

## ***Interactive comment on “Information-based mid-upper tropospheric methane derived from Atmospheric Infrared Sounder (AIRS) and its validation” by X. Xiong et al.***

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We thank the reviewer for constructive comments and suggestion on our paper. Following these comments/suggestion given, we revised the paper accordingly.

*The reviewer is right that AIRS CH<sub>4</sub> has been validated before (Xiong et al., 2008), but this paper is not simply an update validation for AIRS CH<sub>4</sub> operational products. Different from the previous validation, this paper focuses on the derivation of a new product based on the information content, and examines the advantage to use the retrieved CH<sub>4</sub> in the layer 50 to 250 hPa below tropopause to characterize the CH<sub>4</sub> in the free troposphere than using CH<sub>4</sub> in a fixed pressure layer (or geographical layer).*

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*Validation to this new product is made to prove the reasonableness of this method. The importance of this work is because the satellite observation in the HNH is more difficult as the information content of thermal infrared sounder is low, and the most sensitive layers of AIRS as well as the tropopause vary in a much larger range than in tropics. While it is possible to use the retrieved CH<sub>4</sub> in one geophysical layer to analyze its spatial and temporal variation in the real atmosphere in the tropics and mid-low latitude regions, it is highly biased to do so in the mid-high latitude regions. For clarification, one paragraph is added in the introduction and more discussion have been added in the context (for example, Sect.3.2) to justify the importance of this work.*

*The whole manuscript has been revised as suggested. Also, following the detail comments from both reviewers, the typos and grammars have been corrected and double checked.*

Why not carry out AIRS CH<sub>4</sub> validations to the geographically varying layer defined directly from the averaging kernels of the retrievals? Even though the CH<sub>4</sub> averaging kernels are not distributed at DACC, the authors should have the capability to obtain them using the off-line codes.

*Validation of AIRS CH<sub>4</sub> at the geographically varying layer was made by Xiong et al. (2008). Again, the focus of this paper is to derive a new retrieval product (based on the information content that can be used for scientific analysis. Different from in the tropics, it is possible to use the retrieved CH<sub>4</sub> in one geophysical layer to analyze its spatial and temporal variation in the real atmosphere, but it is highly biased to do so in the HNH.*

The correlations between the tropopause heights and the peak locations of AIRS CH<sub>4</sub> averaging kernels (Fig. 2) are not convincing. This added complication is unnecessary for the validation work and makes the paper difficult to understand.

*We found that to use the correlation between the tropopause heights and the peak locations of AIRS CH<sub>4</sub> averaging kernels (Fig. 2) is misleading. So we defined the*

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boundary of the maximum layer as the upper/lower maximum level in which the AK's area is equal to 95% of its maximum. Figs.1 and 2 is re-plotted, and from the histogram it is evident the maximum layer is located in 50 to 250 hPa below the tropopause. Use of the tropopause as reference of the maximum sensitive layer is easier to understand as the tropopause is a physical variable that depends only on the atmospheric state, but the maximum layer derived from AK is also related with the retrieval algorithm and the satellite sensors.

The authors need to discuss the significance and the implications of the biases and rms especially related to climate studies.

*The following discussion is added in Sect.4: This approach provides a simple way to analyze the spatial and temporal variation based on satellite observations without referring to the AK in the mid-high latitude regions. However, this product can not circumvent the impact from the change of information content in the retrieved CH4. For an accurate comparison with model simulations, or in the assimilation of AIRS products into models to improve the estimation of CH4 sources/sinks, AK still needs to be used. Thus, to simply derive the trend for climate study using the AIRS retrieved product in a geographical layer, or in the layer 50 to 250 below tropopause without referring to the AK will be misleading.*

The authors chose 800km as the validation scale and later indicate the sampling size as part of the blame for the disagreements between AIRS CH4 and aircraft in situ data. Why not select a smaller and optimized scale for the validation study?

*More tests to change sampling size have been made, but we found the improvement is small. The following sentence has been added:*

*Use of 800 km is in consistent with Xiong et al. (2008). We also compared the validation results using the aircraft measurements within 500 km or 300 km, and the improvement is insignificant and will not impact the conclusions.*

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