The OCO-2 and OCO-3 missions: Status, results and plans

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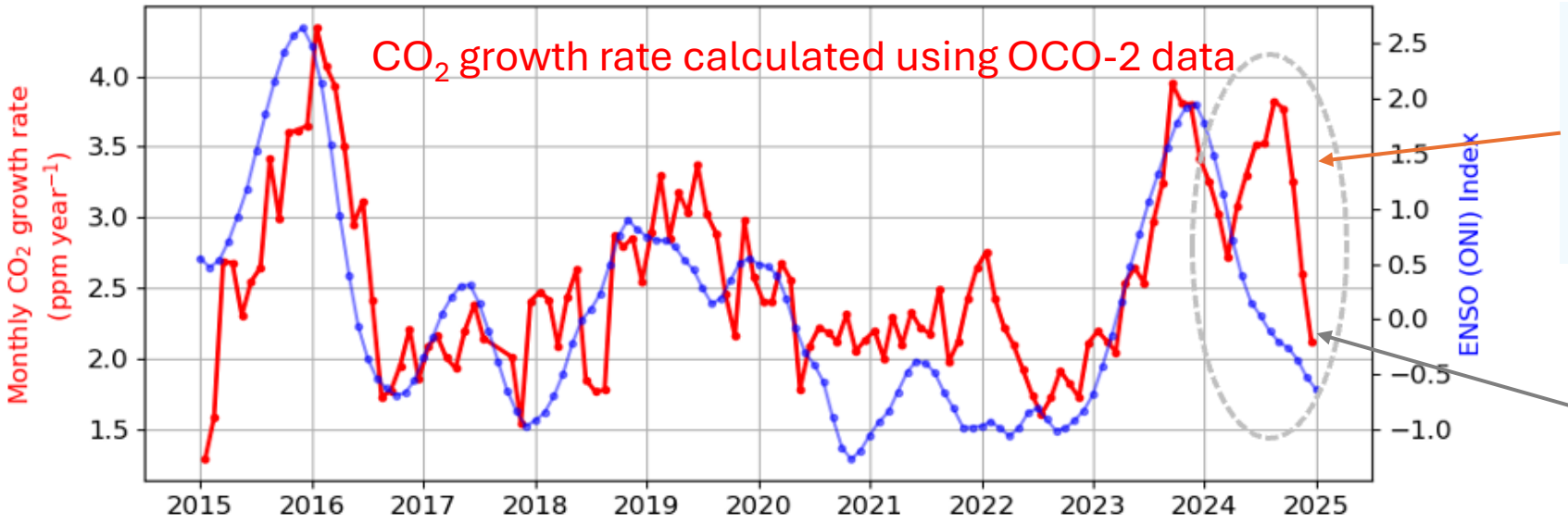
And the OCO-2/OCO-3 Project Teams, Science Team!

Jet Propulsion Laboratory
California Institute of Technology

Tracking the whole-atmosphere CO_2 growth rate in near real time

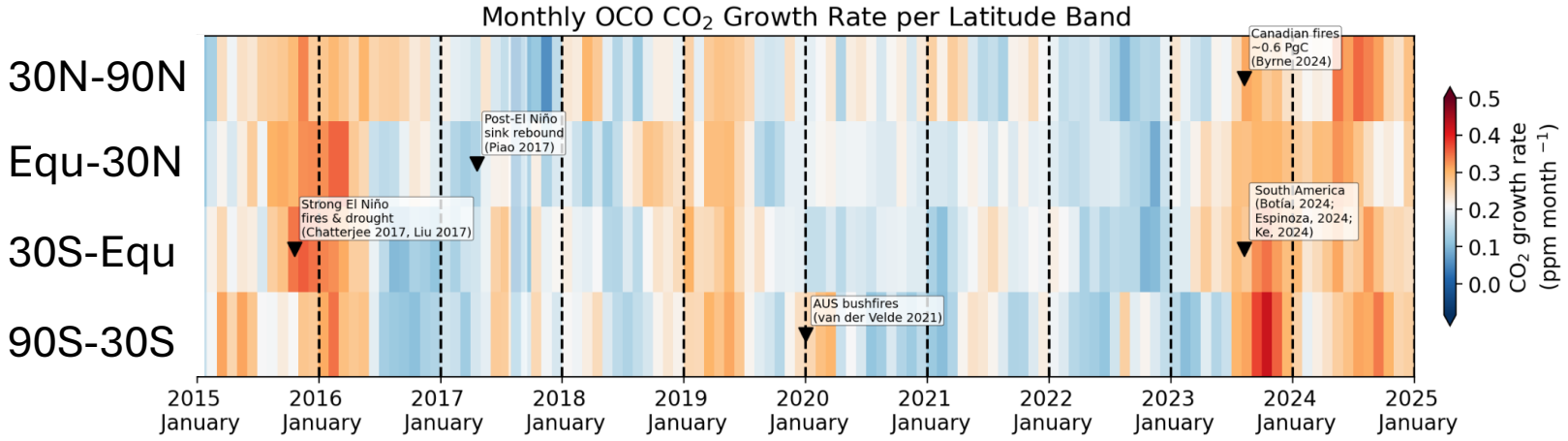


CO_2 growth rate for 2024: One of the highest on record

(Both for NOAA ground-based record and for satellite record)

Strongly decoupled from ENSO index, likely that anomaly originated in the Southern Tropics

- Pandey et al. (2024) **AGU Advances**, 10.1029/2023AV001145
- Pandey et al. (*in preparation*)



Pandey et al. (2024). The plot uses JPL OCO-2 (all) XCO_2 data. Colorscale is centered (white) at the mean growth rate.

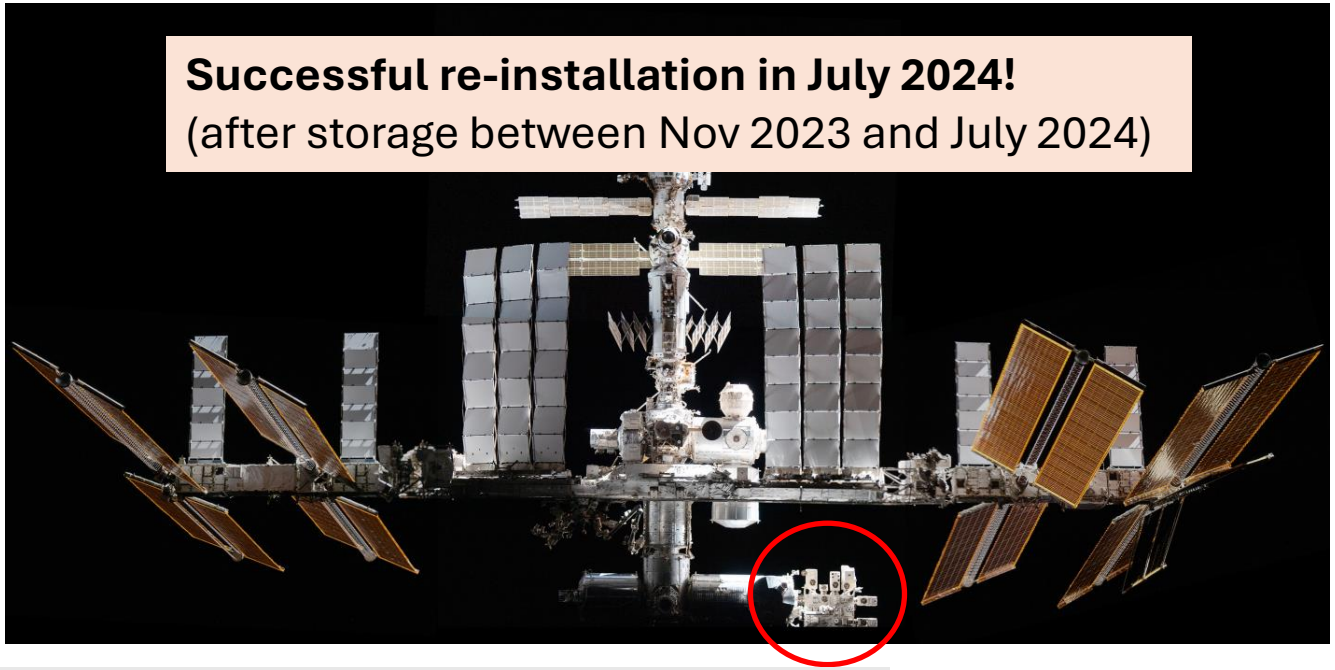
The OCO-2 and OCO-3 missions

Orbiting Carbon Observatory-2 (OCO-2)

- Launched July 2, 2014
- Free flying spacecraft
- Sun-synchronous polar orbit

Orbiting Carbon Observatory-3 (OCO-3)

- Launched May 4, 2019
- International Space Station (ISS)
- ± 52° inclined orbit



OCO-2 and OCO-3 data products are publicly available via the NASA GES DISC

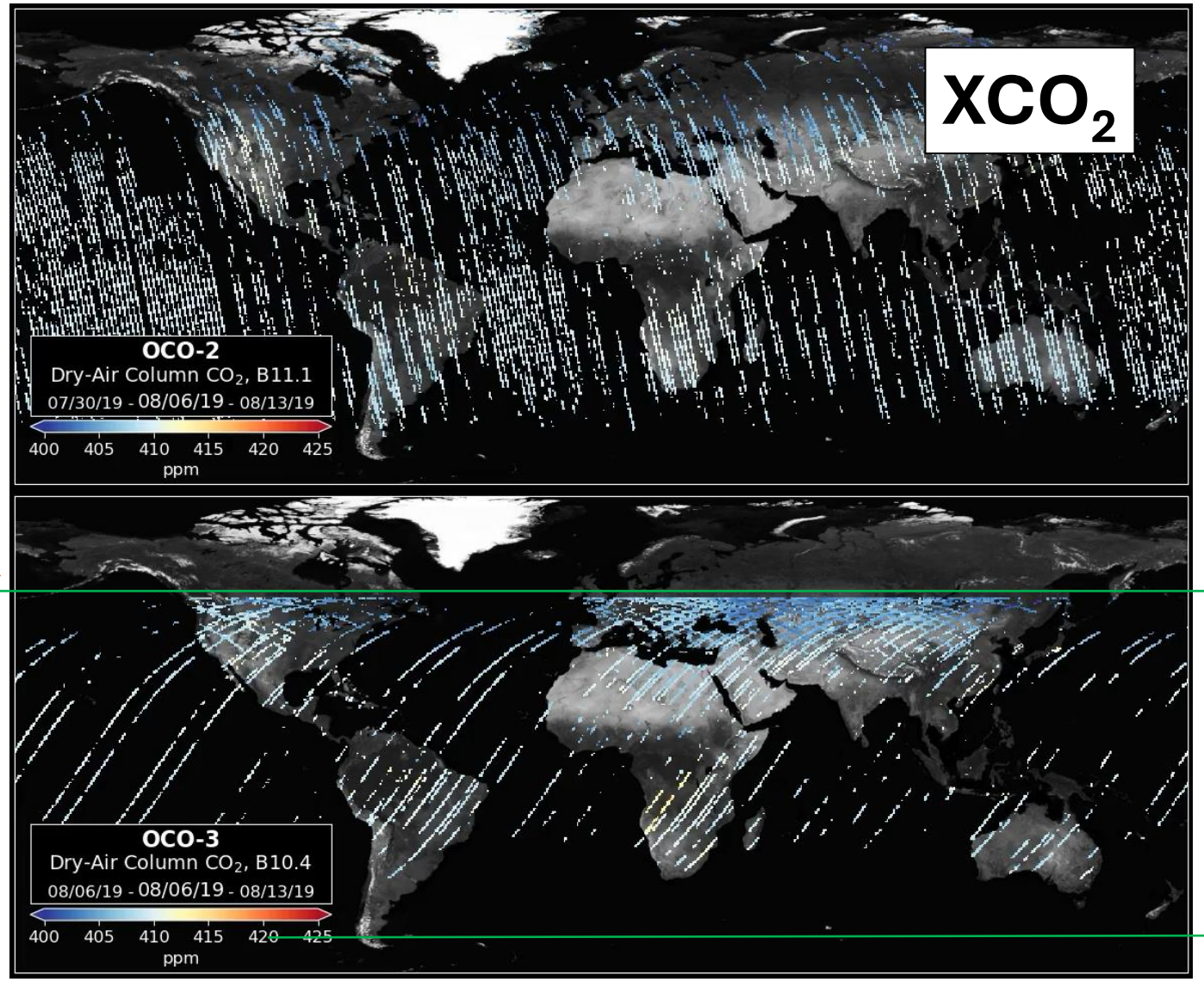
OCO-2 and OCO-3: Complementary coverage and sampling

OCO-2

- ”Pole-to-pole” coverage, depending on season;
- Fixed 1330h equator crossing time (and local overpass time)

OCO-3

- Coverage limited to ±52º latitude, changing with season;
- Observations span all times of day



~~Edmonton~~
Calgary

~~Amsterdam~~
Rotterdam
London

Rio Gallegos
~~Punta Arenas~~

Videos from Thomas Kurosu/JPL

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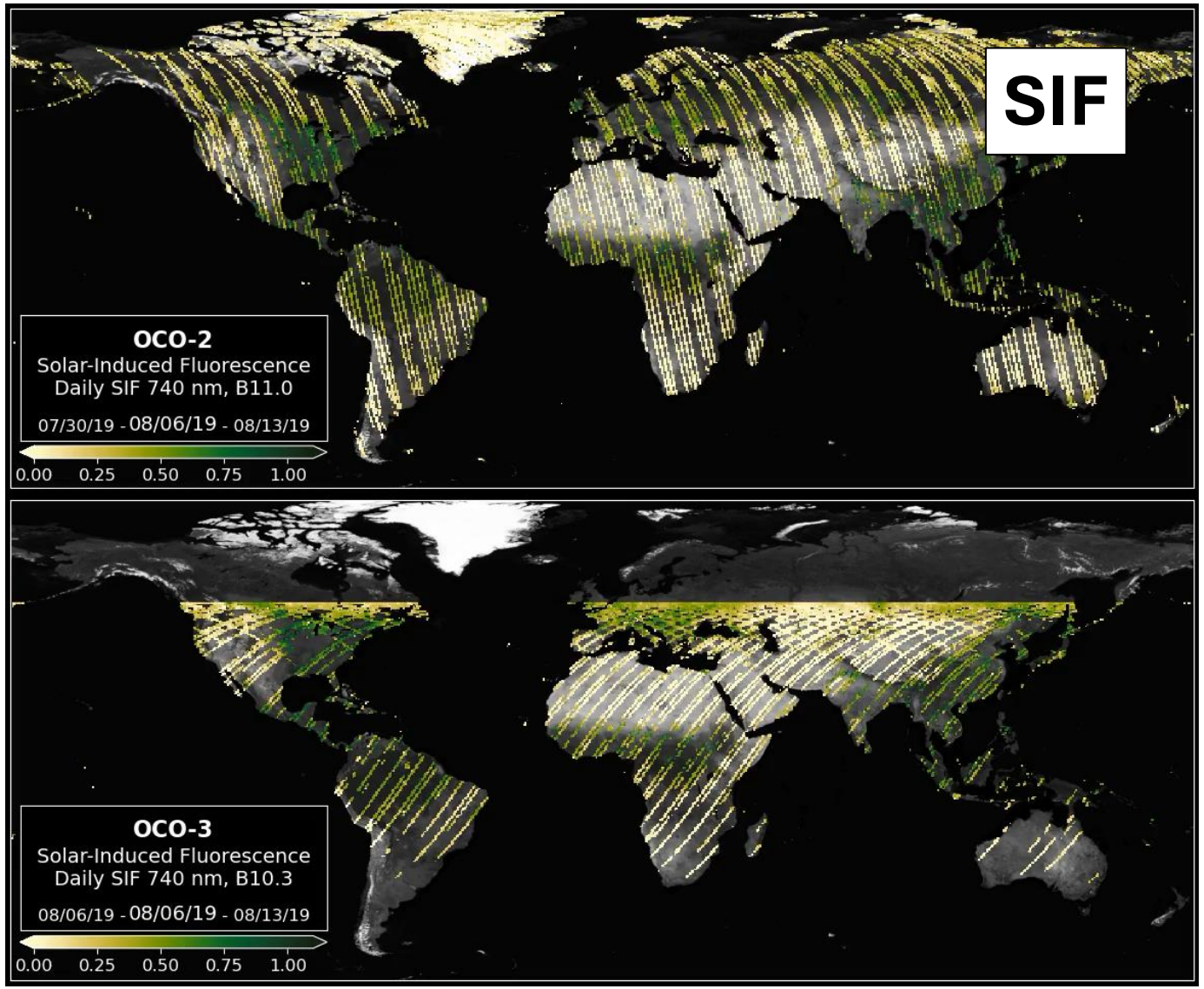
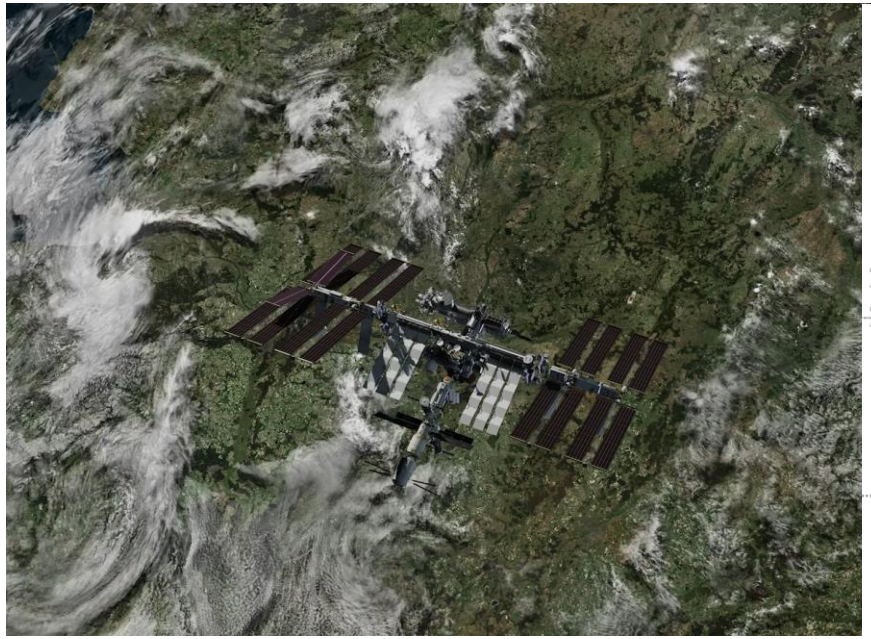
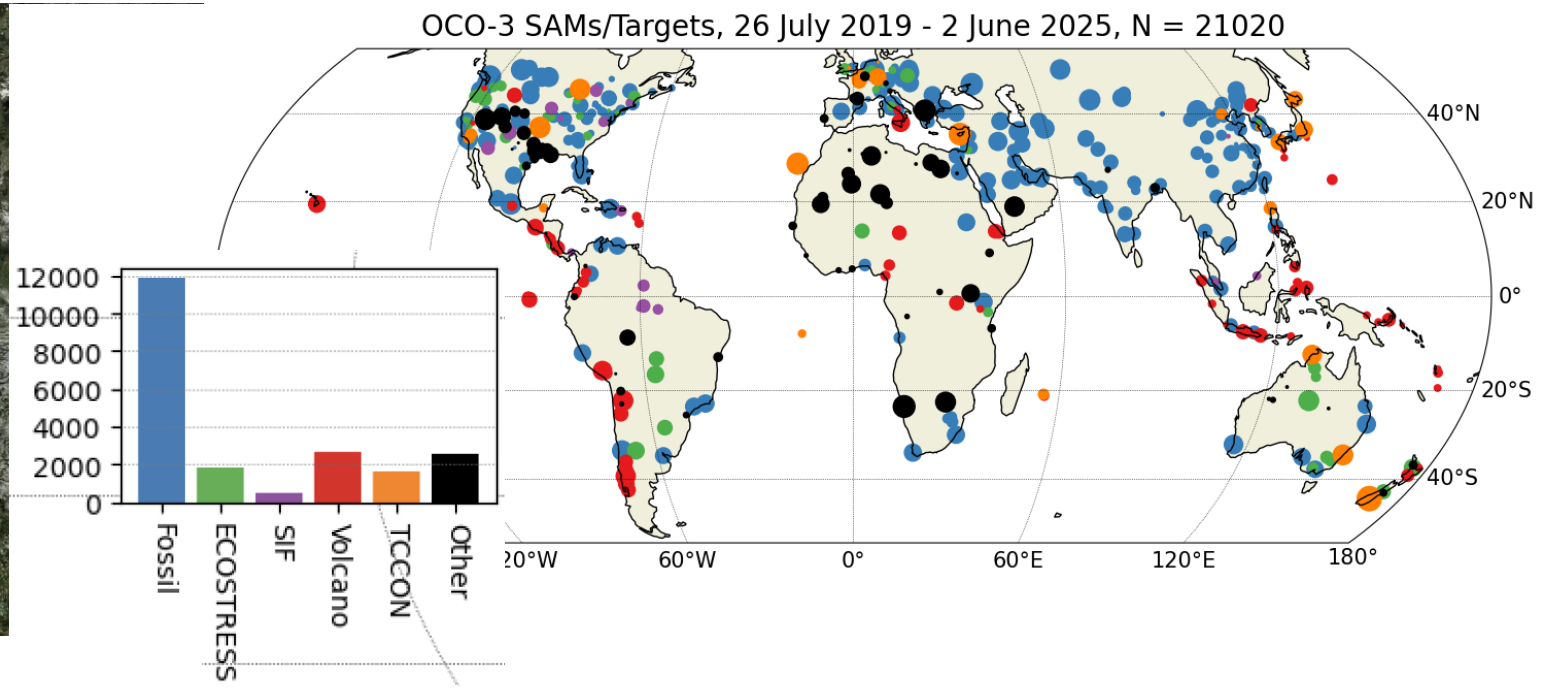


Videos from Thomas Kurosu/JPL

OCO-3 Snapshot Area Maps (SAMs)

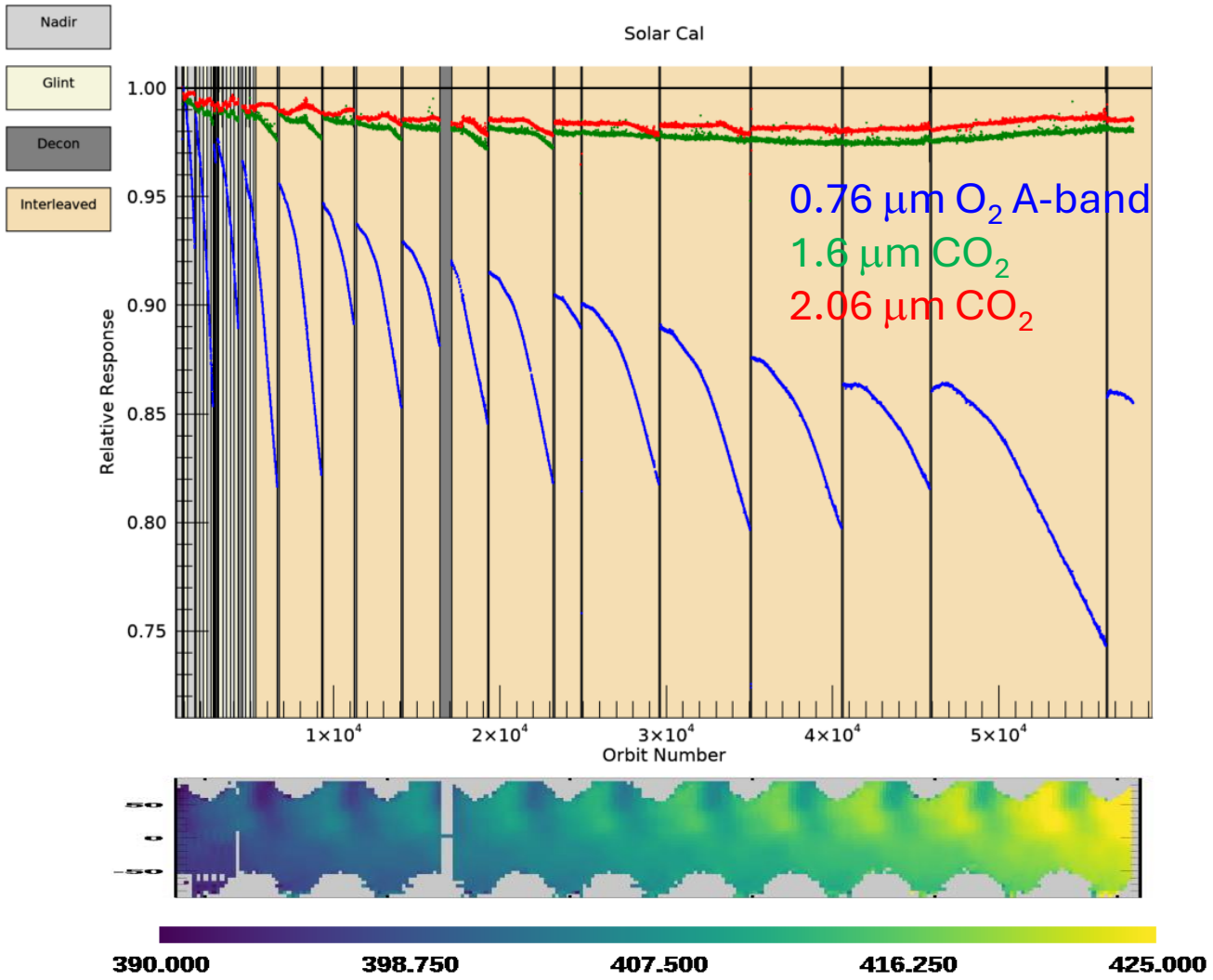
- Collects data over an ~80 km × 80 km area in 2 minutes
- Complements the near-global nadir & glint measurements



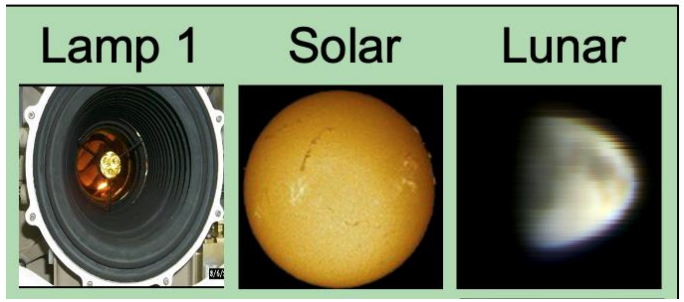


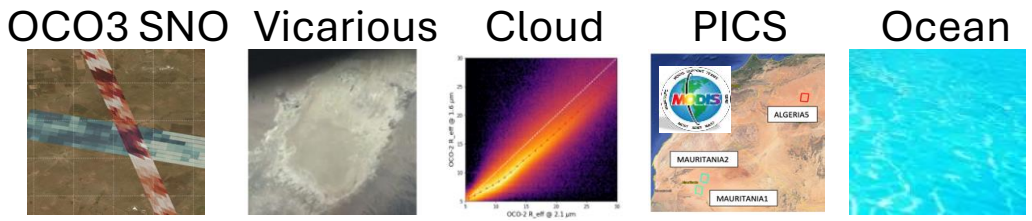
See R. Nelson/A. Chatterjee talk on Tuesday!

OCO-2: Continuing to age like a fine wine!



- Instrument and spacecraft are in excellent health
- Outgassing/icing effects continue to slow as the mission extends in time

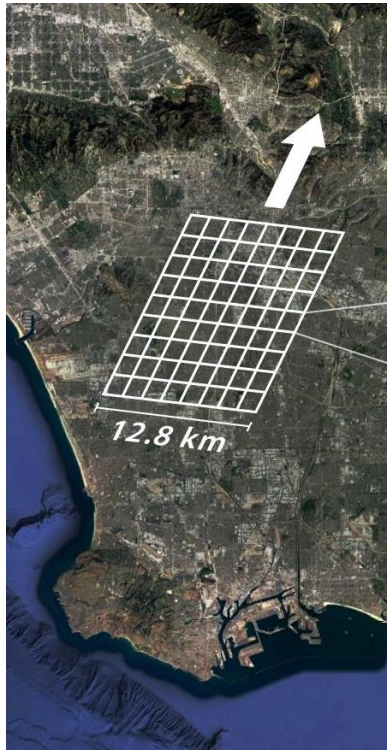


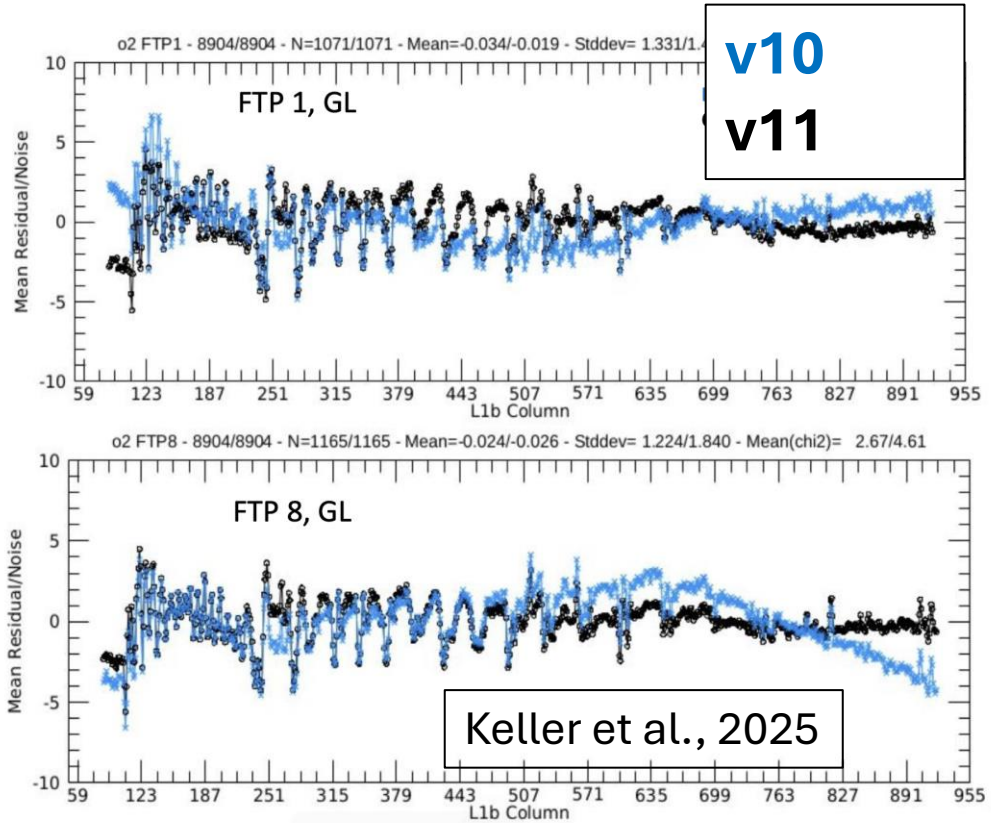


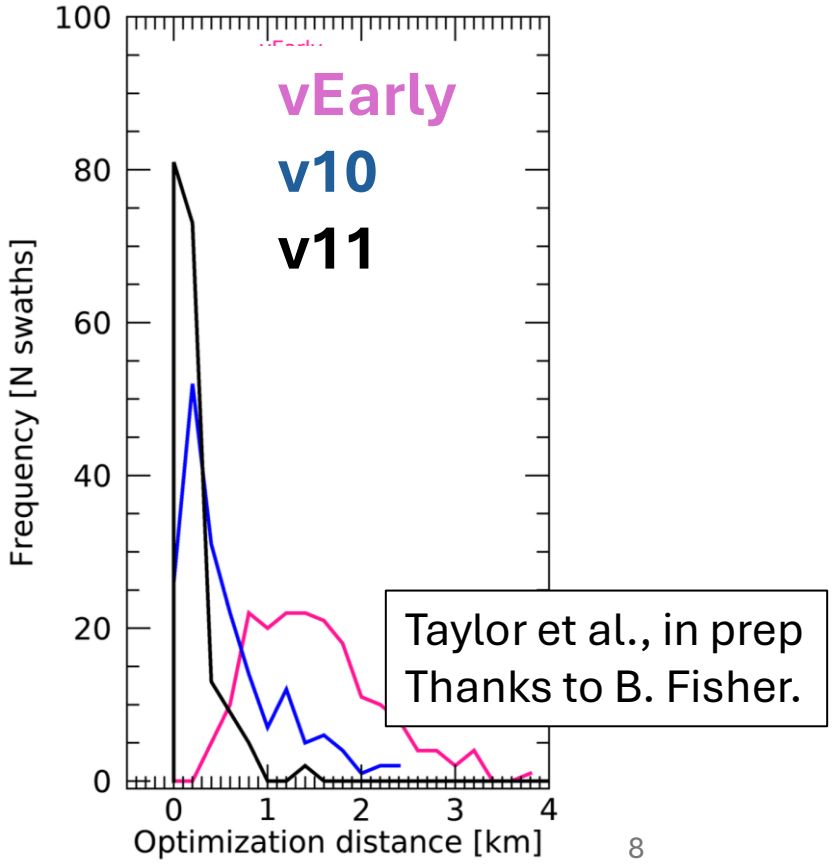
Figures: R. Rosenberg and the OCO-2 cal team

OCO-3: With age (and v11) comes wisdom

- OCO-3 instrument is in excellent health!
- OCO-3 v11: Consistency with OCO-2 v11.2 L2 algorithm, plus OCO-3-specific improvements to L1B calibration and geolocation compared to v10





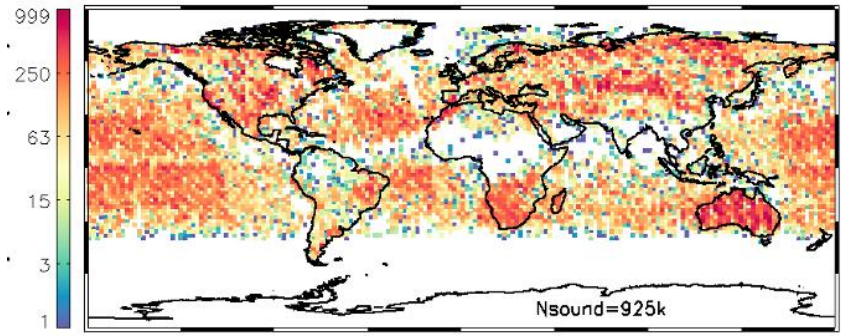


Level 2 XCO_2 and SIF products

- Latest and greatest Level 2 data versions: **v11.2** for OCO-2, **v11** for OCO-3
  - Consistent algorithm used for OCO-2 and OCO-3!

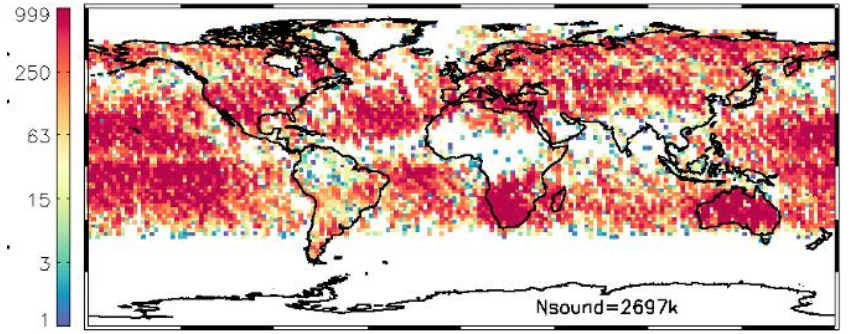
Figure: Chris O'Dell, CSU

- **Forward stream**
  - Subset of soundings, **latency < 1 week**
  - Products removed from GES DISC site on rolling basis
  - **New! Bias-corrected forward stream L2 products**
    - Intended for users who need low latency



OCO-2 coverage, forward stream (06/22)

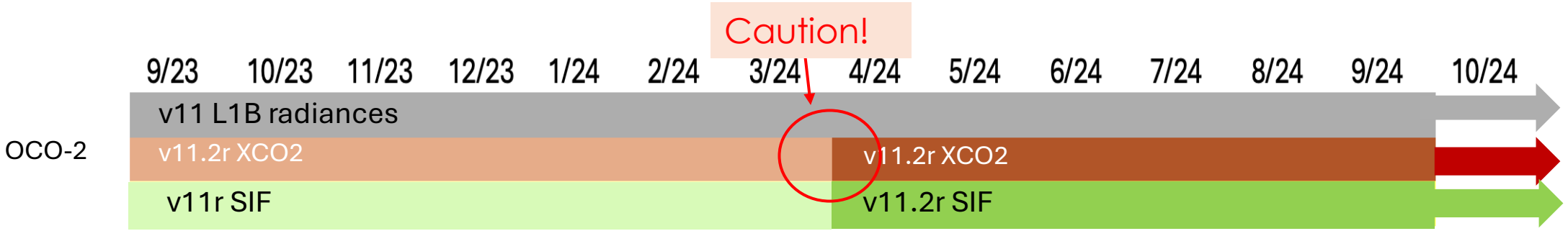
- **Retrospective stream**
  - All "cloud-free" soundings processed, monthly cadence
  - Full record available at GES DISC site
  - L2 **Lite** products: Bias correction, quality filter applied
    - Recommended for most users



OCO-2 coverage, retrospective stream (06/22)

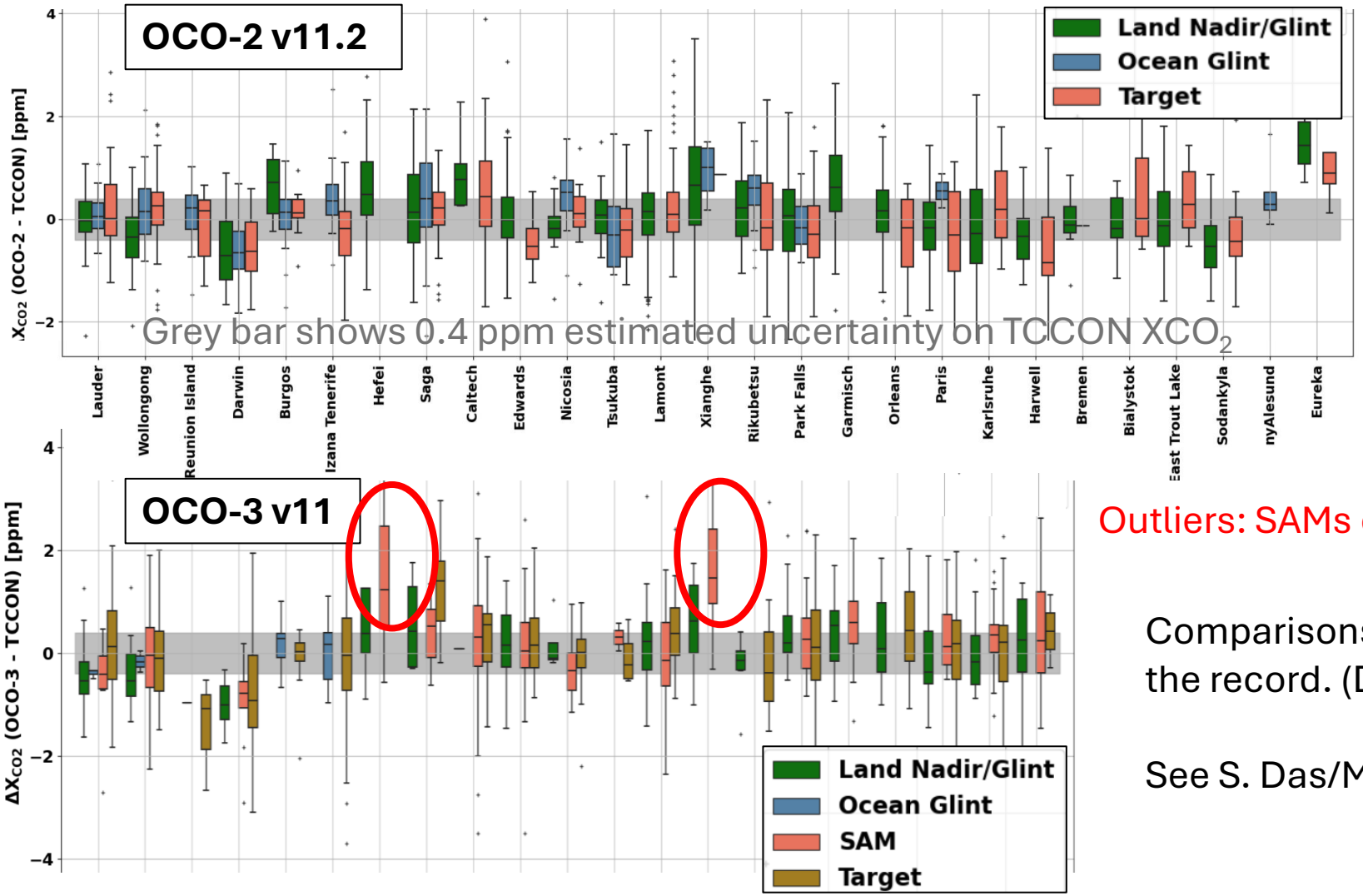
Why “OCO-2 v11.2” but “OCO-3 v11”?

- **OCO-2** v11 → v11.1: Switch to Copernicus Digital Elevation Map
- **OCO-2** v11.1 → v11.2: Transition from GEOS-FPIT to GEOS-IT met fields
  - Date of GEOS-IT transition: 2nd April 2024
  - Users should be aware: Transition introduces subtle but non-zero discontinuity in record
    - Mitigated, but not fully addressed, by v11.2 Lite reprocessing for pre-2024 data
    - To fully address this, a full L2FP reprocessing would be required
  - For more info, see OCO-2 Data User Guide



- **OCO-3 v11 is fully consistent throughout the record**
  - OCO-3 v11 processing started later, was able to “bake in” these DEM, GEOS-IT updates

Validation against TCCON (GGG2020): Agreement < 1 ppm



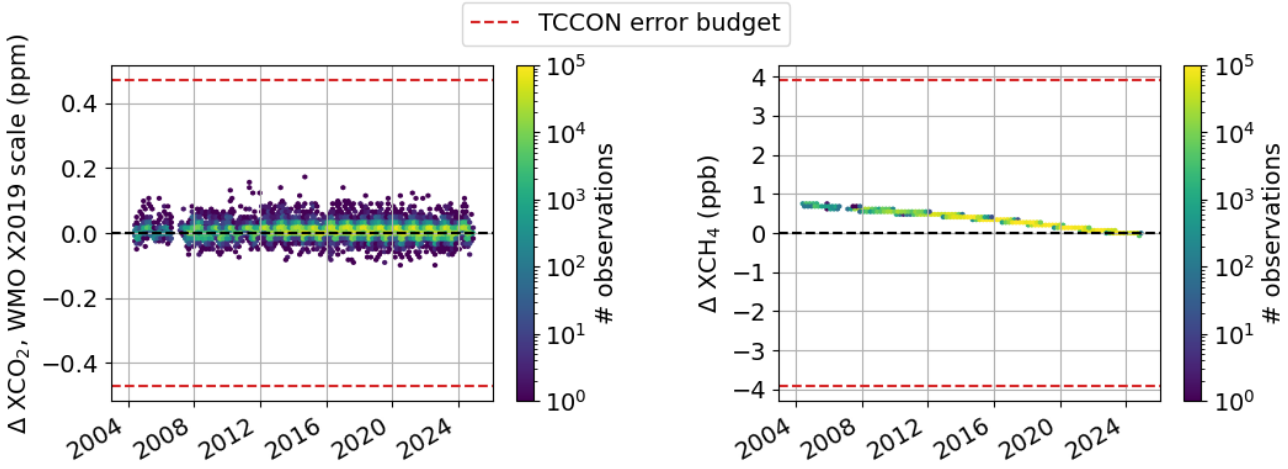
Outliers: SAMs over Hefei, Xianghe

Comparisons with TCCON are stable across the record. (Das et al. (2025), in prep)

See S. Das/M. Sha talk on Tuesday!

TCCON GGG2020.1 status

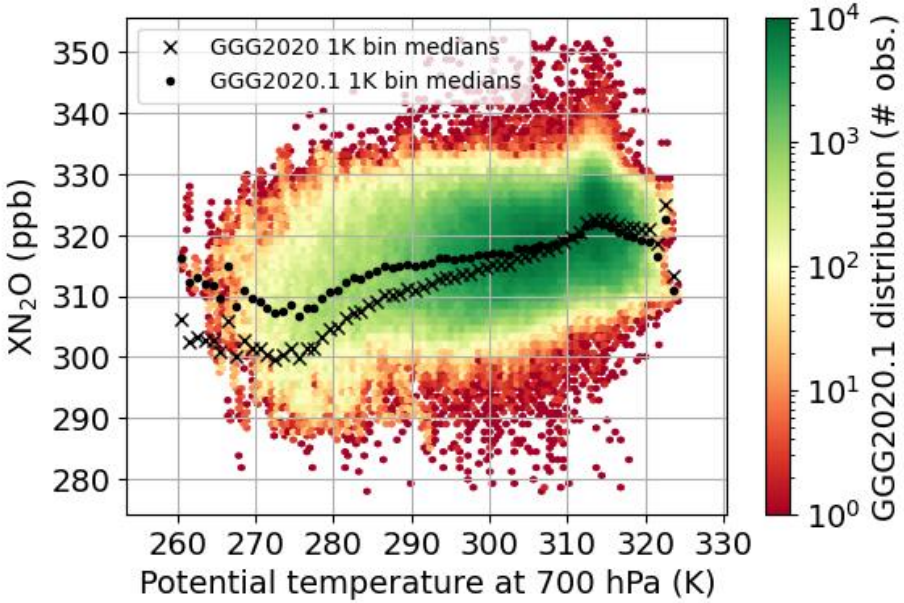
Changes to Xgases from implementation of time-varying O_2 DMF



Progress:

- ✓ Consistent time-varying O_2 DMF for all Xgases
- ✓ N_2O T-dependent bias reduction
- ✓ Track use of alternate CO priors
- ⧗ Upgrade public file creation to support above
- ⧗ Generate alternate pre-Apr 2024 CO priors

Changes to XN_2O from implementation of T-dependent bias reduction

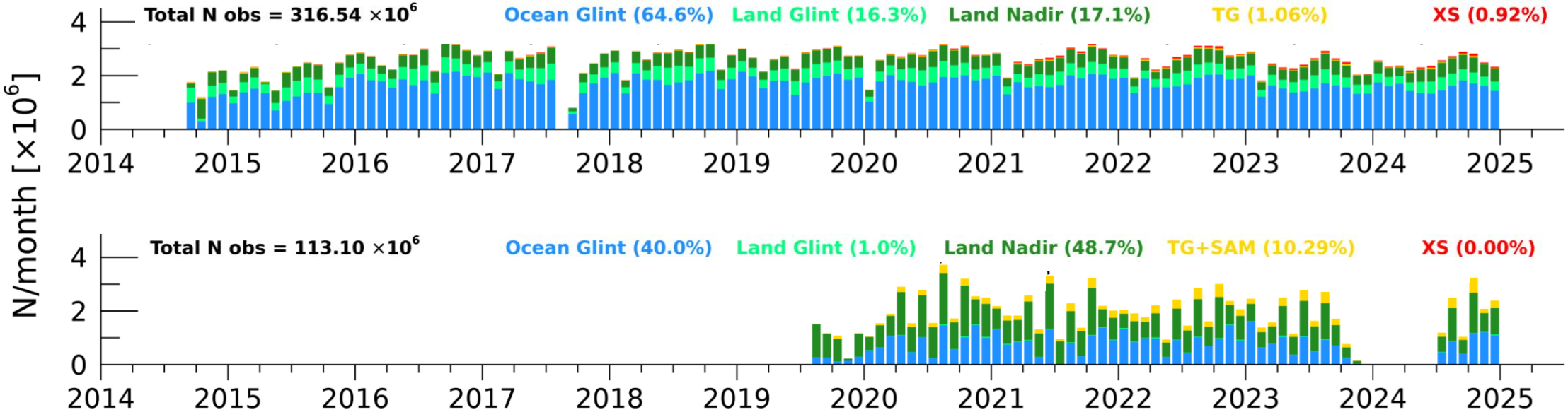


- Impact of new time-varying O_2 DMF is much smaller than the TCCON error budget, benefit is to long timeseries analyses
- XN_2O bias reduction reduces temperature dependence in the common temperature ranges, future work needed to address the coldest temperatures
- Updating TCCON infrastructure to ensure that the GGG2020 to GGG2020.1 processing is applied correctly is taking longer than expected
  - First of three components almost complete
- Aiming now to have development complete by Sep. 2025.
- Sites that wish to use improved CO priors will need time after the GGG2020.1 release to reprocess

“Can I use OCO-2 and OCO-3 together?”

Yes!

- Direct comparisons for XCO2:
  - **OCO-3 v11 agrees with OCO-2 v11.2 to better than 0.5 ppm for co-located soundings**
  - **This is well within the agreement of either sensor with TCCON.**
  - Taylor et al. (2025), in prep



Closing remarks

- **OCO-2 and OCO-3 are both in excellent health**
- With OCO-2 v11.2 and OCO-3 v11, L2 products are now in step
- Accuracy and precision of XCO_2 products:
  - < 1 ppm for **both missions**
- Characterization of a new instrument/data product can take some time….
- XCO_2 and SIF datasets from OCO-2 and OCO-3
  - Shining new light on **natural** and anthropogenic components of carbon cycle
- **Length of the record and quality of the data products are key**
  - Particularly for studies of the natural carbon cycle