Interactive comment on “Satellite observation of atmospheric methane: intercomparison between AIRS and GOSAT TANSO-FTS retrievals” by M. Zou et al.

Anonymous Referee #1

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Thank you for the submission of this work, which overall presents a well-written study into a comparison between AIRS and GOSAT TANSO-FTS retrievals. This work is necessary, as in order to best understand the remote sensing of methane (and other gases) from satellites, it is necessary to compare the retrieval outputs from the different products, and to try and differentiate if there is a substantial difference, and what it is that may be causing this.

The layout of the paper is clear and concise, and the figures are an excellent accompaniment to the study, helping to demonstrate your findings in an illustrative manner. However, there are a number of issues that I think you need to address before this paper is ready for publication. I describe these below, followed by a list of technical corrections that should also be made.

1. In Section 1 in the second paragraph, you mention how aircraft can be used to make measurements of CH4 vertical profiles, which I inferred to mean via in situ sampling. However, it would also be prudent to note that recent advances, such as the ARIES instrument on the UK's Atmospheric Research Aircraft can also retrieve profiles as well as total columns of CH4 using remote sensing techniques.

2. In Section 1 in the final paragraph, you talk about DOFs and information content as if they are two separate entities (Which they can be). However, the context in which you use them in the paper is the same, and this sentence is misleading. Having read this I was expecting further comments on the information content (e.g., Shannon information content etc.) of the measurements rather than simply the DOFS.

3. In Section 1, in the final paragraph you mention the over-constraint in the GOSAT retrieval algorithm without reference, do you mean in terms of comparison to AIRS? This needs to be clearer.

4. In section 2.2 you do not mention how much of the globe is covered on a daily basis by the GOSAT instrument, as you did do for the AIRS instrument. I would advise including this to aid in the comparison.

5. In Section 3.2 you mention that the AIRS a priori is ‘simple’ what do you mean by that? Simple in comparison to what? In Section 3.2, in the last sentence of the second paragraph you claims that the RMS difference to the error of the chi-square ratio, combined with the correlation coefficient indicate good consistency. Why is this the case? You need to provide evidence (e.g. from another study) to indicate why these figures are supportive of your claims.

7. I think that there needs to be a larger discussion in Section 3.2 about the nature of smoothed profiles and retrieved profiles vs. the truth. For example, how does this study tell us which of the products is closer to the absolute truth? I know that it doesn’t, and that the future aircraft validation study will show this, but this needs to be made clear. What this study is doing is showing how similar two retrieval products are to one another, however there is no guarantee that either one is correct, and this should be mentioned.

8. In Section 3.3 you talk about the least correlated case, but you make no comment on
why the data in Fig. 9 and 10 look like they do. You need to provide further comment and possible explanation for some of the inconsistencies in the data. For example, in Fig 9 why is the daily comparison if CH4 in the 30S – 60S region split like it is? Exploring these differences and similarities further may even yield more information as to why the retrievals differ in certain situations. 9. In Section 3.3 and Section 4 I am unsure as to why you did not also compare the AIRS-smoothed GOSAT columns with the AIRS columns of CH4. Having laid out the rationale for doing so with the profiles in Section 3.1, you then ignore this for this part of the study. I think that it would be very constructive to compare these ‘like-for-like’ differences with the ones that you already have, as again it may reveal further information about the differences in the retrievals. At the moment any real differences are masked by the differences in the retrieval algorithms and DOFs. 10. In Section 4 in the last sentence, you say that there are a lot of data points with a very low total column of CH4. Is this for AIRS, GOSAT, or both? 11. Further comment is needed on some of the differences in Figure 12, especially the lag in peak column amount seen in the 30-60S plot at around July-October. In relation to the above point, this may be because the retrieval algorithms are doing something wildly different here, for example the way that they treat sea ice. 12. There is absolutely no mention of retrieval errors. It would support your findings to see how the differences compared to the errors of the retrievals, and also how the errors of the two products compared. 13. All of the graphs need correct labels on all of the axes please.

Technical Corrections

1. Page 10550, line 15: should be ‘the Southern Hemisphere and in the tropics…’
2. Page 10550, line 16: make clear that this is for TC, not profile 3. Page 10550, line 17: should be ‘the Southern Hemisphere…’
pressure layers of the AIRS retrieval grid prior to smoothing.' 41. Page 10557, line 22: should be '1.1 times that of the... 42. Page 10558, line 10: replace 'achieving' with 'achieve' 43. Page 10558, line 22: It should always be 'Fig.' 'Figs.' is incorrect. 44. Page 10559, line 2: replace 'are' with 'is' 45. Page 10559, line 5: should be 'mean differences over a two-year...' 46. Page 10559, line 11: should be 'monthly-averaged' 47. Page 10559, line 15: should be 'the Southern Hemisphere and in the tropics' 48. Page 10559, line 18: remove 'from them' 49. Page 10559, line 19: should be 'in the Southern Hemisphere, the seasonal variation...' 50. Page 10560, line 3: should be 'two years of data...' 51. Page 10560, line 12: should be 'spectra in the 7-8...' 52. Page 10560, line 16: should be 'except that the AIRS...' 53. Page 10561, line 1: should be 'DOFs' (plural) 54. Page 10561, line 1: should be 'suggesting that there is a larger uncertainty in these regions, and as such a much stricter...' 55. Figure 2: should be 'one day of global data' 56. Figure 4: should be 'observations at different...' 57. Figure 7: should be 'at four retrieval pressure levels of...'