

Interactive comment on “Methane (CH₄) and nitrous oxide (N₂O) from ground-based FTIR at Addis Ababa: observations, error analysis and comparison with satellite data” by Temesgen Yirdaw Berhe et al.

Anonymous Referee #1

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This paper presents retrievals of CH₄ and N₂O using a ground-based FTIR instrument at Addis Ababa, Ethiopia with aim to present observations, error analysis, and comparisons with satellite data. The lack of long-term remote sensing observations at Addis Ababa makes this work important. The technique and results of such measurements might be interesting and likely suitable for the journal. However, I have major comments and foremost revisions are warranted before publication. In my opinion, the quality of the paper needs to be improved before publication.

Major Comments

C1

I have the following major comments:

(1) It is not clear to me what exactly is (are) the goal(s) the authors try to achieve. There is a lack of description in both the FTIR measurements and comparison with satellites. The authors need to specify and emphasize what is(are) the goal(s). Is the goal to present a retrieval strategy of CH₄ and N₂O? or compare/validate three satellites with the ground-based FTIR? In the manuscript, it is mentioned that a satellite is used to validate the FTIR, which is quite surprising. Normally, high-resolution FTIRs are used to validate satellite retrievals. In general, the manuscript is short and lack important details in many sections, e.g., FTIR measurements, satellite, and results.

(2) The retrieval strategy applied in this work is different than the NDACC/IRWG recommendations. I highly suggest to try the harmonized NDACC suggested retrievals and compare with your results. In particular, micro-windows applied here are different than NDACC recommended micro-windows. Furthermore, Sussman et al. (2011) found that HDO is an important interfering specie. However, here is not included or even mentioned.

(3) The DOFs obtained from FTIR measurements is limited to a value of approximately 2. Hence, the typical information content will allow to retrieve tropospheric and stratospheric columns. However, the authors show comparison of profiles with satellite, which are mainly sensitive in the stratosphere. Furthermore, comparisons are carried out using limited number of years, even though measurements at Addis Ababa started in 2009. Additionally, the criteria to establish coincident measurements between FTIR and satellite needs to be revised.

Specific Comments

I highly suggest to review exhaustively the English along the manuscript. I have some specific comments below, but they are not exhaustive by any means. P1, L2: Change Addis Ababa with Addis Ababa, Ethiopia

C2

Is the instrument/site part of the NDACC effort?, if not please explain the reason.

Are the measurements automated?, how often do you measure.

Add information about quality control of spectra acquired.

Change ground based with ground-based when mentioned in the manuscript

P3 I13. Change “The Addis Ababa FTIR spectroscopy” for “The ground-based FTIR at The Addis”

P3, L15 add Altitude of the site

P3, Section: In the measurement site section is not clear whether the site is located in the city limits of Addis Ababa or whether is located far from major emission sources. Please add information regarding typical air masses transported at Addis Ababa and/or emitted from local sources. Also, are there other atmospheric measurements carried out in Addis Ababa, which can be used to complement your study?.

P3, L23: remove very

P3, L23, change “to the study of trace gases in the atmosphere” with “to study trace gases in the atmosphere”

P3, L23, remove “terrestrial”

P3, L30: remove very

P4, L7: explain why Tikhonov-Phillips regularization was used and also why is the retrieval performed on a logarithmic scale.

P4, L29: The link <http://www2.cesm.ucar.edu/working-groups> does not work. Similarly, the link: <http://hyperion.gsfc.nasa.gov/DataServices/automailer/index.html>. Consider changing and being consistent with format.

P5, L1: Why different versions of HITRAN were used. Please explain and also, what versions were used for gases.

C3

P5: I suggest to remove Figure 1. I do not see the value of Figure 1. It does not show a result/finding but only the a priori profiles used. Furthermore, in the text the temperature profile from this figure is not even mentioned. Keeping the text would be ok just change it accordingly.

P5. What do you mean by “The micro windows have been adopted from different sources.”, do you mean past works? Expand a description and add references.

P5. L8-10. It is mentioned that micro windows are different than NDACC /IRWG guidelines. Please describe in detail why the NDACC guideline was not adopted. I was able to retrieve the guideline and all micro-windows for CH₄ and N₂O used in this work are different. I imagine the guidelines were created to obtain a harmonized retrieval strategy applied among different locations. This is important and needs to be explained.

In order to characterize the possible impact of the choice of the micro windows I suggest to test and compare the micro-windows/setting applied here with the harmonized NDACC settings.

Table 1. Recommendation: Change T.Gases with Gas; replace parenthesis with dash for micro-windows, change int. gases with interfering species; why is important to show three significant figures in DOF?, and mention here what species are retrieved as profiles and columns.

Table 1. According with the NDACC/IRWG guideline, HDO is an interfering specie but you are not using it, please explain. See also Sussmann et al. (2011).

Along the same lines, water vapor might influence the retrieval of CH₄ and N₂O. However, it is not mentioned what water vapor profile is used. Please describe if climatology (or reanalysis) is used, or do you pre-retrieve water vapor?.

P5, L9: change wondows with windows

P5, L10: The link www.ndacc.org does not have information regarding retrievals of CH₄ and N₂O. Change it accordingly.

C4

Quality of Figures 2 and 3 is not good enough. They are blurry and too small to really see the quality of the fits.

P5, L11. I suggest to split the following sentence: The spectral fit and residual between measured and simulated spectra at five and four microwindows for CH₄ and N₂O respectively are depicted in Fig. 2 and Fig. 3 for example spectra recorded on Feb 26, 2013 and Dec 31, 2009 at Addis Ababa respectively.” And why two different dates are used?, and remove Addis Ababa, you are not using other sites.

P5, L15: What do 0.4% and 0.35% mean?, explain.

P5, L15. It is mentioned that the retrieval strategy is optimized using a single spectra. . . please expand this description, what do you use as criteria for optimization? Is it consistent for all months, zenith angles?.

Regarding figure 4. Averaging kernel matrices are not described in the text. I recommend to remove the matrices and keep the rows of the averaging kernels. Rows of averaging kernels are not visible within the x-axis scale, please re-adjust. The sum of averaging kernels can be divided by 10 to use the same x-axis scale and lines need to be color coded by altitude and show the color bar. As all other figure, increase the quality of the figure.

P7, L12. Along the manuscript Addis Ababa is mentioned, although is clear. I suggest to remove Addis Ababa when is not needed.

P9, L10. Examples of error profiles are shown for CH₄ - Feb 26 2013 and N₂O – Dec 31 2009. Why was decided to use examples that are +3 years apart?

Figure 5. Please improve the quality of the figure. It is extremely hard to find the corresponding error type. I suggest to add the total error for each statistical and systematic errors. Additionally, I don't follow why the retrieved/apriori profiles are shown here. I suggest to replace this by the fraction of the total error with the retrieved profile and one might see the fractional error as a function of altitude.

C5

P10, L7. It is mentioned that the MIPAS reduced spectral resolution is used, what does reduced resolution mean?

P10, L8. Explained why only satellite data between March 2009 to Dec 2010 is used for MIPAS?, what about the other satellite measurements (it is not mentioned)?

P11, L2. What does visibility flag 1 mean?, and how the criteria of diagonal elements has been chosen?

P11, L5. Change Plieninger et al. 2016 with Plieninger et al. (2016) and check format of references along the manuscript.

P11, L17. Under the MLS section it is mentioned: “In this work, we have used version 3.3 MLS of N₂O data set to validate ground-based FTIR results”. This is kind of surprising. Usually, the ground-based FTIRs are used to validate satellite-based measurements. Please explain in detail why you have chosen MLS to validate FTIR. Also, do you also use MIPAS and AIRS to validate FTIR?

P11, L19, Change EOS MLS (Earth Observing System) with EOS MLS

P12, L2. Expand the description “Selection criteria were implemented as stated in Livesey et al. (2013)”. What do you mean by selection criteria?

In order to see the difference in sensitivity among the satellite measurements I suggest to include averaging kernels for the three selected satellites.

Section 5.1. The coincident criteria of ± 2 deg latitude and ± 10 deg of longitude from the FTIR site is extremely large. As in other parts of the manuscript, please expand a description of why this wide range is used. I would try other distances as well. How do you assess the spatial-temporal variability of both CH₄ and N₂O.

Section 5.1. I encourage the authors to rename the following: V5R_CH4_224, V5R_N2O_224, MLS V3.3. These names are constantly but highly distractive.

P13, eq 4. It might be obvious but please describe variables of eq 4.

C6

P13, eq 10. Why is this equation multiplied by 200?. Please revise this and all other equations.

Section 5.2. It is not explained why authors compare FTIR vs satellite vertical profiles. The FTIR information content is limited to 2 DOFs (tropospheric and stratospheric columns) but main figures for the comparison are shown as profiles.

References Sussmann, R., Forster, F., Rettinger, M., and Jones, N.: Strategy for high-accuracy-and-precision retrieval of atmospheric methane from the mid-infrared FTIR network, *Atmos. Meas. Tech.*, 4, 1943-1964, <https://doi.org/10.5194/amt-4-1943-2011>, 2011.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, doi:10.5194/amt-2019-170, 2019.