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Interactive comment on “Retrieval algorithm for CO₂ and CH₄ column abundances from short-wavelength infrared spectral observations by the Greenhouse Gases Observing Satellite” by Y. Yoshida et al.

Anonymous Referee #3

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General comments:

The authors provide a detailed description of the current operational algorithm to retrieve CO₂ and CH₄ column abundances from GOSAT, which is the first satellite to specifically target greenhouse gases. The article is generally well written and organized. I recommend it to be published after addressing the following minor comments:

Specific comments:

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1. In line 9, page 4794, the description of SWIR is not accurate since SWIR observations is sensitive to the total abundance, I suggest changing it to “whereas SWIR observations are also sensitive to gas abundances near the surface” or “SWIR observations are sensitive to gas abundances down to the surface”
2. Line 16, page 4794, the statement of precision of 1 percent order or better in column abundance is quite vague. Do you mean the precision for an individual satellite pixel? The references cited at the end of this sentence talked about monthly/weekly average on an 8 lat x 10 lon grid box. Please clarify this.
3. It is confusing in lines 16-19, page 4794, to say precision of 1 percent or better is required and then says than random errors have less influence, because precision is normally referred to as random (-noise) errors. Please clarify this.
4. Line 25, page 4794, I agree with the first reviewer. In addition, even retrievals with precision of 1-2 percent for individual pixels can be very useful for flux estimation according to the studies of Rayner and O'Brien, and Houwelling et al., 2004) because the precision can be much smaller when averaged weekly/monthly over a large area.
5. I agree with reviewer 1 that the description of the DOAS method is incorrect.
6. About the descriptions of the spatial resolutions of TANSO-FTS and TANSO-CAI: for TANSO-FTS, the nadir footprint diameter is 10.5 km, so TANSO-FTS has circular pixel, right? How about TANSO-CAI, square or circular pixels? It was mentioned that the spatial resolutions of TANSO-CAI is 0.5, 0.5, 0.5 and 1.5 km, is it the same for both along-track and across-track directions? Please clarify.
7. Line 12-15, page 4798, it was mentioned that the high resolution solar irradiance database was used as the incident solar spectrum. Does the GOSAT measure its own solar irradiance at the GOSAT resolution? Because the absolute calibration of this high resolution reference might not be so good relative to the measured GOSAT radiance, large errors might occur. The high resolution solar irradiance is very good

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to be used to perform wavelength calibration, calculate ring effect, convolve radiances from high-resolution to instrument spectral resolution, but might not be good as incident solar spectrum due to systematic differences between it and measured GOSAT measurements.

8. Line 25, page 4798, please briefly explain why 2.1 μm band is not used in the CO_2 retrievals.

9. Lines 1-6, page 4803, what are the initial values for λ ? Is the final λ zero? If not, what are the typical values of λ in the last iteration? What are the typical values for the diagonal scaling matrix? Is it fixed for all the retrievals? Please provide more detail so the reader can clearly understand the algorithm.

10. From Lines 20-25 on page 4803 to Lines 1-7 on page 4804: the use of weighting function might be confusing since it normally means “Jacobians”. Do you mean “profile of dry air partial columns ($W_{\text{dry},i}$, $i=1,n$)”. What are the units of the CO_2/CH_4 state vector X_x , volume mixing ratio? Some of the symbols are not clearly defined. I suggest to add “ X_{target} ” after “the column-averaged dry-air mole fraction” and add “ SIGMA_x ” after “its error components”

11. Also from lines 20-25, on page 4803, it is not clear about how partial dry air column abundance (e.g., h) is derived. In my understanding, it should be related to the retrieved surface pressure from the oxygen-A band, as well as the temperature profiles assumed and the retrieved temperature bias, right? If this is the case, when taking the ratio of x to h to calculate the X_{target} , the error in h should be propagated to calculate SIGMA_x , but I did not see it in equation (12). Please provide more detail about this or to clarify this.

12. Lines 9-16 on page 4804: maybe you could add “The state vector and its a priori and its a priori covariance matrix is summarized in table 1 and will be described subsequently” at the end of this paragraph so the reader know where to find before reading the following several paragraphs.

13. For aerosol optical depth, which wavelength is AOD defined?
14. Line 17-18 on page 4805, it is not clear what do you mean “the target reflectance should be considered as retrieved?” Do you mean that “the target reflectance should be retrieved”
15. In equations 17 and 18, what are the g and β , please define.
16. Line 9 on page 4810, it is not clear about how you reject the retrievals? Do you mean that the sum of DFSs of CH₄ and CO₂ are less than 1? Or do you mean if the DFS for CO₂ is less than 1, then you reject the retrieved CO₂ value and if the DFS for CH₄ is less than 1, then you reject the retrieved CH₄ value?
17. Lines 20-21 on page 4813, In “the retrieved X_{co2} and X_{ch4} show appropriate patterns of global distribution. . .”, the authors describes some latitudinal/seasonal variations but not how they vary with surface type (e.g., land, ocean, desert), I suggest to add some brief descriptions in this aspect. Otherwise, change “global distribution” to “latitudinal”. Also pointed out by the first reviewer, the abstract says “agree well with the current state of knowledge”, but it is only weakly supported in the text. I also think that it is good to add some comparison with model (i.e., also a priori) to support this in a more quantitative manner.
18. For figure 1, it might be better to use a different color for each scene?
19. In Figure 5, label for color bar of the last panel should be “Uncertainty reduction (CH₄)”

Technical comments:

1. In line 24, Page 4793, I suggest to rephrase the “high spatiotemporal-resolution monitoring of global greenhouse gas distributions” to “to monitoring the global distributions of greenhouse gases at high spatiotemporal resolution”
2. Line 26, page 4796, change +/- to “ \pm ”

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3. Line 2 page 4802, “Consider . . . TANSO-FTS.” is not a complete sentence, change “.” to “,”

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