Validation of GOSAT SWIR xCH_4 using TCCON and Airborne Measurements

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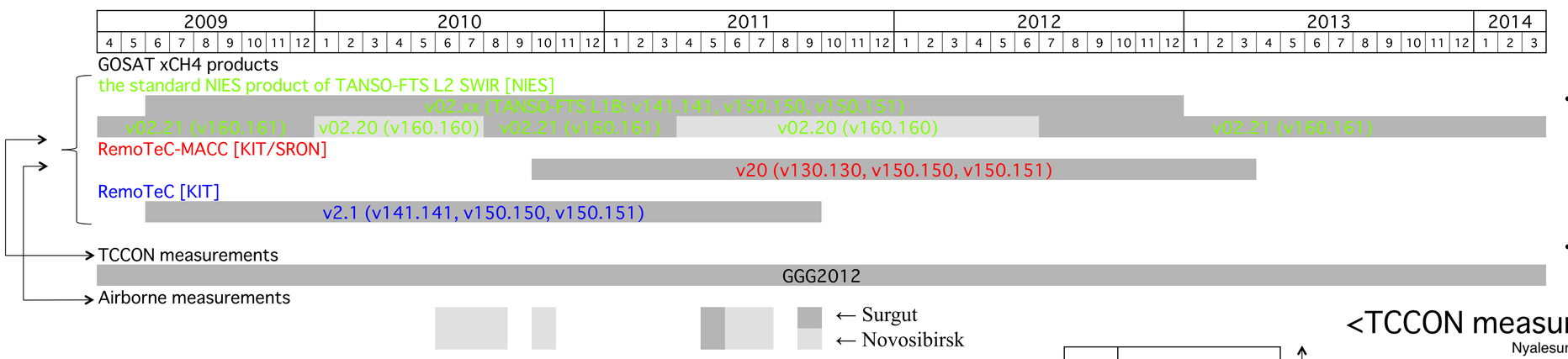
BACKGROUND

- Methane (CH_4) is one of the most important greenhouse gases because its radiative forcing is estimated as the second largest, after carbon dioxide (CO_2) [IPCC, AR5, 2013].
- Greenhouse gases Observing SATellite (GOSAT) was launched in 2009 by Japan Aerospace Exploration Agency (JAXA) for measurements of global distribution of CO_2 and CH_4 concentration from space.
- We validated the GOSAT CH_4 products of the column-averaged dry-air mole fractions (xCH_4) by comparing them with data of Total Carbon Column Observing Network (TCCON).
  Yoshida et al. [2013] → NIES product of TANSO-FTS SWIR L2 (v02.xx) from June, 2009 to December, 2012
  this study → NIES product of TANSO-FTS SWIR L2 (v02.20, v02.21) from April, 2009 to March, 2014
- We also tried to compare GOSAT data with aircraft measurements over western Siberia (Surgut and Novosibirsk).

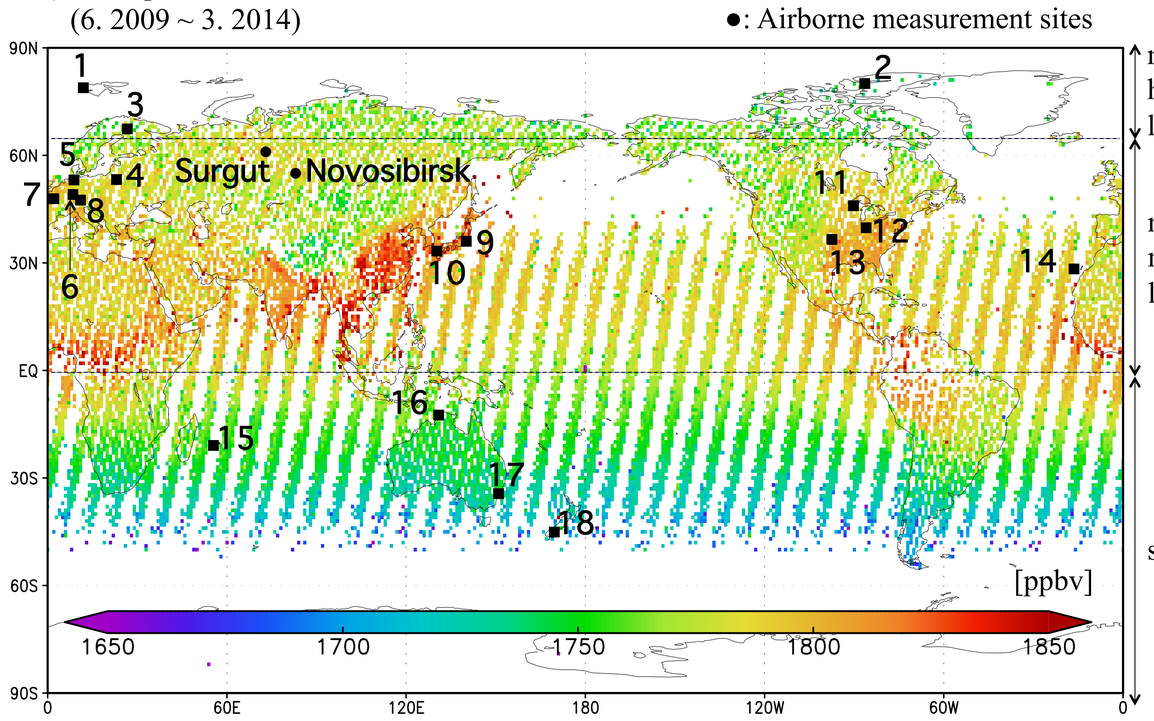
DATA



- GOSAT xCH_4 products
  - NIES product: Full Physics retrieval method
  - RemoTeC-MACC: Proxy retrieval method (bias-corrected)
  - RemoTeC: Full Physics retrieval method (bias-corrected)
- TCCON measurements
  - a global network of ground-based Fourier transform spectrometers
  - measurements of column abundances of CO_2, CH_4 and other molecules with high accuracy and precision (better than 0.25 % for CO_2) [Wunch et al. 2011]
- Airborne measurements
  - conducted by NIES over Surgut (61°N, 73°E) and Novosibirsk (55°N, 83°E)

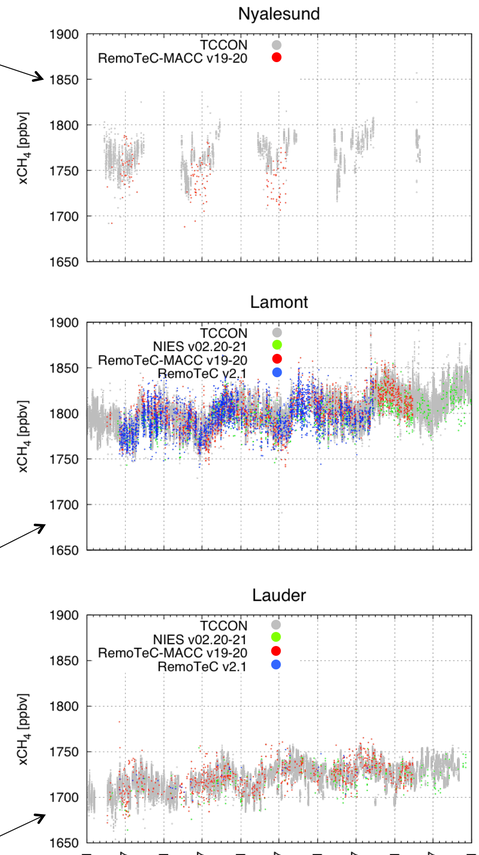
ex.) NIES product of TANSO-FTS L2 SWIR v02.20-21 (6. 2009 ~ 3. 2014)

■: TCCON measurement sites
●: Airborne measurement sites



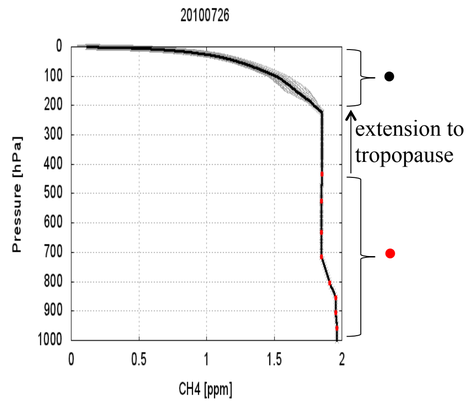
(1)	Ny Alesund
(2)	Eureka
(3)	Sodankyla
(4)	Bialustok
(5)	Bremen
(6)	Karlsruhe
(7)	Orleans
(8)	Garmisch
(9)	Tsukuba
(10)	Saga
(11)	Park Falls
(12)	Lamont
(13)	Indianapolis
(14)	Izana
(15)	Reunion
(16)	Darwin
(17)	Wollongong
(18)	Lauder

<TCCON measurements>



<Airborne measurements>

ex.) 2010/07/26
CH_4 profile



●: the climatology data of HALOE
This dataset is used by NIES a priori.
●: error
●: Airborne measurements

site	measurement dates
Surgut	2011/5/26, 9/23
Novosibirsk	2010/6/14, 7/26, 8/26, 10/26 2011/6/6 , 7/7, 9/28

ANALYSIS and RESULTS

GOSAT product vs. TCCON measurements

$$bias_{TCCON} = xCH_{4\_GOSAT} - xCH_{4\_TCCON}$$

<Yoshida et al. [2013] vs. this study>

- GOSAT: NIES product
- TCCON sites 1: (2)Eureka, (3)Sodankyla, (4)Bialystok, (5)Bremen, (6)Karlsruhe, (7)Orleans, (8)Garmisch, (9)Tsukuba, (11)Park Falls, (12)Lamont, (16)Darwin, (17)Wollongong, (18)Lauder ・・・ 13 sites [Table 1]

	TCCON sites	2009 ~ 2012	2013 ~ 2014	2009 ~ 2014
Yoshida et al. [2013] (± 2 degree, ± 0.5 h)	TCCON sites 1 (13 sites)	-5.9 ± 12.6 ppbv (723)	-	-
this study (± 2 degree, ± 0.5 h)	TCCON sites 1 (13 sites)	-3.93 ± 14.06 ppbv (837)	-5.91 ± 14.28 ppbv (123)	-4.17 ± 14.10 ppbv (960)

- TCCON sites 2: (1) ～ (18) ・・・ 18 sites [Table 2]

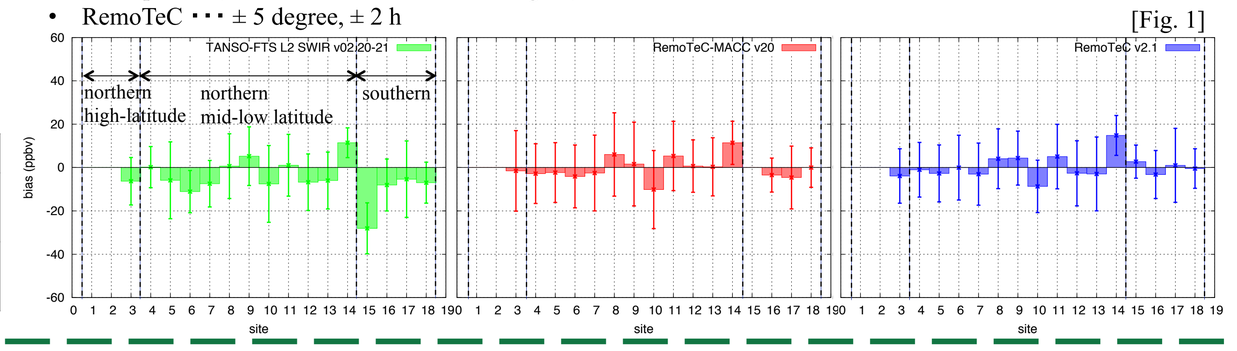
	TCCON sites	2009 ~ 2014
this study (± 2 degree, ± 0.5 h)	TCCON sites 2 (18 sites)	-4.29 ± 14.26 ppbv (1018)
	northern high-latitude* (3 sites)	-6.28 ± 10.95 ppbv (44)
	northern mid-low-latitude (11 sites)	-3.09 ± 14.29 ppbv (666)
	southern (4 sites)	-6.64 ± 14.32 ppbv (308)

*: for only Sodankyla

<NIES product vs. RemoTeC-MACC and RemoTeC>

- TCCON sites 2
- NIES product, RemoTeC-MACC ・・・ ± 2 degree, ± 0.5 h
- RemoTeC ・・・ ± 5 degree, ± 2 h

[Fig. 1]



GOSAT product vs. Airborne measurements

$$xCH_{4\_Airborne} = \frac{Total\ number\ density\ of\ CH_4}{Total\ number\ density\ of\ air}$$

$$bias_{Airborne} = xCH_{4\_GOSAT} - xCH_{4\_Airborne}$$

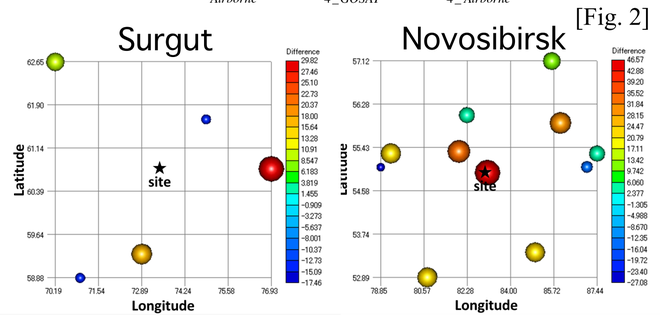
this study [Table 3]

	± 300 km, ± 0 day	± 300 km, ± 1 day
Surgut	7.8 ± 16.2 ppbv (11)	-12.9 ± 9.1 ppbv (4)
Novosibirsk	6.3 ± 17.2 ppbv (17)	10.6 ± 15.1 ppbv (35)

Inoue st al. [2014] [Table 4]

	± 2°, ± 0 day	± 5°, ± 0 day
Land	1.5 ± 14.9 ppbv (43)	2.0 ± 16.0 ppbv (102)
Ocean	4.1 ± 9.4 ppbv (3)	6.5 ± 8.8 ppbv (10)

[Fig. 2]



SUMMARY

- We validated the standard NIES product of TANSO-FTS SWIR L2 of xCH_4 (v02.20, v02.21) from April, 2009 to March, 2014 to clarify its precision by comparing them with TCCON measurements data.
- According to Yoshida et al. [2013], $bias_{TCCON}$ of the standard NIES product (v02.xx) from June, 2009 to December, 2012 is -5.9 ± 12.6 ppbv and we found $bias_{TCCON}$ of NIES product (v02.20, v02.21) from April, 2009 to March, 2014 was -4.17 ± 14.10 ppbv.
- We devided areas into NH and SH, and some TCCON sites at high latitude of NH were excluded and evaluated separately from lower latitudes. The results are shown in Table 2.
- Fig. 1 shows the biases of 18 TCCON sites for three products: NIES product, RemoTeC-MACC product and RemoTeC product. The biases at Izana (site number 14) for all the products are positive, and the bias at Reunion (site number 15) for NIES product are large negative.
- We also compared GOSAT data with aircraft measurements over western Siberia (Surgut and Novosibirsk).
- The results of the comparisons are shown in Table 3 and Fig. 2. The $biases_{Aircraft}$ are not dependent on the distance between measurement points of GOSAT and the airport measurement sites.

ACKNOWLEDGEMENTS

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