Inter-comparison between GOSAT and OCO2 SWIR-band Spectral Radiance over Railroad Valley

Fumie Kataoka [(1)], Akihiko Kuze [(2)], Kei Shiomi [(2)], Hiroshi Suto [(2)], David Crisp [(3)], Carol Bruegge[(3)] and Florian Schwandner[(3)]

(1)Remote Sensing Technology Center of Japan, (2) Japan Aerospace Exploration Agency (3) NASA Jet Propulsion Laboratory

Introduction

The Greenhouse gases Observing SATellite (GOSAT) was launched on January 2009 and continues to operate after more than seven years. The Orbiting Carbon Observatory 2 (OCO-2) was launched on July 2014. Both missions were designed to measure atmospheric carbon dioxide concentrations using reflected solar radiance with three SWIR spectral bands (O2A band, Weak-CO2 band and Strong-CO2 band).

This work describes the inter-comparison of GOSAT and OCO2 SWIR spectra over spatially and temporally coincident observation points. The inter-comparison of spectral radiance is an essential first step of cross-validation of the different spectrometers.

Methodology

Match-up criteria

We took the temporally coincident and spatially collocated GOSAT and OCO2 data. Figure 1 shows the global orbit map of GOSAT and OCO2 satellite. Figure2 shows the focused orbit map near Railroad Valley (RRV).

●GOSAT has 3-days revisit cycle and 44 repeat orbits. The Local equator crossing time in a descending node is 13:00+/- 15 minutes.

●OCO2 join the international Afternoon Constellation, or A-Train, of Earth-observing satellites. A-train has 16-days revisit cycle and 227 repeat orbits. The Local equator crossing time in a ascending node is about 13:30.

[Data period] 2014/09～2016/04

[Math-up criteria]

- GOSAT –OCO2 time difference : 1 hour
- OCO2 footprint data within about 10.5 km-diameter GOSAT footprint
- Satellite geometry : almost nadir (except for Railroad Valley cases)

Figure3 shows the matchup points in global from Sep2014~Apr2016.

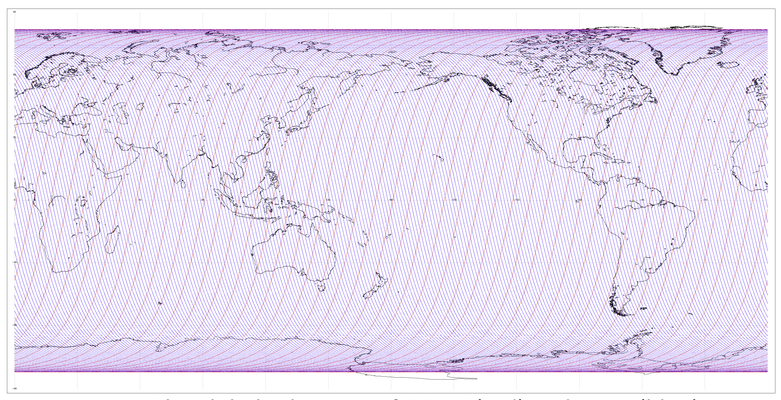

Figure1. The global orbit map of GOSAT(red) and OCO2(blue).

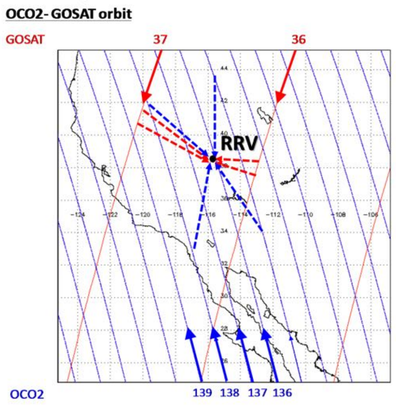

Figure2. The orbit map GOSAT (red) and OCO2 (blue) in Railroad Valley.

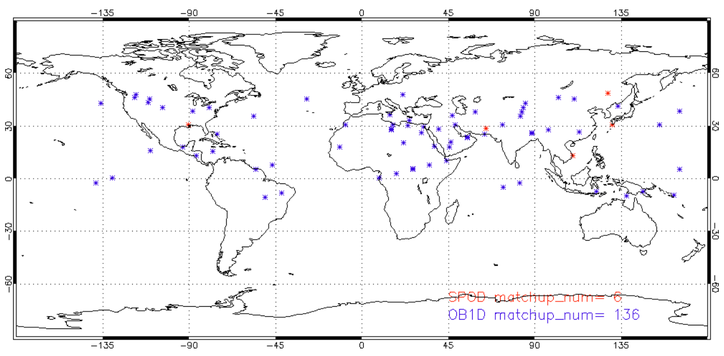

Figure3. GOSAT-OCO2 match-up points (Sep2014~Apr2016) with above criteria.

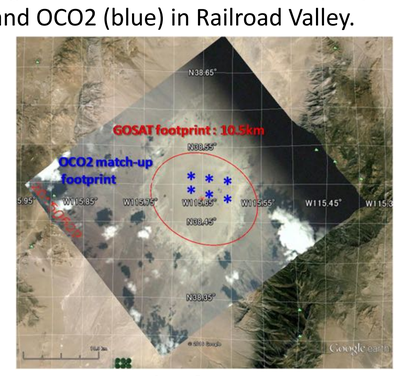

Figure4. Example of GOSAT-OCO2 match-up points in Railroad Valley.

Comparison Data

In this work, we used GOSAT L1B V201201 (or V201202) and OCO2 L1B Science.7r data. For GOSAT spectra, we applied V201 radiance conversion table (currently, V201201 data applied V070 radiance conversion table).

Processing flow chart

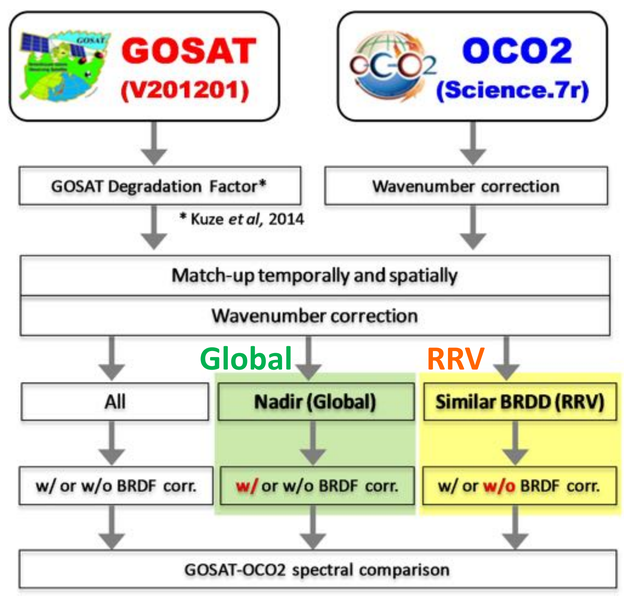

Figure5. The flow chart of GOSAT-OCO2 inter-comparison of spectral radiance.

Figure5 shows the flow chart of inter-comparison of spectral radiance. As described in Kuze et al,2014 paper, GOSAT SWIR sensor indicated significant degradation compared to the prelaunch values. Especially, largest changes were seen in the 0.76 µm O_2A-band (band1). We applied the GOSAT Radiance degradation Factor (RDF) for GOSAT spectra. Figure6 show the GOSAT RDF for past 8years.

In general, the surface reflection is not Lambertian, so we applied the BRDF, calculated from MODIS BRDF product (MCD43B1), for each spectra (only clear land).

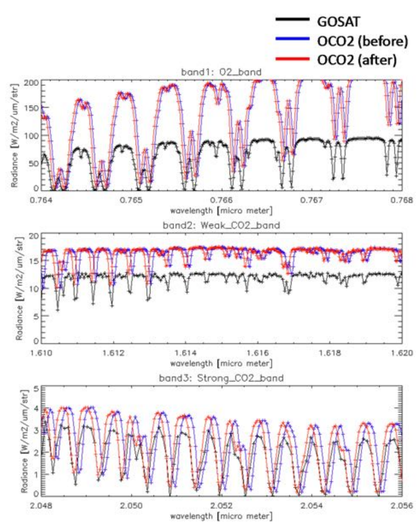

Figure6. Example of GOSAT-OCO2 wavenumber correction.

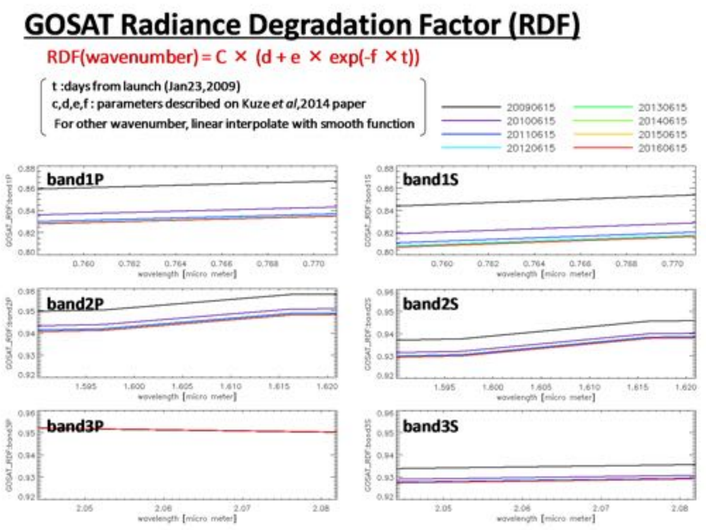

Figure7. GOSAT Radiance degradation Factor (RDF) for past 8 years

Result

Table1 shows the list of GOSAT-OCO2 inter-comparison cases in this work.

For Global analysis, we selected almost nadir observation and checked the uniformity within GOSAT footprint (clear or cloudy). In this analysis, we applied BRDF for GOSAT and OCO2 spectra (except for ocean and cloudy data).

For RRV analysis, we selected similar BRDF characteristic area and not applied BRDF for spectra.

Figure8 show the example of spectral comparison in Global and RRV analysis. We summarized the OCO2 and GOSAT spectral ratio (= (OCO2 – GOSAT)/GOSAT *100 [%]) at three wavelength listed in Table2. Figure9 shows spectral ratio at three different types of target (Land, Ocean and Cloudy), which has different dynamic range.

We will continue to check the stability of both satellites through this kind of comparison method.

Table1. List of GOSAT-OCO2 inter-comparison cases.

	GOSAT L1B filename	Date	Time	Lat	Lon	BRDF	Remarks
1	GOSATTFTS20141213111290190250_1BOB1D201201.01_ex20	2014/12/13	31:15.0	30.4526	24.0401	applied	desert
2	GOSATTFTS20141214053100080260_1BOB1D201201.01_ex13	2014/12/14	32:20.8	26.4504	113.0320	applied	land
3	GOSATTFTS20150216073801202400_1BOB1D201201.01_ex5	2015/2/16	39:09.2	40.5476	84.1712	applied	desert
4	GOSATTFTS20150513201103502441_1BOB1D201201.01_ex5	2015/5/13	11:40.1	40.5537	-104.0036	-	cloudy
5	GOSATTFTS20150517092101502701_1BOB1D201201.01_ex2	2015/5/17	21:48.8	23.5392	55.0572	applied	desert
6	GOSATTFTS20150518095401602701_1BOB1D201201.01_ex22	2015/5/18	56:04.7	17.9378	45.5865	applied	desert
7	GOSATTFTS20150609115702002211_1BOB1D201201.01_ex17	2015/6/9	58:40.4	48.0036	21.3308	applied	land
8	GOSATTFTS20150617095701602911_1BOB1D201201.01_ex4	2015/6/17	58:00.0	10.3558	43.9350	applied	desert
9	GOSATTFTS20150617095701602911_1BOB1D201201.01_ex5	2015/6/17	58:04.6	10.3574	43.9332	applied	desert
10	GOSATTFTS20150705180703102801_1BOB1D201201.01_ex7	2015/7/5	07:31.5	15.4193	-77.6927	-	ocean
11	GOSATTFTS20150705180703102801_1BOB1D201201.01_ex8	2015/7/5	07:36.1	15.4203	-77.6946	-	ocean
12	GOSATTFTS20150818073801202401_1BOB1D201201.01_ex14	2015/8/18	39:43.3	38.0532	83.4286	applied	desert
13	GOSATTFTS20150825211503702301_1BOB1D201201.01_ex6	2015/8/25	15:42.4	46.0863	-118.4781	applied	land
14	GOSATTFTS20150905073701202301_1BOB1D201201.01_ex17	2015/9/5	38:24.2	43.0417	85.0026	-	cloudy
15	GOSATTFTS20150915033000403201_1BOB1D201201.01_ex13	2015/9/15	31:03.8	-9.8552	137.8542	-	ocean
16	GOSATTFTS20151205113301902701_1BOB1D201201.01_ex13	2015/12/5	34:12.9	20.4684	21.6251	applied	desert
17	GOSATTFTS20160111102601702601_1BOB1D201201.01_ex6	2016/1/11	26:52.5	28.2870	39.8643	applied	desert
18	GOSATTFTS20160112092201502711_1BOB1D201201.01_ex3	2016/1/12	22:48.4	23.2587	55.0043	applied	desert
19	GOSATTFTS20160122095501602701_1BOB1D201201.01_ex11	2016/1/22	56:13.5	21.0157	46.2984	applied	desert
20	GOSATTFTS20160205204303602301_1BOB1D201201.01_ex16	2016/2/5	44:44.2	43.3156	-111.2661	-	cloudy
21	GOSATTFTS20160225183403202401_1BOB1D201201.01_ex5	2016/2/25	34:44.7	40.5542	-79.4413	-	cloudy
24	GOSATTFTS20150325211703702421_1BSPOD201201.01	2015/3/25	21:17	38.4840	-115.6852	-	RRV
25	GOSATTFTS20150629211603702421_1BSPOD201201.01	2015/6/29	21:17	38.4840	-115.6852	-	RRV
26	GOSATTFTS20150701204403602421_1BSPOD201201.01	2015/7/1	20:44	38.4840	-115.6852	-	RRV

Table2. Evaluated spectral wavelengh for each band.

Ratio = (OCO2 - GOSAT)/GOSAT * 100 [%]			
O2A band [um]	0.7676	0.7696	0.7707
Weak CO2 band [um]	1.5929	1.6056	1.61616
Strong CO2 band [um]	2.0618	2.0723	2.0795

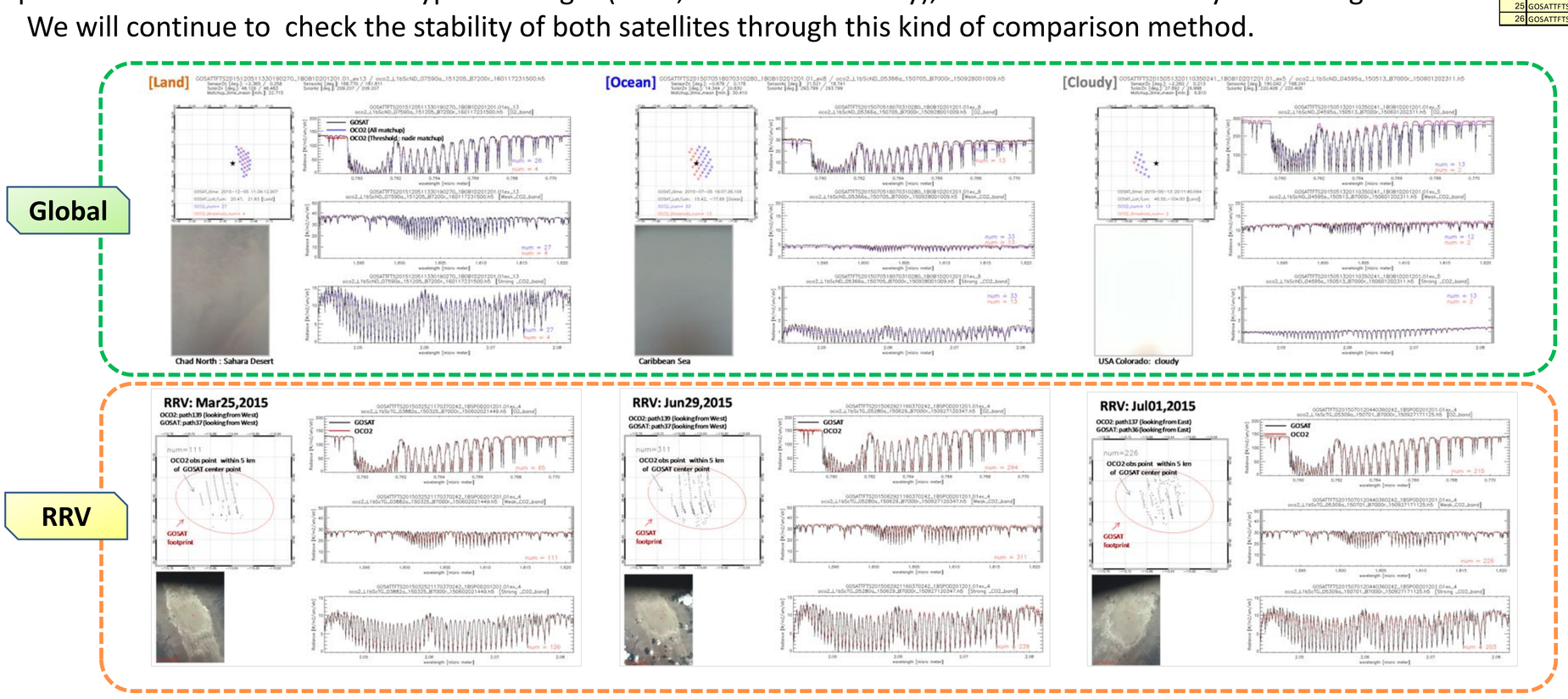

Figure8. Example of GOSAT-OCO2 spectral comparison (Upper: Global cases, Lower: RRV cases).

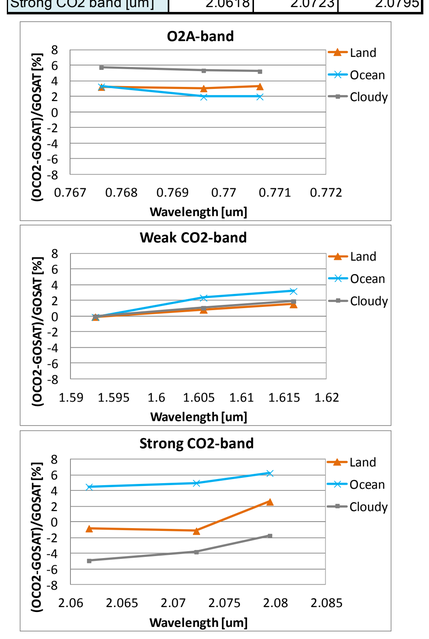

Figure9. Summary of GOSAT-OCO2 spectral comparison.