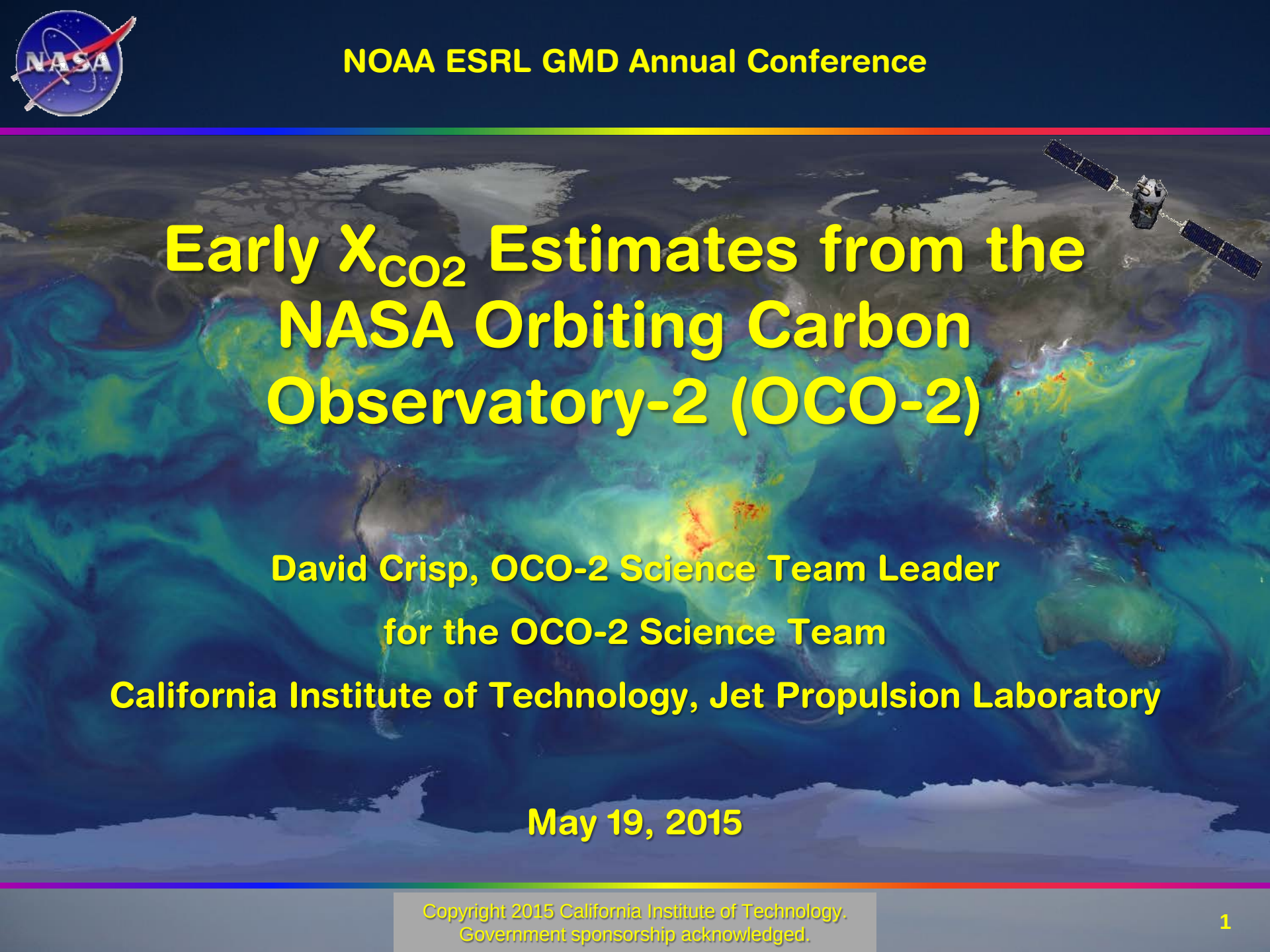

Early X_{CO2} Estimates from the NASA Orbiting Carbon Observatory-2 (OCO-2)

David Crisp, OCO-2 Science Team Leader

for the OCO-2 Science Team

California Institute of Technology, Jet Propulsion Laboratory

May 19, 2015

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Government sponsorship acknowledged.

The Need for Space-based CO_2 Measurements

A Perfect Ride into Space



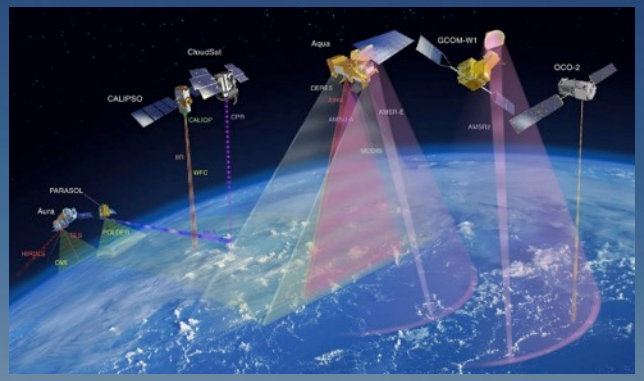
Lift-off at 2:56 am PDT, 02 July 2014





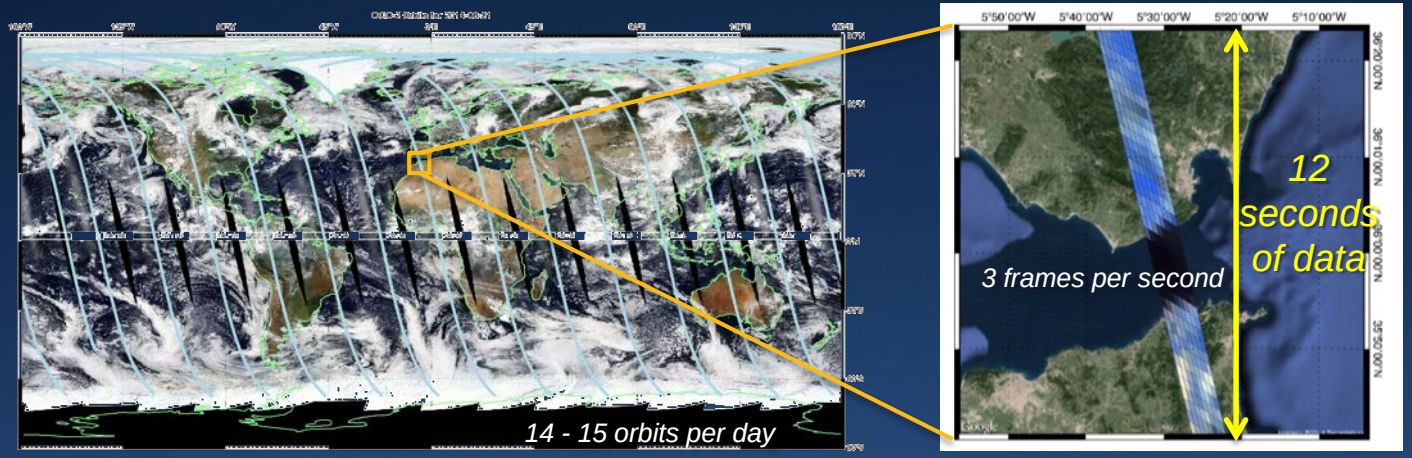


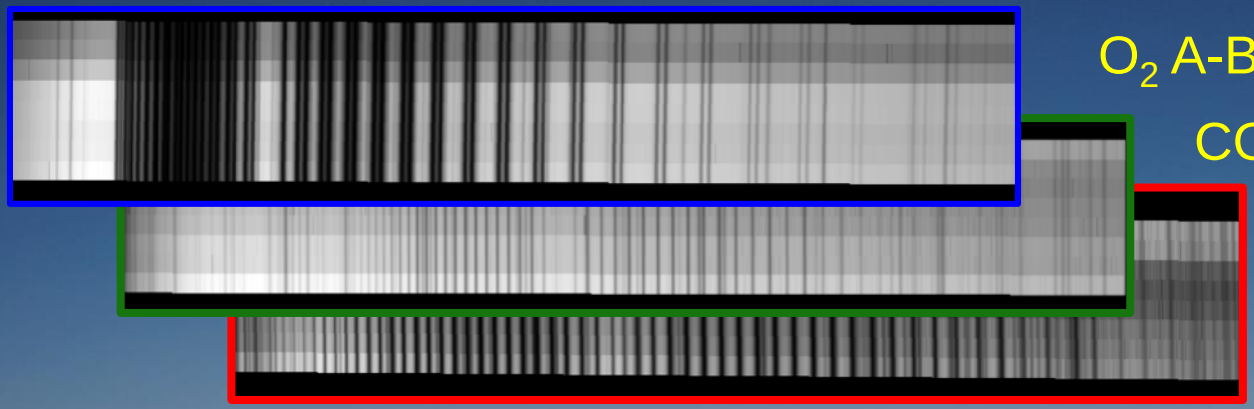
Separation!



Joining the A-Train
3 August 2014

OCO-2 Sampling Approach





O_2 A-Band

CO_2 1.61 μm Band

CO_2 2.06 μm Band

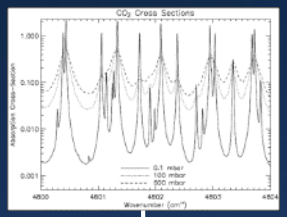
Each 1/3 of a second frame includes 8 spatial footprints with 1,016 wavelengths sampled in the O_2 A-band and Weak and Strong CO_2 bands

yielding almost 1 million soundings each day

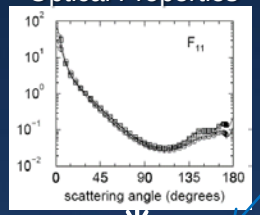
Retrieving X_{CO2} from OCO-2 Spectra

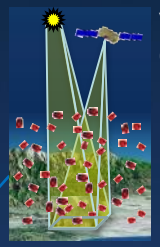
Altitude
CO_2
T
$\delta\tau_{aer}$
Mixing Ratio Temp. Aerosol
State Vector First Guess

Gas Cross Sections



Cloud & Aerosol Optical Properties

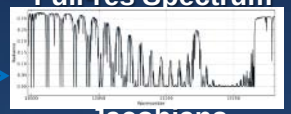




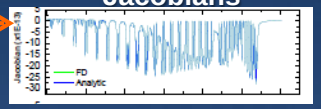
Viewing geometry

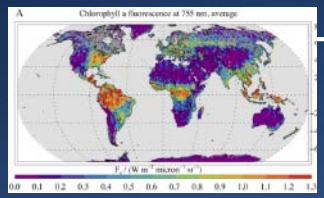
Forward Radiative Transfer Model
Spectra + Jacobians

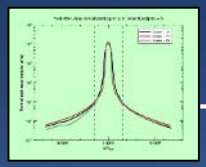
Full-res Spectrum



Jacobians

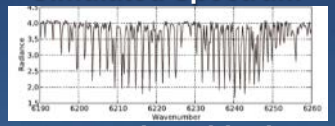




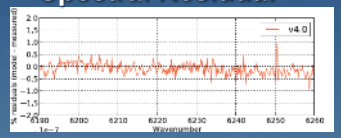


Instrument Model
Spectral + Polarization

Simulated Spectrum



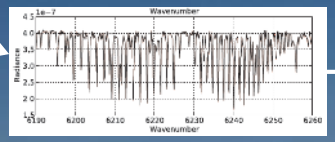
Spectral Residual





$$\begin{pmatrix} I_P \\ I_S \end{pmatrix} = \begin{pmatrix} m_{PI} & m_{PQ} & m_{PU} & m_{PV} \\ m_{SI} & m_{SQ} & m_{SU} & m_{SV} \end{pmatrix} \begin{pmatrix} I \\ Q \\ U \\ V \end{pmatrix} = \mathcal{M}S$$





Inverse Model
- Compare obs. & simulated spectra
- Update State Vector

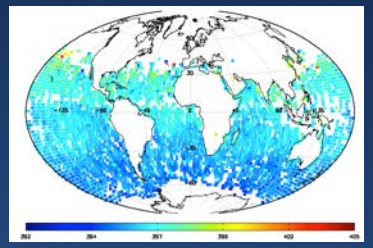
not converged

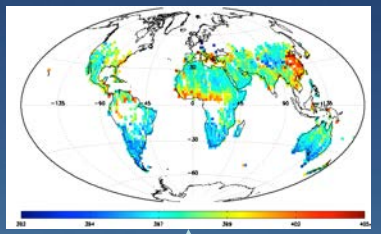
Apriori + Covariance



- Final State
- Diagnostics

converged

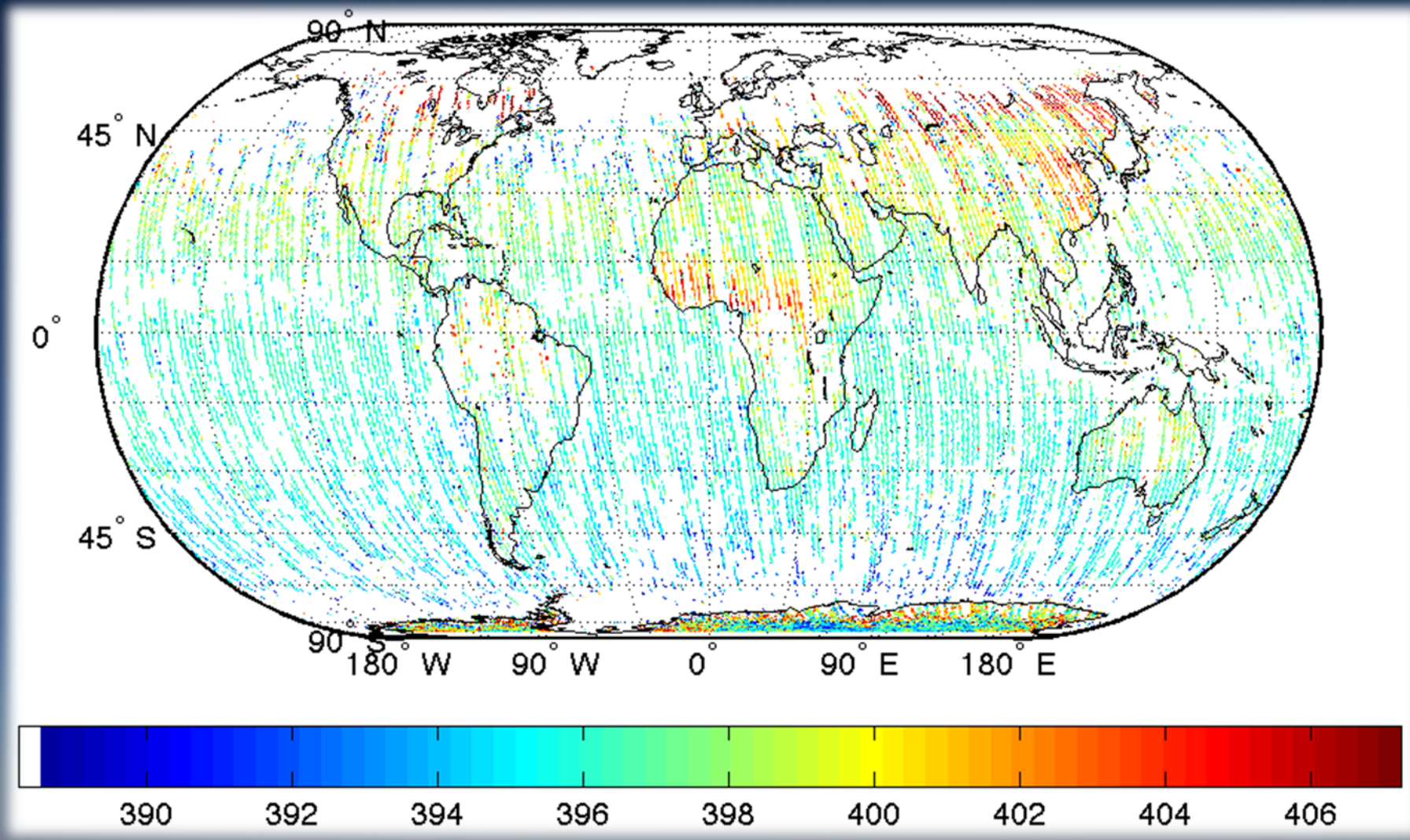




Altitude
CO_2
T
$\delta\tau_{aer}$
Mixing Ratio Temp. Aerosol

GOSAT Data have provided a critical validation of the OCO-2 Algorithm

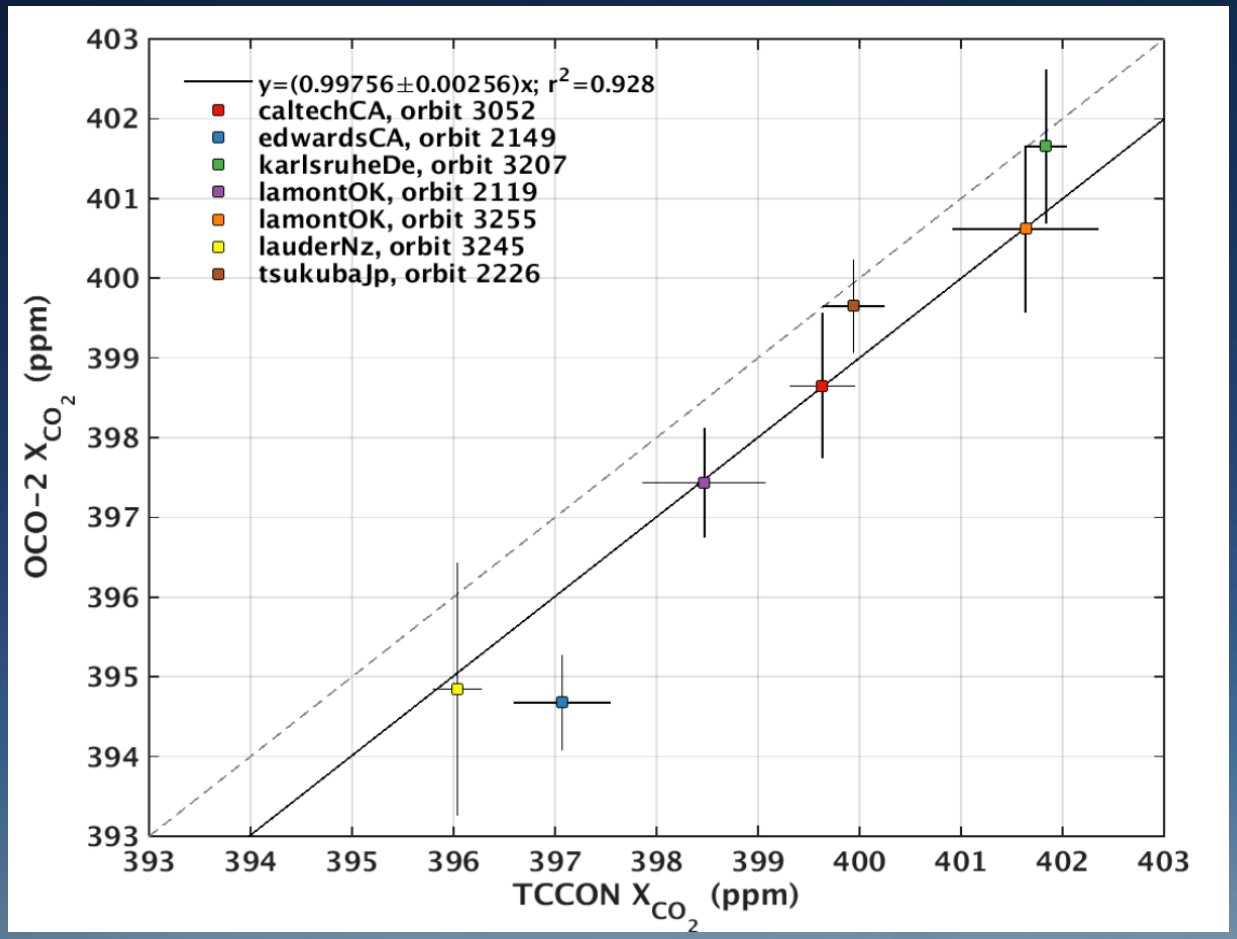
Preliminary X_{CO2} Estimates



Validation: Targeting Total Carbon Column Observing Network (TCCON) Stations



Comparison of TCCON and OCO-2 X_{CO2}

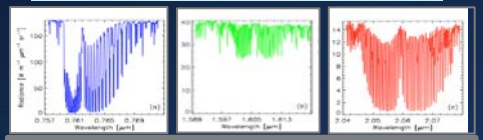


Comparisons with Total Carbon Column Observing Network (TCCON) stations are being used to identify and correct biases in target observations. *(Wunch et al.)*

Initial differences between OCO-2 and TCCON X_{CO2} estimates were smaller than ~2 ppm (0.5%).

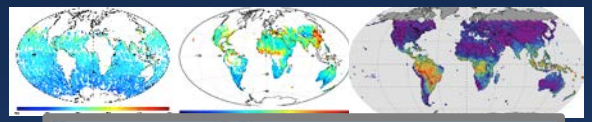
OCO-2 Data Product Deliveries

L1B: Spectra



- oco2_L1bScND_89220a_1009
  - Dimensions
  - FootprintGeometry
  - FrameConfiguration
  - FrameGeometry
  - FrameHeader
  - FrameTemperatures
  - InstrumentHeader
  - Metadata
  - Shapes
  - SliceMeasurements
  - SoundingGeometry
  - SoundingMeasurements

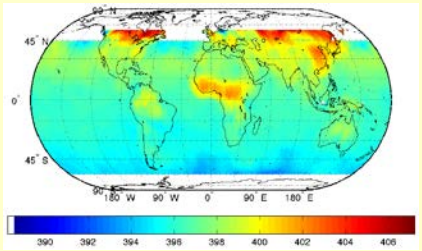
L2: XCO2, SIF, ...



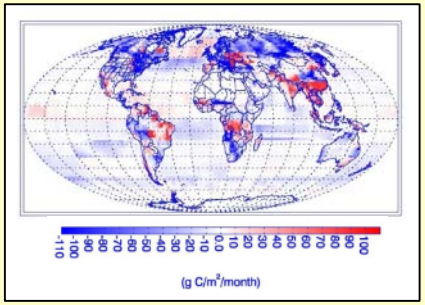
- oco2_L2StdND_89220a_100923_
  - AerosolResults
  - AlbedoResults
  - Dimensions
  - DispersionResults
  - L1bScSoundingReference
  - Metadata
  - PreprocessingResults
  - RetrievalGeometry
  - RetrievalHeader
  - RetrievalResults
  - Shapes
  - SpectralParameters

Mapped Products

L3: X_{CO2} Maps



L4: Fluxes



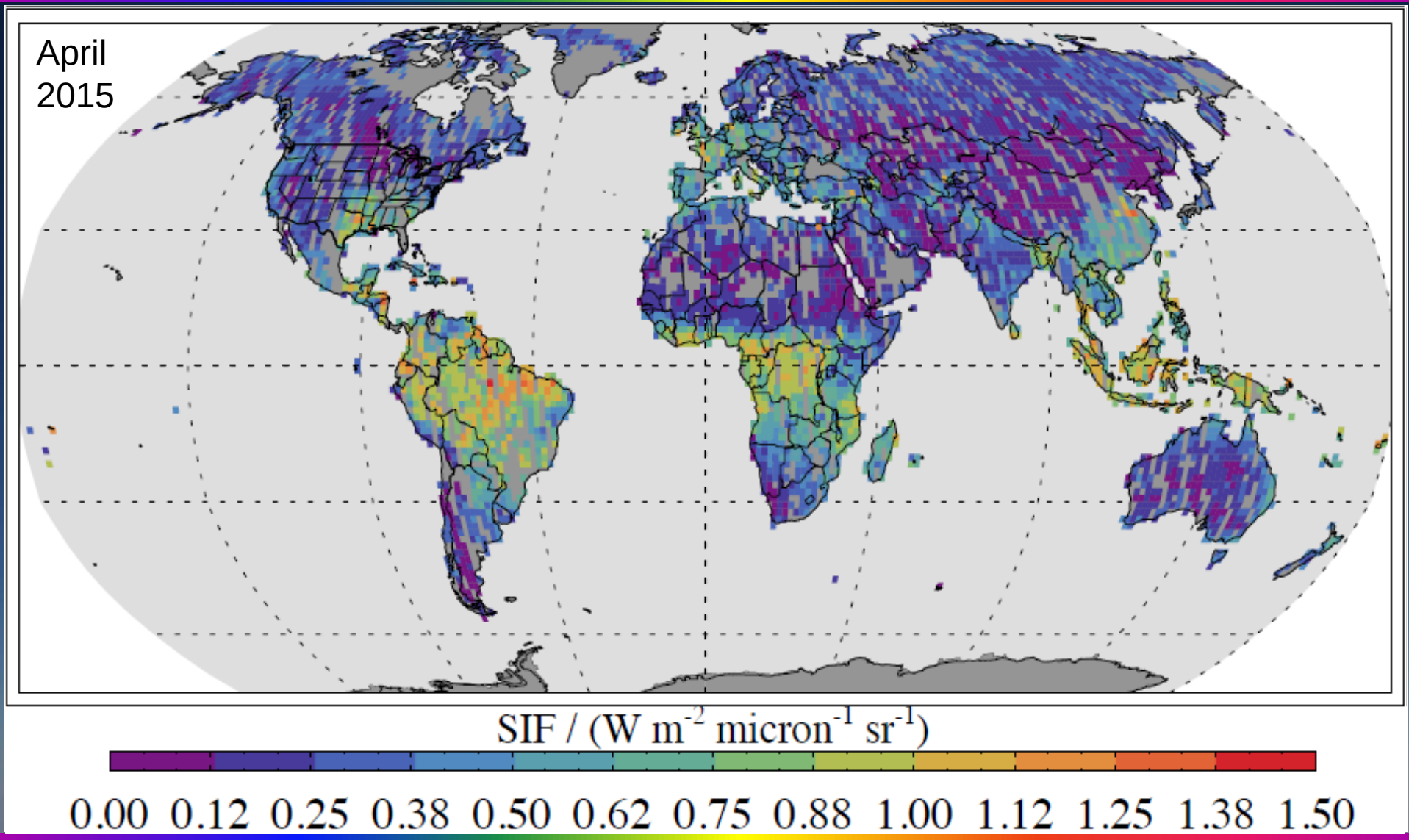
December 30, 2014 — **March 30, 2015** — **As Available**

http://disc.sci.gsfc.nasa.gov/datacollection/OCO2_L1B_Science_V5.html

Known Issues with the Initial Products

- An analysis of the L2 production products revealed large (> 1%) residuals in spectral fits in the CO_2 channels and X_{CO2} biases
- The large residuals were traced to errors in the calibration tables used to produce the version 6 and 6R L1B production products
  - Large numbers of new bad pixels formed between the 2012 pre-launch calibration activities and launch
  - Bad pixels affect both the offset and gain of spectral samples
  - Subtle errors in the way that the bad pixel gain corrections were implemented in the production product introduced the X_{CO2} errors
- All data (back to 6 September 2014) are recoverable.
  - A series of modified gain correction methods were developed and tested, and the results are promising
- A new product (v7/v7R) is currently being tested and will be delivered in mid/late summer

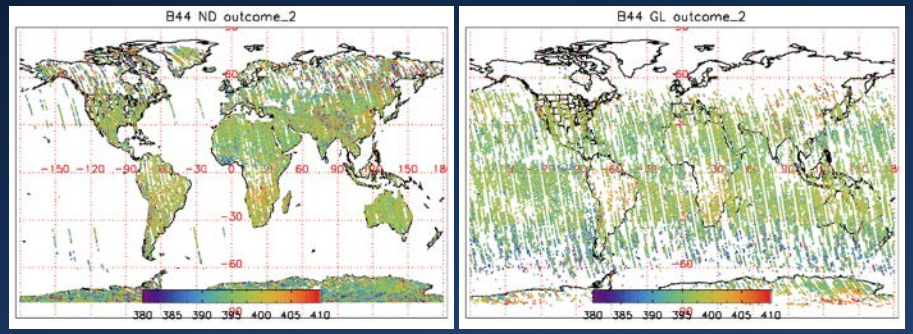
A New Product: Solar-Induced Chlorophyll Fluorescence (SIF)



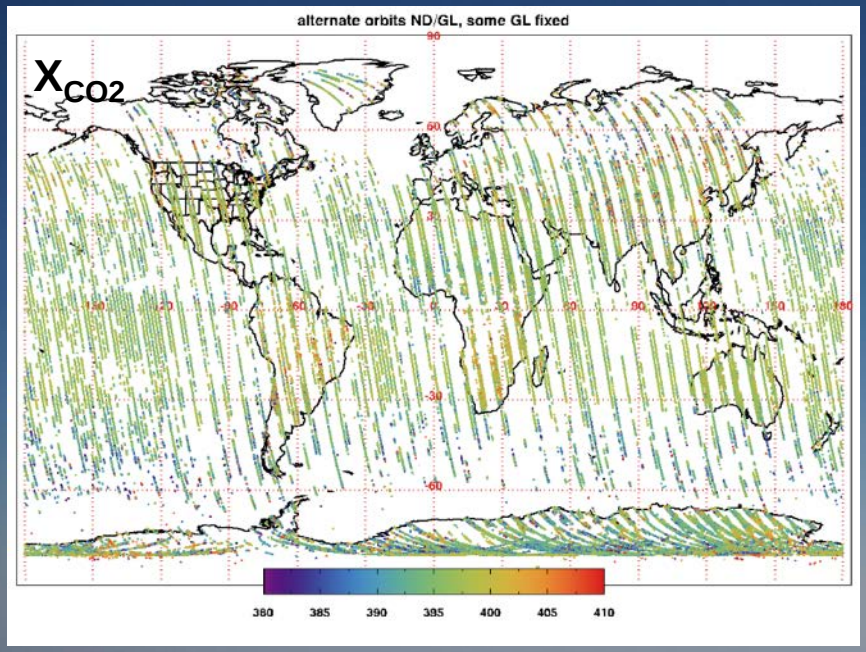
Changes in Observatory Operations

Changes in the Glint/Nadir Scheduling

Current Approach

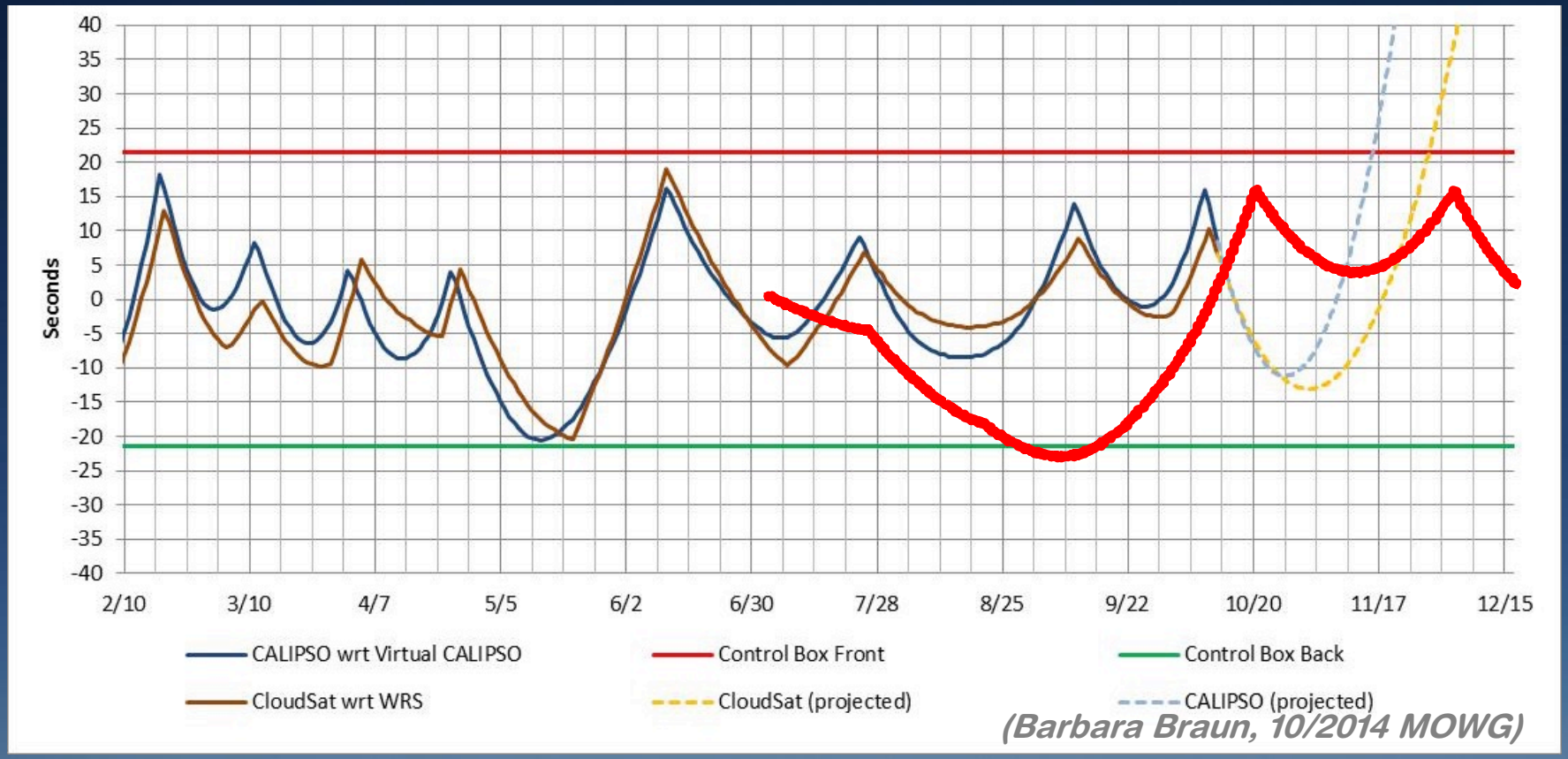


Revised Approach



- A new glint strategy with alternating glint/nadir orbits:
  - Step 1: alternate between glint and nadir on successive orbits
  - Step 2: alternate between glint and nadir on successive orbits for orbits that include some land and some water, but stay in glint for orbits that are predominately over ocean
- This strategy increases the gaps between sampled areas for a single repeat cycle but fill in the gaps over a 32-day period.

Formation Flying for CloudSat, CALIPSO, and OCO-2



(Barbara Braun, 10/2014 MOWG)

- CloudSat & CALIPSO stay within their control boxes and coordinate their maneuvers to align their surface footprints within 4 km of each other.
- OCO-2 has not yet started to coordinate it maneuvers.

Summary

- OCO-2 operations are now back to “NOMINAL”
  - Following a routine decontamination cycle on 20-26 April, the instrument experienced a pair of “safing” events that interrupted data acquisition until 6 May
- An initial L2 data product was released on 30 March
  - An early analysis revealed significant errors that have been traced to calibration issues
  - A product that addresses these issues (v7/v7R) is being tested
    - All data will be reprocessed for delivery in mid/late summer
- Two changes in the operations strategy are being implemented:
  - Modified Glint / Nadir scheduling to optimize coverage
  - Tighter formation flying with CloudSat and CALIPSO to maximize overlap of swaths