Radiance Comparison from OCO-3 and OCO-2 Simultaneous Nadir Observations (SNOs)

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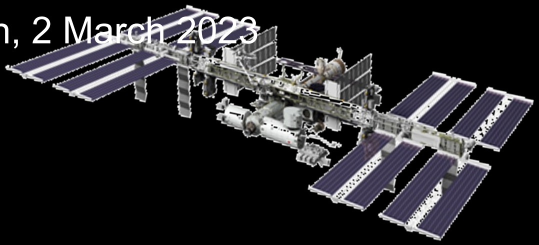
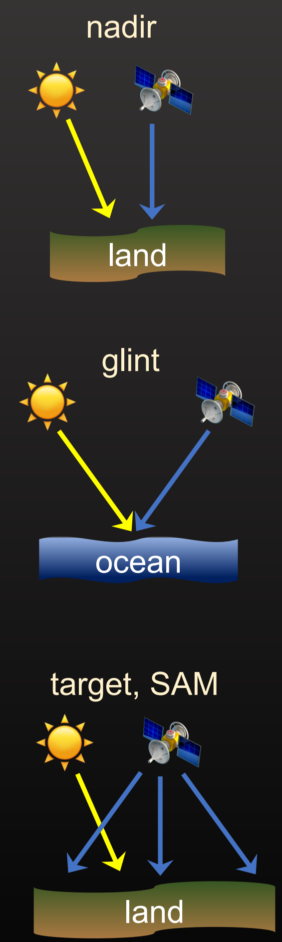
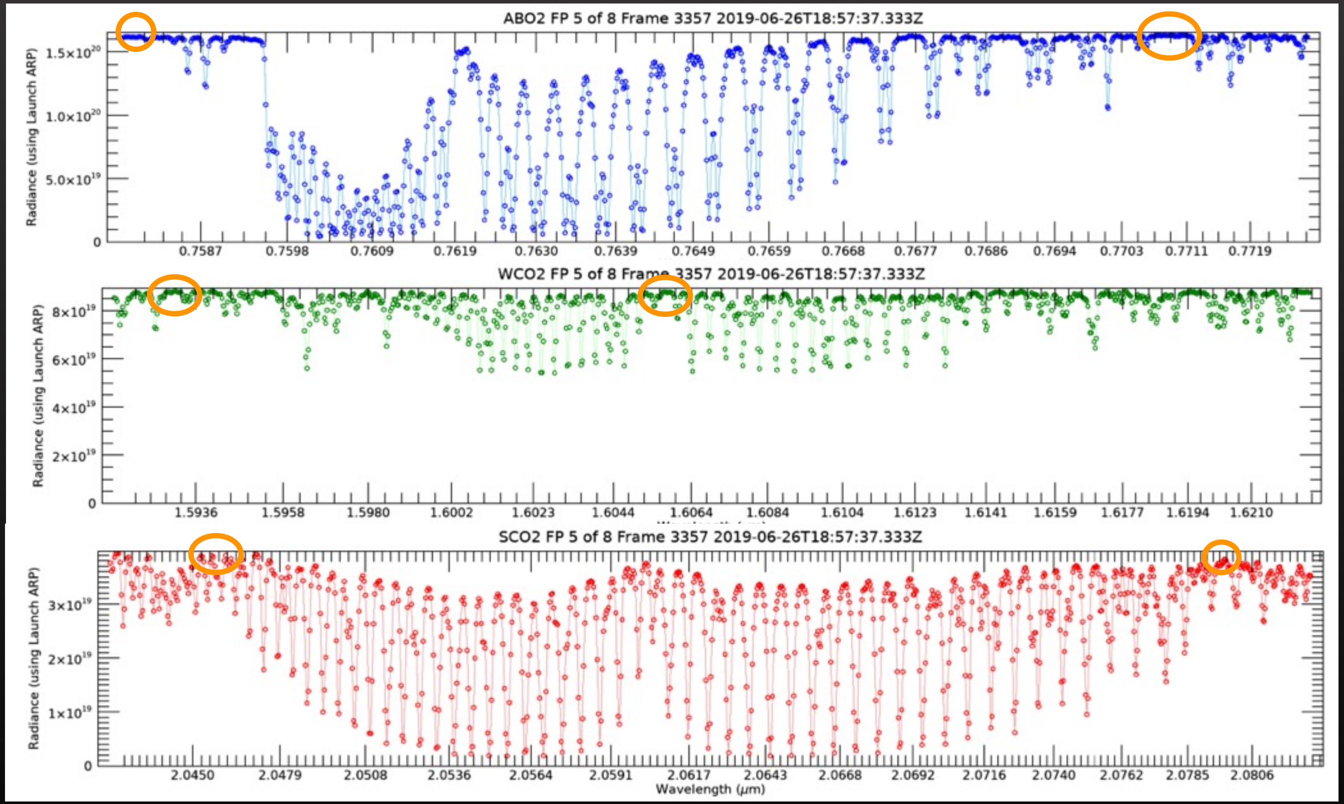


OCO-2 *vs* OCO-3 Instrument Overview

	OCO-2	OCO-3
launch	02 July 2014	04 May 2019
orbit	sun-synchronous, A-Train	precessing, ISS, 51.6° inclination
coverage	pole-to-pole, 1330h ect	52°S – 52°N, variable
footprint size @nadir	3 km^2	4.5 km^2
spectrometer	3 bands: 0.765 µm, 1.61 µm, 2.06 µm, 20,000 resolving power (OCO-3 was built as the OCO-2 spare)	
observed species	CO_2 dry-air column (XCO_2) solar-induced fluorescence (SIF)	
observation modes	nadir, glint, target	nadir, glint, target, **SAM**
off-nadir viewing	move spacecraft	**pointing mirror assembly** two mirrors: azimuth and elevation, moving independently
repeatability of observations	same local time every orbit; spatial repeat after 233 orbits (16 days)	**none!** local time a little earlier each day; day-by-day change in latitude coverage



OCO-3 First Light Radiance Spectra



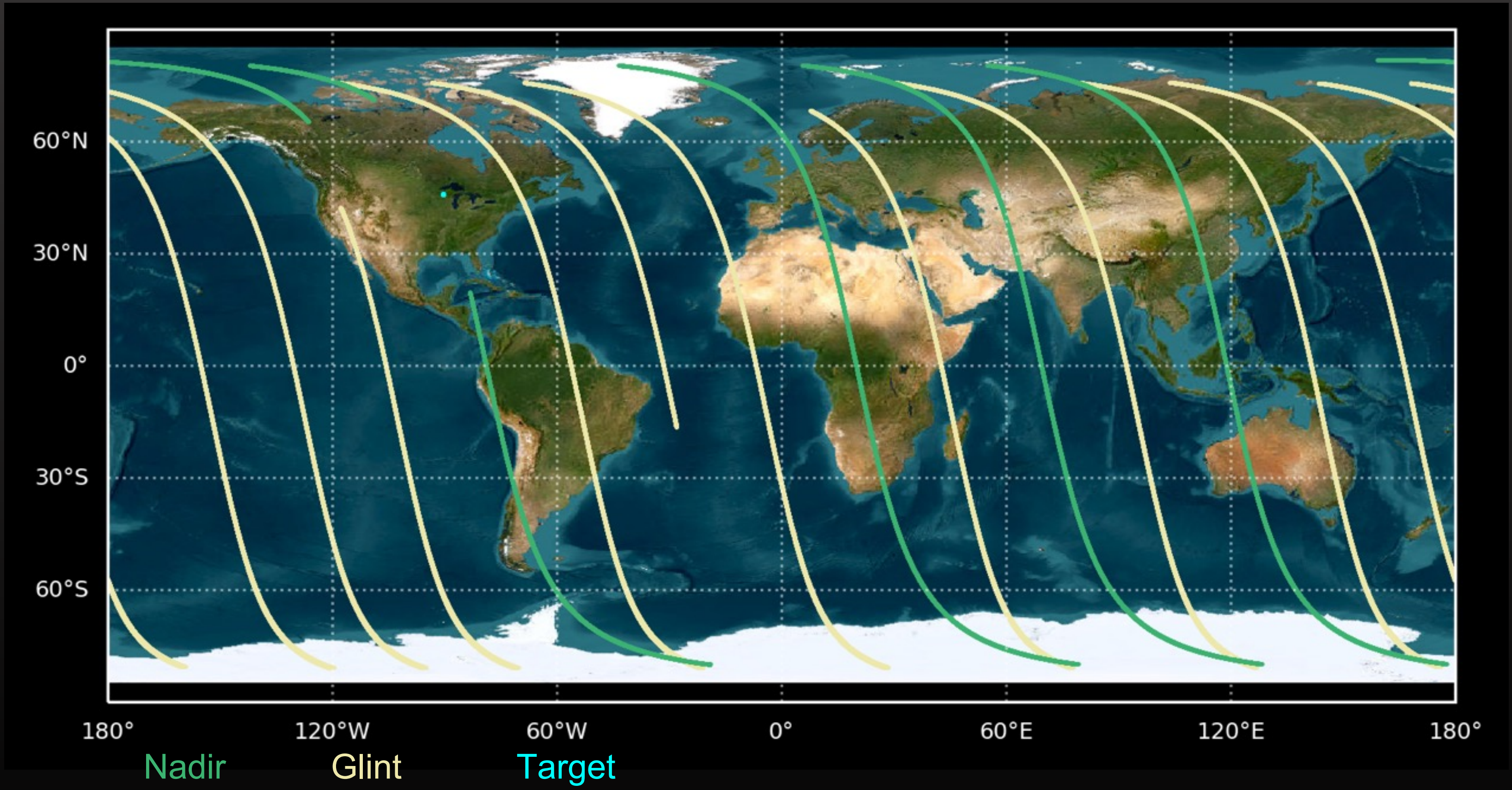
O_2 *A* band channel, 0.765 μm (band center)

weak CO_2 channel, 1.61 μm (band center)

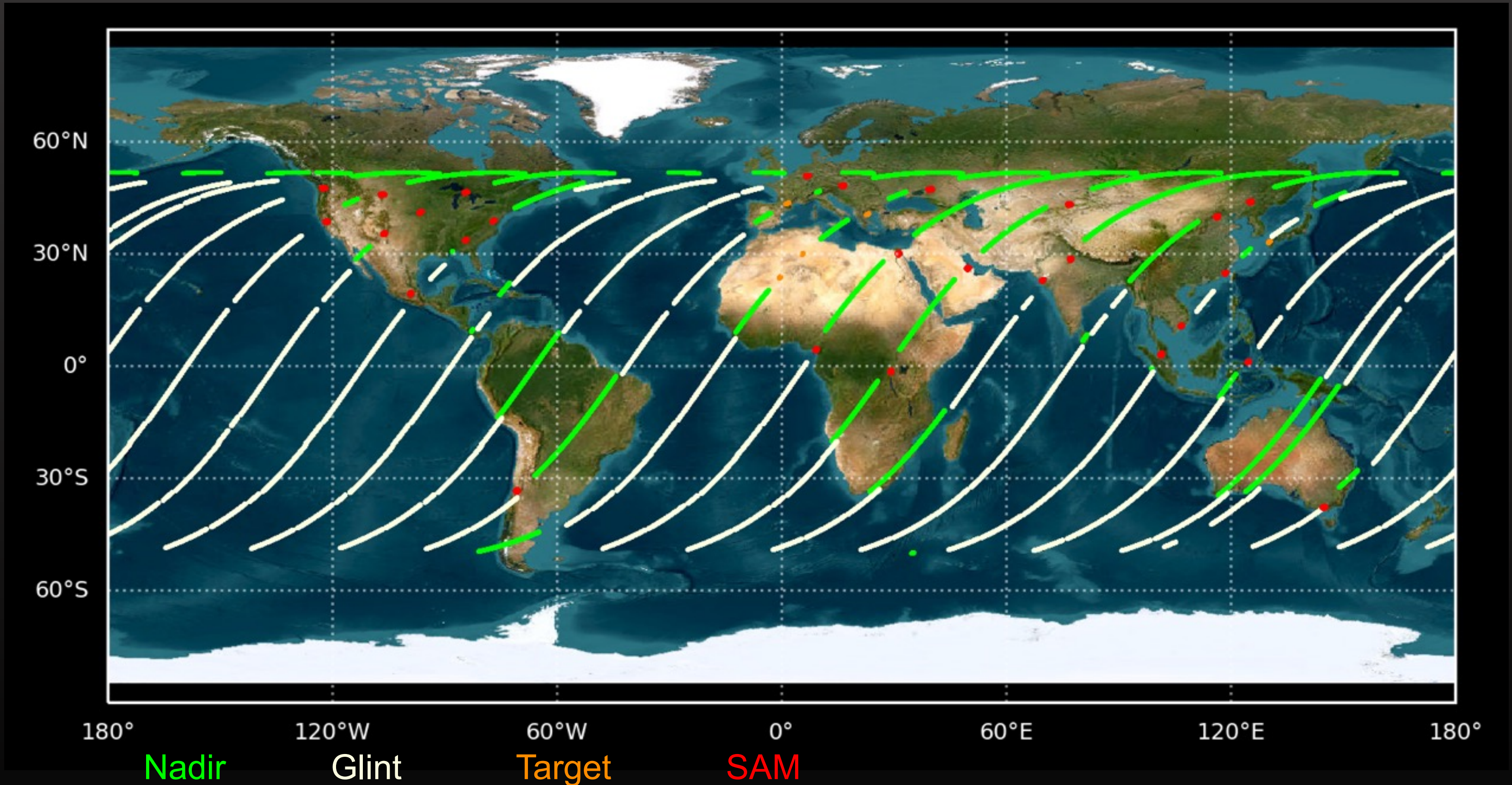
strong CO_2 channel 2.06 μm (band center)

continuum radiance windows – "the gaps between the wiggles" (qualitative)

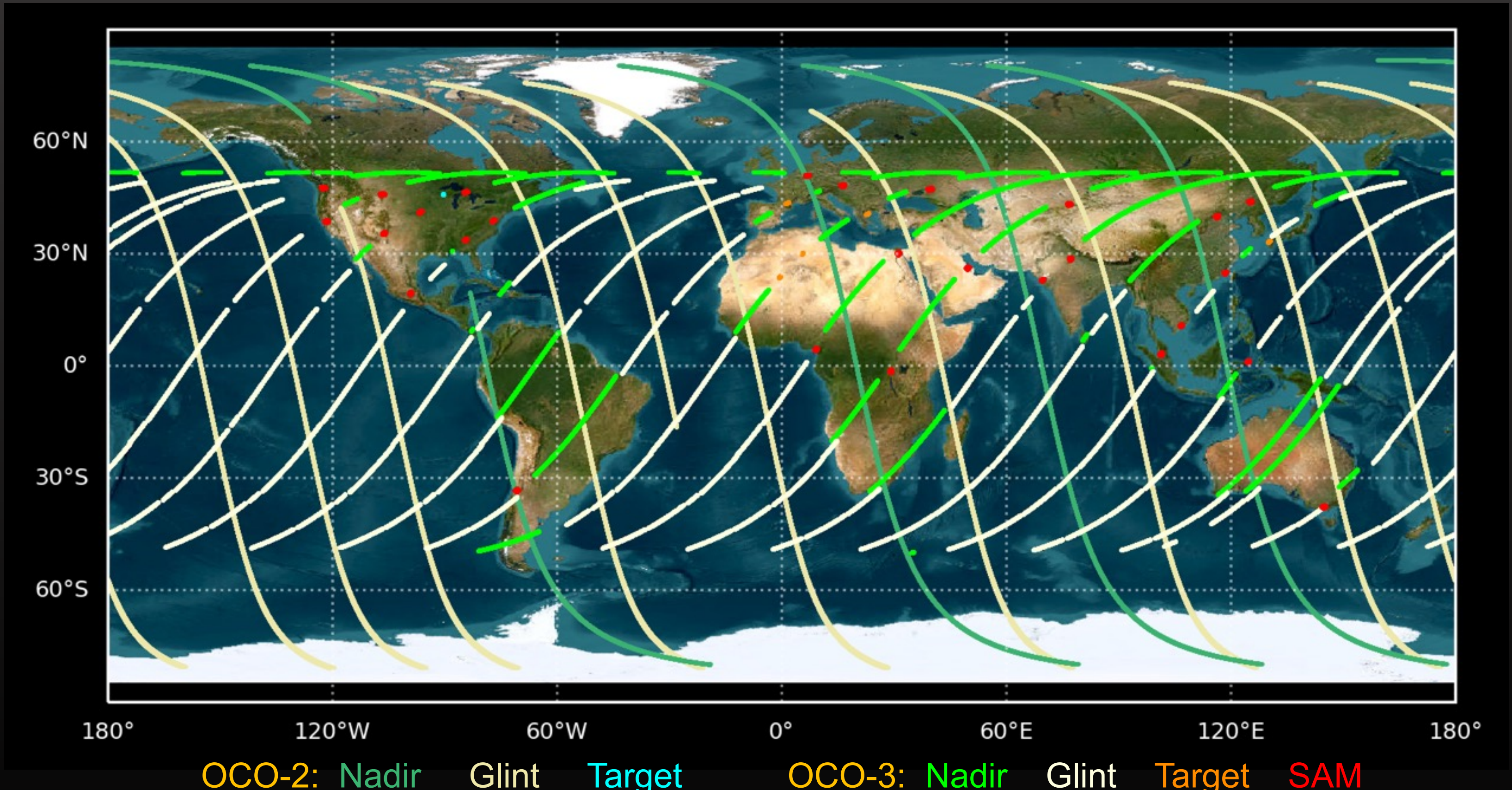
OCO-2 Observation Modes – 2022-10-01



OCO-3 Observation Modes – 2022-10-01



OCO-2&3 Observation Modes – 2022-10-01



OCO-2&3 In-Flight Calibration Sources – Why Consider SNOs?

sources actually used for calibration

Source	OCO-2	OCO-3
On-Board Lamps	every orbit	every orbit
Solar	every orbit	impossible due to ISS constraints
Lunar	monthly	infrequent (not used for B10, work in progress)

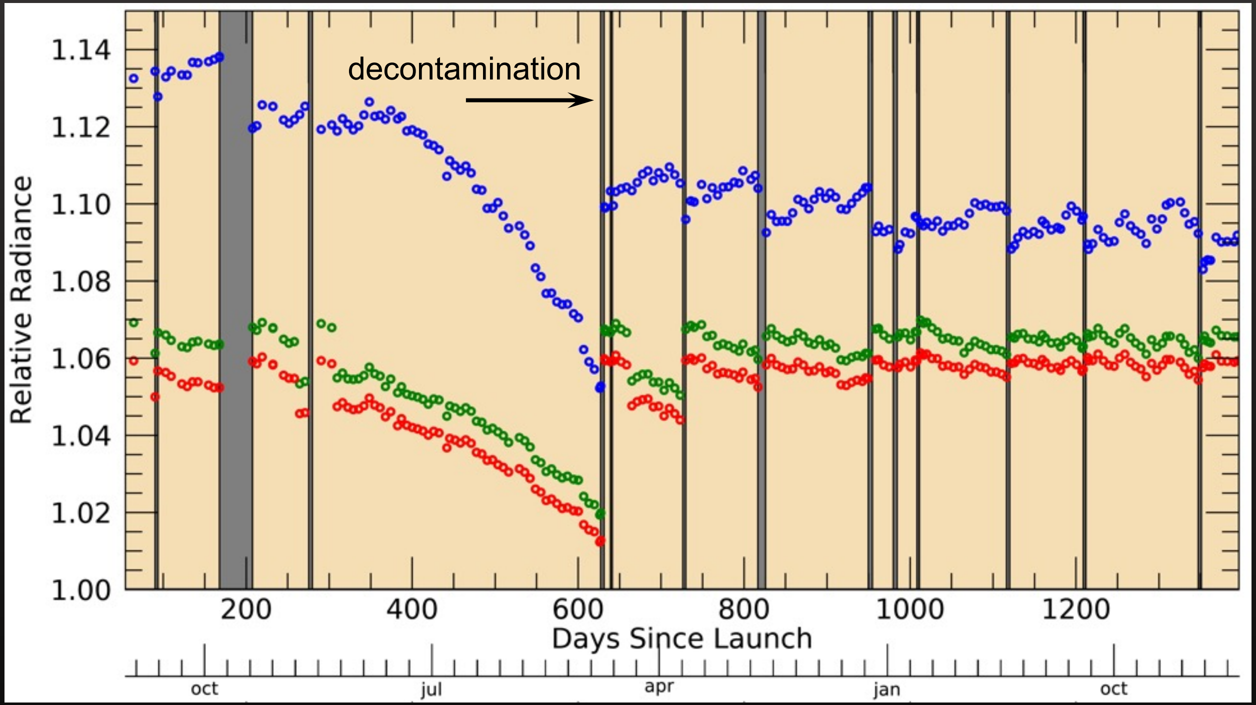
additional sources to test/verify calibration

Vicarious (RRV)	frequent	frequent
Cross-Sensor (SNOs)	when possible	when possible

OCO-3 Challenges:

- On-board calibration lamps are changing/degrading relative to pre-flight measurements
- Solar observations are not possible due to mounting location on the ISS
- Lunar observations are infrequent, and of inconsistent moon phases

OCO-3 In-Flight Calibration Lamp 1 – Change Over Mission Lifetime



Lamp 1 O_2 *A* Band Radiance relative Thermal Vacuum Test (2018)

How Do We Define and Determine an SNO?

OCO-2 and OCO-3 observe the same location over the Earth

- within 20 minutes of each other, and
- have footprints centered within 2 km of each other

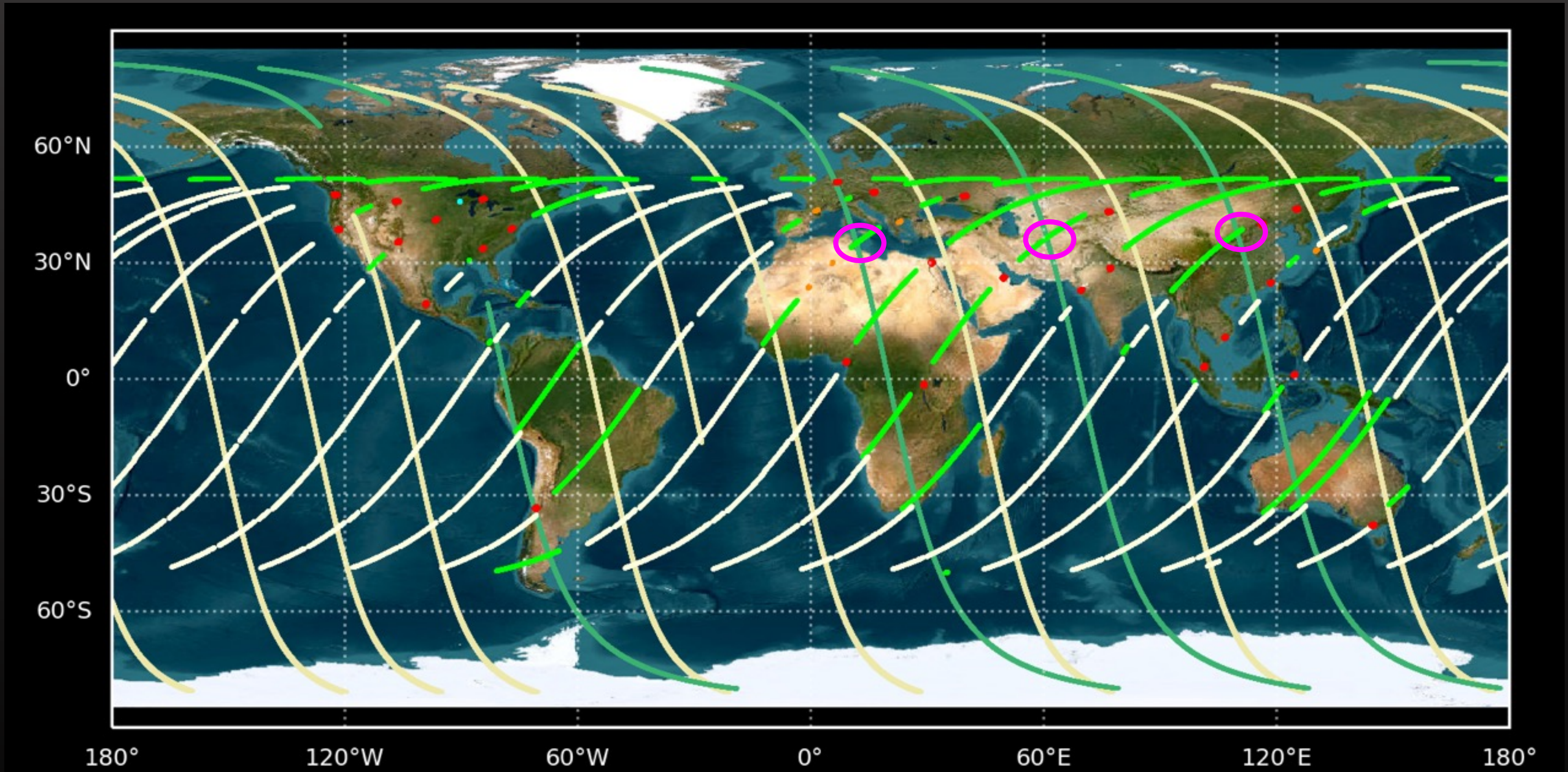
Process of SNO determination

- find ISS/OCO-2 spacecraft crossings within 20 min (OrbNav Tool: https://www.ssec.wisc.edu/~gregq/collopak/orbnav.html)
- identify corresponding L1b data product files (nadir observations only)
- match footprints between the sensors in space and time

SNO analysis is still experimental:

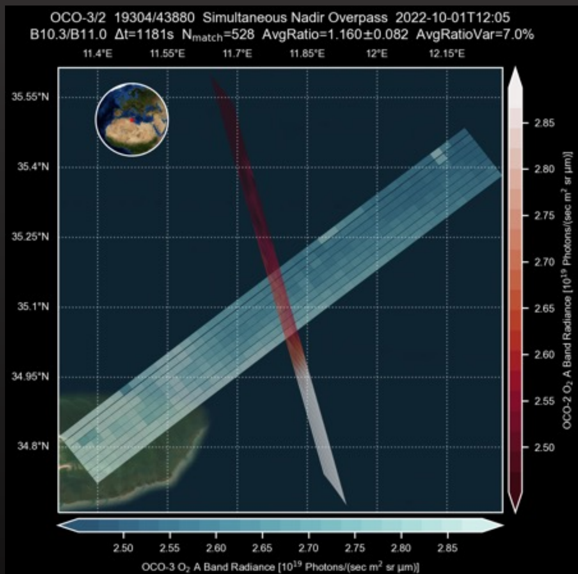
- limited to continuum radiance comparisons
- filter radiance comparisons for homogeneous scenes (low scene/radiance variability)
- compare radiance ratios for overlapping footprints using tessellation-based gridded data (different footprint sizes and footprint overlap)

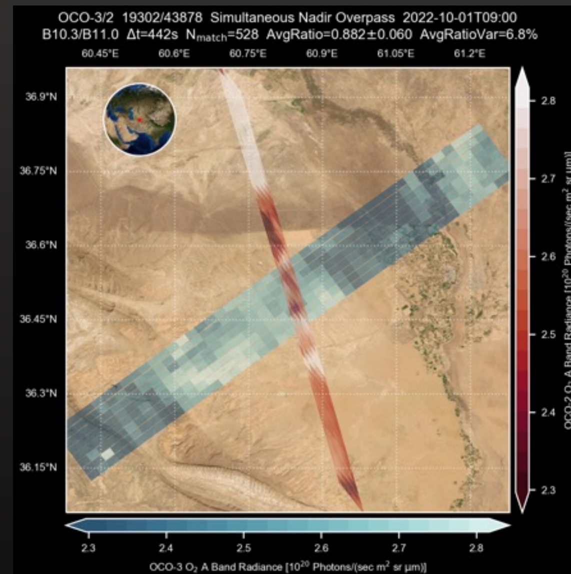
OCO-2&3 Observation Modes – 2022-10-01 SNO Locations

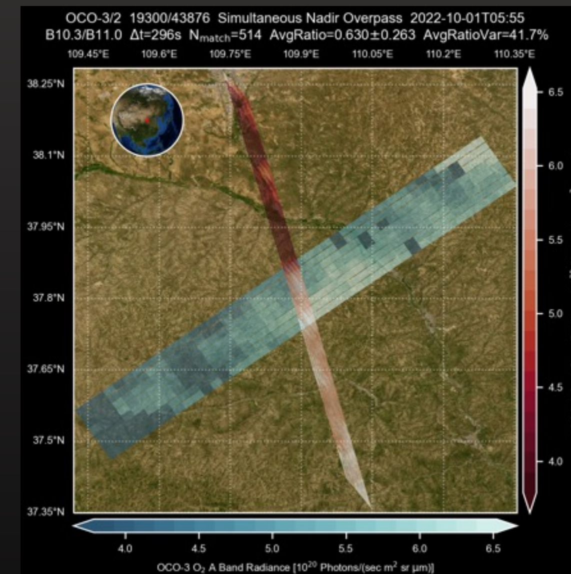


OCO-2: Nadir Glint Target OCO-3: Nadir Glint Target SAM

SNO Maps 2022-10-01: Continuum Radiances, O_2 *A* Band Channel (0.765 µm)



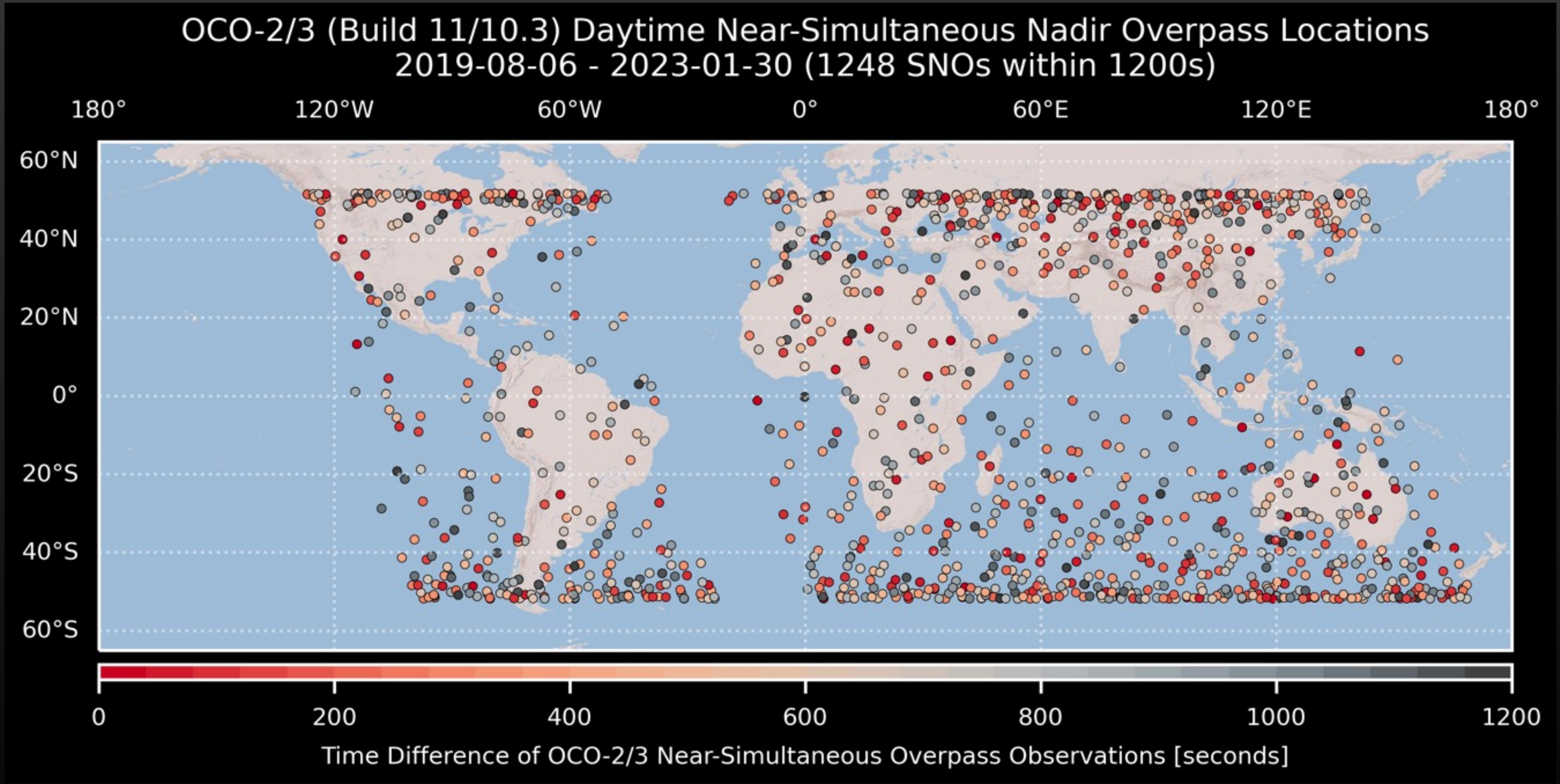




OCO-2 (narrow swath due to rotated spacecraft, for polarization mitigation)

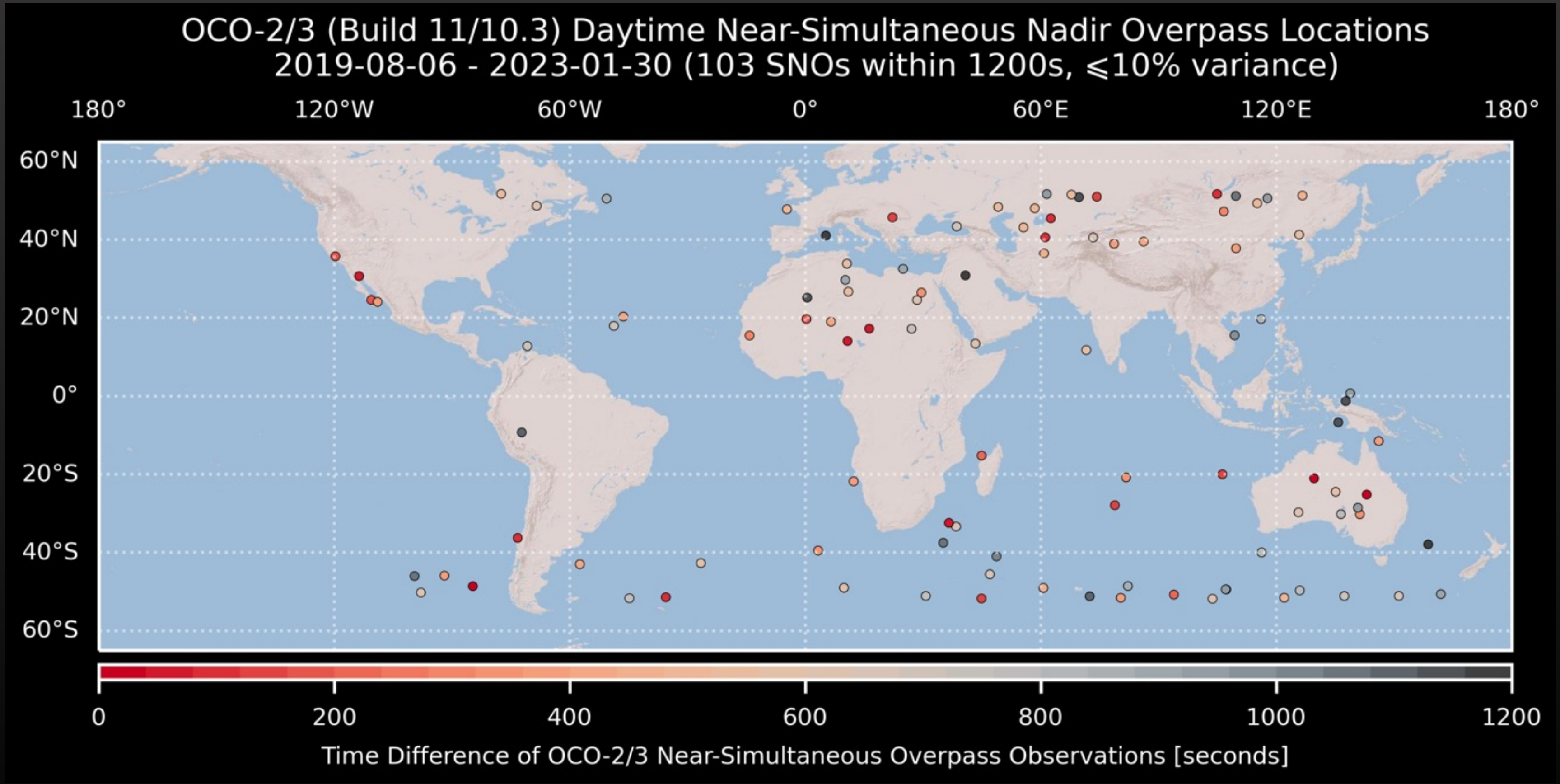
OCO-3

OCO-2 – OCO-3 Simultaneous Nadir Overpasses 2019-08-06 – 2023-01-30



SNOs tend to occur at the ISS turn-around latitudes where OCO-2/3 tracks are at their largest relative angle

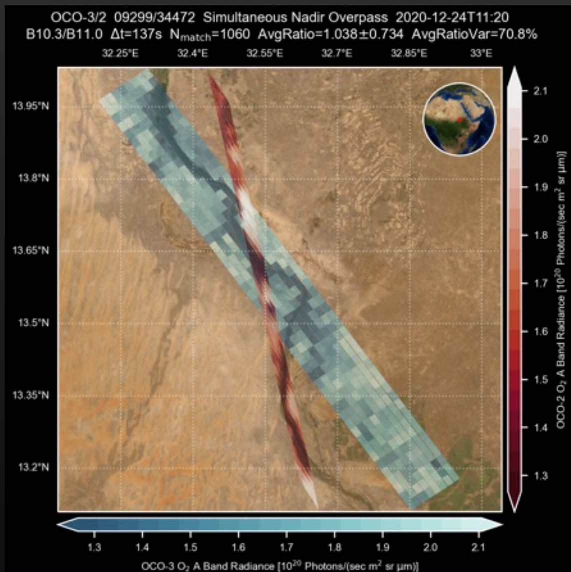
OCO-2 – OCO-3 Simultaneous Nadir Overpasses
2019-08-06 – 2023-01-30, ⩽10% Variation in Radiance Ratio



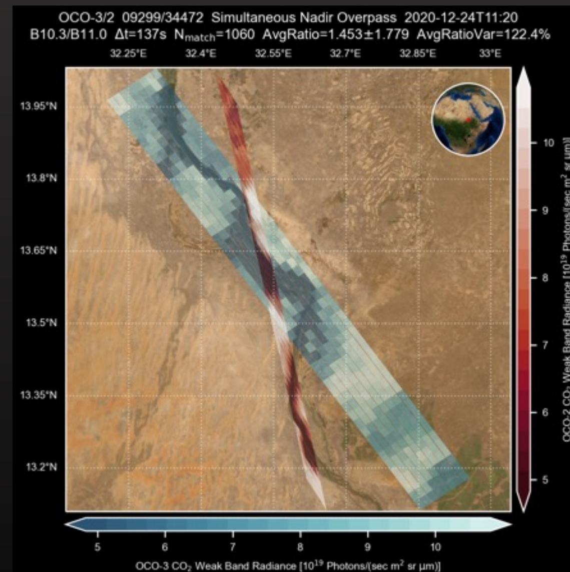
Limiting SNOs by variation in radiance ratio reduces effects from scene inhomogeneity (surface, clouds, *etc.*)

SNO Example: 2020-12-24 1120UTC, All Bands

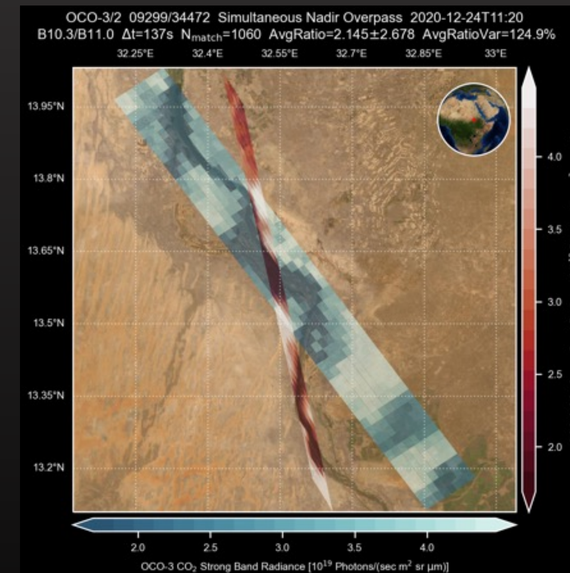
O_2 *A* band channel (0.765 µm)



weak CO_2 channel (1.61 µm)

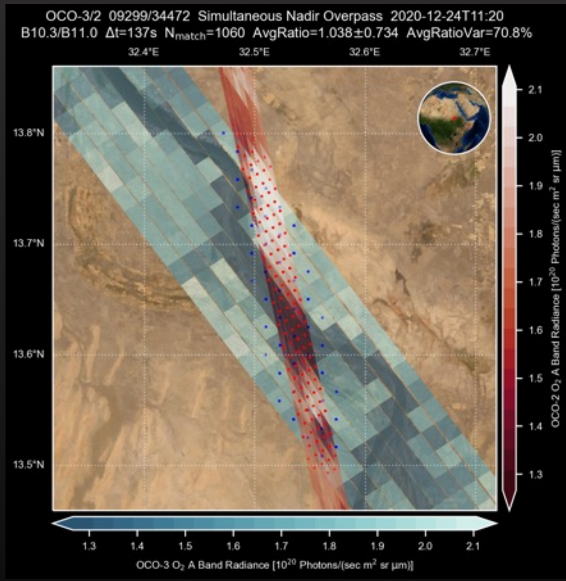


strong CO_2 channel (2.06 µm)



SNO Example: 2020-12-24 1120UTC, All Bands, Zoom of SNO Match Area

O_2 *A* band channel (0.765 μm)



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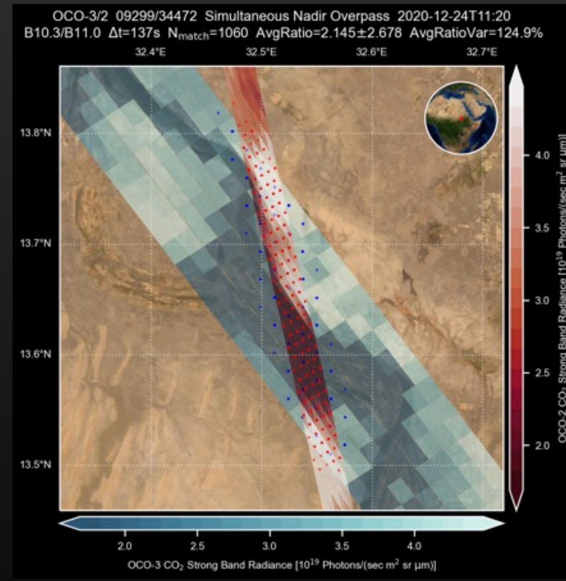

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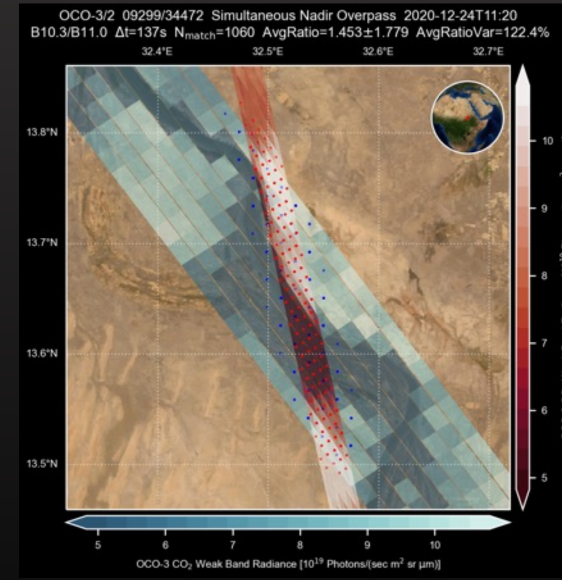
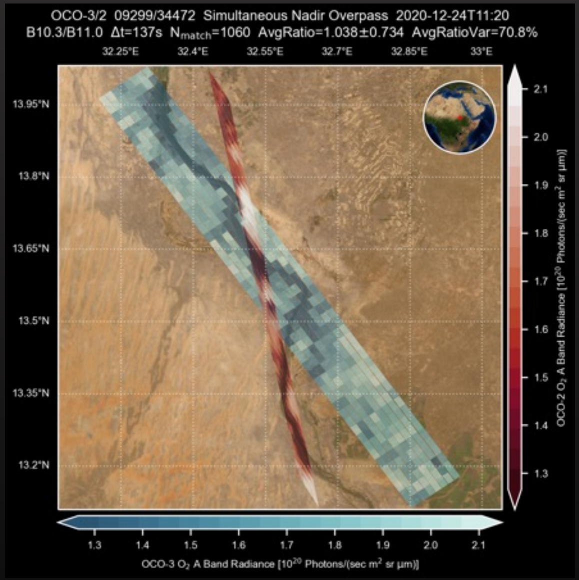


Matched OCO-2/OCO-3 footprints are indicated by red and blue dots. One footprint can have multiple matches, thus the number of matched footprint pairs (here 1060) is usually larger than the number of dotted footprints

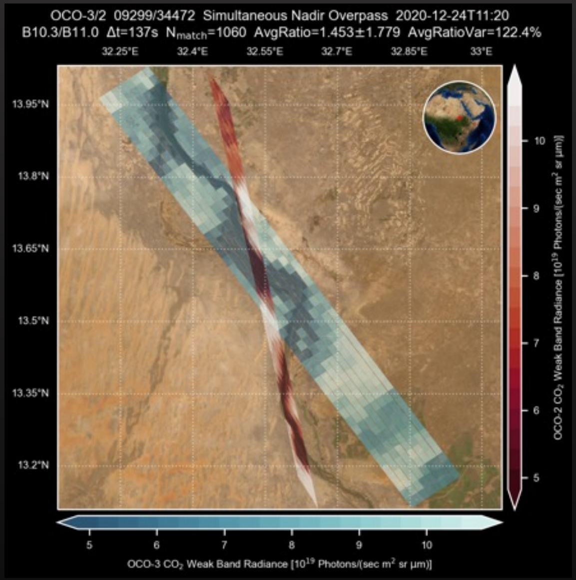
SNO Example: 2020-12-24 1120UTC, All Bands, Radiance Ratio = OCO-3/OCO-2

O_2 *A* band channel (0.765 µm)



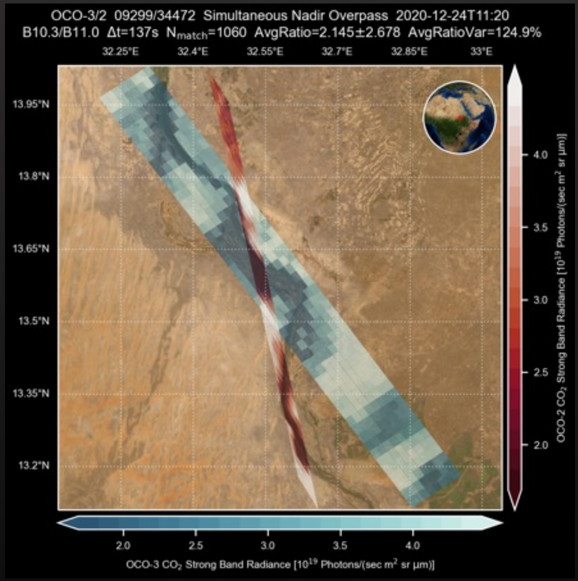
Avg. Radiance Ratio 1.038±0.734

weak CO_2 channel (1.61 µm)



Avg. Radiance Ratio 1.453±1.779

strong CO_2 channel (2.06 µm)

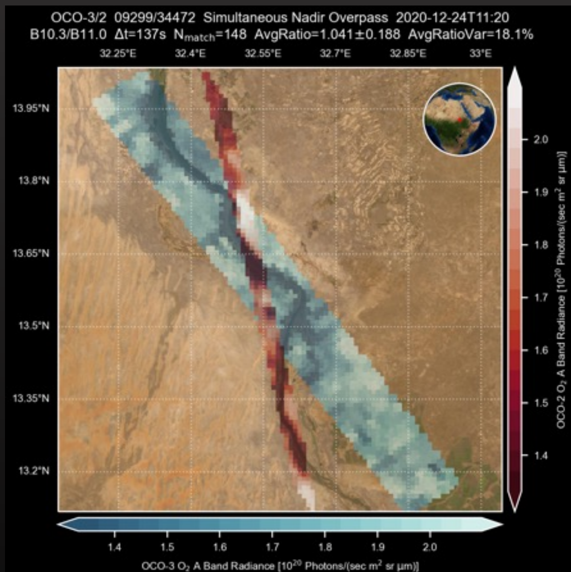


Avg. Radiance Ratio 2.145±2.678

Native Spatial Resolution

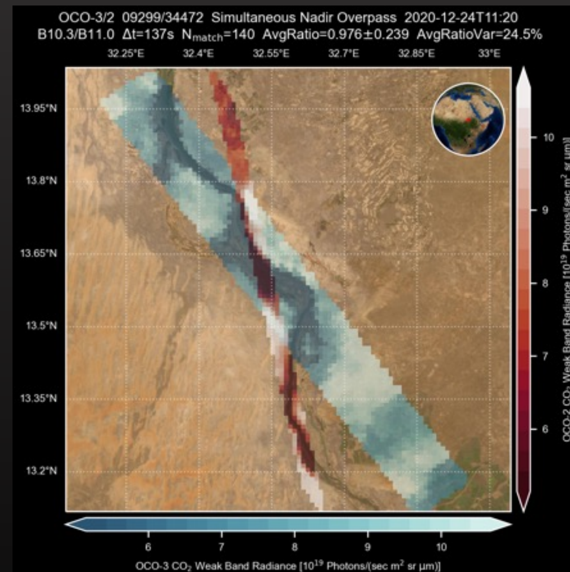
SNO Example: 2020-12-24 1120UTC, All Bands, Radiance Ratio = OCO-3/OCO-2

O_2 *A* band channel (0.765 µm)



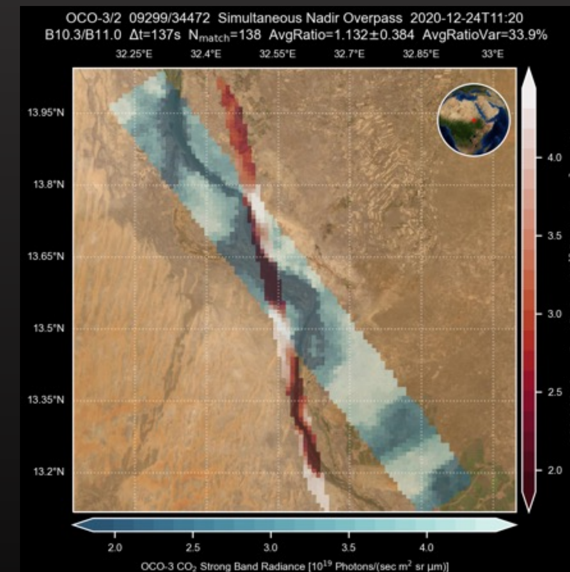
Avg. Radiance Ratio 1.041±0.188

weak CO_2 channel (1.61 µm)



Avg. Radiance Ratio 0.976±0.239

strong CO_2 channel (2.06 µm)

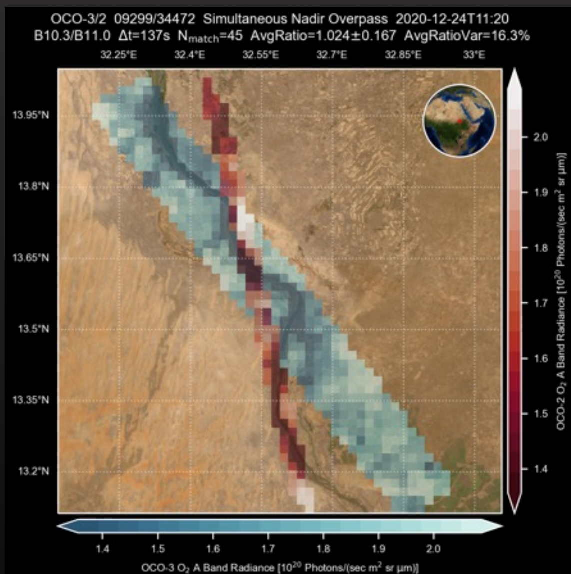


Avg. Radiance Ratio 1.132±0.384

Gridded to 1×1 km^2

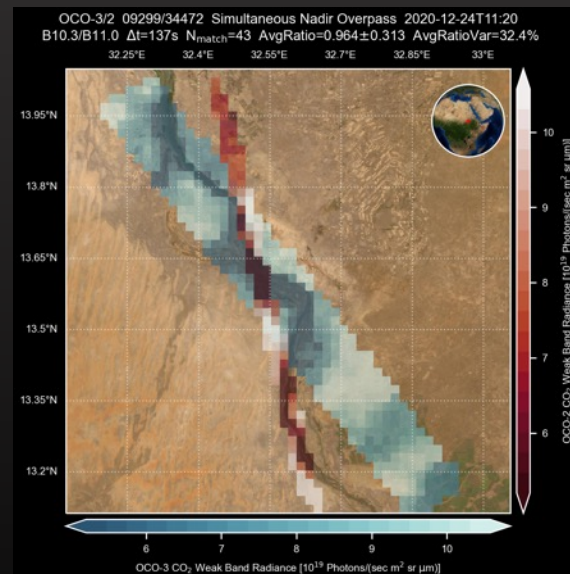
SNO Example: 2020-12-24 1120UTC, All Bands, Radiance Ratio = OCO-3/OCO-2

O_2 *A* band channel (0.765 µm)



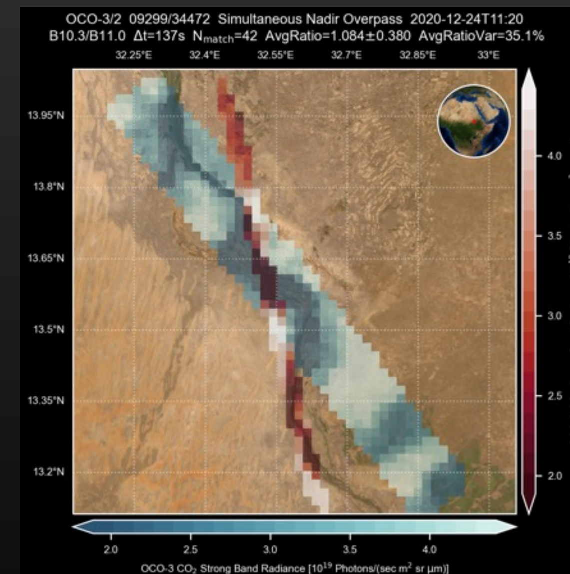
Avg. Radiance Ratio 1.024±0.167

weak CO_2 channel (1.61 µm)



Avg. Radiance Ratio 0.964±0.313

strong CO_2 channel (2.06 µm)

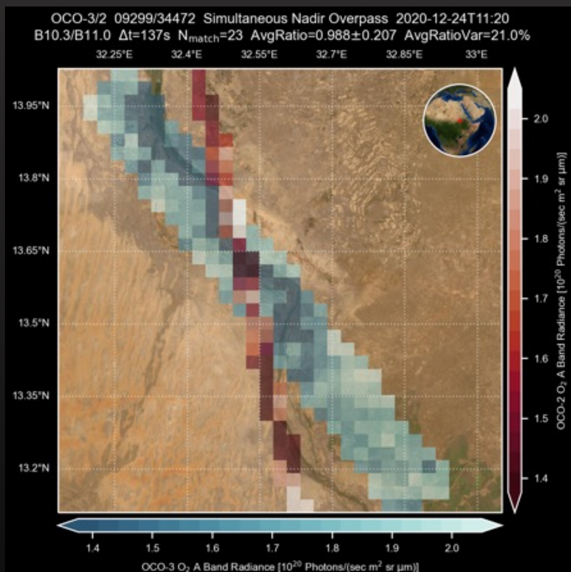


Avg. Radiance Ratio 1.084±0.380

Gridded to 2×2 km^2

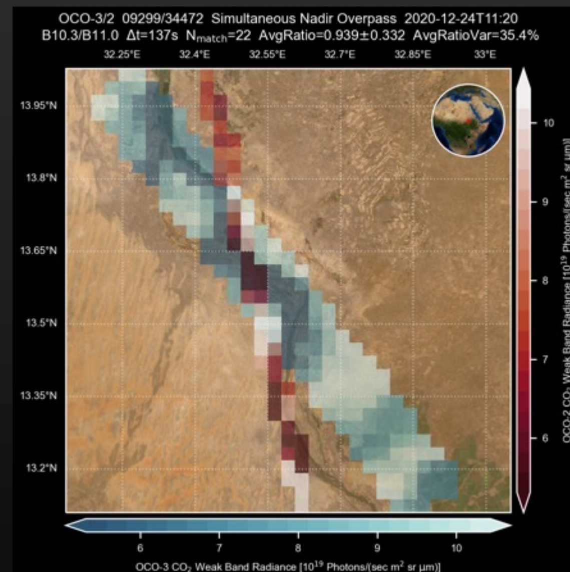
SNO Example: 2020-12-24 1120UTC, All Bands, Radiance Ratio = OCO-3/OCO-2

O_2 *A* band channel (0.765 μm)



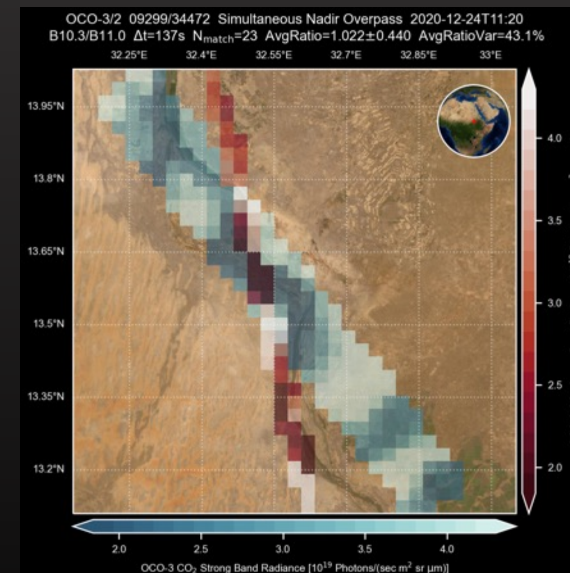
Avg. Radiance Ratio 0.988±0.207

weak CO_2 channel (1.61 μm)



Avg. Radiance Ratio 0.939±0.332

strong CO_2 channel (2.06 μm)



Avg. Radiance Ratio 1.022±0.440

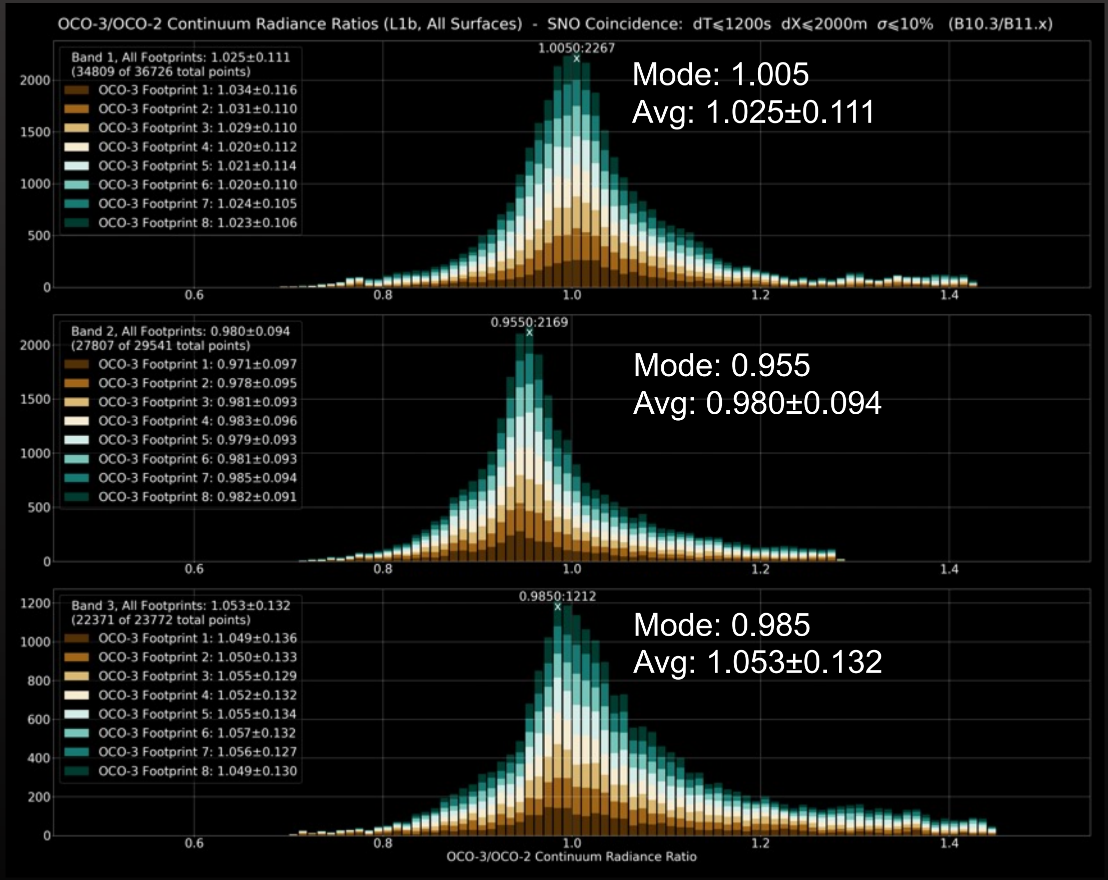
Gridded to 3×3 km^2

OCO-2 – OCO-3 Simultaneous Nadir Overpasses
Histograms of Continuum Radiance Ratios, by Band and Cross-Track Footprint

O_2 *A* band channel (0.765 μm)

weak CO_2 channel (1.61 μm)

strong CO_2 channel (2.06 μm)



native spatial resolution
–
all surfaces

vicarious calibration over RRV indicates OCO-2 wCO_2 band is high

OCO-2 – OCO-3 Simultaneous Nadir Overpasses
Histograms of Continuum Radiance Ratios, by Band and Cross-Track Footprint

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(1.61 μm)

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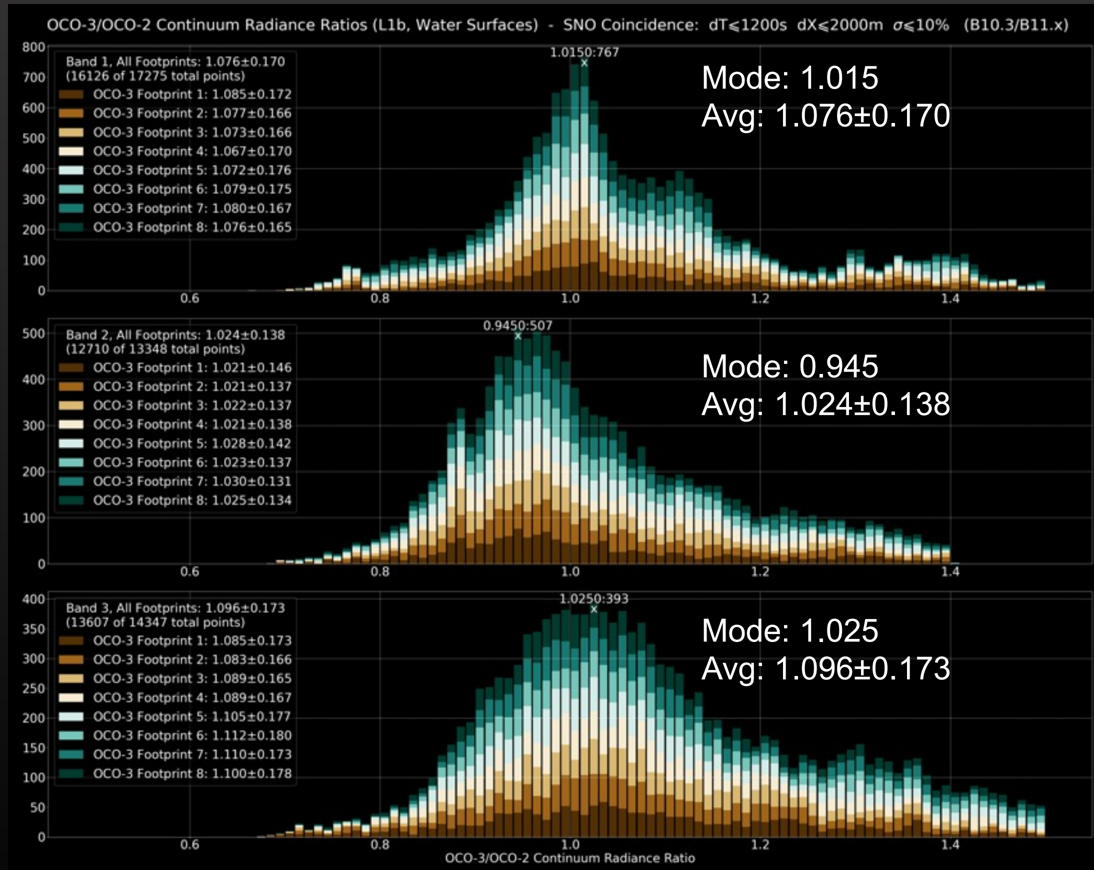

native
spatial resolution
–
ocean surfaces

vicarious
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OCO-2 – OCO-3 Simultaneous Nadir Overpasses
Histograms of Continuum Radiance Ratios, by Band and Cross-Track Footprint

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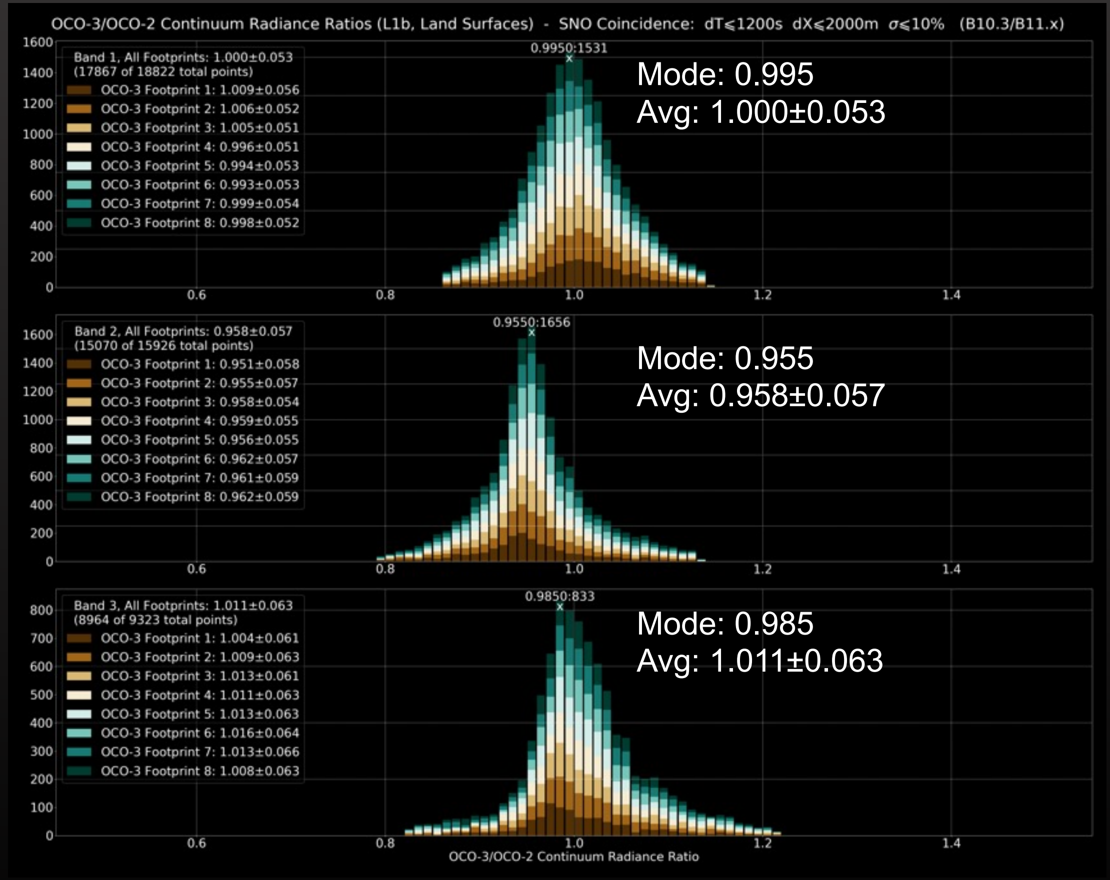

native
spatial resolution
–
land surfaces

vicarious
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OCO-2 wCO_2
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OCO-3/OCO-2 SNO Analysis – Current Summary

- Continuum Radiance comparison shows no obvious footprint-dependent bias
- Indications that OCO-2 weak CO_2 band radiances are high are in line with recent results from vicarious calibration
- Radiance Ratios of native resolution and gridded data indicate strong influence of outlier data (on/off land, on/off cloud)

OCO-3/OCO-2 SNO Analysis – Next Steps

- refine footprint pair selection – screen for obvious ratio outliers
- refine continuum selection
- compare spectral shape of continuum radiances
- quantify analysis by surface type, scene heterogeneity, *etc*.
- refine analysis of spatial gridding resolution, to account for differences in OCO-2 and OCO-3 footprint sizes and adjacent footprint overlap

thank you

https://ocov2.jpl.nasa.gov/
https://ocov3.jpl.nasa.gov/