Interactive comment on "On-orbit radiometric calibration of SWIR bands of TANSO-FTS onboard GOSAT" by Y. Yoshida et al.

Anonymous Referee #2

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This manuscript describes a method to derive the radiometric degradation of GOSAT short-wave-infrared spectra from solar calibration measurements. The strength of the method is that it takes into account wavelength and polarization dependence of the degradation and it is shown that this new degradation model eliminates an increase in chi2 of the fit to the O2 A Band spectra and radiance adjustment factors with time. This manuscript is well presented and well written. It deals with a relatively specific, but still very important issue. From my point of view, the manuscript would have been benefited from a more in-depth discussion in the conclusion section (e.g. are there lessons learned for other satellite missions) and from a more detailed discussion on the impact on the XCO2 or XCH4 retrievals (as this is what most readers will be interested in). I would like to suggest to the authors to consider this but if the authors do not want to make these changes then I would also be fine if the manuscript is published in AMT after addressing my comments below.

=> Thank you for your careful reading of our paper. We decided to touch on the impact on the XCO_2 and XCH_4 due to the exchange of the degradation model. The followings are our reply to your comments. The revised part is marked with "double line (═══; removed)" or "under bar (___; added)".

Comments:

p.4712, L5: spectrum -> spectra

=> Done.

p.4713, L17: precise -> accurate

=> Done.

p.4713, L22: Further -> Furthermore,

=> Done.

p.4713, L28: clarified -> evaluated

=> Done.

p.4714, L5: Residual spectrum in Figure 2b shows large structures. It might be worthwhile to mention that these systematic structures are mostly related to shortcoming in the spectroscopy of O2.

=> According to your comments, following sentence was added at the last part of this paragraph.

"Note that the systematic structures in the residual spectra are probably due to the shortcoming of the spectroscopy of oxygen, because other GOSAT retrieval algorithm and retrieval using other instrument show similar residuals (e.g., Fig. 6

of Crisp et al., 2012)."

p.4714, L10: Rough spectra -> what is that?

=> To make it clear, we added the explanation.

"Rough ~~spectra~~ spectrum structure of ground surface albedo in each band, which was represented by several grid-point values and varied linearly from one grid to the next, were retrieved for the land case, whereas the surface wind speed and radiance adjustment factor were retrieved for the ocean case."

p. 4715, L.13: atmospheric oxygen -> atmospheric molecular oxygen

=> Done.

p. 4715, Eq. 1: Please discuss this equation in more detail, eg. Rˆ2 term is to take into account the variable solid angle of the Sun

=> We revised the last paragraph of the section 3 as follows.

"The general formula of the spectrum observed by TANSO-FTS was a function of the pointing mirror direction. It was expressed as a ~~sum~~ product of several Mueller matrices (e.g., pointing mirror, TANSO-FTS-mechanism, after-optics, rotation according to the pointing mirror angle, etc.; hereafter called optical efficiency) and a Stokes vector of the incident light (Eqs. 9 and 10 of Kuze et al., 2012). ~~The~~ Because the pointing mirror pointed the diffuser plate and did not move during the solar calibration, ~~and the incident solar irradiance was regarded as non-polarized light~~ the optical efficiency of TANSO-FTS becomes only a function of wavenumber ν. To express the solar calibration data, we have to consider the reflection at the diffuser plate. Since we assume that the back side diffuser plate has not been degraded, the diffuser plate reflectance r is a function of ν and incident and relative azimuth angles to the diffuser plate (θ and ϕ, respectively). Furthermore, the temporal variation of a solar flux due to the earth's revolution is considered. ~~Therefore, the~~ The observed spectrum S of the solar calibration can be expressed as

$$S_{P/S}(\nu,\theta,\phi,t)=\frac{F_{SUN}(\nu)\cos\theta}{\pi R(t)^2}r_{P/S}(\nu,\theta,\phi)OPT_{P/S}(\nu)A_{P/S}(\nu,t)$$

where ~~ν is a wavenumber; θ and ϕ are the incident and relative azimuth angles of the incident solar radiation to the diffuser plate, respectively;~~ t is a day after the launch (i.e., t = 0 for 23 January 2009); F_{SUN} is the solar irradiance; R is the distance between Sun and Earth in astronomical units; ~~r is the reflectance of the diffuser plate;~~ OPT is the optical efficiency of the ~~pointing mirror, TANSO-FTS-mechanism, and after-optics~~ TANSO-FTS without diffuser plate; A is the radiometric degradation of TANSO-FTS; and subscripts "P" and "S" indicate the polarization components."

p. 4715, L27: reflectance r. Please point out that you make the assumption that r is not time-dependent itself.

=> Done. See above response.

p.4716, Eq.2: The constant is only a constant wrt to theta, but it is still a function of time and wavenumber

=> We revised the Eq. (2) and added sentence as follows.

"$$\frac{S_{P/S}(\nu,\theta,t_0)}{r_{P/S}(\nu,\theta)\cos\theta} = \frac{F_{SUN}(\nu)}{\pi R(t_0)^2} OPT_{P/S}(\nu) A_{P/S}(\nu,t_0)$$

The right hand side of the Eq. (3) is only a function of wavenumber."

p.4718, Eq.6: say that d,e,f are constants that are fitted.

=> Done.

p.4718, Figure 8: Could you describe in more detail what the figure shows and what it tell us.

=> We moved the last paragraph of the section 4.2 (p.4718, Line 16 to Line 25) into the first paragraph of this section (p.4727, Line 13). Second and third paragraphs of this section (p.4717, Line 16 to p.4718, Line 15) gave the explanations.

p.4719: section 4.3: Could at least give some indication by how much the retrieved XCO2 will change due to the new degradation correction. Otherwise, readers will not be able to assess the importance of this new degradation correction.

=> The main scope of this paper is the improved degradation model. So we just added the differences in XCO_2 and XCH_4 at the end of section 4.3.

"Difference in the retrieval results by using previous/improved degradation models changes with time, and difference in XCO_2 and XCH_4 for our retrieval (improved - previous) are about -1.3 ppm/yr and -6.7 ppb/yr, respectively."

p. 4723, table 1: Define the angle theta(SES) in the caption

=> Done.

p. 4731: I find it confusing to give 4 angles at the top of the figure but to show only 3 curves. I would remove the reference angle theta_0 from the top of the figure and say in the figure caption that the figure gives values relative to a theta_0 of 33 degrees.

=> Done.