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Atmospheric Measurement Techniques Discussions

Interactive comment on "In-flight calibration results of the TROPOMI payload on-board theSentinel-5 Precursor satellite" *by* Antje Ludewig et al.

Anonymous Referee #2

Received and published: 5 March 2020

The paper gives a detailed overview of the in-flight calibration of the TROPOMI instrument on-board the Sentinel-5P satellite platform, launched by the European Space Agency (ESA) as part of the Copernicus Earth observation programme by the European Union. The results from this work leads to an update of the operation Level-1b processor to the version 2, expected to be operational end of 2020.

The paper is well written and in general gives a consistent overview about the investigated and improved calibration issues. The paper will be an important reference for all users of version 2 of the TROPOMI level 1b product.

Main concern from my side is the foreseen radiometric re-calibration of the irradiance

and its impact on the reflectance, see detailed comments below.

With the recommended changes, this paper should be published in AMT.

Detailed comments:

Figures:
Fig 1-3,5,6,11-22: The used fonts are to small, enlarge.
Fig. 7-9: at least the numbers at the color scales need to be larger.
For not so young eyes, the numbers and labels in the printed paper are difficult to read. Please change.

Abstract:
p1 l13: "processing from 2020 on". From my knowledge, late 2020 is the current foreseen start for the version 2 L1b processor. Please adapt the date, also in the conclusions.

1 Introduction:

p2 l41: please define the term "orbit types" (probably the measurement sequence along the orbit.)

p3: Please add (at the end of the introduction) a sketch of the instrument design, it would be very useful for the following paragraphs: Where is the calibration unit, what are the light paths, where are the diffuser etc. Please also add a paragraph or a sketch to the detector layout: row and column is frequently used in the text, but nowhere the spatial and spectral direction is explicitly stated.

2 Thermal stability:

It is observed, that the thermal stability is reduced after orbital manoeuvres. Is there a reason or at least an educated guess for this behaviour? If yes, please add.

7 Pixel saturation and charge blooming:

Are there estimations available, how frequently saturation and charge blooming occur? Which are the suspect conditions (snow? tropical clouds? something else?). Please add.

8 Geolocation:

p9 l161: ..or along-rack.. -> or along-track

9 Spectral annotation:

It is stated, that the calibration key data for the wavelength calibration are updated according to the wavelength fits in the Level 2 algorithms. Are the key data directly used as wavelength axis? There is no Level 1 wavelength calibration?

10 Slit irregularity:

Especially for this section, the definition of rows/columns versus spatial/spectral direction in the introduction would be very useful!

Figure 6:
Change y-axis name to 'binned row counter' (this is the used name in the text). Please add in the caption, that the row 335-337 corresponds to the binned counter 144.

12 Absolute radiometry and instrument degradation

p16 l303ff:
"The specific degradation curves ... are perfect exponential curves".
Here it is assumed, that the degradation behaves exponential, so write something like: "It is assumed, that the diffuser degradation behaves exponential with time. Therefore, the specific degradation curves ... are modelled as exponential curves". Also the exponential behaviour of D_{com} is an assumption and should be stated as such.

p16 l315ff:
"For each of these super pixels the linear system in Eq. (1) is solved. For the UVIS, NIR and SWIR no spectrometer degradation D_{spec} could be determined and this term

is therefore set to unity."
I think, this is the wrong order: For UVIS, NIR, and SWIR, no spectrometer degradation can be derived, therefore D_{spec} is set to 1.0 for theses channels. With this assumption, the linear equations system is solved for each super pixel if UVIS, NIR and SWIR. Right?
Please also give a number, how many pixels are in one super-pixel.

p 16 l317:
"The solutions for D_{q1} , D_{q2} and D_{com} are all three exponential decay functions and perfectly smooth in the temporal dimension."
Your model fits exponential decay functions for this quantities, therefore this is trivial message. What could be stated here is something like:
The assumption of an exponential decay for D_{q1}, D_{q2} and D_{com} is approved by the small residuals R_k/P_k, as shown by the right plots in Fig 12-14.

The explanation for estimating D_{spec} for the UV leaves a few questions open:

D_{com} is extrapolated to the UV region. What about D_{q1}/D_{q2}? What type of extrapolation do you use, so what are the assumptions made? Towards shorter wavelengths, the degradation is expected to increase. According to the left plot in Fig. 11, this is not the case for D_{spec}.

p 17, l 347-352:
For the forward processing, an extrapolation of the degradation parameters is used. It is stated, that this new degradation parameters will be regularly updated by incorporating the recent measurements. With the update, also the extrapolation will change. This might introduce jumps in the irradiance time series, which might be an issue for users. Is there a strategy to monitor and/or avoid this? Please add some information about the details here.

p22, Table 4: The *mean* degradation per Band is given, right? Please clarify.

13 Absolute irradiance calibration:

Why is the OMPS irradiance measurement choosen as the reference measurement for the radiometric calibration? To my knowledge, OMPS is an unusual solar reference measurement. OMPS does not even distribute there irradiance measurements as regular product. The cited literature [Jaross 2014] gives no information about the absolute radiometric calibration except a plot together with an unnamed "synthetic" spectrum. If possible, at a reference for the radiometric calibration of the OMPS irradiance.

Recently re-calibrated and published solar spectra are SOLSPEC (Meftah et al 2018) or SCIAMACHY (Hilbig et al, 2018), which would be a better choice. Both are also independent from other reference spectra.

Nothing is said about the radiance calibration. Is the discontinuity observed in the overlap region also visible in radiances? What about the reflectance?

The light path is the same for radiance and irradiance except the QVD. The QVD is the same for the the UV / UVIS overlap and cannot cause the discontinuity. Therefore, in the reflectance the discontinuity should cancel. If only the irradiance is mitigated here, the discontinuity is introduced in the reflectance. The radiance calibration and the impact of the irradiance mitigation on the reflectance needs to be discussed here.

Conclusions:

p 25, l 434/ 436: 'v1' / 'v2' change to 'version 1' / 'version 2'.
p 25, l 449 : radiometry -> radiometric

References:

Many references contain both the the DOI based URL and a direct URL. Only the DOI URL as permanent URL is needed, skip the second URL (which is also not added consistently...).

For Ingmann et al. the URL is erroneous.

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