Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-84

Anonymous Referee #2

Referee comment on "GFIT3: a full physics retrieval algorithm for remote sensing of greenhouse gases in the presence of aerosols" by Zhao-Cheng Zeng et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-84-RC2, 2021

This paper presents progress towards implementing an aerosol retrieval to the existing CLARS-GFIT algorithm. The CLARS-FTS instrument is a peculiar ground-based FTS as it collects solar spectra from reflected sunlight rather than observing the sun directly. Because of the much lower signal with reflected sunlight, the effect of aerosols must be included in the forward model. The paper presents experiments with the new algorithm to estimate the effect on retrieved GHGs of simultaneously retrieving the aerosol optical depth and aerosol layer height. This article should be published after addressing the following comments and questions:

General comments:

GFIT3 may be a confusing name. GFIT2 enables profile retrievals and has a separate implementation of the inverse method. I would assume a “GFIT3” would add something to GFIT2.

I feel section 5.3 should come before Section 5.2 as it should be shown that the retrieved AOD compares well to independent measurements (and is an improvement from the a priori AOD) before comparing CLARS-GFIT and GFIT3 GHG retrievals.

Is CLARS-FTS able to target the Pasadena TCCON site located at CalTech? Can it be used to validate its GHG retrievals? This could be discussed in the text.

How much more time does it take to run a retrieval with LIDORT 32 streams compared to

O-PCA? Figs. 10 and 11 seem to show that the effect on XCO_2 and XCH_4 MAE of using the less accurate model is comparable to switching from 3-hourly to monthly a priori GHG profiles and aerosol composition.

Specific comments:

Table 1: add units for aerosol layer height.

Figure 3: is the post-processing step really done before the final iteration of the optimal estimation method that yields the a posteriori state vector? Is the retrieved state changed during post-processing and becomes the "optimized state vector"?

Figures 11(c): it looks like the ALH panel has more simulations than the other panels and more than the "60 different observation scenarios" mentioned on Line 337. Is it the sum from simulations with all AODs? Clarify in the text or in the caption.

The "asymmetric factor" is only included in captions of Figs. 7 and 12, mention in the text what it is and why it is important.

Line 46: spell out AERONET.

Line 63-64: specifying that GFIT2 uses optimal estimation makes it sound like GFIT does not, both GFIT and GFIT2 use the optimal estimation method.

Line 85-86: I feel there should be a sentence to indicate if airglow would also have an impact on CLARS-FTS measurements.

Line 139: given the upcoming release of a new GGG version with major updates to the spectroscopic linelist, it should be mentioned here that you have been using the GGG2014 linelist (if this is what you used).

Line 143: is (4) referring to the RMS of fit residuals? 1-sigma above the mean of what? The mean of the RMS of residuals from multiple spectra? The mean of the residuals of the current spectrum?

Line 149: Washenfelder et al. (2006) is missing from the reference list.

Line 223-224: the a priori ALH is derived from an aerosol profiling lidar, but the a priori value in Table 1 is 0.7 (km?), does the a priori change based on the MiniMPL observations or were these observations used to determine a fixed 0.7 would be used as a priori value?

Line 227: I suggest rephrasing to: "The goal of optimal estimation is to produce the state vector with maximum a posteriori probability by minimizing the following cost function"

Line 346: please explicitly state what the retrieval error is. I would assume "retrieval error" to be the square root of the diagonal elements of the a posteriori covariance matrix, so always positive and smaller than the a priori uncertainties. Explicitly state what the errors are on the horizontal axes of Figs. 10 and 11, are these the % differences between each retrieved quantity and the values used to generate the synthetic spectra?

Line 350: if the a priori aerosol layer height is 700 m with a 50 m uncertainty, an "average error less than 1 km" is large. Does 50 m correspond to the variability in the MiniMPL data? In Fig. 11(c) Why did one of the simulations produce a ~50% error in ALH?

Line 353 and Fig. 12(c): is the "bias In PBL enhancement" the difference between the 3-hourly and monthly a priori profiles? Clarify in the text.

Line 362: indicate the number of spectra that are included in the analysis after filtering.

Line 375: including a new fitting parameter can only reduce the RMS of spectral fit residuals. This alone is not sufficient to conclude that adding aerosols to the fit improves the retrieval. Did you observe that spectral residual features specifically attributable to the presence of aerosols were reduced?

Line 391: could you provide a value for the AERONET AOD accuracy?

Line 395: is a RMSE value of 0.02 really indicating "good agreement" for a quantity that ranges from ~0.01-0.15? Is it for the coarse or fine AOD, or some combination of both?

Line 403: do we know which other factors?

Line 404-405: In the conclusion you suggest the results could be improved by first retrieving ALH and then using it as a fixed (?) input to retrieve GHGs, this could also be stated here too.

Line 430: I found that sentence confusing, specify if you are referring to the O_2 or CO_2 SCD.

Typos:

Line 45: "Although the GHG retrievals show good agreement with ground-based Total Carbon Column Observing Network (TCCON) results, the retrieved aerosol optical depth (AOD) values have larger differences compared with collocated AERONET measurements"

Check wording (larger => large?), AOD differences with AERONET cannot be "larger" than GHG differences with TCCON.

Line 397: CLARS-FP => CLARS-GFIT or CLARS-FTS ?

Line 421: shorter => shorten