

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

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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?
6. 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

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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 of 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...”
4. Page 10550, line 22: should be “degrees of freedom” (plural)
5. Page 10550, line 22: should be “AIRS, which also...”
6. Page 10550, line 23: should be “GOSAT-TIR retrievals...” (plural)
7. Page 10550, line 24: insert comma after ‘observed’
8. Page 10550, line 27: replace ‘time’ with

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‘seasons’ 9. Page 10551, line 1: replace ‘long life’ with ‘long-lived’ 10. Page 10551, line 1: replace ‘gases’ with ‘gas’ 11. Page 10551, line 4: insert comma after ‘long-wave radiation’ 12. Page 10551, line 18: ‘Thermal InfraRed’ should be capitalised to indicate the acronym. Please check all other instances in the document as well. 13. Page 10551, line 20: insert ‘the’ before ‘Tropospheric Emission...’ 14. Page 10552, line 7, replace ‘the two’ with ‘these two’ 15. Page 10552, line 11, should be “validation of the GOSAT product, which may give some insight about the possible over-constraint in the GOSAT retrieval algorithm, as illustrated...” 16. Page 10553, line 1: should be “in the 4.2 μ m region (lower troposphere sounding) to 0.35 K in the 15 μ m region (upper troposphere sounding).” 17. Page 10553, line 5: capitalise ‘Field Of View’ 18. Page 10553, line 7: capitalise ‘Field Of Regard’ 19. Page 10553, line 13: insert ‘the’ before ‘7.66...’ 20. Page 10553, line 15: replace ‘were’ with ‘are’ 21. Page 10553, line 19: insert ‘AIRS’ before ‘CH₄ retrievals...’ 22. Page 10553, line 27: capitalise ‘Maximum A Priori’. Also you do not need to introduce an acronym if you never refer to it again in the paper. 23. Page 10554, line 6: ‘spectral library’ does not need capitalising 24. Page 10554, line 9: capitalise ‘Thermal InfraRed’ 25. Page 10554, line 10: insert ‘the’ before ‘7-8...’ 26. Page 10554, line 11: remove ‘set’ 27. Page 10554, line 18: ‘research announcement’ should not be capitalised, and does not need an acronym. 28. Page 10554, line 27: replace ‘resulted’ with ‘resulting’ 29. Page 10555, line 1: replace ‘considering’ with ‘given that’ 30. Page 10555, line 1: replace ‘long residence’ with ‘long-lived’ 31. Page 10555, line 11: insert ‘a’ between ‘As’ and ‘GOSAT’ 32. Page 10556, line 2: replace ‘match-up’ with ‘coincident’ 33. Page 10556, line 2: should be ‘from one day of global data...’ 34. Page 10556, line 17: should be ‘one day of global data...’ 35. Page 10556, line 18: replace ‘their’ with ‘both’ 36. Page 10556, line 22: capitalise ‘Degree Of Freedom’ 37. Page 10556, line 24: should be ‘variation of DOFS at different latitudes, and on average the DOFS for AIRS CH₄ is approximately 1.1, whereas the mean DOFS for the GOSAT-TIR retrieval of CH₄ is...’ 38. Page 10557, line 10: should be ‘Considering that the AIRS...’ 39. Page 10557, line 13: should be ‘is then compared...’ 40. Page 10557, line 15: should be ‘interpolated onto the 1-

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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...'.

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