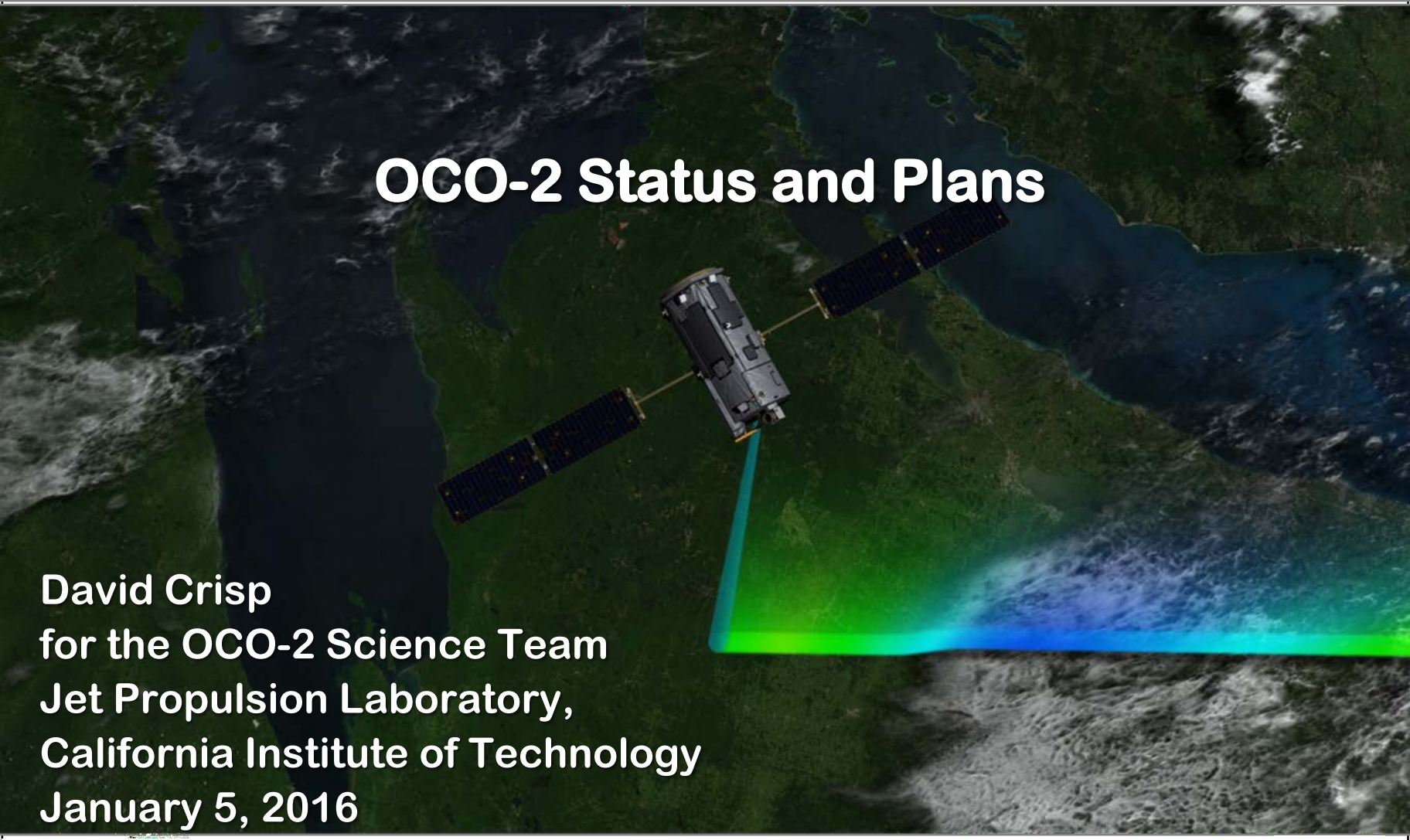
OCO-2 Status and Plans



David Crisp
for the OCO-2 Science Team
Jet Propulsion Laboratory,
California Institute of Technology
January 5, 2016

Copyright 2016 California Institute of Technology.
Government sponsorship acknowledged.

Agenda

- Evolution of the OCO-2 Team
- OCO-2 status update
  - Observatory Status
  - Instrument Status
- OCO-2 data product update
- Progress and plans for V8 testing
- OCO-2 plans for reprocessing GOSAT data
- Upcoming Meetings
  - Plans for AMS
    - Monday Sessions
    - Hyperwall

Evolution of the OCO-2 Team

- Project Management
  - Ralph Basilio, who has been the OCO-2 Project Manager since 2010, has moved on to manage another JPL project (NEOCam)
    - Ralph will continue to serve as the OCO-3 Project Manager
  - The new OCO-2 project manager is P.J. Guske
    - P.J. served as the Mission Operations lead for the OCO and the Mission Operations Manager for OCO-2
    - He is now continuing in that role in addition to serving as the OCO-2 Project Manager

- Science Management
  - Mike Gunson is continuing to serve as the Project Scientist, but must return half time to his role as Global Change and Energy Program Manager at JPL.
  - Annmarie Eldering is continuing to serve as the Deputy Project Scientist for OCO-2, but will most likely be spending substantially more time in her "additional duty" as the OCO-3 Project Scientist

Observatory Status

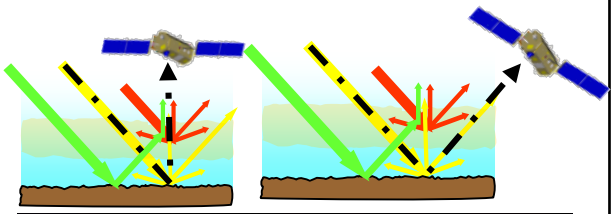
OCO-2 Observatory Status

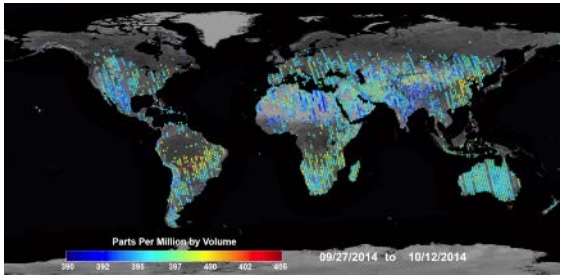
- The OCO-2 spacecraft operations are "NOMINAL"
  - Optimal Observing Strategy Implemented on 11/11/2015
    - Alternating Glint/Nadir observations for orbits flying over land
    - Glint-only for orbits primarily over ocean
  - Risk Mitigation Maneuver # 5 (RMM 5) on 12/10/2015
  - Drag Makeup Maneuver #9 (DMM 9) on 12/30/2015

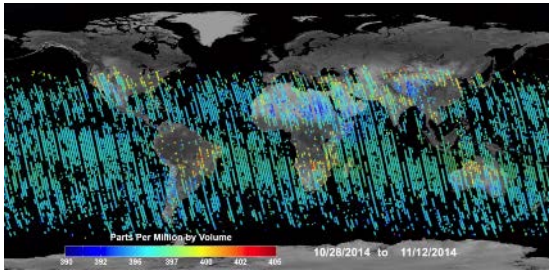
- Data outages:
  - 11/12-11/16: Orbits 7260 – 7280 Optimal Observing tests – Optical Bench T's unstable - data collected but not processed past L1A
  - 11/18: Orbits 7336 -7337 lost due to DMM 8
  - 11/21: Orbit 7389 lost Due to RMM 4
  - 11/26: Orbits 7447 – 7453) power outage at Alaska Satellite Facility
  - 12/10: Orbits 7666 and 7670 lost due to RMM 5
  - 12/30: Orbits 7960-7961 lost due to DMM 9

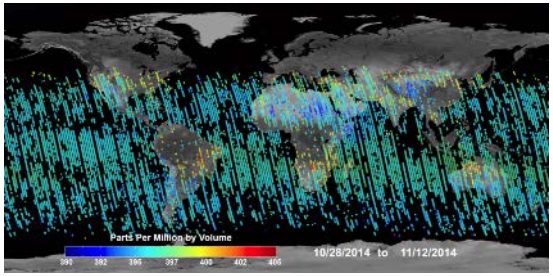
Changes in the OCO-2 Observing Strategy

- OCO-2 collects science measurements while observing:
  - Nadir: along ground track at local nadir
    - more useful data over high latitude land
  - Glint: toward the "glint spot," where sunlight is specularly reflected by surfaces
    - better S/N over ocean
- Initially, Nadir and Glint observations were collected observations on successive, 16-day ground repeat cycles
  - Leaves 16-day gaps over oceans
- July 2: Began collecting Nadir and Glint data on alternating orbits
- On November 11th, the strategy was refined further to always collect glint data on predominately ocean orbit tracks









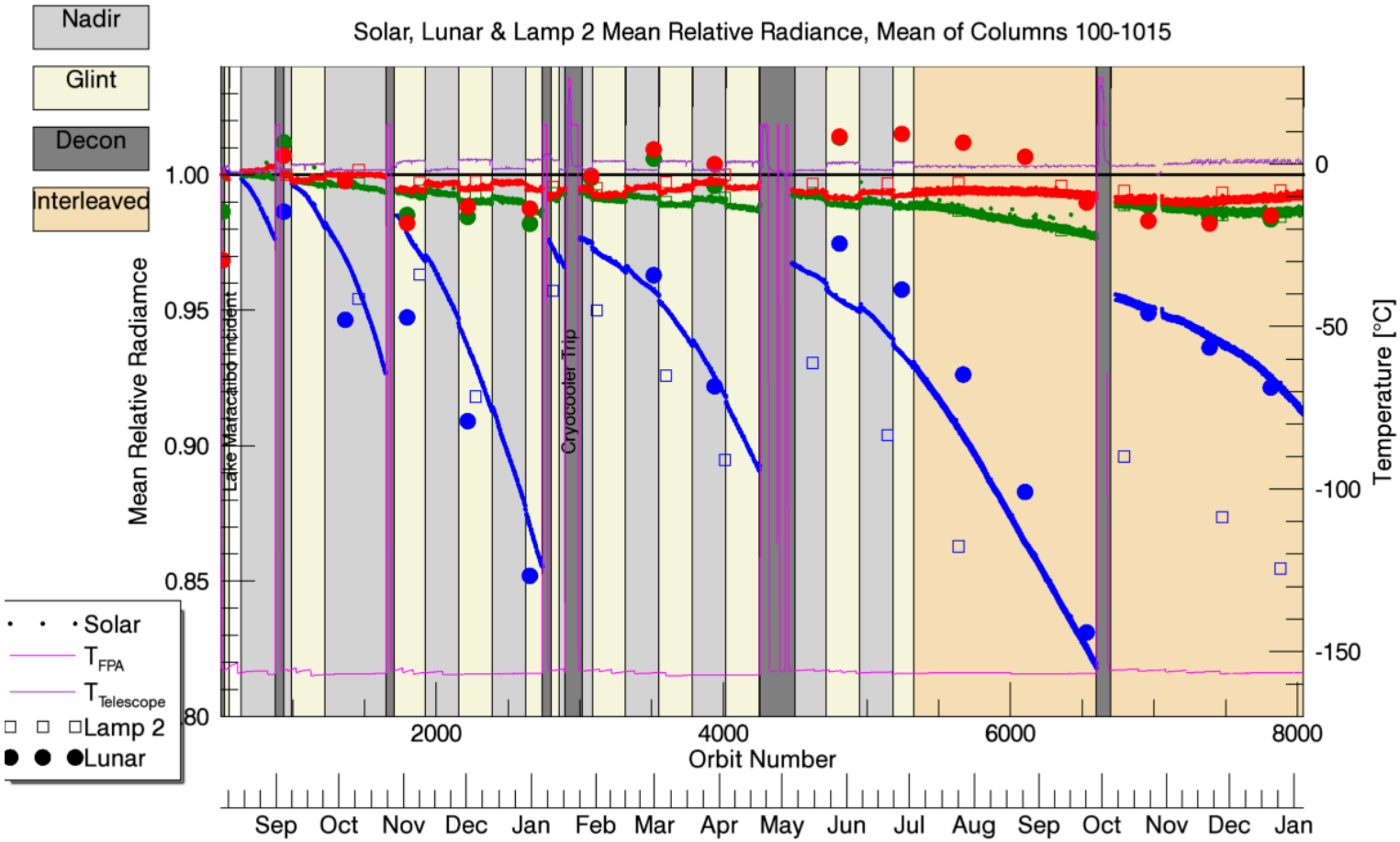
Instrument Status

OCO-2 Instrument Status

- The instrument operations are nominal following change to optimal observing mode
  - Optical Bench temperatures unstable: orbits 7261 - 7279
  - Optical bench temperature range now stabilized at ±0.1 °C
  - Optimized Sci. mode, orbit range: orbits 7280 - onward

- A-Band Sensitivity Variations
  - The sensitivity degradation has two separate components
    - A "fast degradation" that is reversed by decontamination cycles
    - A "slow degradation" that is monotonic
  - A plausible root cause for the "fast" sensitivity degradation has been identified -- ice on the focal plane and cold filter degrades efficiency of the anti-reflection coating
  - The root cause for the slow degradation is still under investigation
  - Both fast and slow degradation are corrected in the L1b product
- Next decontamination cycle some time in March 2016

A-Band Sensitivity Degradation



The rate of sensitivity loss in the ABO2 channel (blue) is decreasing with time, for both the “fast” (correctable) and “slow” (monotonic) components of the loss.

OCO2- GOSAT spectra comparison

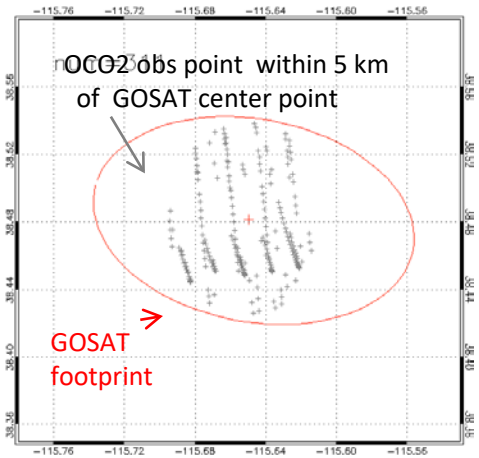
Jun29,2015

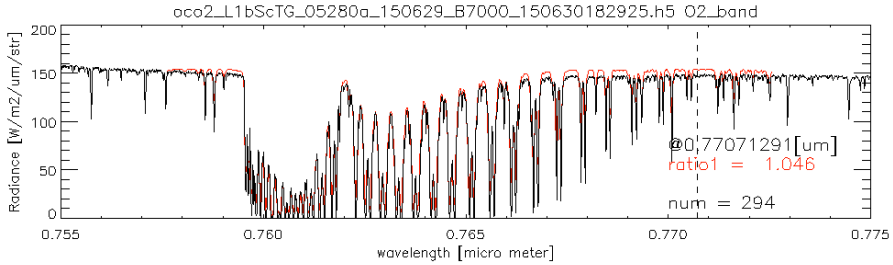
oco2_L1bScTG_05280a_150629_B7000_150630182925.h5
GOSATTFTS20150629211603702 42_1BSPOD161161.01

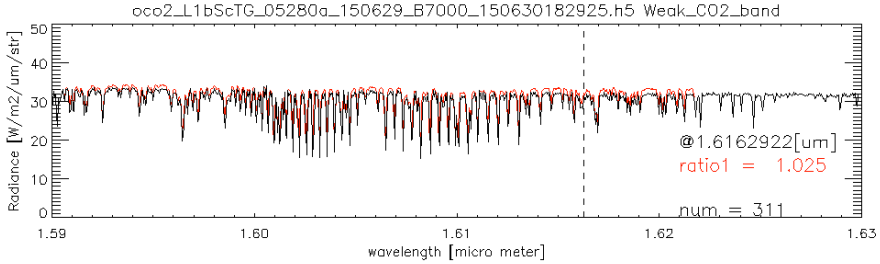
GOSAT Rad
OCO2 average Rad within 5km of GOSAT cnt point X 2

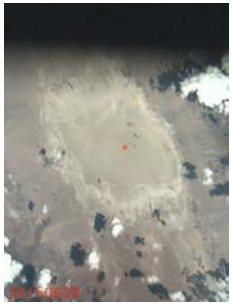
ratio1 = OCO2/GOSAT

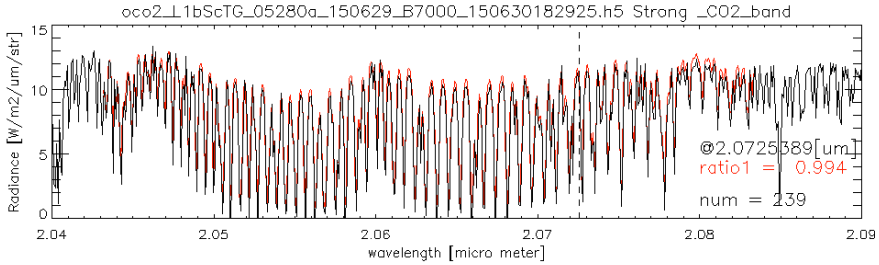
OCO2: path139 (looking from West)
GOSAT: path37 (looking from West)









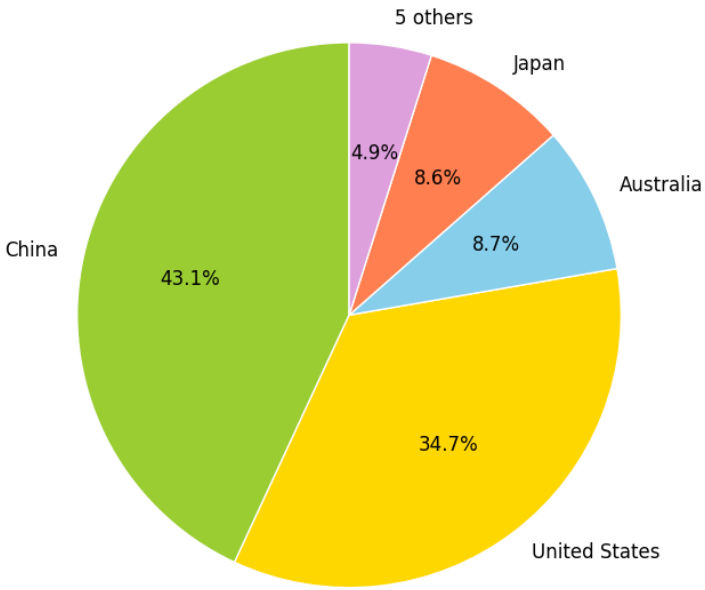


A. Kuze et al.

Progress and Plans in Delivering OCO-2 Level 2 Products

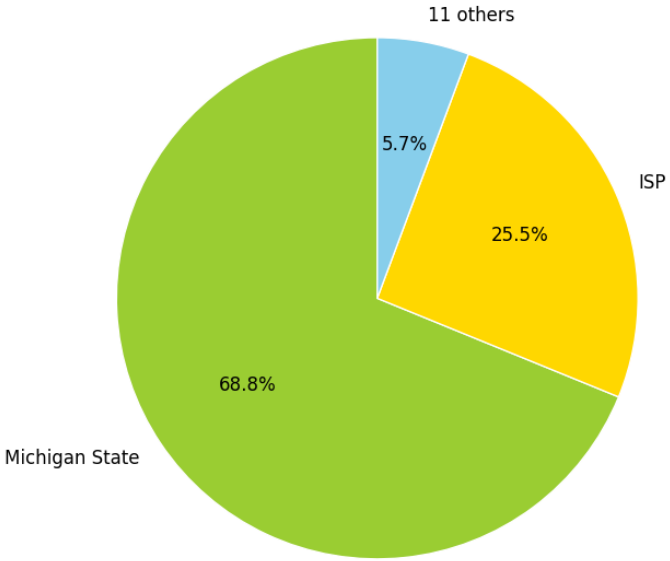
December Downloads of V7 L2 Standard Product

By Country



Michigan State?

By US Organizations



ISPs = Individuals accessing via commercial Internet Service Providers

OCO-2 B7r Standard Production Calendar

as of 12/30/2015 Build 7.0.00 L2 XCO2 Production & Delivery Status - Retrospective Calibrat

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July																															
August																															
September						D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
October	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D				D	D	D	D	D
November	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
December	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
January-15	D	D	D	D	D	D				D	D	D	D	D	D	D	D								D	D	D	D	D	D	D
February	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D			
March	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
April	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D											
May							D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
June	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
July	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
August	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
September	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D			
October							D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D				D	D
November	D																														
December																															

Warm

Cold, unstable

Cold, stable

Completely without Science

B7 processing
complete

incomplete

not begun

B7r processing
complete

incomplete

not begun

Facility
cluster

Pleiades

Amazon

Days delivered to GES DISC
D all orbits delivered

OCO-2 B7r Lite Production Calendar

as of 12/30/2015 Build 7.0.00 Lite XCO2 Production & Delivery Status - Retrospective Calibra

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July																															
August																															
September						D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
October	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D					D	D	D	D
November	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
December	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
January-15	D	D	D	D	D	D				D	D	D	D	D	D	D	D								D	D	D	D	D	D	D
February	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D			
March	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
April	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D											
May							D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
June	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	
July	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
August	D		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
September	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D			
October							D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D				D	D
November																															
December																															

Warm | Cold, unstable | Cold, stable | Completely without Science

B7 processing
complete | - incomplete | not begun

B7r processing
complete | - incomplete | not begun

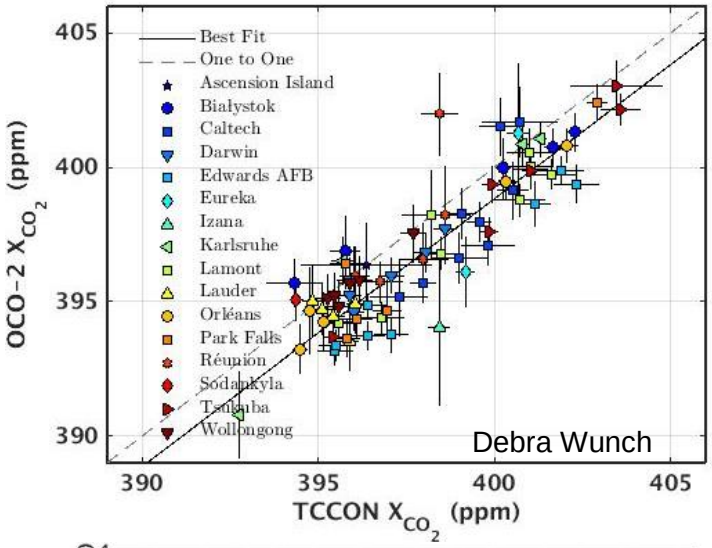
Facility
cluster | Pleiades | Amazon

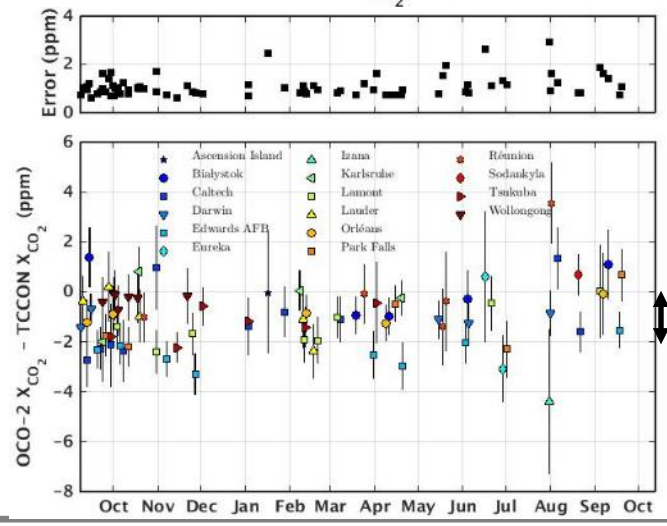
Days delivered to GES DISC
D all orbits delivered

The B7r Lite file deliveries are currently lagging the B7r Standard file deliveries by about one month.

Filtered and Bias-Corrected OCO-2 vs TCCON

- OCO-2 made 179 target observations since August 2014
  - 80-90 are of good enough quality for comparisons to TCCON data Now making 8-10 target observations each month
  - Top figure: Relationship between OCO-2 target mode data and TCCON data recorded during the target observation
  - Bottom figure: Time series of OCO-2 comparisons to TCCON
    - no drift in comparisons over the first year
- OCO-2 data source: "Lite" products
  - removed the small offset between the satellite and TCCON observations
  - screening with OCO-2 "Warn Levels"





Version 8 Testing Status and Plans

V8 Schedule

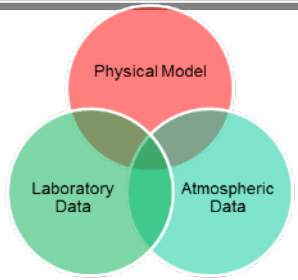
DRAFT

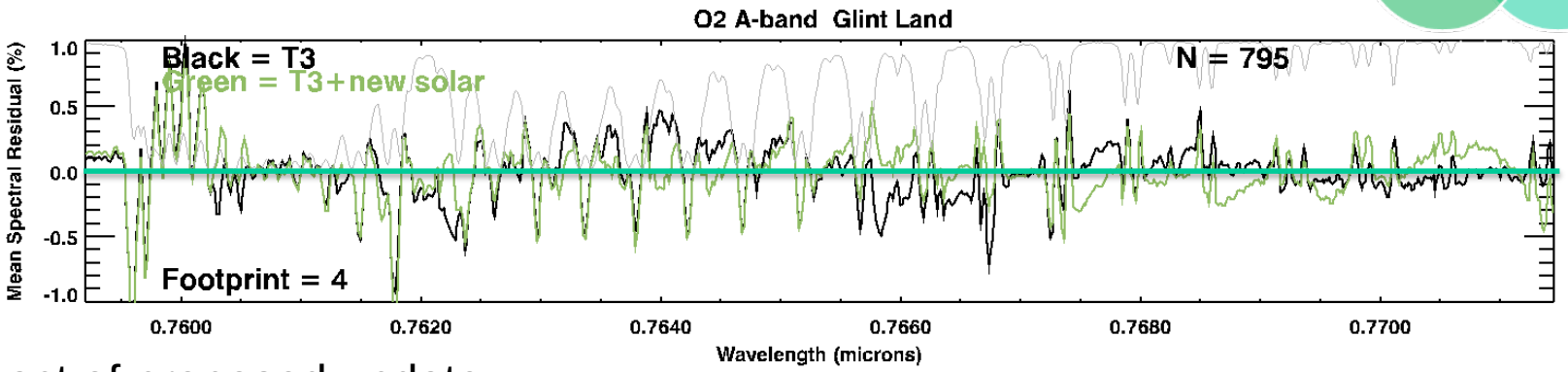
- Aerosol testing focus – Dec 2015
- Spectroscopy testing – Dec 2015
- Complete all changes and clean up – Feb 2016
- EOF development, check ABSCO scaling, etc… - early Mar 2016
- Prototype test and delivery - Mar 2016
- Run and analyze data required for bias correction and WL (~10 % run) – Apr 2016
- Software test and delivery – mid-May 2016
- Begin forward stream – late May 2016
- V8 L1b reprocessing campaign, if necessary – Jun-July 2016, but duration depends on resources used
- V8 L2 reprocessing campaign, if necessary – Jun-Jul 2016, but duration depends on resources used

Note: Months in RED are notional and may shift, but indicate the time needed to implement V8 once all changes for are finalized.

Updated spectroscopy for the O_2 A-Band [Payne et al.]

Problem: XCO_2 retrievals require accurate characterization of the dry air mass. OCO-2 uses the 0.76 μm oxygen A-band for this. Persistent spectral residuals and biases/airmass dependence in retrieved surface pressure indicate a need for improved A band spectroscopy.





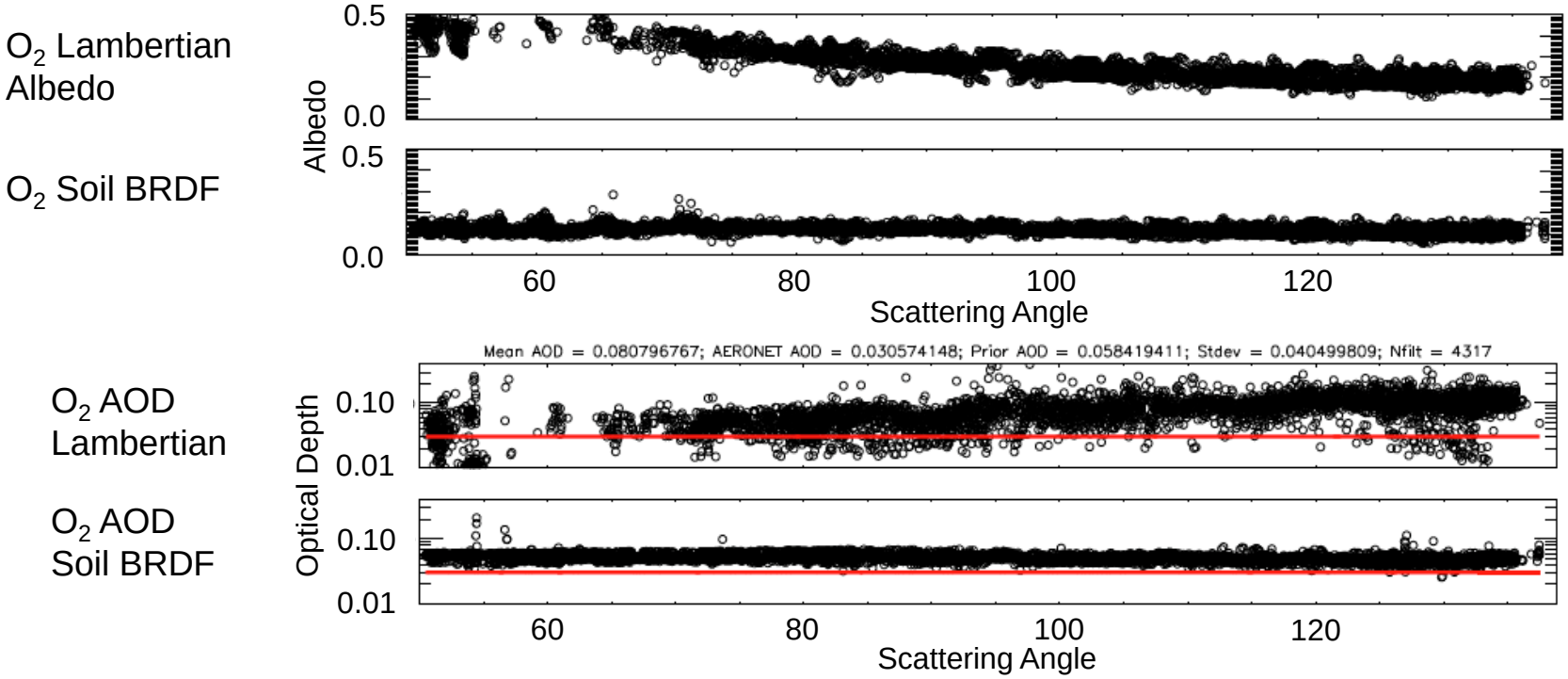
Impact of proposed update

- **O_2 A-band χ^2 values improve, residual envelope is flatter**
- **Reduction in retrieved-ECMWF P_{SUR}**
- Systematic features between O_2 doublets
- Systematic features near R-branch bandhead

	Small area		TCCON	
	Bias (hPa)	Std. dev. (hPa)	Bias (hPa)	Std. dev (hPa)
V4.2	-3.0	4.1	-3.1	3.8
new	-0.7	4.1	0.2	3.0

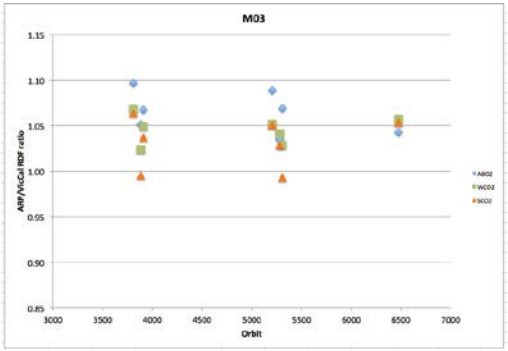
Issues in Work – Improved Surface BRDF [Natraj et al.]

- The L2 algorithm uses a Lambertian surface reflectance instead of a realistic bi-directional reflection distribution function (BRDF)
  - This simplification introduces air mass dependent biases in the albedo, aerosol optical depth (AOD) in target observations
  - May introduce airmass biases in X_{CO2}
- These biases are reduced when a realistic BRDF is used

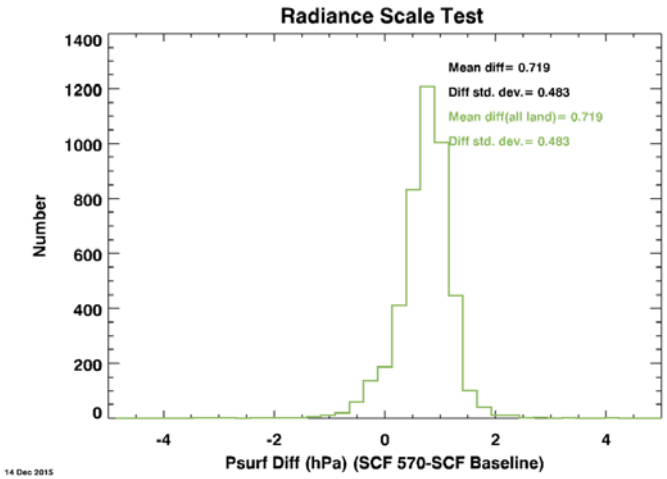


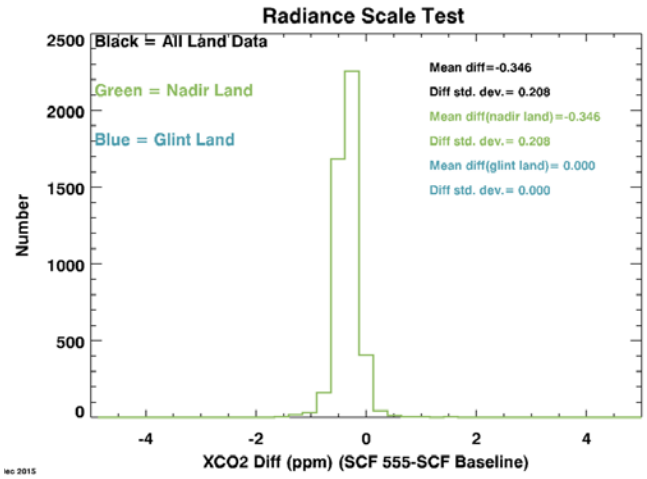
Issues in Work – Radiance Scaling

- Comparisons of OCO-2 calibrated radiances and Vicarious Calibration results from RRV indicate that the OCO-2 radiances are ~5% too high.
- Comparisons to GOSAT (which is calibrated against RRV) reinforce this result.
- To assess the impact of this calibration uncertainty, and develop a correction, a test was conducted as part of the version 8 development.

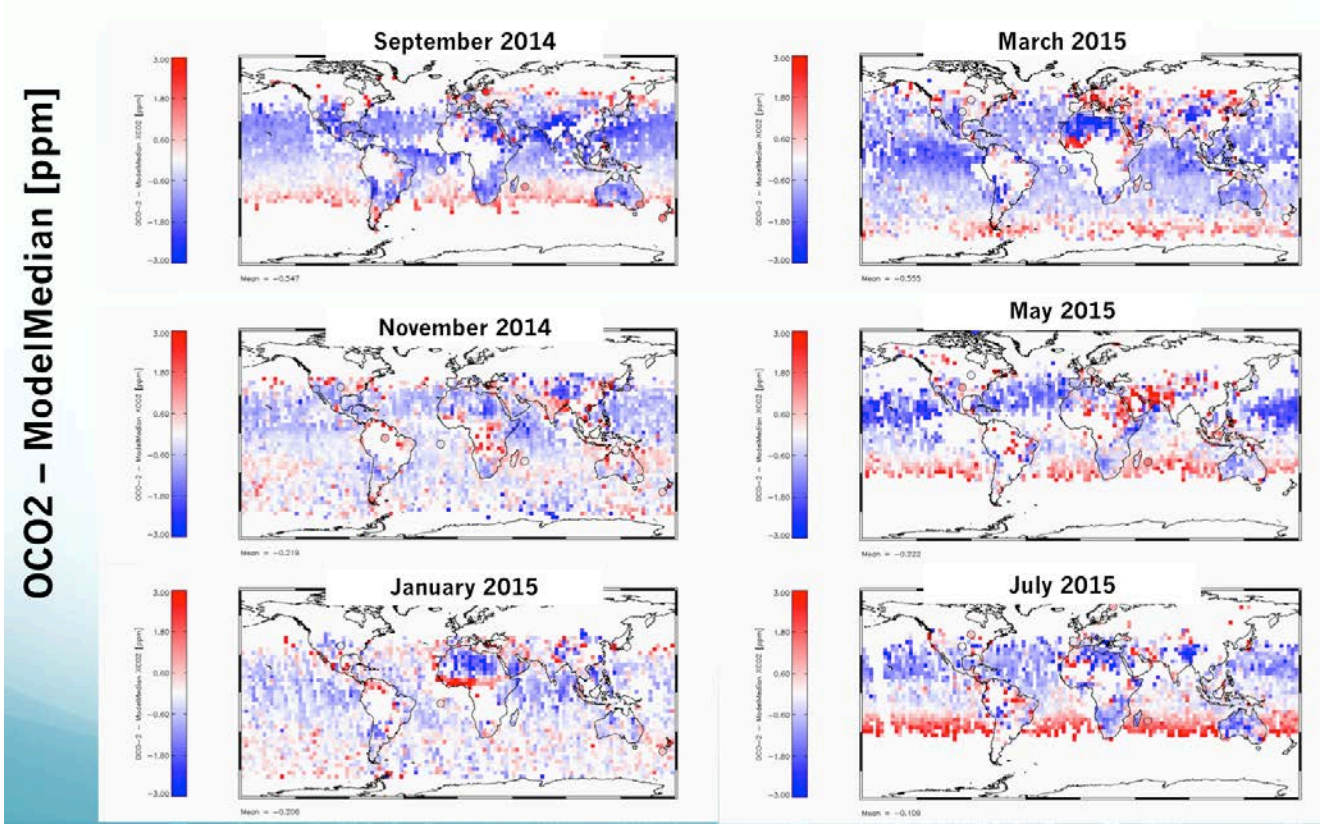


The radiometric calibration change introduced a 0.72 hPa pressure change and a -0.35 ppm XCO2 change





Biggest item without resolution: High Latitude Glint Anomaly



- Glint data looks incorrect at high latitudes for part of year
- Will have smaller focus group meeting daily over next two weeks to try to find a solution

Plots from Chris

V8 Update Status and Plans

Accepted updates

- Spectroscopy
- Cirrus height prior

Ongoing Tests

- BRDF updates (need to complete testing, design prior strategy)
- SAA screening in prescreeners – in test. Need assessment of how it will impact data yield
- Aerosols – need update, but daily prior from GEOS FP-IT looked promising
- L1b updates
- Assessment of High latitude glint anomaly

For all these items, need a timeline of next steps

Other V8 Changes under consideration

The following changes are interesting but may not make an impact

- EOFs in wavelength space (instead of pixel space)
- EOF = EOF1 + α EOF2
- Quadratic dependence of surface albedo
- Updated solar spectrum

Again, for each of these tests, we need a timeline of next steps, and commitment from assignee

GOSAT v201201 Processing Plans

Plans for Processing the GOSAT v201201 Product

- There is a strong consensus among the OCO-2 Science Team that a uniform, 6+year GOSAT product processed through the same algorithm as the OCO-2 product would be valuable for several investigations.

- The OCO-2 Science Data Operations System (SDOS) team is preparing to reprocess the v201 product
  - Updated documentation on the differences between this product and the v160160 product has been obtained
  - Some questions remain to be answered.

- A testing program is currently under development

- The timing of the reprocessing effort is currently under discussion, and will be modified pending the outcome of the tests

Theme Group Meeting/Telecon Schedules

- Absorption Coefficient, Monday, January 3, 11 AM PST
- Calibration: Wednesday, 6 January 2-3 PM
- Cloud/Aerosol:
- Flux Inversion: Friday, January 8, 1-2 PM PST
- Level 2 Algorithm: Monday and Wednesday at 10 AM PST
- Uncertainty Quantification:
- Validation: January 25, noon PST

Upcoming Meetings

- 10-14 January 2016: American Meteorological Society (AMS), New Orleans, USA
- 26-28 January 2016: ESA Carbon from Space, Exeter, U.K.
- 21-23 March 2016: OCO-2 Science Team Meeting
- 17-22 April 2016: EGU, Vienna
- 17-22 April 2016: International Radiation Symposium, Auckland, New Zealand
- 9-13 May 2016: ESA Living Planet Symposium, Prague
- 17-18 May 2016: NOAA ESRL GMD Annual Meeting, Boulder
- 22-26 May 2016: Japan Geosciences Union (JpGU), Makuhari Messe, Japan
- 6-7 June, 2016: GOSAT RA PI Meeting, Kyoto
- 7-9 June, 2016: IWGGMS-12, Kyoto