
- The ACOS/SDOS team is now routinely generating global maps of X_{CO2} and other L2 data products
  - Now processing all GOSAT repeat cycles
    - Only land values are available because L2 algorithm still cannot process glint data from GOSAT
    - Products include XCO2 and a series of other retrieved components of the surface/atmosphere state vector (P_s, aerosol optical depth (AOD), surface albedo, etc.)

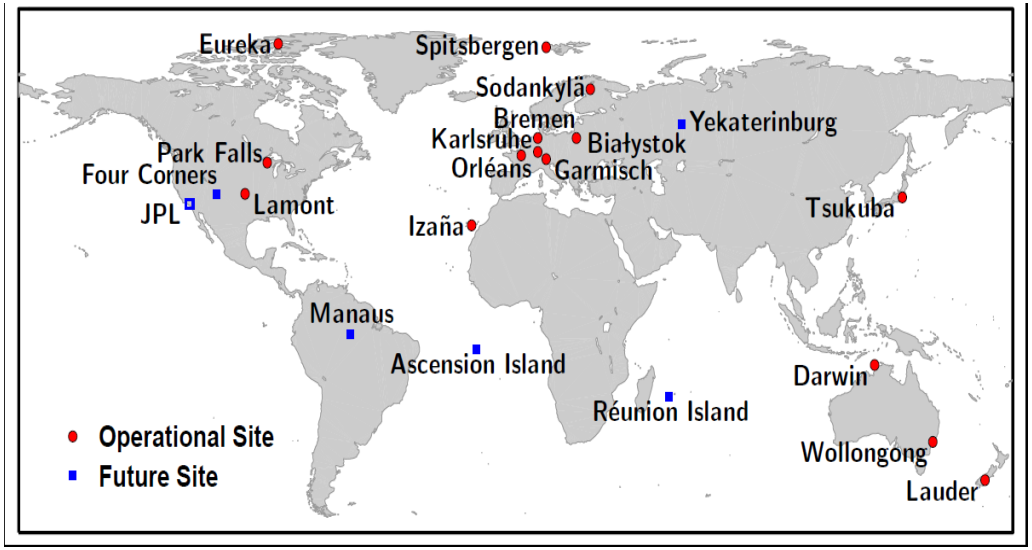
- An experimental ACOS "Standard Product" is currently being released from the GSFC DAAC

  http://mirador.gsfc.nasa.gov/



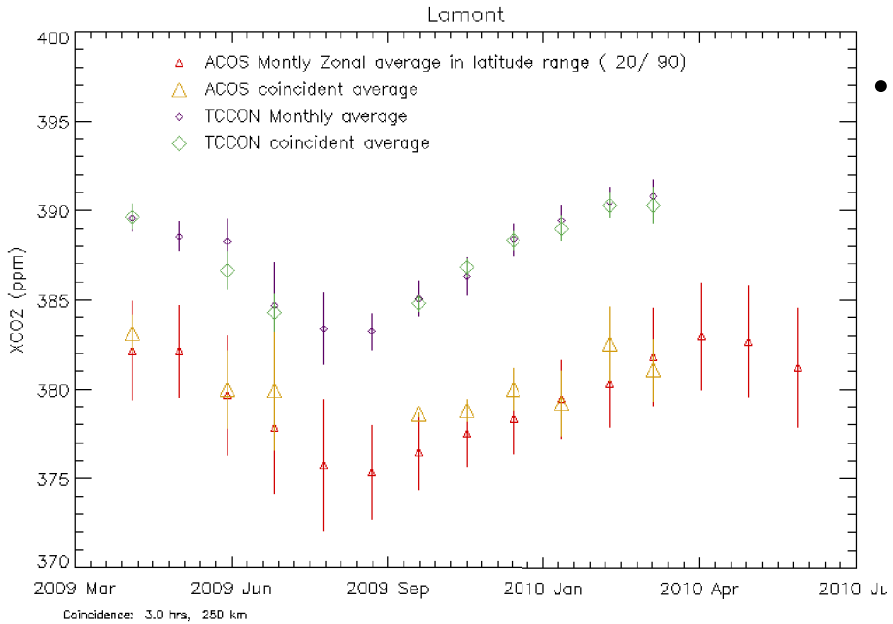
Validation of GOSAT Products





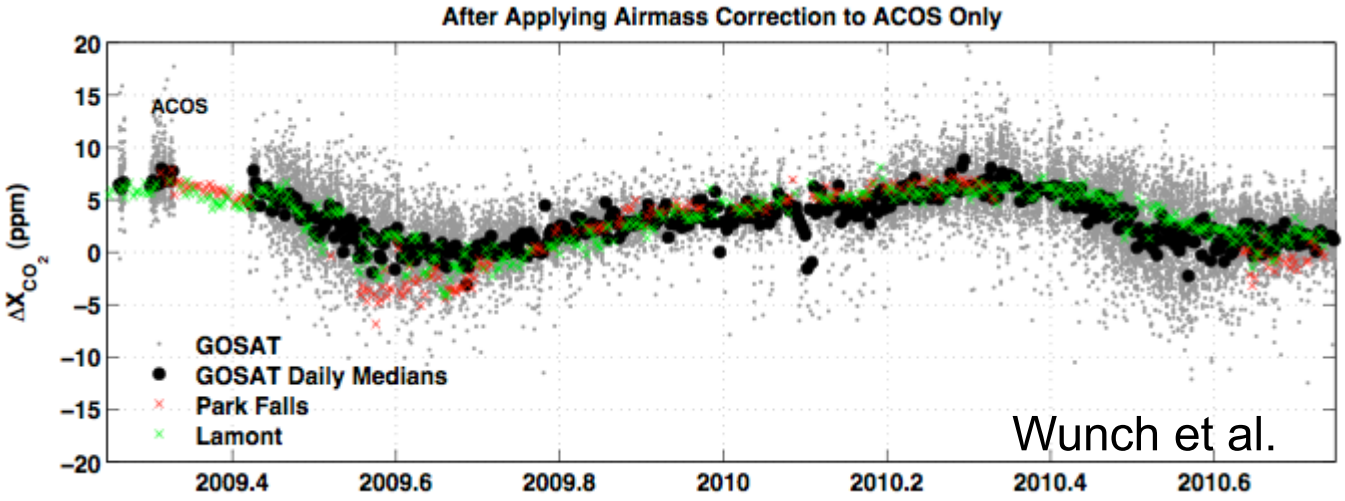
GOSAT X_{CO2} retrievals are being compared with those from the ground based Total Carbon Column Observing Network to very their accuracy

Comparisons of GOSAT and TCCON



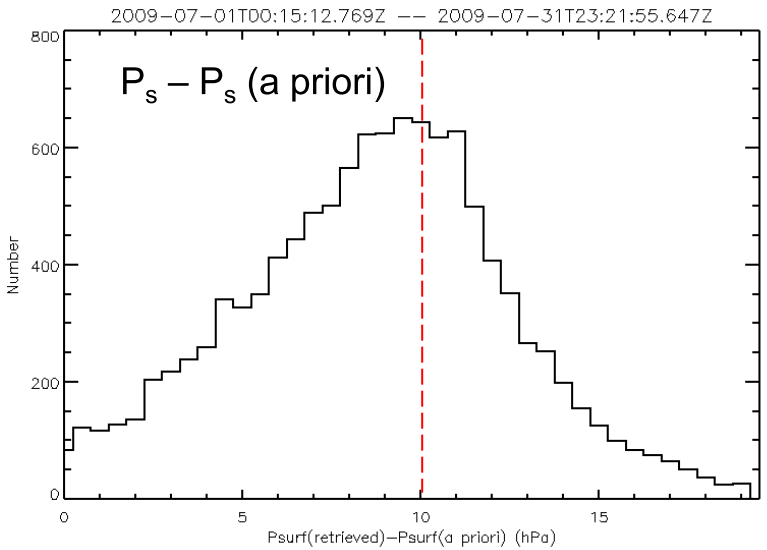
- ACOS GOSAT retrievals show
  - A consistent global bias of ~2% (7 ppm) in X_{CO2} when compared with TCCON and aircraft measurements.
  - A systematic air mass bias
  - X_{CO2} variations that are a factor of 2 to 3 larger than that measured by TCCON.

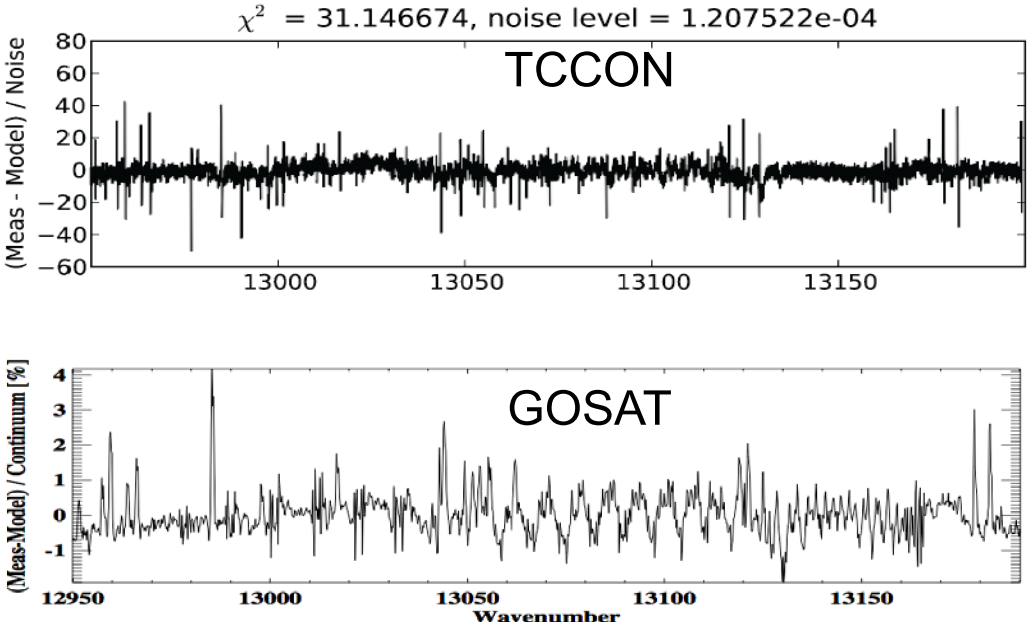
When the global and airmass biases are removed, the ACOS/GOSAT X_{CO2} retrievals do a good job of simulating the seasonal cycle over North America



Biases in the X_{CO2} Maps

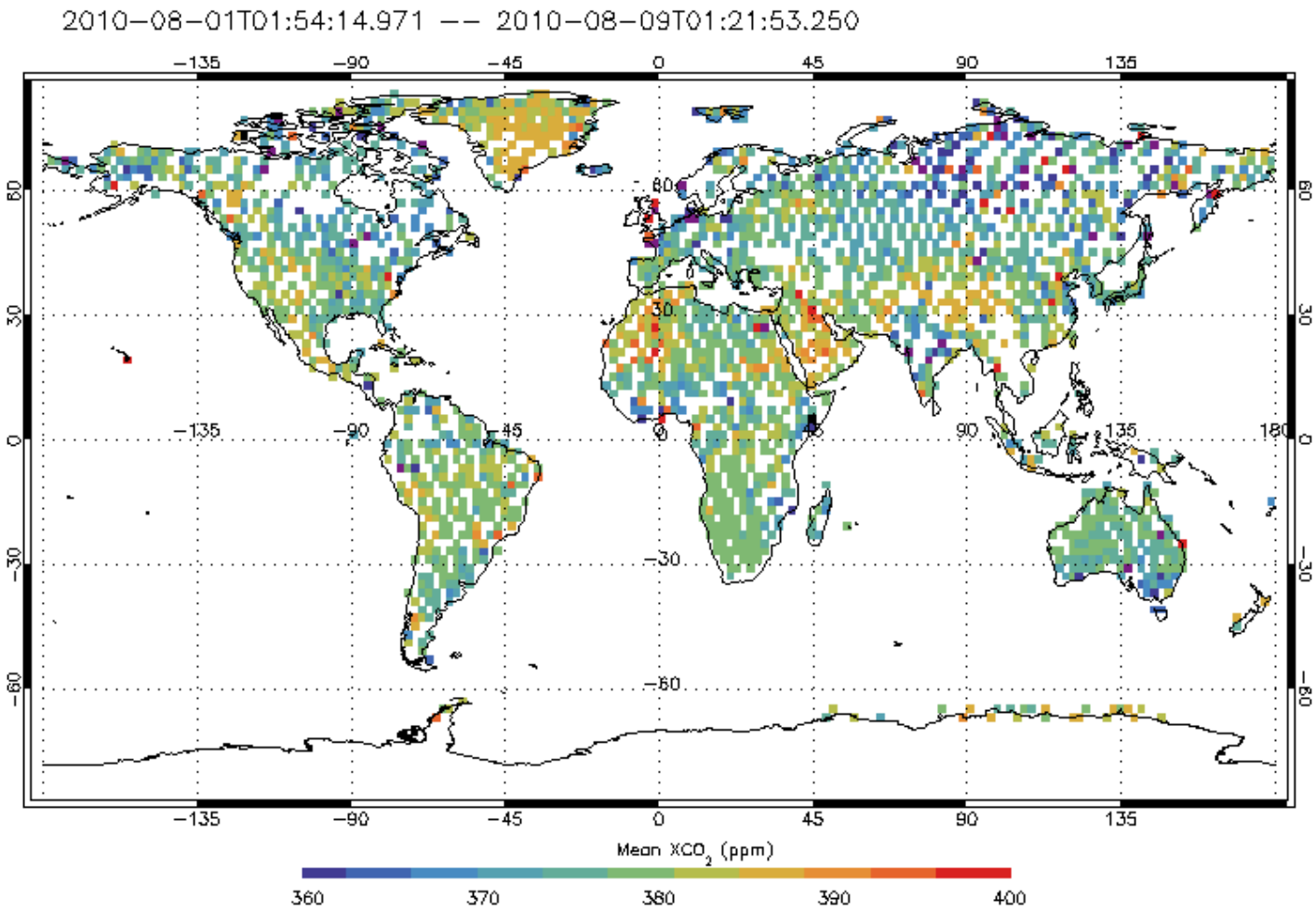
- A ~10 hPa (1%) high surface pressure bias contributes ~2/3 or the bias
- This bias may be associated with
  - Radiometric and spectroscopic calibration errors in the ACOS L1B data
  - Line mixing, line shape or other issues with the O_2 A-band absorption cross sections





Typical O_2 A-band retrieval residuals.

Unscreened GOSAT Retrievals for 1-8 August 2010 (includes some cloudy data)



Unscreened X_{CO2} retrievals from 1-8 August also show anomalously high values over the Sahara Desert (due to dust contamination), but enhanced CO_2 near Moscow.

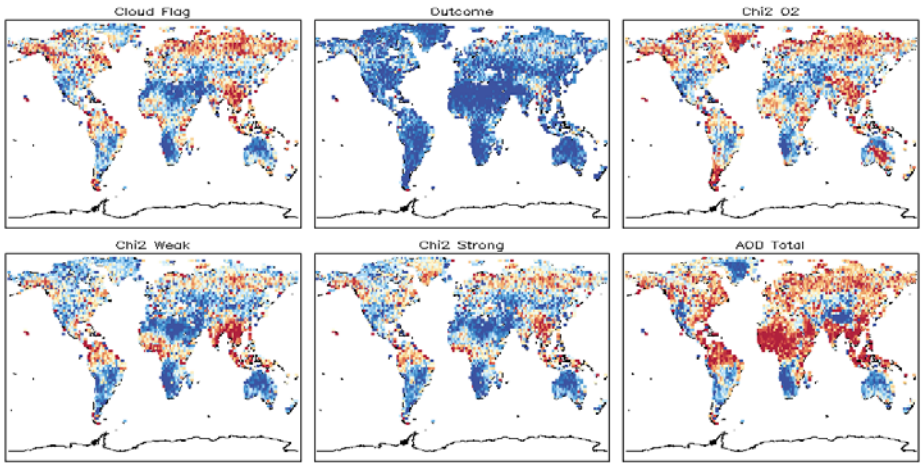
Post Screening Improves Accuracy

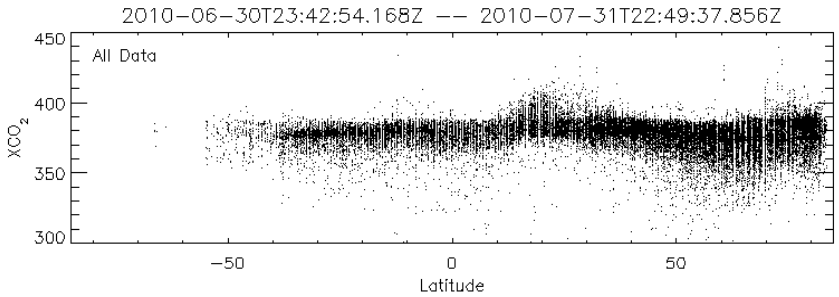
Errors can be further reduced by post-screening retrievals, based on a series of criteria, including:

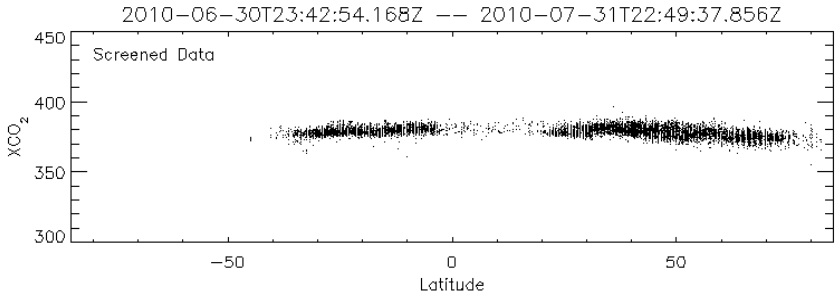
- Measurement SNR
- Convergence
- Goodness of spectral fit
- Surface pressure error
- Evidence for clouds or optically thick aerosols
- A postiori retrieval error
- Evidence of known biases

The cloud screen is responsible for the largest data reductions.

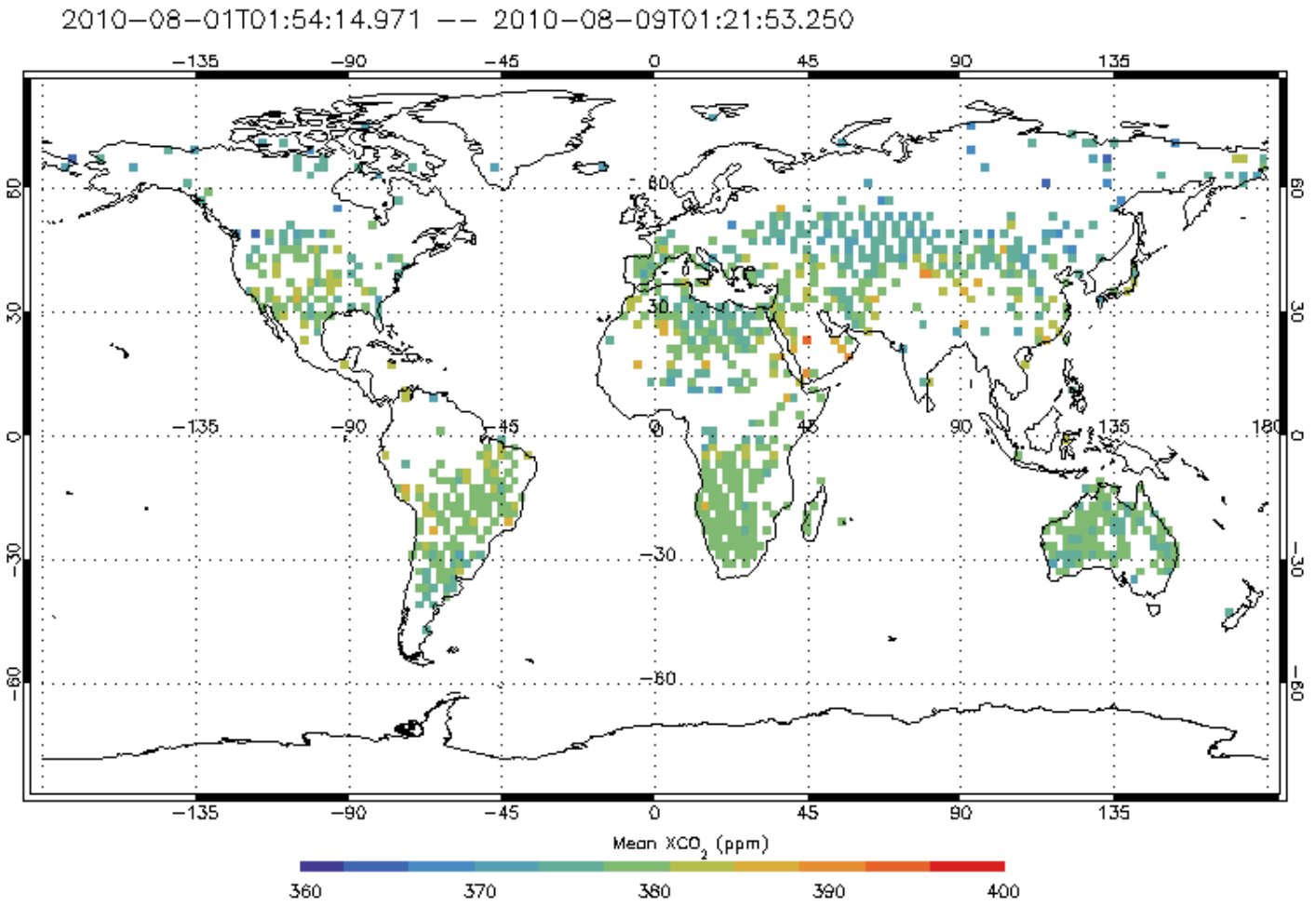
- Improved cloud screening algorithms are a major focus of our development effort







Screened GOSAT L2 Products for 1-8 August 2010 (Vigorous Cloud and Data Quality Screening)



Screening removes anomalous dust contaminated values over the Sahara, but also removes most data north of 50 degrees latitude.

Conclusions

- The ACOS/GOSAT collaboration is beginning to return benefits to both teams
  - The vicarious calibration experiments have helped to identify and correct for changes in the pre-launch GOSAT radiometric calibration parameters.
  - Comparisons with TCCON measurements have revealed a global, -2% bias in the preliminary ACOS X_{CO2} retrievals
  - Comparisons between surface pressure retrievals and the ECMWF prior indicate that about half of this bias can be attributed to a +10 hPa bias in the retrieved surface pressure
- GOSAT data are also being used to assess the impact of clouds, optically thick aerosols, and other environmental conditions on the accuracy, coverage, and total yield of X_{CO2} soundings
- Lessons learned from this experience are expected to substantially accelerate the delivery of high quality products from the OCO-2 mission, which is currently scheduled for launch in February 2013