

GOSAT and OCO-2 validation activities at Saga station and campaign sites

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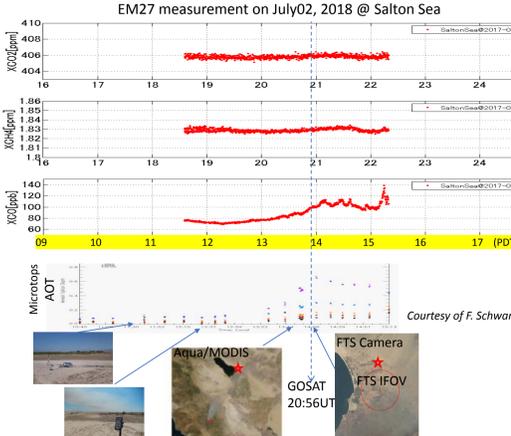
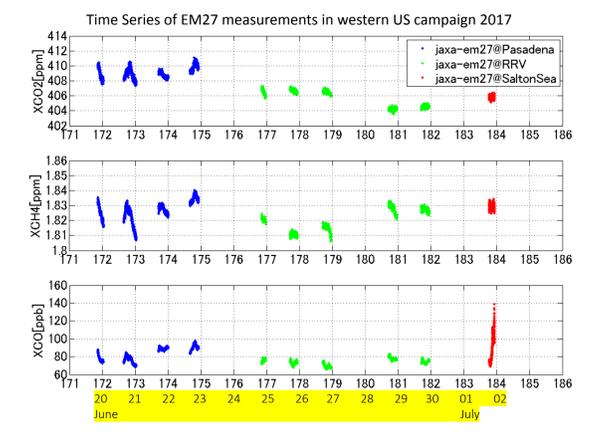
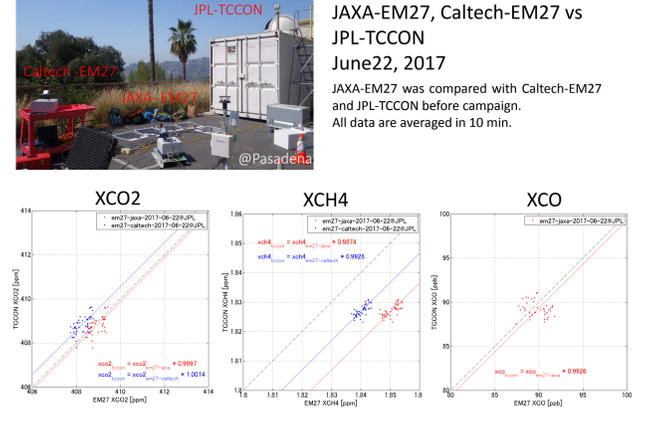
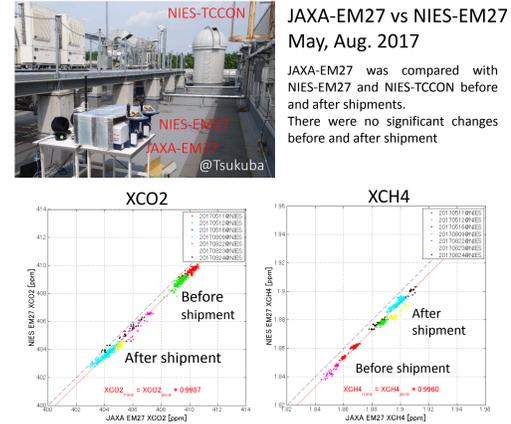
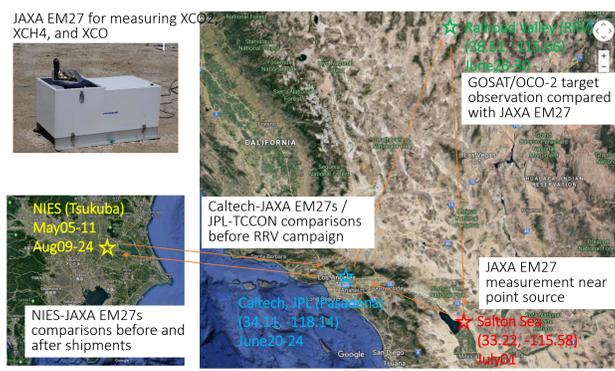
GOSAT and OCO-2 joint campaign in western US 2017

A portable FTS (EM27/SUN) is an effective tool for campaign measurements instead of the ground-based FTS. We have started the EM27 measurements since 2014. Simultaneous detection of CO is helpful to characterize CO₂ source type. We measured XCO along with XCO₂ and XCH₄ using the upgraded EM27, in western US field experiments at Caltech and JPL in Pasadena as a northern Los Angeles suburb, Railroad Valley (RRV) as a desert playa in Nevada, and Salton Sea as a terminal high-salinity lake in southern California's Imperial Valley. These measurements were conducted during the GOSAT/OCO-2 joint campaign in the early summer of 2017.

Before and after US shipments, the JAXA-EM27 was compared with the NIES-EM27 and Tsukuba-TCCON station to quantify the measurement bias and to identify any unanticipated changes. The correlation factors of NIES-EM27/JAXA-EM27 before and after shipments were ~0.9987 and ~0.9960 for XCO₂ and XCH₄, respectively, that showed no significant change by the US campaign and transportation. After US shipment, the JAXA-EM27 was compared with the Caltech-EM27 and the JPL-TCCON station, which was carried from Dryden for the OCO-3 pre-flight test. The correlation factors of Caltech-EM27/JAXA-EM27 were ~0.9985 and ~0.9949 in 4-day comparison for XCO₂ and XCH₄, respectively. Those of JPL-TCCON/JAXA-EM27 are ~0.9997, ~0.9874, and ~0.9926 in 1-day comparison for XCO₂, XCH₄ and XCO, respectively. Finally, we corrected the JAXA-EM27 data by using the JPL-TCCON correlation factor.

At RRV, we performed the simultaneous measurements of the JAXA-EM27 with GOSAT and OCO-2 target observations. The GOSAT observed the RRV by M gain operation for a bright surface target. The NIES L2 in M gain has ~3 ppm higher than H gain as reported by Uchino et al., 2017. After RRV, Salton Sea also had a simultaneous measurement with GOSAT. We deployed the JAXA-EM27 on the south side of the Salton Sea, where agriculture, active volcanism and geothermal power plants might produce CO₂ and CH₄ as sources. A large CO enhancement originating from wildfires was serendipitously measured in conjunction with a large AOT measured by the Microtops. It had a thick aerosol at the GOSAT overpass. The RemoTeC L2 (not full-physics) is based on the pressure from metrological data, that generates a biased retrieval in a thick aerosol condition.

We assessed the western US campaign with good retrieval conditions as the NIES L2 data except RRV (M gain), the RemoTeC L2 data except Salton Sea (large AOT). The GOSAT XCO₂ had bias < +0.5 ppm and std < 2 ppm with both algorithms. The OCO-2 XCO₂ had bias ~ -0.5 ppm and std < 0.1 ppm for the RRV targets. The GOSAT XCH₄ had bias ~ +10~+20 ppb and std < 10 ppb.



GOSAT and OCO-2 XCO₂ comparisons with EM27 in western US campaign 2017

Site	GOSAT overpass	JAXA-EM27 (calibrated) XCO ₂	GOSAT-RemoTeC XCO ₂	GOSAT-NIES XCO ₂	OCO-2 overpass	JAXA-EM27 (calibrated) XCO ₂	OCO-2 XCO ₂	GOSAT-RemoTeC XCO ₂ dif.	GOSAT-NIES XCO ₂ dif.	OCO-2 XCO ₂ dif.
Caltech	6/20 20:55	410.1	409.1	409.2				-0.97	-0.87	
Caltech	6/21 21:26	409.0	411.4	409.9				2.40	0.90	
Caltech	6/23 20:55	410.3	408.5	408.9				-1.84	-1.44	
RRV(gainM)					6/25 21:05	406.8	406.5			-0.47
RRV(gainM)	6/26 20:53	406.7	407.9	411.4				1.22	(4.70)	
RRV(gainM)	6/27 21:26	406.5	408.5	410.2	6/27 20:53	406.5	405.9	2.04	(3.74)	-0.62
RRV(gainM)	6/29 20:54	404.0	402.2	407.3	6/29 20:41	403.9	403.3	-1.76	(3.34)	-0.55
RRV(gainM)	6/30 21:26	404.7	406.9	409.7				2.22	(5.02)	
Salton Sea	7/02 20:56	405.9		408.4				(9.75)	2.65	
								bias(good)	0.47	0.31
								stdev(good)	1.92	1.85
								bias(gainM)		4.20

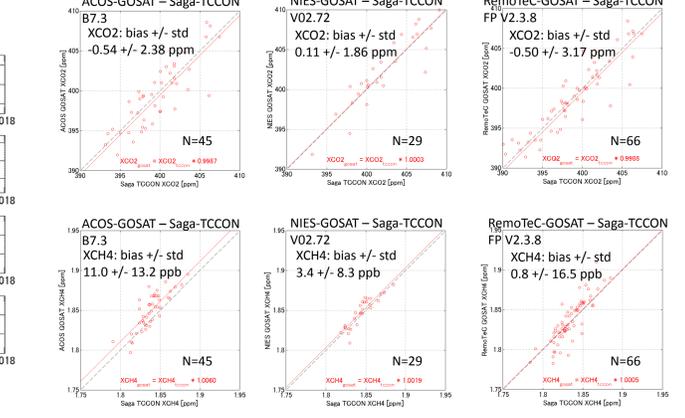
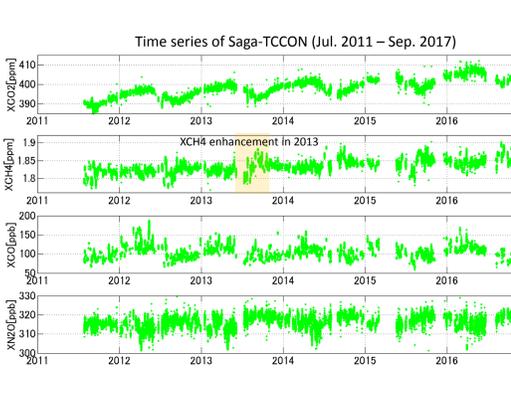
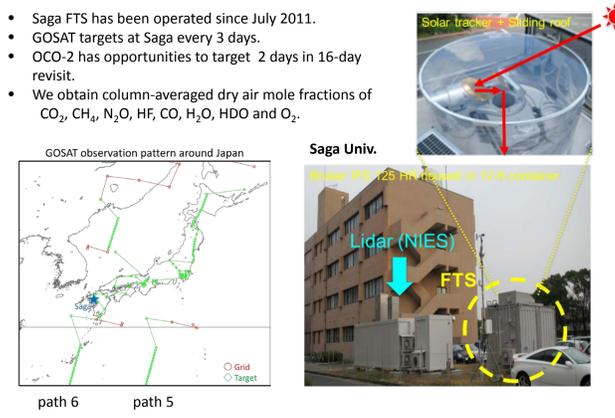
T XCH₄ comparison with EM27 in western US campaign 2017

Site	GOSAT overpass	JAXA-EM27 (calibrated) XCH ₄	GOSAT-RemoTeC XCH ₄	GOSAT-NIES XCH ₄	GOSAT-RemoTeC XCO ₂ dif.	GOSAT-NIES XCO ₂ dif.
Caltech	6/20 20:55	1.833	1.827	1.832	-0.006	-0.001
Caltech	6/21 21:26	1.821	1.828	1.819	0.007	-0.002
Caltech	6/23 20:55	1.836	1.813	1.826	-0.023	-0.010
RRV(gainM)						
RRV(gainM)	6/26 20:53	1.810	1.835	1.823	0.025	0.013
RRV(gainM)	6/27 21:26	1.816	1.833	1.826	0.017	0.010
RRV(gainM)	6/29 20:54	1.829	1.846	1.842	0.017	0.013
RRV(gainM)	6/30 21:26	1.826	1.856	1.843	0.030	0.017
Salton Sea	7/02 20:56	1.829		1.839		0.010
						0.010
						0.019

Saga-TCCON station for satellite validation

High spectral resolution ground-based FTS (IFS-125HR) has been operated at Saga Univ. by JAXA since July 2011 as a member of TCCON (Total Carbon Column Observing Network) for XCO₂ and XCH₄ (Ohyama et al., 2015). Beside the FTS, DIAL is also operated for profiling of aerosols, thin cirrus clouds, and tropospheric ozone by NIES (Uchino et al., 2014, 2017). Saga is located at North part of Kyushu, where the air mass comes from the continent over the sea. It is a good location for measuring both GHG and polluted atmosphere. We make coincident measurements at GOSAT and OCO-2 target observations for XCO₂ and XCH₄ validations. Currently, TROPOMI also uses the Saga XCH₄ data in the commissioning phase. GOSAT targets at Saga every 3 days. OCO-2 has opportunities to target 2 or 3 days in 16-day revisit. The Saga-TCCON has been now almost remotely operated by Saga Univ. students supported by JAXA, then it has increased the measurement dataset.

The time series show all the from 2011 to 2017. Large CH₄ anomalies observed in summer, especially 2013 was analyzed by Ishizawa et al., 2016, which reported air mass from the emission area had reached at Japan. We compared XCO₂ and XCH₄ between the Saga-TCCON and the GOSAT retrieval results by ACOS B7.3, NIES v02.72 and RemoTeC-FP v2.3.8. The coincident numbers were different because of the quality filter by the prior or post screenings are different. It is affected to the deviation. XCO₂ is validated as -0.54 +/- 2.38 ppm, 0.11 +/- 1.86 ppm, and -0.50 +/- 3.17 ppm for ACOS, NIES, and RemoTeC-FP, respectively. XCH₄ is validated as 11.0 +/- 13.2 ppb, 3.4 +/- 8.3 ppb, and 0.8 +/- 16.5 ppb, for ACOS, NIES, and RemoTeC-FP, respectively.



Summary of the activities

We calibrated the JAXA-EM27 with the TCCON station before and after campaigns. The Saga-TCCON station is fully operated remotely for not only GOSAT but OCO-2 and other satellites. We summarized the comparison results of GOSAT and OCO-2 with the EM27 in the western US campaign 2017 and the Saga-TCCON since 2011.

XCO ₂ (bias +/- std) [ppm]	ACOS B7.3	NIES v02.72 GU	RemoTeC v2.3.8	OCO-2
Saga-TCCON	GainH -0.54 +/- 2.38	0.11 +/- 1.86	-0.50 +/- 3.17 (FP)	
UScampaign2017	GainH	0.31 +/- 1.85	0.47 +/- 1.92 (not FP)	-0.55 +/- 0.08
	GainM	4.20 +/- 0.79		

XCH ₄ (bias +/- std) [ppb]	ACOS B7.3	NIES v02.72 GU	RemoTeC v2.3.8
Saga-TCCON	GainH 11 +/- 13	3 +/- 8	1 +/- 17 (FP)
UScampaign2017	GainH	6 +/- 9	10 +/- 19 (not FP)
	GainM		

