

# Validation of recent results of the GOSAT-2 and GOSAT SWIR L2 products

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I will be standing by on Gather Town from 1:00-3:00 hrs (UTC) on July 12, and 06:00-08:00 hrs (UTC) on July 13. I will also accept questions by email (tsutsumi.yukitomo@nies.go.jp)

## 1. Introduction

The Ministry of the Environment (MOE), the Japan Aerospace Exploration Agency (JAXA), and the National Institute for Environmental Studies (NIES) are conducting the Greenhouse gases Observing SATellite ("Ibuki" (GOSAT) and "Ibuki-2" (GOSAT-2)) series project to measure concentrations of the major greenhouse gases (GHG), such as carbon dioxide and methane, from space. For use of GOSAT and GOSAT-2 products in scientific researches and GHG reduction policies, it is essential to make continuous validations to ensure the accuracy of GOSAT and GOSAT-2 products on GHG concentrations. We conducted the validation of the recent versions of GOSAT-2 FTS-2 SWIR L2 Full Physics product (Ver. 01.04 & 01.07) and GOSAT FTS SWIR L2 products (Ver. 03.00) by being compared with Total Carbon Column Observing Network (TCCON) data.

## 2. Conditions and collocations of GOSAT-2 and GOSAT SWIR L2 product for comparison with TCCON data

### 2.1 GOSAT-2 FTS-2 SWIR L2 Full Physics product

The versions of 01.04 & 01.07 with the period of March 2019 – November 2021 (not overlapped) are used in this validation. The area definitions are "Land" ( $\geq 10\%$  of land fraction) and "Ocean" ( $< 10\%$  of land fraction). Only data with the quality flag "good" are used. No distinction is made by gain in these analyses. The TCCON data are obtained from the TCCON data archive (<http://tccondat.org/>). They are as of December 2021 and processed by GGG2014. The TCCON data are averaged over within  $\pm 30$  min of GOSAT-2 overpass time for the validation.

The conditions and collocations for the comparison of GOSAT-2 and TCCON data are as follows:

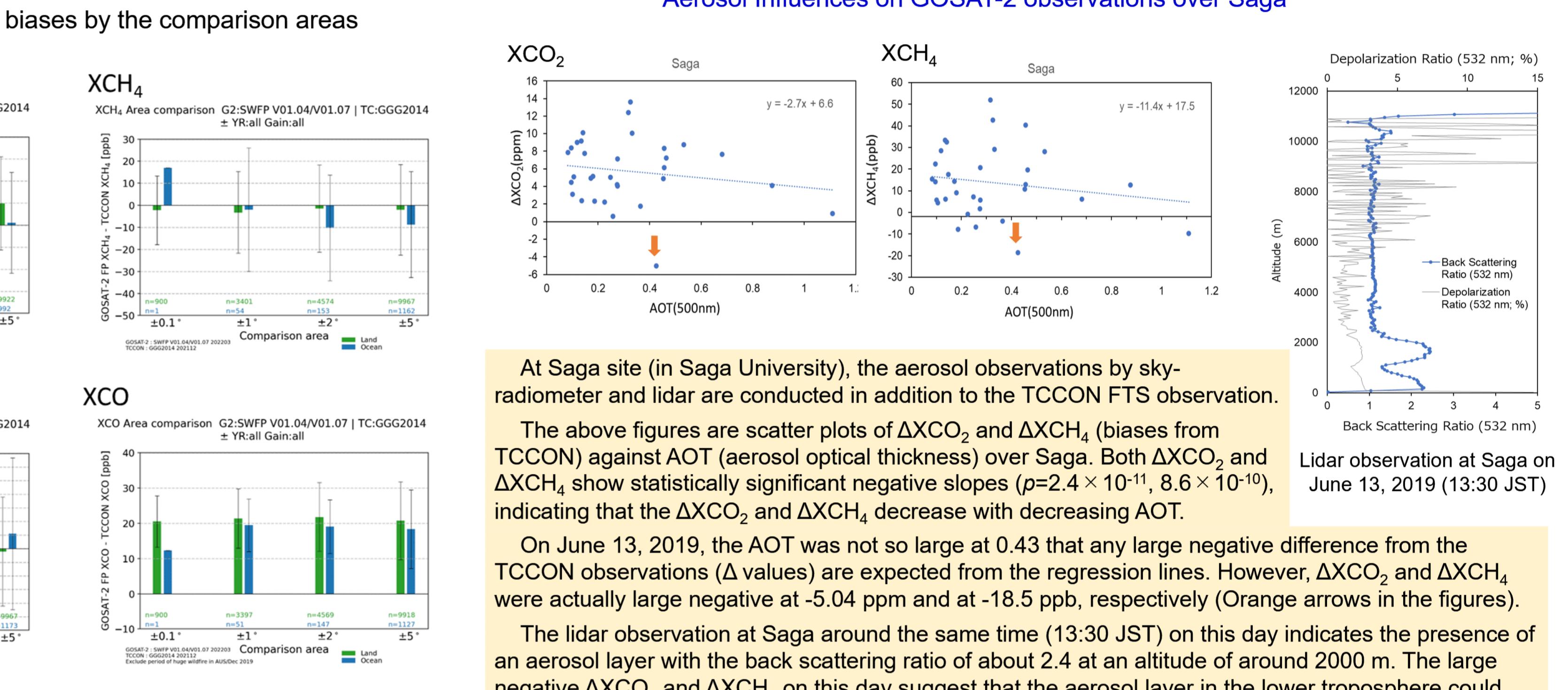
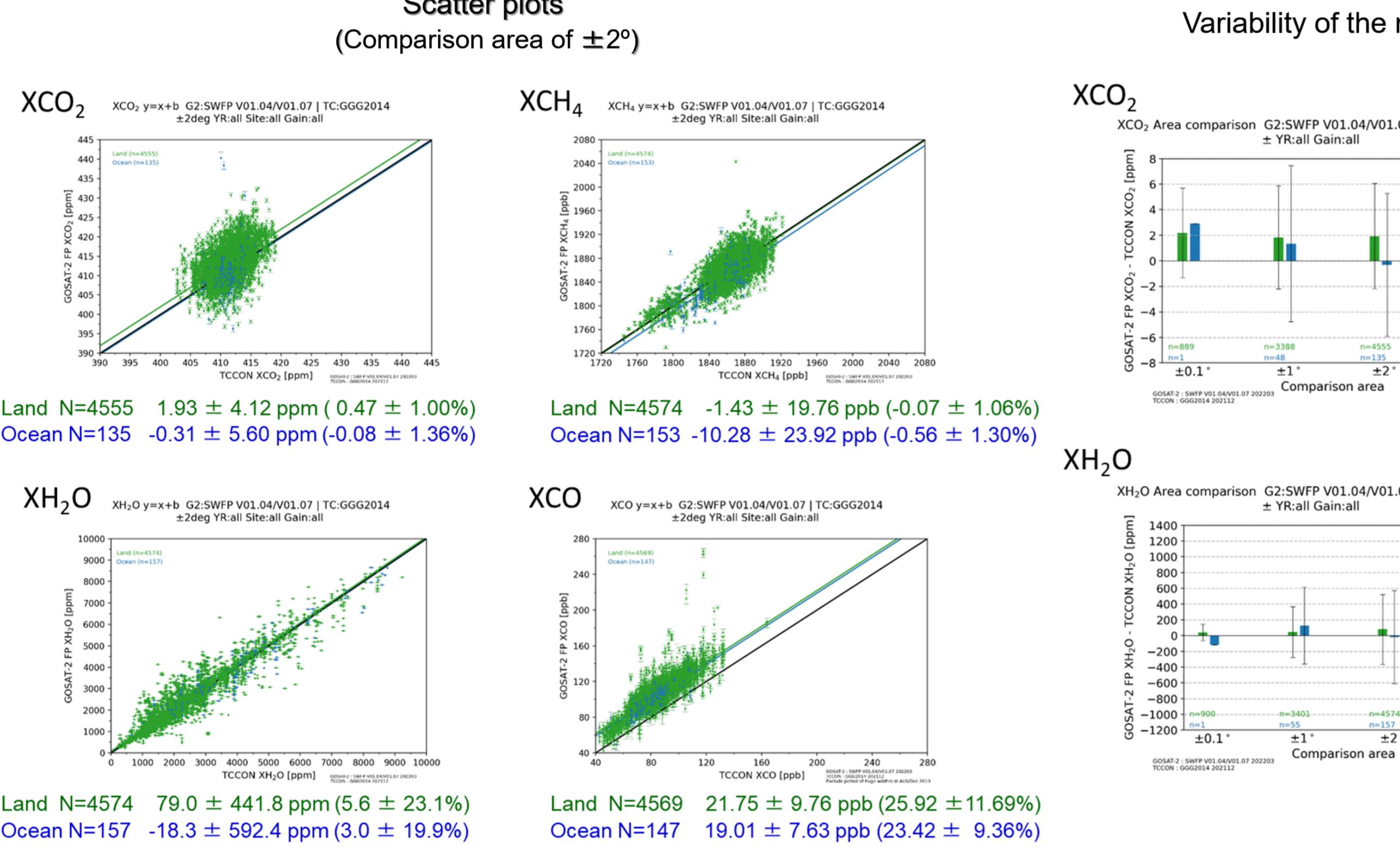
- Comparison area:  $\pm 0.1^\circ$ ,  $\pm 1^\circ$ ,  $\pm 2^\circ$ ,  $\pm 5^\circ$  latitude / longitude box centered at the TCCON sites.
- Column averaging kernels and prior profiles are not considered for the validation analysis.
- The GOSAT-2 Full Physics product with a difference between the footprint altitude and the altitude of the TCCON site greater than 500 m are excluded from the comparison.
- Large forest fires occurred in Australia in Autumn 2019. Therefore, for XCO, the GOSAT-2 Full Physics product in Wollongong in Australia whose absolute bias (the difference from the TCCON data) is greater than 40 ppb are excluded from the comparison.

### 2.2 GOSAT FTS SWIR L2 product

The GOSAT FTS SWIR L2 product of Ver. 03.00 with the period of April 2009 – December 2019 is used in this validation. The area definitions are "Land" (100% of land fraction) and "Ocean" (0% of land fraction). The gains used are gain H and gain M over Land and gain H over Ocean. The TCCON data are obtained from the TCCON data archive (<http://tccondat.org/>). They are as of September 2021 and processed by GGG2014. The collocations for comparison are the same as GOSAT-2.

Please note that the GOSAT FTS SWIR L2 product of Ver. 03.00 has not been released yet.

## 3. Results of comparison of GOSAT-2 FTS-2 SWIR L2 Full Physics product (Ver. 01.04 & 01.07)



### Summary of validation of GOSAT-2 FTS-2 SWIR L2 Full Physics product (Ver.01.04 & 01.07)

The GOSAT-2 L2 Full Physics product (Ver.01.04 & Ver.1.07) for XCO<sub>2</sub>, XCH<sub>4</sub>, XH<sub>2</sub>O and XCO (March 2019 – November 2021) are compared with the TCCON data. In the comparison area of  $\pm 2^\circ$ , the validation of GOSAT-2 Full Physics product is summarized as follows.

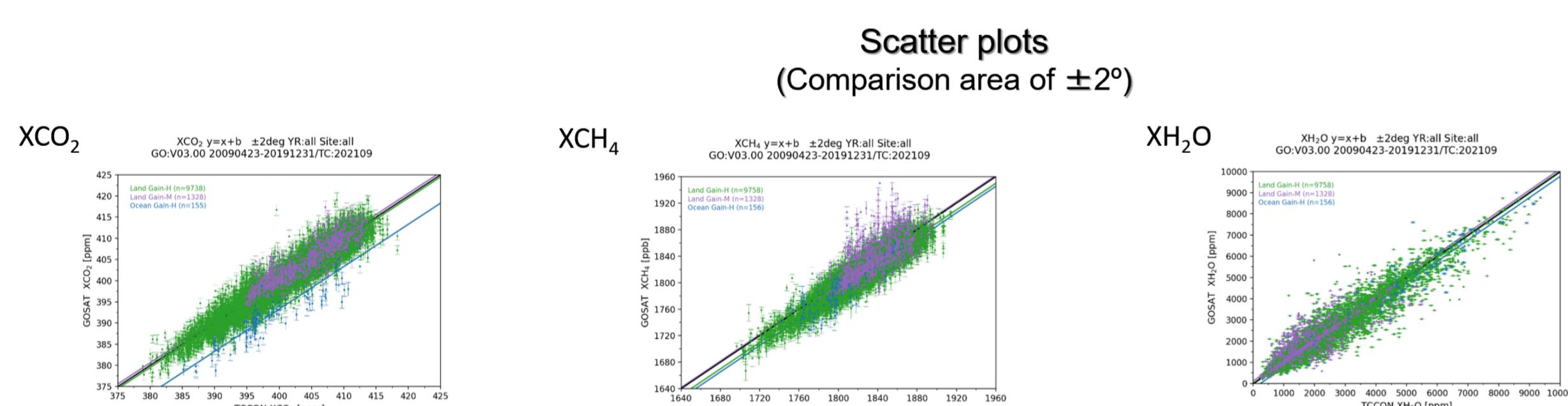
- The mean biases and their standard deviations of XCO<sub>2</sub> over Land and Ocean are  $1.93 \pm 4.12$  ppm ( $0.47 \pm 1.00$ ) and  $-0.31 \pm 5.60$  ppm ( $-0.08 \pm 1.36\%$ ), respectively.
- The mean biases and their standard deviations of XCH<sub>4</sub> over Land and Ocean are  $-1.43 \pm 19.76$  ppb ( $-0.07 \pm 1.06\%$ ) and  $-10.28 \pm 23.92$  ppb ( $-0.56 \pm 1.30\%$ ), respectively.
- The mean relative biases and their standard deviations of XH<sub>2</sub>O over Land and Ocean are  $5.6 \pm 23.1\%$  and  $3.0 \pm 19.9\%$ , respectively. Their standard deviations are relatively large.
- The mean biases and their standard deviations of XCO over Land and Ocean are  $21.75 \pm 9.76$  ppb ( $25.92 \pm 11.69\%$ ) and  $19.01 \pm 7.63$  ppb ( $23.42 \pm 9.36\%$ ), respectively.
- The trends of biases for XCO<sub>2</sub> and XCH<sub>4</sub> do not show large variations during the observation period, the period is not so long though (not shown in the poster).

The validation of GOSAT-2 Full Physics product under the other conditions (collocations) is summarized as follows.

- For XCO<sub>2</sub>, the mean biases over Land are around 2 ppm in all comparison areas.
- For XCO, the mean biases over Land and Ocean are around 20 ppb except the comparison area of  $\pm 0.1^\circ$  whose case number is only one. Their standard deviations are smaller than the mean biases in all comparison areas.
- Significant negative slopes of the biases ( $\Delta XCO_2$  and  $\Delta XCH_4$ ) against AOT over Saga are found, suggesting that the  $\Delta XCO_2$  and  $\Delta XCH_4$  decrease with increasing AOT. Similar relationships were also shown in Tsukuba and Lauder (New Zealand).
- It is found that there is a case that the aerosol layer in low altitude could cause large negative biases on XCO<sub>2</sub> and XCH<sub>4</sub> in the GOSAT-2 Full Physics product.

We are now reprocessing the GOSAT-2 data using the modified software based on Yoshida et al.(AGU Fall Meeting 2021). If this reprocessing goes smoothly, we will release the updated product (Ver. 02.00) for RA by the end of July, and then release it to the public after the approval of the Three Parties (MOE, JAXA, and NIES). Scatters of the new product against TCCON will be significantly reduced and expected to approach to the GOSAT level.

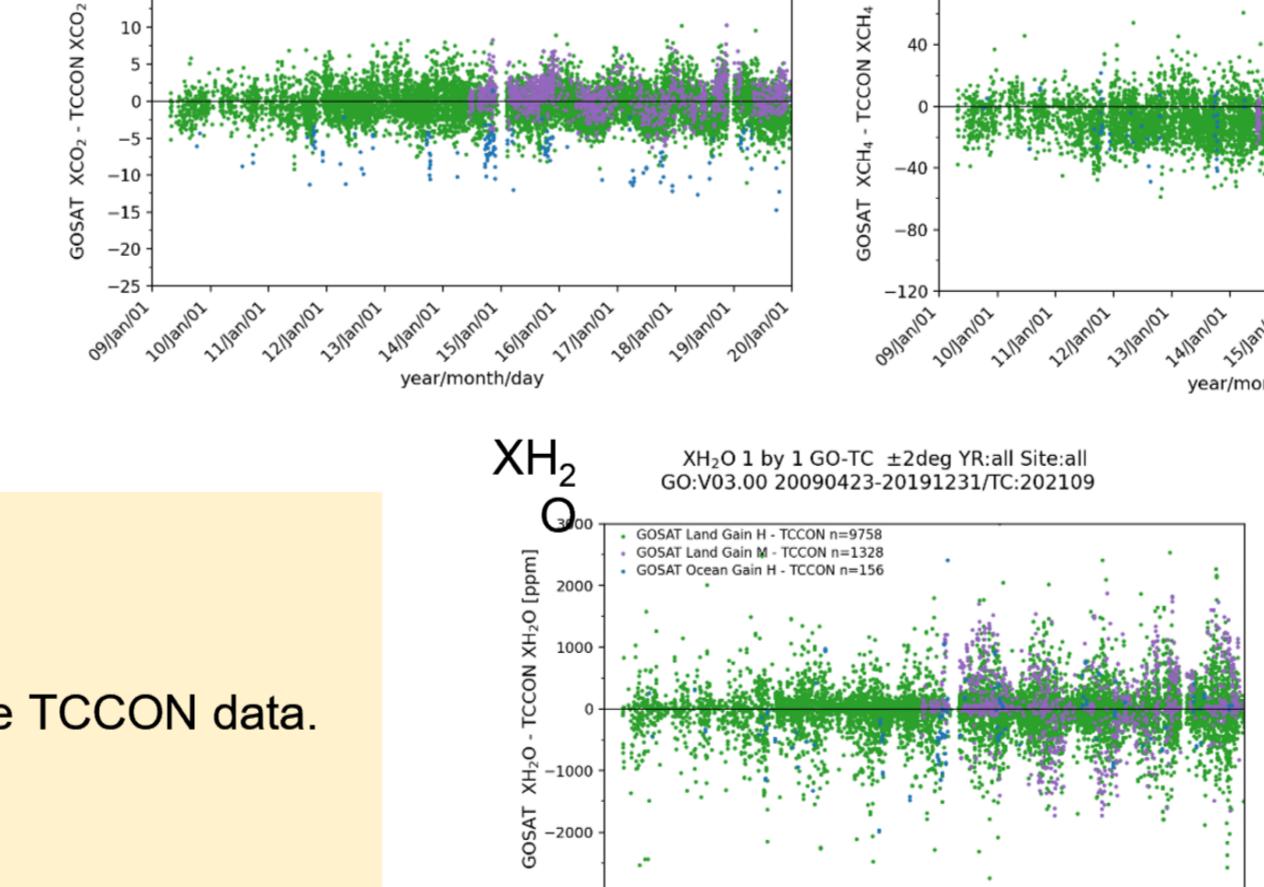
## 4. Results of comparison of GOSAT FTS SWIR L2 product (Ver. 03.00)



### Summary table of biases for GOSAT-2 Full Physics product (Ver. 01.04 and 01.07)

SWFP V01.04+V01.07 2019/3-1 2021/11/30	Comparis on area	Land				Ocean					
		N	Bias [ppm] or [ppb]	Std [ppm] or [ppb]	Bias [%]	Std [%]	N	Bias [ppm] or [ppb]	Std [ppm] or [ppb]	Bias [%]	Std [%]
XCO <sub>2</sub>	$\pm 0.1^\circ$	889	2.18	3.51	0.53	0.85	1	2.92	-	0.71	-
	$\pm 1^\circ$	3388	1.84	4.04	0.45	0.98	48	1.33	6.11	0.32	1.48
	$\pm 2^\circ$	4555	1.93	4.12	0.47	1.00	135	-0.31	5.60	-0.08	1.36
	$\pm 5^\circ$	9922	1.97	4.23	0.48	1.03	992	0.21	4.57	0.05	1.11
XCH <sub>4</sub>	$\pm 0.1^\circ$	901	-2.23	15.59	-0.12	0.84	1	17.05	-	-0.95	-
	$\pm 1^\circ$	3401	-3.25	18.52	-0.17	0.99	54	-12.79	27.93	-0.10	1.52
	$\pm 2^\circ$	4574	-1.43	19.76	-0.07	1.06	153	-10.28	23.92	-0.56	1.30
	$\pm 5^\circ$	9967	-2.07	20.53	-0.11	1.10	1162	-8.73	24.03	-0.47	1.30
XH <sub>2</sub> O	$\pm 0.1^\circ$	900	41.0	104.8	1.5	4.5	1	-11.72	-	-5.2	-
	$\pm 1^\circ$	3401	45.4	321.6	2.9	16.8	55	126.4	486.1	6.0	18.9
	$\pm 2^\circ$	4574	79.0	441.8	5.6	23.1	157	-18.3	592.4	3.0	19.9
	$\pm 5^\circ$	9967	20.47	800.4	3.6	32.0	1173	218.3	1146.6	30.0	104.2
XCO	$\pm 0.1^\circ$	900	20.47	7.30	24.99	7.96	1	12.24	-	17.89	-
	$\pm 1^\circ$	3397	21.33	8.41	25.33	10.26	51	19.41	7.46	23.24	7.75
	$\pm 2^\circ$	4569	21.75	9.76	25.92	11.69	147	19.01	7.63	23.42	9.36
	$\pm 5^\circ$	9918	20.69	11.01	24.96	12.54	1127	18.28	11.14	23.61	13.92

### Time series of bias of GOSAT product (Comparison area of $\pm 2^\circ$ )



### Summary table of biases for GOSAT product (Ver. 03.00)

GOSAT V03.00 2009-2019	Comparison areas	N	Bias [ppm] or [ppb]	Std [ppm] or [ppb]	Bias [%]	Std [%]
			[ppm] or [ppb]	[ppm] or [ppb]	%	%
	XCO <sub>2</sub>	1979	-0.43	1.85	-0.11	0.46
	XCH <sub>4</sub>	6775	-0.41	2.19	-0.10	0.54
	XH <sub>2</sub> O	9738	-0.			