Jet Propulsion Laboratory
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OCO-2 and OCO-3 Calibration Report

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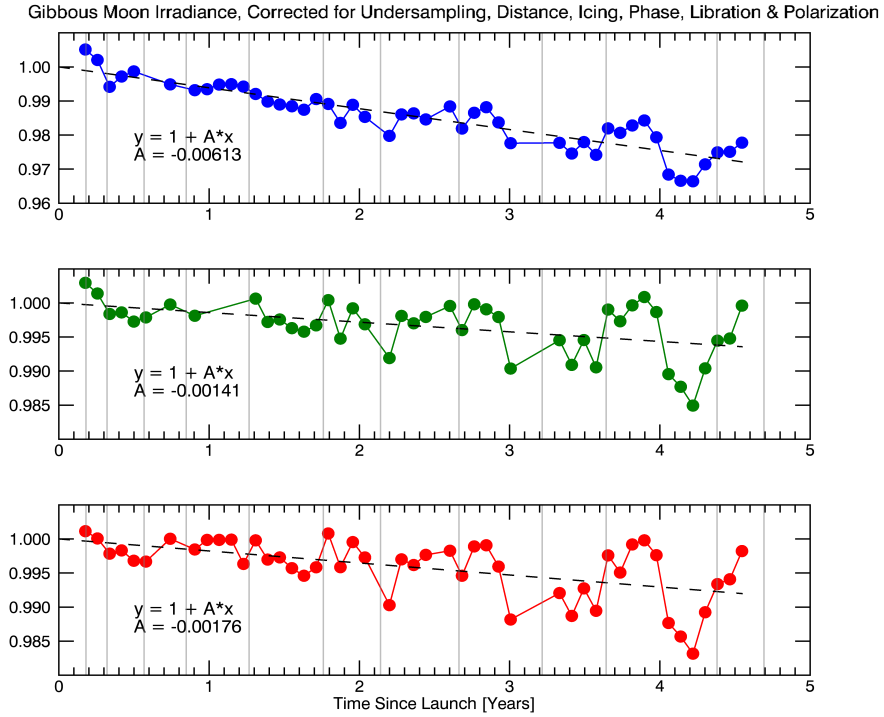
Outline

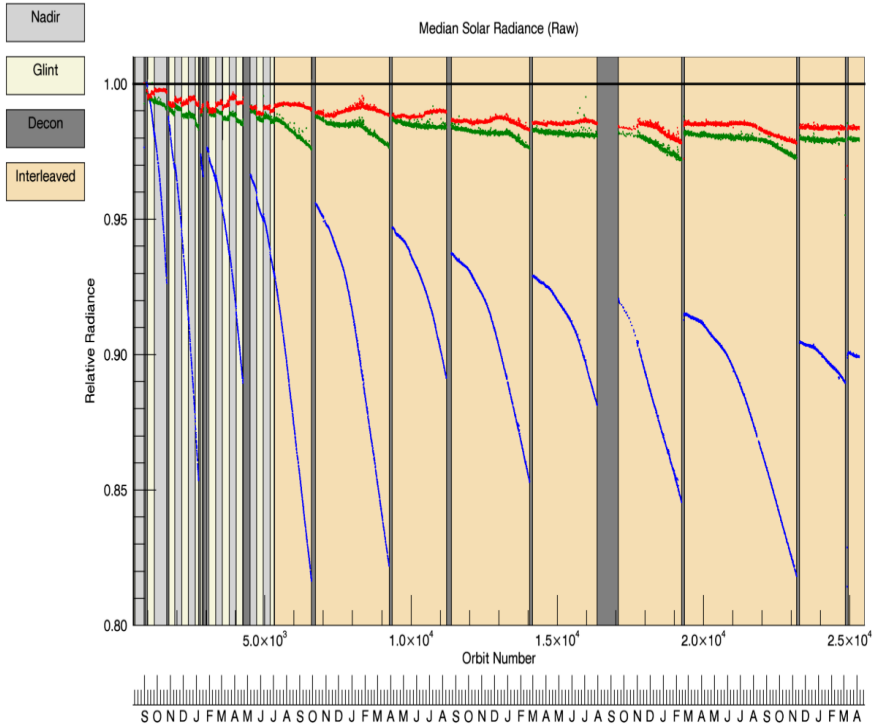
- OCO-2 changes from B8 to B10
- B10 development schedule
- OCO-3 key calibration features
- OCO-3 milestones during IOC & early Ops
- Uplooking heliostat analysis
- Cross calibration of OCO-2 vs. OCO-3

OCO-2 B8-B10 Changes: Gain Degradation

- ABO2 Gain Degradation:
  - Regular lamp observations track icing, solar calibrator corrects lamp aging, but what about solar calibrator aging?
  - B7: all solar degradation interpreted as instrument degradation (radiances too high after correction)
  - B8: all solar degradation attributed to diffuser, none to instrument (radiances too low after correction)
  - B10: some solar degradation attributed to diffuser, and some attributed to instrument based on lunar calibration trends
  - Also tracking OCO-2/MODIS ratio over pseudo-invariant desert sites
- WCO2/SCO2 Gain Degradation:
  - B7, B8: Band Medians (1 coefficient describes 8128 samples)
  - B10: Footprint Medians (8 coefficients describe 8128 samples)
- ZLO, Dispersion Trending, SNR Model, Dark, etc. consistent with B8

Gain Degradation Visualizations





Observations of the ¾ Gibbous show consistent trends in instrument throughput degradation (0.6%/yr, < 0.2%/yr, < 0.2%/yr). Fit residuals are highly correlated in all 3 channels, indicating that they are associated with sampling biases.

Observations of the solar diffuser show signal losses from icing that are reversed with decontamination, and then an irreversible trend (2.2%/yr, 0.4%/yr, 0.4%/yr). This rate combines instrument and calibrator degradation.

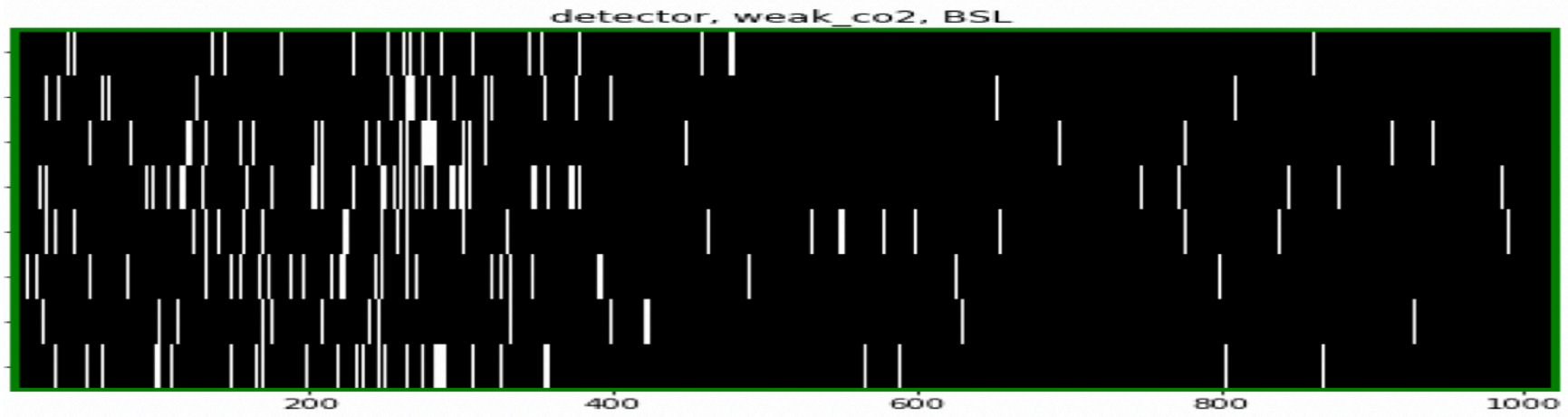
OCO-2 B8-B10 Changes: Bad Samples

- BPM = Bad Pixel Map, applied irreversibly as part of onboard data compression
- BSL = Bad Sample List, an ARP variable that can be revised on the ground

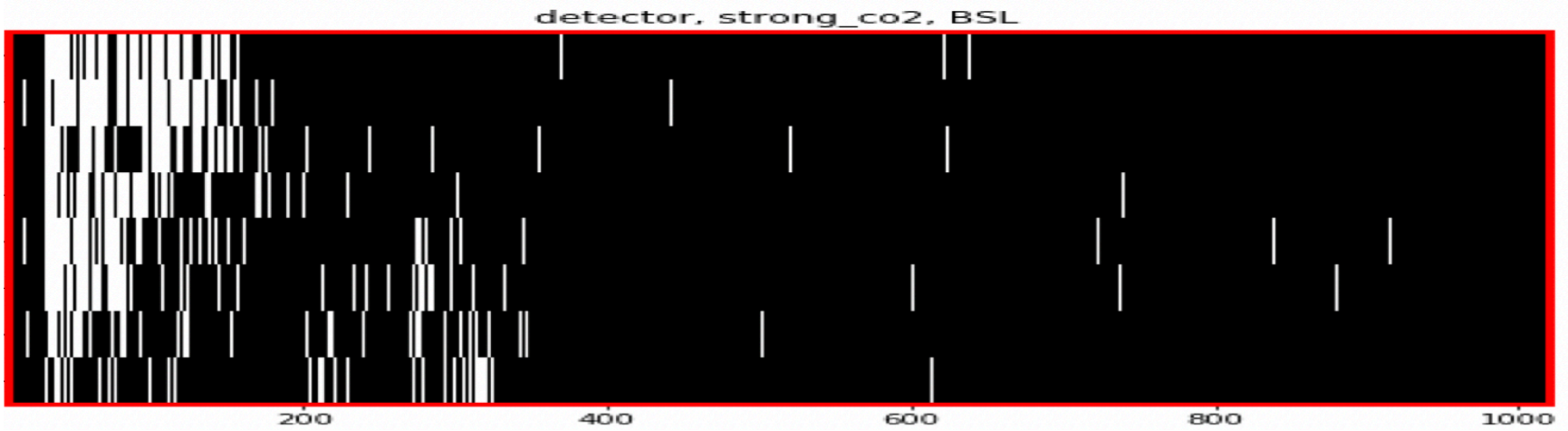
- Bad Samples:
  - B7: Defined by O'Dell based on 2015 B7 Test spectral residuals
  - B8: Previous list incrementally updated as new features appeared
  - B10: New results from machine learning classifier augmented by results from ARP validation
    - One BSL for ARPs covering BPM 6-8 period (Sep 2014 – Nov 2014)
    - One BSL for ARPs covering BPM 9 period (Nov 2014 – Feb 2015)
    - One BSL for ARPs covering BPM 10 period (Feb 2015 – Aug 2018)
    - One BSL for ARPs covering BPM 11 period (Aug 2018 – Mar 2019)
    - Rolling 10R will incorporate new bad samples as they arise

BSL for WCO2 and SCO2 Matching BPM 10

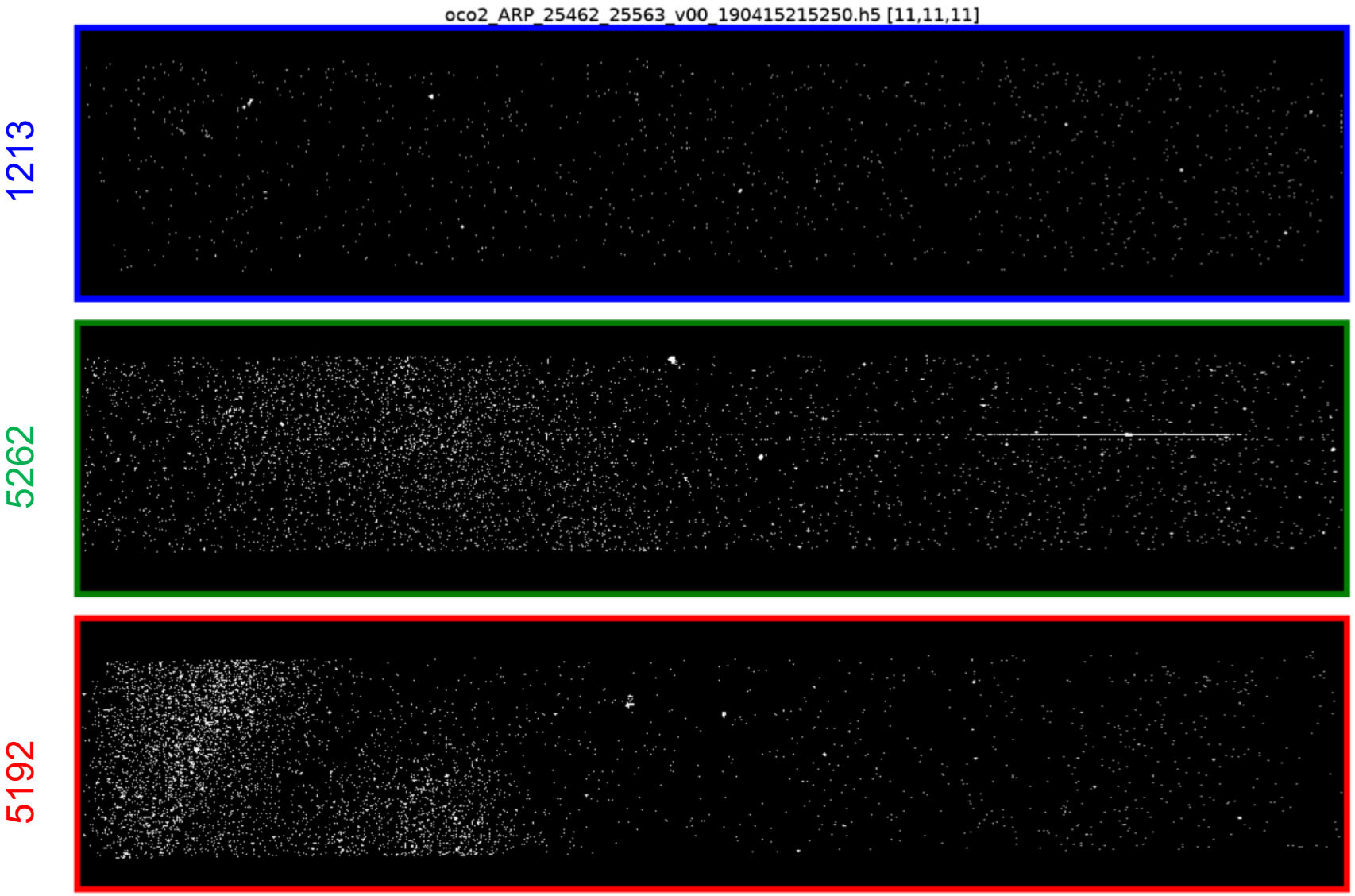
New BSL (426)



New BSL (676)



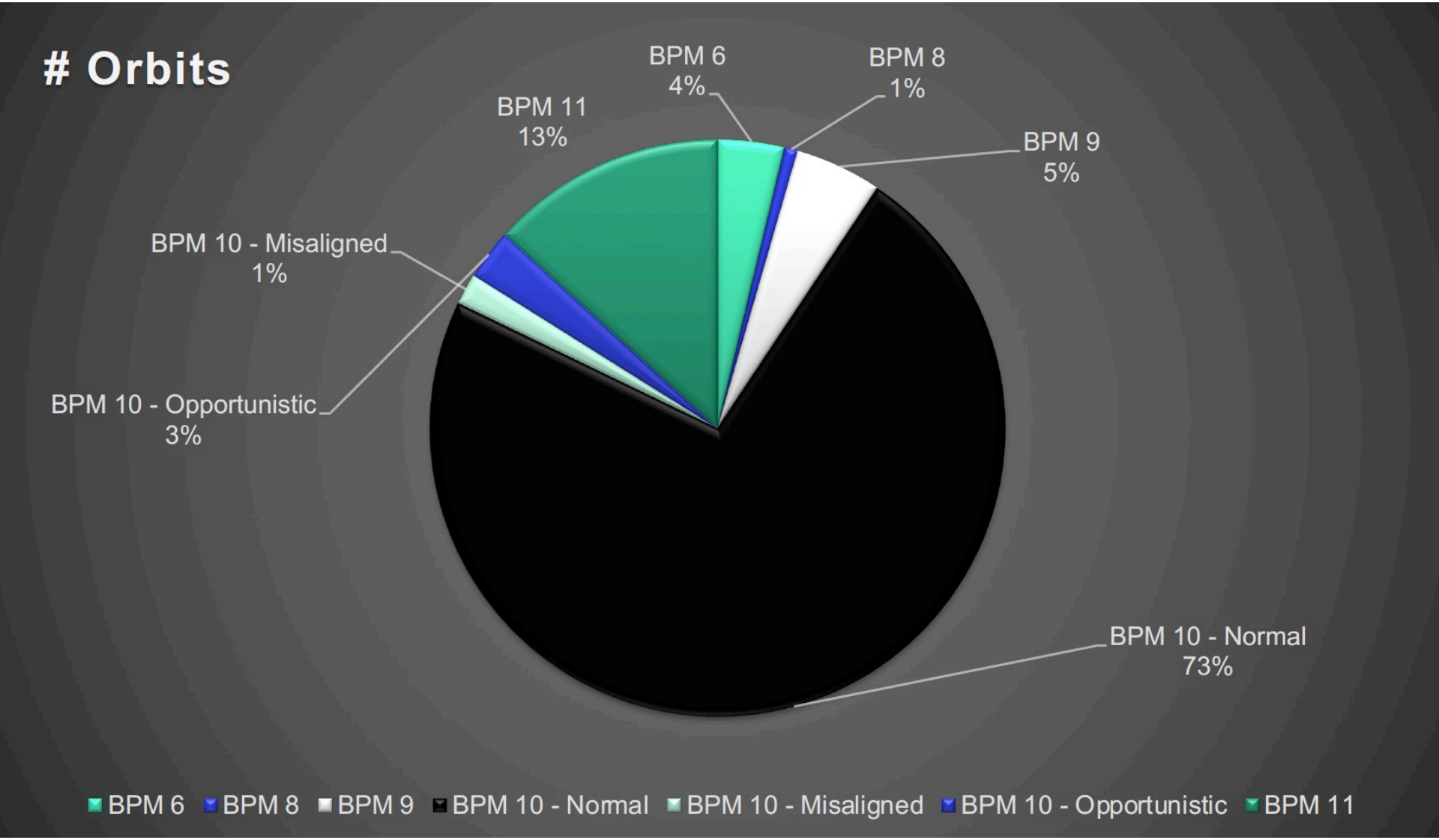
OCO-2 BPM [11,11,11] – Loaded Aug 2018



OCO-2 B10 Development Schedule

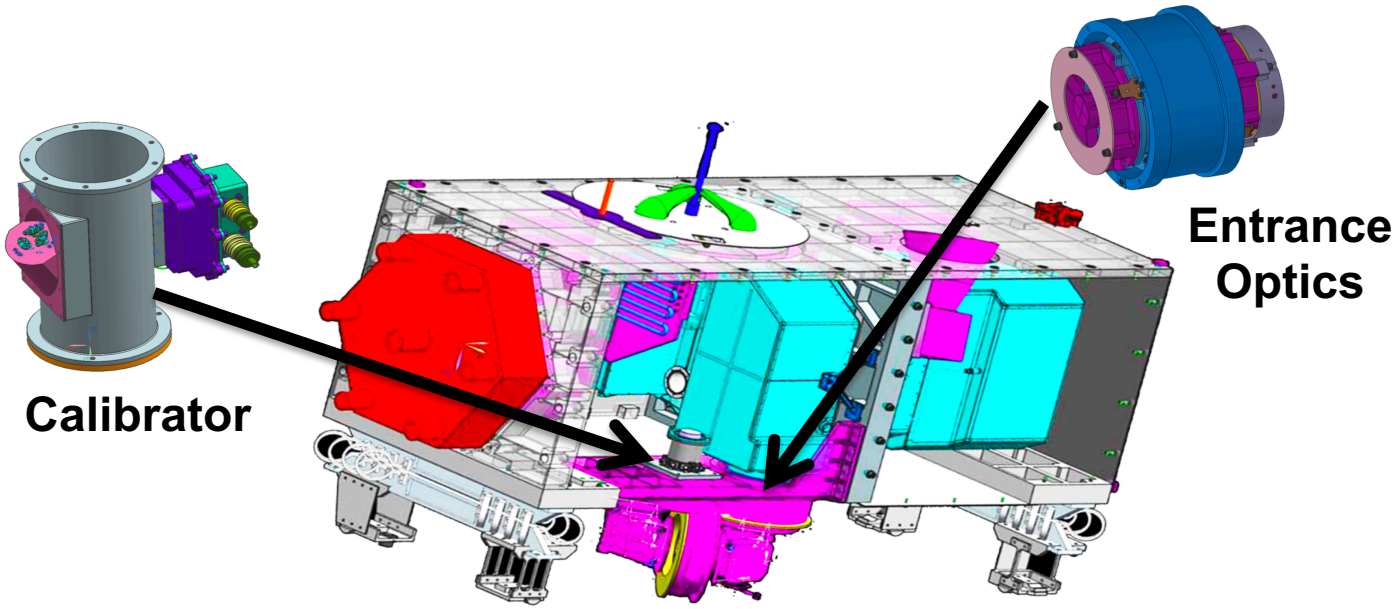
- First B10 ARPs were delivered Dec 2018
  - BPM 10 time period only
  - QTS has been run and is being analyzed
- Revised B10 ARPs were delivered Apr 2019
  - BPM 10 time period only
  - ARP Validation underway
  - Revised QTS will follow
- B10 ARPs to fill in rest of the mission record by Jul 2019
  - BPM 6, 8, 9, 11
  - Will need ARP Validation
  - Will need to define expansions of the QTS because it ends in Jul 2018

L1B Delivery Status – BPM 10 Normal First



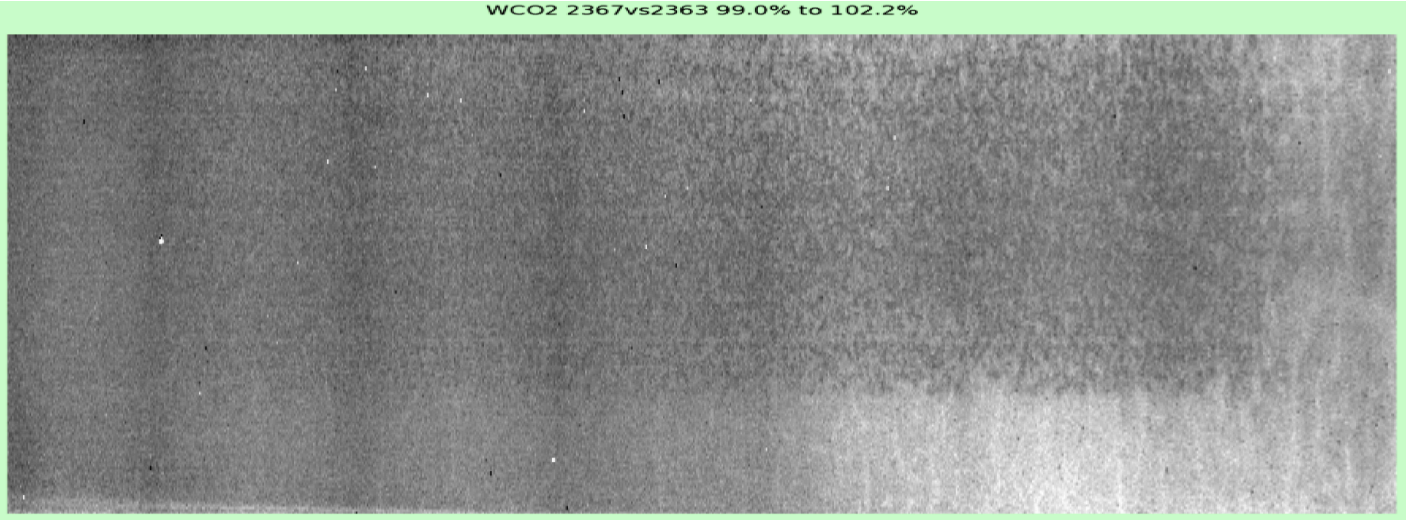
OCO-3 Highlights

- Hardware changes: new telescope + new polarizer, PMA, new FPAs, new calibrator
- Larger field of view to keep same footprint on ground. OCO-2 0.8˚, OCO-3 1.8˚
- Sharper focus
- No clocking in WCO2 and SCO2, only 3 jumps in ABO2
- No solar calibration & reduced lunar calibration opportunities will make it more difficult to separate lamp degradation from instrument degradation
- More frequent use of secondary lamps, more reliant on VicCal & cross cal
- More frequent views of desert sites from ISS, but with less consistent solar geometry



Features and Challenges Unique to OCO-3

- Crazing – network of thin “veins” on FPAs, temperature dependent
- Fringing – etalon from new polarizer moves as telescope temp. changes
- Gain instability – changes with resets or AFE temperature changes
- Sensitivity to lamp alignment
- **Magnitude of these effects is < 1%**
- If changes are slow, artifacts **should be corrected by gain degradation**



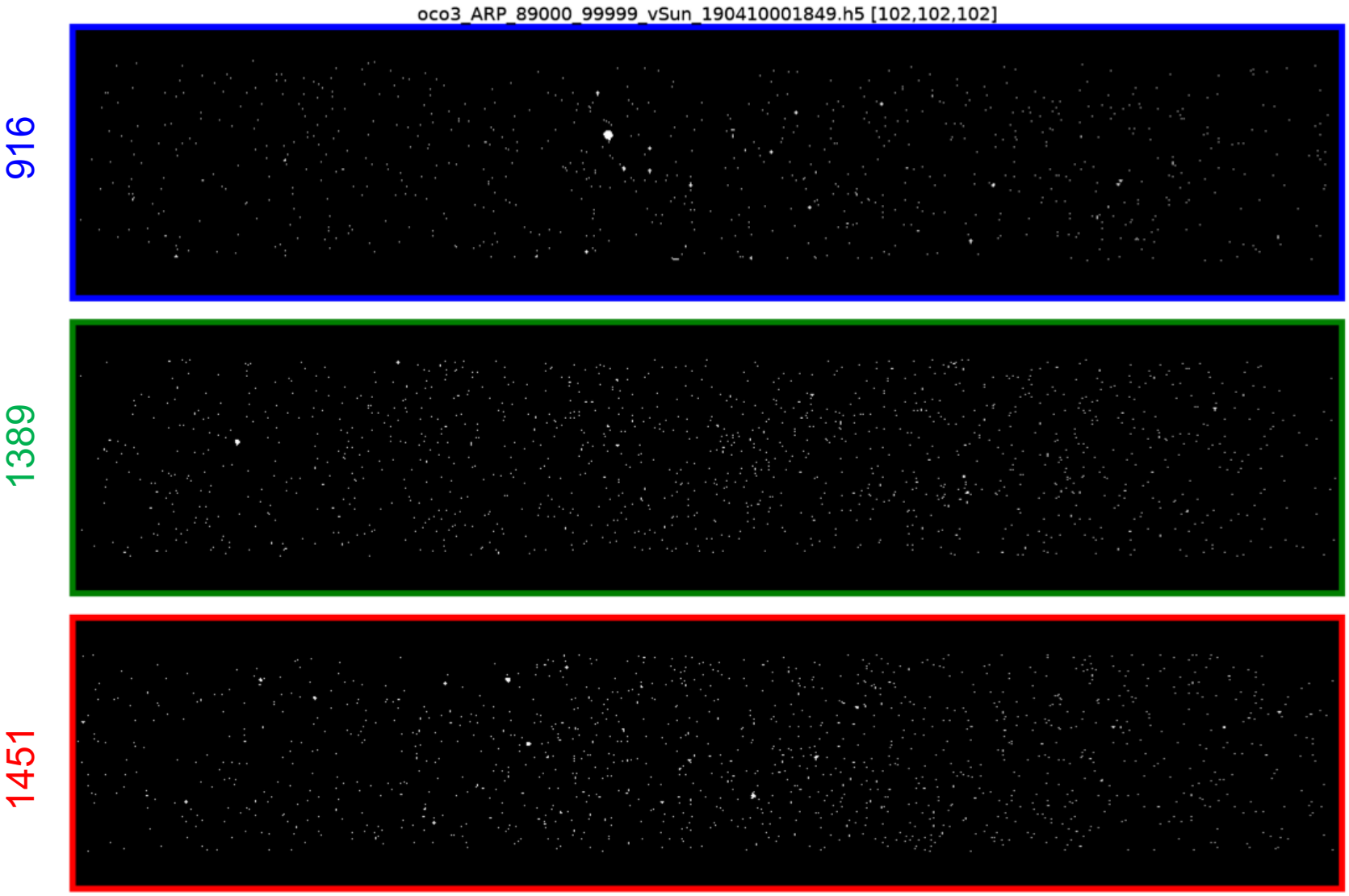
OCO-3 Milestones in IOC and Early Ops

- First light in early June (exact timing depends on decon, PMACal, etc)
- Nominally 3 weeks from first light to end of IOC
- First week: data collection without updating any calibration parameters
- Second week: initial updates and further analysis
- Third week: final updates, confirm necessary updates executed successfully

- Dark correction can be updated after ~50 orbits
- Need to check how well lamps compare to TVAC 3 signal levels
- ~100 orbits each of lamp and dark data can be used to update the bad pixel map
- **After a successful BPM update, the Cal Team will be ready to exit IOC**

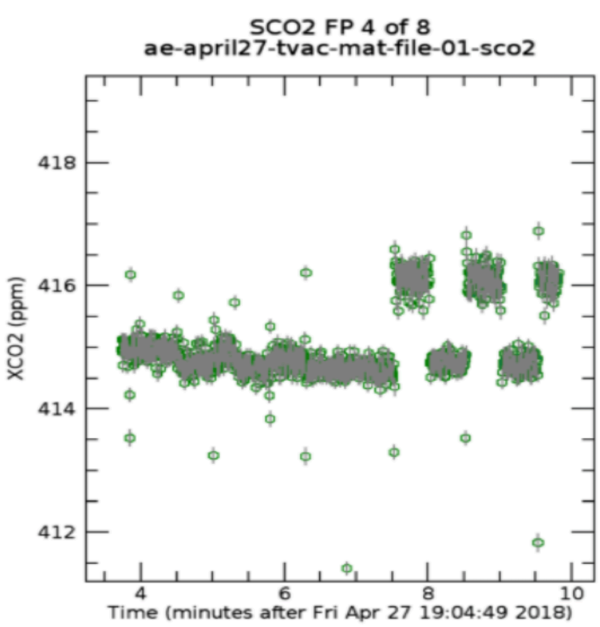
- Will deliver a batch of consistent retrospective ARPs in ~August to support L1b public release in ~September
- IOC will focus on Radiometric Calibration, but in early ops we will also check Geometric, Spectral, and Polarimetric as appropriate

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



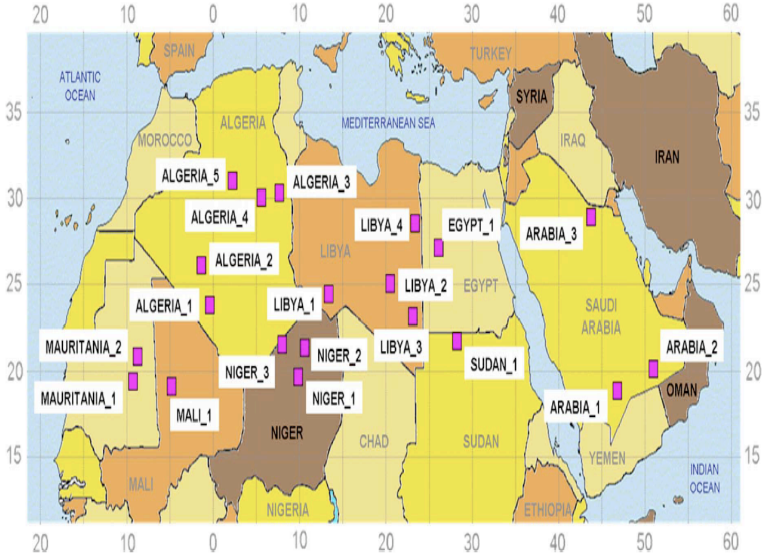
Uplooking Heliostat Analysis

- The instrument was reset twice between collection of heliostat and laser data, making it more difficult to interpret spectral verification (TCCON residuals)
- The L1b ratio “matador” test passed, though slightly worse than OCO-2
- The better-focused telescope amplifies artifacts from the matador screen
- Will continue to process as improved ILSs are developed

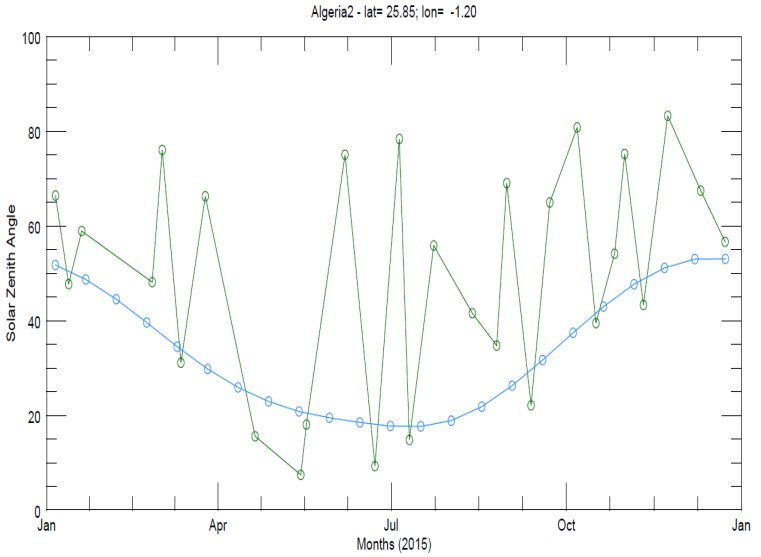


OCO-2 / OCO-3 Cross Calibration Plans

Map of PICS Sites



Trend of SZA vs Time @ Algeria 2



Railroad Valley, NV

Three campaigns planned during IOC and early ops

6/16 - 6/17

6/30 – 7/05

8/03 – 8/04

Conclusion

- OCO-2 Build 10 is nearly complete, and we are eagerly awaiting evaluation of the new L1b data
- OCO-3 IOC will focus on dark correction, lamp checkout, and an updated bad pixel map
- OCO-3 Early Ops will prepare gain degradation and other updates as needed for first reprocessing campaign
- There are several subtle differences between the two instruments, but the calibration process is largely the same