

Interactive comment on “Characterization and correction of stray light in TROPOMI-SWIR” by Paul J. J. Tol et al.

Anonymous Referee #2

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General Comments:

This paper presents the laboratory characterization of stray light for the TROPOMI SWIR spectrometer, and the development of a correction algorithm to remove the stray light. The stray light is characterized using a monochromatic quasi-point light source; the signal is obtained with more than 7 orders of magnitude by combining saturated and unsaturated measurements taken at different exposure times. Analysis of the spectral-spatial spread function (SSSF), indicates that the stray light can be approximated by the far field of a stable kernel and a main reflection kernel, both of which do not vary with wavelength and across-track position. A correction algorithm is developed to correct stray light in in-flight observations. Application of the stray light correction to stray light measurements as well as synthetic earthshine observations show that the stray

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light can be significantly reduced. This study presents key information about TROPOMI SWIR and its performance and is very suitable for publication in AMT. This paper is generally well organized, and the methodology and results are generally well described. However, one of the important conclusions “this reduces stray light error sufficiently for accurate gas-column retrievals” is not supported by details. It does not say if the developed correction algorithm is the operational algorithm or will be implemented for operational processing. If it is not the operational algorithm (i.e., described in ATBD). The authors should talk about it in the introduction and if possible compare the performance between this correction algorithm and the operational algorithm. Some of the sentences are difficult to understand and the English writing needs to be improved. The abstract and conclusion can be improved to include more important aspects of this study. Overall, I think that this paper can be published after addressing the comments mentioned here and specific comments below.

Specific Comments:

1. In abstract, L3, the sentence needs to be rephrased to make it read well. You can change it to “For this purpose, it is required to have calibrated radiance measurements in which ...”
2. In abstract, L6, suggest adding “from different exposure times” after “unsaturated measurements”
3. In abstract, L6-8, the sentences do not read well. You may add a little more detail about the algorithm, including the approximation representation with a far-field stable and reflection kernels. Suggest changing the order of sentences to something like “... unsaturated measurements. Analysis of the stray light indicates about 4.4% of the detected light is correctable stray light. An algorithm was then devised ... Applying this correction significantly reduces the stray-light signal for example ...”
4. P1, L15, change “distance” to “interval” as it is more frequently used for the spectral dimension

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5. P2, L7, if it is a common telescope, should it be called as “SWIR telescope”? Suggest changing it to “telescope”
6. P3, first paragraph, it is not clear about why to avoid saturation at the shortest exposure time, and why fewer frames are averaged at longest exposure time. Based on section 3, the shortest exposure is to measure the strong signal while the longest exposure time is to measure the weakest signal in the wing of point spread function. L3-5 of page 4 can be moved here to help understand the purpose of taking measurement at 4 exposure times.
7. P3, L13-14, change to “ensures that no important features only closer to specific wavelengths or swath angles are missed”
8. P3, L15, change to “background measurements”
9. P3, L17, add “as background measurements” after “is used”
10. P3, L18, suggest changing to “The peak in a given detector area only occurs in a small subset of the light measurements, ...”
11. P3, L20, suggest “at which” to “and”, because “the longest exposure time of 1998 ms”, meant by “which” does not occur before “at which”
12. P4 L6, suggest changing to “. . . does not saturate a pixel (a saturated signal . . .)”
13. P4, L8-9, suggest changing to “the signal can be measured with a dynamic range of more than seven orders of magnitude”
14. P4, L11-12, suggest changing to “the signal of unsaturated pixels becomes too high due to spilling from a direct neighbor pixel saturated by light, not dark current”
15. P5, L10-11, agree with the first reviewer, the sentence of “The peak positions and . . . Gaussian and a block distribution in these two dimensions . . .” is not clear
16. P5, L13, change to “After discarding”

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17. P5, last paragraph in Sect. 3, do the last four sentences describe the PRNU correction as it is not clear to me. If not, it is useful to describe the PRNU in a few sentences.
18. P9, L2-3, it is not clear why only stray light originating at spatial coordinates is corrected. Does it mean that the spectral stray light is not corrected? Please clarify it.
19. P10, L4, change “using the element-wise product o” to “where o is the element-wise product”
20. P10, L21, add “is as follows” after “The rationale of this algorithm” as it is not a sentence and change “which is” to “and is”
21. P11, L1, change to “. . . center. The iteration consists of . . .”
22. P11, L7, change to “, as explained”
23. P15, L8, suggest adding “After the stray light correction” before “Some stray light . . .” to make it more readable.
24. P16, Figure 14 caption, change “measurement” to “measurements”
25. P16, the last paragraph that continues on P18 is not easy to understand and seems to distract the flow from Fig. 15a to Fig. 15b. I think that the main purpose is to describe how to construct signal with stray light by convolving Fig 15 a with the SSSF. It is not clear to me about the need to talk about merged frame and conversion to kernels here. Please make the description clearer.
26. Figure 16 caption, suggest changing to “. . . respectively, for the forest spectrum in 2305-2385 nm located four rows from the cloud spectra”
27. P18, L9-10, it is not clear about “one merged frame per 20 pixels”. Do you mean merging 20 pixels across the track (i.e., merging 20 rows)?
28. P19, can you provide more quantitative details to support the last sentence of

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section 8 as this is an important conclusion in abstract and conclusion and the residual error is still up to 1%. In addition, has the instrument noise been added to the simulation? Will the inclusion of instrument noise affect the performance of stray light correction?

29. Also, it is not clear if this stray light correction algorithm is the operational algorithm to be used in level 0 to 1b processor (i.e., described in ATBD)? It looks like it is not, then how is the performance and speed of this correction compared to those of the operational correction?

30. In conclusion, it is useful to expand a little bit about the main idea of the fast correction algorithm (e.g., stable kernel, reflection kernel etc.)

31. P20, L2, this sentence does not read well, suggest changing to "The fitted r_center is 127.5, exactly ..."

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