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# ***Interactive comment on “Space-borne observation of methane from atmospheric infrared sounder version 6: validation and implications for data analysis” by X. Xiong et al.***

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## General Comments

This paper presents the new version of the methane (CH<sub>4</sub>) retrievals, one of the most important greenhouse gases, as observed from the remote sensor Atmospheric Infrared Sounder (AIRS) aboard NASA's Aqua platform as well as a comprehensive validation study. The paper is well structured, and concise. However, the methodology used (retrieval and validation strategies) as well as all the discussion and plots shown are equivalent of an author's previous work entitled "Mid-upper

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tropospheric methane retrieval from IASI and its validation (<http://www.atmos-meas-tech.net/6/2255/2013/amt-6-2255-2013.html>”), but using the Infrared Atmospheric Sounding Interferometer aboard MetOp satellites. Therefore, the authors should make clearer that the approach used in the paper under discussion is a 1:1 equivalent of their prior IASI work. This clarification allows both studies can directly be compared in the current paper. In fact, including an intercomparison of the methane IASI and AIRS products would provide an added value to the paper. For example, the authors could document whether both methane products are consistent and, then, they can be combined to create a common methane database. Finally, the overall treatment of the theoretical and experimental errors is imprecise through the manuscript, so the authors should improve its description and quantification.

I suggest this paper may be suitable for publication after major revisions regarding these issues and the specific ones listed below.

### Specific Comments

#### Title

The title of the paper suggests that the implications of the improvements of AIRS CH4 products on the data analysis will be discussed through the manuscript, but I have not identified this discussion. Do the authors refer to the “Error Analysis” discussion addressed by Section 4.2? If so, please consider revising the title of the paper or clarify this issue in the discussion.

#### Introduction

The paper basically addresses the improvement of the AIRS-Version 5 CH4 retrievals, but any information about its expected and/or observed uncertainties is given. Thereby, include this information to better quantify the real improvements done in V6.

#### Section 2

1) To avoid being redundant in the title of the section and subsections, consider simplifying



fying the title to "CH4 Retrieval in AIRS-V6". 2) Including a brief analysis of the impact the thermal contrast and the latitude on the sensitivity would help the discussion of the discrepancies observed in section 4.2. This can easily be done by plotting the DOFS versus latitude distinguishing the land/ocean pixels as Figure 2.b. 3) The authors state that the increase of water vapour in summer enhances the total sensitivity of AIRS. Include a brief explanation supporting this statement: how does the water vapour increase the total sensitivity of methane? How is the cross-interference of water vapour taken into account in the retrieval strategy?

### Section 3

1) Section 3.1: The validation is carried out by using five measurement campaigns. Specify the added value of including each validation dataset. 2) Section 3.2: The aircraft profiles used for the validation are extended by using an Atmospheric General Circulation Model. Consequently, the smoothed aircraft profiles are a combination of the two experiments with their respectively uncertainties. Including an estimation of the expected errors in the smoothed aircraft profiles due to this extension would complete the error analysis discussion. 3) Section 3.3: The authors introduce an experimental quality flag based on the CH4 retrieval values and their experiences, but any post-quality control implies a prior knowledge about the expected results. Have the authors thoroughly checked the criteria that defined the quality flags in the previous steps (quality flags 0 and 1)? Have the authors investigated the causes of the observed oscillation in the retrieved CH4 profiles (clouds ...)? If so, please include this information as well as a brief explanation about the criteria defining the quality flag equal to 0 and 1.

### Section 4

1) The presentation and discussion of the validation results are mixed through the two subsections. Thereby, consider merging both subsections into one. Also, part of the discussion presented in the Error Analysis could be included in the section 2.1. For example, the first paragraph of this section details the error sources affecting the CH4

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retrievals, but the authors really provide a description of the error sources affecting the comparison results, i.e., the “theoretical errors” affecting the retrievals (the two first error sources cited) and errors introduced by the comparison strategy used. Therefore, consider moving the first part of this discussion to the section 2.1, where the retrieval strategy is described. Also, include an overall estimation of the expected theoretical uncertainties due to the different error sources. This information would be very useful because it indicates where a special effort should be paid to improve the precision of the CH4 products in the future. 2) Consider moving the Figure 6.b to the section 3.1, where the different validation datasets are introduced, because it is a bit confused that the authors show the number of samples above 350 hPa when the section 3.2 states that the aircraft profiles with their ceiling beneath the 350hPa pressure level were not used in the validation. 3) The comparison between the AIRS and the smoothed aircraft profiles is done for four partial columns spanning from 777 hPa to 272 hPa when the AIRS is only sensitive to the CH4 variations in one layer (recall Figures 2 and 4). Thereby, what is the added value of comparing these 4 layers? For example, for the uppermost layer the authors are rather comparing the extended aircraft profiles (by the climate model) to the priori profiles used in the AIRS retrievals. Therefore, consider including only the comparison for the most sensitive layer, whose levels could be re-defined taking into account the sensitivity studied done in previous sections. This layer could be used in the subsequent analysis. 4) Have the authors analyzed/observed differences between the day-time and night-time AIRS overpass retrievals or between ocean/land pixels? Analysing the possible non-linearity of the AIRS retrievals would be explain part of the discrepancies found or reject these error sources in the discussion. For example, Figure 8 shows a worse correlation for comparison in summer when the AIRS sensitivity is expected to be higher. Also, the authors suggest that part of differences observed for mid-latitude region is due to the latitudinal gradient, but not include the typical values of these gradients to justify this statement. Consider including this information. 5) The description of the error sources is a bit imprecise (section 4.2), because the authors do not provide any estimation or error value. This makes diffi-

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cult an interpretation of the relative influence/impact of the different error sources on the AIRS retrievals. An example could be when the authors detail the influence of the temporal collocation. 6) Regarding the discussion of Figure 10, include the description of the cloud fraction parameter (i.e., how this parameter is calculated) and clarify the discussion. The authors state that the DOFS for high northern latitude (above 60°N) is between 0.6-0.8 when the figure only distinguishes between tropics and other regions. Also, the best correlation is found in summer, when this information is not contained in the referred figure. Also, as aforementioned, including a figure in section 2 plotting the DOFS versus the latitude could help the discussion of the discrepancies observed. Finally, the authors compare independently the correlation of the retrieval error versus the cloud fraction and DOFS, suggesting the latter is the dominant factor. To analyse this I would recommend using a linear multivariate approach to take into account two variables at the same time. This analysis will allow the authors to estimate the real relative weight of each factor on the retrieval error. 7) The discussion of the validation and error results do not include any comparison/reference to the previous AIRS version. Therefore, as aforementioned, the readers are not able to quantify the real magnitude of the improvements done in the new version 6. 8) In order to better follow the discussion of the results, consider summarizing the validation results in a Table. Also, including the uncertainties found for the previous AIRS version would help to better quantify the improvements of the new version. 9) Revise the number of significant figures included in the Figure 7, 8 and 9.

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