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Atmospheric Measurement Techniques Discussions

Interactive comment on "Quantifying the impact of aerosol scattering on the retrieval of methane from airborne remote sensing measurements" *by* Yunxia Huang et al.

Anonymous Referee #2

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This paper studies the impact of aerosols on methane retrievals from synthetic AVIRIS-NG-like measurements using two retrieval methods, the traditional match filter (MF) method, and the more modern and quantitative optimal estimation (OE) method that uses radiative transfer model and can include more physics. It shows how both retrievals are sensitive to various AOD, CH4 concentration, surface albedo, SSA and g. The scope of this study is well suited for AMT. This paper is generally well organized and methodology is generally good. However, a lot of results are shown without much further explanation about the physics behind. Some of the statements may be questionable due to different definitions of retrieval biases between the two retrievals. Some key information (e.g., surface albedo treatment in OE retrieval) is not clearly de-

scribed. The abstract also needs to be improved as it does not clearly summarize this study. Overall, I think that this paper can be published after addressing the specific comments below.

Specific comments:

1. Subscripts and superscripts in the text are disproportionally too small to read

2. L19-21, this sentence is not consistent with the text as real AVIRIS-NG data are mainly used to compare both MF and OE retrievals, rather than analyze the impact of aerosol scattering on CH4 retrievals. That is probably why the first reviewer commented that section 3 is loosely connected with the main purpose of this paper. I suggest clearly describing the purpose of this section 3 probably in the introduction section in relation to the main topics of this study.

3. In abstract, the sentence in L25-29, it is not clear about what kind of scenario for the retrieval bias. Please make it clear here that this for retrieval underestimation of CH4 when aerosol is present but neglected in the retrieval. The use of 50% here and also in the text in Section 4.4 is very confusing especially you have >100% enhancement and < 50% enhancement and also the retrieval bias is actually on the order of 1.5-6%. You may use something like "half of the retrieval bias" or provide specific retrieval bias ($\sim$2-6% for OE and 1,5-3.5% for MF) based on Figure 9. The sentence is also too long. You may rephrase it in a couple of sentences.

4. In abstract, L29-31, it is good to summarize main results instead of just describing what are discussed.

5. L74, suggest changing "large" to "large number of " as it implies coarser spatial resolution contrary to "fine spatial resolution"

6. L78, suggest changing to "a spectral resolution of 5 nm full width at half maximum (FWHM)"

7. At the end of the introduction, it would be useful to add how this paper is organized

in following sections

8. Units on both sides of Equation (5) do no match. According to the text, V has a unit of liter / mol or 1E-3 mˆ3/mol, and 1/(V*1E3) has a unit of mol/mˆ(-3). Maybe 1/(V*1E3) should be V*1E-3 instead. Or V has a unit of mol/liter, then it should not be called V as it is confusing. So please clarify this.

9. L132-135, the sentence does not read well here as the purpose of using real AVIRIS-NG data has not been introduced yet. You may rephrase it to something like "To illustrate the MF retrieval and its difference from the OE method, we perform MF retrievals from AVIRIS-NG measurement made on . . . as shown in Fig. 2. The samples for . . ." Or it might be even better to move these two sentences to Section 3 before showing MF retrieval results.

10. L167, it might be good to describe some of the retrieval artifacts and why they are produced. Are some of the retrieval artifacts related to aerosols or surface albedo?

11. L169-172, the first sentence seems to be redundant with previous description and can be removed. Also good to describe how the normalization is done and its main purpose.

12. L173-174, the sentence "The radiance has units .." can be removed as the spectral range has already been mentioned earlier in the paragraph and it is not necessary to mention the units of radiance.

13. L206, the spectral resolution of 0.5cmˆ-1 seems to be too coarse to resolve monochromatic spectral features in this spectral region. Have you performed sensitivity calculation to see how this affect the synthetic AVIRIS-NG radiance?

14. L178-186, it is good to mention clearly whether aerosol is included in both the forward model and retrieval. It seems that aerosol is not retrieved, but not sure if fixed aerosol model is used in the forward model as it mentions "Single scattering . . . using all moments of the phase function"

15. L187-191, although H2O is not retrieved and taken into account in the MF method, it should also cause retrieval bias/uncertainty to the MF result. Probably it will cause different retrieval errors to MF method and OE method due to its different retrieval treatments. Also are some of the differences due to aerosols and surface albedo?

16. L226, the absorption cross-section is independent of concentration, suggest removing "cross-section"

17. L228, why does the effect of aerosol loading cause underestimation? Would be good to provide some explanation. Due to the shielding of CH4 absorption below aerosol layer?

18. L232-233 and in Fig. 5c, are the results really independent of surface albedo here? Or is this simply because a background with the same surface albedo is used? In actual MF retrievals, surface albedo is not necessarily known (or be the same as that in the background). Also according to normalization procedure shown in Fig. 2, looks like most of the surface albedo can be taken into account after the normalization if surface albedo is not perfectly known as in real retrievals, but bias will occur. Please clarify this.

19. L236, good to explain why larger biases at large AOD and surface albedo values. Also since the enhancement in units of ppm m is retrieved with the MF method, it is better to mention the bias in enhancement ($\sim$-700 ppm m) rather than saying "maximum bias .. close to 0.06 x 1.822 ppm), or you can say "the maximum bias is close to $\sim$-700 ppm m (equivalent of -0.06 x 1.822 ppm) . . ."

20. L242-243, why does the bias decreases with increasing CH4 concentration for the MF method? The reason givens on L244-245 only shows that the enhancement is more underestimated at larger XCH4 concentration (as shown from the curves in Figure 5a that deviated from a straight line), and seems not able to explain the enhancement difference between without and with aerosols decreases with increasing CH4 concentration.

21. Figure 6, the bias is negative (underestimated) as indicated in the text. Suggest making it clear in Fig. 6 caption that the figure shows the magnitude of underestimation.

22. L255 and Figures 7,8,9, is the bias also negative? If so, please make it clear.

23. L258, good to explain how the bias varies with SSA and g.

24. L259-267 and results in Figure 8: is surface albedo retrieved? It seems to me that it is retrieved with XCH4 so that the error is small for different surface albedo when AOD=0. While for other cases (e.g., surface albedo is kept constant at 0.3), maybe surface albedo is not retrieved. Please make it clear probably at the end of section 2.2 or in this paragraph about whether surface albedo is retrieved and how it is retrieved (e.g., wavelength independent or dependent)

25. L264, it seems to me that the bias is defined differently for the MF case, as the enhancement between without and with aerosols (L239-240), while the bias for OE is defined as the difference between retrieved and true XCH4. If we use a similar definition, according to Figure 5a, there is larger underestimation at higher XCH4 values for both without and with aerosols in the MF method.

26. L273, please check if it should be between "with and without aerosols" as the case with zero AOD is the truth reference for the MF method.

27. L275-281, how is this OE retrieval sensitive to the assumed a priori error of 20%? If you use a larger a priori error for the OE method, will the conclusion here be changed?

28. L280, an example is given for a XCH4 of 1.1x1.822ppm. It is useful to give another example at high XCH4, for example XCH4=5.0.

29. Section 5 is a summary of this paper and discussion about future work, I suggest changing this section title to "Summary and discussion"

30. L289-291, the sentence might not be true as mentioned earlier due to different bias definitions used for OE and MF methods.

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