Committee on Earth Observation Satellites

Status of the CO_2 Data Products from GOSAT and OCO-2

David Crisp, Jet Propulsion Laboratory, California Institute of Technology

CEOS AC-VC 2020

Agenda Item # 1.02

Virtual

08 – 12 June 2020

Background

- **The availability of GOSAT and OCO-2 data products have fostered continuous improvements in space-base XCO_2 estimates over the last 11+ years**
  - **Errors and biases of several ppm have been reduced to roughly 1 ppm or below.**
  - **Important science can be (and is) done with these error levels:**
    - **e.g. local scale work, interannual variability, large anomalies**
  - **But even $\mathcal{O}$(1 ppm) biases can cause serious problems in carbon inversions!**
- **Here we focus on the status and near-term plans for the GOSAT and OCO-2 XCO_2 products due to their greater maturity**

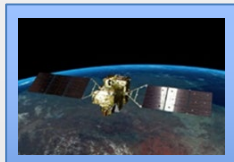
MILESTONES

GOSAT
2009-present

Current version: V02.81
(ACOS/GOSAT v9)

OCO-2
2014-present

Latest ACOS versions:
v10



GOSAT-2
8/2019-present

Latest versions: V01.01
(V01.02, internal)

OCO-3
8/2019-present

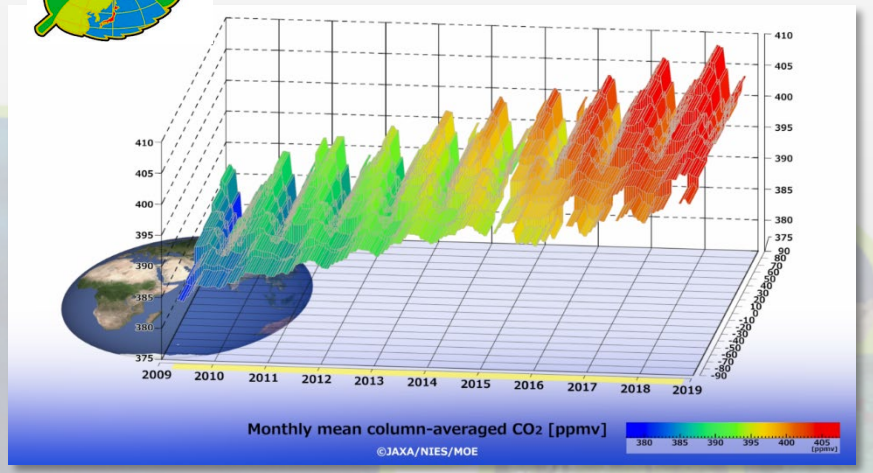
Latest ACOS versions: 10
(vEarly)

Adapted form C. O'Dell IWGGMS-8 presentation

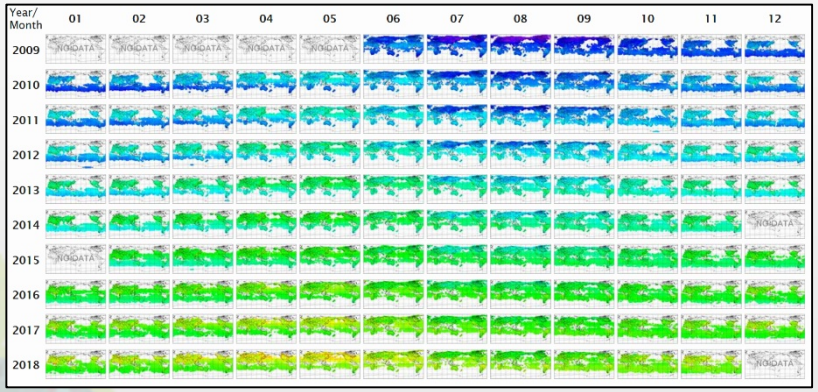
The latest status of GOSAT after 11-years operation and GOSAT-2 initial in-orbit operation

GOSAT is still in its peak!

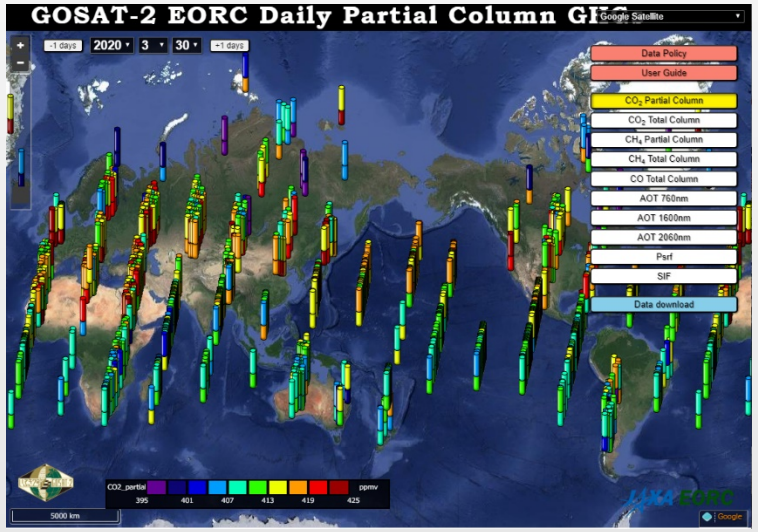
- GOSAT has been operating successfully for over 11 years, overcoming several anomalies.
- TANSO-FTS instrument is currently the most stable in orbit: no pointing fluctuation, almost no zero path difference (ZPD) shift
- FTS L1B v230 can provide seamless TIR data after December (solar-paddle-rotation-stop) by considering the thermal environment change in 2019.
- EORC is working on new products of GOSAT and GOSAT-2 partial column densities for upper and lower troposphere.



https://data2.gosat.nies.go.jp/gallery/fts_l3_swir_co2_gallery_en.html



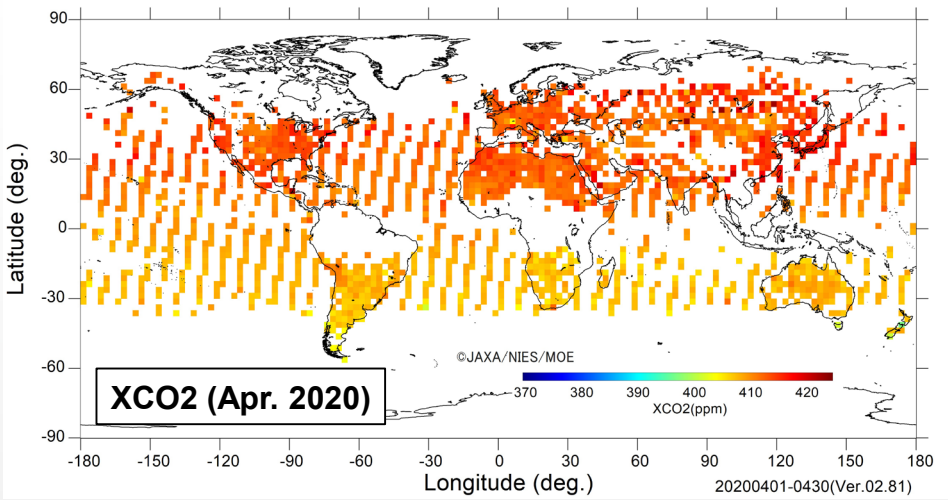
Monthly maps of GOSAT XCO_2 at the WDCGG

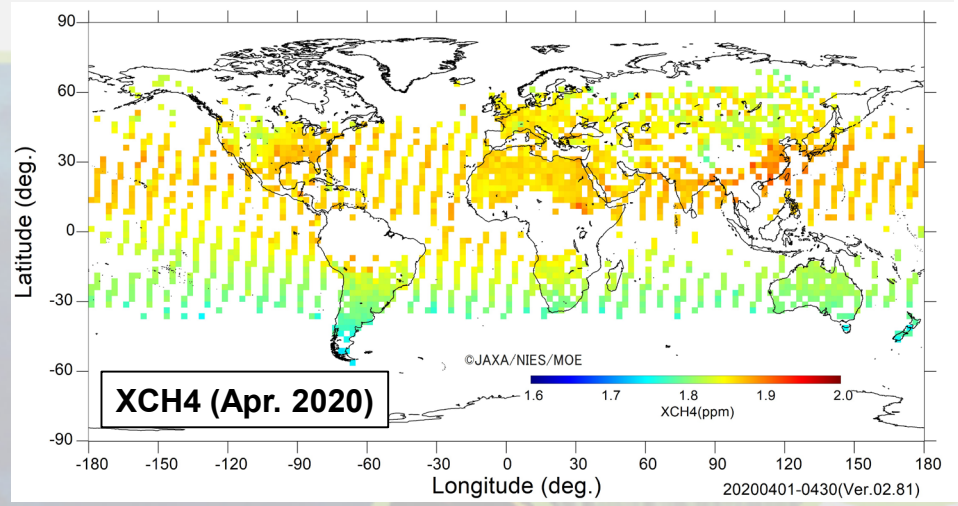


Daily Partial Column GHG densities (JAXA/EORC)

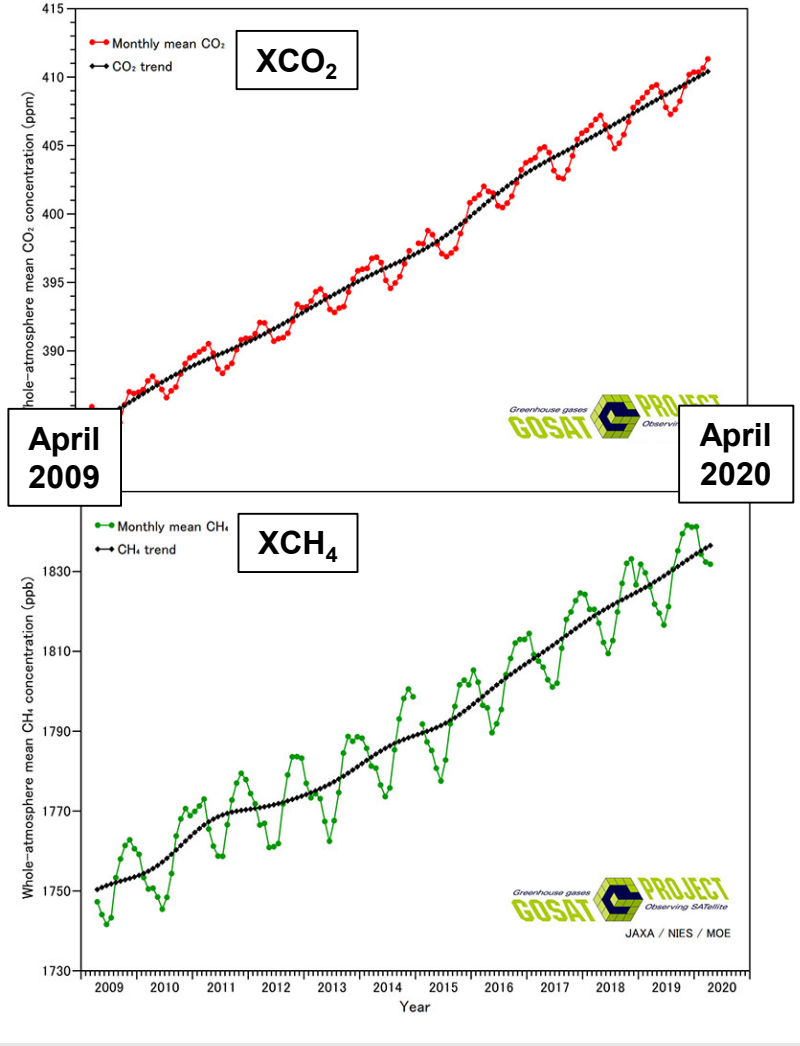
Adapted from Hiroko Imai, et al. IWGGMS-16

Latest GOSAT FTS SWIR Level 2 Product (V02.81)
Global Maps and Long Term Trends of XCO2 and XCH4





Whole-atmosphere Monthly-mean Concentration



TCCON validation (±0.2 deg, ±30 min)
ΔXCO_2 = 0.2 ± 1.8 ppm (N = 2025)
ΔXCH_4 = -0.2 ± 9.5 ppb (N = 2026)

Next version = V02.90

- without bias correction,
- to be released in June 2020

Next version = V02.95

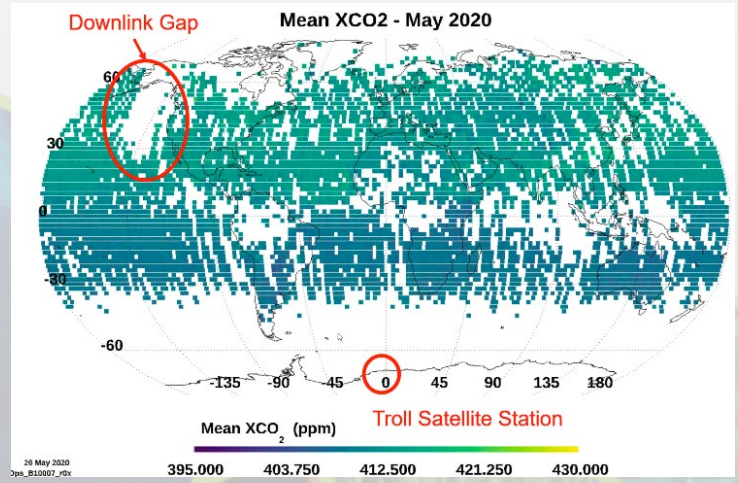
- with bias correction

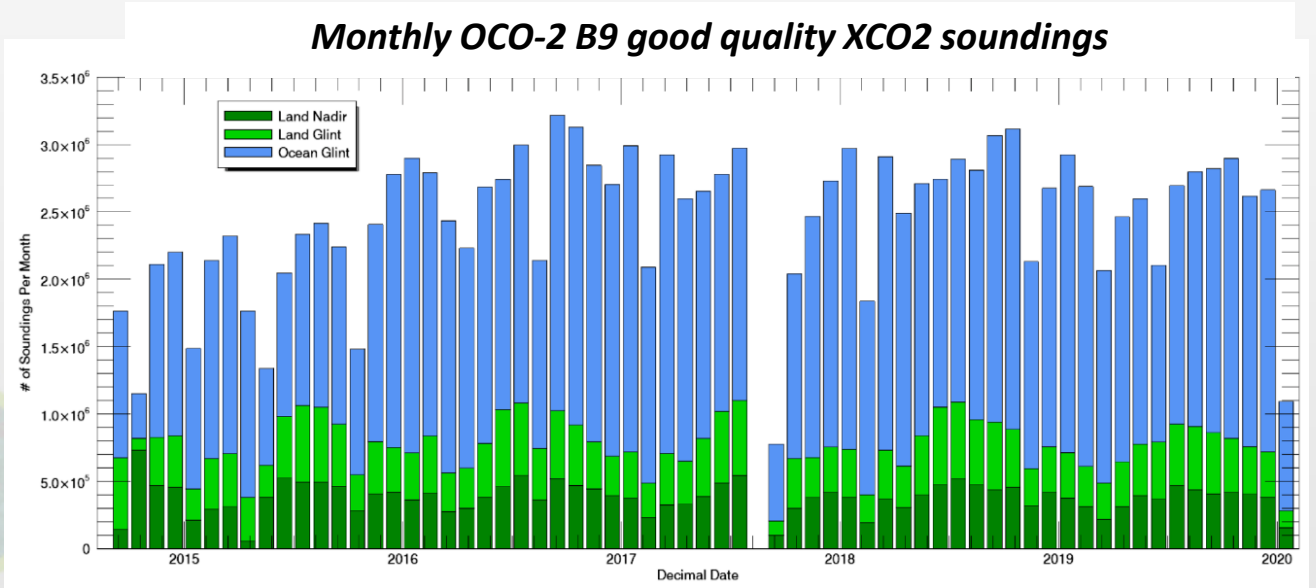
Future version = V03 (in FY2020)

Tsuneo Matsunaga (NIES)

Status of the OCO-2 Observatory and Data Products

- **Almost 5.75 years of nearly continuous data available!**
- **Gyro-less operations since July 2019. Downlink maneuvers reduce science data over the west coast of the US and area around Alaska.**
  - **May be rectified with possible use of "TrollSat" Downlink station in Antarctic**
- **Instrument decontamination campaigns cause loss of about one week of data every 6-12 months**
- **Instrument and spacecraft are in good health and are expected to operate for many years**

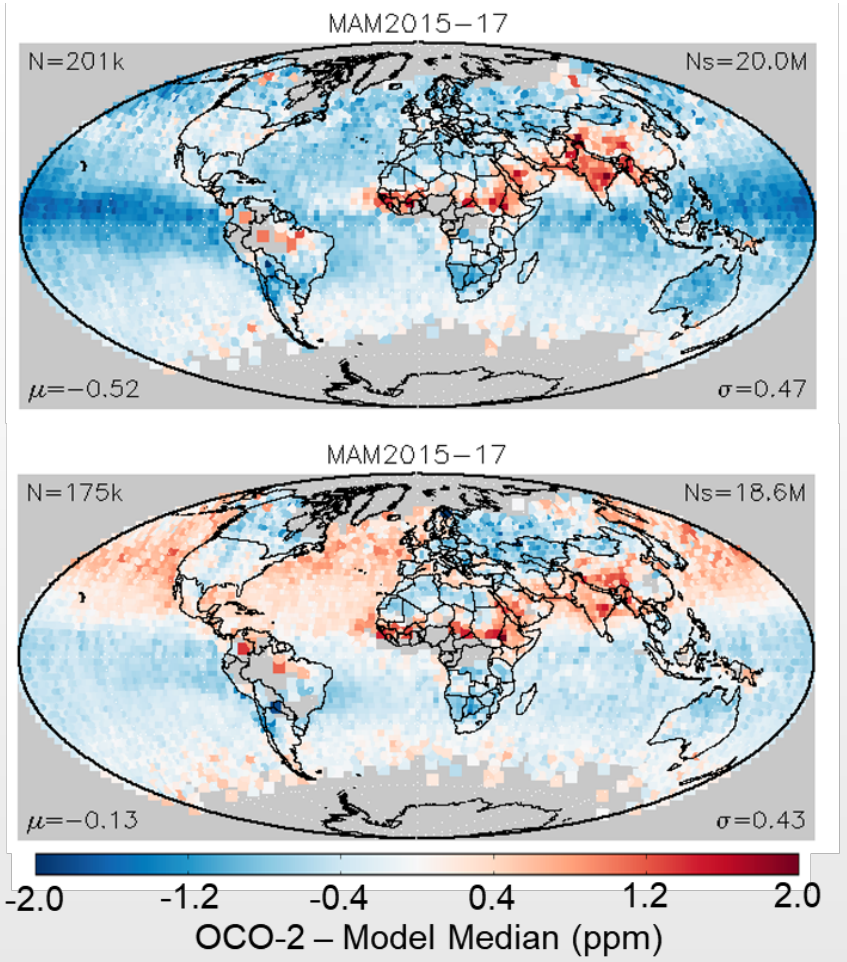




Adapted form C. O'Dell IWGGMS-8 presentation

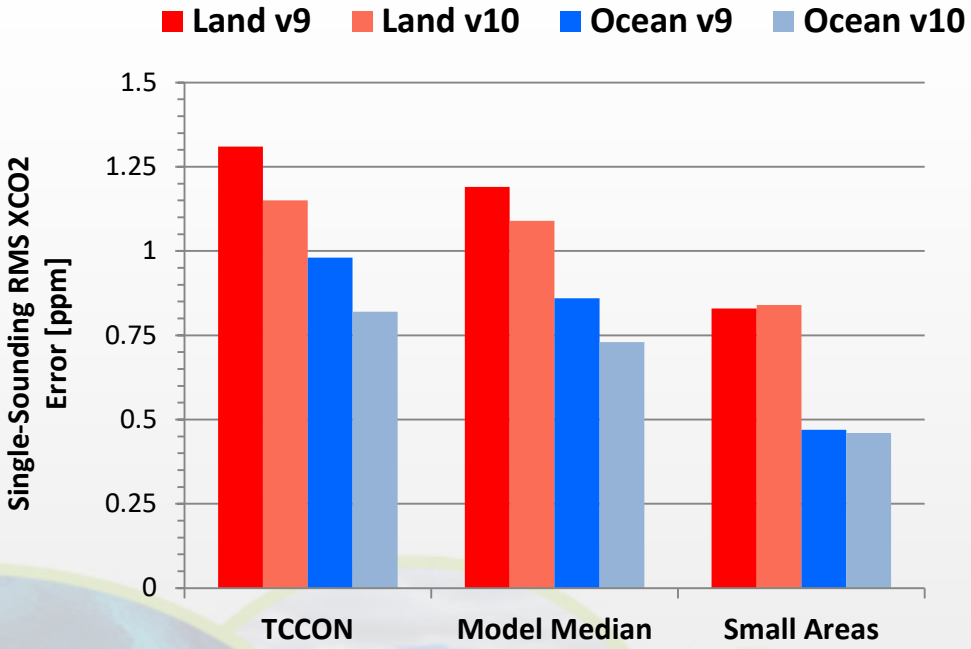
5.5 Year Record Reprocessed with Version 10 (v10)

- **Differences between OCO-2 v9 and OCO-2 v10**
  - Calibration: ABO2 radiometric degradation, bad samples
  - ABSCO 5.1 + O_2 A-band scaling (reduces mean P_s bias)
  - Improved solar continuum model (based on TSIS SIM)
  - Improved aerosol priors from GEOS5-FP-IT, tighter aerosol constraint. (Nelson et al. AMT, 2018)
  - New CO_2 Prior (consistent with GGG2020)
  - Quadratic (instead of linear) Albedo over land surfaces
  - Loosened SIF prior constraint over land
- **Results for OCO-2 v10r**
  - Better agreement with TCCON, Small Areas and Models
  - Low-bias over tropical oceans & some land regions mitigated
  - Noticeable differences with models remain
    - e.g., Sahel region of Africa
  - Higher-than-expected sensitivity to prior over ocean.
  - Lite files to be available in early July 2020

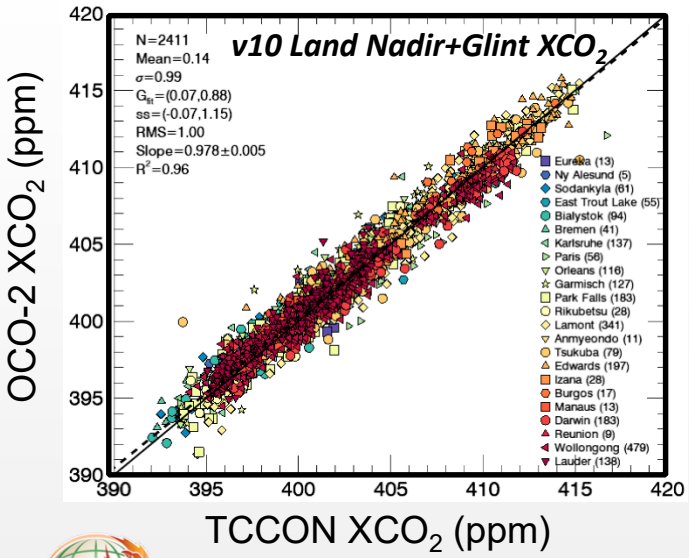


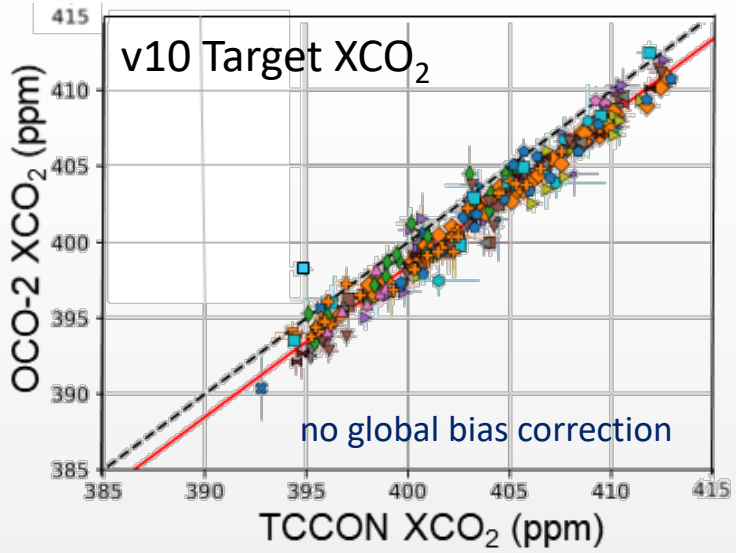
OCO-2 v9 Lite (top) and v10 (bottom) XCO_2 results compared to a 4-model median. The B10 products have reduced bias and variance with the models.

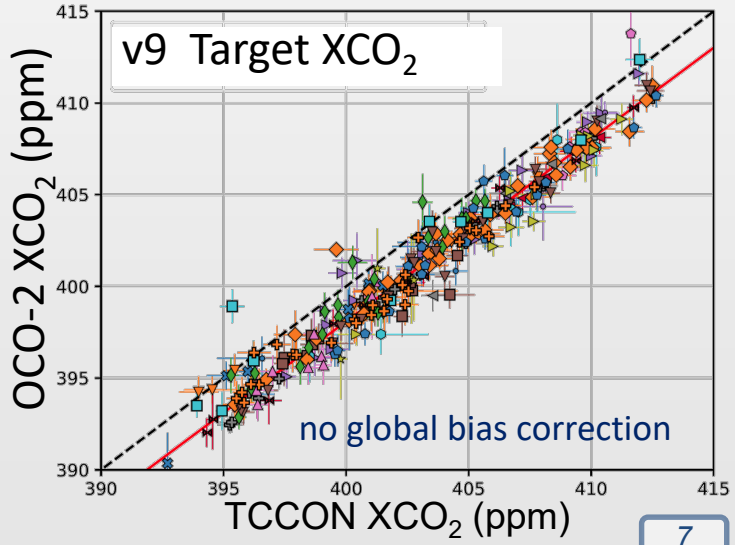
OCO-2 v10r Validation Statistics



- v10 Error statistics are improved vs. TCCON, Models and Small Areas.
- v10 Coverage (not shown) also slightly improved at high latitudes over land.





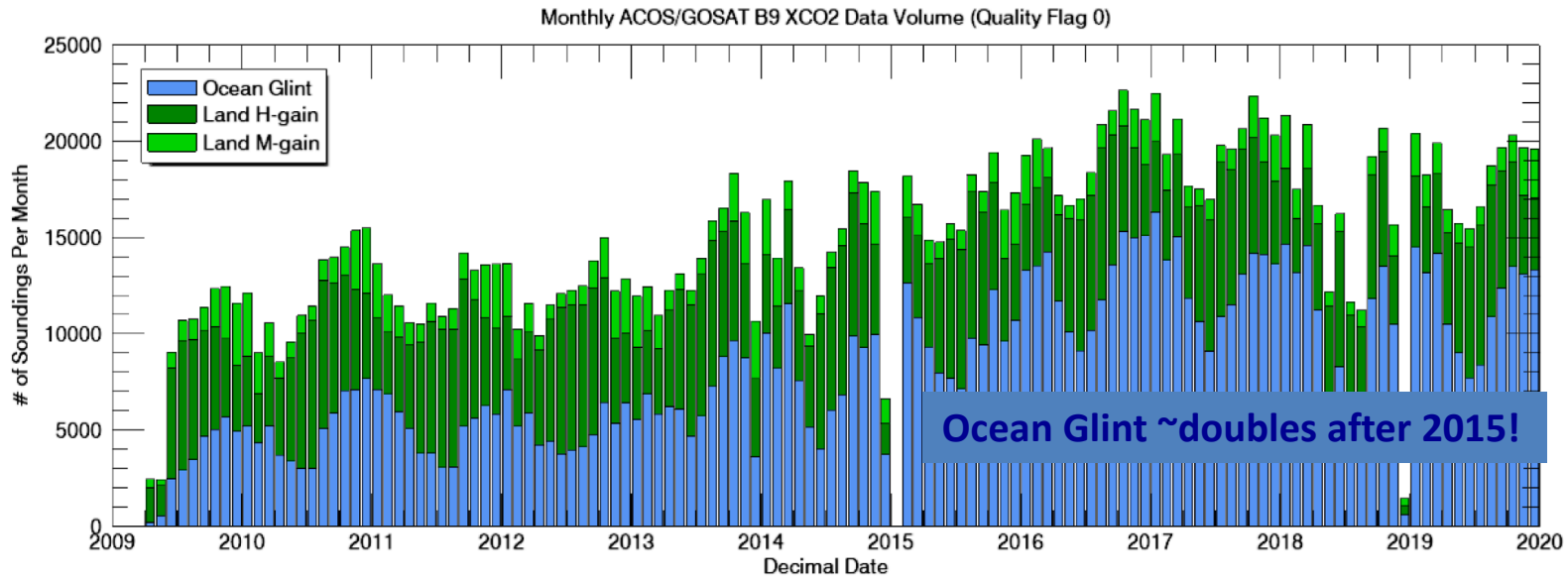


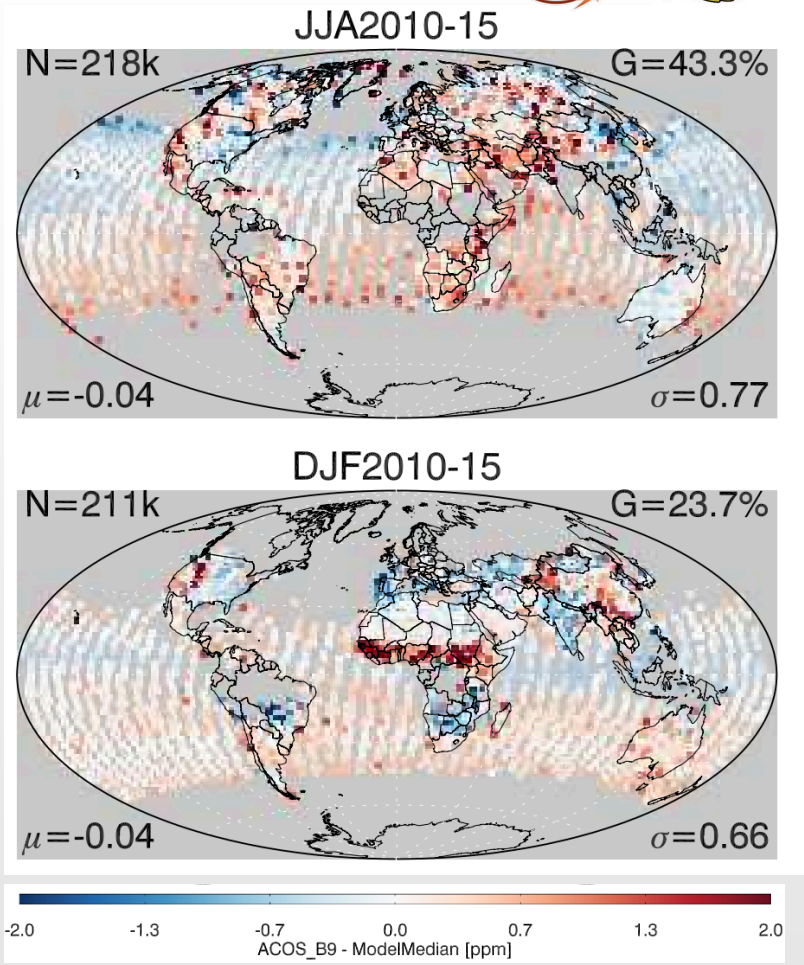
The OCO-2 v10 products (above) have lower bias and scatter than the v9 products (right) relative to TCCON in all viewing modes.

The OCO-2 v10 products will be released later in the summer of 2020.

The ACOS/GOSAT v9 Product

- **10+ years of data! (April 2009-Dec 2019, currently)**
- **The ACOS/GOSAT v9 product has reduced scatter and bias and better coverage than the earlier v7.3 ACOS/GOSAT product**
  - Now includes land gain M (v7.3 lacked this)
- Can this product be combined with the OCO-2 product to produce a harmonized, 11-year XCO2 data product for use in flux inversion experiments?





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Summary of XCO_2 Products

- **The GOSAT and OCO-2 XCO2 products have improved steadily over the past 11+ years**
  - Errors and biases have been reduced to < 1 ppm relative to TCCON and other standards for the ACOS/GOSAT v9 and OCO-2 v10 XCO2 products
- **The OCO-2 v10 product has substantially reduced biases than earlier products**
  - Remaining biases are still under investigation
    - Even biases as small as 0.2 ppm can introduce unacceptably large (> 1 GT) flux errors
- **The ACOS/GOSAT v9 product has much better accuracy and coverage than earlier ACOS/GOSAT products**
- **Critical questions:**
  - Is the accuracy and coverage of these XCO_2 products adequate for producing a pilot, global atmospheric CO_2 inventory in time to support the 2023 global stocktake?
  - Can these products be combined to produce a harmonized, 11+ year XCO_2 climate data record with better coverage than either product alone?