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Atmospheric Measurement Techniques Discussions

Interactive comment on "TanSat ACGS on-orbit spectral calibration by use of individual solar lines and entire atmospheric spectra" *by* Yanmeng Bi et al.

Anonymous Referee #1

Received and published: 6 July 2020

The manuscript deals with spectral calibration of the ACGS sensor on TanSat. Two spectral calibration methods are explained and insight is given on the spectral variations and stability of the sensor. The information on the choices made on the calibration approach and the spectral stability of the sensor is of interest to the greenhouse gas retrieval community. Overall, the topic is considered adequate for publication in AMT. A revision of the manuscript is needed before publication addressing the issues identified below.

General Comments

1. Abstract and introduction fall short in explaining the role of the two methods and

to which kind of observation they are applied. Later in the manuscript it seems that Method 1 (using individual Fraunhofer lines) is applied to solar irradiance measurements only and allows the determinations of ground-to-orbit shifts and to monitor day to day variability as well as longer-term trends, and that Method 2 (using entire atmospheric spectra) is applied to Earth radiance measurements only and allows also the determination of intra-orbital variations. Please clarify this upfront, already in the abstract and the introduction.

2. It is stated that Method 2 is used for verifying Method 1 (Section 3.2) and that close consistency has been found (abstract). Please clarify how this verification has been made and what exactly has been compared for this purpose. Have orbital averages from Method 2 been take for this? A figure with results from both methods depicted over the orbital phase would help to illustrate the level of consistency. Have longer time series of the two methods been compared? Please add such figures.

3. It is not clear whether the two spectral calibration methods are employed only for off-line analysis by hand or to which degree they are implemented in the systematic processing op to Level-1 (as suggested at Line 110 for Method 1). Please clarify this upfront.

4. Please introduce the spectral requirement(s). Are there separate requirements on a) shifts with respect to the ground characterisation, b) on in-flight spectral stability (at Level-0 prior to spectral calibration), and c) in-flight spectral knowledge at Level-1b (after spectral calibration). Please introduce the requirements explicitly. It would be nice if the spectral calibration requirements were introduced with a short discussion on the tracing to the CO2 product uncertainty requirement.

5. The L1b users are certainly interested in the performance of the two methods, which is unfortunately not reported. If possible, please give estimates for the uncertainty of the spectral axis obtained by the two methods.

Specific Comments

Abstract line 9: it is stated that the observed spectral variations are partly caused by vibrations. This is not understood. It is expected that mechanical vibrations within the spectrometer, in particular causing displacement of the slit with respect to the detector can cause a widening of the instrument spectral response, but not a shift of its barycentre.

Please introduce a blank space between numbers and units throughout the manuscript.

Line 39: When discussing the aim of the study ("only study the wavelength offset or shift with respect to pre-launch spectral calibration.") please distinguish between ground-to-orbit change and in-orbit variability. Also please include a discussion of the spectral knowledge needs.

Line 40: It is argued that the ILS can be assumed to be constant on orbit "because a common diffuser is used for solar observation". This is not understood. In what sense and across which elements is the diffuser "common"? Across the spectral bands? It is not clear how diffuser features or the use of different diffusers would possibly introduce spectral variation.

Line 41: It is referred to "decon events". Please expand / clarify what is meant: decontamination"?

Line 41: Please complete the discussion of "decon events" by stating whether such events could affect spectral variability, e.g. by changes in thermo-mechanical loads within the spectrometer.

Line 46: Please change "methods to evaluate the ACGS's wavelength calibration connecting each focal plane array (FPA) pixel to a specific wavelength." to "methods to assign a specific wavelength to each focal plane array (FPA) pixel of the ACGS."

Line 55: expand "shift and squeeze" to "shift and squeeze of the spectral axis".

Line 61: Typo: change "telescope aperture" to "spectrometer aperture". Section 2.1 It is not explained how the coefficients of the spectral axis (Eq 1) are derived from the

in-flight spectral shifts determined at individual Fraunhofer lines. Please clarify.

Line 71: please add: the number of SPECTRAL pixels in the . . . bands.

Line 72: please use the label "O2A band" as introduced earlier for the ACGS spectral band throughout the manuscript (as opposed to the "O2 A-band" as labelled by Fraunhofer in 1814).

Line 72: typo: change "s" to "a"

Line 72: please change "two pixels per full width at half maximum (FWHM)" to "two pixels per spectral resolution increment (defined as the full width at half maximum (FWHM) of the ILS"

Line 76: change "in three band" to "in the three bands"

Line 77: what is meant with "some middle pixels"? in the centre of the field? In the spectral centre of the bands?

Line 84: Please justify the adequacy of this parameterization e.g. by discussing the expected or observed smoothness of the wavelength as a function of pixel number. The polynomial used is a function of the index p rather than the index difference with respect to the centre pixel index. This asymmetry would cause instabilities to occur near the band edge with higher index numbers, if they occur. Please discuss if this is relevant here.

Line 87: Please clarify what is meant with "the sampling resolution" of the Kurucz's spectra. Is it spectral sampling or spectral resolution?

Line 87: The solar reference spectrum by Chance and Kurucz (JQSRT, 2010) has a spectral resolution of 0.04 nm and a spectral sampling of 0.01 nm. Please correct or clarify. Please clarify which spectrum is used for which spectral domain, as the solar reference spectrum by Chance and Kurucz does not cover wavelengths larger than 1000 nm. Please specify spectral sampling and resolution of the reference spectrum

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Line 90: The statement that the spectral resolution of the solar reference spectra is one order of magnitude higher than the spectral resolution of the ACGS seems not valid (see comment on Line 87). Please correct or clarify.

Line 109: change “are” to “is”

Line 114: Reformulate “The wavelength offsets of each band have annually variation in a year.” Proposed “The wavelength offsets of each band exhibit an annual variation.”

Line 116: Reformulate “There are little thermal gradient” to something like “thermal gradients are small”, please quantify.

Line 117: The slit is missing in the listing of relevant optical component in this context. Please add.

Line 118: changeS

Line 118: It is stated that “offset which are similar for each FOV”. Please clarify if that is expected because of the spectrometer design or whether this is simply a finding of this analysis.

Line 124: Please add “insensitivity” to “insensitivity of the spectral response”

Line 126: it is not clear in which sense the detector material is relevant for the sensitivity to thermal variations. Please explain. Is it about thermal expansion of the detector?

Line 129: Change “in UV-visible bands” to “in the O2A band”. ACGS does not cover the UV.

Equation 3: The contributions to the cost function are weighted by the inverse of the measurement noise, so the weight is lower in the Fraunhofer and their wings lines as compared to the continuum. It is not clear whether this weighting strategy is useful, in view of the fact that the spectral information is exactly in these spectral regions. Please

discuss / consider.

Line 142: It is not satisfactory to state that “the search routine” is used to find the minimum of equation (3). Please specify the minimization routine, at least by specifying its class / type, maybe the library from which this routine is taken.

Line 148: The statement “Hence, the result of this method is independent of solar lines and can be compared with the calibration results shown in section 2.” Is confusing. Please discuss in which sense the two methods bring different information and what has been learnt. Please discuss the parts of the orbit in which solar irradiance and Earth radiance spectra are acquired and in which the two methods are applied. Please discuss the thermal behavior of the spectrometer as a function of the orbital phase.

Line 155: the statement “Totally, ACGS has 1242x9, 500x9 and 500x9 different ILS tables in O2 A-band, WCO2 and SCO2 band, respectively.” Is not understood. Are so many ILSs stored in the tables?

Line 170: Please clarify which Earth radiance scenarios are eligible for the spectral calibration. It is assumed that the O2A band all scenes are eligible, while in the SCO2 and WCO2 bands dark ocean scenes might have to be excluded due to low signal and hence low signal to noise ratio levels. It is expected that cloudy scenes are eligible for spectral calibration in view of the high signal to noise ratio and the presence of Earth atmospheric signatures.

Line 176: Please discuss the implication of the observation that “shifts derived from this method agree closely with that calculated from solar spectra”. Please discuss what can be learnt on the orbital variations.

Figures 4-6 caption: Please specify for which year(s) the data are plotted. Clarify whether the wavelength changes shown are averages of spectral shifts determined at a set of Fraunhofer lines, or band-averaged shifts.

Figure 6 caption: Typo. Change “spectral resolution in WCO2 band” to “spectral reso-

lution in SCO2 band".

Figures 7-9 caption: Please specify over which domain and range the statistics are evaluated (is it the temporal variation in the domain as shown in Figures 4-6?

Figure 10 caption: Please mention that results from the second method applied to Earth radiance spectra are shown. Add labels to the three panels indicating the spectral bands.

Figure 11 caption: Change "plus squeezed" to "and squeezed"

Table 2 Caption. It is not clear over what exactly the mean and the standard deviation are evaluated. Is it the statistics shown in Figures 7-9? Is it the spectral variation in all irradiance spectra or in all radiance spectra acquired on the specified day (or something else).

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