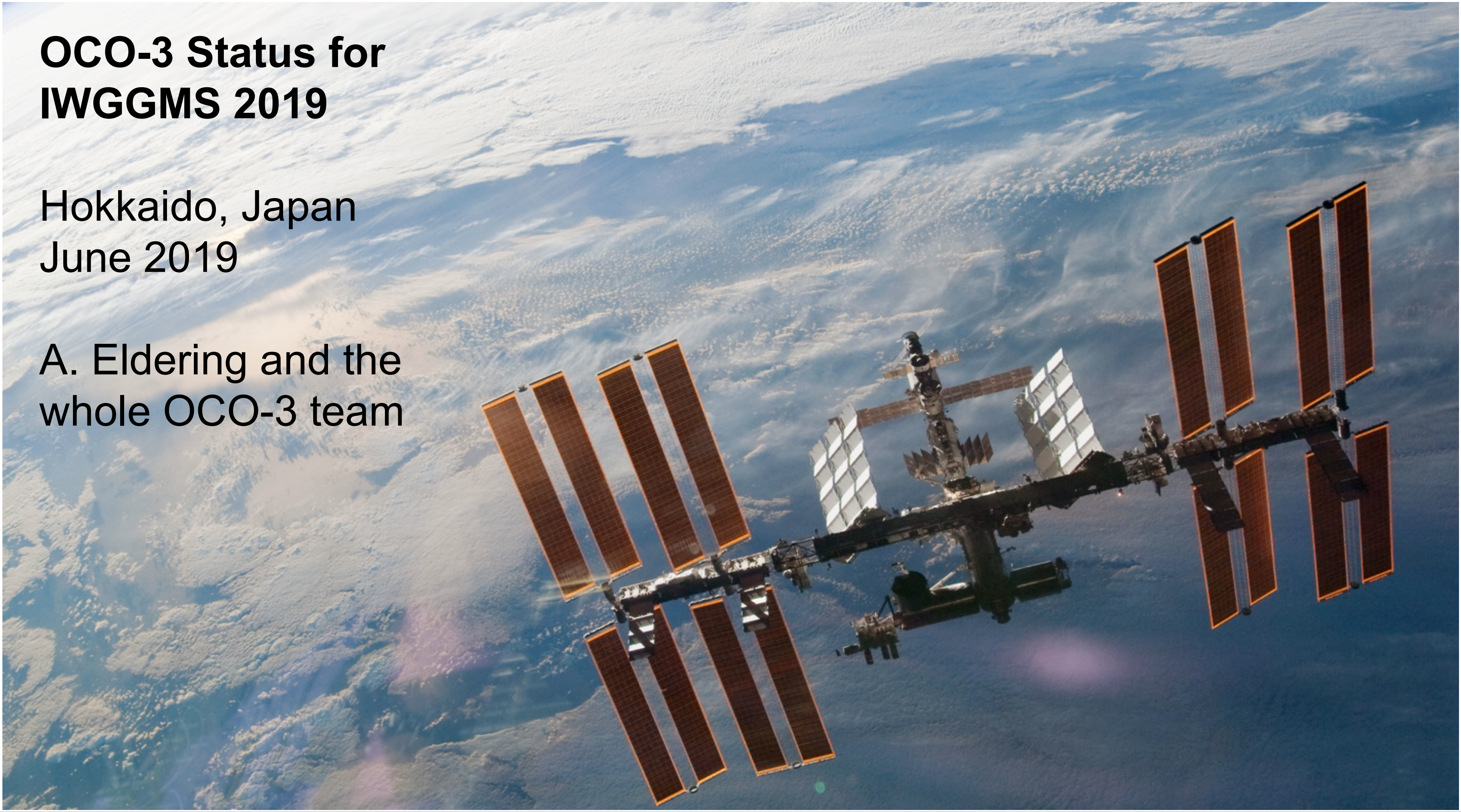
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

OCO-3 Status for IWGGMS 2019



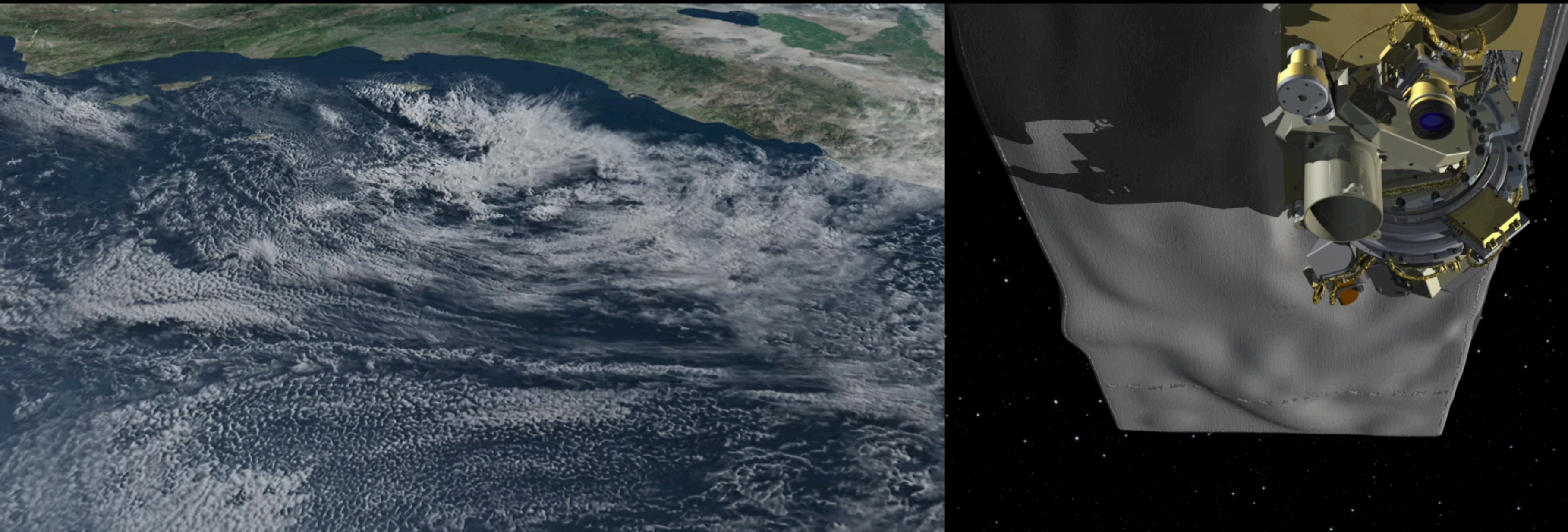
Hokkaido, Japan
June 2019

A. Eldering and the whole OCO-3 team

Outline

- Launch video
- Camera imagery
- Events in the next few months
- Expectations based on calibration
  - Rad cal/matador
  - ILS development
  - Heliostat results


OCO-3
ORBITING CARBON OBSERVATORY



Orbiting Carbon Observatory-3 (OCO-3)
Payload Functional Checkout Status

Power Conditioning Electronics (PCE)

Central Electronics Unit (CEU)
- Rad 750 Flight Computer*
- Digital Processor Unit (DPU)
- Housekeeping unit (HKU)

Pointing Control System (PCS)
- Stellar Reference Unit (SRU)
- Inertial Measurement Unit (IMU)
- Global Positioning System (GPS)

* Currently operating on Flight Software v4.0. Will be updated to v4.1 during IOC.

Thermal Control System
- Cold Panel
- Cryocooler Electronics (CCE)
- Cryocooler Interface Electronics (CCIE)
- Cryocooler Assembly (CCA)
- Heaters
- Thermo-Electric Coolers (TECs) and Exchangers
- Heat Rejection System (HRS)
- Thermal Plane

Pointing Mirror Assembly (PMA)
- Azimuth (Az) Axis Actuator
- Elevation (El) Axis Actuator
- PMA Drive Electronics (PDE)

Instrument (Three-Channel Grating Spectrometer)
- Telescope and Relay Optics
- Diffraction Grating (x3)
- Remote Electronics Module (REM)
- Optical Bench Assembly (OBA)
- Camera (x3)
- Analog Front-End Electronics (AFE)
- Spectrometer/Collimator (x3)
- Focal Plane Array (x3)

Digital Context Cameras (DCC)
- External Context Camera (ECC)
- Internal Context Camera (ICC)

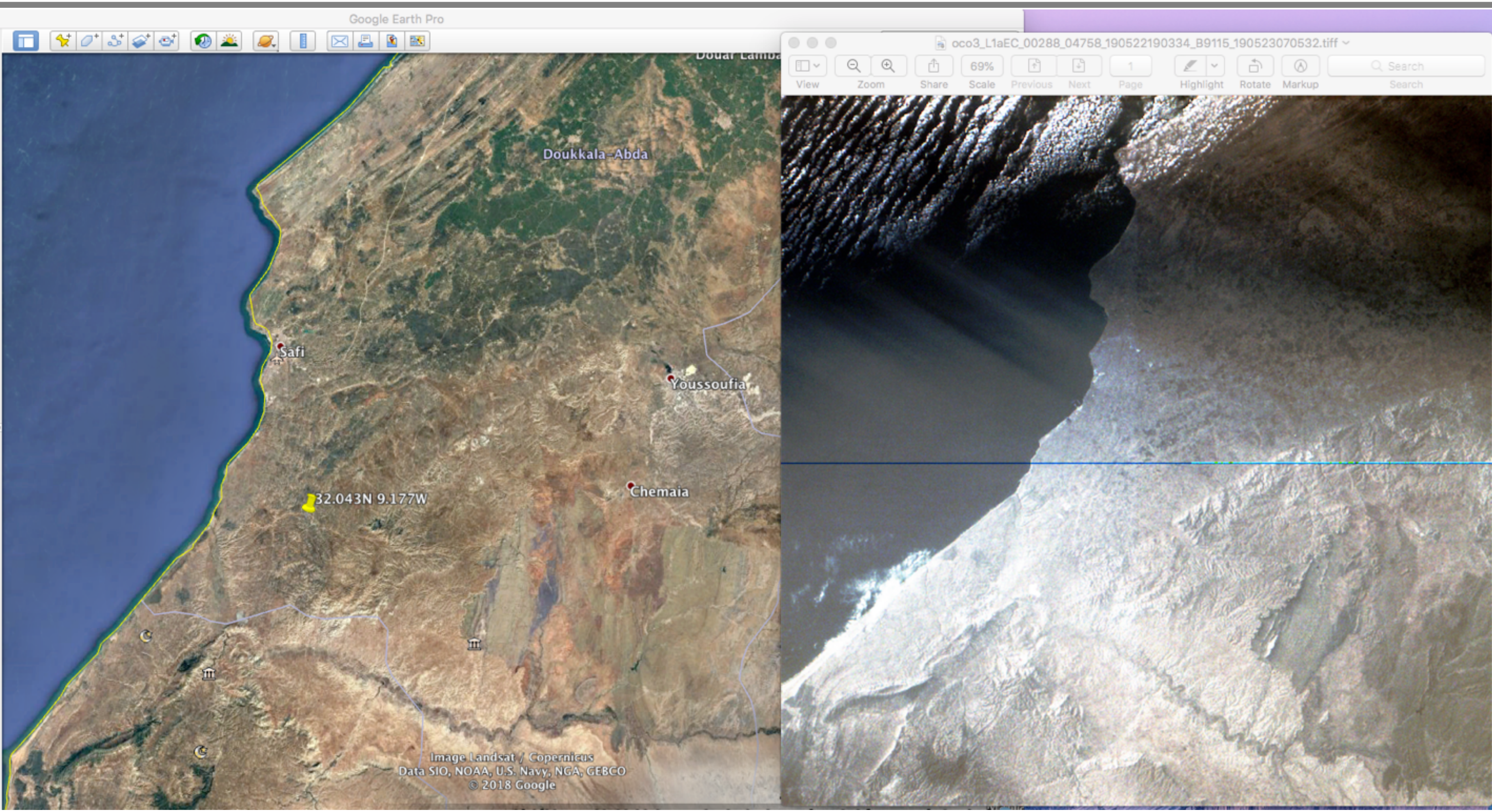
On-Board Calibration Lamps

Legend:
- Functional Check Complete
- Initial Functional Check complete, but requires additional verification (e.g., with instrument operating)
- Functional Check Still Pending

OCO-3 upcoming activities

- Calibration of pointing mirror system is underway
  - Collect images at a wide set of AZ/EL pairs
  - Register to ground control points (using Landsat type data)
  - Create correction table if needed, so we point exactly where commanded
- Update flight software (June 18)
- Cool detectors
- First light and confirmation of pointing (~ June 24)
- Update calibration parameters (dark correction, bad pixels, etc)
- Science checkout
  - Railroad Valley Observations (June 30 – July 5)
  - First target measurements
  - Verify signal levels and SZA dependence
  - Examine any dependence on viewing geometry
- Review to end IOC, August 9th
- L1b to be delivered 90 days after end of IOC.

Some Early examples of OCO-3 imagery



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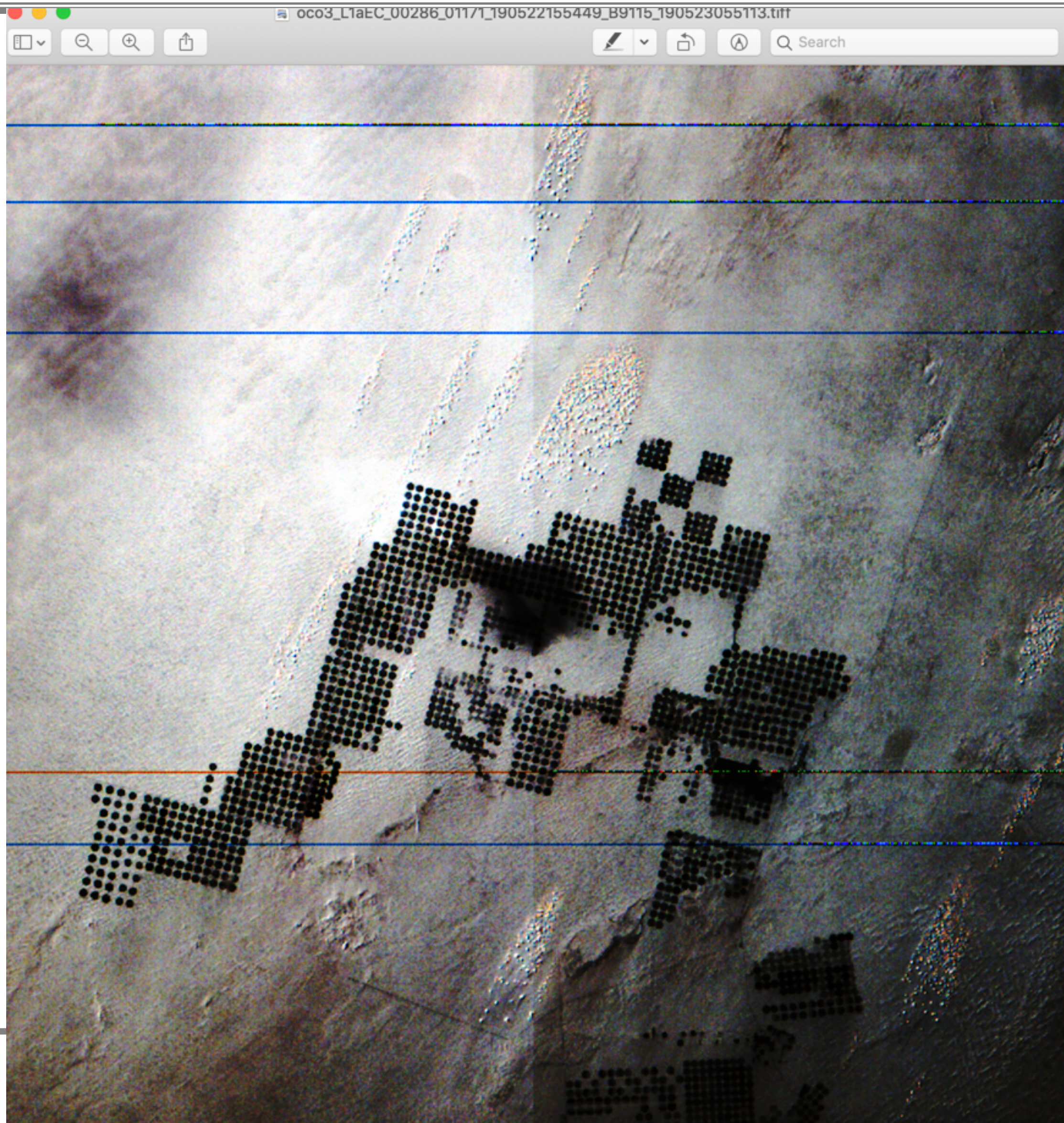
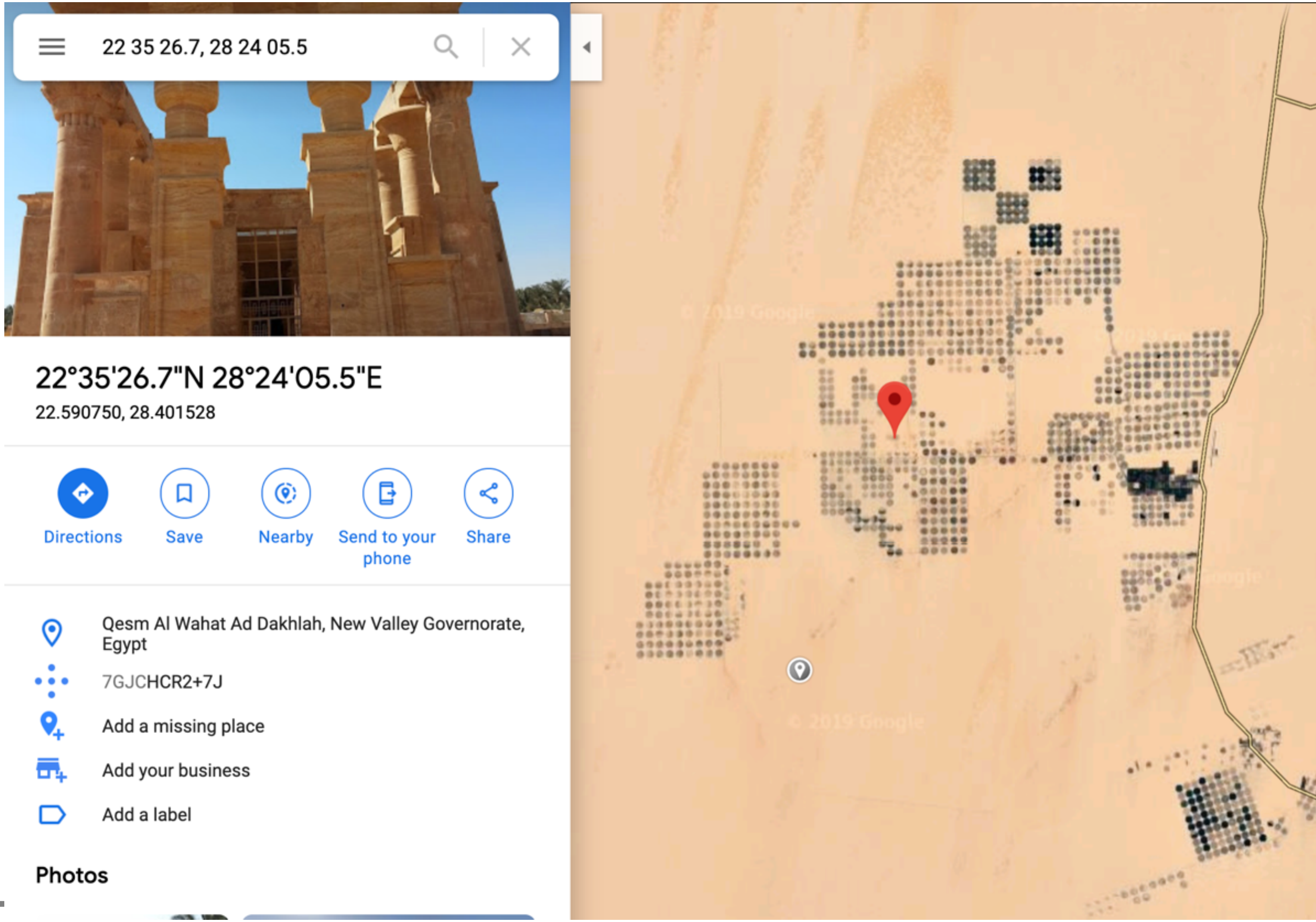
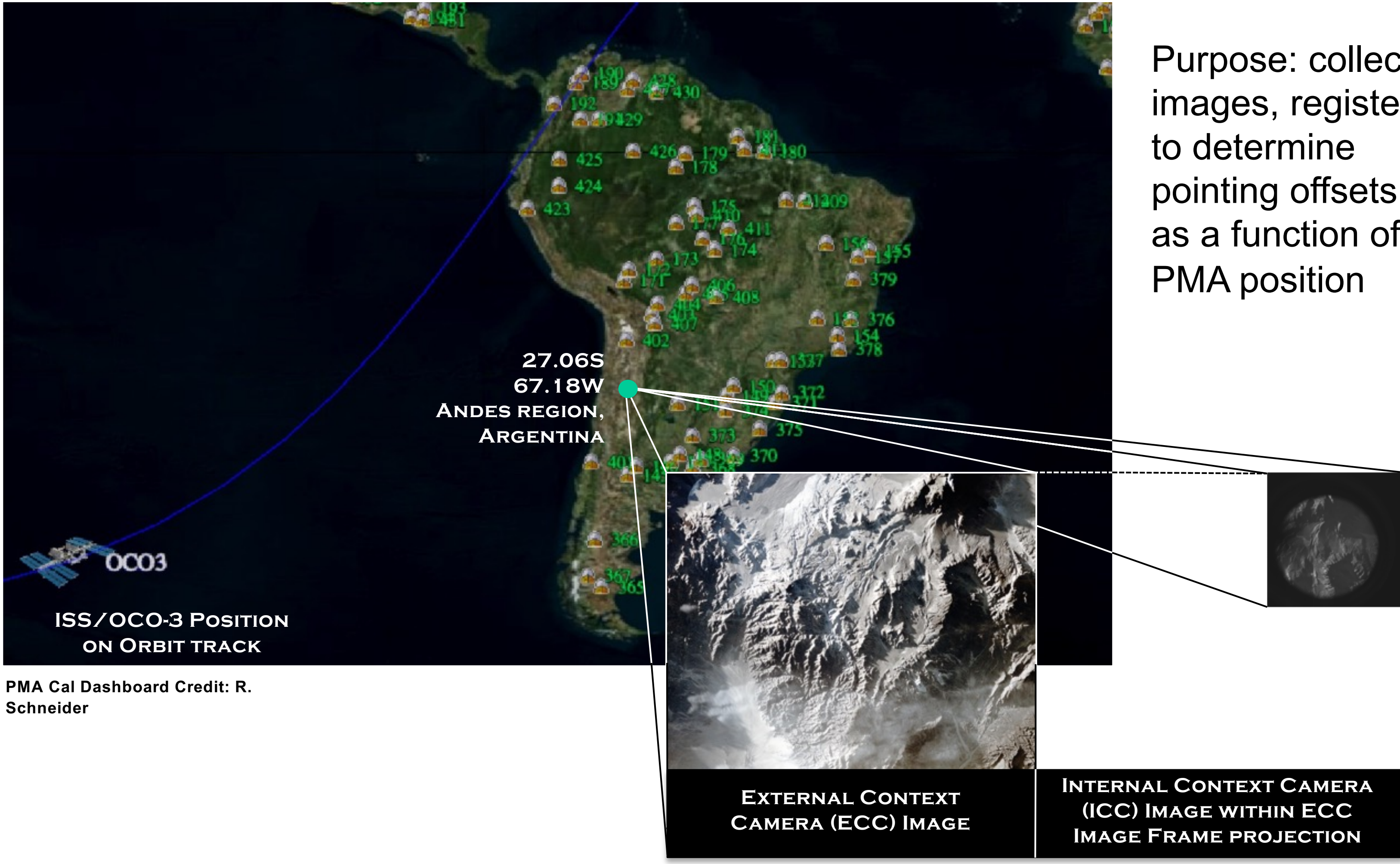

oco3_L1aEC_00286_01171_190522155449_B9115_190523055113.tiff
Search

Agricultural phenomena!



Pointing Mirror Assembly (PMA) Cal, Part 1



Purpose: collect images, register to determine pointing offsets as a function of PMA position

PMA Cal Dashboard Credit: R. Schneider

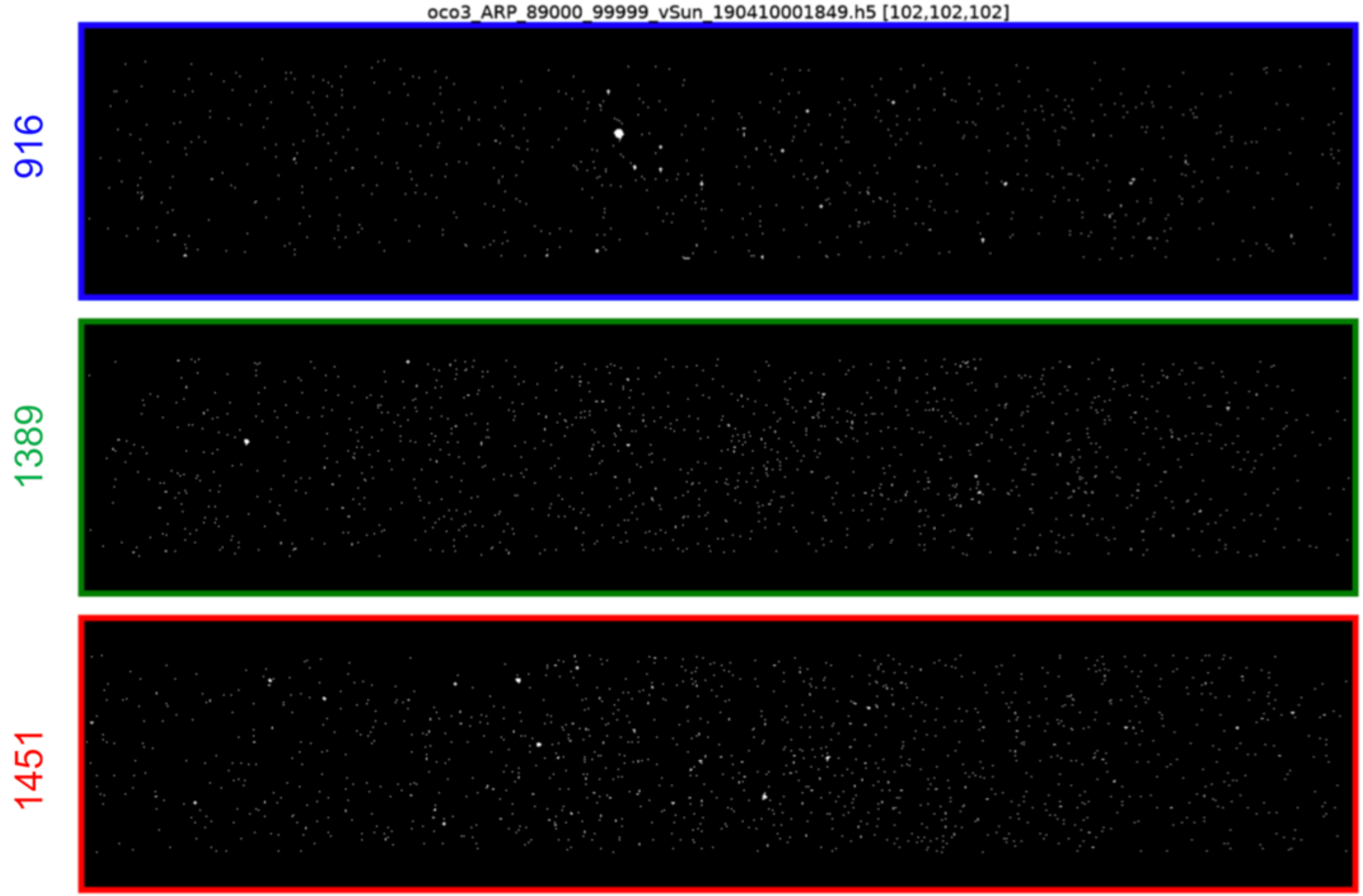
Expected performance of OCO-3

- TVAC testing provides characterization of the instrument
  - Evaluated against requirements
  - Compared to OCO-2
  - Used in end to end testing with heliostat data

- Review
  - Bad pixels
  - Linearity/dynamic range
  - ILS characterization
  - Expected SNR
  - Heliostat retrievals

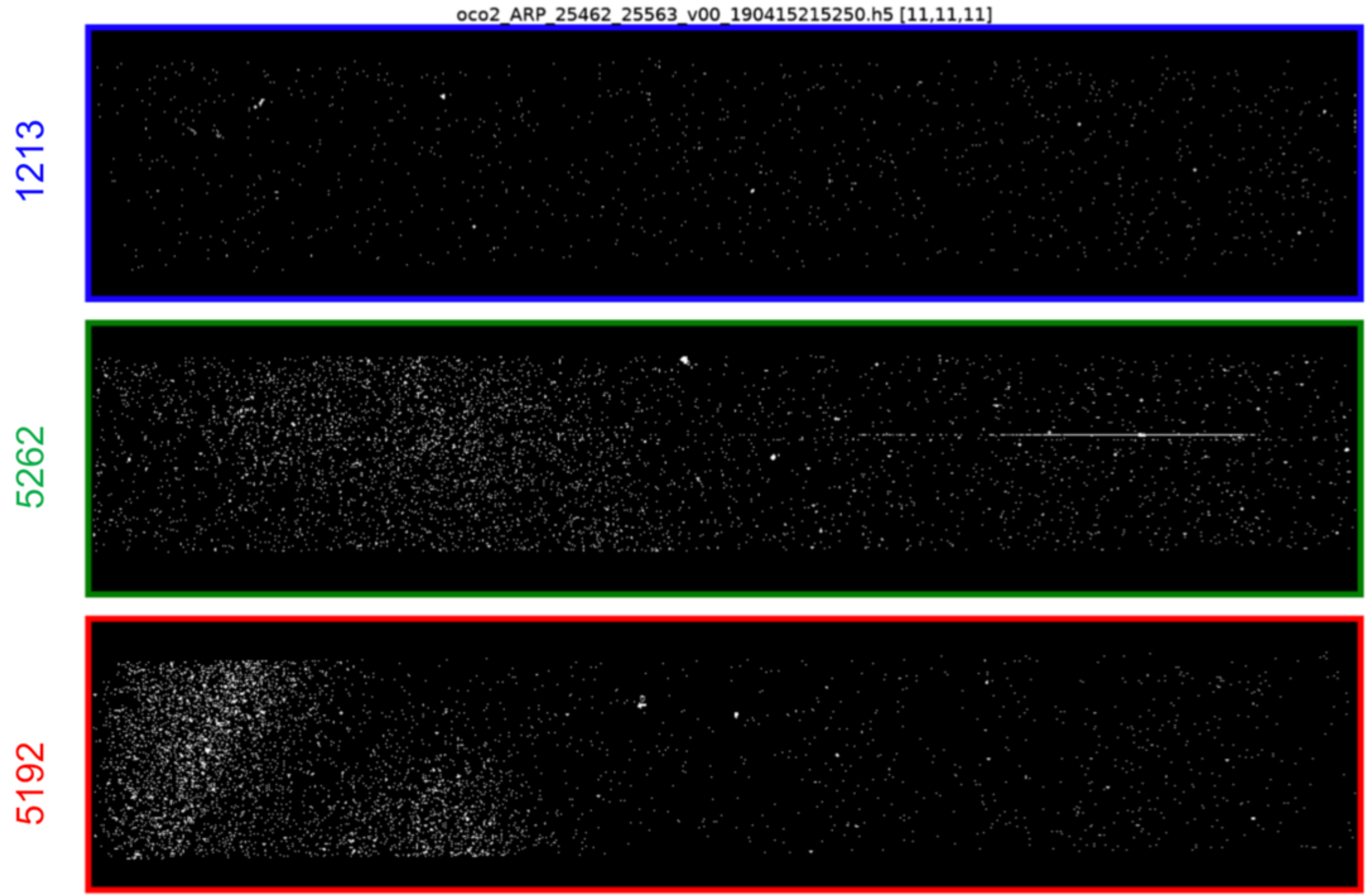
Bad Pixels on OCO-3

OCO-3 BPM [102, 102, 102] – Loaded Apr 2018



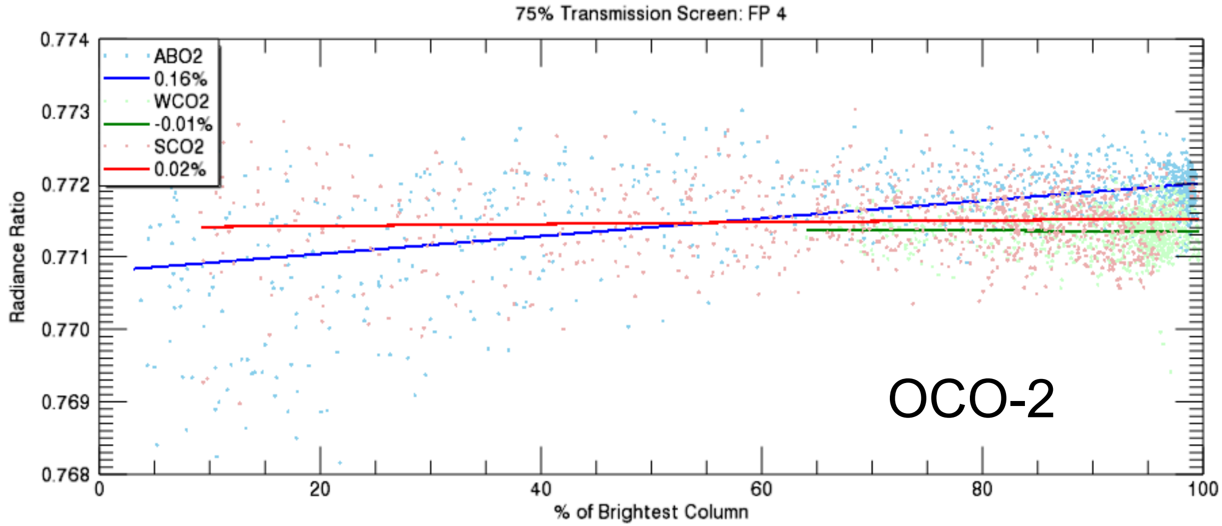
OCO-2 for comparison

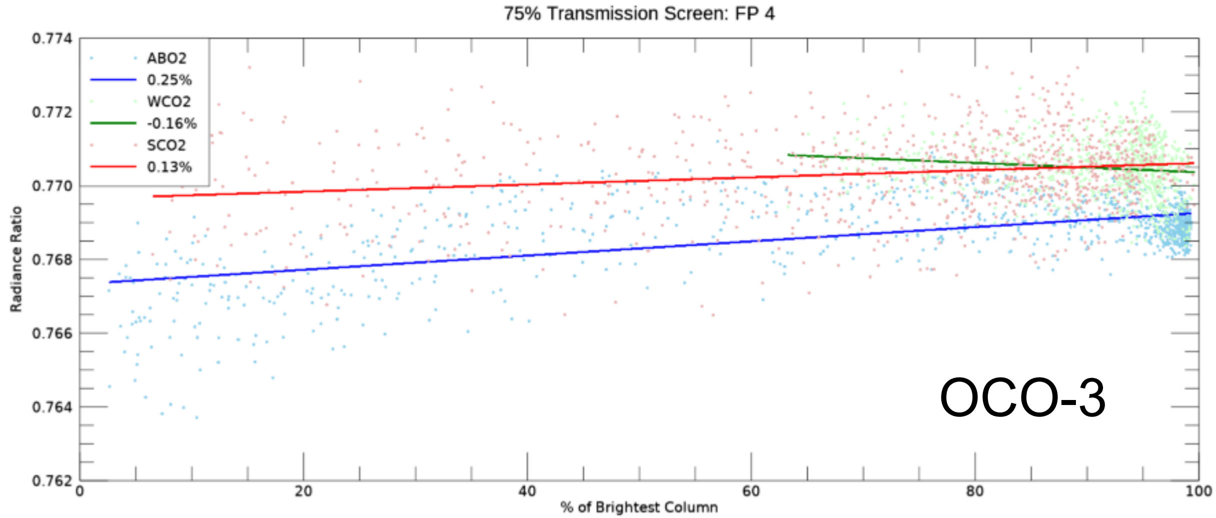
OCO-2 BPM [11,11,11] – Loaded Aug 2018



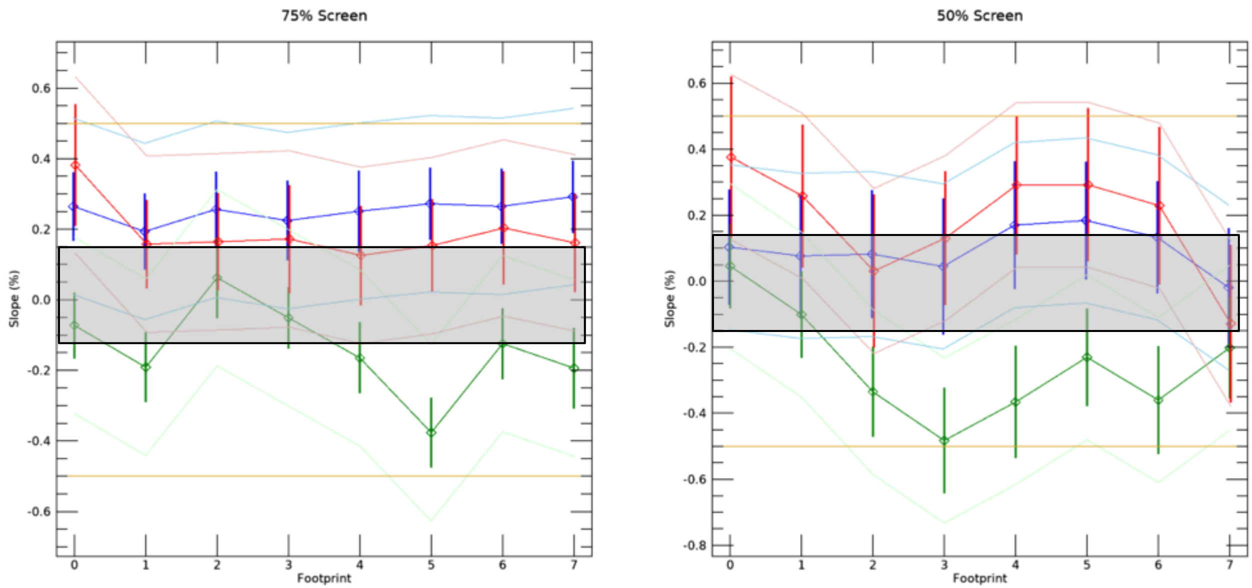
Matador test – how linear is response with varying input levels of light?

- Use screen to reduce input light level (to 75% in this case)
- Ratio to 100% light level
- Find slope with brightness level (in and out of absorption lines)

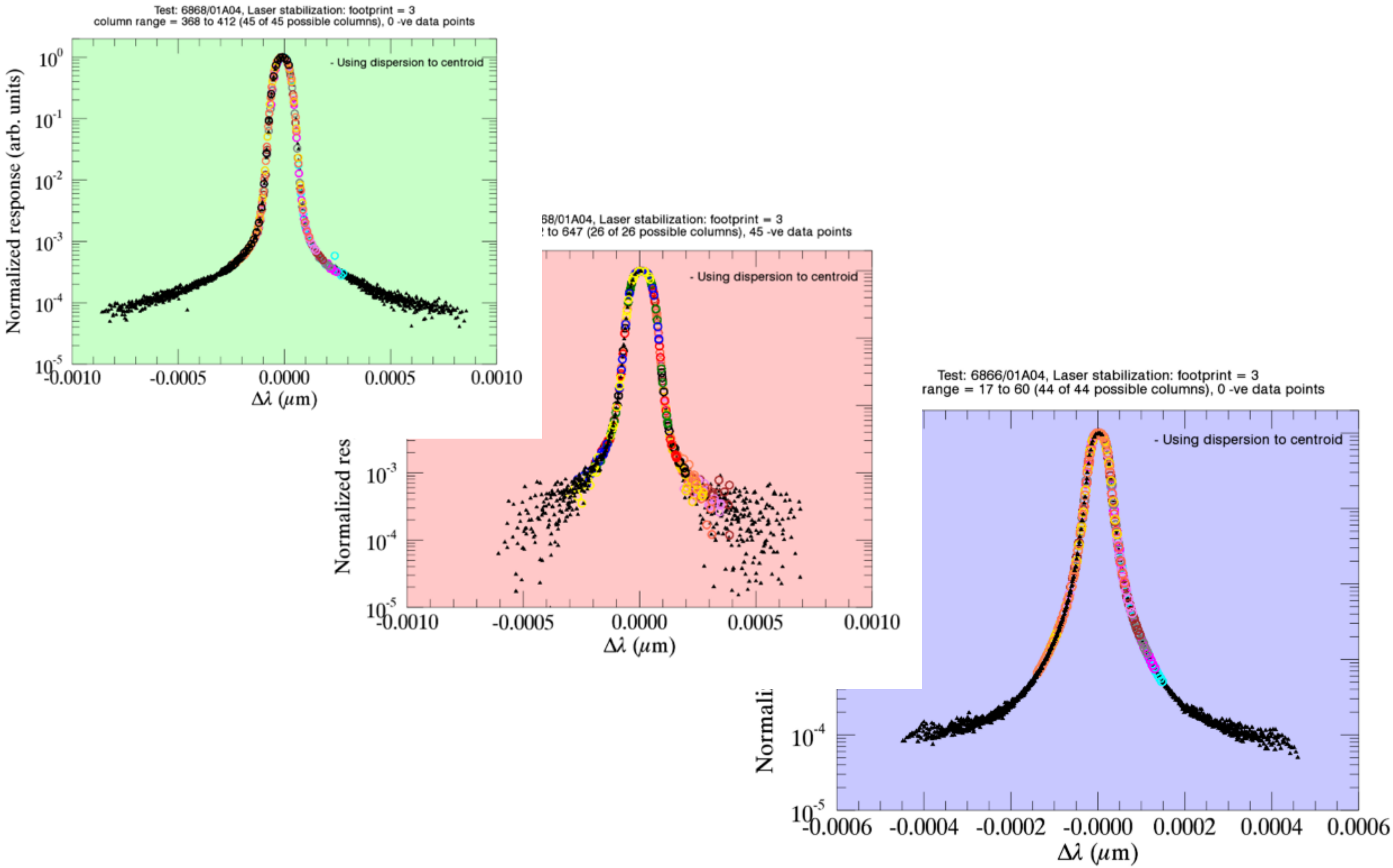




- Yellow lines are requirements. Both OCO-2 and OCO-3 meet requirements
- OCO-2 slopes were lower than OCO-3 (shown in gray box)

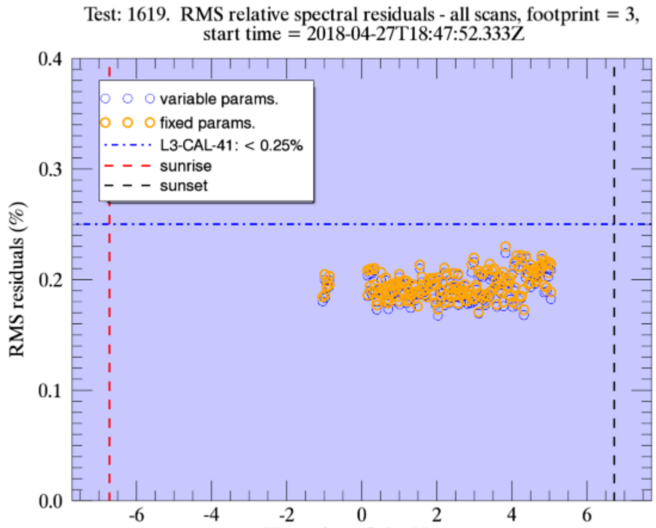


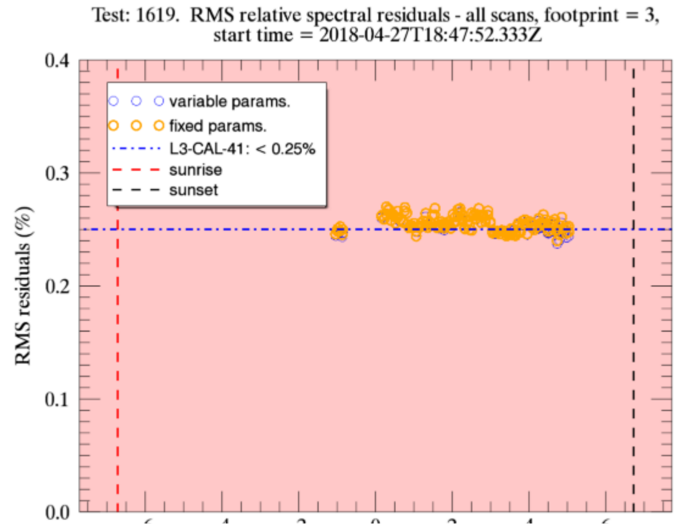
ILS

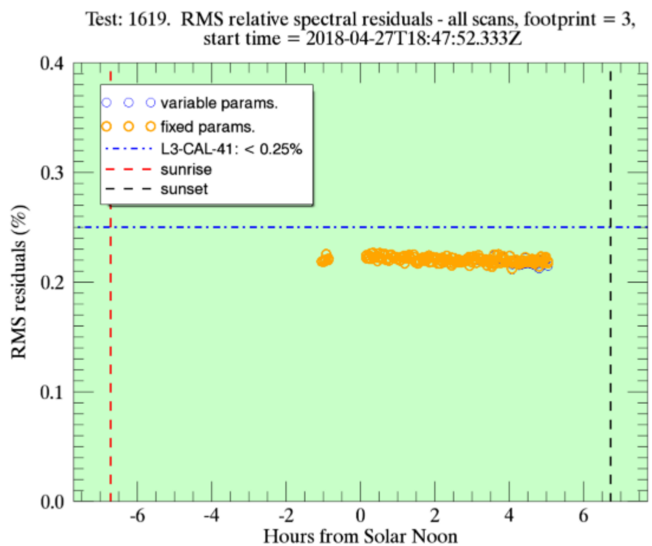

Test: 6868/01A04, Laser stabilization: footprint = 3
column range = 368 to 412 (45 of 45 possible columns), 0 -ve data points
- Using dispersion to centroid
Normalized response (arb. units)
Δλ (μm)
68/01A04, Laser stabilization: footprint = 3
! to 647 (26 of 26 possible columns), 45 -ve data points
- Using dispersion to centroid
Normalized res
Δλ (μm)
Test: 6866/01A04, Laser stabilization: footprint = 3
range = 17 to 60 (44 of 44 possible columns), 0 -ve data points
- Using dispersion to centroid
Normali
Δλ (μm)

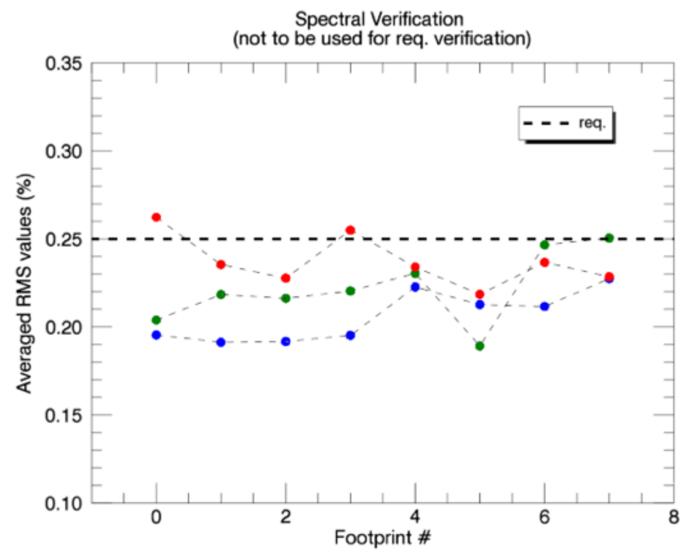
Spectral verification

- Requirements are met
- Cal team working on one more update to ILS
- Aiming for more OCO-2 like performance (below 0.2%)









Signal to Noise Ratio

- Overall, OCO-3 characteristics should provide sufficient SNR for XCO2 and SIF retrievals
- OCO-3 SNR lower than OCO-2 at low signal levels, similar (80 to 100% of OCO-2) for typical signal levels

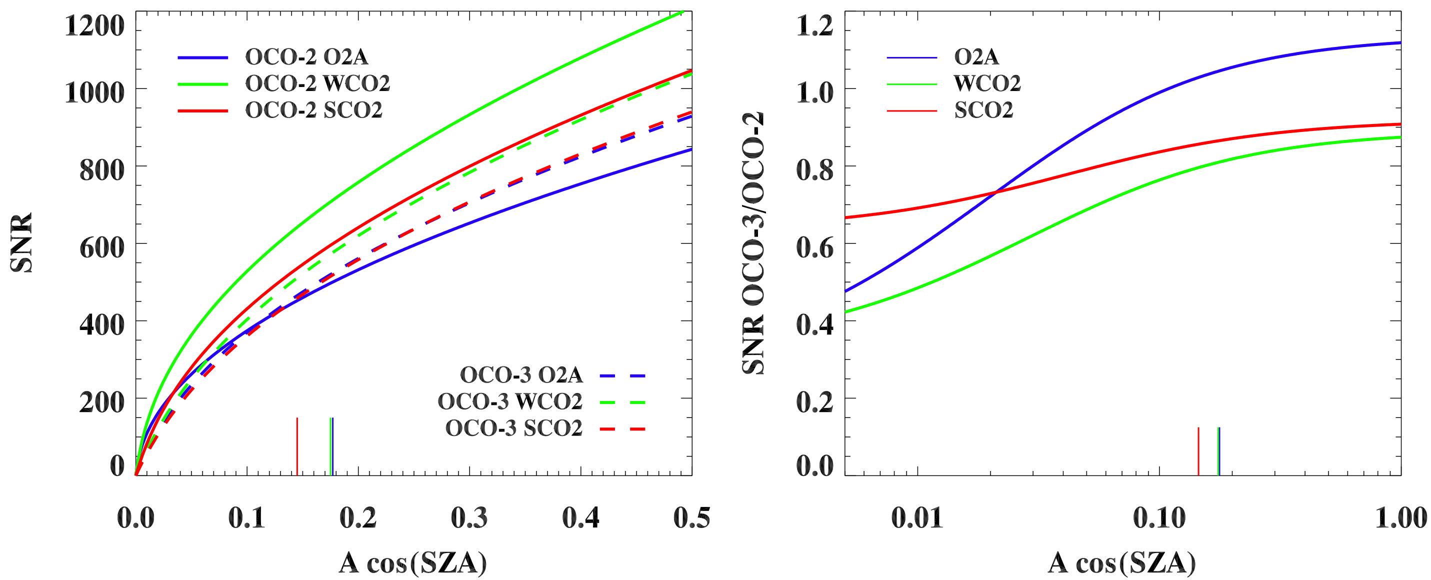


Figure from Tommy Taylor

Heliostat measurements

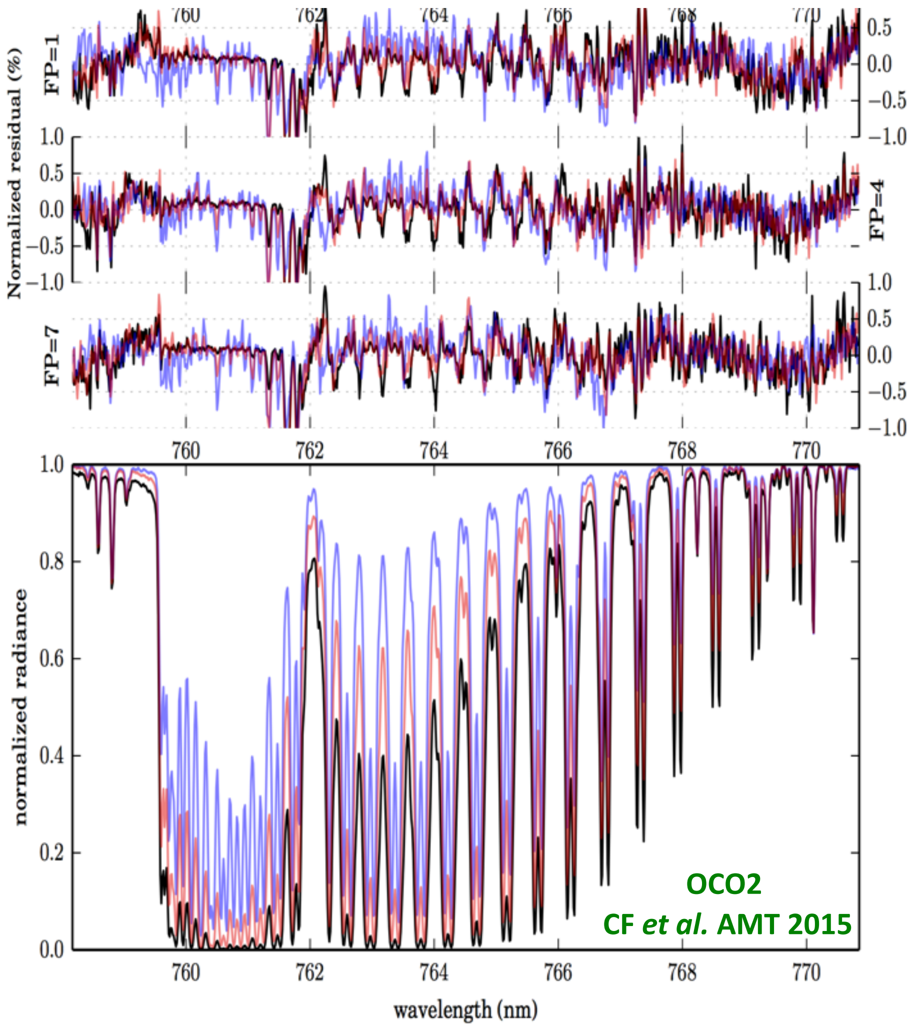
- Matador test (vary light levels) with direct sun as source
- Direct sun measurements over the day to sample large range of airmasses

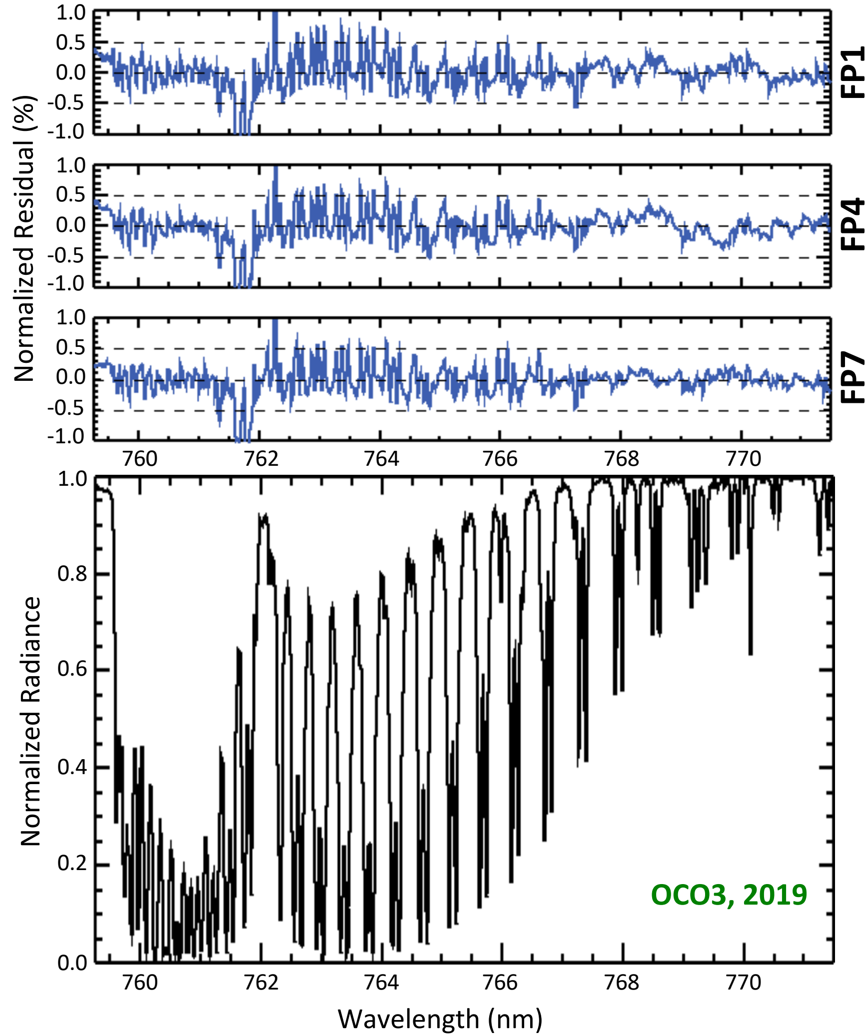
- TCCON station located at JPL for the measurement period

- Objectives
  - Evaluate spectral residuals
  - Footprint to footprint differences
  - Comparisons to TCCON
  - Also comparing performance to OCO-2

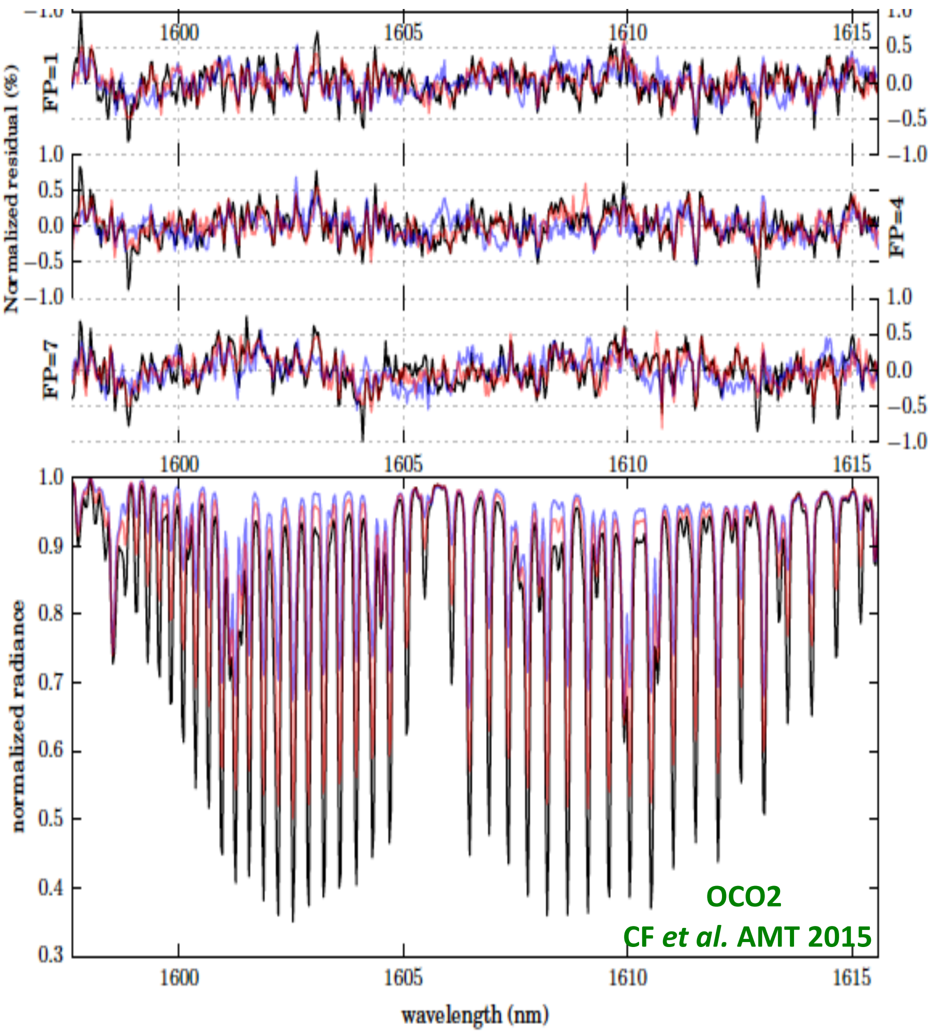
- Conclusion – algorithms and approaches, including bias correction, used for OCO-2 will be appropriate for OCO-3.

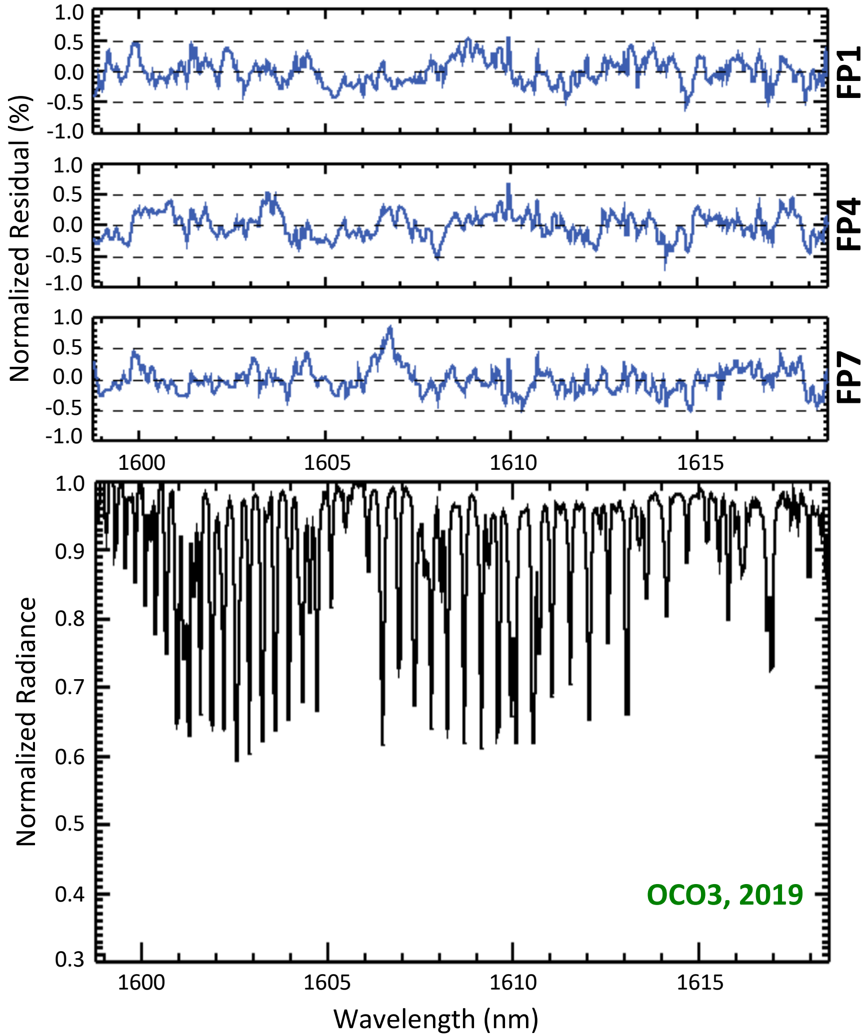
ABO2 Spectral Fit, Direct Sun



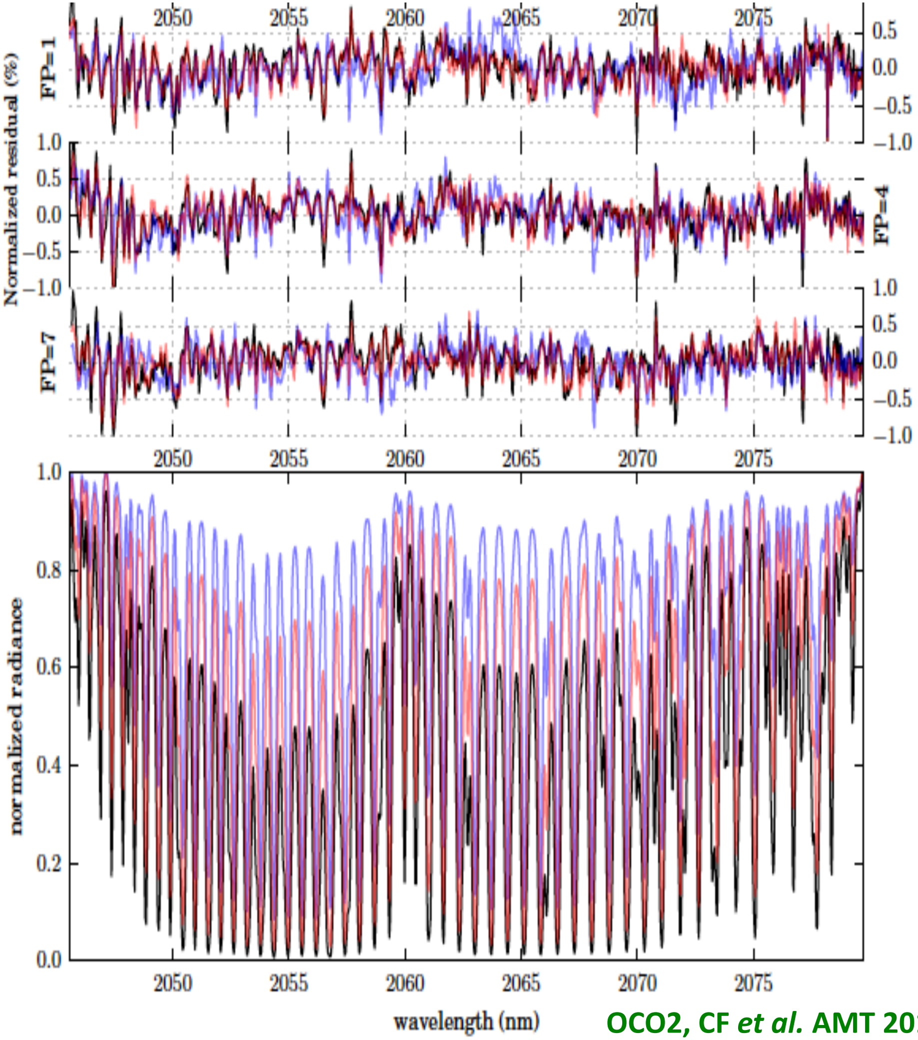


WCO2 Spectral Fit, Direct Sun

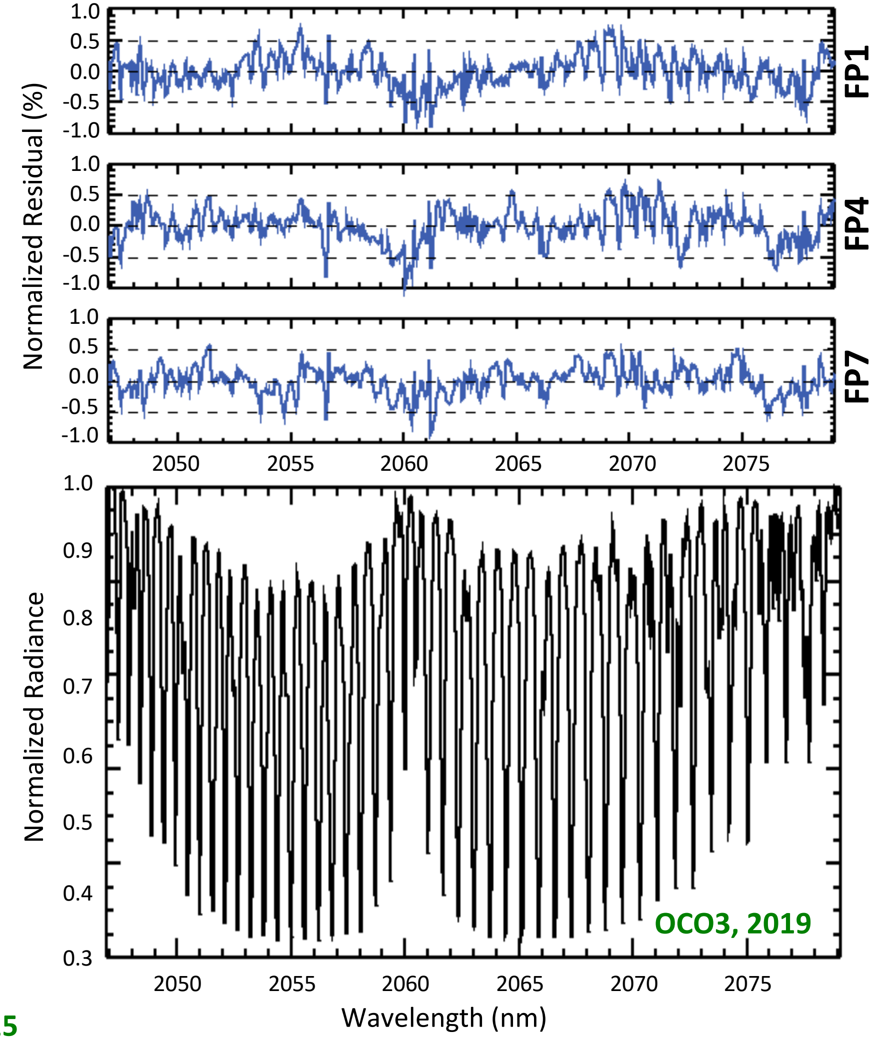




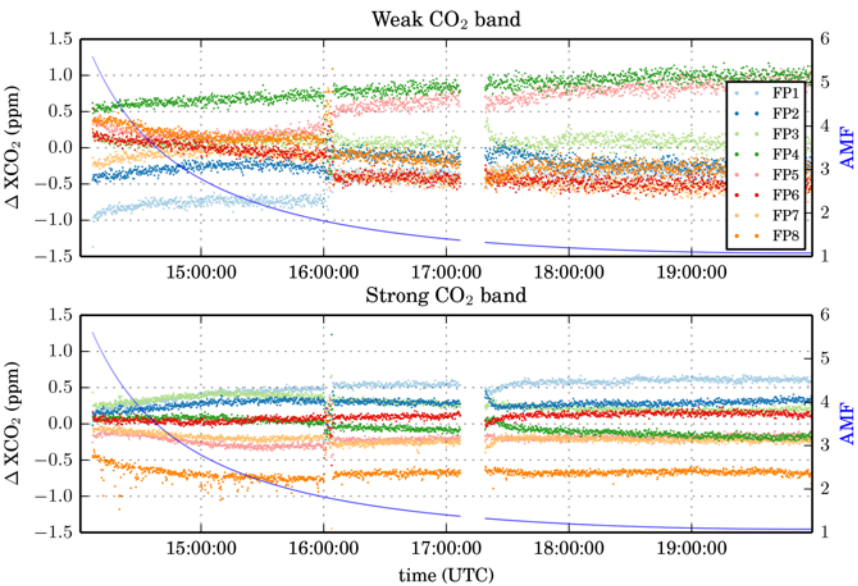
SCO2 Spectral Fit, Direct Sun



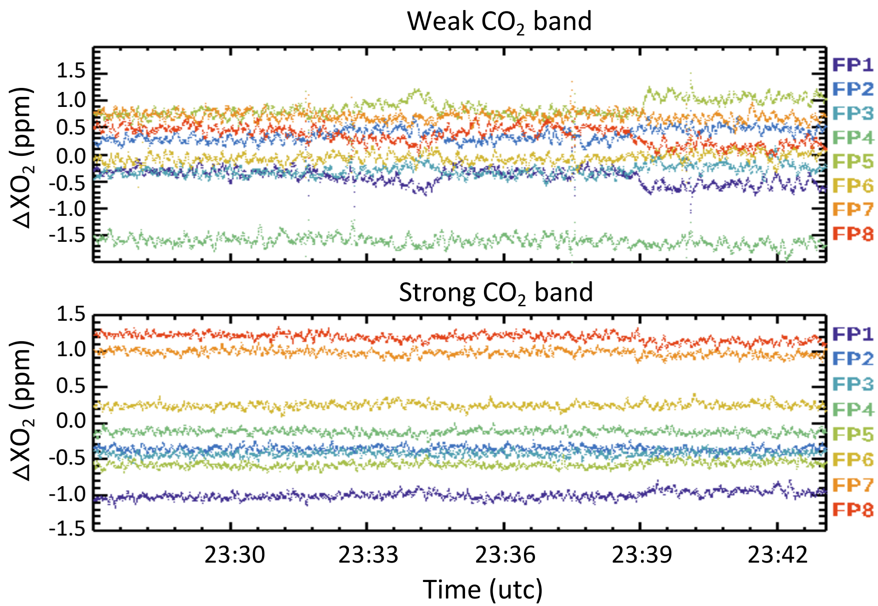
OCO2, CF *et al.* AMT 2015



Footprint Differences in XCO2



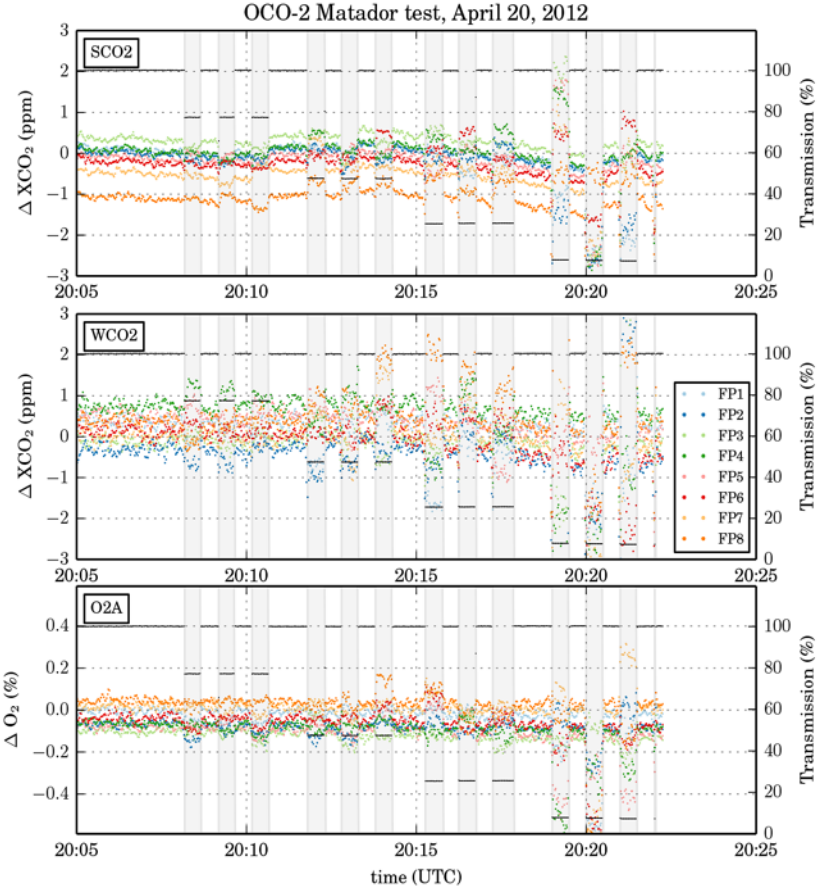
OCO2, CF et al. 2015



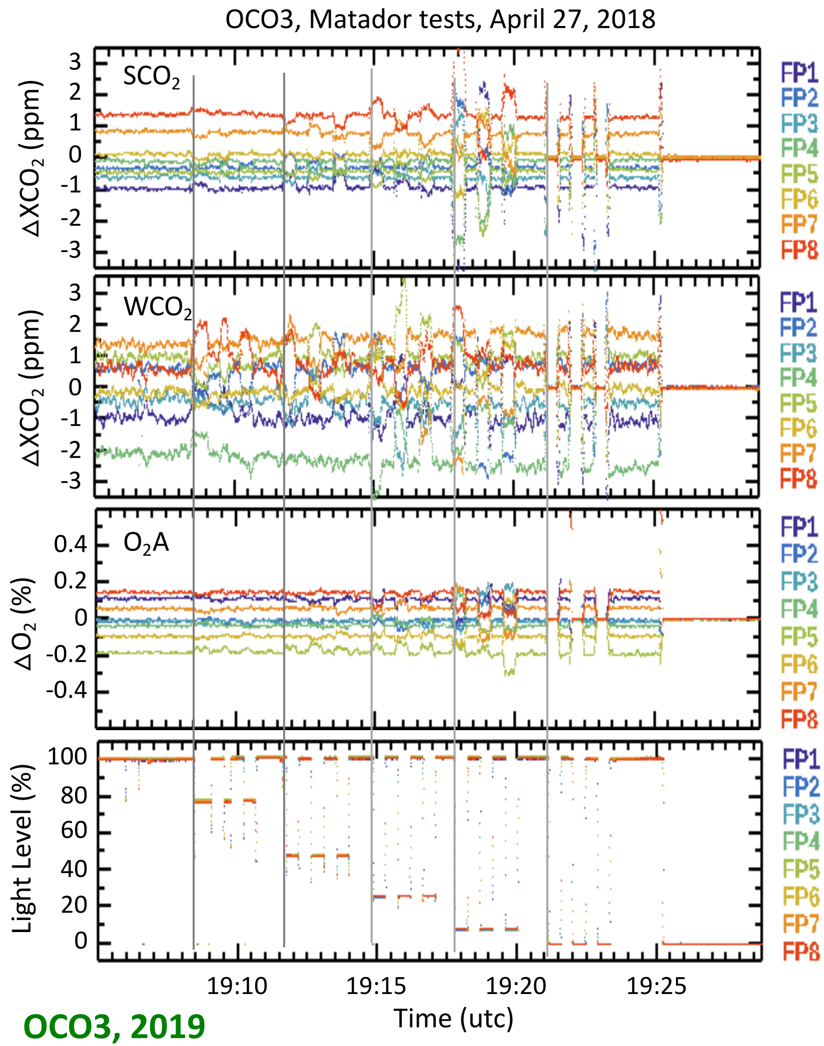
OCO3, 2019

Footprint to footprint differences similar in weak band
Somewhat larger in strong band, but consistent in time

XCO2 (per footprint) with changing light levels

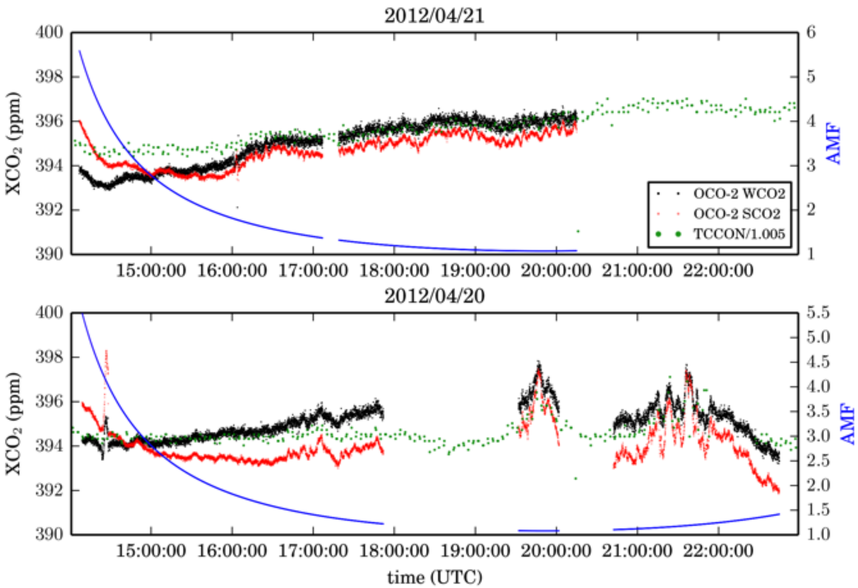


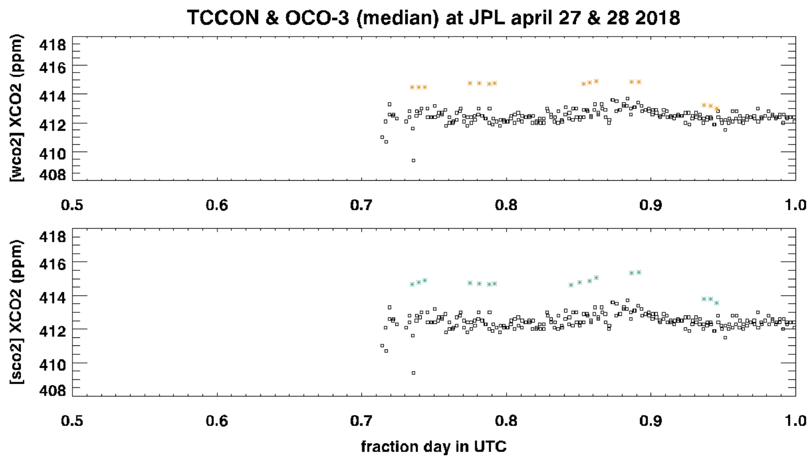
OCO2, CF *et al.* AMT 2015



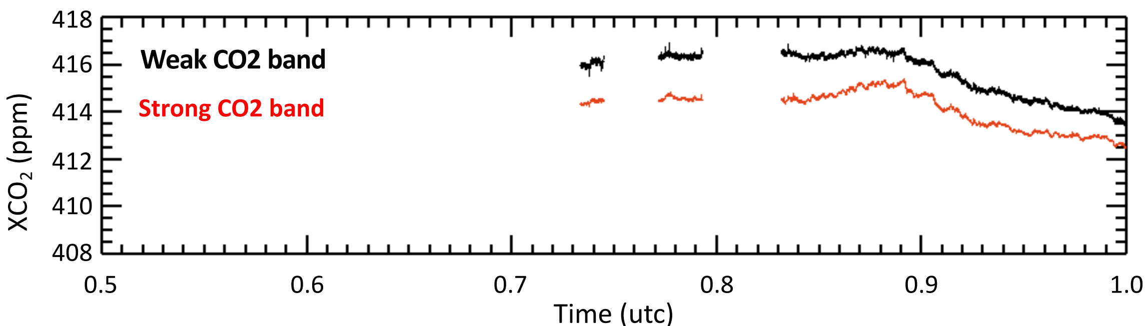
OCO3, 2019

Comparisons with TCCON measurements





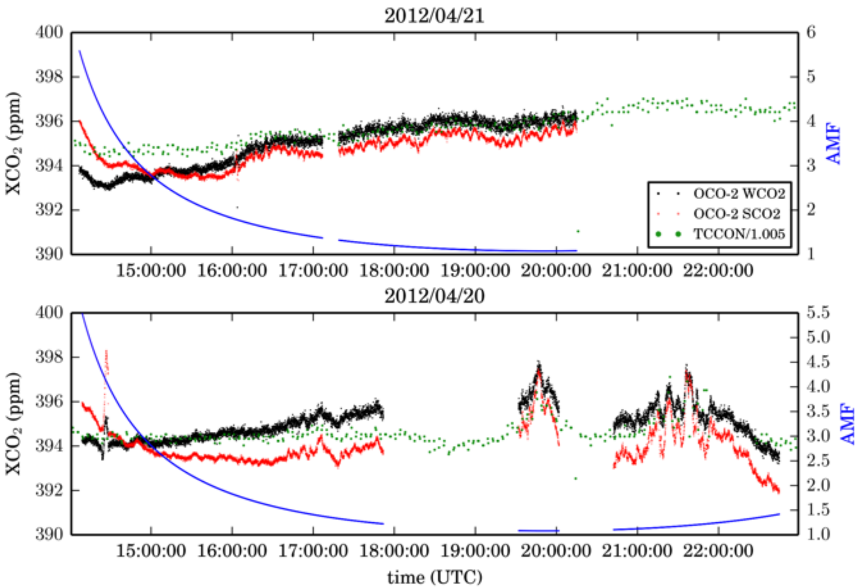
OCO2, CF *et al.* AMT 2015

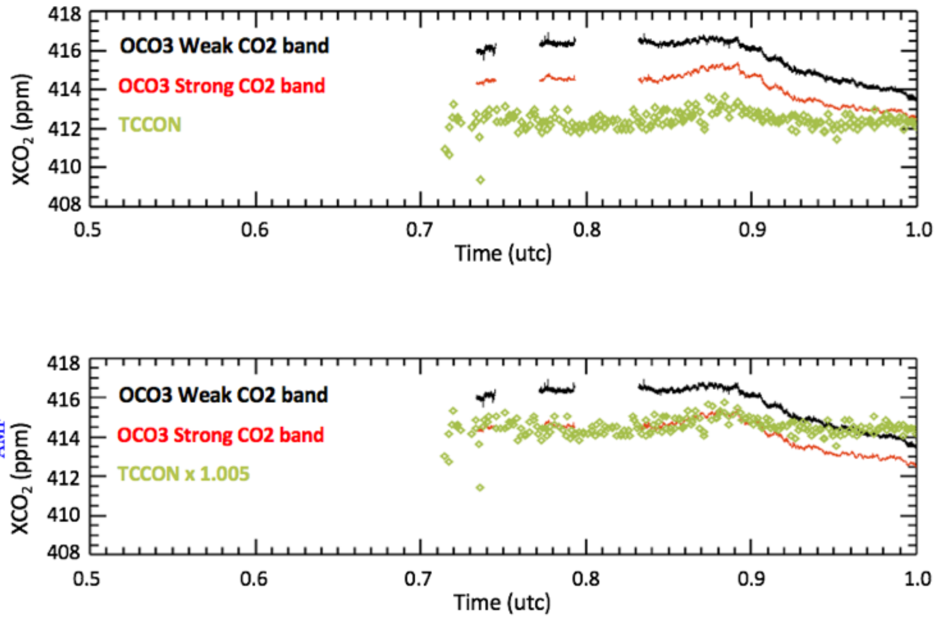


OCO3, 2019

OCO-3 heliostat data had less clear sky data. Offset between TCCON and influenced by version of ABSCO data. Similar patterns as OCO-2.

Comparisons with TCCON measurements





OCO2, CF *et al.* AMT 2015

OCO3, 2019

OCO-3 heliostat data had less clear sky data. Offset between TCCON and influenced by version of TCCON and ABSCO data. Similar patterns as OCO-2, including some disagreement at high airmasses.

Conclusions

- OCO-3 is installed on the International Space Station, JEM-EF
- Performing in-orbit checkout and calibration of pointing mechanism.
- Expect to have first light by June 24th
- Updates to calibration parameters to follow shortly thereafter
- Will also be carefully checking geolocation and pointing characteristics

- Instrument characterizations shows us that the OCO-2 approaches should work for OCO-3
  - Expect somewhat larger footprint to footprint differences
  - Will observe RRV early in the mission to check for any dramatic changes in radiometric response
  - Calibration with TCCON and cross-cal to OCO-2 are key objectives in the early mission
- We look forward to collaborating with the community on the early data

- Please see talks and posters by T. Kurosu, D. Crisp, R. Nelson!!

THANK YOU!!