Evaluation of OCO-2 and OCO-3 version 10 XCO_2

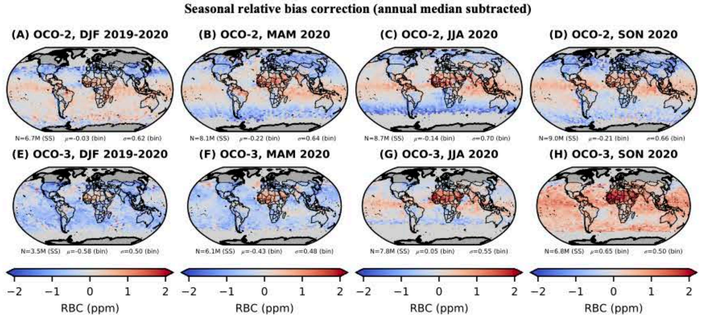
Thomas E. Taylor (tommy.taylor@colostate.edu) and **Chris O'Dell** (Christopher.odell@colostate.edu) :: Cooperative Institute for Research in the Atmosphere, Colorado State Univ., Fort Collins, CO, U.S.A.
A. Chatterjee, B. Fisher, G. Keller, M. Kiel, T. Kurosu, J. Laughner, R. Nelson, V. Payne, G. Osterman, R. Rosenberg, G. Spiers :: Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, U.S.A.
P. Somkuti :: Univ. Oklahoma, College of Atmospheric and Geographic Sciences, Norman, OK, U.S.A.
A. Merrelli :: Univ. Michigan, Ann Arbor, MI, U.S.A.

ACOS v10 L2FP retrieval algorithm

		ACOS v8/v9	ACOS v10
1	Spectroscopy	ABSCO v5.0	ABSCO v5.1
2	Aerosol prior source	MERRA monthly climatology	GEOS5 FP-IT with tightened prior uncertainty
3	CO_2 prior source	TCCON ggg2014	TCCON ggg2020
4	Solar continuum model	ATLAS 3 SOLSPEC	SOLAR-ISS
5	Digital elevation model and land water mask	NASA SRTM v3	N/C
6	Ocean surface model	Cox&Munk + per-band Lambertian component	N/C
7	Land surface model	BRDF	N/C
8	Meteorology prior source	GEOS FP-IT Cartesian	N/C

- Significant updates to the ACOS v10 algorithm from v8/v9 include spectroscopy, aerosol and CO_2 priors, and solar continuum model.
- Both OCO-2 and OCO-3 records have been reprocessed with v10.
- The data are available on the NASA GES DISC.
- A manuscript describing L2FP updates and data sets is in preparation.

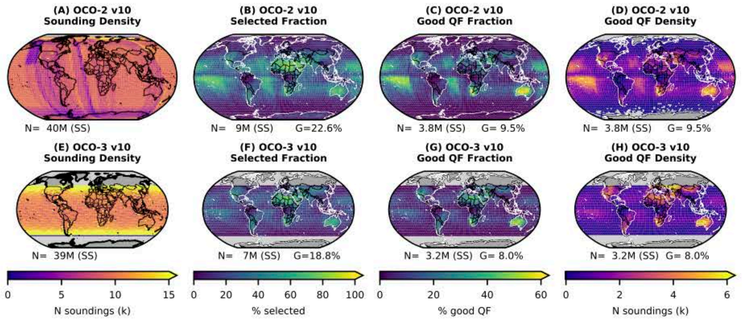
v10 quality filtering/bias correction



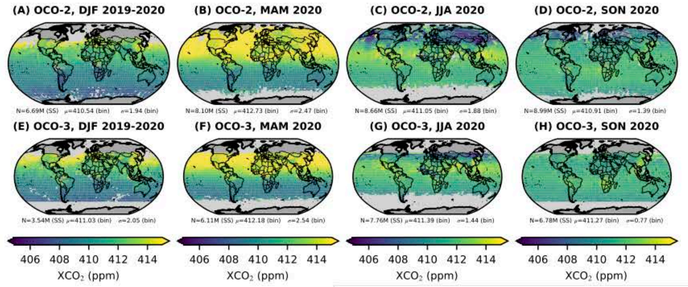
- No fundamental changes were made to the v10 OCO quality filtering and bias correction procedure [O'Dell, AMT, 2018].
- Magnitude of the relative bias correction is of same order (+/- 2 ppm) for both sensors, but with seasonally dependent behaviors driven partly by differences in sampling.
- The sensors exhibit comparable scatter in XCO_2 against 3 truth metrics, and show improvement with QF and BC applied.

Mode	Truth Metric	Sensor	N (soundings)	Throughput (%)	Sigma (ppm) Raw	QF	QF & BC
Land	Models	OCO-2	3.95 M	44.0%	3.77	1.67	1.09
		OCO-3	2.15 M	56.3%	2.76	1.49	1.16
	TCCON	OCO-2	0.70 M	67.1%	2.74	1.74	1.15
		OCO-3	0.20 M	68.9%	2.02	1.50	1.33
	SAA	OCO-2	1.40 M	69.4%	2.18	1.53	0.84
		OCO-3	0.87 M	66.7%	1.70	1.11	0.97
Ocean-Glint	Models	OCO-2	2.03 M	52.1%	2.52	1.12	0.73
		OCO-3	1.56 M	55.0%	2.22	1.21	0.72
	TCCON	OCO-2	0.24 M	70.8%	1.73	1.07	0.82
		OCO-3	0.17 M	53.5%	2.05	1.15	1.01
	SAA	OCO-2	0.75 M	71.9%	1.52	0.90	0.46
		OCO-3	0.91 M	73.4%	1.59	0.97	0.47

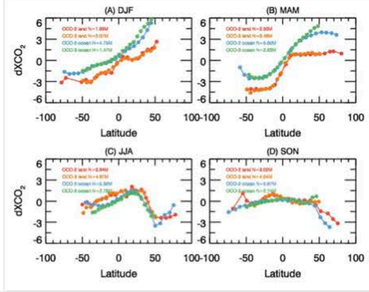
v10 data volumes and XCO_2



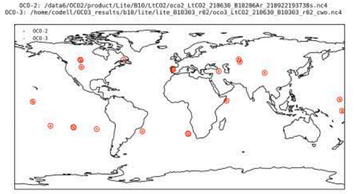
- The polar orbit vs precessing orbit determine vastly different sampling patterns for OCO-2 (A) and OCO-3 (E). The L2FP prefiltering patterns, i.e., sounding selection, are similar (B and F), as are the patterns of good quality soundings (C) and (G), although differences exist due to filtering choices. The final density of good XCO_2 retrievals are qualitatively similar for the overlapping latitude space (D and H).

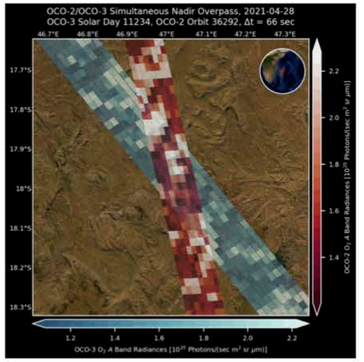


- As expected, the seasonal patterns of XCO_2 from both sensors agree qualitatively, although OCO-3 is limited to < 52° latitude (above).
- Due to the vastly different sampling strategies, coupled with the atmospheric transport of CO_2, it is difficult to produce a meaningful comparison of XCO_2 from the two sensors at large spatiotemporal grids.
- The two sensors agree in latitudinal gradients of $dXCO_2$ (median subtracted), which vary by season and viewing mode. (right)



Collocated OCO-2/3 v10 XCO_2





- A set of closely collocated soundings (25 km radius, +/- 4 h) were identified to allow direct comparison between the two sensors.
- Examples of global collocations on a single day (above), and details of a single overpass (right).

- Early in the development of OCO-3 v10, a diverging time trend against OCO-2 v10 XCO_2 was noted (A).
- As OCO-2 is considered the more mature instrument, especially in regard to radiometric calibration, the working hypothesis was that there was an unidentified calibration error in OCO-3 v10 L1b.
- It was found that the divergence in $dXCO_2$ was highly correlated with the WCO2 spectral band Zero-Level-Offset, derived from sub-daily on-board calibration measurements (B, C, D).
- ZLO increases with time in between instrument decontamination cycles (vertical green/red bars), which are used to remove ice from the detectors, as with OCO-2 [Crisp, AMT, 2017].
- A correction was made to the OCO-3 v10 XCO_2 to mitigate the diverging time trend (E).
- OCO-3 L2Lite files were regenerated and delivered to the NASA GES DISC in spring 2022 as v10.4.