The Orbiting Carbon Observatory (OCO-2) L2 Retrieval Algorithm: First Tests With Greenhouse gases Observing SATellite (GOSAT) Data

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and the OCO-2 L2 Algorithm Team

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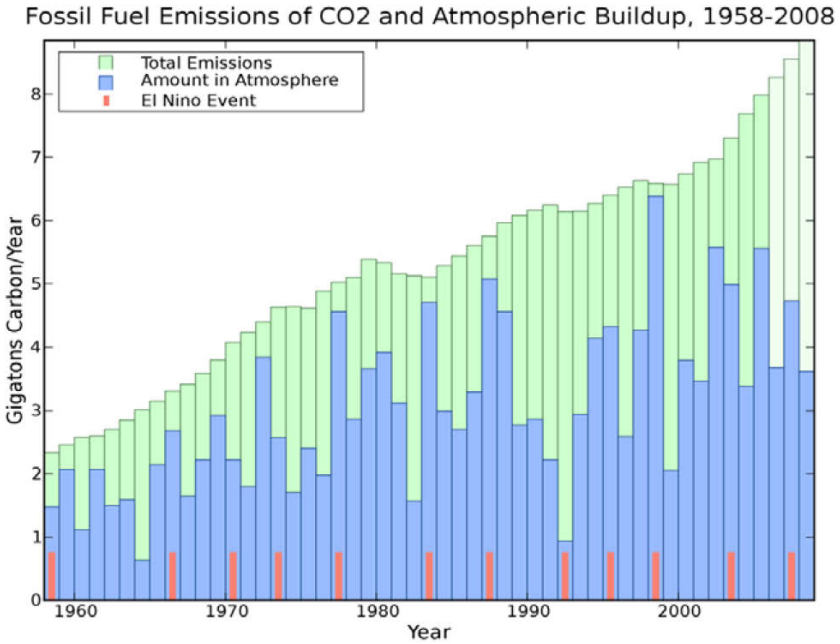
Overview

- Driving Science Questions
- Overview of Measurement Approach
- Driving Requirements
  - Flight System
  - Algorithms
  - Validation
- Retrievals of GOSAT Data

The Mystery of the Missing CO_2

- Humans have added >200 Gt C to the atmosphere since 1958
- Less than half of this CO_2 is staying in the atmosphere
- Where are the *sinks* that are absorbing over half of the CO_2?
  - Land or ocean?
  - Eurasia/North America?
- Why does the CO_2 buildup vary from year to year with nearly uniform emission rates?
- How will these CO_2 sinks respond to climate change?



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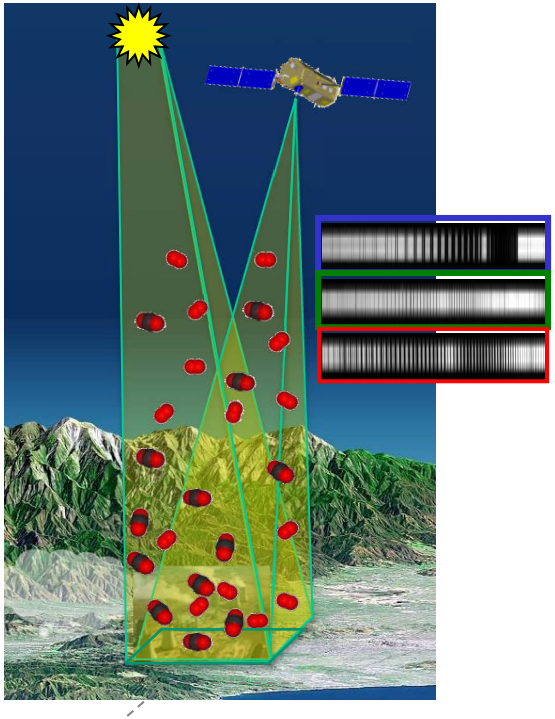
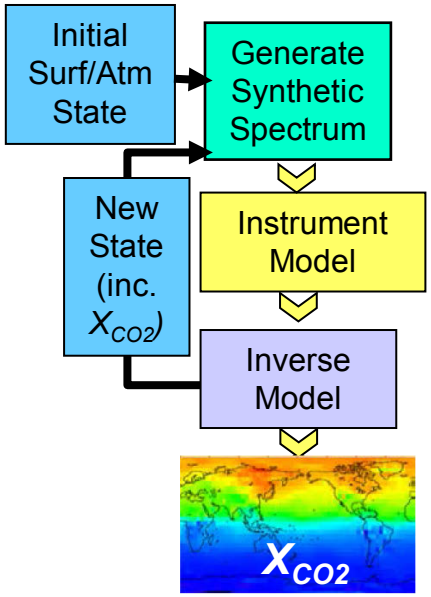
Measuring CO_2 from Space

- **Collect** spectra of CO_2 & O_2 absorption in reflected sunlight over the globe



V&V in Pre-launch Tests

- **Retrieve** variations in the *column averaged CO_2 dry air mole fraction, X_{CO2}* over sunlit hemisphere



Documented in L2 ATBD.
Verified with GOSAT data.

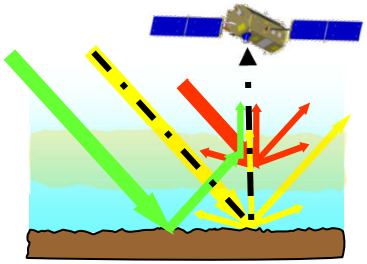
- **Validate** measurements to ensure X_{CO2} precision of 1 - 2 ppm (0.3 - 0.5%)

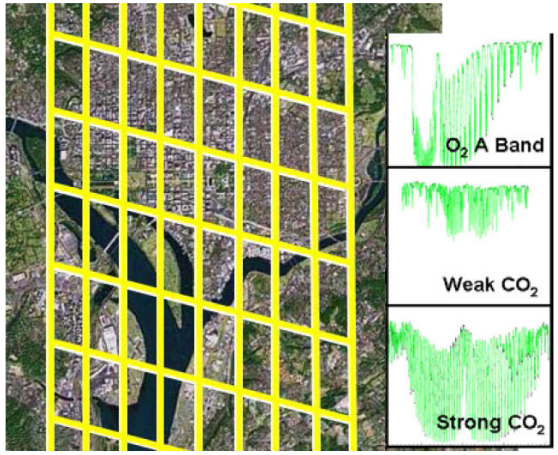
Documented in OCO-2 Validation Plan.
Verified with GOSAT Data

OCO-2 Requires Agile Spacecraft

Nadir Observations:

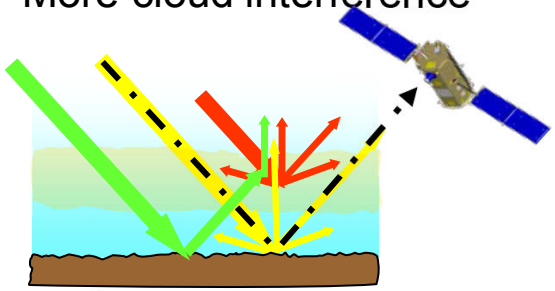
+ Small footprint (< 3 km^2)
– Low Signal/Noise over dark surfaces (ocean, ice)

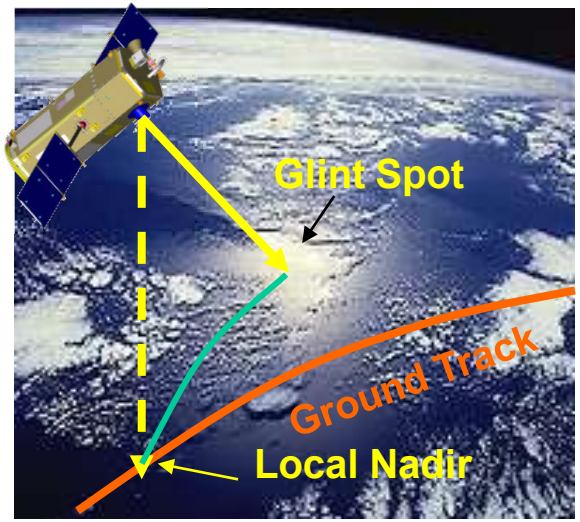




Glint Observations:

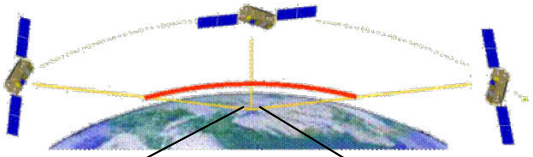
+ Improves Signal/Noise over oceans
– More cloud interference

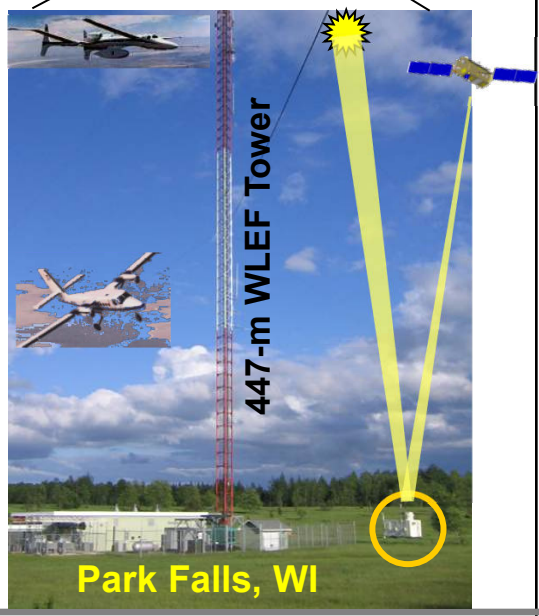




Target Observations:

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

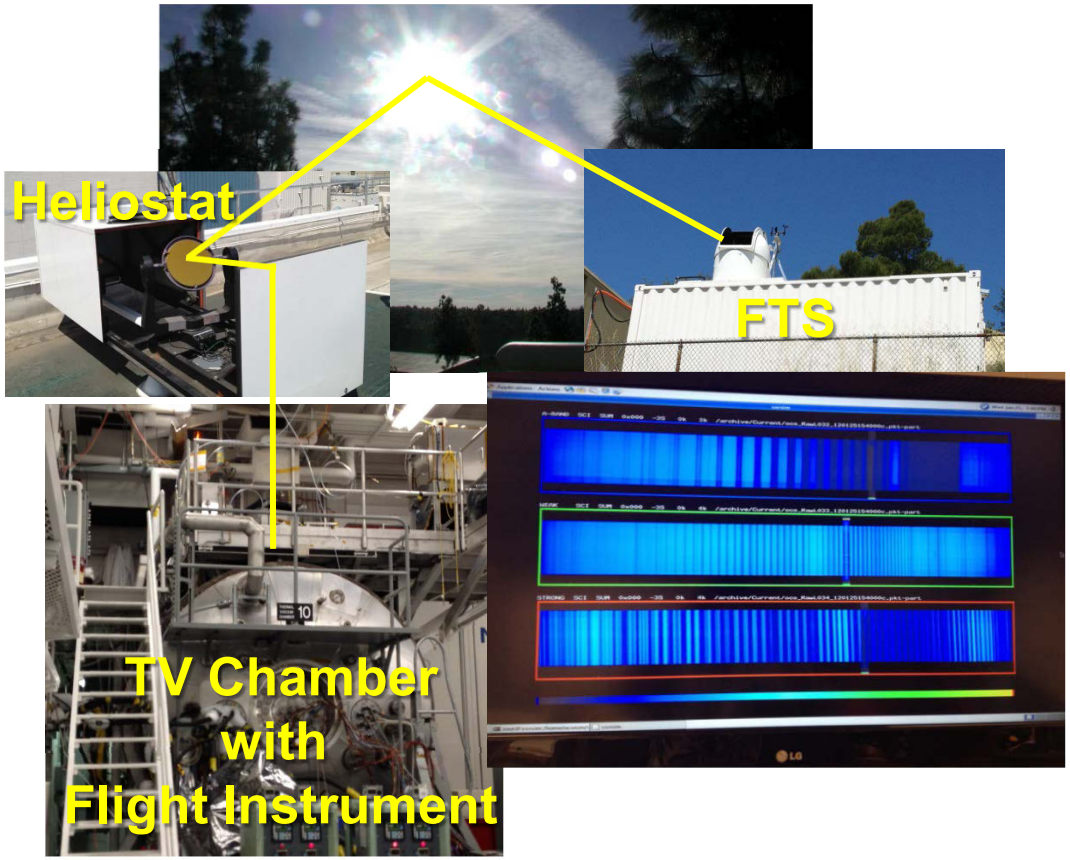




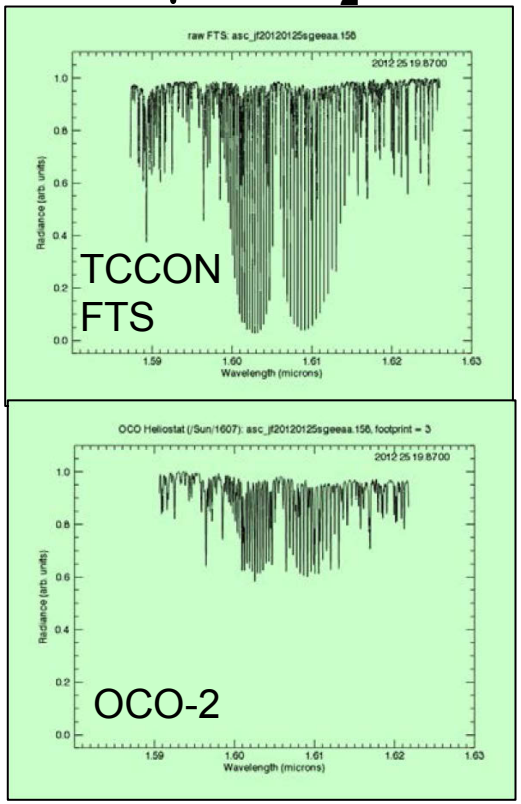
Heliostat/TCCON Observations Verify End-to-End Instrument Performance

Jet Propulsion Laboratory
California Institute of Technology

Observations of the sun with the flight instrument taken during TVAC tests provide an end-to-end verification of the instrument performance.



1.6 μm CO_2



11:52 am on 25-Jan-2012

Retrieving X_{CO2} from OCO-2 Spectra

Jet Propulsion Laboratory
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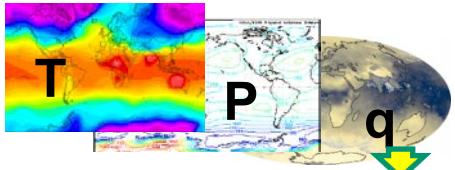
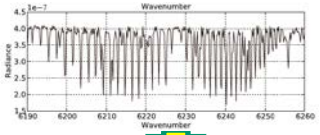
Interpolated Meteorology

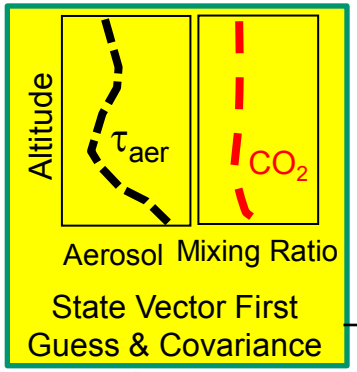


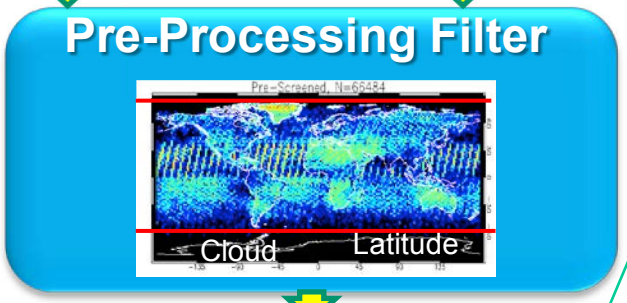
Level 1B Data

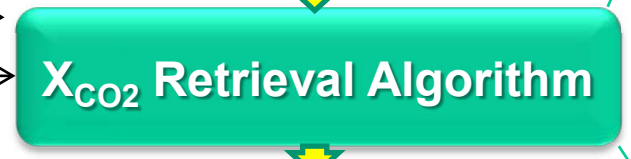


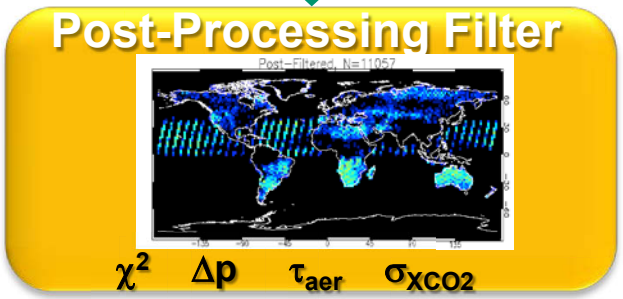
OCO-2 Retrieval Algorithm

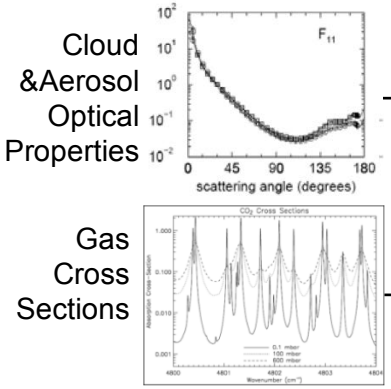
- Optimal Estimation
- "Full Physics"
- 3-band (ABO2, WCO2, SCO2)

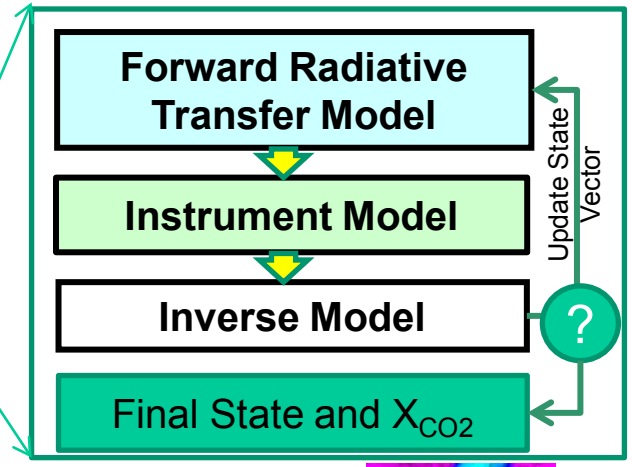


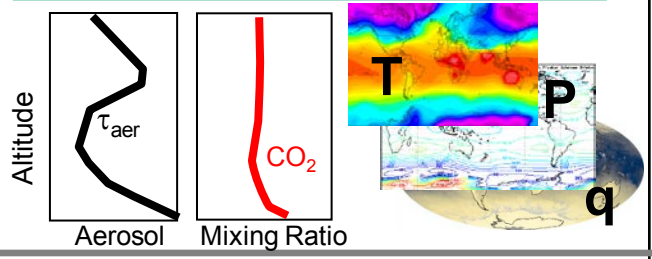






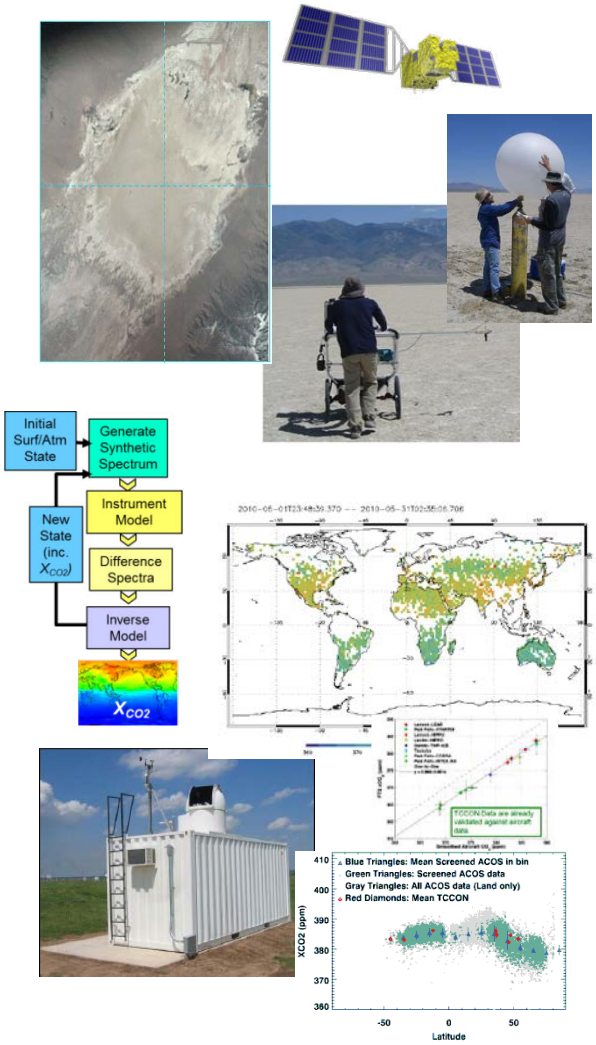




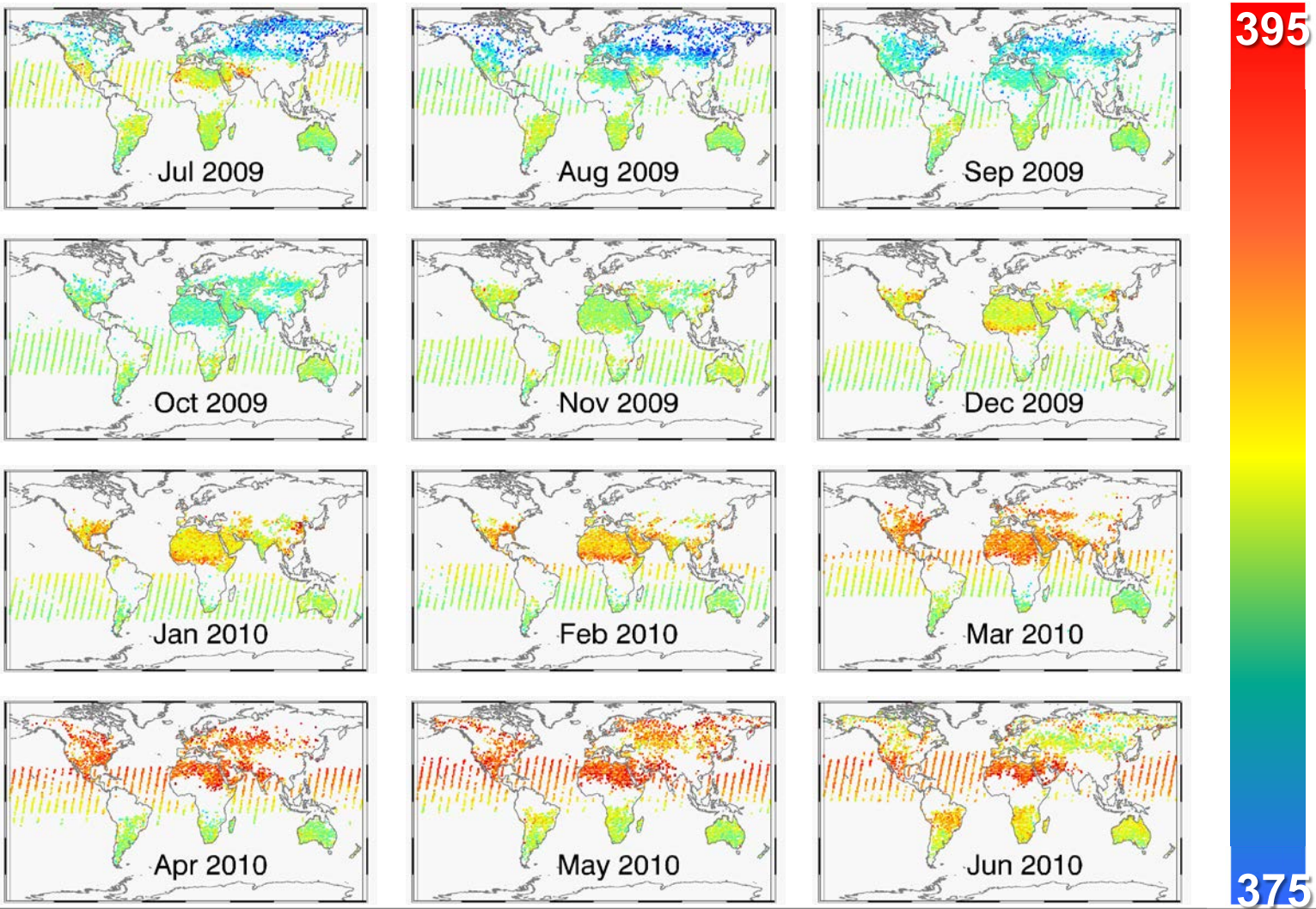


The ACOS/GOSAT Collaboration: V&V of OCO-2 Calibration, Retrieval, and Validation Approach

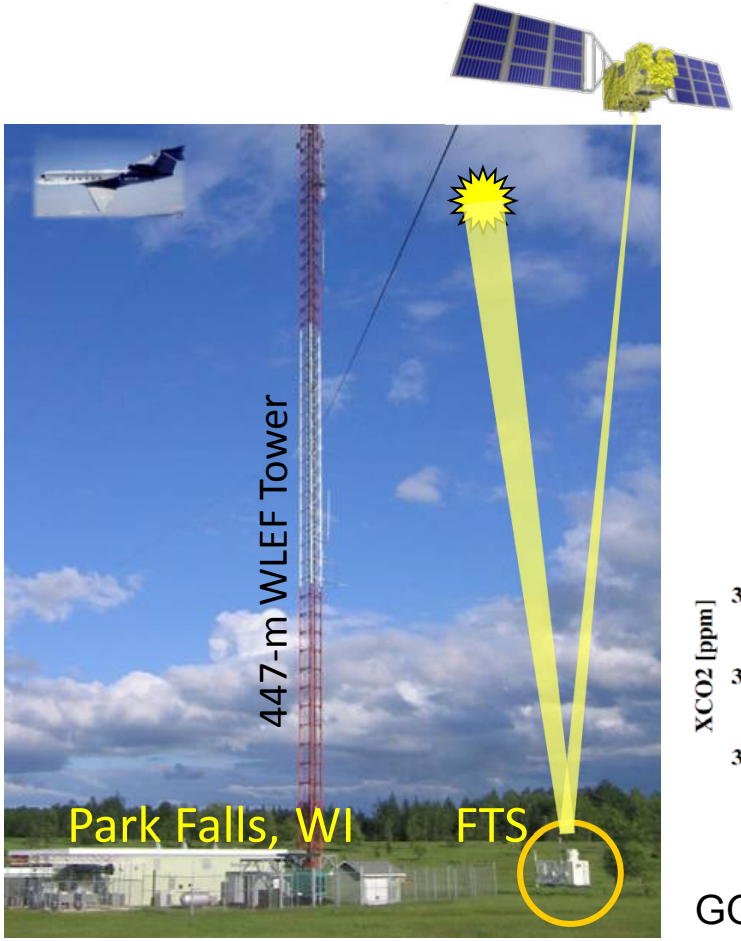
- Immediately after the loss of OCO, the GOSAT Project manager invited the OCO Team to participate in GOSAT data analysis
- The ACOS team is collaborating closely with the GOSAT teams at JAXA and NIES to:
  - Conduct vicarious calibration campaigns in Railroad Valley, Nevada, U.S.A.
  - Retrieve X_{CO2} from GOSAT spectra
    - Algorithm development & testing
    - Data production and delivery
  - Validate GOSAT retrievals by comparing GOSAT retrievals with TCCON measurements and other data



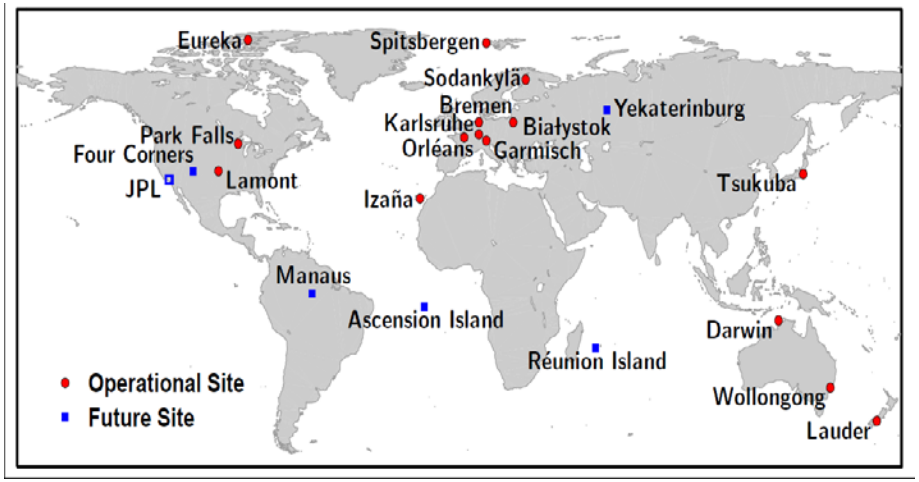
ACOS GOSAT B2.10 X_{CO2} Retrievals

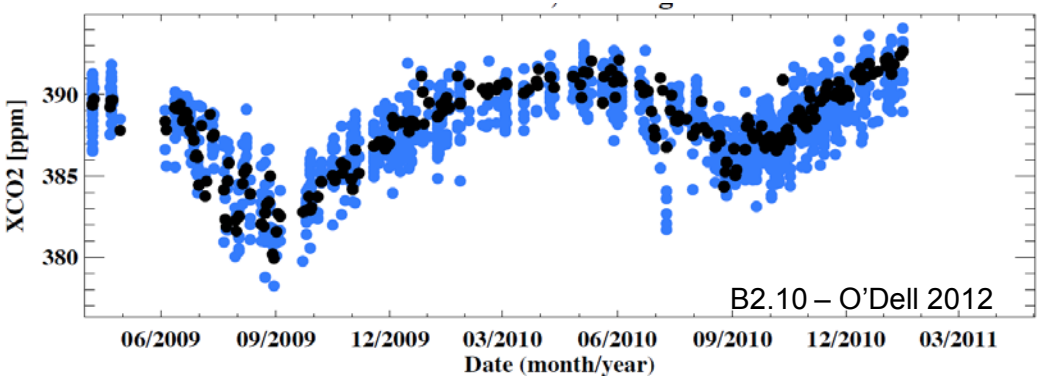


Validation of GOSAT Products against TCCON Reduces Regional Scale Bias



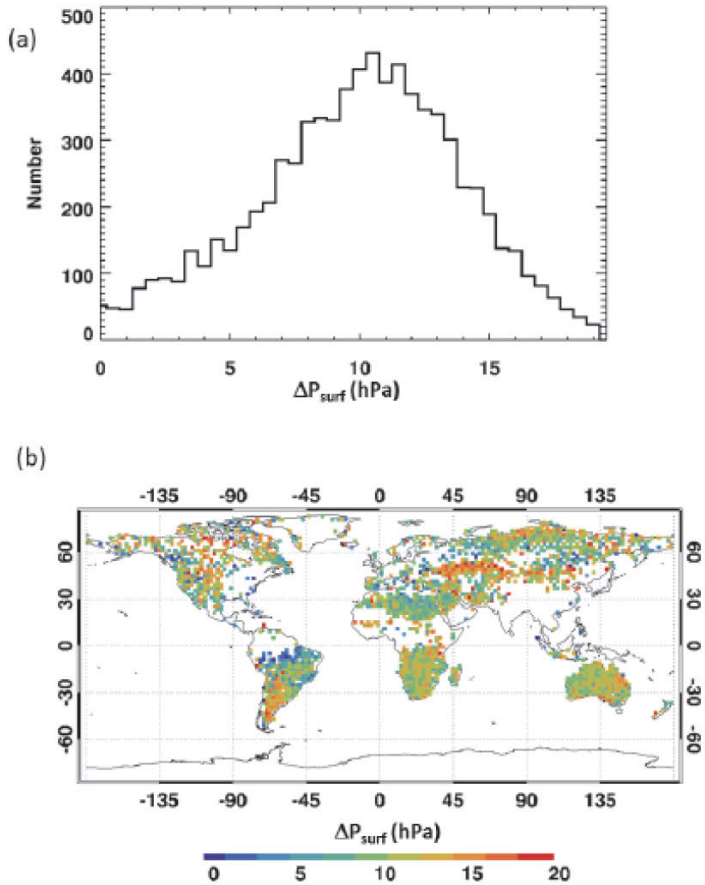
Near-simultaneous observations are acquired over TCCON station.



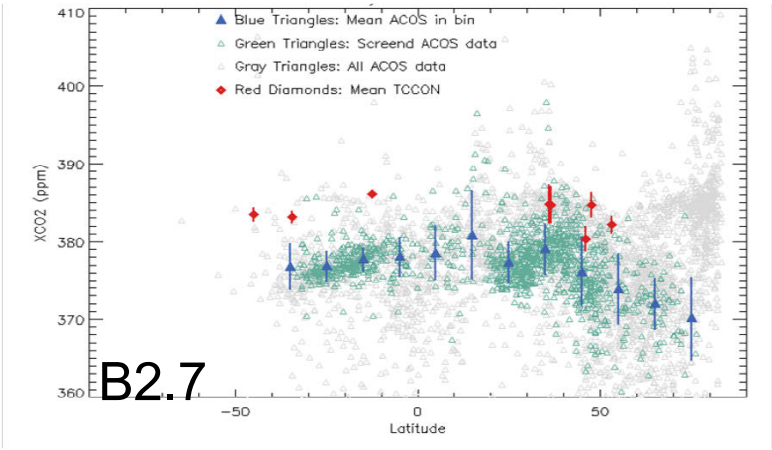


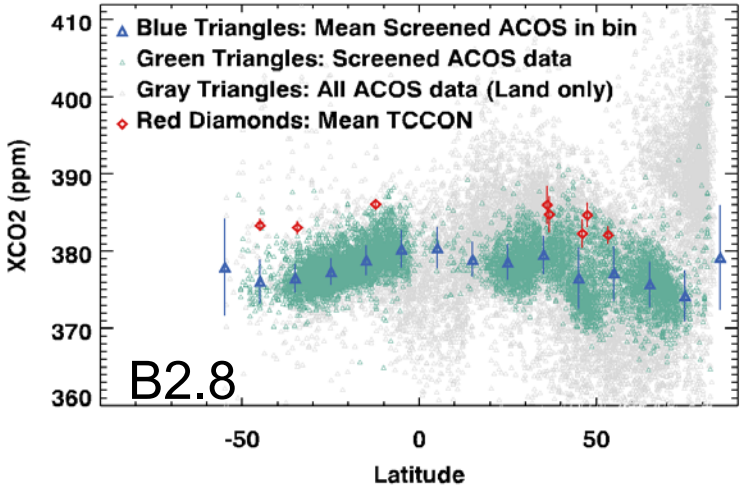
GOSAT X_{CO2} retrievals are compared with those from the ground based Total Carbon Column Observing Network (TCCON) to verify their accuracy

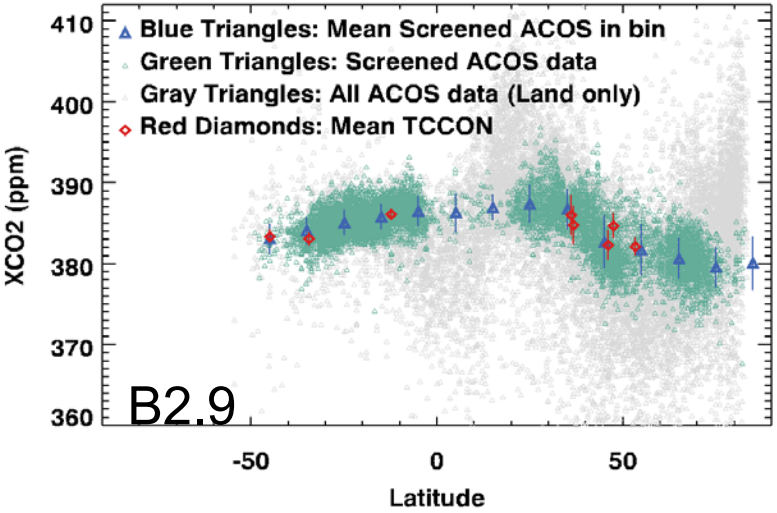
Surface Pressure Bias

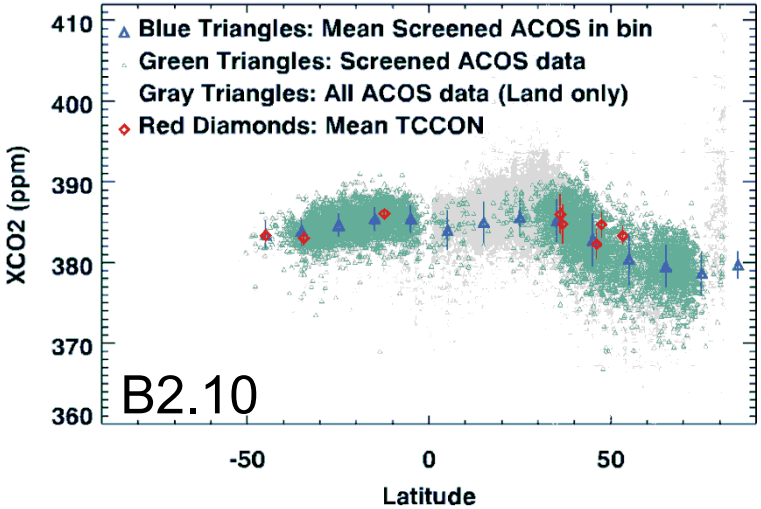


TCCON Comparisons Show Improvements in Bias and Random Error over Time

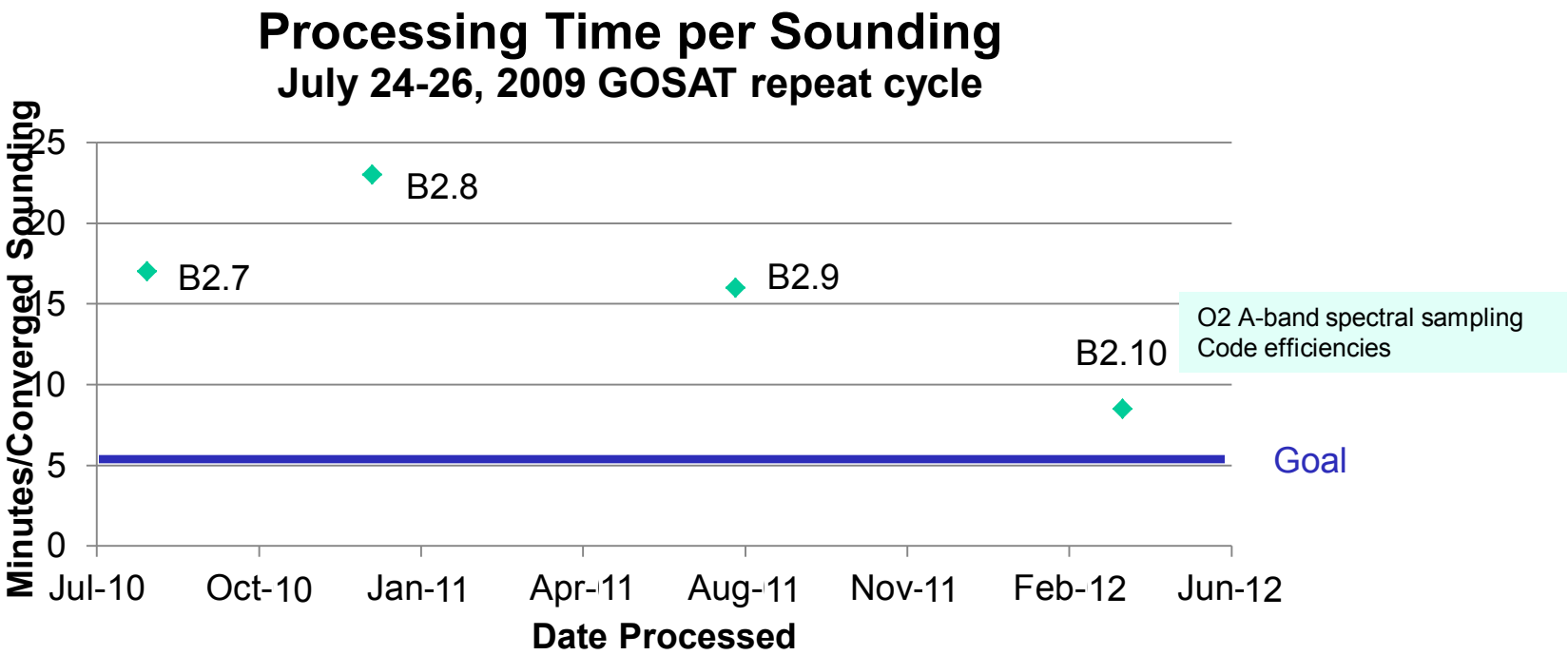




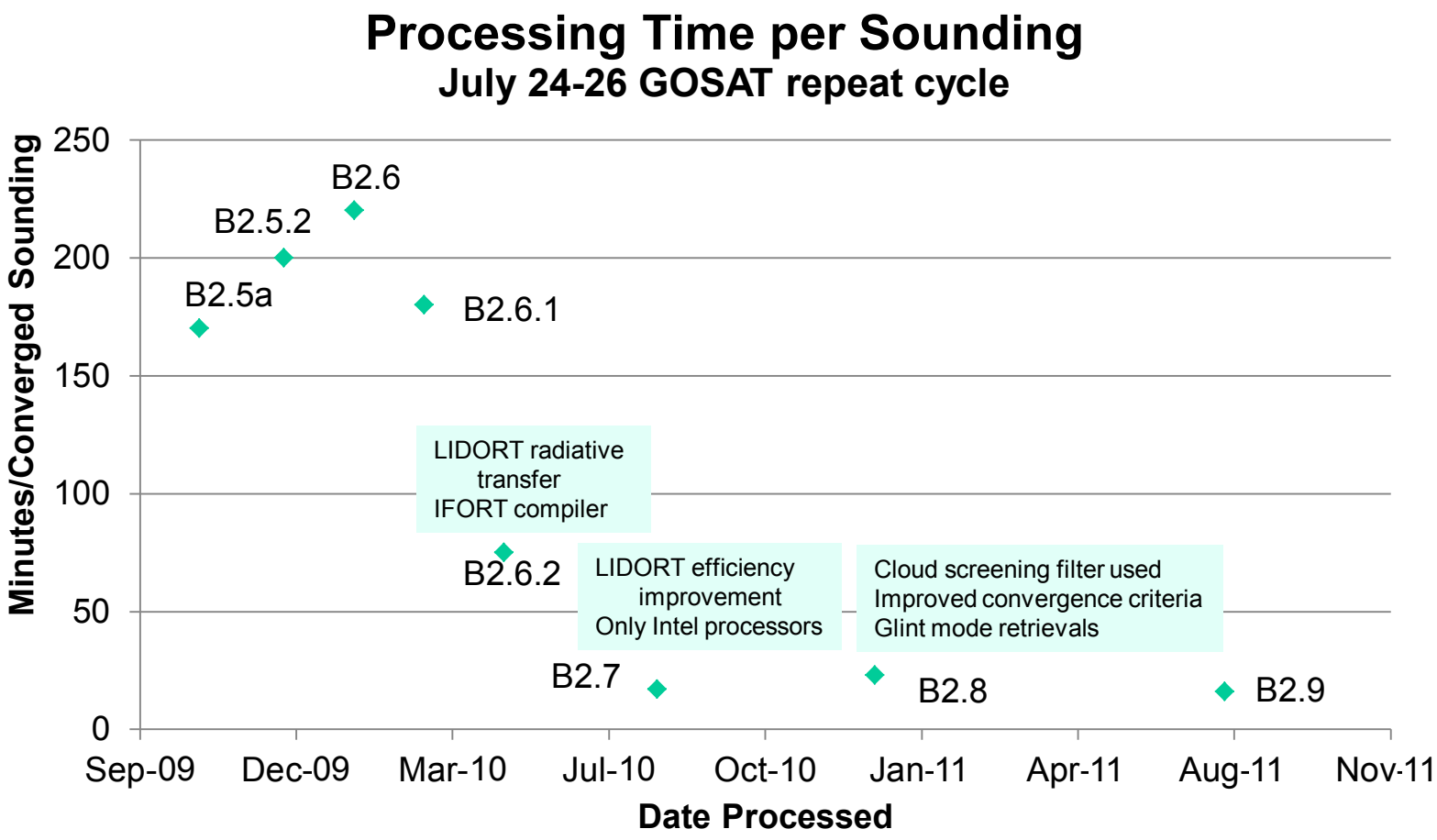




Retrieval Processing Time



Retrieval Processing Time



Conclusions

- GOSAT data provide invaluable resource to test ACOS/OCO-2 L2 algorithm
- Spectroscopy and radiative transfer model improvements have helped remove most of the bias in X_{CO2} retrievals
- Detection and quantification of regional scale biases in ACOS X_{CO2} product by comparing ACOS/GOSAT and TCCON retrievals
- Opportunities to refine vicarious calibration and validation approaches for OCO-2 mission
- Ready for large inflow of data from OCO-2 due to L2 algorithm speed improvements

Outlook

- Instrument characterization and thermo-vacuum testing completed
- Instrument meets specifications
- Observatory undergoing final testing
- Launch vehicle selected
- Launch date set for July 2014