

OCO-2 Status

July 3, 2018

*Happy
Anniversary
OCO2*

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



Overview

- **Observatory Status: Nominal**
 - Passed 4th anniversary on 2 July 2018
 - Latest Drag Makeup Maneuver on 7 June 2018
 - Formation flying overlap expected to be 73% through this cycle
- **Instrument Status: Nominal**
 - Most recent Decontamination Cycle conducted 13-20 February
- **Science Status: Nominal**
 - Two reprocessing efforts are ongoing
 - “Version 9” Lite file updates (geolocation, met re-sampler fix)
 - ACOS GOSAT V8 processing
 - Plans for the Version 10 product coming together
 - Brief report from the 10th Annual Railroad Valley Campaign

Spacecraft Status

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Spacecraft Status

The spacecraft is in excellent health as it enters its 5th year in orbit

- All trending to date has been nominal with no concerns for extended operations

Examples:

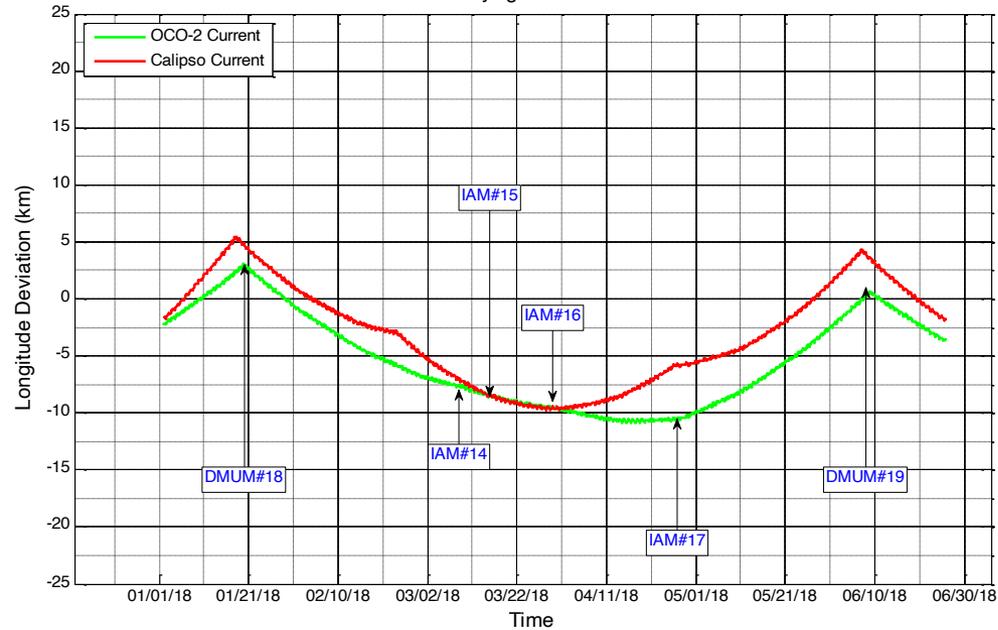
- **Electrical Power Subsystem**
 - Battery remains healthy with no signs of degradation over the past year
 - Loads continue to be less than predicted, providing more margin for battery charging
 - Array degradation rate has been 0.4%/year since first Winter Solstice
 - Even if the worst case degradation rate of 2.5%/year (Solar Max) were to start today, it would still take an additional 13 years before power production became an issue.

Propulsion	
As of 15 Nov 2017 in kg	
Ascent	2.365
RMMs/MCMs	0.078
DMUMs	0.237
IAMs*	3.199
Total	6.879



OCO-2/CALIPSO Ground Track Overlap

Formation Flying Ground Track Error

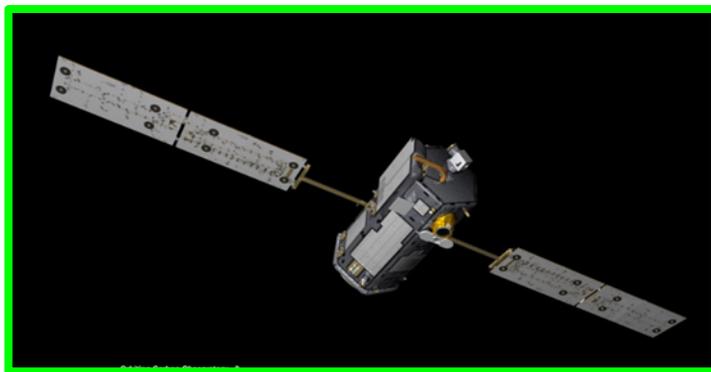
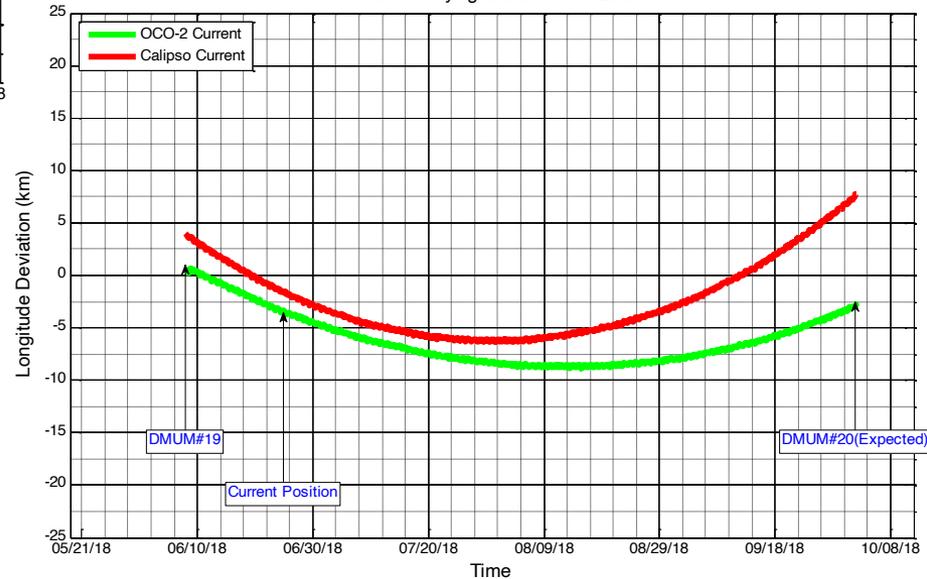


Performance this year



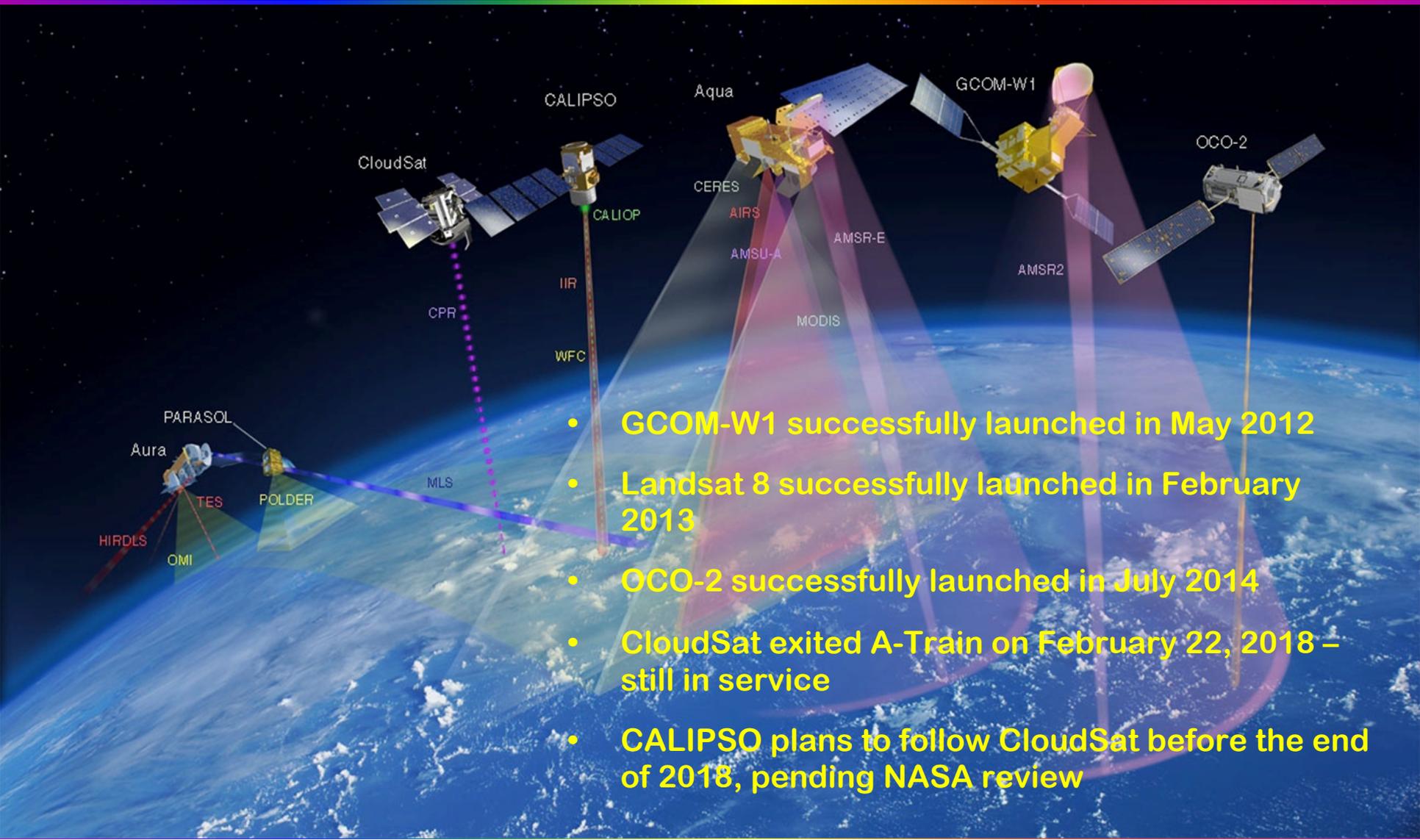
Prediction for this IAM cycle

Formation Flying Ground Track Error





A-Train Constellation Evolution



- GCOM-W1 successfully launched in May 2012
- Landsat 8 successfully launched in February 2013
- OCO-2 successfully launched in July 2014
- CloudSat exited A-Train on February 22, 2018 – still in service
- CALIPSO plans to follow CloudSat before the end of 2018, pending NASA review



OCO-2 Instrument Status

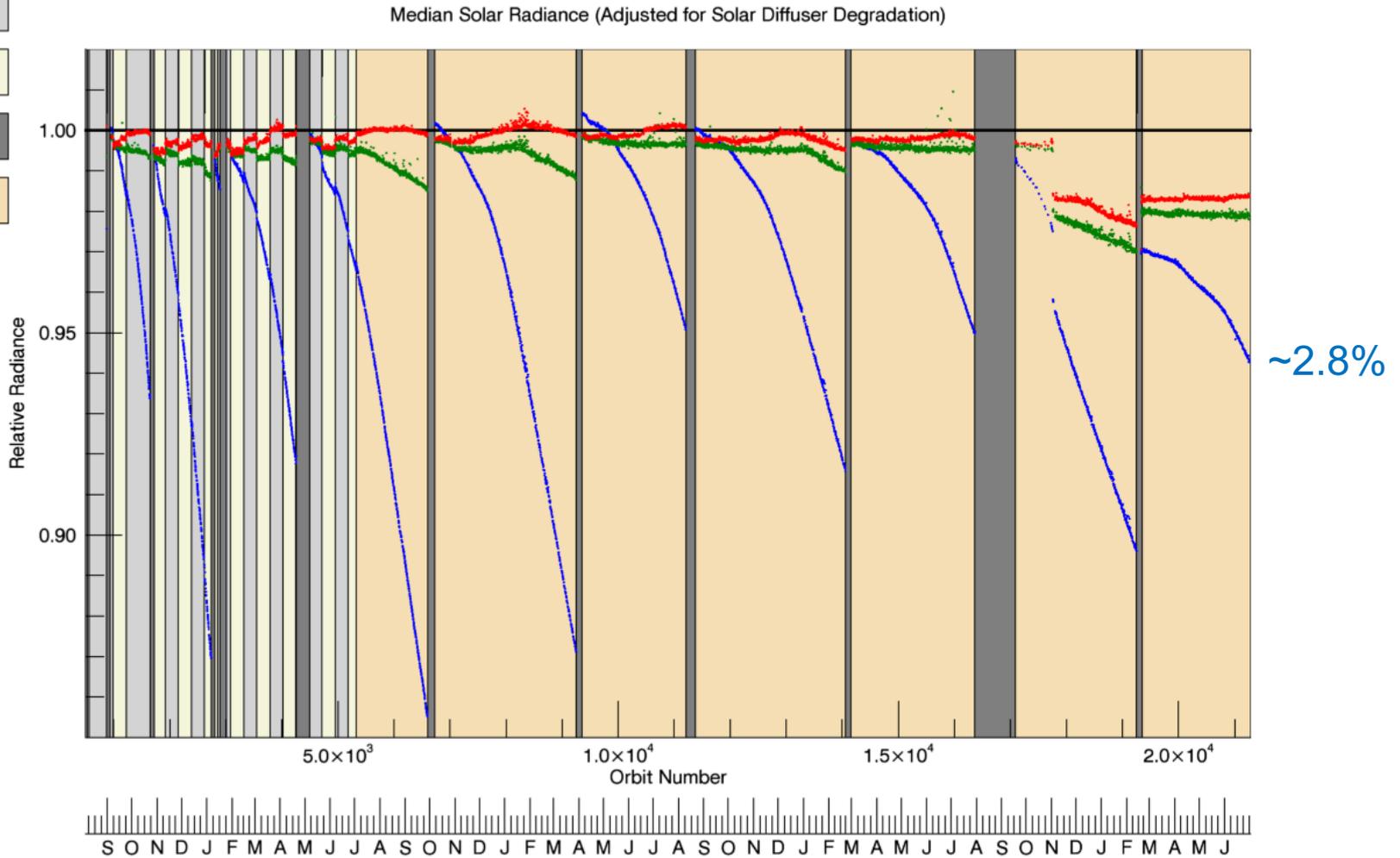
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Decontamination Status

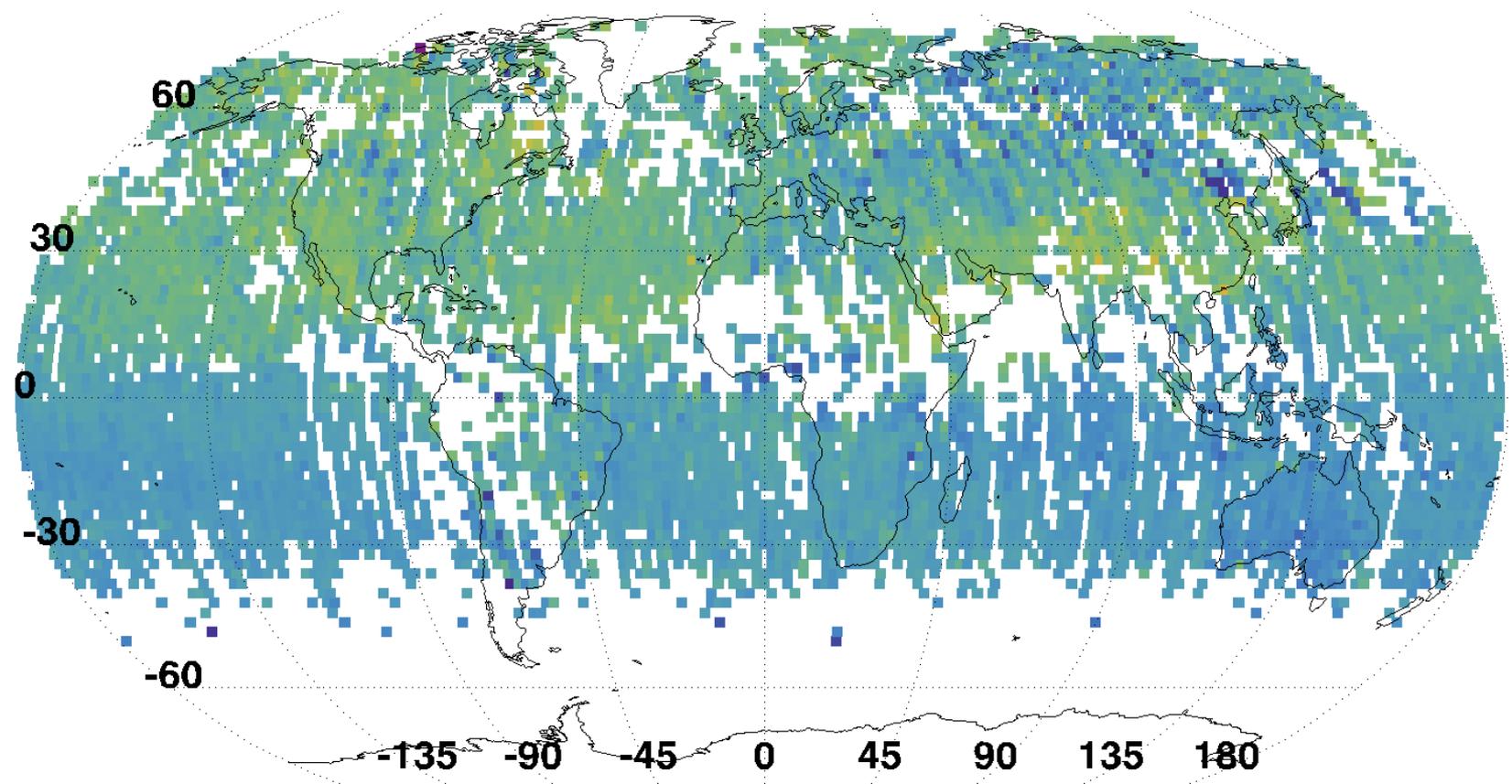
Most recent Decontamination Cycle conducted 13-20 February

- Nadir
- Glint
- Decon
- Interleaved





Mean XCO₂ for June 2018 (V8)



Mean XCO₂ (ppm)



2 Jul 2018
Ops_B8100_r0x



OCO-2



OCO-2 Instrument Status

The instrument is healthy as it enters its 5th year in orbit

- **Cryocooler**

- ~4 years into its 10-year qualified life
- Indication of only very slight wear based on its on-orbit performance
- 6 more years against qualification

- **Focal Plane Assemblies**

- 44 thermal cycles into 100 cycle qualified life
 - Currently planning only 2 cycles/year
 - 28 more years!

- **Lamps**

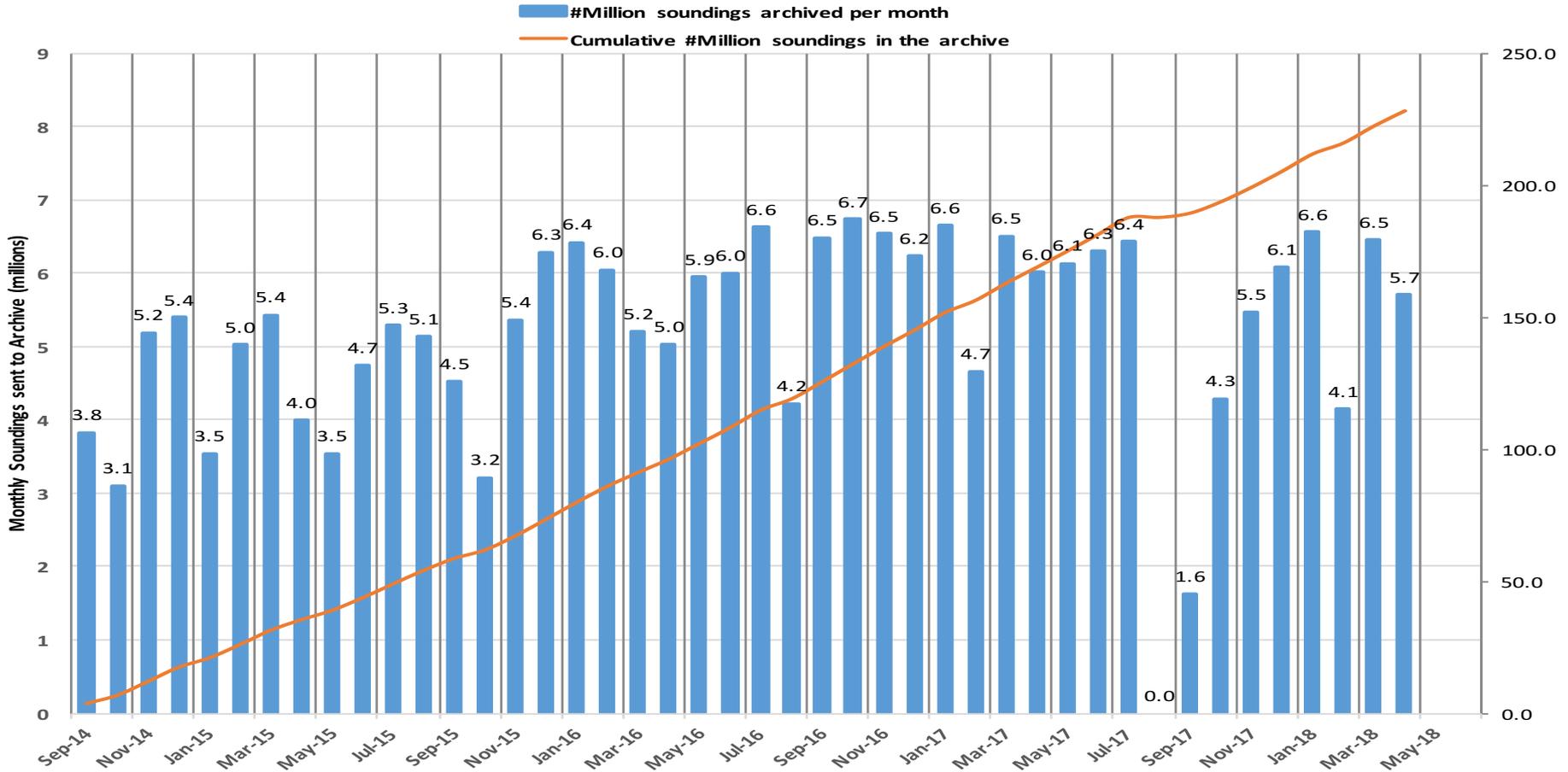
- Lamp 1: 744 hours out of 10,000 hours life
 - Currently in use ~ 200 hours/year
 - 46 more years!

- **Baffle Calibrator Assembly**

- 18,839 cycles out of 62,500 cycles life
 - Currently using ~ 4900 cycles/year
 - 9 more years against qualification



Number of Soundings Archived at GES DISC for V8r



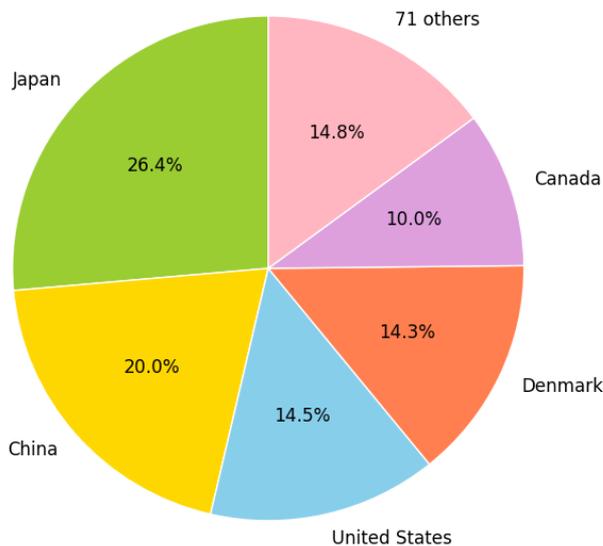
228 Million Soundings archived at GES DISC for V8r through April 30, 2018



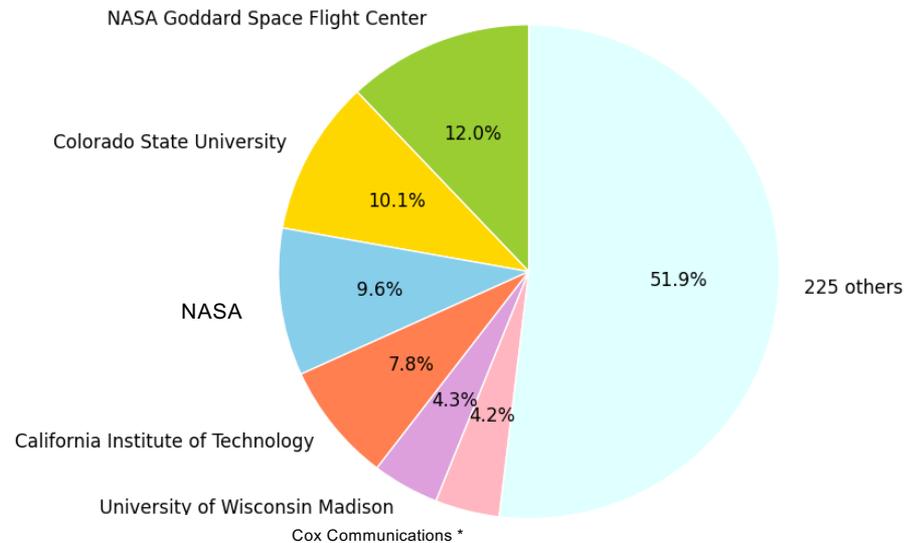


V8 and V8r Products Downloaded to Date

By Country



By Domestic Organizations



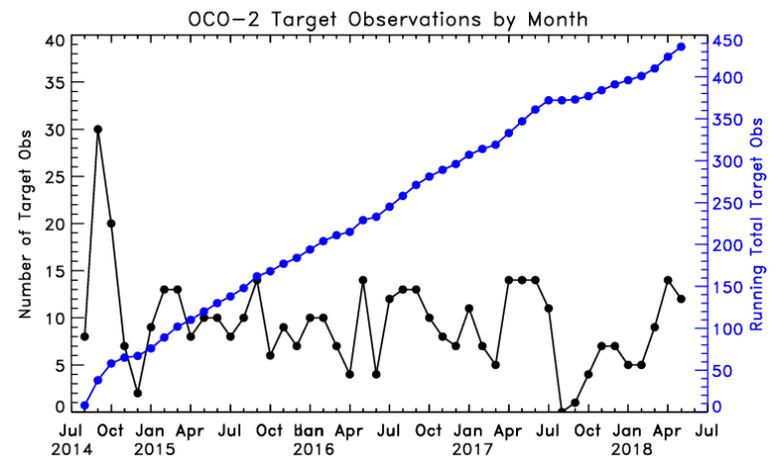
To date, the top 3 users by country are: Japan, China and the United States.
The top 3 users by domestic organizations are: NASA, Colorado State University & Cal Tech.



OCO-2 Validation Updates – May 2018

- OCO-2 has executed 443 target observations since August 8, 2014
- There have been 7 target observations made in June 2018
- Validation campaign activity in June:
 - Supported the Multi-Agency European campaign MAGIC-CoMet campaigns with OCO-2 orbit track predictions and target observations at Orleans and Sodankyla
 - Targeted observations at Railroad Valley for the campaign there.

Target Location	Date/Time	MODIS Image
Sodankyla	2018-06-26 09:53:02	-
Tsukuba	2018-06-25 04:03:39	-
Railroad Valley	2018-06-14 20:53:42	
Park Falls	2018-06-14 19:14:49	
Los Angeles	2018-06-03 21:08:56	
Fairbanks	2018-06-02 22:13:21	
Lamont	2018-06-01 19:43:13	





OCO-2 Target List

Site	# Obs	June 2018	Last Observation	Site	# Obs	June 2018	Last Observation
Anmyeondo	4	0	2017-02-15 04:46:43	Los Angeles	2	1	2018-06-03 21:08:56
Ascension Island	12	0	2018-01-15 14:40:05	Manaus	4	N/A	2015-07-29 17:40:51
Bialystok	10	0	2017-03-30 11:08:35	Mexico City	3	N/A	2016-01-24 19:56:38
Boulder	0	0	-	Niwot Ridge	4	0	2018-05-26 20:21:20
Bremen	2	0	2016-03-17 12:10:17	Orleans	19	0	2018-05-25 13:04:45
Burgos	4	0	2018-05-17 05:31:46	Paris	5	0	2017-11-14 13:04:24
Caltech	28	0	2018-04-23 21:15:43	Park Falls	24	1	2018-06-14 19:14:49
Darwin	19	0	2017-07-28 05:03:39	Poker Flat/Fairbanks	20	1	2018-06-02 22:13:21
Dryden (Armstrong)	17	0	2017-05-17 20:56:38	Railroad Valley	48	1	2018-06-14 20:53:42
East Trout Lake	5	0	2018-05-09 19:42:27	Reunion Island	28	0	2018-03-07 10:11:31
Eureka	4	N/A	2015-06-28 17:06:58	Rikubetsu	4	0	2018-04-19 03:35:19
Hyytiala	6	N/A	2017-07-01 10:39:52	Rosemount	1	N/A	2016-07-01 19:19:56
Izana	10	0	2018-03-24 14:26:18	Saga	8	0	2018-04-18 04:28:14
Karlsruhe	10	0	2017-07-06 12:33:21	Sao Paulo	1	N/A	2016-02-03 17:03:55
Lamont	44	1	2018-06-01 19:43:13	Shanghai	3	N/A	2016-02-07 05:22:09
Lauder	26	0	2018-04-05 03:00:03	Sodankyla	15	1	2018-06-26 09:53:02
Libya	5	N/A	2017-02-20 11:38:42	Tsukuba	22	1	2018-06-25 04:03:39
Litchfield	0	N/A	-	Wollongong	26	0	2018-05-06 03:58:36



Publications Statistics

As of 27-Jun-2018:

- 2014: OCO-2: 7 refereed papers, 1 book chapter
- 2015: OCO-2: 8 refereed papers
- 2015: ACOS: 3 refereed papers, 1 book chapter
- 2016: OCO-2: 18 refereed papers
- 2016: ACOS: 12 refereed papers
- 2017: OCO-2: 48 refereed papers
- 2017: ACOS: 2 refereed papers
- 2018: OCO-2: 15 refereed papers



2018 Publications (1 of 2)

- Basu, Sourish et al., The Impact of Transport Model Differences on CO₂ Surface Flux Estimates from OCO-2 Retrievals of Column Average CO₂, *Atmos. Chem. Phys.*, 18, 7189–7215, 2018. doi:10.5194/acp-2017-1158
- Brynjarsdottir, J., Hobbs, J., Braverman, A. et al., Optimal Estimation Versus MCMC for CO₂ Retrievals *JABES* (2018). <https://doi.org/10.1007/s13253-018-0319-8>
- Chylek, Petr, Tans, Pieter, Christy, John, and Dubey, Manvendra K, The carbon cycle response to two El Nino types: an observational study. *Environ. Res. Lett.* 13, 024001. 2018. doi: 10.1088/1748-9326/aa9c5b
- Cressie, N, Mission CO₂ Control: A Statistical Scientist's Role in Remote Sensing of Atmospheric Carbon Dioxide, *JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION*, 113 (521), 152-181, Theory and Methods, 2018
- Li, Xing , Xiao, Jingfeng, He, Binbin, Chlorophyll fluorescence observed by OCO-2 is strongly related to gross primary productivity estimated from flux towers in temperate forests., *Remote Sensing of Environment*, 2017. doi.org/10.1016/j.rse.2017.09.034
- Lu, Xinchun; Cheng, Xiao; Li, Xianglan; et al., Opportunities and challenges of applications of satellite-derived sun-induced fluorescence at relatively high spatial resolution, *SCIENCE OF THE TOTAL ENVIRONMENT* Volume: 619 Pages: 649-653 Published: APR 1 2018
- Maximilian Reuter, Michael Buchwitz, Oliver Schneising, Stefan Noël, Heinrich Bovensmann and John Burrows, A Fast Atmospheric Trace Gas Retrieval for Hyperspectral Instruments Approximating Multiple Scattering—Part 2: Application to XCO₂ Retrievals from OCO-2, *Remote Sensing* 2017, 9, doi: 10.3390/rs9111102
- Miller, S., M., Michalak, A. M., Yadav, D., and Tadic, J.M., Characterizing biospheric carbon balance using CO₂ observations from the OCO-2 satellite, *ATMOSPHERIC CHEMISTRY AND PHYSICS* Volume: 18 Issue: 9 Pages: 6785-6799, 2018, DOI: 10.5194/acp-18-6785-2018



2018 Publications (2 of 2)

- Oda, Tomohiro; Maksyutov, Shamil; Andres, Robert J., The Open-source Data Inventory for Anthropogenic CO₂, version 2016 (ODIAC2016): a global monthly fossil fuel CO₂ gridded emissions data product for tracer transport simulations and surface flux inversions EARTH SYSTEM SCIENCE DATA Volume: 10 Issue: 1 Pages: 87-107 Published: JAN 18 2018
- Oh, Y.-H. et al., Characteristics of greenhouse gas concentrations derived from ground-based FTS spectra at Anmyeondo, South Korea, Atmos. Meas. Tech., 11, 2361–2374, 2018. doi: 10.5194/amt-11-2361-2018, doi: 10.5194/amt-11-2361-2018
- Richardson, Mark; Stephens, Graeme L., Information content of OCO-2 oxygen A-band channels for retrieving marine liquid cloud properties, ATMOSPHERIC MEASUREMENT TECHNIQUES Volume: 11 Issue: 3 Pages: 1515-1528 Published: MAR 16 2018
- Sun, Ying; Frankenberg, Christian; Jung, Martin; et al., Overview of Solar-Induced chlorophyll Fluorescence (SIF) from the Orbiting Carbon Observatory-2: Retrieval, cross-mission comparison, and global monitoring for GPP. REMOTE SENSING OF ENVIRONMENT Volume: 209 Pages: 808-823 Published: MAY 2018
- Wu et al., Carbon dioxide retrieval from OCO-2 satellite observations using the RemoTeC algorithm and validation with TCCON measurements, Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2017-415>.
- Yi, H., Liu, Q., Gameson, L., Fleisher, A.J., Hodges, J.T.: High-accuracy ¹²C/¹⁶O₂ line intensities in the 2 μm wavelength region measured by frequency-stabilized cavity ring-down spectroscopy. Journal of Quantitative Spectroscopy & Radiative Transfer, 206, 367 - 377, 2018
- Zammit-Mangion, Andrew; Cressie, Noel; Shumack, Clint, On Statistical Approaches to Generate Level 3 Products from Satellite Remote Sensing Retrievals, REMOTE SENSING Volume: 10 Issue: 1 Article Number: 155 Published: JAN 2018

**10th Annual Railroad Valley
Calibration Campaign**

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The 2018 RRV Campaign



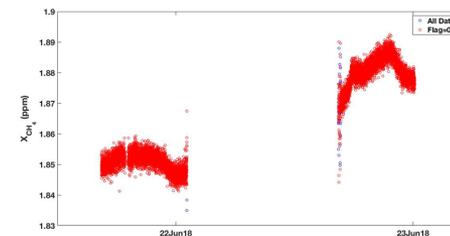
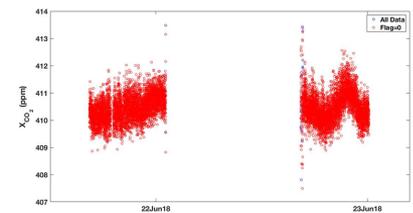
The campaign started at Caltech, with a cross calibration of the EM27 FTSS against the Caltech TCCON.



The JAXA team at Caltech



As has been the tradition in recent years, the EM27's were then deployed for field measurements in Chino.



Caltech EM27 (courtesy of H. Parker-san)



Overpass times

Sensor	Date	Time, UTC	Path	View
GOSAT	Wed. 27Jun2018	21:05	36	20° from East
GOSAT	Thur. 28Jun2018	21:37	37	33° from West
MISR	Fri. 29Jun2018	18:40	40	Nadir
GOSAT	Sat. 30Jun2018	21:05	36	20° from East
OCO-2	Sat. 30Jun2018	20:54	138	Nadir
GOSAT	Sun. 01Jul2018	21:37	37	33° from West
OCO-2	Mon. 02Jul2018	20:41	136	21° from East



A quick Look at RRV in 2018



June 24, 2018



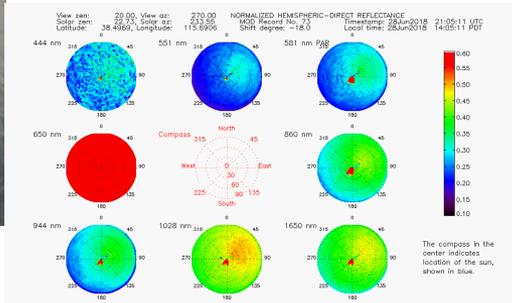
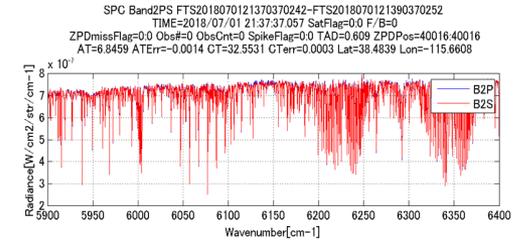
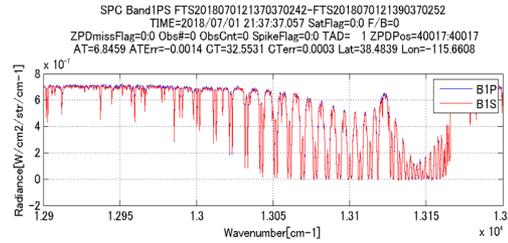
June 27, 2018



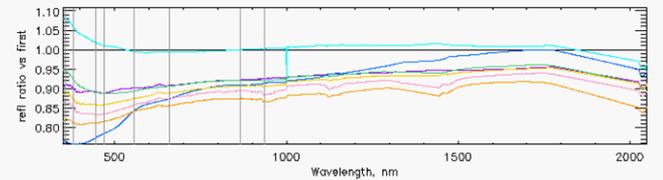
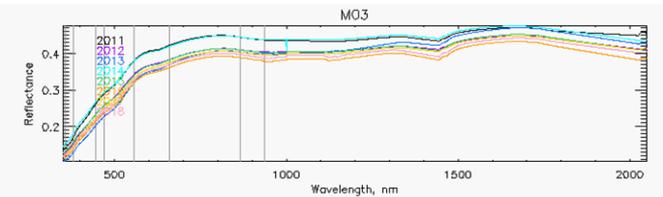
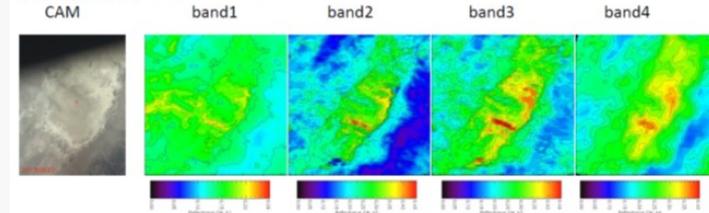
June 29, 2017



July 1, 2018



2018/06/27 CAI Reflectance

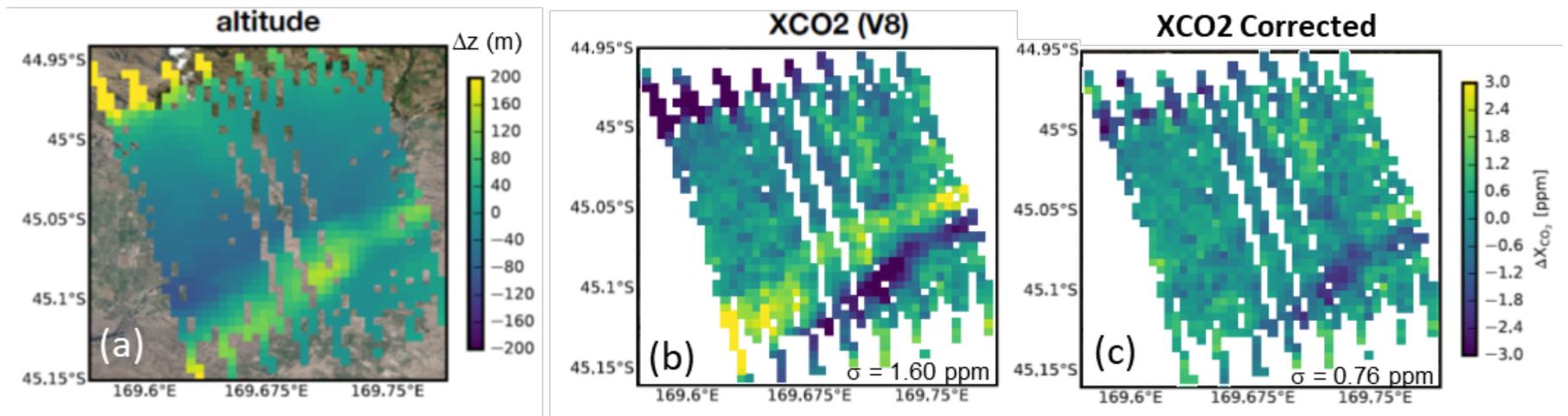


Reprocessing Efforts

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Reminder: Why Is There a V9 Lite Product?



Matt Kiel and Paul Wennberg

OCO-2 observations of the Lauder TCCON station and other regions with moderate to large topographic variability show strong correlations between topographic slope and X_{CO_2} bias (b).

These errors were traced to a small (0.03 degree) pointing error that was $< 1/6$ the angular size of the sounding footprint.

Correcting the pointing error reduced by X_{CO_2} bias by more than half.



Version 9 Production Status

- The SDOS team is processing the data needed for the v9 update. Processing is predicted to complete by July 12.
- The algorithm team will then develop updated filtering and bias correction --> will re-evaluate land/ocean performance
- We are working on updated documentation
- The planned completion of for v9 development is the end of July
- The GES-DISC will receive updated MetResampler data and Lite files which will contain updated geolocation
- Users of the L2 data (still v8 L2Std and L2Dia) will need to grab geolocation from the lite files
- Documentation will include more details on the magnitude and location of changes in geolocation and XCO₂



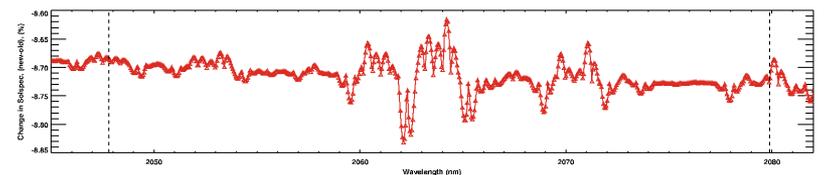
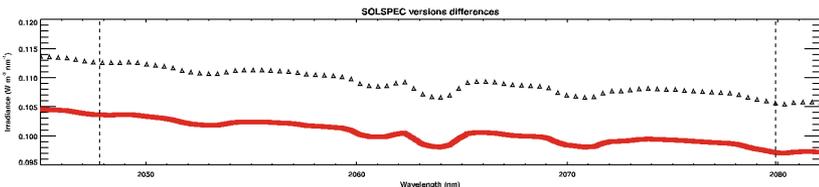
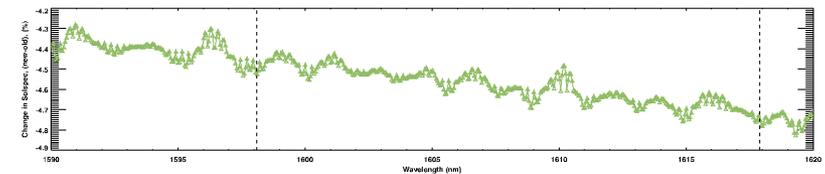
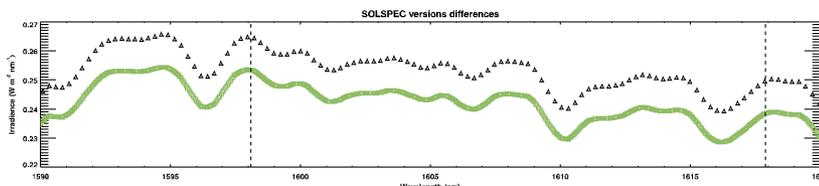
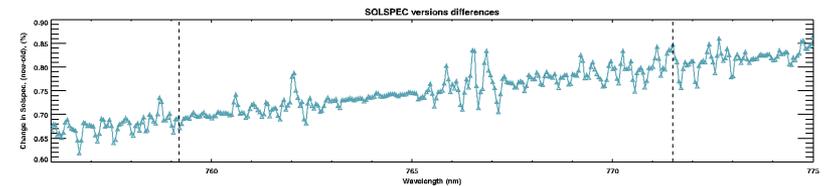
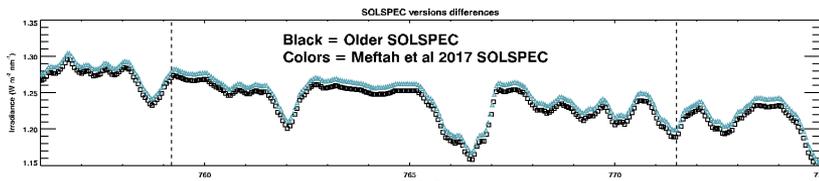
ACOS GOSAT Reprocessing

- Objectives
 - provide a consistent XCO₂ (and SIF) record from GOSAT that can be compared to or combined with OCO-2
- Known differences between v205 and v201 (B7.3)
 - New radiance conversion tables
 - Extended ABO₂ wavenumber range to capture new Fraunhofer lines for SIF (12900.008 - 13249.919)
 - Adjustments to the A-band non linearity correction
- Status
 - L1b data (v205.205) has been downloaded to JPL
 - Geos5 meteorology implemented
 - ABP screener is tuned and delivered to JPL
 - IMAP screener is in testing
 - L2 code setup needs to be confirmed and tested.
 - Once this is completed, EOFs will be developed



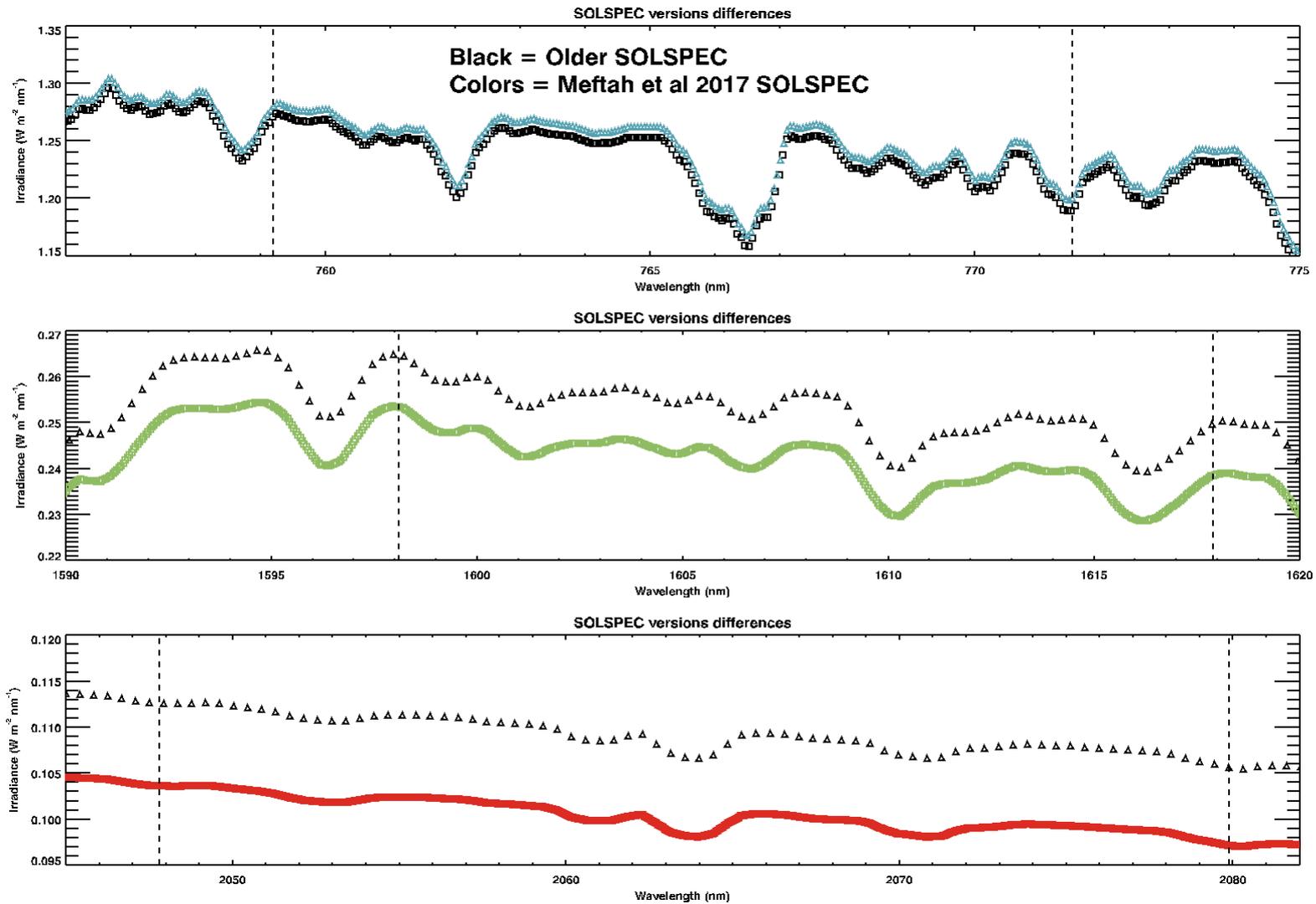
Looking Forward to B10

- Working to have updates ready for a FY20 complete reprocessing
- ABSCO team working on the next updated (version 5.1 - in Oct 2018)
- The calibration team is prioritizing effort for next update (due Oct 2018)
- L2 will prioritize their testing (some candidates include solar model, CO2 prior, convergence criterial, Psurf)
- Need to hear from user's - what are your key concerns with the L2 and SIF data??





Updated Top-of-Atmosphere Solar Fluxes





Near Term Key Planned Activities

Planned Date	Activity Description
14-22 Jul 2018	42nd COSPAR Scientific Assembly, Pasadena, CA, USA
TBD Summer 2018	Purchase/deliver/install planned science data operations and science computing facility hardware
23-25 Oct 2018	OCO-2 Science Team meeting in Boulder, CO
TBD (week of 5 Nov)	End of Year Mission Ops Review in Dulles, VA
TBD (4-6 Dec 2018)	Fall MOWG, tentatively hosted by OCO-2 @ Caltech
10-14 Dec 2018	Fall AGU in Washington, DC