Committee on Earth Observation Satellites

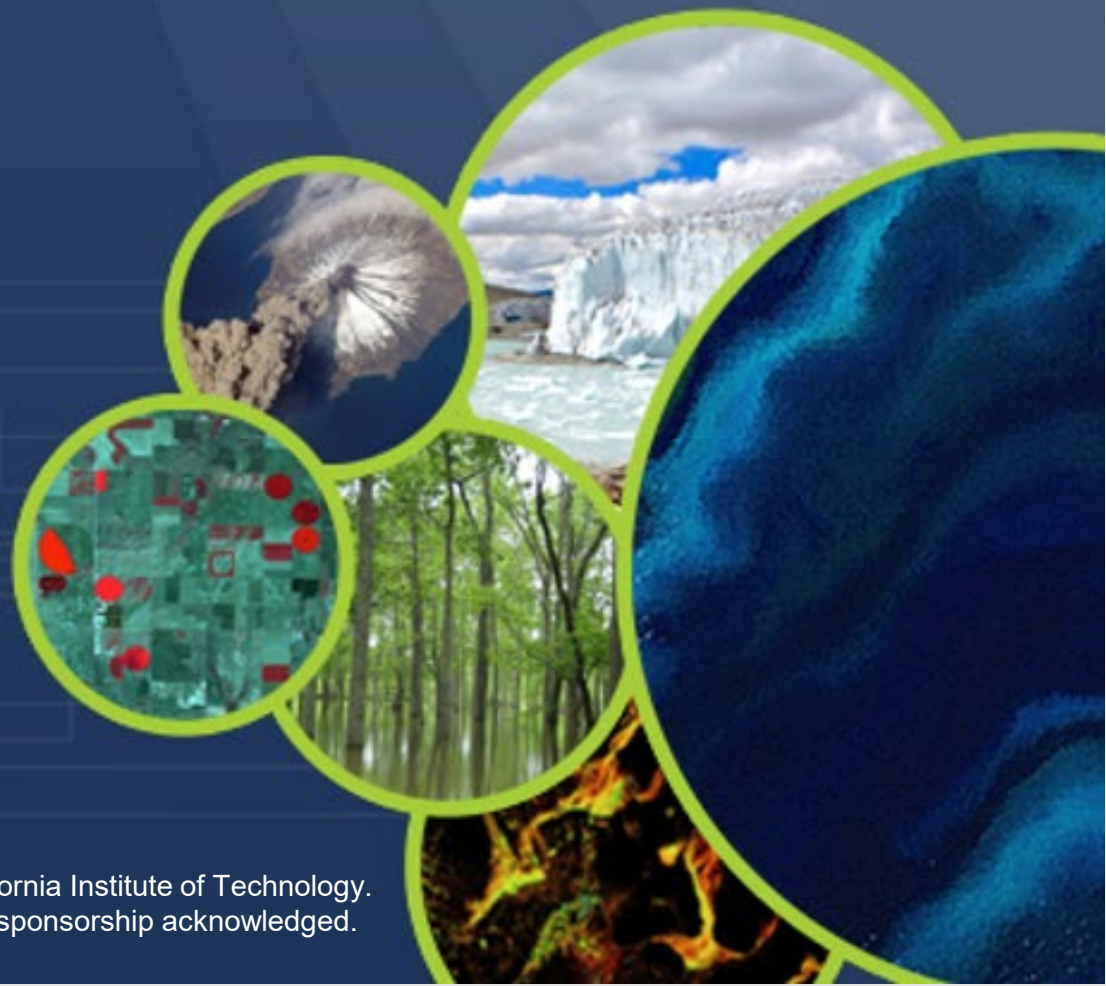
OCO-2 and OCO-3

David Crisp (Jet Propulsion Laboratory,
California Institute of Technology)

CEOS AC-VC-15

Nakano Sun Plaza, Tokyo, Japan

10 – 12 June 2019



Status Summary

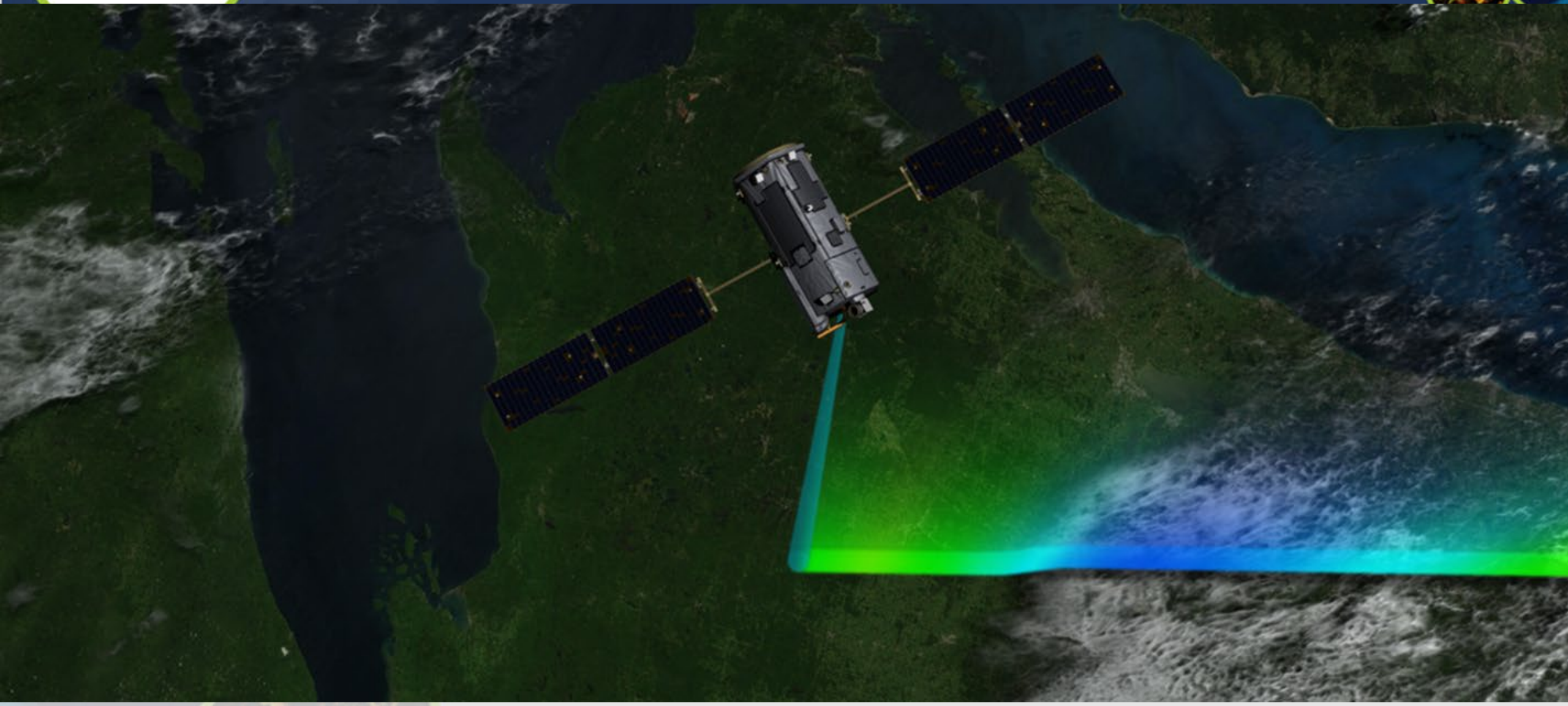
OCO-2 Status

- Observatory Status: Nominal
  - Degradation of z-axis gyro in the inertial measurement unit
- Instrument Status: Nominal
  - Most recent decon - 4 - 11 March 2019 executed nominally
- Science Status: Nominal
  - ACOS/GOSAT version 9 – 2013 Run completed
  - “Build 10” testing ongoing

OCO-3 Status

- Successfully Launched on 4 May and docked with ISS on 6 May
- Installation on JEM-EF module on 10 May
- In-Orbit Checkout in progress

OCO-2 Status

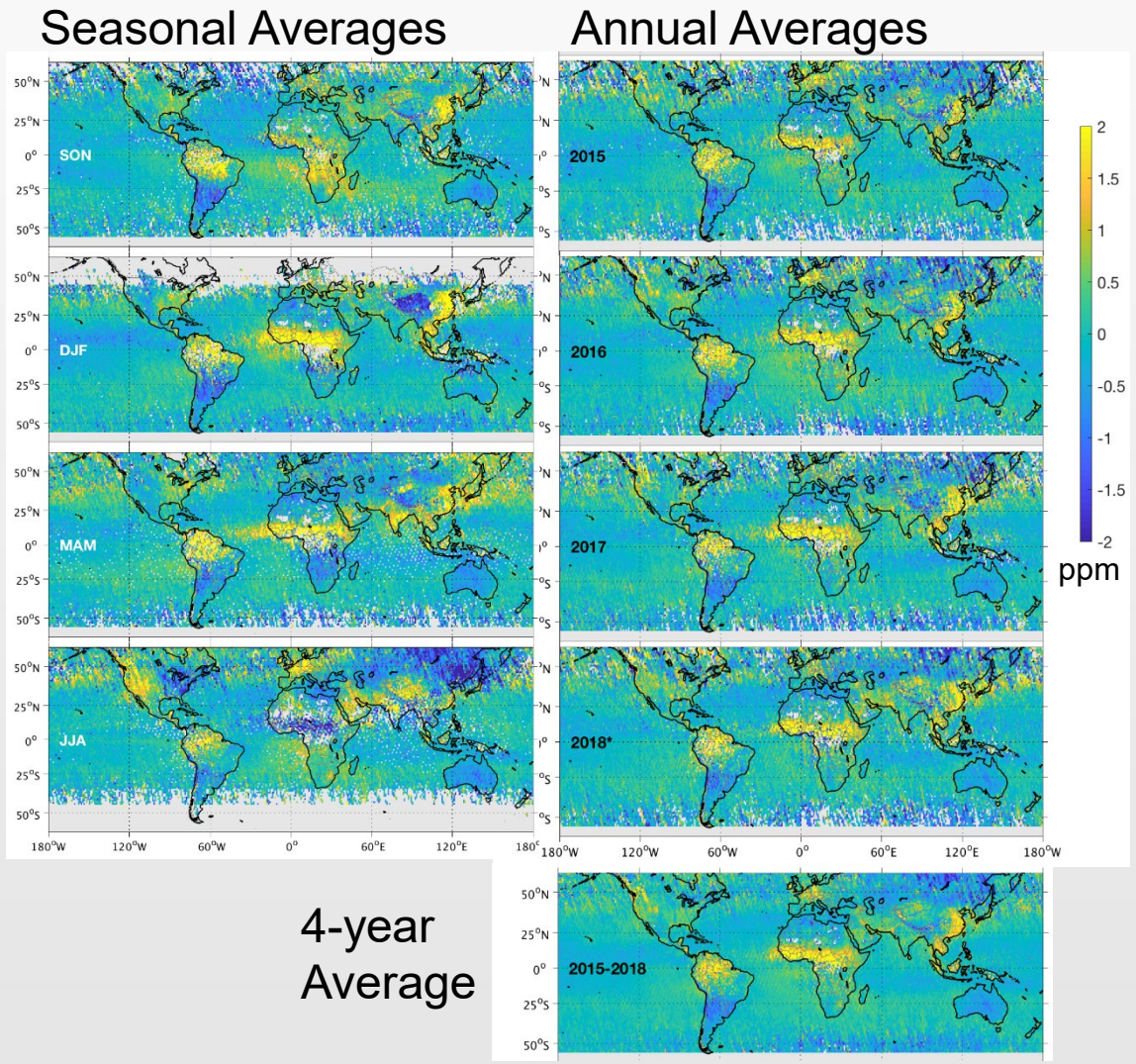


Inertial Measurement Unit Issue

- The OCO-2 attitude control system uses data from a star tracker, an inertial measurement unit (IMU), sun sensors, and a magnetometer to determine the spacecraft attitude.
- The IMU includes 3 ring laser gyros for monitoring rotation about the spacecraft's x, y, and z axes. The z-axis is gyro is degrading rapidly.
- The flight software must be patched to remove dependencies on the IMU. Those changes are currently under way
- Science impacts of the loss of the IMU
  - Will not affect nominal science operations
  - Will require more careful scheduling of Target observations and downlinks
  - Will preclude future Full Moon Lunar Calibration and Solar Doppler calibration operations due to obscuration of star tracker field of view by the disk of the Earth – neither loss will compromised routine calibration

OCO-2 Tracks Persistent XCO_2 Anomalies

- Seasonal (left) and annual (right) average XCO2 anomalies were derived for 2015-2018.
- Positive XCO_2 anomalies dominate the tropics throughout the 4-year period, except equatorial Africa during JJA – are the tropics now a net source of CO_2?
- High latitudes land shows negative XCO_2 anomalies, that are strongest during JJA

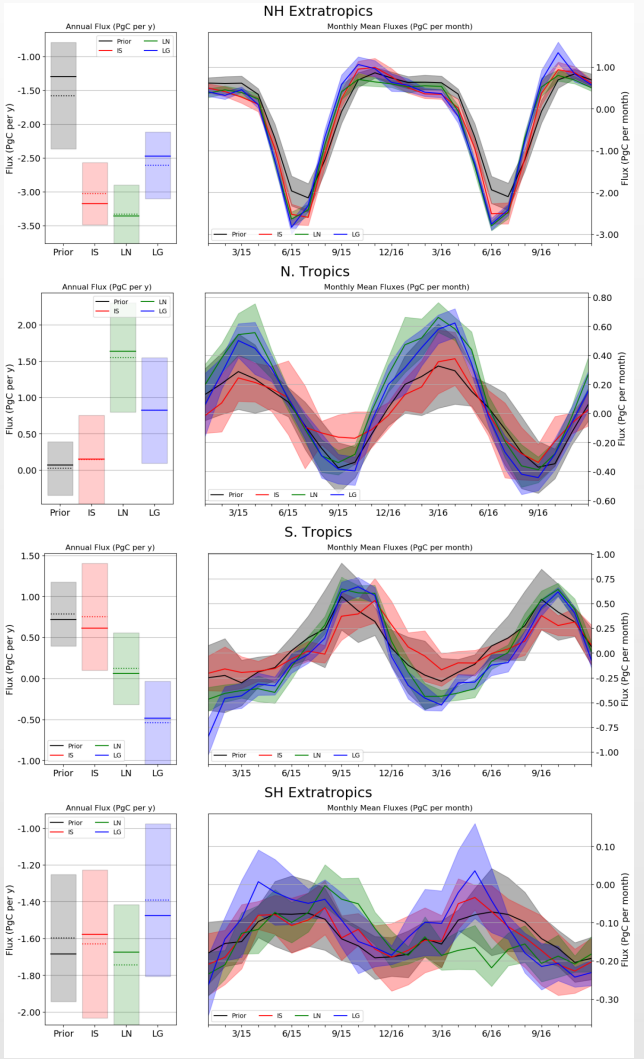


Hakkarainen, J., Iolongo, I., Maksyutov, S., and Crisp, D., Analysis of Four Years of Global XCO_2 Anomalies as Seen by Orbiting Carbon Observatory-2, Remote Sens. 2019, 11(7), 850; doi:10.3390/rs11070850

2015-2016 Fluxes as seen by OCO-2 and the Global in situ Network

- The OCO-2 team has been running a global multi-model intercomparison to improve our ability to retrieve CO_2 sources and sinks on regional scales from in situ and OCO-2 observations
  - Current experiments using only OCO-2 version 7 data over land
- Results
  - OCO-2 and in situ data indicate a global annual carbon sink of 3.7±0.5 PgC
    - Land contribution is 1.5±0.6 PgC
  - Agreement is best in northern hemisphere extratropics, which are well sampled by the surface networks
  - The largest difference occur over tropical Africa where there are few in situ measurements

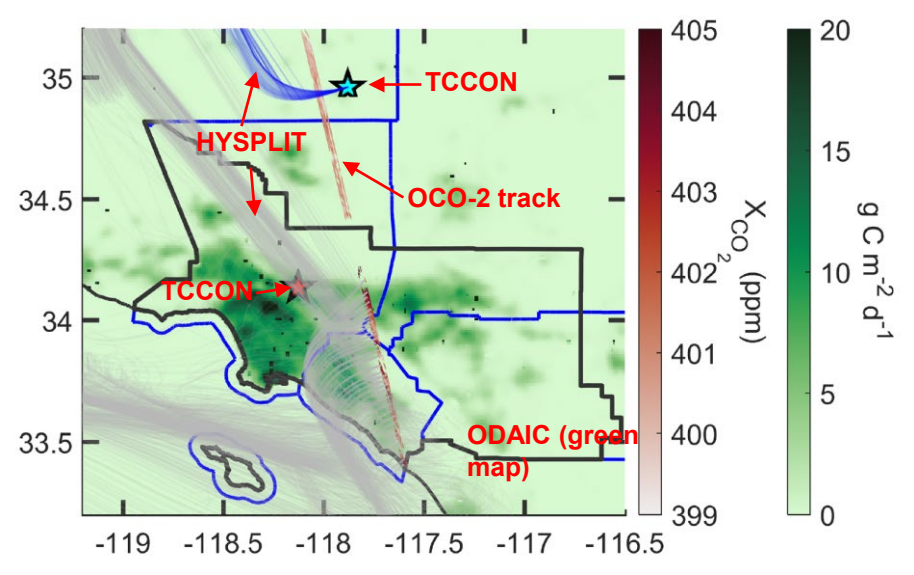
Crowell et al. Atmos. Chem. Phys. Discuss, 2019



What is the total CO_2 flux from greater Los Angeles?

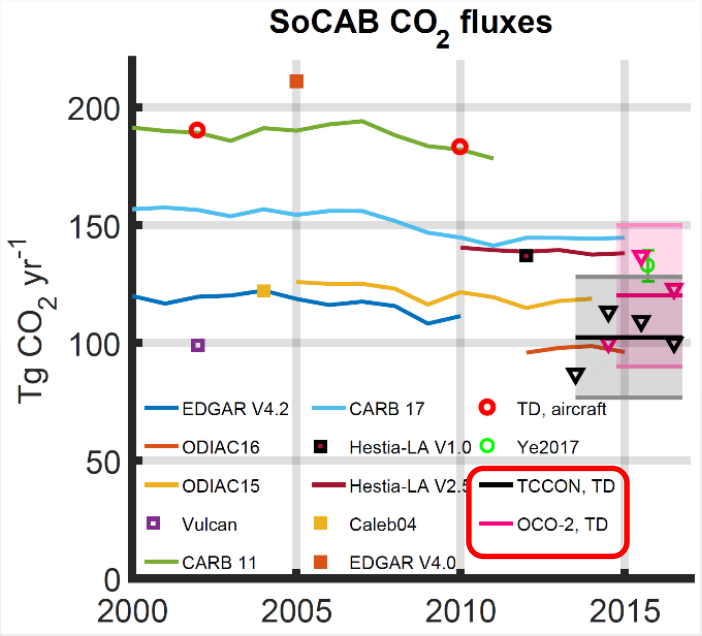
Tools

- OCO-2 satellite data, TCCON ground data
- NOAA meteorology (NAM 12km, HYSPLIT)
- ODIAC and Hestia-LA emissions
- Inversion model developed for this work



Results

- Found fluxes in between ODIAC16 and Hestia-LA
- Performed 10 tests to estimate uncertainty, total is 25% - biggest source is meteorology



Significance

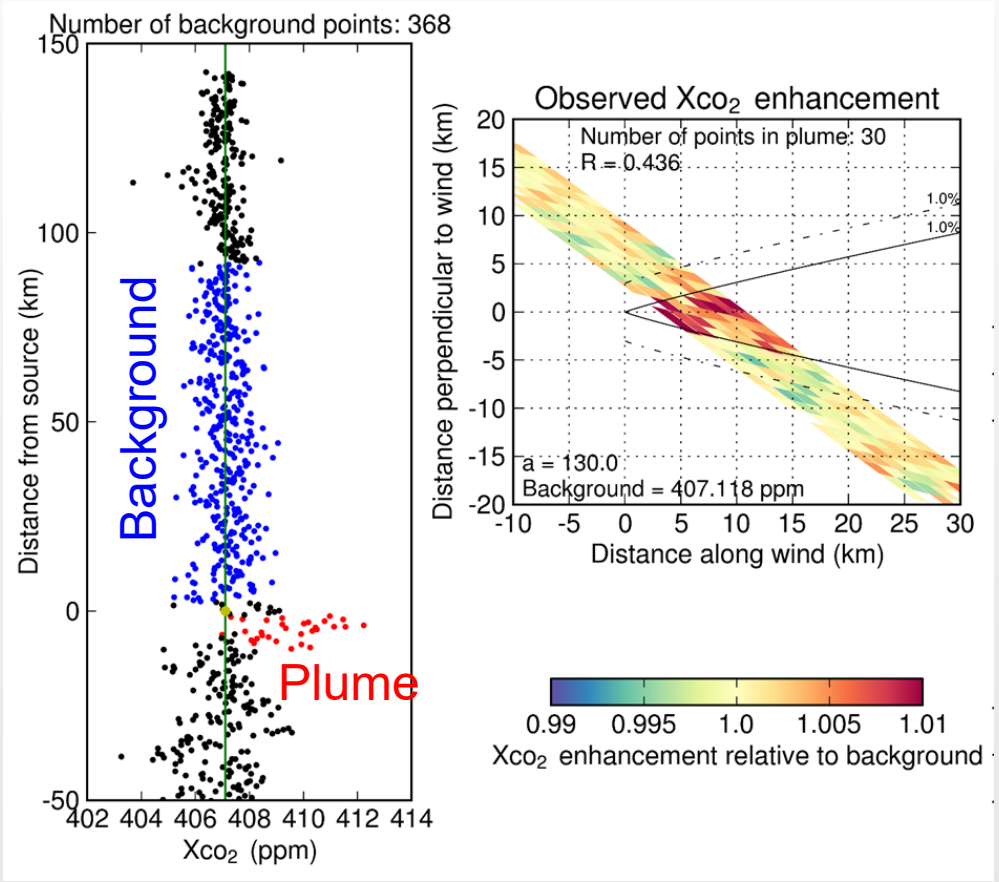
- Demonstrates a method to convert OCO-2 observations to urban emissions in Tg CO_2 yr^{-1}
- Coupled with future studies (e.g., with OCO-3) may help show urban carbon flux trends

Jacob Hedelius, Junjie Liu, Tomohiro Oda, Shamil Maksyutov, Coleen Roehl, Laura Iraci, James Podolske, Patrick Hillyard, Jianming Liang, Kevin Gurney, Debra Wunch, Paul Wennberg, Atmos. Chem. Phys., 18, 16271–16291, 2018

Emissions from Large Power Plants

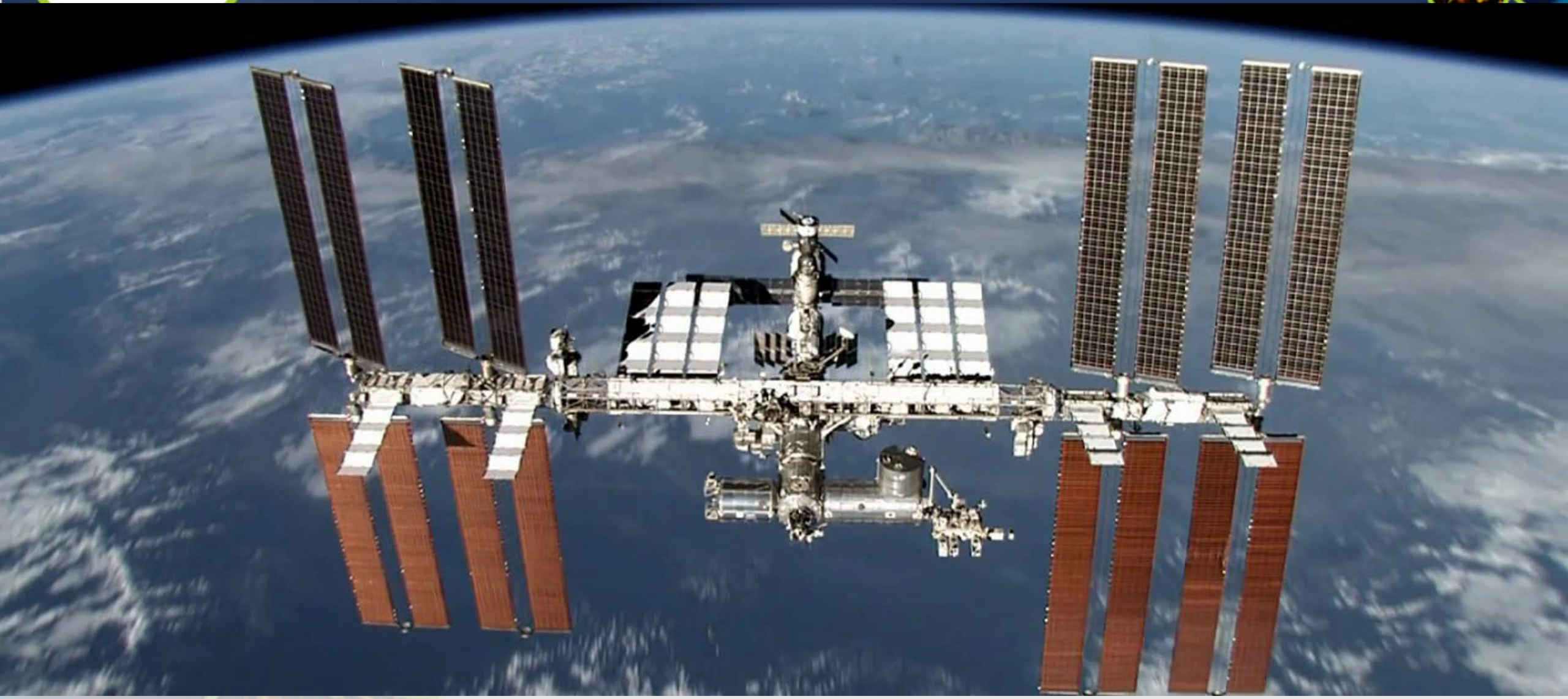
- **Goal:** Demonstrate that OCO-2 can detect and quantify emission from large power plants
- **Approach:** Quantify emission rates using OCO-2 XCO_2 enhancements and local wind data
- **What we've Learned:** OCO-2 data can be used to quantify emissions at the 7 to 20% level in a single overpass
- **Benefit:** Space-based CO_2 measurements will play a critical role in future emissions monitoring

Ray Nassar and Calium McCracken, Remote Sensing, 2019



OCO-2 flew over the Belchatow Power Station in Poland March 28, 2017, detecting 89±12 kilotons of CO_2 per day – consistent with other reports.

OCO-3 Status

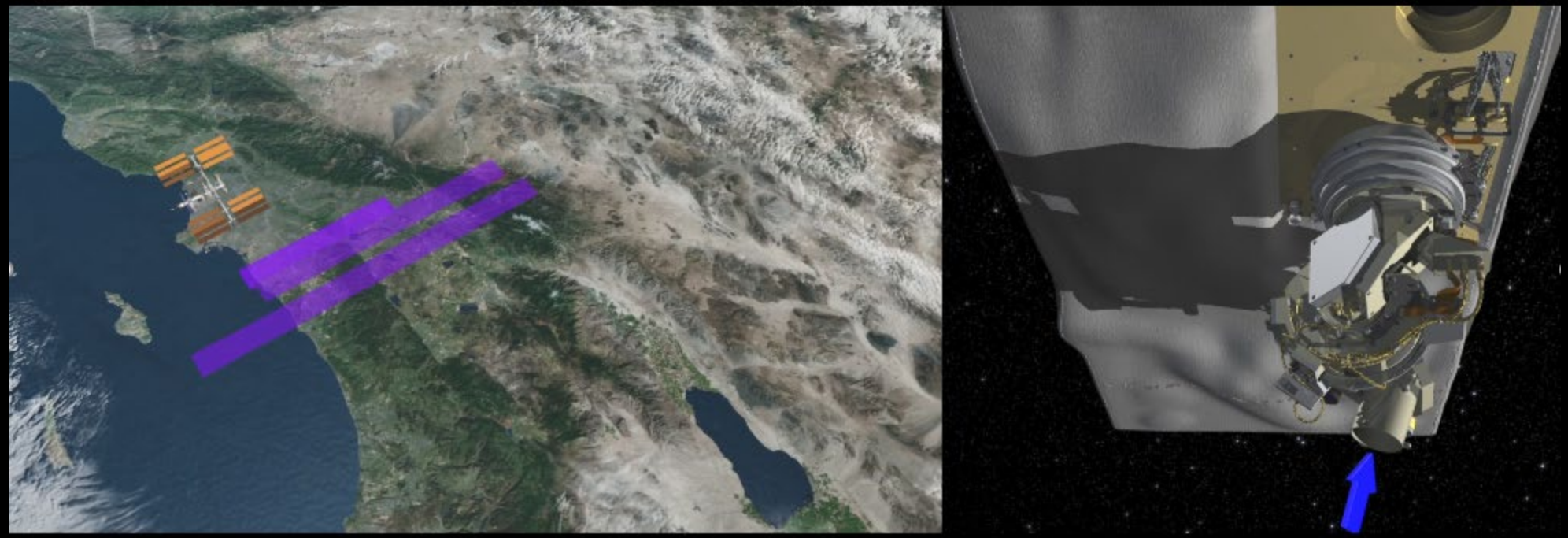


Status of In-Orbit Checkout

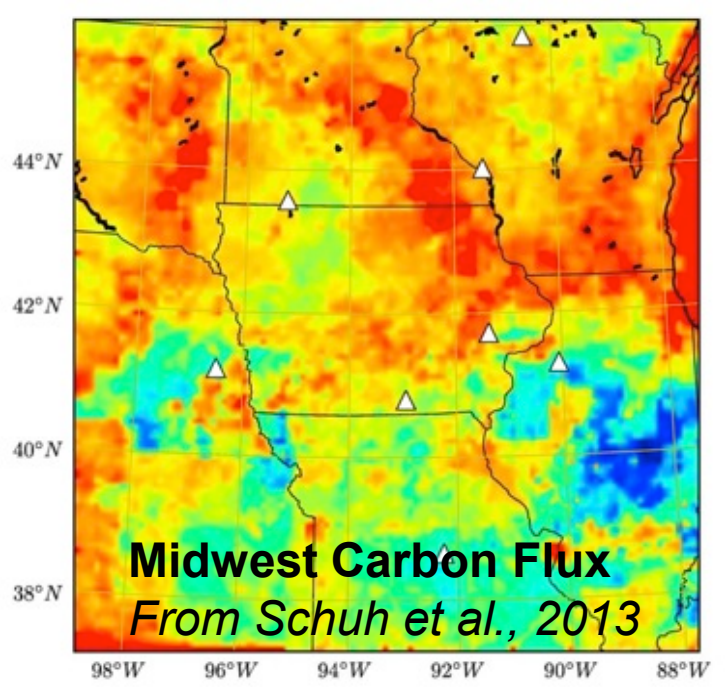
- OCO-3 successfully launched into orbit aboard SpX-17 on May 4th at 0648 UTC.
- Rendezvous with ISS and Dragon berthing on ISS Node 2 Nadir was successful on May 6th (Monday).
- Robotic extraction of OCO-3 on late May 9th
- Installation on JEM-EF on May 10th
- Pointing Mirror Assembly (PMA) functional testing complete
- Context camera functional testing complete
- PMA calibration ongoing

Integration, Launch and Early Operations

OCO-3 Snapshop Mode



Unique Science Opportunities with OCO-3



Terrestrial Carbon Cycle

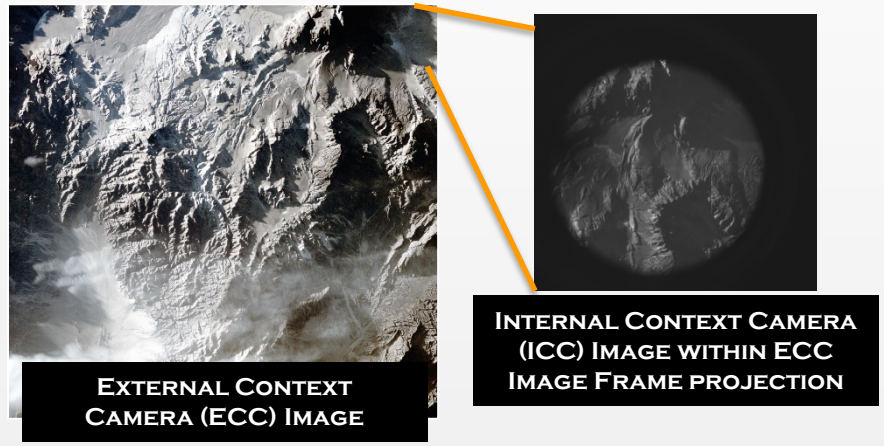
Process studies enabled by measurements at all sunlit hours, including SIF. ISS will contain complementary instrumentation.

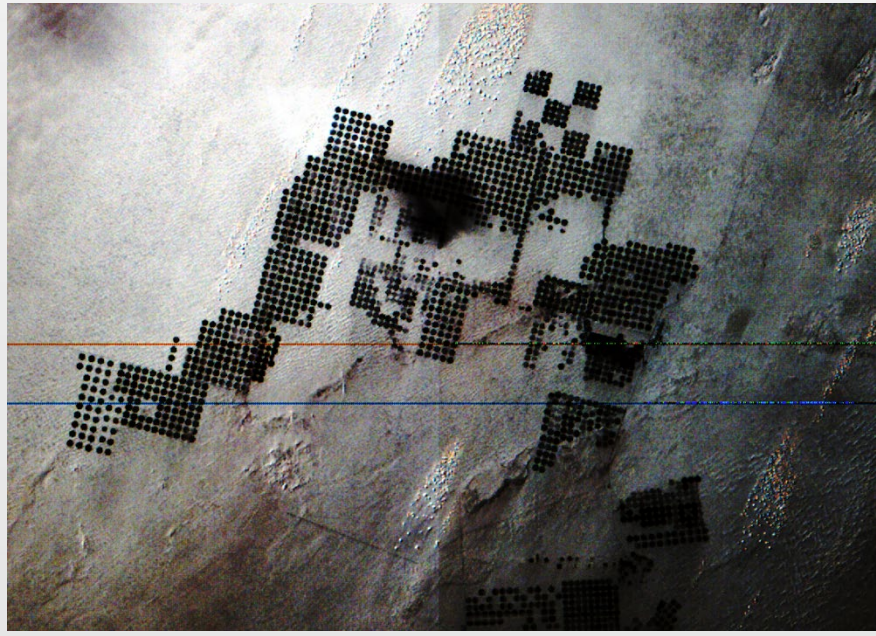
Anthropogenic Emissions

Enabled by enhanced target mode using pointing mirror assembly

Near-term Plans or In-Orbit Checkout (IOC)

- Calibration of pointing mirror system is underway
- Cool detectors (around June 20)
- 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.





OCO-3 Summary

- 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

- Next steps:
  - OCO-3 will observe RRV this month 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