

Interactive comment on
“Mid-upper tropospheric methane retrieval from IASI and its validation”
by X. Xiong et al.

We thank both reviewers for their helpful comments and positive suggestions on improving the manuscript.

Responses to Reviewer 2 Comments

The manuscript describes the validation of the IASI methane retrieval product from product from the National Oceanic and Atmospheric Administration (NOAA). Retrievals have been validated against aircraft profile measurements from the HIPPO campaigns, which are well suited for application to validation of satellite measurements. The material is within the scope of this journal. The data is new, and should be of interest to the atmospheric community. The approach is clearly described and the results are sufficient to support the conclusions. In my opinion, the paper is suitable for publication in AMT after minor revisions.

R2: General comments:

On balance, the paper reads well, but there are some important areas where the analysis and discussion are lacking.

The manuscript is rather vague when it comes to the discussion of systematic errors. I would like to see more discussion of this. The authors state that channels were selected to be sensitive to CH₄ but not to N₂O or HNO₃. No mention is made anywhere in the paper that the spectral region used for this CH₄ retrieval is strongly affected by water vapor interference. (There is no way to avoid that). Errors in the water vapor (and the temperature) that were retrieved in previous steps can propagate through to the CH₄ retrieval. The impact of temperature and water vapor errors ought to be estimated.

A: We completely agree. In the channel selection in section 2.2, we added “Channels with strong absorption of H₂O are also avoided. “. As suggested, in Section 4 we added “Errors in the water vapor (and the temperature) that were retrieved in previous steps also propagate to the CH₄ retrieval.”

As one way to estimate the impact of temperature and water vapor errors on the retrieval, we changed Figure 1, which now shows the change of brightness temperatures in IASI CH₄ band corresponding to the change or error in the surface temperature (1.5 K), water vapor (10%) and CH₄ (5%) in the tropics using data on Nov.08, 2009. Red triangles are the channels used in the retrieval. From Fig.1 we can see that the impact of the error in surface temperature occurs in weak absorption channels below 1240 cm⁻¹. The impact of water vapor occurs in the whole CH₄ band, and a 10% error in water vapor (shift of the whole profile) is almost equivalent to 5% change in CH₄ for most channels except in the Q-branch near 1306 cm⁻¹.

R2: The discussion of the empirical bias correction to the radiances is lacking in information. Are the correction coefficients available anywhere? Is the bias correction really applied to the radiances and not to the absorption coefficients in the RTA? How can the same radiance correction be applied to AIRS and IASI, when the two instruments have different spectral resolution? This is an important factor in understanding the observed bias.

A: It is a typo to write “AIRS”, and we changed it to IASI. In section 4, we added: Current bias correction was pre-computed as the difference of IASI observed radiance minus the RTA computation using night ocean cases and with the most knowledge of atmospheric profiles and surface emissivity. This bias correction was applied to the radiances globally and not to the absorption coefficients in the RTA. Improvement in the future version can be made by more aircraft measurements of trace gases profiles as truth, and the correction will be made to both the absorption coefficients and the radiance, and the best one will be used in application.

R2: Users of the data will wish to know whether the bias with respect to aircraft data is constant, or whether it varies in latitude and/or time. This is not discussed in the paper. It should be.

A: Figure 10 shows the bias with latitude and cloud cover. For clarification, in Section 4 we added “The largest bias occurs in winter (HIPPO1). The error has some dependence with latitude and cloud cover, and it is larger in the high northern latitude regions and/or cloudy conditions. “.

R2: This is not so much a comment on the manuscript, but on the data products themselves. The authors state that the averaging kernels are not supplied with the data products. It will be extremely difficult for the user community to make proper use of this product without the averaging kernels. I hope that this group will consider supplying the averaging kernels with these NOAA CLASS products.

A: We will try to add the averaging kernels in the output in the future version.

R2: Specific comments:

The list of references (page 2504, lines 14-15) for GOSAT CH₄ retrievals ought to be expanded/updated. For example, the existing reference to the retrievals from the Japanese group is for an AGU abstract from 2008. This should at least be updated to the following: T. Yokota, Y. Yoshida, N. Eguchi, Y. Ota, T. Tanaka, H. Watanabe, and S. Maksyutov, “Global concentrations of CO₂ and CH₄ retrieved from GOSAT: first preliminary results,” *Sci. Online Lett. Atmos.* 5, 160–163 (2009) I would also suggest including a reference to the work of the group at the University of Leicester: Parker, R., H. Boesch, A. Cougan, A. Fraser, L. Feng, P. I. Palmer, J. Messerschmidt, N. Deutscher, D. W. T. Griffith, J. Notholt, P. O. Wennberg and D. Wunch, Methane observations from the Greenhouse Gases Observing SATellite: Comparison to ground-based TCCON data and model calculations, *Geophys. Res. Lett.*, vol. 38, L15807, doi: 10.1029/2011GL047871, 2011

A: As suggested, both references have been added.

R2: Page 2507, line 24: “near 7.66 microns” – previous references to spectral region have used wavenumber units. It would be helpful for the reader to follow if either microns or cm^{-1} were used consistently (or the numbers in the alternative units are provided in brackets).

A: we changed CH₄ band “near 7.66 microns” to “between 1200-1400 cm^{-1} ”

R2: Figure 2 needs improvement. The level index for the 101 forward model levels is not helpful for the general reader, and in my opinion, does not add value to this figure. It should be removed. The authors might consider using a larger number of colors instead of using the dashed lines. Also, the numbers/text on the right of the figure overlap in places. This should be fixed (or these numbers/text should perhaps simply be removed altogether).

A: Figure 2 has been re-plotted as suggested.

R2: In the discussion of Fig. 5 (page 2508), the reference to such wide layers when referring to “peak sensitivity” is misleading. The text implies that the retrieval sensitivity has a very wide peak. In fact, Fig. 5 shows that the peak sensitivity is somewhere around 250 to 300 hPa in the tropics, not 100 to 600 as stated in the text. The retrieval sensitivity at 600 hPa is in fact quite low, and a statement that 600 hPa has any relation to the peak is inaccurate. The same comment applies to the description of “peak sensitivity” at other latitudes.

A: As already explained in answers to review#1, the word “peak” was deleted to avoid misleading.

R2: In Figure 6, there are some isolated dots at the top of the figure that do not look like places where the aircraft flew. Are these supposed to be there?

A: Figure 6 has been re-plotted as suggested.

R2: Figure 7 needs improvement. The legend should be positioned so that the text does not spill over the plot axes. Also, I see that an explanation of the blue profiles is provided in the caption, but it is a little confusing that there is nothing on the legend to explain what the blue profiles are. Is it really necessary to show the profiles that did not pass quality control? I would suggest removing them.

A: Figure 7 has been re-plotted as suggested.

R2: Figure 9(a) could be improved by adding a zero line.

A: Figure 9(a) has been re-plotted as suggested.

R2: Page 2512: “A larger retrieval bias than the first guess ...” Are the authors referring to the upper atmosphere in Figure 9? If so, please make this clear.

A: Yes. For clarification, this sentence in Section 4 was reworded as:
A larger retrieval bias than the first guess bias in the upper atmosphere (Figure 9) is most likely from the uncertainty in the spectroscopy near methane Q-branch and errors in the RTA, and in the empirical bias correction to the radiance.

R2: Page 2513, lines 5-6: The authors state that the error resulting from the time difference between the IASI and aircraft measurement is expected to be small. Wecht et al [2012], in their validation of TES CH₄ against HIPPO, actually examined this in detail. The authors could reference that study here.

A: As suggested, in the end of “... measurement is expected to be small” we added reference: “, as already examined by [Wecht et al., 2012].”

R2: Discussion and summary: “To help users utilize this product appropriately...
” What would really help users utilize this product appropriately would be to supply the averaging kernels as part of the product.

A: agree.

R2: in the discussion of possible reasons for the observed bias, the authors do not mention possible errors in the temperature or water vapor profiles. Those also could have a strong effect on the retrieved methane. The channels used in the CH₄ retrieval are strongly affected by interference from water vapor.

A: As mentioned before, in section 2.2, we added “Channels with strong absorption of H₂O are also avoided. “. In Section 4, we added “Errors in the water vapor (and the temperature) that were retrieved in previous steps also propagate to the CH₄ retrieval.”

R2: Technical corrections:

Page 2502, line 8: “The degree of freedom of” should be “The number of degrees of freedom for”

A: These corrections have been made as suggested.

R2: Page 2502, line 9: “The most sensitivity layer is between...” should read, “The retrievals show greatest sensitivity between ...

A: These corrections have been made as suggested.

R2: ” Page 2504, lines 16-17: The Payan et al. paper should be dated 2009, not 2007

A: After double-check, we believed we are right in citing the paper of Payan in 2007.

Page 2505, line 8: “detail” should be “detailed”

A: These corrections have been made as suggested.

Page 2505, line 13 states “a nadir resolution of roughly 50 by 50 km” while page 2506, lines 12-13 states “a nadir spatial resolution of about 45 km”. This seems inconsistent.

A: For clarification, we deleted “a nadir spatial resolution of about 45 km”

Page 2506, lines 4-5: “can be referred to” should read “can be found in” Page 2506, line 23: “triangle” should be plural (triangles).

A: These corrections have been made as suggested.

Page 2508, line 11: “can be referred to” should read “can be found in” Page 2508, line 18: “HNH” has not been spelled out anywhere in the manuscript.

A: These corrections have been made as suggested.

Page 2508, line 20: “Fig. 5 plots ...” should read “Fig. 5 shows”

A: These corrections have been made as suggested.

Page 2509, line 14: “FOR” has not been spelled out anywhere in the manuscript.

A: it is spelled out as: Field of Regard (FOR).

Page 2510, line 1: “NSF” has not been spelled out anywhere in the manuscript.

A: it is spelled out as: National Science Foundation.

Page 2514, line 9: “The reasons for this negative bias might be due to..” is grammatically incorrect. I suggest using “Possible reasons for the negative bias may include”

A: These corrections have been made as suggested.