



# The **O**rbiting **C**arbon **O**bservatory-2 (**OCO-2**) Mission

*Watching The Earth Breathe... Mapping CO<sub>2</sub> From Space*

## Progress with The Atmospheric Carbon Observations from Space (ACOS) Project in Preparation for The Orbiting Carbon Observatory (OCO-2)

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AGU Fall Meeting, San Fransisco,  
Thursday December 8



# Talk Topics

- OCO-2 Observation Overview
- GOSAT and OCO
- ACOS B2.9 data
  - Current data product development
  - Importance of fundamental spectroscopy
  - Rescaling the O2 A-Band spectroscopy
  - Ocean scenes
  - Validation using TCCON
  - Fluorescence, aerosol optical product, and other products
- OCO-2 Status
- Summary



# The OCO-2 Mission System is Based on OCO



3-Channel Spectrometer (JPL)

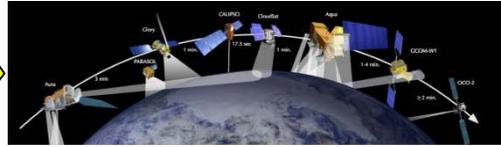
Dedicated Spacecraft Bus (OSC)

Taurus XL Vehicle (OSC)

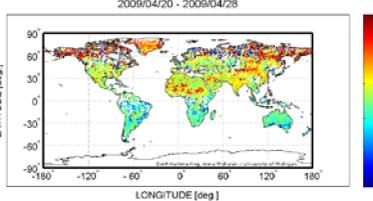
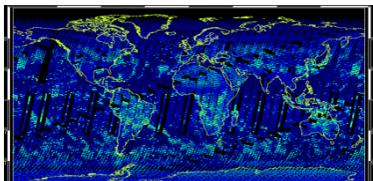
Mission Operations (OSC)

Formation Flying as Part of the A-Train Constellation

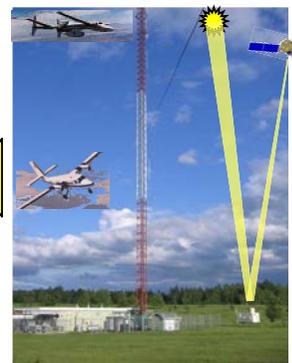
NASA NEN (GSFC) and SN (TDRSS)



Products Delivered to the GSFC DAAC



Validation Program

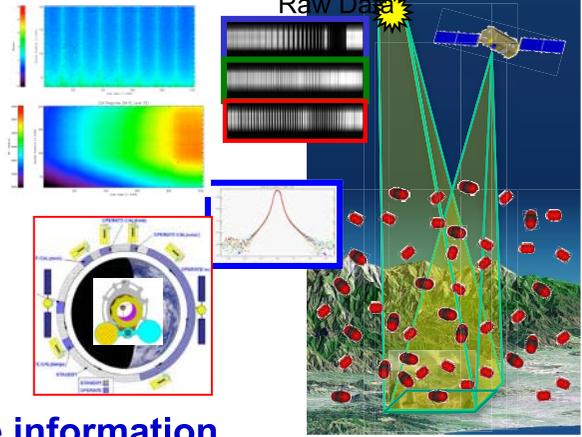
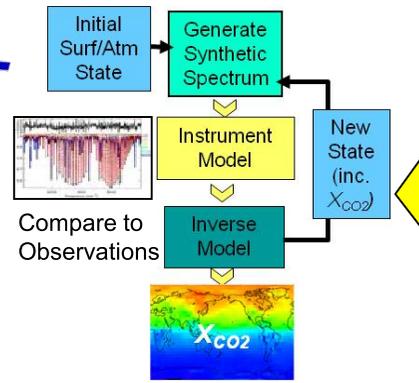


Science Data Operations Center (JPL)

L2 X<sub>CO2</sub> Retrieval

Calibrate Data

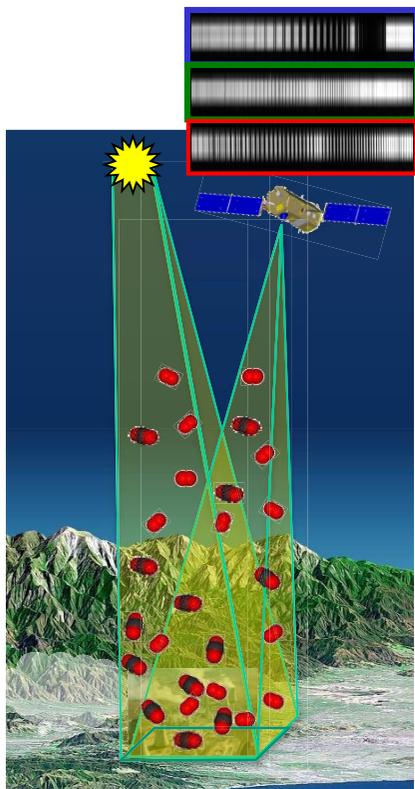
Raw Data



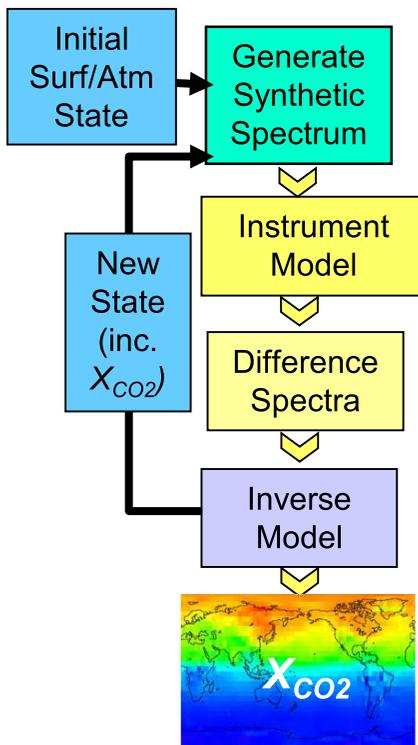
Please visit <http://oco.jpl.nasa.gov> for more information



**Collect** spectra of  $\text{CO}_2$  &  $\text{O}_2$  absorption in reflected sunlight over the globe



**Retrieve** variations in the *column averaged  $\text{CO}_2$  dry air mole fraction,  $X_{\text{CO}_2}$*  over sunlit hemisphere

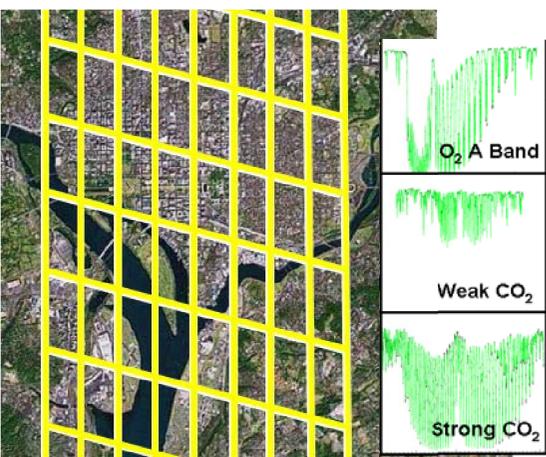
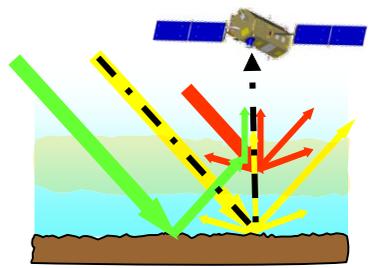


**Validate** measurements to ensure  $X_{\text{CO}_2}$  precision of 1 - 2 ppm (0.3 - 0.5%)



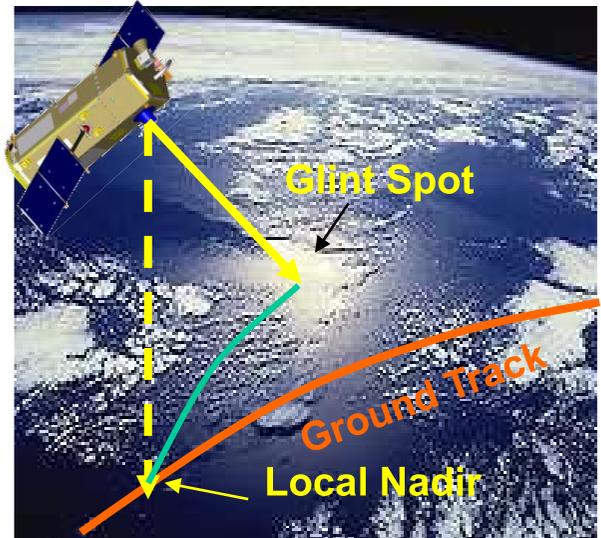
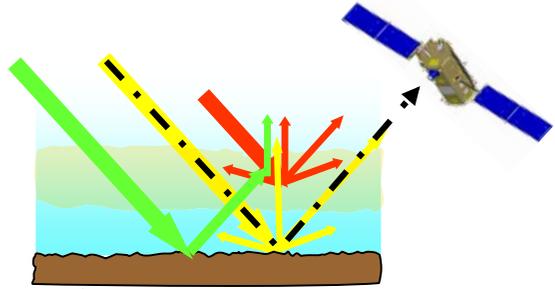
## Nadir Observations:

- + Small footprint (< 3 km<sup>2</sup>)
- Low Signal/Noise over dark surfaces (ocean, ice)



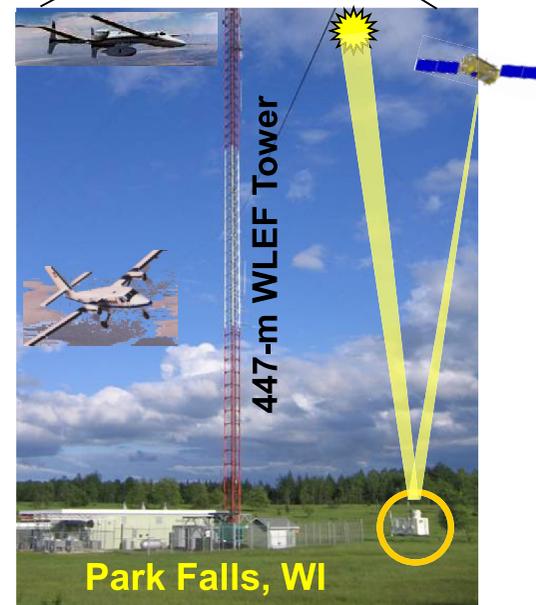
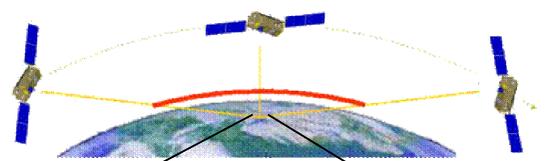
## Glint Observations:

- + Improves Signal/Noise over oceans
- More cloud interference

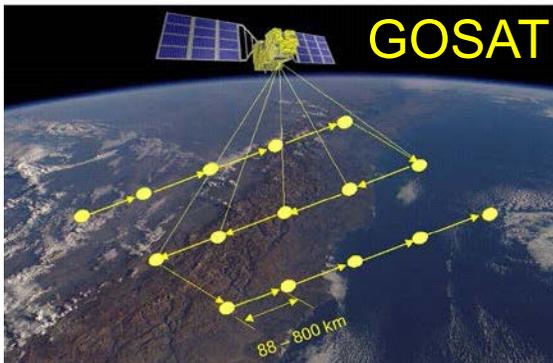


## Target Observations:

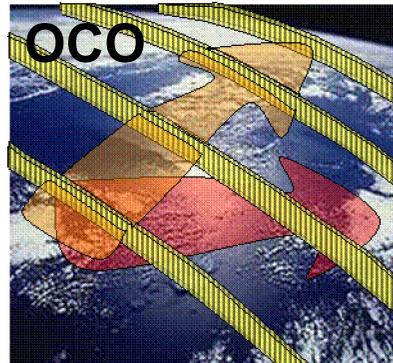
- Validation over ground based FTS sites, field campaigns, other targets



- The OCO and GOSAT teams formed a close partnership during the development phases of these two missions to:
  - Cross calibrate the OCO instrument and TANSO-FTS
  - Cross validate OCO and GOSAT data against a common standard
- If OCO-2 can be completed and launched, GOSAT may still be operational



3-day ground track repeat cycle  
• Resolves synoptic-scale weather



Continuous sampling along track  
• High resolution along track



# Comparison of OCO-2 and GOSAT

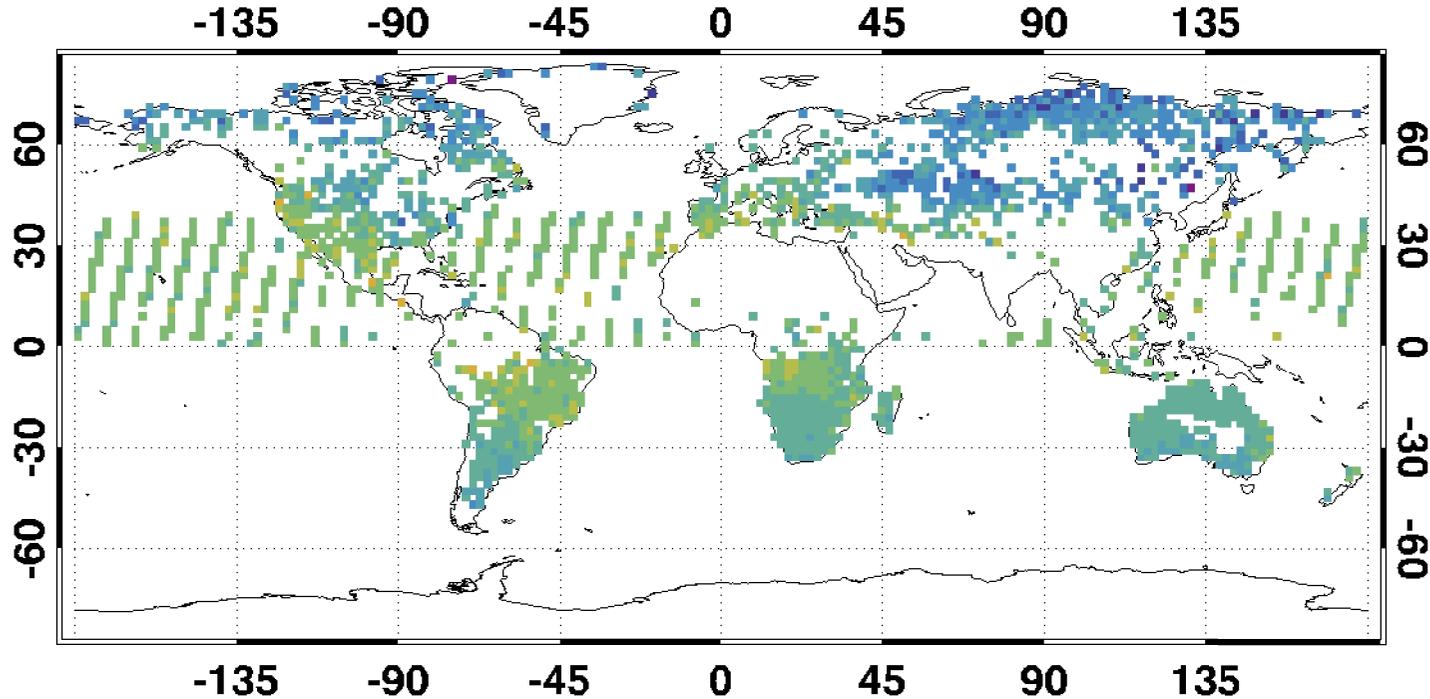
	<b>GOSAT</b>	<b>OCO-2</b>
Gases Measured	CO <sub>2</sub> , CH <sub>4</sub> , O <sub>2</sub> , O <sub>3</sub> , H <sub>2</sub> O	CO <sub>2</sub> , O <sub>2</sub>
Instruments	SWIR/TIR FTS, CAI	Grating Spectrometer
IFOV / Swath (km)	FTS: 10.5 / 80-790 (160) CAI: 0.5 / 1000	1.29 x 2.25 / 5.2
Sampling rate	0.25, 0.5, 1	4 x 3Hz
Spectral Ranges (µm)	0.758-0.775, 1.56-1.72, 1.92-2.08, 5.56-14.3	0.757-0.772, 1.59- 1.62, 2.04-2.08
Observatory Mass	1750 kg	441 kg
Power	3800 Watts	887 Watts
Orbit Altitude	666 km	705 km
Local Time	12:48	13:30
Revisit Time/Orbits	3 Days/72 Orbits	16 Days/233 Orbits
Launch Vehicle	H-IIA	????
Launch Date	January 2009	2013
Nominal Life	5 Years	2 Years



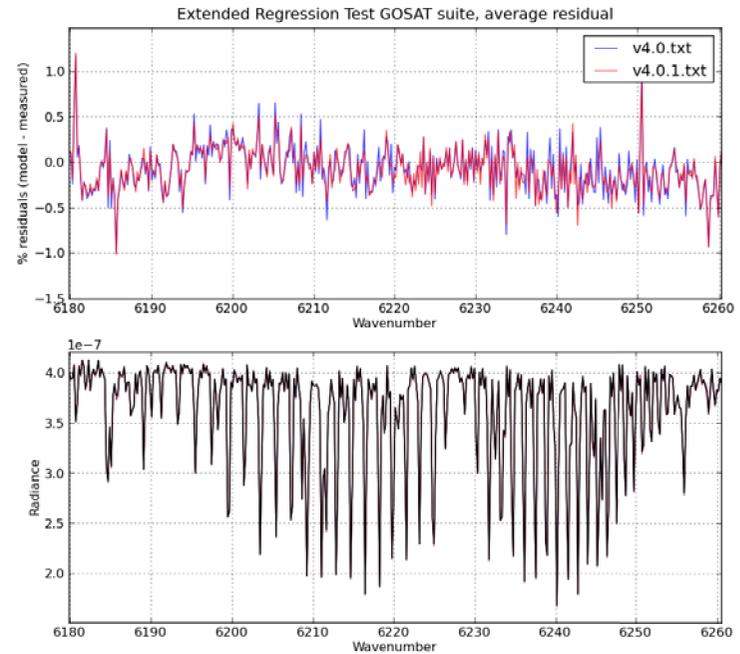
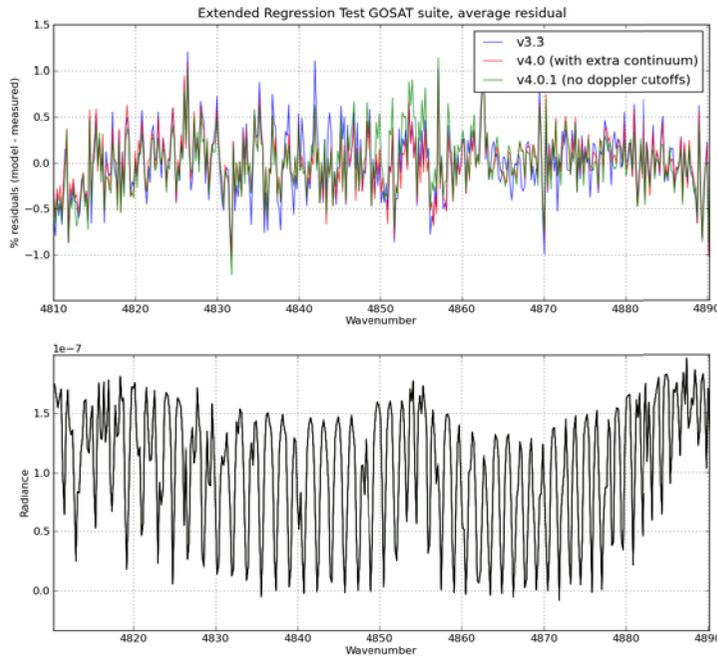
# ACOS products at GES DISC



2009-07-01 -- 2009-07-30 both

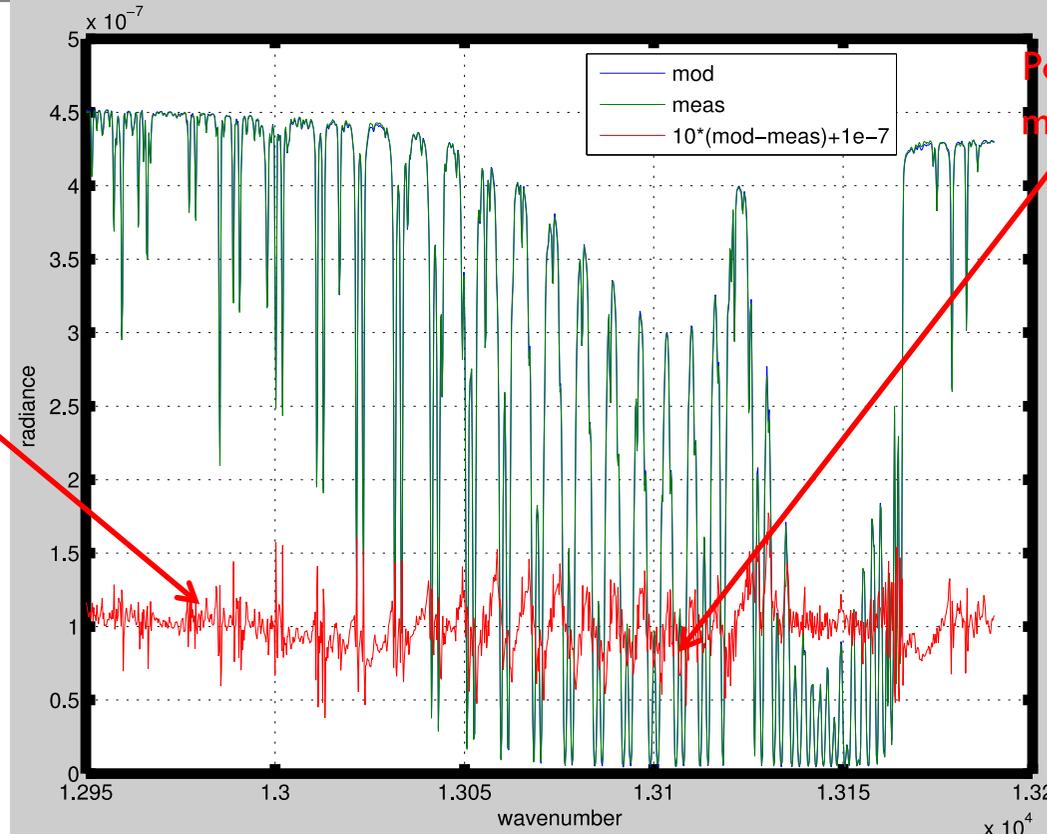


[Courtesy  
Brendan Fisher]



- Steady improvements made in fundamental spectroscopy
- Tested against laboratory, TCCON, and GOSAT spectral data for consistency
- Systematic errors (or residuals) lead to systematic errors in retrieved profiles but smaller differences in retrieved  $X_{CO_2}$  [Courtesy Davis Thompson]

Possible Dicke narrowing or temperature dependence errors or ILS



Possible line mixing errors

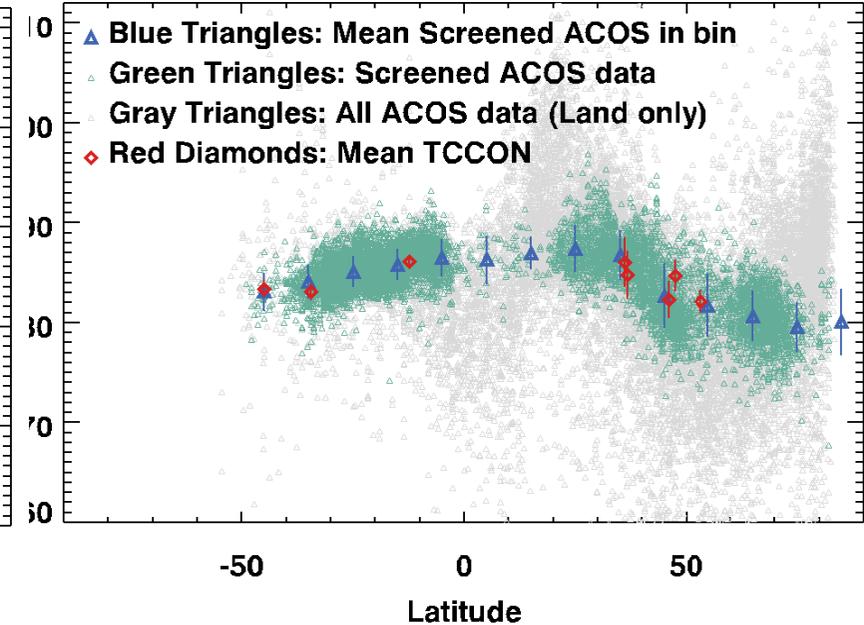
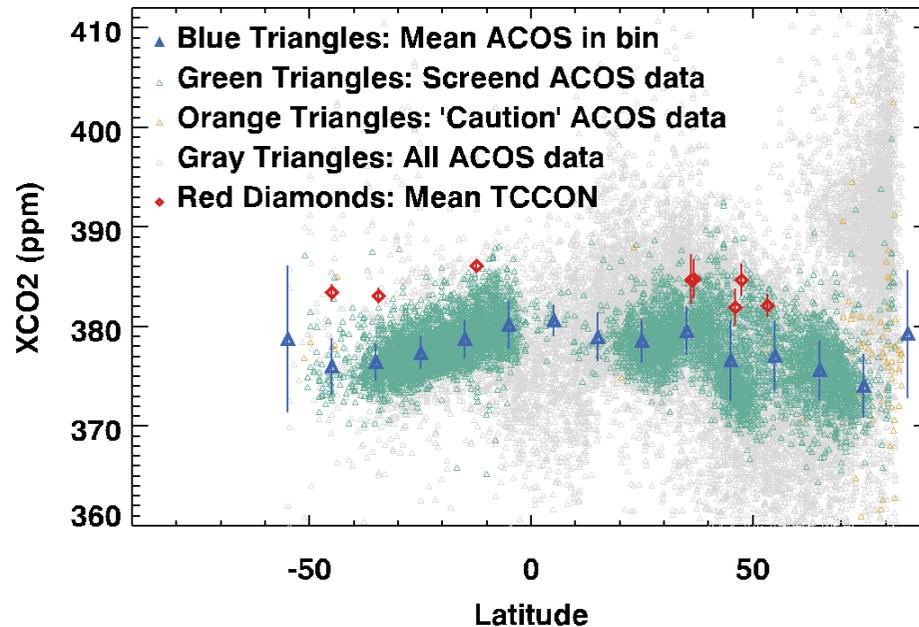
- Challenging laboratory measurements to provide basis of improved spectroscopic parameters
  - Choose empirical scaling of band strength to minimize retrieved surface pressure difference from *a priori* values
- [Courtesy Davis Thompson]

July 2009 B2.8

July 2009 B2.9

July 2009 B280

2009-07-01/2009-07-31 B29 set6h

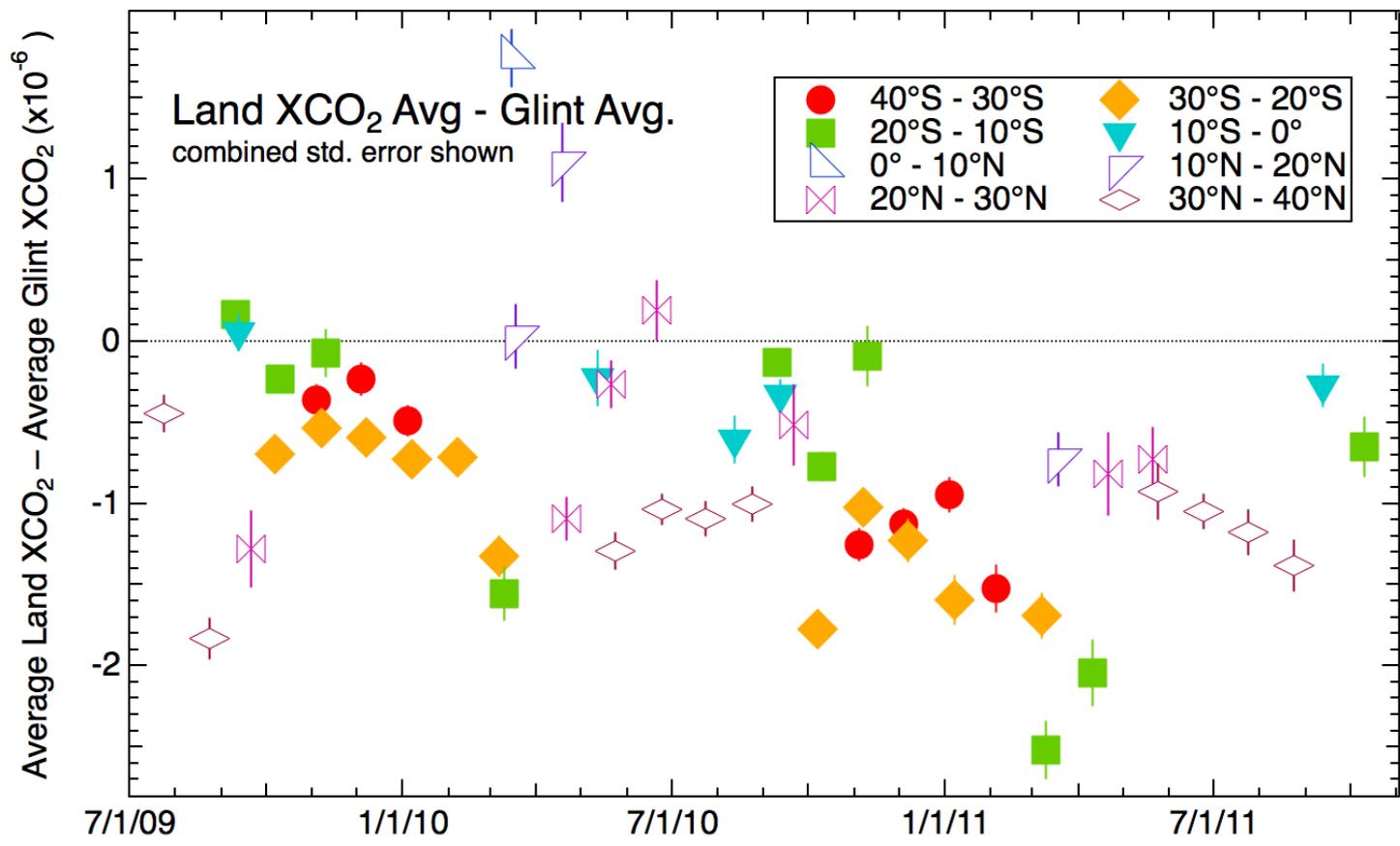


Results shown for land only

[Courtesy Becky Castano]



# Ocean (Glint) and Land Differences



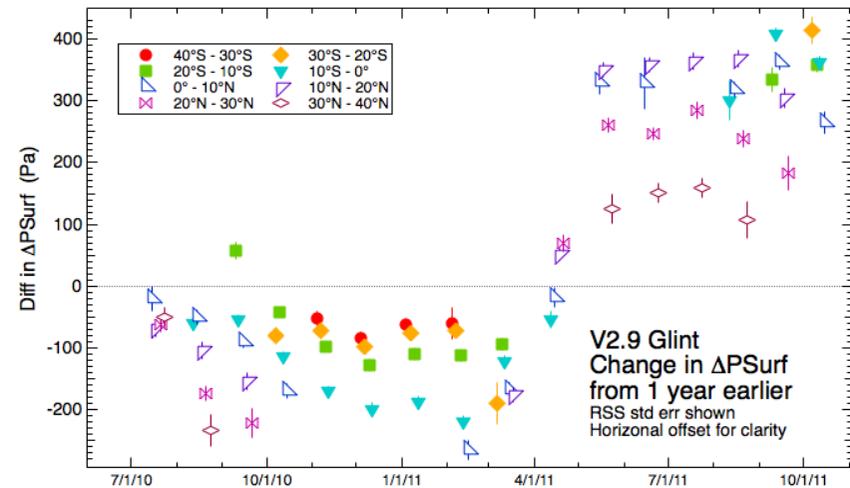
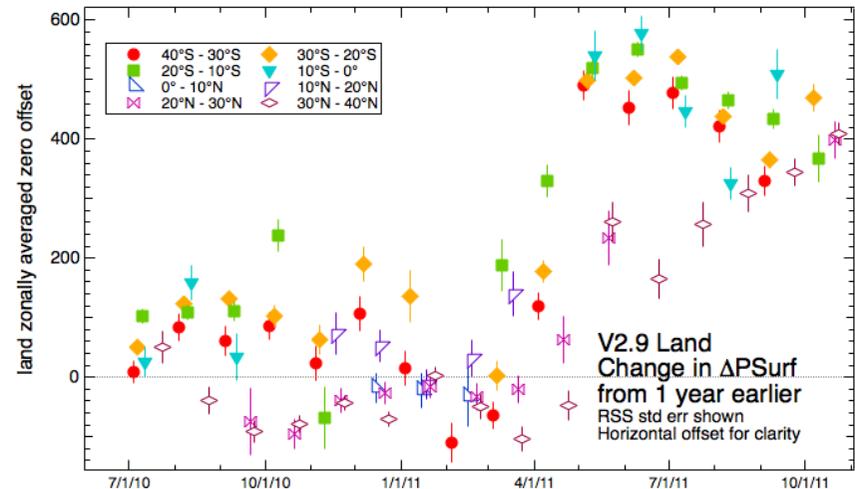
[Courtesy Bill Irion]





# Impact of L1B changes

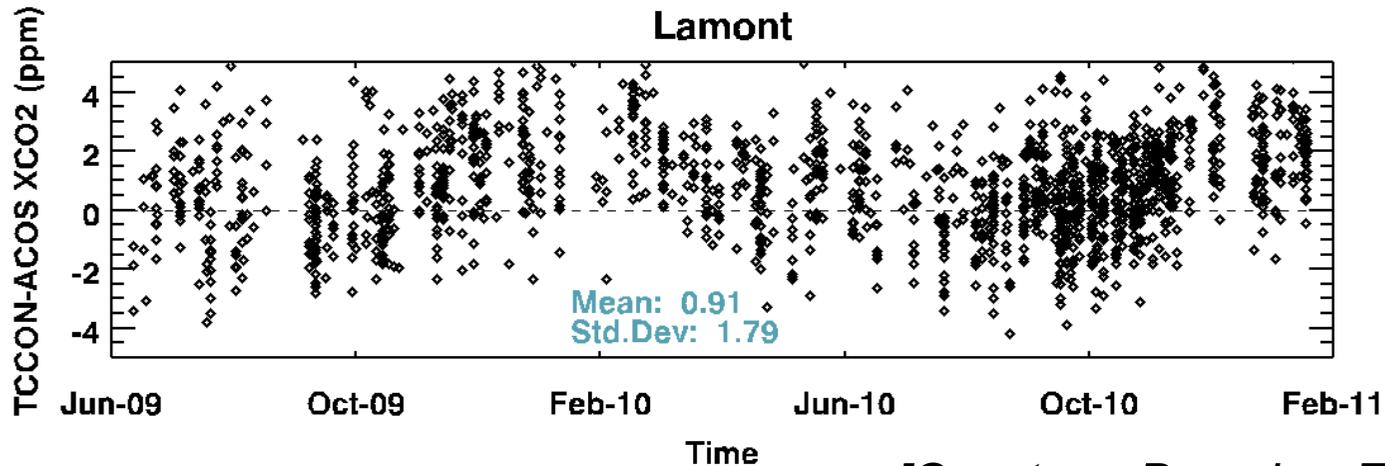
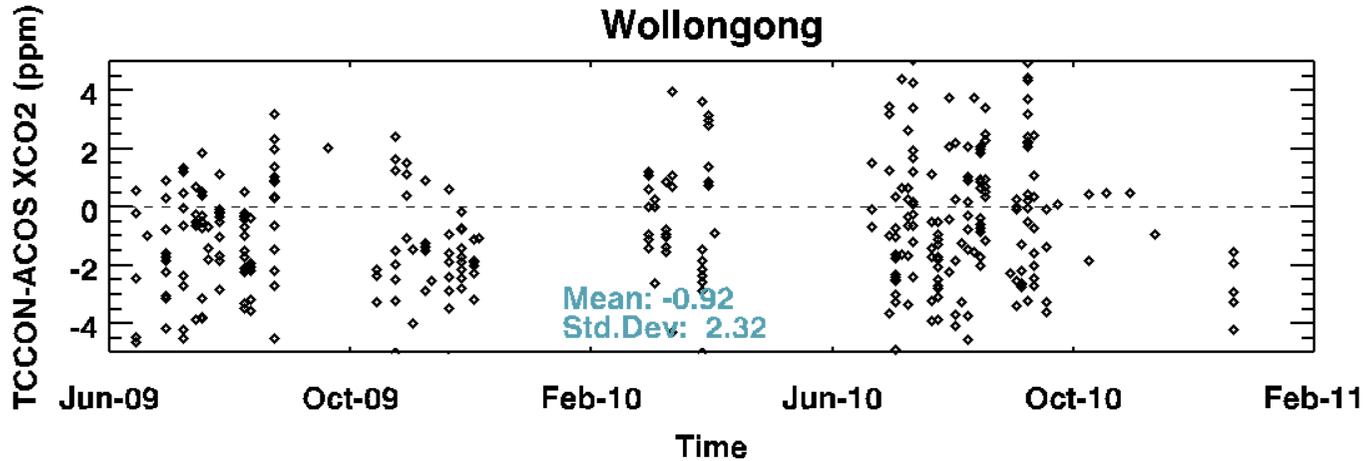
Change in difference between retrieved and a priori surface pressure coincident with change in L1B calibration method (“v130130”) after 4/19/2011



[Courtesy Bill Irion]



# Time Series Comparisons With TCCON



*[Courtesy Brendan Fisher]*



# Summary of TCCON and ACOS Comparisons



Site	2009 July	2009 Aug	2009 Sep	2009 Oct	2009 Nov	2009 Dec	2010 Jan	2010 Feb	2010 Mar	2010 Apr	2010 May	2010 June	2010 July
Eureka													-1.0
Sodankyla											-2.1	-2.4	-0.8
Orleans			0.2	0.2	1.2			3.4	3.0	-0.3		-3.1	-2.0
Garmisch		-0.6	0.1	-0.8					1.4	-1.2	-2.4	1.0	-3.1
Park Falls	0.8	0.9	0.1	1.0	0.7				1.4	-0.2			
Lamont	0.6	0.3	-0.2	-0.1	0.8	2.4	2.0	2.2	2.1	1.1	-0.2	1.1	0.2
Tsukuba		1.3	-2.0	-1.4	-1.8	-0.4	-1.2	-0.2	-0.6				
Darwin	0.7	0.6	0.7		1.3								
Wollongong	-1.5	-1.7	0.2		-1.5	-2.2			-0.4	-0.7			-0.5
Lauder			-1.1					0.3					
Lauder HR125								-0.3			-0.2		

[Courtesy Brendan Fisher]





# Algorithm Improvements – ACOS B2.9

- Significant L2 changes
  - Zero level offset in the spectral domain is retrieved in the A-band
  - The cross sections for the A-band were rescaled, eliminating the surface pressure bias
  - Instrument line shape is now interpolated, rather than using tabulated data
  - Only data passing the cloud screening is processed in the Level 2 algorithm
- L1B
  - Time-varying calibration coefficients have been updated (use JAXA Nov 2010 data)
  - The noise estimate now has time dependent corrections, so there is no longer a time dependence to the fraction of data passing the screening criteria
  - Geometric correction factors were added to L1B fields



- ACOS B2.9 data now available through the GES DISC
  - <http://disc.sci.gsfc.nasa.gov/acdisc/documentation/ACOS.shtml>
- The algorithm is faster and more robust but there are still areas for development to reduce biases
- OCO-2 instrument is in thermal vacuum testing
- ***OCO-2 will be prepared to rapidly process, evaluate, and validate the OCO-2 data early after on-orbit operations begin***
- Working with the GOSAT data has provided the team with critical tests of the OCO retrieval algorithm and validation approach
- ***Special thanks and acknowledgement to the JAXA and NIES the GOSAT teams***

