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Atmospheric Measurement Techniques Discussions

Interactive comment on "Level 1 algorithms for TANSO on GOSAT: processing and on-orbit calibrations" *by* A. Kuze et al.

Anonymous Referee #2

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General Comments.

From a technical perspective, the paper has improved significantly from the January 2012 version. The authors have successfully clarified many of the technical issues raised in my March 2012 review.

The quality of the English, however, is still unacceptable. There are many errors on every page, and there are still several sentences that are incomprehensible to me. The paper must be extensively edited by a fluent English-speaking FTS expert before it can be accepted for publication.

Below is a list of specific questions/comments of a technical nature, and also sugges-

tions for improving the English. The latter are incomplete – there are still many other instances of poor English.

Specific Comments.

Page 2960, line 4: Change: “In this paper, first, the most recent operational Level 1 algorithms to produce the spectral radiance from the acquired interferogram are described.” To “In this paper, we first describe the most recent operational Level 1 algorithms that produce radiance spectra from the acquired interferograms.”

Page 2960, Line 12: Change: “However, the Level 1B algorithms of TANSO-CAI are not mentioned, here in this paper.” To “The Level 1B algorithms of TANSO-CAI, however, are not described in this paper.

Page 2960, Lines 20-24: Comment: It isn’t clear whether the two orthogonal polarizations apply to all bands, or to just the CH4 (band 2). Perhaps describe the polarization properties in a separate sentence.

Page 2961, lines 5-10: Comment: This sentence is too long – break into two sentences. For example, “JAXA is responsible for producing the Level 1A (raw interferogram) and the Level 1B (spectral radiance) products of TANSO-FTS and the Level 1A (raw digital number) product of TANSO-CAI. NIES provides the Level 2 (CO2 and CH4 concentrations from each Level 1B spectra), the Level 3 (global distribution of CO2 and CH4 concentrations by interpolating the Level 2 products), and the Level 4 (net CO2 sources and sinks) products of TANSO-FTS and the Levels 1B, 1B+, 2, and 3 products of TANSO-CAI.”

Page 2961, Line 10: Comment: What is level “1B+” ? Why isn’t it mentioned in Table 1? Either define level 1B+ or don’t mention it.

Page 2961, line 23: Change: “The camera (CAM) data is not processed ...” To “The camera (CAM) data are not processed . . .”

Page 2961, line 24: Comment: “ . . .the camera was originally installed to check align-

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ment onboard." What alignment? The interferometer, the pointing mirror?

Page 2962, lines 3-5 state: "The two axes optical mirror pointing mechanism has pointing and image motion compensation functions and the views of the earth and the calibration sources". Comment: Perhaps re-write as: "The two-axis optical mirror pointing mechanism has pointing and image motion compensation functions, allowing precise viewing of the earth and the calibration sources."??

Page 2962, Line 6: states: "the grid points". Comment: What grid points? You haven't introduced figure 2 yet. The grid points are not described until the next section (1.3). Suggest you modify this sentence to "the earth close to nadir", or introduce the grid point concept earlier.

Page 2962, line 9: Change: "an actuator rotary voice-coil" to "a rotary voice-coil actuator".

Page 2962, lines 10-11: Change: "The performance of these two mechanisms on orbit has to be carefully characterized and the performance is described in Sects. 2.2.3 and 3.4." to "The performance of these two mechanisms on orbit has been carefully characterized and is described in Sects. 2.2.3 and 3.4."

Page 2962, lines 15-16: Change: "During the day time both SWIR and TIR of TANSO-FTS and TANSO-CAI data are acquired and during the night time only TANSO-FTS TIR data is acquired" to "During the day time both SWIR and TIR of TANSO-FTS and TANSO-CAI data are acquired. During the night time only TANSO-FTS TIR data are acquired"

Page 2962: lines 19: Change: "On orbit the response change with time has been monitored for three years and characterized in this paper. To "The on-orbit response changes have been monitored for three years and their characterization is described in this paper.

Page 2962, line 21: Change: "performances" to "performance"

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Page 2963, lines 11-13: Change: “GOSAT has a 3-day revisit orbit cycle and a 12-day operation cycle. There are three operation patterns on how to insert the target observations to the nominal grid observations.” to “GOSAT has a 3-day revisit orbit cycle and a 12-day operation cycle. Three different operational patterns have been employed to insert target observations into the nominal grid observations.”

Page 2963, lines 24-25: Change: “The FTS mechanism controller counts laser fringes for uniform-speed scans within the maximum optical path difference (MOPD) and then drives the FTS-mechanism scan-arm to motion. Turnaround is a loss of observation time, which needs to be minimized” To “The FTS mechanism scan arm is servo-controlled using the laser fringes. This achieves uniform scan speeds within the maximum optical path difference (MOPD) followed by rapid reversal of the scan-arm motion (turn-around). Since no useful data are acquired during turn-around, its duration is minimized.”

Page 2964, lines 6-21: Comment:. I don’t understand how the M-shaped scan pattern avoids the along-track dead bands. Perhaps add the location of these dead bands to figure 2.

Page 2964, line 25: Change “a total of 56 000 points globally” to “a total of 56 000 soundings globally”. A more general comment is that the word “point” is over-used in the manuscript. It is used to mean several different things: an interferogram sample, the number of difference places on the earth that are viewed (grid-points), the number of times that the earth is viewed every 3 days. I strongly suggest that different words (e.g. soundings, samples) are used to replace some of the usages of “points”, avoiding over-use.

Page 2966, line 6: Change: “Step S2: Correction of spike noise detection caused by cosmic rays onto the detector” to “Step S2: Correction of spikes caused by cosmic rays hitting the detector”

Page 2967, line 12: ”65400”. Question: Why is this different from 2ˆ16 = 65536?

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Page 2968, line 25: Comment: Don't say: "the most recent version. . .". Instead, state the current version number. Otherwise, somebody reading this paper in a few years will be mis-led if you subsequently re-instate the ADC non-linearity correction.

Page 2979, line 23: Change: "The vertical lines in the figures represent the time of the vicarious campaigns." To "The three vertical lines in each panel of figure 8 represent the times of the vicarious campaigns."

Page 2969, line 26 states: " TANSO-FTS has. . . two 1.31 μm distributed-feedback (DFB) lasers, which have much longer life time than a conventionally used HeNe laser". Comment: I'm surprised to see lifetime cited as the main advantage of diode lasers. I would have thought it more important that they are much smaller, more robust, and their low voltage power supplies don't arc azt low pressure.

Page 2969 line 27 to page 2970 line 6. Comment: This needs to be re-written. The reason for the Band 1 being AC-coupled is not adequately explained.

Page 2970, line 11: "Scene signal modulation". Question: Is this the interferometric modulation, or something else?

Page 2971, line 15-20: Change: "The high gain of Band 1 has high amplitude and its high-gain amplifier uses . . .." To "The high gain amplifier of Band 1 uses a Chebyshev filter with a sharply peaked gain and cut-off to avoid aliasing of noise. Unfortunately, its gain is sensitive to the capacitance in the circuit, which varies with input voltage, temperature, and time. For the other bands, Butterworth filters are used, which have much flatter responses, so capacitance change results only in small shifts in their cut-off.

Page 2972, line 12 states: "As the difference is constant with time on orbit, this non-uniformity is corrected by resampling the interferogram.". Comment: Since the sampling interval varies with OPD and scan direction, which are continually changing, it cannot be "constant with time". It is, however, reproducible/predictable, which allows a

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correction to be made once you have established the functional form. But how was this done on orbit?

Page 2973, line 10: Question: What is this "background radiation"? Is it the instrument self-emission?

Page 2973, line 19 states: "the exact maximum OPD are 1309.742nm$\times$76 336/2=$\pm$2.4995 cm" This is confusing. The sampling interval is 1309.742 / 2 nm because TANSO-FTS samples twice per laser wavelength. I suggest rewriting as "the exact OPD maxima are 1309.742 / 2 nm $\times$ $\pm$38168 = $\pm$2.4995 cm". To me this is more intuitive and numerically correct"

Page 2972, line 22-23: Comment: You state that a prime number IFFT is employed to save computation time. How much faster is a 76545-point prime factor FFT than a 217-point FFT? I suspect that the difference is small. The real advantage of the prime factor FFT is that the size of the resulting spectrum is minimized without any loss of information.

Page 2980, line 4: Change: "solar the zenith angle" to "the solar zenith angle".

Page 2983, line 10 states: "There is no stable onboard white light source available today for radiometric calibration purposes. Therefore, SNR cannot be measured explicitly. It is estimated from the imaginary spectra or out-of-the band real spectra." Comment: Isn't the sun a stable white light source? Please explain the desire for an on-board white light source. Which kinds of spectra are used for estimating the SNR? Deep space, glint, nadir, spectralon?

Page 2983, lines 15-22 state: "There are two dominant noise sources for TANSO-FTS bands 1, 2, and 3. One is the detector and its electronics noise, which is independent of the input signal level and proportional to the square root of the band width. The performance can be measured with dark input data and can be expressed with specific detectivity (D*). The second source is the shot noise, which is proportional to the

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square root of the total number of input photons. Band 2 has wide band width of 5800–6400 cm−1 to cover CO2, CH4 and H2O lines, while the shot noise contribution is larger than in the other two bands." Question: Why is the shot noise contribution larger in Band 2 larger than in the other two bands? It is stated that both the detector/electrical and the shot noise scale as the square root of the band width. So the larger band width of Band 2 will increase ALL noise terms. So why is the relative shot noise contribution larger in band 2? Perhaps the "band width" on line 17 is not the same thing as the "band width" on line 20.

Page 2984, line 15, Suggestion: Please describe the nature of the "monochromatic light". Is this the same thing as the "onboard diode laser" mentioned in the figure 10 caption?

Page 2984, lines 25-27, Question: What is the wavelength of the ILSF calibration laser? Does the laser fill the finite FOV of the interferometer.

Page 2985, line 7: Change "%" to "ppm".

Page 2985, line 8: Change: "We expect the laser has sufficient level of control after 10 yr of operation." To "We expect the laser will still have a sufficient level of control after 10 yr of operation."

Page 2985, lines 5-6 state: ". . .we have observed a gradual decrease of the laser signal detection level and an increase of the apparent wavenumber of the Fraunhofer lines". Question: Are these two things related? If so, please explain how.

Page 2985, lines 9-10 state:" Because all the bands of 1, 2 and 3 have the constant wavenumber shift, the most probable cause is the optical alignment change of the laser beam on orbit". Comment: A change in the alignment of the laser beam would cause a shift that was proportional to wavenumber (i.e., a stretch), not constant.

Page 2985, lines 10-12 state: "..the most probable cause is the optical alignment change of the laser beam on orbit as illustrated in Fig. 11. Consequently, MOPD

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has become larger and spectral resolution has become slightly higher." Comment: I'm struggling to reconcile this statement with figure 11, which illustrates that the misaligned laser OPD is *shorter* than the well-aligned laser path. Since the MODP actually got *larger*, does this mean that the laser alignment has improved since the start of the mission?

Page 2985, lines 20-21: Change: "The optical mirror pointing mechanism has two different speed motions; IMC and pointing of the earth surface during turnarounds." To "During interferogram scans, the optical pointing mirror is turned very slowly to perform IMC. Then, during turnarounds, it quickly steps to the next point of the grid pattern."

Page 2986, line 19-20 states: "The protection coating on the pointing mirror made of silver surface has a polarization phase." Comment: In this sentence it isn't clear whether the term "made of a silver surface" refers to the protection coating or the pointing mirror. Usually, protective coatings are made from a dielectric, not silver. Or perhaps the authors mean "reflective coating", not "protection coating".

Page 2988, lines 9-15: Change: "The quality flag of spike noise flag in the Level 1B product shows both fluctuation of the interferogram and spike caused by the cosmic rays. For the last three years after the launch, no spike caused by the cosmic ray has been detected. The FTS mechanism scan speed instabilities larger than 2% are to be detected by monitoring the passing time of the 10 different OPD positions. However, the stability on orbit is much better than 1% and the speed instability has never been detected since the launch." to "The noise spike quality flag in the Level 1B product can be triggered by rapid fluctuation of the interferogram intensity and by spikes caused by cosmic rays. For the three years since launch, no spikes caused by cosmic rays have been detected. FTS mechanism scan speed instabilities larger than 2% would be detected by monitoring the passing times of 10 different OPD positions. However, the stability on orbit has so far been much better than 1% and so the speed instability flag has not yet been triggered.

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Page 2988 linea 21-23: Comment: I'm surprised to read that the TANSO spectra are corrected for the ILS broadening due to the finite-FOV-effect. What is the advantage of doing this in the case of TANSO? I understand that in the case of AERI this allows a more direct comparison of spectra from instruments having different FOV's, but this advantage does not seem to apply to TANSO.

Page 2990, lines 14-15 state: "Radiation from the aperture of the integrating sphere has angular distribution especially for bands 1 (UV) and 4 (SWIR)." Comment: Ignoring the missing article before "angular", what does this sentence mean? The radiation must have an angular distribution for all bands. What is special about bands 1 and 4? Perhaps the authors mean that "Radiation emanating from the aperture of the integrating sphere has a non-Lambertian angular distribution, especially for bands 1 (UV) and 4 (SWIR)."

Page 2990, lines 20-21: Question: What is this "limb darkening"? This term usually refers to the solar disk, but in this case it is evidently something else.

Page 2991, lines 12: Explain briefly how an airplane (v=0.25 km/s) stays in formation with GOSAT (v=7 km/s).

Page 2991, lines 16-18: Change: "First, we selected the site data where standard deviation of the measured earth albedo between 3 by 3 pixels of TANSO CAI was lower than 0.005." To "First, we selected the site data where the measured earth albedo was uniform to better than 0.5% across the 9 (3 by 3) pixels of TANSO CAI."

Page 2991, lines 19-20: Change: "...degradation of..." to "...degradation over...". Comment: It is not the site that is degrading, it is TANSO.

Page 2992, line 11: Change: "THETA_atc and THETA_atc are the AT and CT angles from the nadir" To "THETA_atc and THETA_ctc are the AT and CT angles from the nadir"

Page 2998, Table 2: Comment: It is not clear whether the Notes apply to FTS, CAI or

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Interactive Comment

both. And what is the meaning of the ">" symbols in the notes?

Page 3003, Figure 1: Suggestions: Add blue arrow from Spectralon Diffuser to Pointing mirror. Change "After Optics" to "Aft Optics".

Page 3005, Comment: In Figure 3 the spectral radiance units are denoted as "V/cm-1". Elsewhere in the paper the units are denoted as "V cm", which is the same thing, but in my opinion less intuitive. You should express the spectral units consistently throughout the paper.

Page 3010, Figure 8: Suggestion: Add labels (a) and (b) to the appropriate panels.

Page 3011, Figure 9: Questions: Why does the y-axis annotation say "Jun-Jul". I thought that the ratio was for June 2009 and June 2010. And why does site "Sahara 8" have ratios of 1.00 for all bands? Is this just a coincidence, or has some normalization taken place?

Page 3012, Figure 10: Suggestion: Add labels (a) and (b) to the appropriate panels. Specify the wavelength of the on-board diode laser.

Page 3018: Figure 16: Suggestions: Add labels (a) and (b) to the panels. Also, change: "Fig. 16. (a) TANSO-CAI degradation in one year between 2009 and 2010 over the Sahara and Arabian deserts in June. (b) The same as (a) but for between 2010 and 2011." to "Fig. 16. TANSO-CAI degradation over the Sahara and Arabian deserts. (a) between June 2009 and 2010, (b) between June 2010 and 2011.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 2959, 2012.