

Summary of the validation on GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product

December 2021
Updated in November 2022
NIES GOSAT-2 Project

The column-averaged dry-air mole fractions of carbon dioxide (XCO_2), methane (XCH_4), water vapor (XH_2O), and carbon monoxide (XCO) in GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product (Ver. 01.07) (hereinafter abbreviated as GOSAT-2 Full Physics product) are compared with XCO_2 , XCH_4 , XH_2O , and XCO in the previous version (GOSAT-2 Full Physics product (Ver. 01.04)).

The observation period that overlaps with the previous version at this time is May 1, 2020 to May 18, 2020. The scatter plots of GOSAT-2 Full Physics products (XCO_2 , XCH_4 , XH_2O , and XCO) by the global Land and Ocean against the previous version are shown in Figures 1 to 4. Land data are defined for data with a land ratio between 60% and 100%, and Ocean data are defined for data with a land ratio of between 0% and 10%. Only data with the quality flag “good” are used. The number of data compared and the mean and its standard deviation of the difference against the previous version are shown in the figure.

The uncertainty of GOSAT-2 Full Physics product (Ver. 01.07) for XCO_2 , XCH_4 , XH_2O , and XCO is considered to be equivalent to that of the previous version (see Appendix), because the mean and its standard deviation of the difference against the previous version are very small.

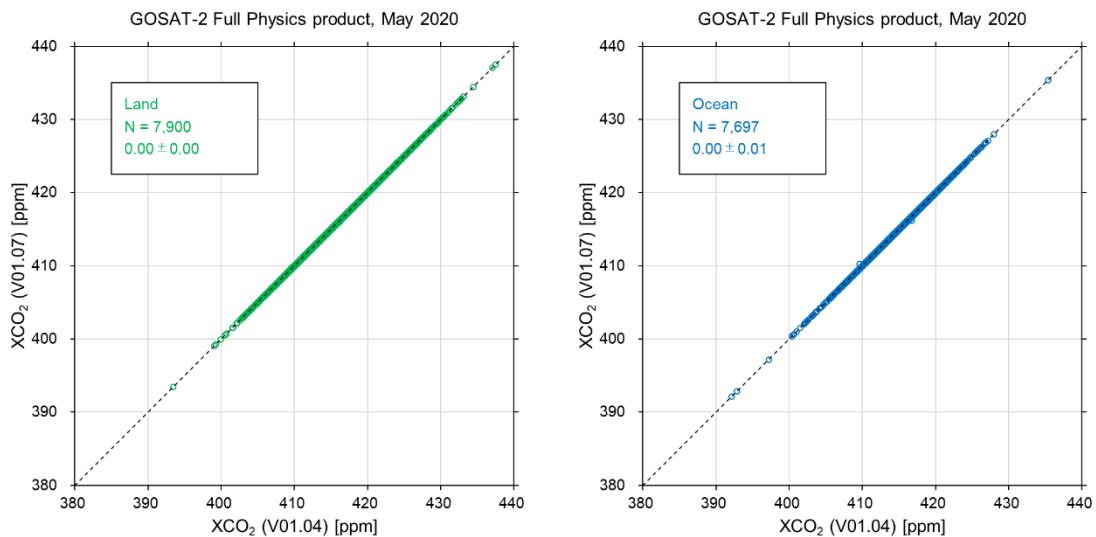


Figure 1. Scatter plots of GOSAT-2 Full Physics product (XCO_2) by the global Land and Ocean against the previous version (green: Land data, blue: Ocean data).

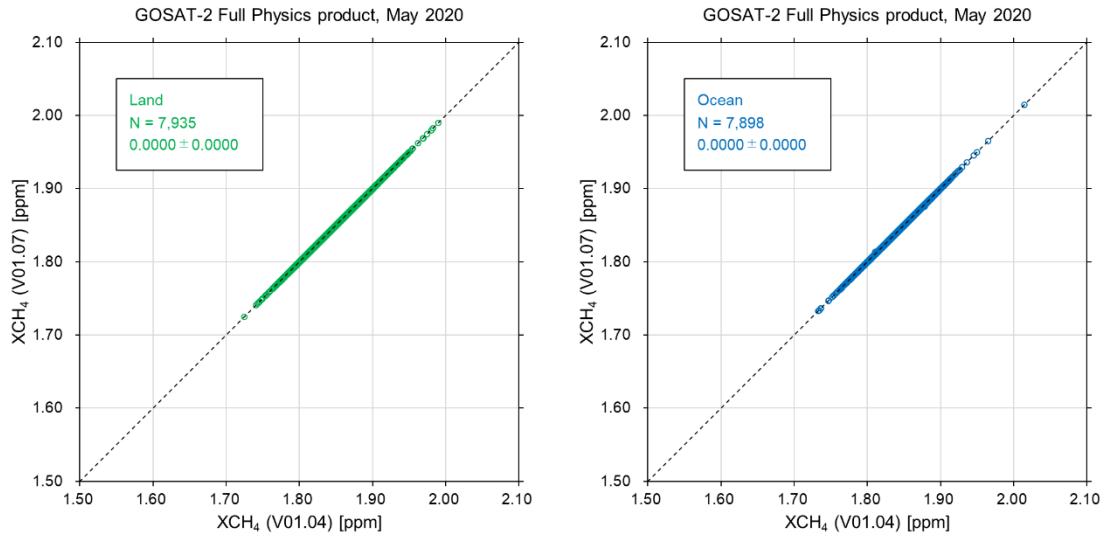


Figure 2. Scatter plots of GOSAT-2 Full Physics product (XCH₄) by the global Land and Ocean against the previous version (green: Land data, blue: Ocean data).

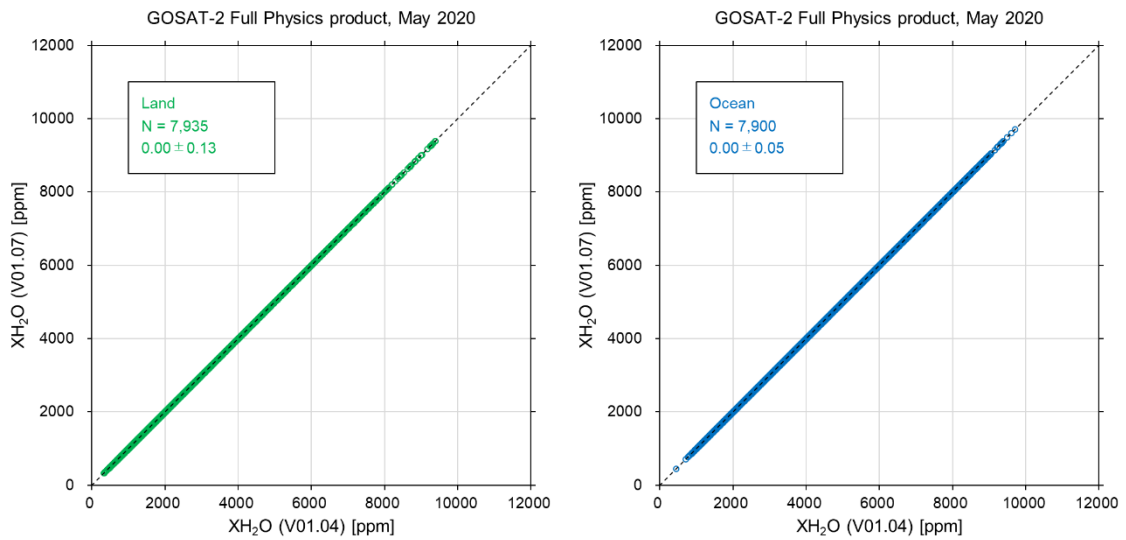


Figure 3. Scatter plots of GOSAT-2 Full Physics product (XH₂O) by the global Land and Ocean against the previous version (green: Land data, blue: Ocean data).

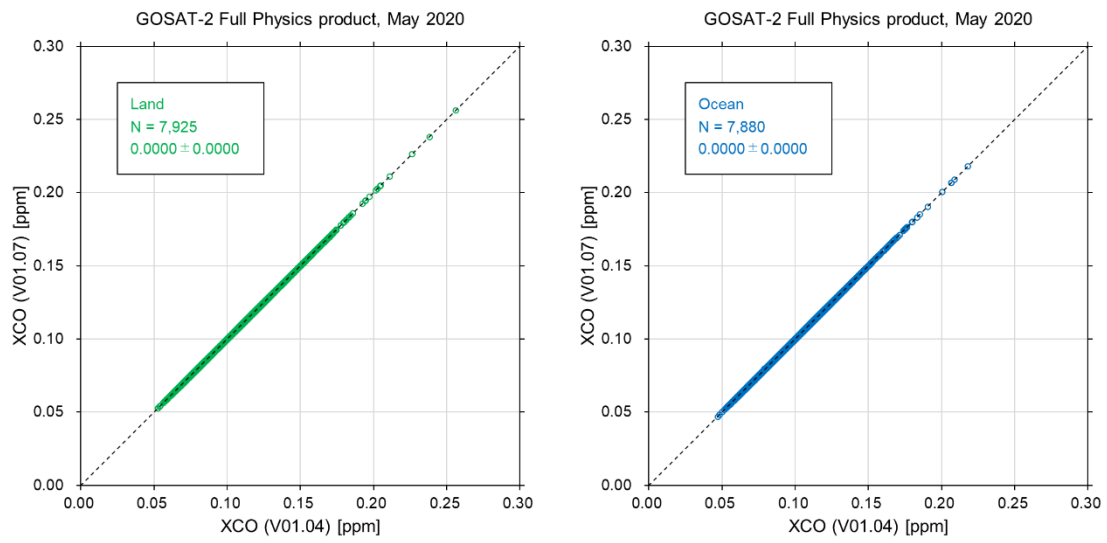


Figure 4. Scatter plots of GOSAT-2 Full Physics product (XCO) by the global Land and Ocean against the previous version (green: Land data, blue: Ocean data).

Summary of the validation on GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product (Ver. 01.04)

For the validation of GOSAT-2 TANSO-FTS-2 SWIR L2 Column-averaged Dry-air Mole Fraction Product (hereafter abbreviated as GOSAT-2 Full Physics product), the column-averaged dry-air mole fractions of carbon dioxide (X_{CO_2}), methane (X_{CH_4}), water vapor (X_{H_2O}), and carbon monoxide (X_{CO}) are compared with those obtained by the ground-based high-resolution Fourier transform spectrometers (FTS) belonging to the Total Carbon Column Observing Network (TCCON) (hereinafter abbreviated as TCCON data). The results of the validation are briefly summarized as below.

GOSAT-2 Full Physics product

The GOSAT-2 Full Physics product of Ver. 01.04 is used. The comparison period is from March 1, 2019 to May 18, 2020. Land data is defined for data with a land ratio of 10% or more in the comparison area, and Ocean data is defined for data with a land ratio of less than 10% in the comparison area. There is no distinction between gains. Only data are used with the quality flag “good”.

TCCON data

The TCCON data used are obtained from the TCCON data archive, which are retrieved by the algorithm GGG2014. In the comparison with in-situ airborne measurement of CO_2 , CH_4 , and CO , and radiosonde measurement of water vapor (H_2O), the uncertainties (2σ) of X_{CO_2} , X_{CH_4} , X_{H_2O} , and X_{CO} are found to be ~ 0.8 ppm, ~ 4 ppb, ~ 400 ppm, and ~ 7 ppb, respectively. The average value of the data obtained within 30 minutes before and after the GOSAT-2 passed over each TCCON site is used.

Comparison conditions of GOSAT-2 Full Physics product with TCCON data

- The column averaging kernels and prior profiles are not considered for the quick validation analysis.
- The GOSAT-2 Full Physics product obtained within the comparison areas of $\pm 0.1^\circ$, $\pm 1^\circ$, $\pm 2^\circ$, and $\pm 5^\circ$ in latitude and longitude centered at the TCCON site are compared with the TCCON data by Land and Ocean. Since many TCCON sites are located inland, the number of Ocean data is smaller than that of Land data.
- Among the GOSAT-2 Full Physics product, those with a difference between the footprint altitude and the altitude of the TCCON site greater than 500 m are excluded from the comparison.
- The large forest fires occurred in Australia in the early summer of 2019. Therefore, for X_{CO} , 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.

Results

The numbers of comparison, biases, its standard deviations, and their relative values in the comparison areas by Land and Ocean are listed in Table A1.

Table A1. The number of comparison data (N), mean bias (Bias), its standard deviation (Std), and its relative values in comparison areas. Land indicates land data, and Ocean indicates Ocean data. Except relative values, units are ppm for XCO₂ and XH₂O, and ppb for XCH₄ and XCO respectively.

GOSAT-2 Full Physics product (V01.04) (2019/03/01–2020/05/18)		Coincidence criteria	N	Bias [ppm] or [ppb]	Std [ppm] or [ppb]	bias [%]	std [%]
Land	XCO ₂	±0.1°	532	2.63	3.29	0.64	0.80
		±1°	1981	2.29	3.86	0.56	0.94
		±2°	2640	2.34	4.04	0.57	0.98
		±5°	5510	2.14	4.31	0.52	1.05
	XCH ₄	±0.1°	539	-0.15	15.20	0.00	0.82
		±1°	1990	-1.36	17.44	-0.07	0.94
		±2°	2654	-0.03	19.33	0.00	1.04
		±5°	5537	-1.76	20.64	-0.09	1.11
	XH ₂ O	±0.1°	539	37.9	96.5	1.4	4.5
		±1°	1990	28.7	309.4	1.7	15.2
		±2°	2654	51.8	413.9	3.9	21.3
		±5°	5537	-69.9	790.1	2.2	32.3
	XCO	±0.1°	539	20.08	7.00	24.75	8.15
		±1°	1986	21.17	7.52	25.02	9.42
		±2°	2649	21.18	8.33	25.07	10.19
		±5°	5494	20.25	9.95	24.02	11.66
Ocean	XCO ₂	±0.1°	1	2.92	-	0.71	-
		±1°	31	0.27	6.85	0.07	1.67
		±2°	92	-0.14	5.79	-0.03	1.41
		±5°	733	0.26	4.65	0.06	1.13
	XCH ₄	±0.1°	1	17.05	-	0.95	-
		±1°	34	-7.24	30.34	-0.39	1.66
		±2°	102	-11.70	22.97	-0.63	1.25
		±5°	863	-9.42	23.61	-0.51	1.28
	XH ₂ O	±0.1°	1	-117.2	-	-5.2	-
		±1°	35	102.5	355.9	3.9	12.5
		±2°	104	-43.8	567.9	1.4	16.2
		±5°	872	235.9	1156.6	32.5	107.7
	XCO	±0.1°	1	12.24	-	17.89	-
		±1°	32	20.51	8.13	24.66	7.81
		±2°	101	18.66	7.64	22.92	8.91
		±5°	838	17.90	11.78	23.09	14.53

The scatter plots of GOSAT-2 Full Physics product in the comparison area of ±2° by Land and Ocean are shown in Figure A1. The time series of biases in the comparison area of ±2° by Land and Ocean are shown in Figure A2. The mean biases in the comparison areas by Land and Ocean are shown in Figure A3.

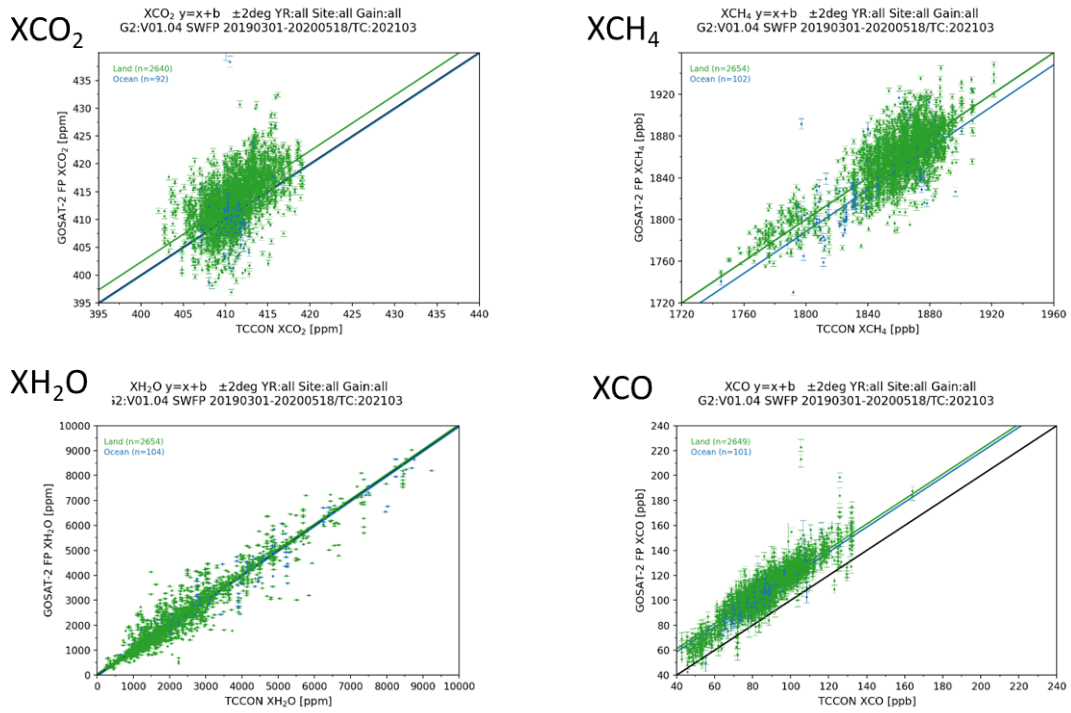


Figure A1. Scatter plots of GOSAT-2 Full Physics product in the comparison area of $\pm 2^\circ$ by Land and Ocean for XCO₂, XCH₄, XH₂O, and XCO (green: Land data, blue: Ocean data).

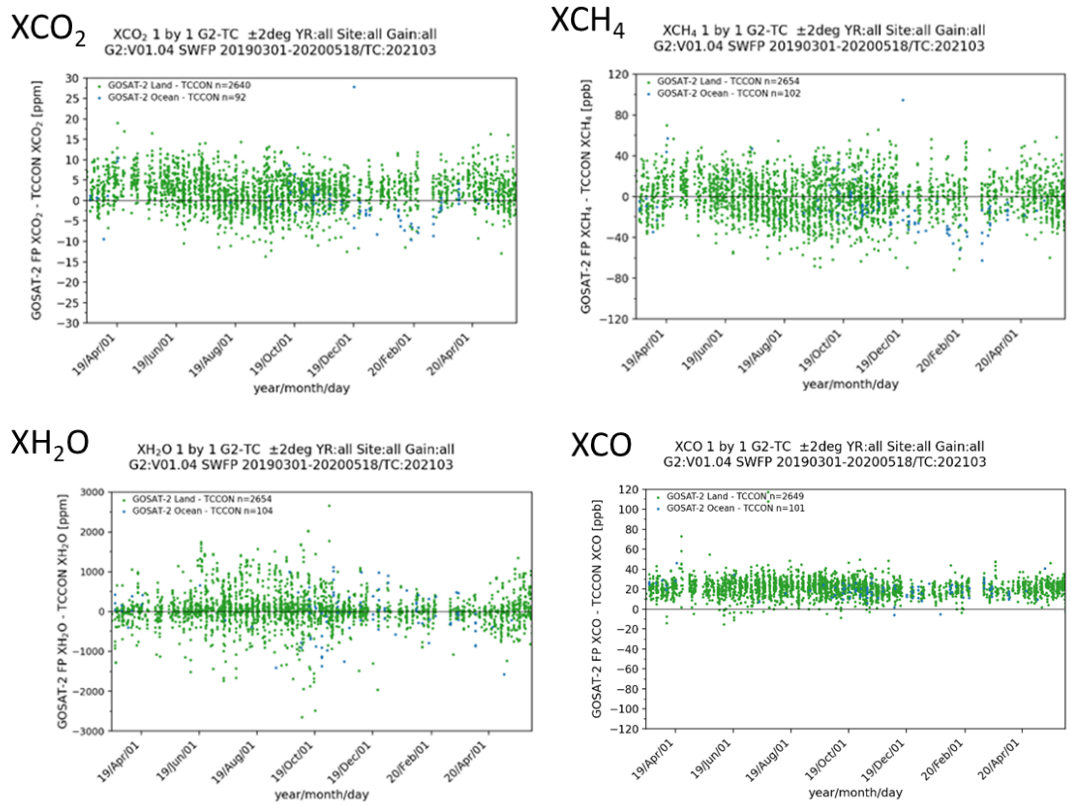


Figure A2. Time series of biases in the comparison area of $\pm 2^\circ$ by Land and Ocean for XCO₂, XCH₄, XH₂O, and XCO from March 2019 (green: Land data, blue: Ocean data).

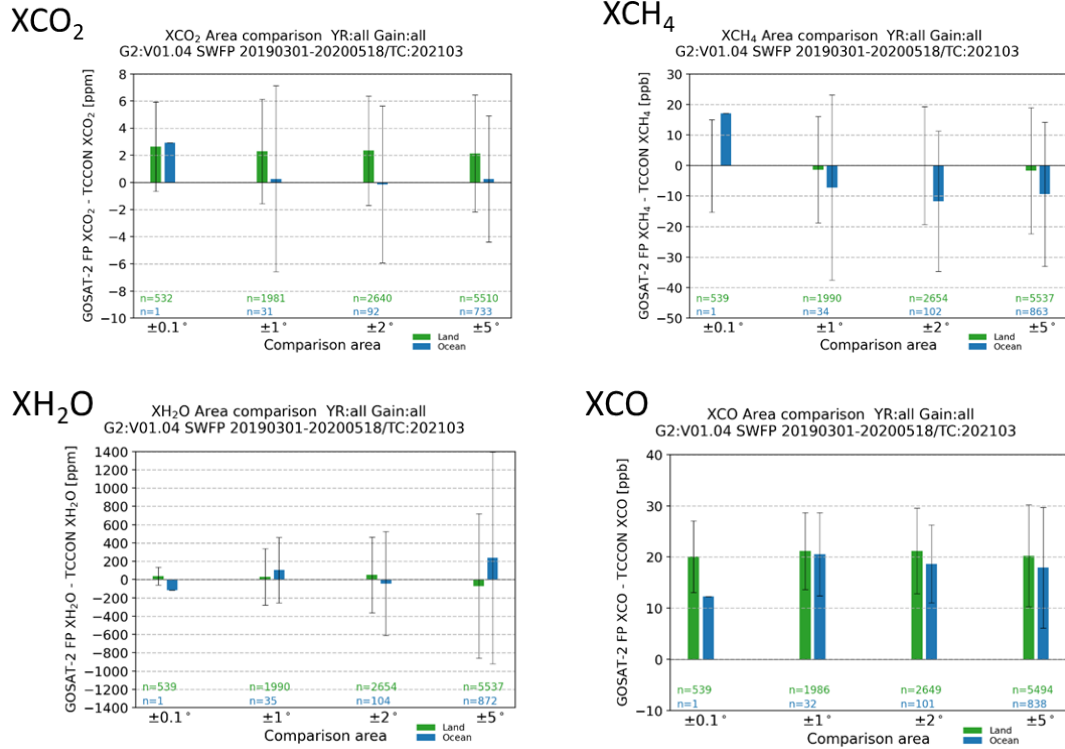


Figure A3. Mean biases in the comparison areas by Land and Ocean for XCO₂, XCH₄, XH₂O, and XCO (green: Land data, blue: Ocean data).

Influences of the forest fire

Regarding Land data, there is no data excluded due to the influence of forest fire in the comparison areas of $\pm 0.1^\circ$, but the numbers of data excluded in $\pm 1^\circ$, $\pm 2^\circ$, and $\pm 5^\circ$ are 1, 1, and 24, respectively. For Wollongong, the differences of mean bias with and without exclusion (mean bias including forest fire data – mean bias excluding forest fire data) are -1.42 ppb, -0.79 ppb, and -1.88 ppb in the comparison areas of $\pm 1^\circ$, $\pm 2^\circ$, and $\pm 5^\circ$, respectively. For All sites, the differences of mean bias with and without exclusion are -0.04 ppb, -0.02 ppb, and -0.16 ppb in the comparison areas of $\pm 1^\circ$, $\pm 2^\circ$, and $\pm 5^\circ$, respectively.

Regarding Ocean data, 4 data are excluded in the comparison areas of $\pm 5^\circ$, and no data are excluded in the other comparison areas. In the comparison areas $\pm 5^\circ$, the differences of the mean bias with and without exclusion are 1.30 ppb for Wollongong and 0.14 ppb for All sites.

Summary of GOSAT-2 Full Physics product validation

The GOSAT-2 Full Physics product (Ver. 01.04) for XCO₂, XCH₄, XH₂O, and XCO are compared with the TCCON data. In the comparison area of ±2°, the validation of GOSAT-2 Full Physics product is summarized as follows.

- The mean biases and their standard deviations of XCO₂ over Land and Ocean are 2.34±4.04 ppm (0.57±0.98%) and -0.14±5.79 ppm (-0.03±1.41%), respectively.
- The mean biases and their standard deviations of XCH₄ over Land and Ocean are -0.03±19.33 ppb (0.00±1.04%) and -11.70±22.97 ppb (-0.63±1.25%), respectively.
- The relative values of mean biases and its standard deviations of XH₂O over Land and Ocean are 3.9±21.3% and 1.4±16.2%, respectively. Their standard deviations are relatively large.
- The mean biases and their standard deviations of XCO over Land and Ocean are 21.18±8.33 ppb (25.07±10.19%) and 18.66±7.64 ppb (22.92±8.91%), respectively.
- The trends of bias for XCO₂ and XCH₄ show some variations during the observation term, the term is not so long though.

The validation of GOSAT-2 Full Physics product in other conditions is summarized as follows.

- For XCO, the mean biases are positive and larger than their standard deviations in all comparison areas.

In order to improve the quality of GOSAT-2 Full Physics product, further studies in calibration, algorithm and validation are necessary.