Review of the AMT manuscript amt-2022-129

Overall assessment

This is an important paper from the Japanese team of GOSAT (with one US co-author) on the radiometric calibration of TANSO-FTS-2 in the TIR bands with some discussion of the earlier TANSO-FTS instrument. The paper is rather technical but deserves publishing in AMT after accounting for the modifications suggested in this review and consideration of some questions. Figures, although numerous, are presenting in a compact and visual manner the main results of the radiometric differences between the Japanese instruments and two well validated infrared sounders (IASI from CNES and AIRS from JPL). An extensive reference is done to a previous paper on the subject by Suto et al. (2021). But as suggested below, the authors should help the reader to read this manuscript in a more stand-alone mode. A final recommendation is given at the end of this review.

Note that remarks from an anonymous reader at https://doi.org/10.5194/amt-2022-129-RC1 are endorsed by the present review and should also be taken into account.

Suggested detailed modifications

The reviewer is using **l.xxx** (in bold) for the line to be modified and the convention old text → new text for the proposed changes. [A text between brackets is a comment/question/explanation as this is done here!]

General comment: one could just use TANSO-FTS-2 and TANSO-FTS instead of "the TANSO-FTS-2" and "the TANSO-FTS". This has been done in the following proposed modifications but not everywhere in the text.

l.12 …to longwave Thermal InfraRed radiation (TIR) with 0.2cm^{-1} spectral intervals.

→ …to the longwave Thermal InfraRed (TIR) with a 0.2 cm^{-1} spectral sampling.

[Space between value and unit; "intervals" is a little confusing; one could add that the FWHM of the unapodized spectra is ~0.240 cm^{-1} (in the infrared channels)]

l.56 …consistent with these satellite's intercalibration data,…

→ …consistent with the intercalibration data of the other TIR sounders mentioned above,…

l.70 …a non-linear response… → …the non-linear response of the infrared detectors…

l.99 …considers up to the linear and quadratic terms.

→ …considers only the linear and quadratic terms (neglecting the cubic one).

l.105 with a quadric term… → with a quadratic term only…

L.140/l.142 Choose between Mueller or Muller but do not use both forms! What about Müller?]

l.142 …and CT rotation… → …and cross-track (CT) rotation angle (called θ_{CT} in the following)…

[In several instances specific notations for the various parameters or variables are used in the equations but not defined early enough for the reader to follow them smoothly. The reviewer has tried to improve this situation. But the question of equations is also discussed below in a dedicated section of this review]

l.176 The term in equation (11) already corrected the non-linear effects.

→ The multiplicative factor of the first term of equation (10) is called Cal_b in the following equation (11) and includes the non-linearity correction. [Check if it is OK and see the discussion below on the equations concerning the subscripts *b* and *d*]

l.179 Equation (11) should read Cal_b = […]

l.181 …equation (6), the equation (11) is extracted as equation (12).

→ …equation (6), equation (11) can be recast as equation (12).

l.186 [The symbol a_2 is not specifically defined in equation (12). It should (perhaps) be related to $a_{nlc,b}$ of equation (2). The variable p_g is not precisely defined. Overall the text there is hard to follow!]

[Check if equation (12) coul read:] Cal_b = […] = […]

l.189 the polarization axis of the internal optics is rotated at 90° from the nadir observation.

[This is not quite clear and the reviewer is suggesting the following]

→ the pointing mirror is rotated along its axis by ±90° (from the nadir observation) to view the deep space (ds) or the internal calibration target (ict).

[This would be consistent and will recall the notations introduced earlier in the text. The polarization effect is implicit because the incidence angle on the mirror would change. Relating the angle to the CT angle θ_{CT} already introduced would be even better. Could one specify that $\theta_{CT} = 0$ is exact nadir?]

l.190 …the difference in input optical angles. → …the difference in incidence angle on the pointing mirror.

l.202 …(ict or internal target) is a contamination of a direct emission from the blackbody and reflected…

→ …(ict for internal target in the various symbols used) is a combination of the direct emission from the black body (at the temperature T^{ict}) and the reflected…

[One has to decide between black body and blackbody consistently in the text]

l.223 for p and s → for p and s polarizations (see subscripts p and s in the corresponding symbols)

l.224 Transmittance for p- and s-polarization signals for internal optics → Transmittance for the p- and s-polarized beams within the FTS

l.225 Radiance for temperature T^{ict}, and wavenumber $\sigma_b[n]$

→ Radiance for black body at a temperature T^{ict} and wavenumber $\sigma_b[n]$

[The authors should better explain what is [*n*]. Is it the channel index (CO_2, window, O_3, CH_4) used in Tables 1, 2 and 3 as well as in the figures?]

l.226 …between calibration angles (ICT and Deep-space)

→ …between different pointing mirror angles towards the black body (ict in the various symbols) or deep space (ds in the various symbols)

l.229/230 [The symbol SAA is not precisely defined and could induce confusion with the South Atlantic Anomaly. Could the authors propose a different acronym?]

l.231/232 [Same question for the definition of OMA]

l.238 …complex index of the mirror sample… → …complex index of refraction of the mirror material (with coating)….

l.239 …actual mirror. → …actual flight mirror.

l.240 [One could add:]

→ A star as superscript is used for the complex conjugate in equations (25) and (26).

l.241 Equation (22)

[The authors should define more precisely CTang and ATang and make the link with θ_{CT} already introduced or could possibly use θ_{AT}? The angles CTang and ATang are appearing in Figure 3 and are called "AT angle" and "CT angle". This is fine but this is introducing new notations. TANSO-FTS is on the same footing as IASI and AIRS and the corresponding viewing direction across track is called "scan angle". A better explanation of these various angles (in particular a more consistent choice of notations) would be useful. The same type of comment is appearing several times below]

L.259 **[**Is there a difference between the "pointing mirror" and the "scan mirror"? The scan mirror could be understood as the moving mirror of the interferometer. This is to be clarified and consistent notations should be used in equations (27) and in **l.234**]

l.272 …the ratio of the p and s internal optics against… → …the ratio of the p and s transmission against…

[It is unclear at this point if it is the ratio of the signals at the output of the detector or if it is the ratio p_1/s_1 or p_2/s_2 or the compound product. The caption of Figure 2 seems to indicate that this is the transmittance ratio p_2/s_2. The authors should clarify this point and make a better link between words in the text and symbols in the equations]

l.281/282 …the difference of spectral radiance between the TANSO-FTS-2 and IASI with SNO condition. → …the difference of spectral radiances between TANSO-FTS-2 and IASI in SNO condition.

l.282 The variation range of brightness temperature between the TANSO-FTS-2 and IASI is wider than that of AIRS, then the SNO condition for IASI data is applied.

→ The range of brightness temperatures for the comparison between TANSO-FTS-2 and IASI is wider than that of AIRS, so the SNO condition for IASI also apply for AIRS.

[Is this what is meant? The initial sentence is not very clear]

l.317 …in the channels of CH_4. → …in the region around 7.6 µm covering the strong CH_4 signature.

[See below for the exact definition of "channel"]

l.327 …of the brightness temperatures difference… → …of the brightness temperature difference…

[plural not needed]

l.328 …for four channels…

[An exact definition of these channels is needed. How are the radiances in the wavenumber interval (to be specified) converted into scene brightness temperature? This is important since brightness temperature differences are then plotted and discussed]

l.332 …for the TANSO-FTS comparison. → …for comparison with the first TANSO-FTS instrument.

l.337 The comparison between the TANSO-FTS-2 and TANSO-FTS has a discrepancy in the low-temperature region, but we concluded that version v230231

→ The comparison between TANSO-FTS-2 and TANSO-FTS shows a significant difference for low-temperature scenes but we have to conclude that version v230231

l.349 …with TANSO-FTS-2 1° bin averaged along and cross-track angles.→ …with TANSO-FTS-2 in 1° bins of the pointing mirror angles along and across track.

[The authors could introduce the corresponding symbols. The symbol θ_{CT} has already been defined. Could one use θ_{AT}? See a similar comment above]

l.350 The coincident observations between the TANSO-FTS-2 and the AIRS were selected +40° and -40° of the AIRS cross-track angle and the related along-track of the TANSO-FTS-2 listed in Table 1. For the IASI cross-track angle, +20° and -20° of the IASI data were selected.

[As such, the sentence in the text is hard to understand but Table 1 is helping. Again, using better notations for the angles will help both in the text and in the table. One could use θ_{CT}(TANSO-FTS-2) and θ_{AT}(TANSO-FTS-2) as well as θ_{CT}(AIRS) and θ_{CT}(IASI), insisting on the possibility of TANSO-FTS-2 to acquire footprints with large along-track angles as compared to the 3 other infrared sounders]

→ The coincident observations between TANSO-FTS-2 and AIRS in the 2O-SONO configuration presented in Figure 7 were selected with θ_{CT}(TANSO-FTS-2) angles in the range +40° and -40° and θ_{CT}(AIRS) angles in the range +40° and -40°, whereas the related θ_{CT}(IASI) angles are in the range +20° and -20°as listed in Table 1.

l.354 …within the ±10° along-track angle.

→ …with θ_{AT}(TANSO-FTS-2) angles in the range ±10°.

l.354/355 Figure 7(a) also … along-track angle.

[This sentence is redundant with the preceding one and with the proposed modification. It can be suppressed]

l.356 …of the TANSO-FTS-2→ …of TANSO-FTS-2

l.357/358 In contrast, … is not clear except for the CH_4 channel in a cross-track angle of 5° to 10°.

→ In contrast, … is not striking except for the CH_4 channel for θ_{CT}(TANSO-FTS-2) in the range 5° to 10°.

l.359 to **l.383**

[The reviewer recommends using symbols for θ_{CT}(sounder) and θ_{AT}(sounder) with sounder = TANSO-FTS-2, TANSO-FTS, AIRS and IASI to make the text more fluid, like what has been proposed above. The changes are not explicitly proposed here but should be made by the authors]

l.366 …and window. →…and in the atmospheric window region.

[Again the corresponding wavenumber interval should appear somewhere in the text or in a Table. See also the question on the conversion of spectral radiance (middle of the interval or integration over the full interval) to brightness temperature and then brightness temperature difference]

l.371/372 **…**results of comparing AIRS and IASI are not supported.

[This sentence is quite unclear]

l.378 …to the temperature bias on TANSO-FTS… → …to the temperature bias in TANSO-FTS…

l.380 the scene selection mirror… → the scene pointing mirror…

l.384 and IASI is well. → and IASI is quite satisfactory.

l.395 …for scenes brighter than… → …for scene temperatures brighter than…

l.398/399 In the nominal temperature region, such as 280 K brightness temperature, the agreement… is well.

→ For scenes with brightness temperatures around 280 K, the agreement… is quite satisfactory.

l.399 However, only TANSO-FTS suggests the brightness temperature bias in a cold scene over a high latitude region and is a challenge of TANSO-FTS.

→ However, comparisons of the 3 other infrared sounders with TANSO-FTS suggest a cold brightness temperature bias for cold scenes in high latitudes regions and this is an indication that the current products of this latter instrument have to be improved in these observation conditions.

l.469 [The link in blue should be of the same font as the other ones used in other references]

Equations

More care should be given to the consistency between the equations and the notations defined either in the text or following them. As an example in (1), the variables $DAC_{\mathrm{scale}b}$ and $DC_{\mathrm{offset}b}$ are used whereas they appear as DAC_scale_b and DC_offset_b in the following text. The latter version is probably better to avoid subscript of subscript.

Similarly, DN_b is used whereas $DN_{b,d}$ is appearing below. The corresponding definition could be "Digital count for each interferogram" rather than "Digital number for each interferogram".

In equation (5) the slowly varying terms $DC_b - a_{nlc,b}DC_b^2$ that appear in (4) have been neglected. This should be explained by saying that during the FFT numerical processing these terms are suppressed. It would have been interesting to plot a real interferogram to show how what is considered as the baseline is really constant or slowly varying. A comment about this would be welcome.

Equations (7) and (8) are quite difficult to follow without helping the reader to understand the various variables that should be explained upfront. In the Stokes vector S_{T_input}, the symbol $B(T_{scene})$ is used. What is $B(T_{scene})$? This could be appropriate for a black body view, but not for an atmospheric scene. Or is it a "mean" scene temperature? [See question for **l.327**]

In **l.143**, 3 variables are introduced but two only seem to be defined just after their symbols.

The term $2p_1\ (\sigma)q_1\ (\sigma)$ should read $2p_1(\sigma)q_1(\sigma)$ [no space] in the matrices of **l.155** and **l.160**

The matrix E in **l.160** is not defined explicitly and is (probably) the identity matrix. This should be made clear.

The following definitions should be explicit [superscripts are used since one needs this form to be consistent with similar symbols found in equations (10) to (13)]

S^{ds} is the deep space signal [or radiance? This is to be defined]

S^{obs} is the atmospheric signal [or radiance? This is to be defined]

S^{ict} [written as S_{bb} in (9)] is the signal [or radiance? This is to be defined] when viewing the calibration black body at temperature T^{ict} [not T_{bb} since *b* is already used as subscript for band]

In **l.171**, one finds $B(T_{scene}) = L_{b,d}^{obs}$ [and this could be an answer to one of the above questions]. But why adding the additional subscript *d* without further explanation? Is *d* referring to one of the 4 "domains" or channels. The subscript *b* seems to be used for the band (B4 or B5). It would be easier to just drop *d* and explain that the equations pertain to both infrared bands and 4 domains with specific parameters for each of them. Is this why the wavenumber variable σ is appearing in the variables $p1(\sigma)$, $q1(\sigma)$, $p2(\sigma)$ and $q2(\sigma)$?

In equation (10) the variables $B_{b,d}^{ict}$ [that could be simplified as B_b^{ict} if the subscript *d* is dropped] and $L_{b,d}^{m\_obs}$ should be defined and/or related to previously defined variables.

In equations (15) to (20) the notation [*n*] is appearing without detailed explanations. This question has already been raised for **l.225**.

In equation (21) the variables A with superscript are dimensionless since their sum is unity. They are later defined as "view" and that is unclear. The symbol BS appears **l.233** and should be defined there as beam splitter. The same is true for SAA and OMA as already noted in comments for **l.229/230** and **l.231/232**.

Overall a more consistent use of symbols with subscripts/superscripts in the text and in the equations is needed.

Tables

Table 1

Title: Temporally and spatially co-incident conditions

→ Temporal and spatial coincidence conditions

First column header: Coincident type → Coincidence type

Table 2

Title: The averaged difference (Ave.) and deviation (SD.) of brightness temperatures between TANSO-FTS-2 and multi-satellite sensors with SNO

→ Average brightness temperature difference (mean) and standard deviation (stdv) between TANSO-FTS-2 and 4 other infrared sounders in the SNO configuration

[The proposed notations seem better than Ave. and SD.]

First column: [Since SNO is in the title, there is no need to repeat it after the name of the sounder. The column header could just be Sounder and this would help to avoid the unnecessary increased line spacing for TANSO-FTS. Try to reduce the width of the second column by replacing "Matchups" by "SNO". Include the line for sub-column headers defining mean and stdv into the line defining the channels. The word channel could even be replaced by the limits in wavenumber of the corresponding spectral domain]

Table 3 [As above, the proposed title could be]

→ Average brightness temperature difference (mean) and standard deviation (stdv) between TANSO-FTS-2 and 4 other infrared sounders in the 2O-SONO configuration

[Try to have changes consistent with the ones proposed for Table 2]

Figures

Figure 2

Caption: p- and s-polarization against → p- and s-polarization $p_1(\sigma)/q_1(\sigma)$ against

Figure 4

Caption: for SNO (a) and SONO(b) → for SNO (a) and 2O-SONO (b)

Figure 5

…differences in 1 K gridded against window temperature… → …differences in 1 K bins against scene temperature…

[See below for the distinction between "window" and "channel"

…and each shade presents a standard deviation (1σ) for each 1 K grid

→ …and each shaded area presents the standard deviation (1σ) for each 1 K bin

Figure 6

Caption: average against window temperature → average against channel temperature

(d) window channels → (d) atmospheric window

[This is to avoid "window" used for channel (d). But as recommended above the limits of the domains or channels should be given]

Figure 7

… temperature difference in 1° grided bins average against …

→ … temperature difference in 1° angular bins against …

The shaded lines present the deviation (1σ) for each grid

→ The shaded area presents the standard deviation (1σ) for each 1° bin

[The definition "Coincident num." on the right vertical axis of each sub-panel (a), (c) and (e) is too close to the definition "Diff. Temp [K]" of the sub-panels (b), (d) and (f)]

Figure 8

The 1° × 1° gridded… → The 1° (AT) × 1° (CT) gridded…

Figure 9

… temperature difference in 1 K gridded average against …

→ … temperature difference in 1 K bins against …

…with deviation (shaded lines) → …with the corresponding standard deviation (shaded area)

(d) window channels → (d) atmospheric window

Final recommendation

The reviewer took from its time to propose a large number of modifications because he thinks that the work is important to pass the proper information to the wider user community of TANSO-FTS-2 and TANSO-FTS data (L1 and L2). Some minor changes are easy to implement, but a more challenging task will be for the authors to make a better link between the text, the notations and the equations. The reviewer is hoping that this can be done so that a revised version can reach the proper level of clarity for AMT readers. The huge amount of work done in comparing the radiometry of the Japanese sounders TANSO-FTS-2 and TANSO-FTS with IASI and AIRS is deserving it (if properly presented).