Extension of the targets for the GOSAT SWIR XCO_2 and XCH_4 retrievals

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2 Total Carbon Column Observing Network
https://tccon-wiki.caltech.edu/

About GOSAT

Objective of GOSAT project:

To estimate CO_2 and CH_4 column abundances from space.

Improve the precision of the estimation of fluxes of CO_2 from the surface.

Sensors of GOSAT:

TANSO-FTS

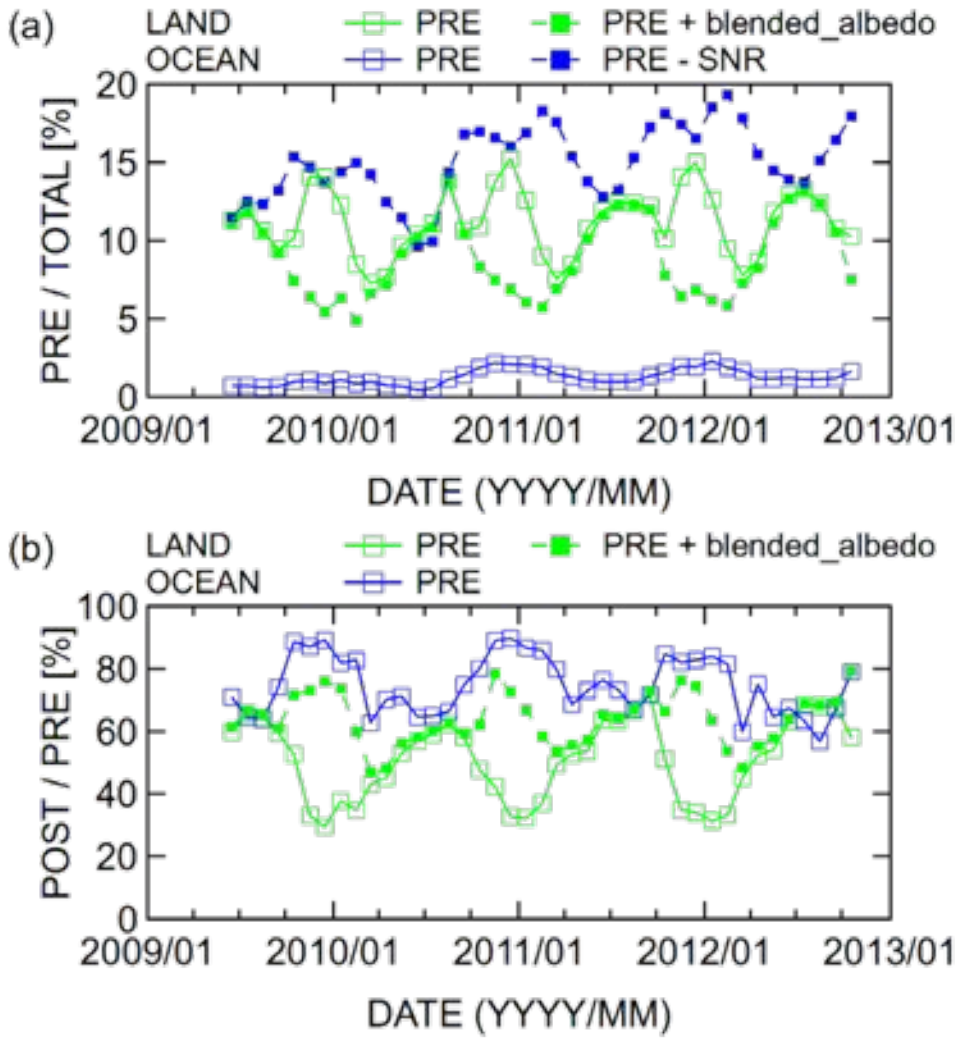
	Band 1	Band 2	Band 3	Band 4
Spectral coverage [μm]	0.758~0.775	1.56~1.72	1.92~2.08	5.56~14.3
Spectral resolution [cm^{-1}]	0.5	0.27	0.27	0.27
Target species	O_2	CO_2 · CH_4	CO_2 · H_2O	CO_2 · CH_4
Instantaneous field of view/ Field of observation view at nadir	Instantaneous field of view: 15.8 mrad Field of view for observation (footprint): diameter of app. 10.5 km			
Single-scan data acquisition time	1.1, 2.0, 4.0 seconds			

* 1 μm = 1/1000 mm

TANSO-CAI

	Band 1	Band 2	Band 3	Band 4
Spectral coverage [μm]	0.370~0.390 (0.380)	0.668~0.688 (0.678)	0.860~0.880 (0.870)	1.56~1.68 (1.62)
Target substance	Cloud, Aerosol			
Swath [km]	1000	1000	1000	750
Spatial resolution at nadir [km]	0.5	0.5	0.5	1.5

Introduction



Yoshida et al. 2013, AMTD, 6, 949-988

NIES GOSAT project has operationally processed and distributed the SWIR L2 V02.xx products (XCO_2 and XCH_4).

To avoid low-quality and/or cloud-contaminated measurement, we checked them from multiple sides and apply strict criteria in the pre-screening processing (safety-side approach).

=> There might remain over rejection.

Not only the improvement of the optimal estimation, but also the reexamination of the pre-screening items and their criteria is needed.

SWIR L2 V02.xx Retrieval Setting

see Yoshida et al. 2013, AMTD, 6, 949-988

V02.xx: TANSO-FTS Band 1, 2, and 3

Land	CO_2 profile (15-layer)	CH_4 profile (15-layer)	H_2O profile (15-layer)	aerosol profile (6-layer, 2-type)	surface press.	temp. profile bias	wave-number disper-sion	band 1 zero-level offset	surface albedo
Ocean									surface wind speed

Degradation correction by Yoshida et al. (2012, AMT, 5, 2515-2523)

No channel selection

Apply empirical noise

Fine-/coarse-mode aerosols are considered

Pre-Screening (rejection criteria):

L1B quality flags (pointing stability, ZPD saturation, spike noise, etc.)

CAI cloud flag, FTS 2-μm band, CAI spatial coherent (only ocean)

SZA >70 deg., SNR < 70 for O_2 A sub-band (12950-13200 cm^{-1})

Post-Screening (rejection criteria):

Chi-squared for each sub-band, DFS < 1, AOD@1.6μm > 0.1

Blended Albedo > 1, $|P_{SRF,rtrv} - P_{SRF,prior}| > 20$ hPa

Pre-Screening Results

	A [%]	B [%]		A [%]	B [%]
PMflg	0.25	1.60	spike1P	0.48	0.00
ELU	0.64	0.00	spike1S	0.36	0.00
Pstbl	0.76	2.01	spike2P	5.36	0.01
AT err.	0.21	2.03	spike2S	5.71	0.17
CT err.	0.08	0.00	spike3P	5.75	0.17
Sat. Att.	0.03	0.00	spike3S	4.09	0.00
yaw steer	1.20	0.22	spec1P	1.83	0.13
miss1P	0.00	N/A	spec1S	5.20	0.21
miss1S	0.00	N/A	spec2P	4.16	0.01
miss2P	0.00	N/A	spec2S	5.55	0.02
miss2S	0.00	N/A	spec3P	0.18	0.14
miss3P	0.00	N/A	spec3S	0.16	0.18
miss3S	0.00	N/A	cloud flag	81.71	1.23
sat1P	0.00	N/A	coherent	60.92	1.41
sat1S	1.50	0.00	FTS 2-μm	35.96	0.83
sat2P	4.05	0.00	srf. rough.	3.76	4.75
sat2S	5.43	0.00	land frac.	1.50	1.06
sat3P	0.08	0.00	SZA	22.18	0.00
sat3S	0.07	0.00	SNR	19.41	0.00

~ 12 million scans are checked. (Jun. 2009 ~ Dec. 2012)

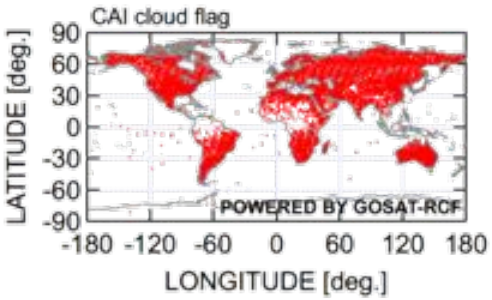
A: Fraction of BAD scan to the total scans.

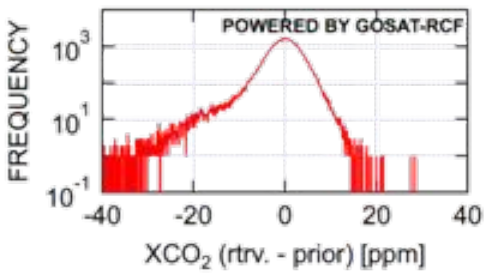
B: Fraction of pre-/post-screening passed scan to category-A when this item is not considered.

Are category-B data over rejected ?

Red-colored items shows high-potential to increase the number of effective data.

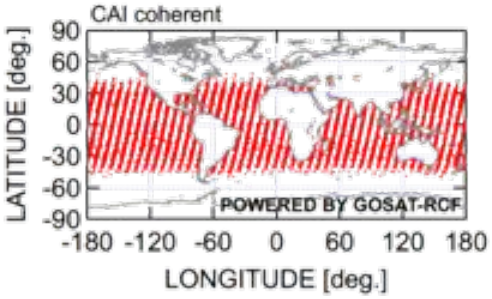
Check category-B data

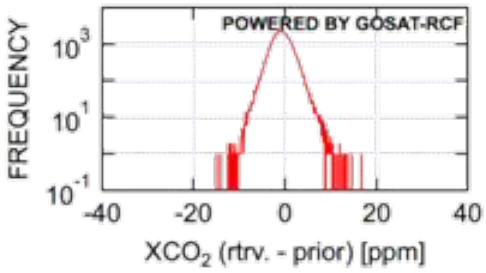




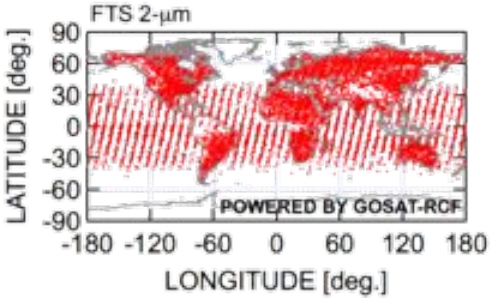
Many outlier still remain.

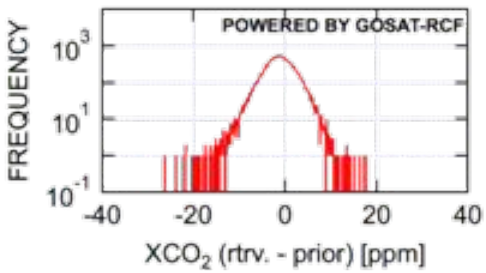
=> Need precise investigation.





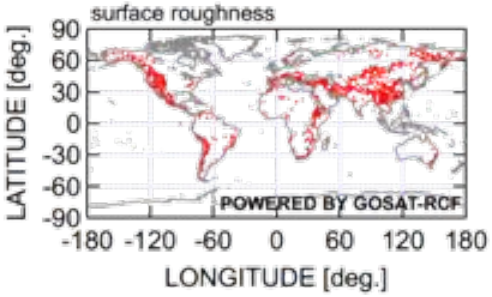
Look reasonable.

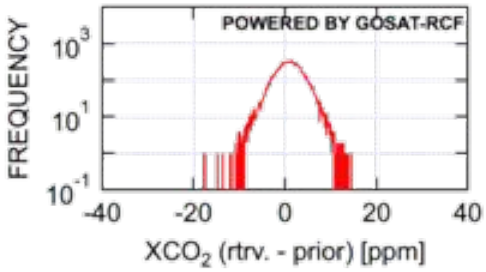




Slightly wide scatter with some outlier.

=> Better to retrieve cirrus parameters (see next topic).





Look reasonable.

CIRRUS CASES (preliminary results)

Spectral range:

12950-13200 cm^{-1}, 5900-6150 cm^{-1}, 6180-6380 cm^{-1}, 4800-4900 cm^{-1}, and 5150-5200 cm^{-1}

State Vector:

Add cloud-top pressure, optical thickness, and effective dimension of cirrus

~ Homogeneous cirrus layer is considered.

Pre-Screening (rejection criteria):

L1B quality flags (pointing stability, ZPD saturation, spike noise, etc.)

CAI cloud flag, ~~FTS 2-μm band~~, CAI spatial coherent (only ocean)

SZA >70 deg., SNR < 70 for O_2 A sub-band (12950-13200 cm^{-1})

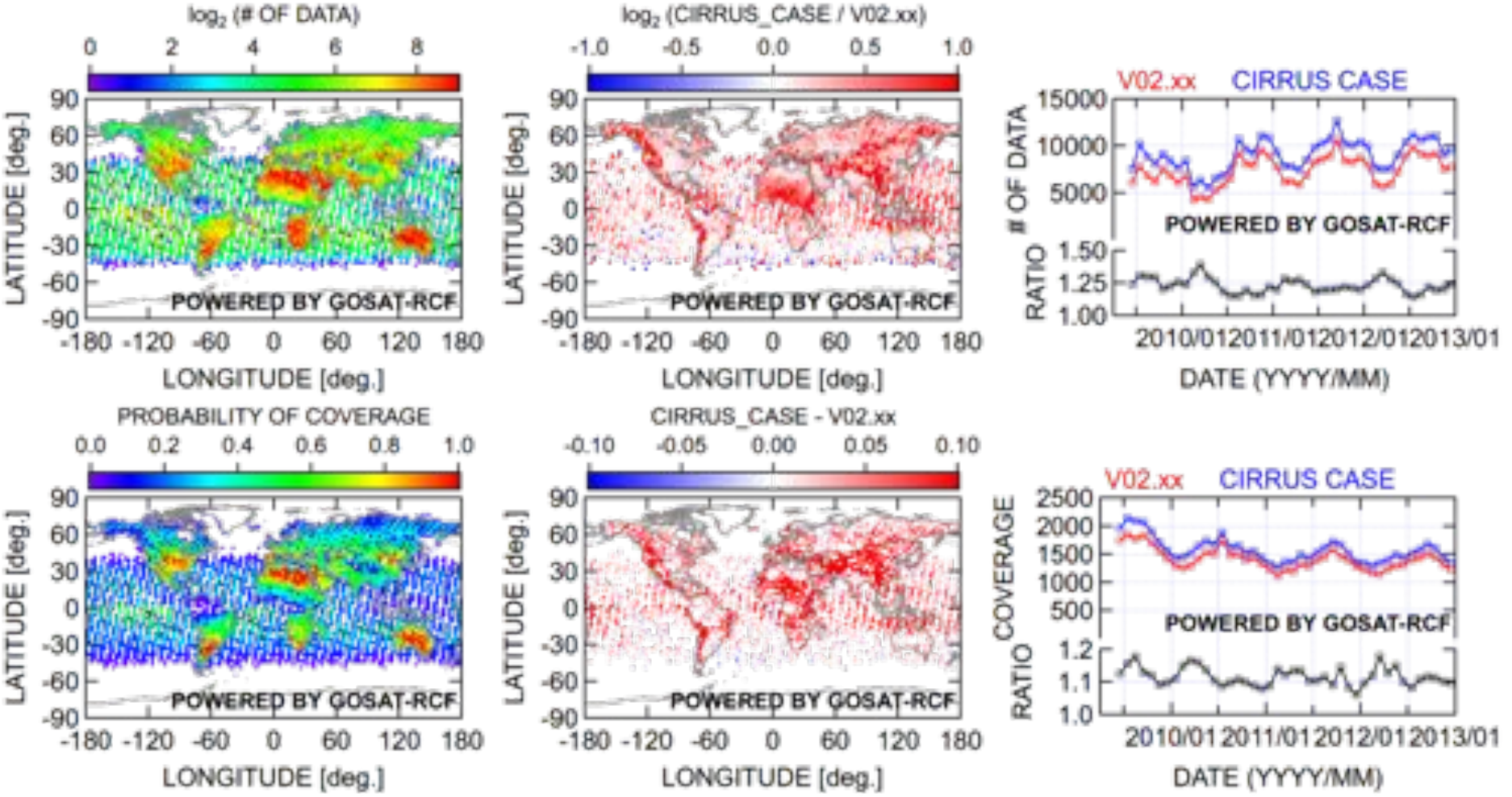
Post-Screening (rejection criteria):

Chi-squared for each sub-band, DFS < 1, AOD@1.6μm > 0.1

Blended Albedo > 1, $|P_{SRF,rtrv} - P_{SRF,prior}| > 20$ hPa

Cirrus optical thickness > 0.1, Cloud-top pressure > 400 hPa

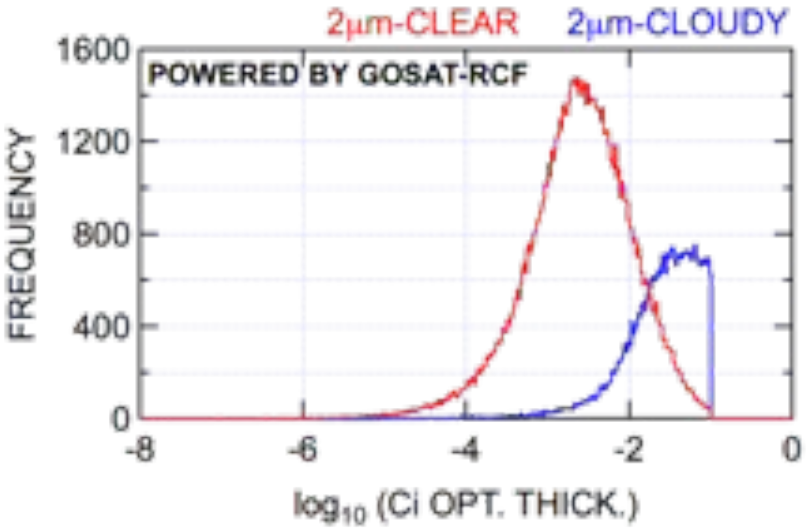
CIRRUS CASES (preliminary results)



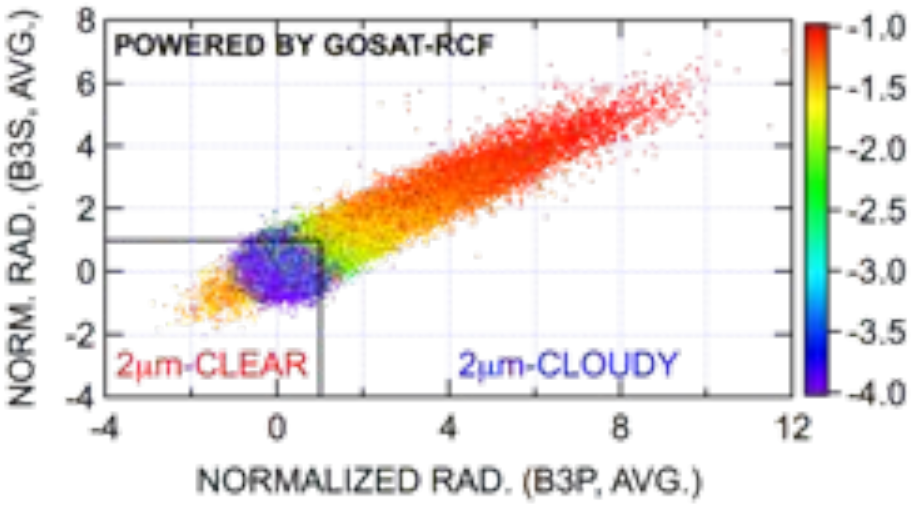
About twice of data is available over tropics and high-elevation area.

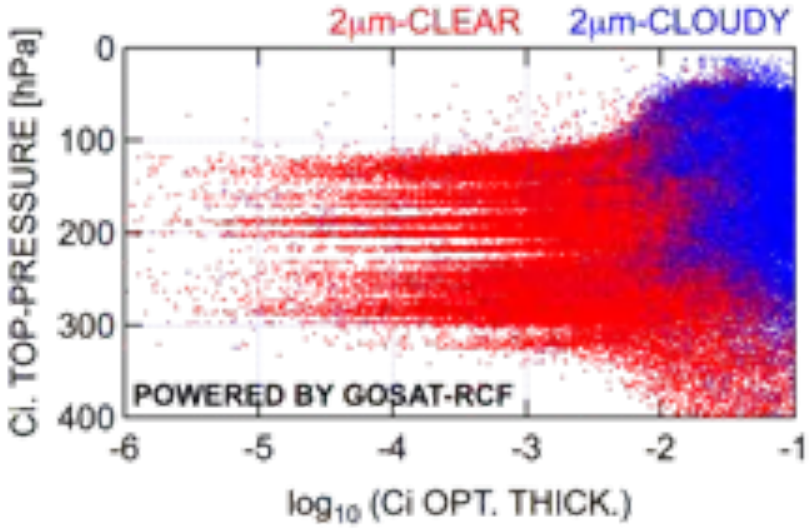
~ FTS 2μm method might misidentified high-elevation area as cloudy.

CIRRUS CASES (preliminary results)

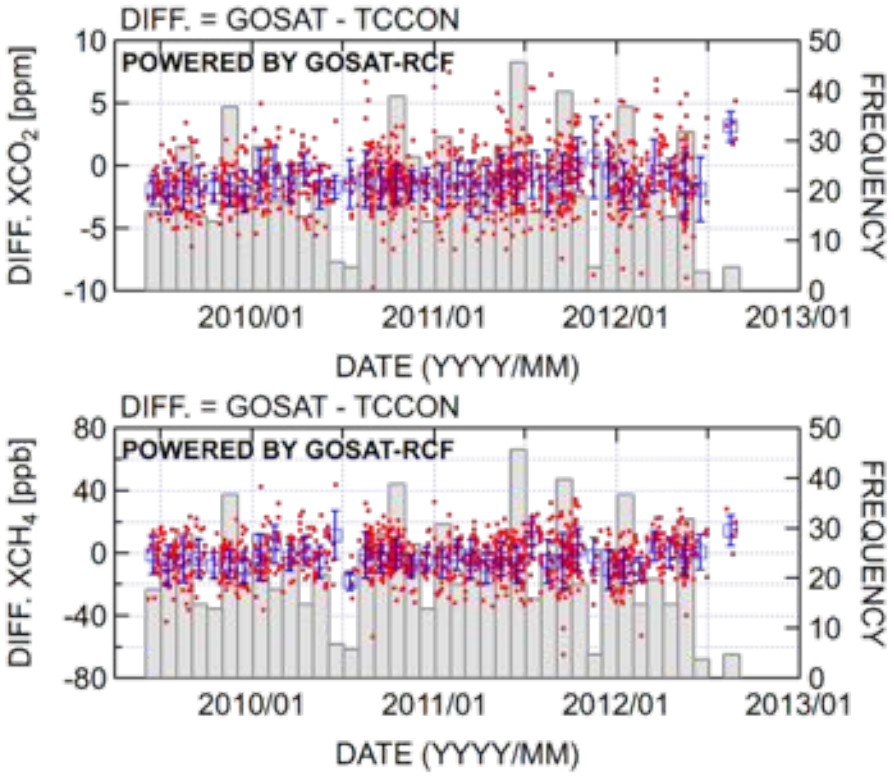


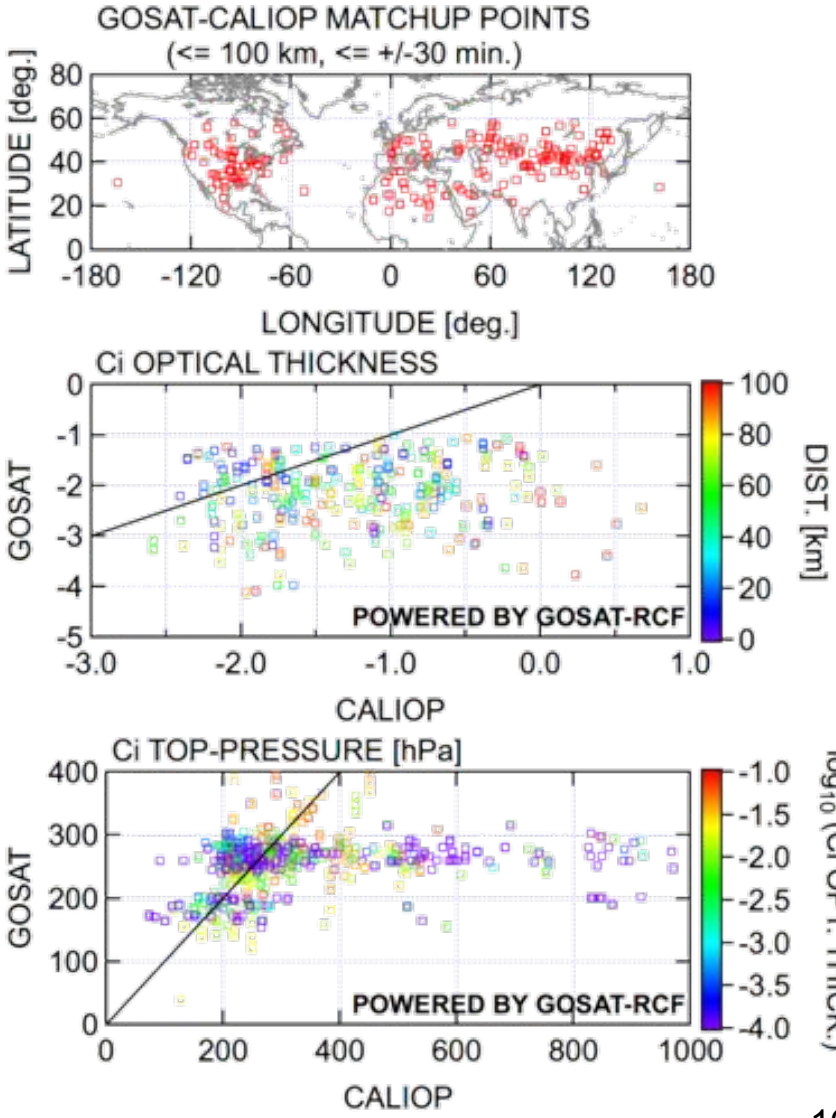
Based on the retrieved cirrus optical thickness, the FTS 2μm-band method can detect cloud with its optical thickness of about 0.01.





CIRRUS CASES (preliminary results)





Bias and scatter of XCO_2 and XCH_4 for cirrus cases are almost same as those for V02.xx (cloud-free cases).

CIRRUS CASES (preliminary results)

XCO_2 comparison for each TCCON site

Site	Lat. [deg.]	Lon. [deg.]	V02.xx (cloud-free)			CIRRUS CASES		
			#	avg. [ppm]	std. [ppm]	#	avg. [ppm]	std. [ppm]
Eureka	80.05	-86.42	5	-1.49	0.98	6	-1.16	1.30
Sodankyla	67.37	26.63	28	-0.97	1.57	29	-1.35	1.56
Bialystok	53.23	23.03	4	0.61	2.04	4	0.58	1.92
Bremen	53.10	8.85	6	0.25	1.25	9	-0.82	2.03
Karlsruhe	49.10	8.44	32	-1.48	2.12	40	-1.45	2.26
Orleans	47.97	2.11	20	-1.14	1.55	23	-0.71	2.18
Garmisch	47.48	11.06	20	-0.35	2.20	26	-0.39	2.20
Park Falls	45.95	-90.27	49	-1.56	1.70	55	-1.55	1.55
Lamont	36.60	-97.49	326	-2.23	1.62	345	-1.92	1.45
Tsukuba	36.05	140.12	77	0.90	2.04	103	0.63	2.24
Darwin	-12.42	130.89	32	-1.82	1.63	42	-1.88	1.47
Wollongong	-34.41	150.88	92	-1.25	2.66	110	-0.87	2.35
Lauder	-45.04	169.68	28	-1.67	1.30	46	-1.63	1.49
TOTAL	single-scan		719	-1.48	2.09	838	-1.28	1.99
	station bias		13	-0.94	0.98	13	-0.96	0.83

<= 2 deg. BOX, +/- 30 min.

Summary

To obtain more effective data, pre-screening results are reevaluated.

More accurate cloud detection and/or improvement of cloud treatment in the optimal estimation show high-potential to increase the available data effectively.

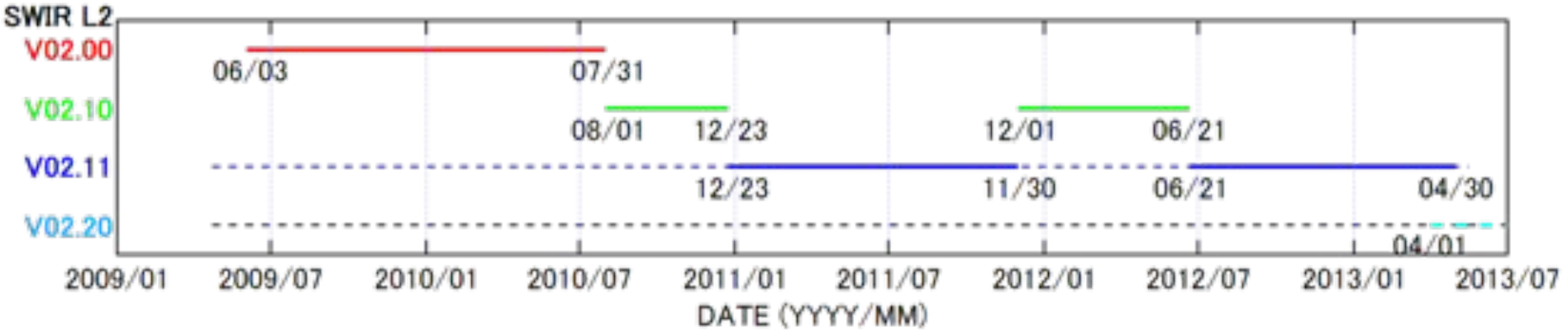
Preliminary retrieval study including cirrus parameter in the state vector is conducted.

The number of available data and its spatial coverage increase about 20% and 10%, respectively.

From the comparison with TCCON data, biases and scatters in the retrieved XCO_2 and XCH_4 for cirrus case are almost same as those for cloud-free case.

Also, retrieved cirrus top-pressure and optical thickness are roughly consistent with those obtained by CALIOP measurement.

SWIR L2 V02.xx Processing Status



Last two digits of L2 version name depend on input L1B version.
L2 algorithm is completely the same for following V02 series.

TANSO-FTS L1B V141.141 => SWIR L2 V02.00
TANSO-FTS L1B V150.150 => SWIR L2 V02.10
TANSO-FTS L1B V150.151 => SWIR L2 V02.11

V02.00 and V02.10 have been reprocessing as V02.11.

TANSO-FTS L2 V02.20

TANSO-FTS L1B V160.160 => SWIR L2 V02.20

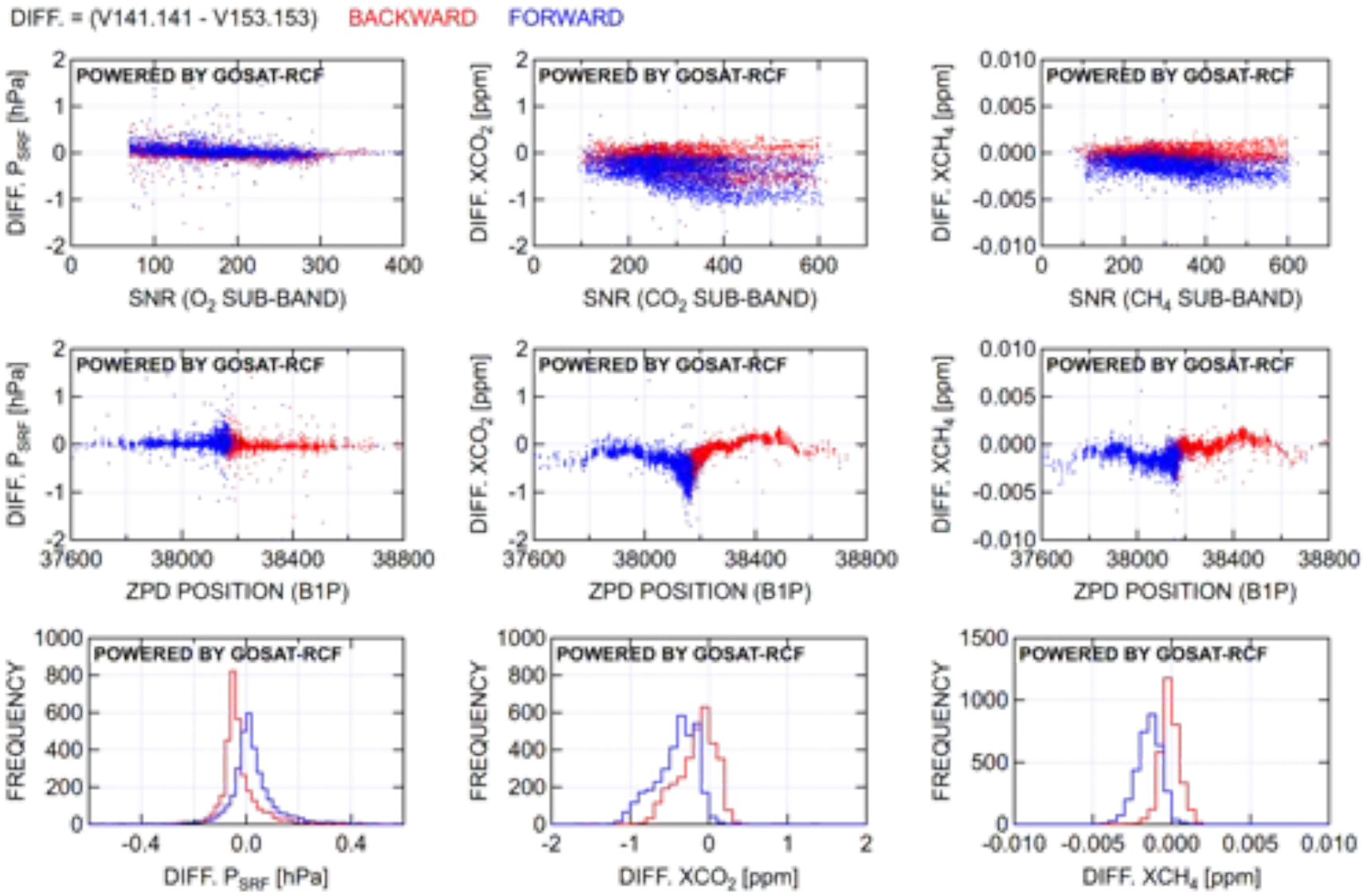
Due to the turn-off of the sampling interval non-uniformity correction (SINUC), SWIR L2 V02.20 will show slightly different bias characteristics; i.e., biases in XCO_2 and XCH_4 will show a scan-direction dependency.

Also, we stop to use "surface roughness determination" result for pre-screening processing from SWIR L2 V02.20 (checked result is stored in the product for reference).

We recommend NOT to use SWIR L2 V02.20 mixed with V02.11 and before.

Reprocessing of TANSO-FTS L1B V160.160 (by JAXA) and SWIR L2 V02.20 (by NIES) for all observation period is planned.

TANSO-FTS L2 V02.20



* V153.153 is a preliminary sample of V160.160.