Response to referee comments on manuscript amt-2020-360

First of all, we would like to thank referee #1 for his/her constructive comments, which helped us to improve the manuscript. We replied all comments and questions as follows. The referee's comments are in blue text.

Anonymous Referee #1

General Comments:

Referee:

The authors have provided a very thorough description of the mission, instrument, and operations process. Both successes and challenges are presented. For several quantities that are listed, it was not always clear what the target/threshold performance level is, or what the consequence was when it was not achieved.

Author's reply:

Thank you very much for reviewing our manuscript. We revised our manuscript with changes tracked.

Specific Comments:

Referee:

Line 84: why do the spectral ranges of the forward and backward channels of CAI-2 differ?

Author's reply:

The cloud detection is performed in the 674, 869 and 1630 nm bands, which are common to the forward and backward direction. The cloud detection algorithm is described in Ishida et al (2009) and Oishi et al (2018). In the operational XCO2 and XCH4 retrieval algorithm, developed by NIES, the cloud location information from CAI-2 is used to pre-screen cloudy observation scenes. The three spectral bands are mounted on both, the forward and backward looking directions to avoid missing any spatial cloud information.

The four UV and VIS bands are not used in GOSAT-2 operational cloud detection processing. Their wavelengths have been chosen after consultation of the Japanese science community and in the view of the available GOSAT-2 system resources. We added the additional two references for CAI-2 in the manuscript.

Ishida, H., and Nakajima, T.Y.: Development of an unbiased cloud detection algorithm for a spaceborne multispectral imager, J. Geophys. Res., 114, D07206, doi:10.1029/2008JD010710, 2008.

Oishi, Y., Ishida, H., Nakajima, T. Y., Nakamura, R., Matsunaga, T.: The impact of

different support vectors on GOSAT-2 CAI-2 L2 Cloud disclination., Remote Sens. 2017, 9, 1236; doi:10.3390/rs9121236, 2017.

Referee:
Line 182: were CO2 or CH4 also detectable?

Author's reply:
CO_2 and CH_4 in the 1.6 μm region are not detectable in our pre-launch test configuration. In contrast, CO_2 in the region from 4900 to 5000 cm^{-1} and water vapor are detectable and cause some interferences when characterizing the signal-to-radiance conversion coefficients. This is a reason why we combined atmospheric tests and thermal vacuum tests.

We corrected the manuscripts as follows;

"Due to the interference of oxygen lines in band 1, water vapor and CO_2 lines in band 3,"

Referee:
Line 283: at what radiance levels does saturation occur? How often is the saturation flag set?

Author's reply:
Saturation is diagnosed in the interferogram domain. Due to the 14-bit resolution (+/-8191) of the ADCs, the saturation criterion is set as full bit range (+8191) in digital number units. The saturation rate, which is defined as the ratio between the total observation number and the number of saturated observations, during February 2019 to March 2020 is 8.9%, 13.0%, 6.3%, 6.6%, 2.9%, and 3.7% for the b1p, b1s, b2p, b2s, b3p, and b3s detectors, respectively.

We added the following two sentences are added in section 4.1 and 5.1;

In section4.1:

In this case, the saturation criterion is set to +8191 digital number units.

In section5.1

In addition, to minimize the acquisition of useless data, the gain settings for each of the bands are examined during the first year of operation. As a result, the saturation rate, which is defined as the ratio between the total observation number and the number of saturated observations, during February 2019 to March 2020 is 8.9%, 13.0%, 6.3%, 6.6%, 2.9%, and 3.7% for bands 1p, 1s, 2p, 2s, 3p, and 3s detectors, respectively. For bands 4 and 5, there was no saturated data during the considered period. The main reason for saturation is cloudy scene observation, especially in band 1.

Referee:
Line 546: Instead of "slightly wider", quantify the typical difference in ILS width

Author's reply:
We added the following sentence is added in the manuscript.

"The best-estimated ILS function for band 1 is slightly wider than that of the prelaunch test. The difference of the FWHM between the prelaunch test and the orbit best-estimated one is found +0.03cm^{-1}. However, a time-dependent term is not implemented in the current best-estimated ILS function."

Referee:
Table 5: why are separate wavenumbers listed for s & p when they're always the same?

Author's reply:
As you suggested, wavenumbers for analyses are always the same for both, p and s bands. We modified the Table 5 as follows;

Table 5. Wavenumbers considered for the radiometric performance analyses.

Color	Band 1p & 1s	Band 2p & 2s	Band 3p & 3s
red	12975.2 cm^{-1}	6174.7 cm^{-1}	4808.8 cm^{-1}
orange	12993.8 cm^{-1}	6186.8 cm^{-1}	4822.9 cm^{-1}
green	13027.6 cm^{-1}	6229.6 cm^{-1}	4849.9 cm^{-1}
blue	13122.1 cm^{-1}	6257.8 cm^{-1}	4871.4 cm^{-1}
purple	13171.8 cm^{-1}	6277.9 cm^{-1}	4880.4 cm^{-1}

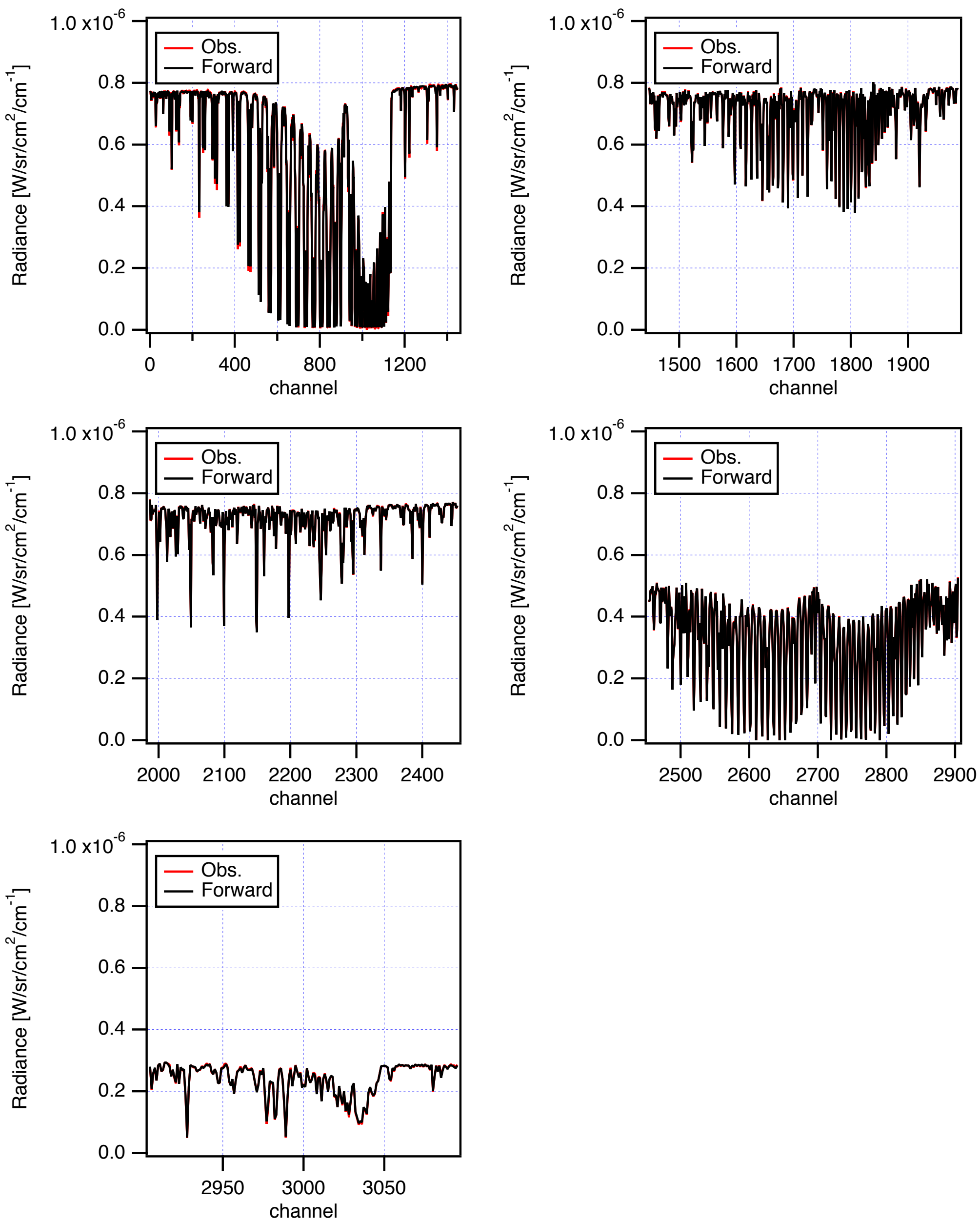
Referee:
Fig 5d: why does Band 5 have a linear relationship between SNR and Radiance while the other bands show a square root dependence?

Author's reply:
In the case of photon shot noise dominating, the relationship between SNR and radiance shows a square root dependence. The band 5 has electronic noise that exceeds the photon-dependent noise. As described in the manuscript, the non-linearity correction for band 5 requires improvements. If the non-linearity correction is not perfect, it also contributes to the distortion of the relationship between SNR and radiance. We believe that this finding indicates that calibration of band 5 needs to be revisited.

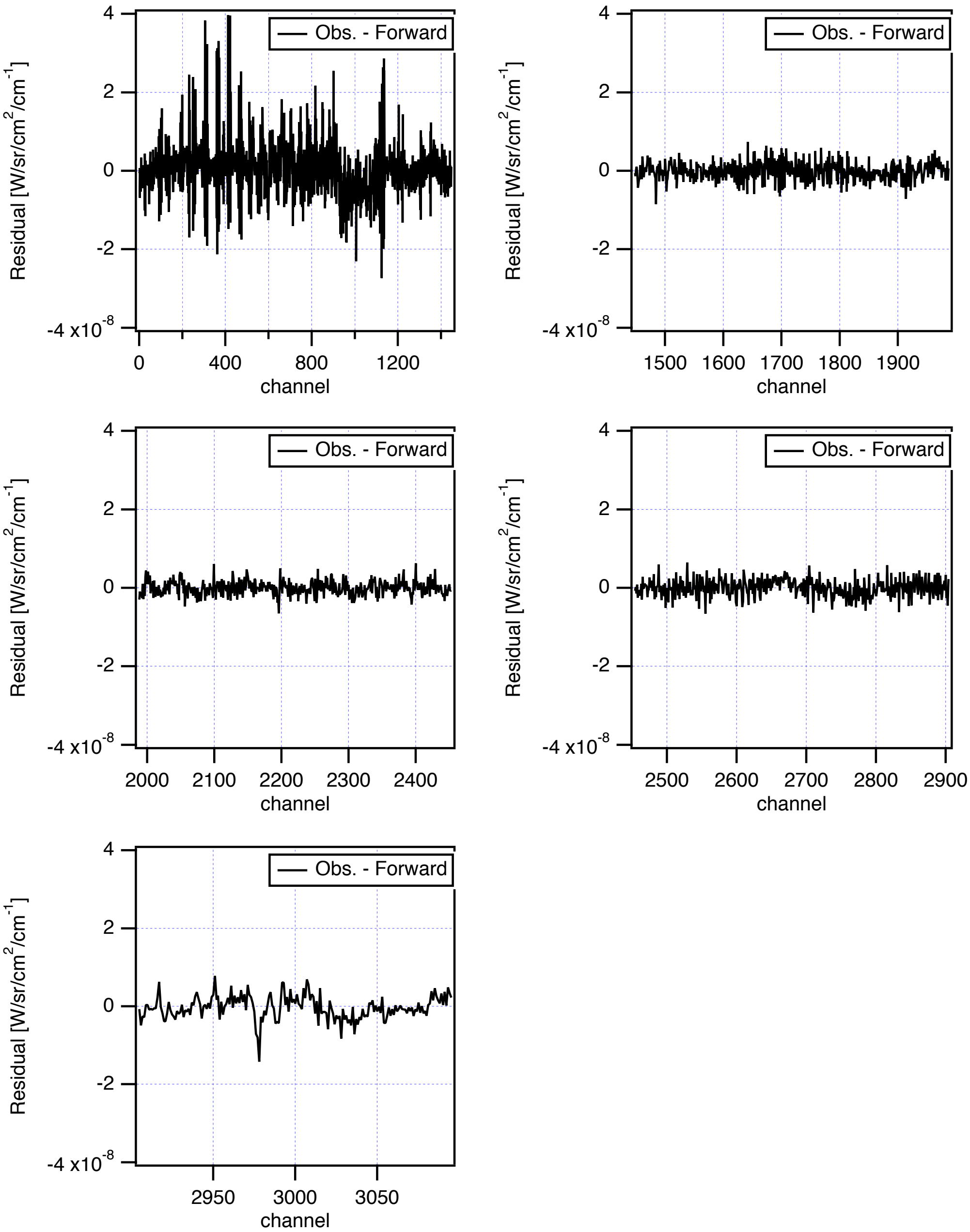
Referee:
Fig 18b: This would be more informative if the bands were split and the residuals were not in absolute radiance units, but relative to the continuum signal.

Author's reply:

We split the Figure 18 in the individual bands, but we kept the display of residuals in absolute radiance units. Since our spectra cover optically thick absorption lines and since FTS-2 has high spectral resolution, radiances become very small for some spectral samples. Relative residuals would be dominated by these samples (division by small number) and would mask the rest of the residuals.



(a)



(b)

Figure 18. An example of residual spectra between observed and forward calculated over vicarious calibration site (RRV) on July 1, 2019; (**a**) difference between the observed spectra and the forward calculation for each window; (**b**) the residual between the observed spectra and the forward calculation for each window.

Technical Corrections:

Referee:

Capitalize "Earth"

Author's reply:

We changed a small letter of "earth" to capitalized "Earth".

Referee:

Use greek mu (μ) instead of "u" for micrometer

Author's reply:

We changed the notation in the revised manuscript.

Referee:

use "sr" for steradian instead of "str"

Author's reply:

We corrected the word "str" to "sr" including Fig. 5, Fig. 8, Fig.13, Fig. 18.

Referee:

Line 371: reword "emissivity presents higher"

Author's reply:

We modified the sentence to "The emissivity of the black body, which was characterized during the prelaunch test phase, is higher than 0.999 in the relevant spectral region, "

Referee:

Line 590: "increased by 1.7" -> "increased by a factor of 1.7"

Author's reply:

We corrected the wording in the revised manuscript.

Referee:

Fig 7a: check punctuation in flowchart

Author's reply:

We corrected the punctuation in flowchart.

Referee:

Fig 9 caption: check spacing between (a) and the panel description

Author's reply:

We corrected the spacing for (a), (b), (c), (d), (e) and (g).

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