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 1 Comments

R1: The paper illustrates the inversion method applied to measurements by the high resolution hyperspectral infrared sounder IASI on-board the MetOp-A satellite for the retrieval of mid-upper tropospheric CH4 profiles and the validation of the resulting products against collocated airborne observations from in situ measurements acquired during the HIPPO airborne campaigns. The outcomes of the activities reported by Xiong and co-authors is of primary interest as dealing with analysis, validation and quality assessment of data about one of the most important short-lived climate forcers in the terrestrial atmosphere. As properly pointed out in Section 4, the results presented in the paper are relevant as being part of the on-going effort to build a 20+ years data archive of CH4 measurements, including retrieval products from three different space-borne missions (IASI, AIRS and CrIS). As clearly stated by the authors, the description of the methodology of the NOAA retrieval system applied to IASI data processing and reported here was already given in more details in previous papers. The new information delivered by this article is mostly concerned with validation of CH4 products. The overall quality of the paper is good and the topics covered are very well suited for the scope of the AMT journal. I recommend, therefore, the manuscript for publication, after minor revisions according to the specific comments/indications and to the technical corrections outlined below.

In the Introduction (Section 1), the difference is highlighted between the NOAA system and two inversion algorithms (by Crevoisier et al., 2009 and Razavi et al., 2009, based on neural network and Optimal Estimation approach, respectively) previously used for CH4 retrieval from IASI and the statement is made that "the data from either of them have not been fully validated". It is not clear, whether the comparison with the aircraft measurements described in this paper is supposed to achieve the "full validation" of NOAA's CH4 products that is missing for the other datasets. If this is not the case, please clarify (e.g., explain which are the major differences compared to the validation of the other CH4 IASI products).

A: "the data from either of them have not been fully validated" was deleted. We just recognized some recent validation by Crevoisier et al.(2013), so we added the comments and citation:
" Recent validation by Crevoisier et al.(2013) indicated that IASI can capture well the evolution of mid-tropospheric methane in the tropics.".

In Section 4, we added:

“ However, these cases validated are mostly over the ocean, so the retrieval errors over the land are expected a little larger. “

R1: Moreover, the valuable set of HIPPO airborne measurements used in this case as the “reference truth” for validation is derived from five field campaigns over the Pacific Ocean. The authors underline the unique character of the HIPPO dataset, but its only feature they mention in an explicit manner is the wide latitudinal coverage. My suggestion is rather to add some comments on the advantages of using measurements acquired over ocean only to validate the satellite data; and, on the contrary, if this choice put some limit to the results of the validation process.

A: As suggested in Section 4, we added” However, these cases validated are mostly over the ocean, so the retrieval errors over the land are expected to be a little larger.”

R1: The expressions “peak sensitivity” and “most sensitivity”, presumably referring to the same quantitative concept, are used throughout the paper in a vague manner. The concept is not introduced by means of an explicit definition and this makes difficult to interpret some of the statements reported in Section 2 (e.g., page 13, lines 9-10) and in Section 4 (e.g., page 24, lines 15-16). We recommend to add a rigorous definition of the “peak sensitivity” and to check that this is used in a consistent manner to describe where CH4 retrieval sensitivity achieves the largest values as a function of altitude and latitude.

A: Instead of adding a definition of “peak sensitivity”, we think it is better to just delete this word in both Section 2 and Section 4 to avoid misleading.

R1: A weakness of the NOAA CLASS IASI dataset is that it does not include the averaging kernels in the standard outputs. Consequently, the comparison of IASI products with airborne convoluted data cannot rely on the use of the averaging kernel associated to the individual measurements, but uses spatial and temporal averages of the AKs calculated over a 3x3 degree and on a monthly basis, respectively. This aspect of the validation process is not adequately stressed in the paper, where the convolution of aircraft measurements with IASI averaging kernels is reported (also in the abstract) as if implemented without approximations. The impact of the use of a mean value for the averaging kernels on the comparison between airborne and satellite data should be evaluated. I recommend that the authors include some consideration in the text and report the application of “mean averaging kernels”, at least in the abstract. I strongly suggest including the averaging kernel in the output of the NOAA CLASS IASI data archive for future exploitation.

A: In abstract we added applying the “monthly mean” averaging kernels. Also in Section 4 (discussion and summary), we added “Some error is attributed to the use of the monthly mean averaging kernels approximately to convolve the aircraft measurements, and this error is estimated to be less than 0.6%. As part of the product, the averaging kernels need to be added as output in the NOAA CLASS system in next version, and the averaging kernels for individual retrieval should be used in validation.

To evaluate the error due to the use of the mean averaging kernels, in Section 3.2, we added eq.(4) and estimated the error is less than 0.6% :

The error due to the use of the mean averaging kernels ($\bar{A}$) can be estimated as:

$$\Delta\hat{x} = (A - \bar{A})(x - x_a) \qquad (5)$$

We found that the difference between x_a, the first guess, and x, in situ aircraft measurement profile from HIPPO, is mostly less than 3%. With an estimate of the variation of averaging kernels within one month is less than 20%, the error due to the use of the mean averaging kernels are less than 0.6%.

ˇ

R1: Technical corrections
p.3, line 9 - change “e.g.Brassuer” to “e.g. Brassuer”.
p.3, line 11 - change “billion(ppb)”to “billion (ppb)”.
p.3, line 21 - change “CH4 sources” to “CH4 sources”.
p.4, line13 - change “IR(NIR)” to “IR (NIR)”.
p.4, line 13 - change “(with sensitivity” to “(withsensitivity”.
p.4, line 14 - change “(with sensitivity” to “(with sensitivity”.

A: These corrections have been made as suggested.

R1: p.4, line 23 –Examples of space-borne TIR and NIR observations are given here with reference tothe instrument and satellite platform (e.g. IMG on ADEOS, SCIAMACHY on ENVISAT, etc.); I would recommend indicating the name of the instrument (TANSO-FTS) also for the TIR measurements of the GOSAT mission.

A: As suggested, we rewrote this sentence as
… the Thermal And Near infrared Sensor for carbon Observation (TANSO) onboard the Greenhouse gases Observation SATellite (GOSAT) from 2009-present, which carried the Fourier Transform Spectrometer (TANSO-FTS) to make both NIR and TIR observations (*Yokota et al.*, 2009; *Park et al., 2011*; *Schepers* et al., 2012).

R1: p.6, line 7 - change “0.25 cm-1” to “0.25 cm-1”.
p.6, line 13 - change “280K” to “280 K”.
p.6, line 18 - change “are used in order” to “are used, in order”.
p.7, line 2 - change “al.(2003)” to “al. (2003)”.
p.7, line 11 - change “NOAA CLASS” to “NOAA CLASS.”.
p.7, line 17 - change “AIRS CH4” to “AIRS CH4”.
p.8, line 3 - change “the CH4 first-guess” to “the CH4 first-guess”.
p.12, line 5 - change “(2008).As” to “(2008). As”.

A: These corrections have been made as suggested.

p.12, line 12 – the acronym HNH is not explicitly defined and is used only once in the paper, while the full expression High Northern Hemisphere is used elsewhere. We suggest either (1) to define the acronym at the beginning and then use it in all cases or (2) not to use the acronym at all.

A: changed HNH to High Northern Hemisphere

p.13, line 4 - change “(see Table 1).In order” to “(see Table 1). In order”.
p.13, line 7 - change“plots the the color” to “plots the color”.
p.15, line 4 - change “greater than 0.4;” to“greater than 0.4.”

R1: p.15, line 3 – spell out the acronym “FOR”
A: added Field of Regard (FOR)

p.15, line 10 – change “CH4 Profile” to “CH4 Profile”
p.16, line 15 – spell out the acronym “NSF”
A: changed NSF to “National Science Foundation”

R1: p.18, line1 - change “corresponding the aircraft profile” to “corresponding aircraft profile”.
p.18, line 2 - change “so the retrieve” to “so the retrieved”.
p.18, line 13 - change “indicates that” to “indicate that”.
p.20, line 19 - change “between the the” to “between the”.
p.22,line 6 - change “is slight larger” to “is slightly larger”.
p.24, line 16 - change “showed that a large” to “showed a large”.
p.25, line 8 - change “and better” to “and to better”.
p.25, line 18 - change “observation” to “observations”
p.25, line 19 - change “source”to “sources”
p.34, line 5 - change “Red triangles marks” to “Red triangles mark”.
p.34,line 12 - change “Table 1).In” to “Table 1). In”.

A: These corrections have been made as suggested.

Use a consistent notation throughout the paper for “in situ” (not “in situ” and “in-situ”)
A: A consistent notation of “in situ” has been used.

Use a consistent notation throughout the paper for “first guess” (not “first guess” and “first-guess”)
A: A consistent notation of “first guess” has been used.