Characterization of GOSAT TANSO Level 1 V160.160 TIR spectra

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The Greenhouse Gases Observing Satellite (GOSAT) is dedicated to monitor greenhouse gases such as CO_2 and CH_4 from space. The GOSAT was launched on January 23, 2009 and obtains normal operation data over 4 years. The FTS covers wide wavelength range from SWIR 3 bands to TIR band from 5.5 to 14.3 microns by simultaneous observations. The TIR Level 2 CO_2 and CH_4 profiles were released in public [Saitoh et al., SOLA, 2012]. The previous version V130.130 of TIR spectra were evaluated by using airborne-FTS combined with ground-based emissivity measurements over desert campaign [Kataoka et al., TGRS, 2013]. The latest FTS Level 1 product was updated to V.160.160 on May 16, 2013 [Kuze et al., AMT, 2012]. In this study, we estimate the uncertainty of the TANSO-FTS TIR radiometric calibration with consideration of measurement uncertainty of polarization, detector non-linearity, and blackbody.

1. Update to V160.160 TIR spectra

Notes on update

(1) Deep space (DS) view obscuration is disabled because pointing anomaly offset (<0.5deg) is less than the DS window clearance (0.768deg). DS view obscuration correction (temperature of the DS view hood = 250K, obscuration rate = 3%) was on active processing in V130.130 – V150.151SE, but off in V160.160. It works to decrease brightness temperature at 700 cm^{-1} (Fig. 1-1).

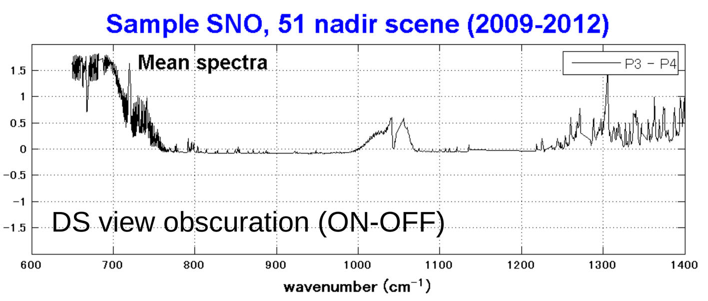

Fig. 1-1

(2) Polarization parameters of mirrors, beam-splitters, dichroic filters are optimized at precise treatment of incident angles (Fig. 1-2) after checking the pre-flight test results. Revision of the polarization correction works to increase brightness temperature at 700 cm^{-1}.

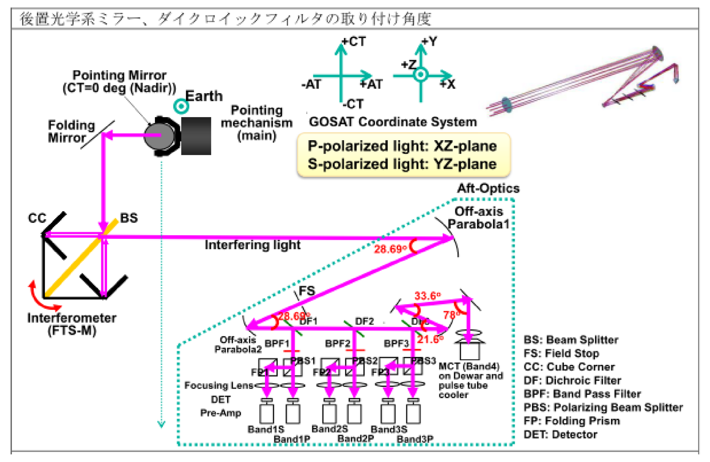

Fig. 1-2

(3) Engineering model on-board blackbody emissivity, which is a plate-type arrayed-pyramids with diffuse surface, is measured precisely by heated-halo method with S-HIS interferometer (Fig. 1-3). Also, inner radiation is estimated with the view factor of blackbody.

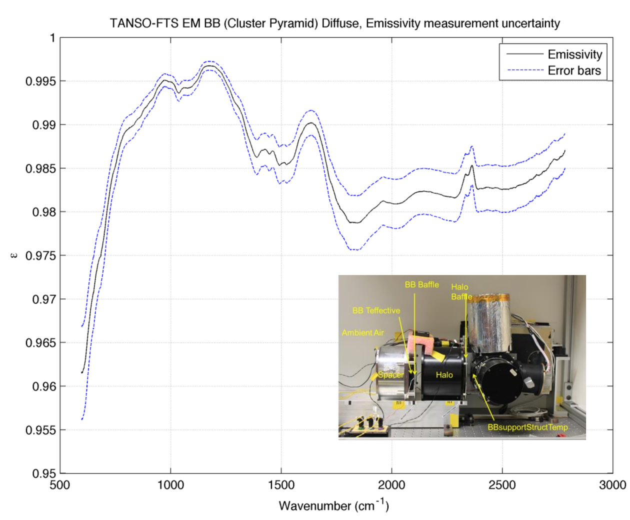

Fig. 1-3

(4) Blackbody monitoring temperature decreases 0.1K around 10degC after improvement of engineering conversion table (Fig. 1-4).

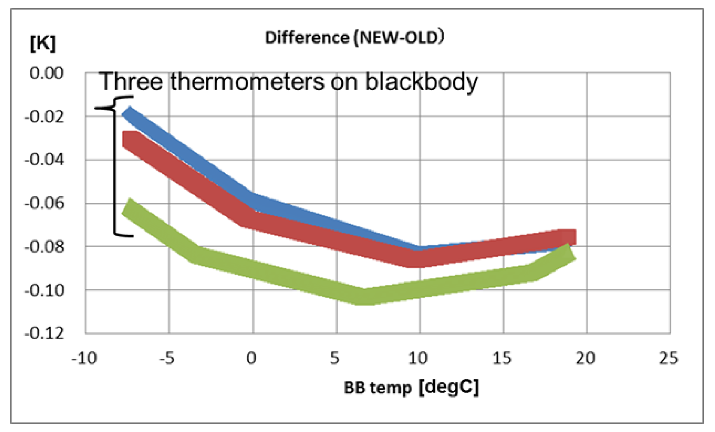

Fig. 1-4

(5) DC zero-level offset at no-photon input gradually changes on orbit by monitoring of deep space calibration. The detector non-linearity correction is affected by this change. We have a 10-year table estimated from 3-year monitoring (Fig. 1-5).

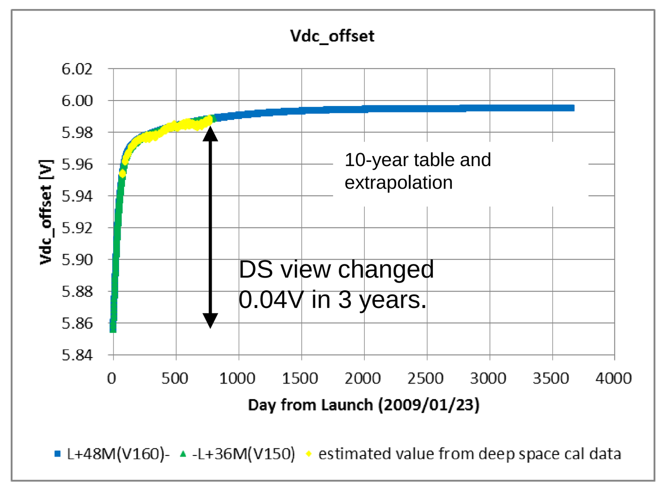

Fig. 1-5

Simultaneous nadir observation compared to AIRS

The accuracy of GOSAT TIR radiometric calibration is evaluated by comparison with AIRS simultaneous nadir observations (SNOs). The spectral differences between GOSAT and AIRS are analyzed for V150.151(SE) and V160.160 with SNOs results of 51 spectra in 2009 – 2012 (Fig. 1-6).

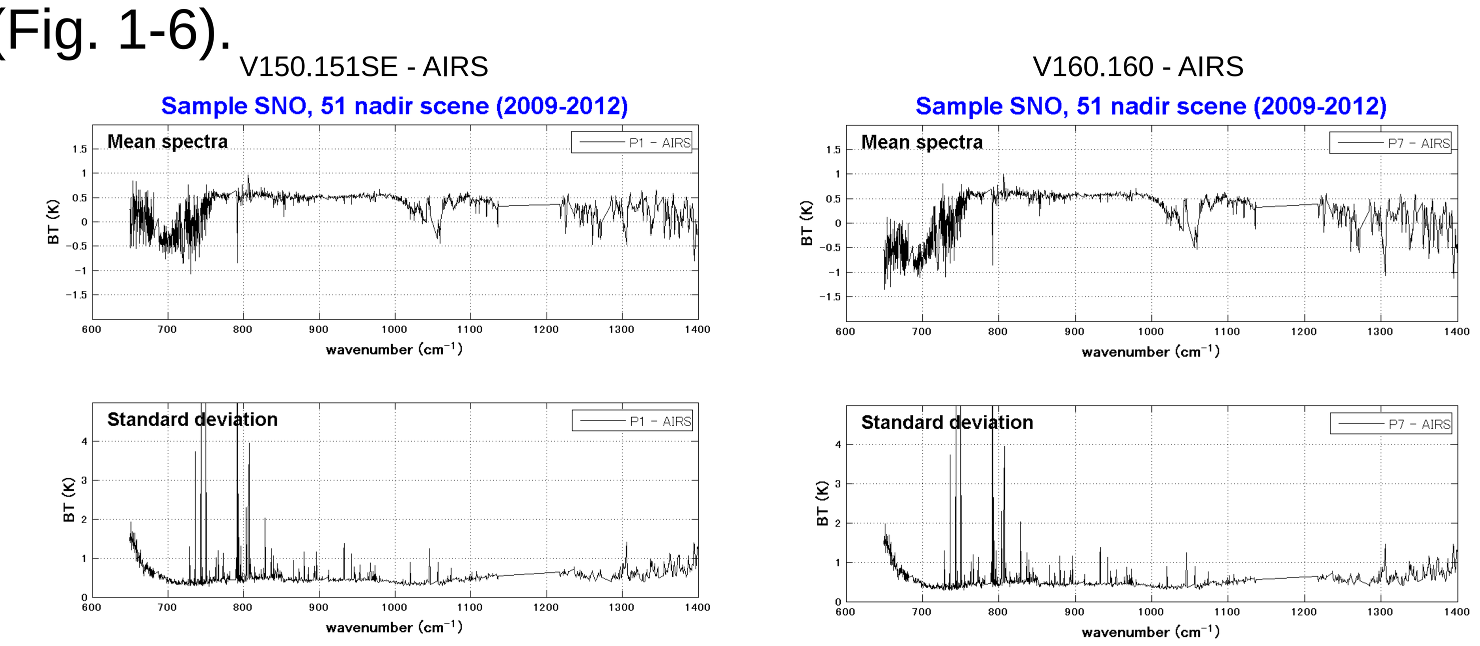

Fig. 1-6 : Spectral difference of AIRS SNOs

2. Uncertainty of TANSO-FTS TIR radiometric calibration

TANSO-FTS TIR radiometric calibration formula

We employs a polarimetric calibration expressed with Mueller matrix of pointing mirror reflectivity, which is different between blackbody calibration and observation, FTS interferometer transmittance, aft-optics optical efficiency, and pointing mirror radiation. Blackbody calibration effectively includes the background reflected radiation, which is the rest of the emissivity.

$$B_{obs}(\nu) = \frac{S_{obs}(\nu,d) - S_{DS}(\nu,d)}{S_{BB}(\nu,d) - S_{DS}(\nu,d)} \cdot \left[\frac{(M_{AO} \cdot M_{FTS} \cdot M_{PM\_BB} \cdot e_1) \cdot e_1}{(M_{AO} \cdot M_{FTS} \cdot M_{PM\_obs} \cdot e_1) \cdot e_1} \right] B_{BBeffective}(\nu) - \frac{\Delta PM}{(M_{AO} \cdot M_{FTS} \cdot M_{PM\_obs} \cdot e_1) \cdot e_1}$$

Uncertainty of calibration parameters

Parameter	Symbol	Uncertainty of measurement
Detector non-linearity correction	a_{nlc}	+/- 10% * a_{nlc} [Fig. 2-1]
Reflectivity of the pointing mirror (P-pol) Reflectivity of the pointing mirror (S-pol)	P_{pm} Q_{pm}	[Fig. 2-2]
Transmittance of the FTS interferometer	PQ_{fts}	+/- 0.05 [Fig. 2-3]
Optical efficiency of the aft-optics (P-pol) Optical efficiency of the aft-optics (S-pol)	P_{ao} Q_{ao}	[Fig. 2-4]
Blackbody temperature	ΔT_{BB}	+/-0.03K
Blackbody emissivity	ε_{BB}	< +/- 0.6% * ε_{BB} [Fig. 1-3]

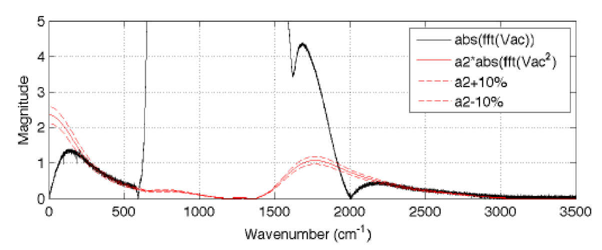

Fig. 2-1

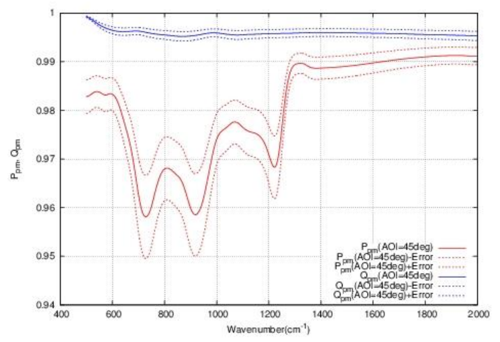

Fig. 2-2

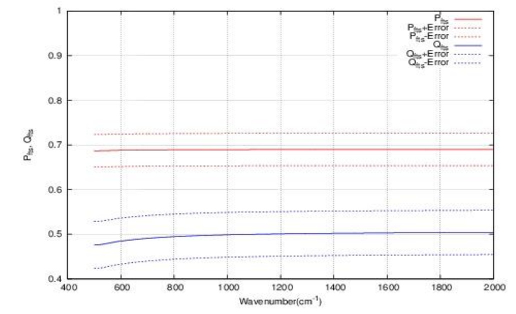

Fig. 2-3

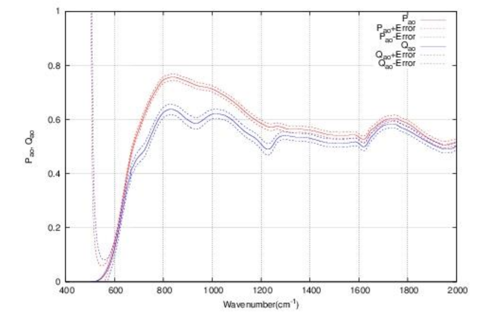

Fig.2-4

Uncertainty of radiometric calibration

On-board blackbody calibration and atmospheric observation spectra, which have brightness temperature around 280 K are chosen for this study (Fig. 2-5). Uncertainty of calibration sensitivities are calculated. Large uncertainty comes from the beam-splitter polarization, pointing-mirror reflectivity (P-pol), and detector non-linearity (Fig. 2-6). Calibration RSS uncertainty is given for atmospheric observation and on-board calibration spectra (Fig. 2-7).

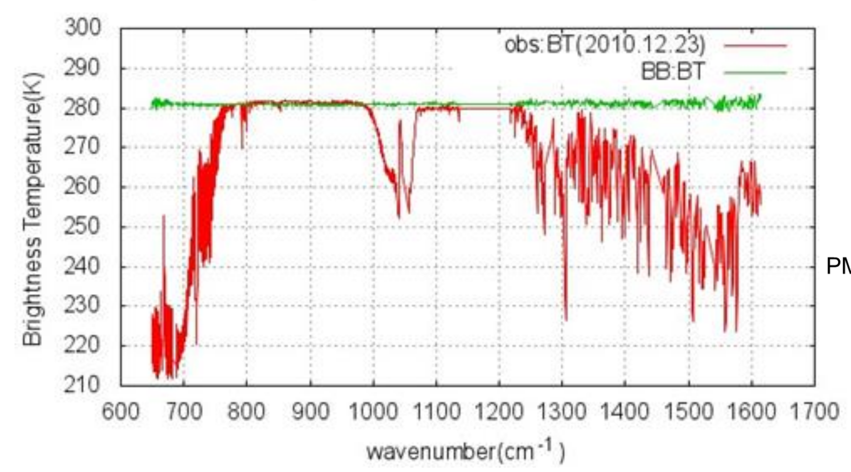

Fig. 2-5

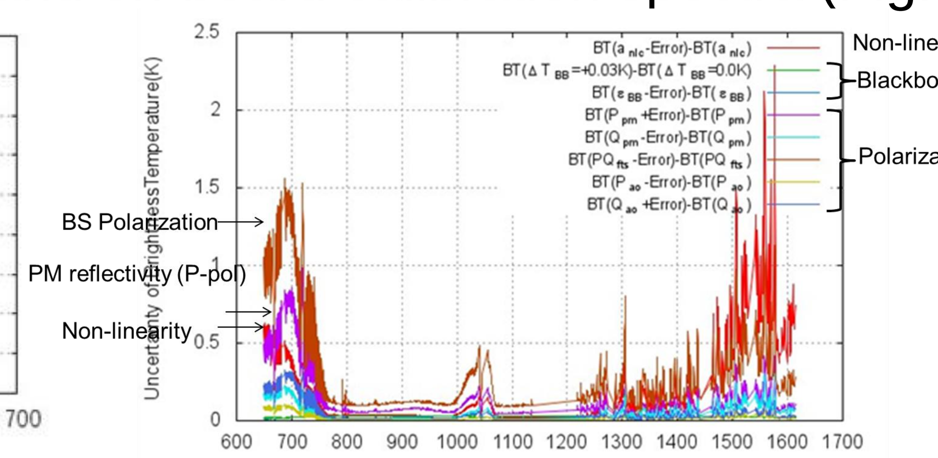

Fig.2-6

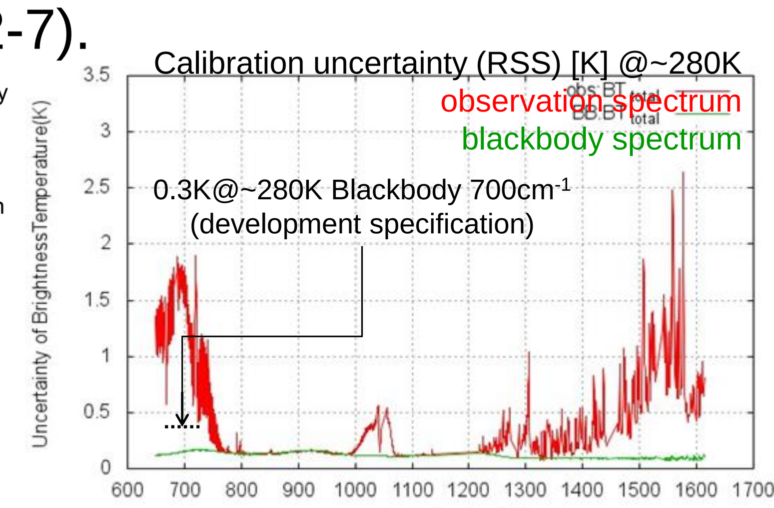

Fig. 2-7

IWGGMS-9, Yokohama Symposia, Yokohama, May 30, 2013 (Poster-15)