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Atmospheric Measurement Techniques Discussions

Interactive comment on "Evaluation of single-footprint AIRS CH_4 Profile Retrieval Uncertainties Using Aircraft Profile Measurements" *by* Susan S. Kulawik et al.

Anonymous Referee #1

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It is challenging but worth to tackle to discuss how we perform meaningful comparisons between aircraft and satellite measurements that have different vertical resolution and altitude range and how we know errors inherent to satellite measurements. This paper tackles straightforwardly these issues and provides a useful perspective for validation work. The paper is suitable for the purpose of AMT journal and I recommend it to be published after some revisions.

Major comments:

1) "3. MUSES-AIRS Optimal Estimation of CH4 from single-footprint, original (non-cloud-cleared) AIRS radiances", page 5, "Good quality and sensitivity flagging for AIRS

CH4:" 1-1) The authors should give more explanations on the quality flags which they have applied to AIRS CH4 data. Are "radiance residual rms and mean" for all wavelength regions used in the AIRS CH4 retrieval? What are "NESR", "|KdotdL|", and "TSUR"? These terms may be referred to in some previous papers describing AIRS CH4 retrieval algorithm, but the authors should at least spell them out and give their definition. 1-2) "Cloud OD < 0.3" means that clouds that partially exist in the AIRS FOVs probably affect the AIRS retrievals and the amount of the effects would vary depending on the cloud OD itself. How did the authors evaluate the effects in this research? 1-3) How did the authors define tropopause height at each CH4 measurement location and calculate its tropospheric and stratospheric degrees of freedom? 1-4) What is "predicted error"? The authors discuss the "predicted error" in the later part of the text, but they should here mention the definition.

2) "3.1 Retrieval Error Characteristics", page 6, Equation (2) The authors should briefly explain the definition of A_xy. In this case, x indicates a methane profile and y does simultaneous retrieved parameters such as temperature and there is no relationship (cross-term) in nature between methane and temperature.

3) "3.2 Approach for Comparing AIRS measurements to aircraft profiles", page 7, Equation (4) In my understanding, A_cc is a symmetric matrix with a dimension of the number of atmospheric layers that can be observed by aircraft, while A matrix has a dimension of the number of full atmospheric layers from the surface to the top of the atmosphere. A_cs should be a non-square matrix, and how is it defined by the cross-terms of the A matrix? More explanation should be needed for readers.

4) "3.2 Approach for Comparing AIRS measurements to aircraft profiles", page 8, Equation (6) Sa matrix should in principle includes random errors only. The first term A_cb Sbb_a A_cb(T) comes from radiance biases that should have systematic characteristics. The other three terms or the second and the last terms only may be randomly distributed errors. Is it possible to treat errors that may have different characteristics in the same manner?

5) “3.2 Approach for Comparing AIRS measurements to aircraft profiles”, page 9, lines 259-260 It should be more explained why “red” (mean obs. errors) minus “green” yields the cross-state error.

6) “3.3 Estimating validation error due to aircraft not measuring the stratosphere”, page 9 I agree that the assumption in the stratosphere could significantly contribute to the differences between AIRS and aircraft data, but the amount of the validation error attributed to the stratosphere where aircraft cannot make observations should depend on how accurate each of the models (a priori, LMDz, and GC) can define the tropopause height; this may be a reason why we see relatively larger variabilities in the differences between AIRS and aircraft (simulated) in northern mid-latitudes.

7) Overall, it is better to describe a bit more clearly which of errors the authors think is a systematic or random one. The authors have already referred to which is which for each of the error components in several parts of the text, but there are too many error values and they sometimes resemble another one; it is an option to add a table to summarize the characteristics of each of the error components.

Minor comments:

1) Figure 1 It is easy to see if the international dateline is centered.

2) page 5, line 137 “... such as check on the “ “2, residual signals, ...”, a symbol before “2” is missing.

3) page 6, line 165 The symbols in the text do not correspond to those in the equations.

4) Figure 2 The authors should explain the color shading in more details; which pressure layers do colors indicate?

5) page 8, line 251 Which is correct, A_cn in the text or A_cs in Equation (6)? Or A_cs and A_cs are used as the same meaning?

6) Figure 3 The authors should give more explanations in the caption using the terms

in the equations in the text.

7) Figures 5 and 6 It may be better to replace the figure numbers.

8) page 10, lines 294-295 Why did the author choose HIPPO-4 observations to estimate bias correction values?

9) page 10, lines 295-296 Equation 5 is split into two: Eq. 5a and Eq. 5b. Are they combined?

10) Figures 6 and 7 The bias values shown in the figures do not correspond to the values in the text. The authors should explain the values in the captions of the figures.

11) page 12, line 350 Where does “24” come from?

12) page 12, line 363 It is better to add an explanation of 5.4 ppb (growth rate per year calculated at this site?).

13) page 12, lines 378-380 Does this sentence mean that there are some correlations among each of the differences between collocated AIRS and aircraft pairs and the correlations cannot be compensated when taking averages on a daily basis?

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