

## Reply to comments raised by Referee #2.

The original comments are in plain texts, and our replies are in **bold texts**.

General comments:

This study used ground-based FTIR Mid-infrared observations at Xianghe to retrieve C<sub>3</sub>H<sub>8</sub> column through optimal estimation approach. Compared with CH<sub>4</sub> and H<sub>2</sub>O, the absorption of C<sub>3</sub>H<sub>8</sub> is weak at 2964.5-2970.0 cm<sup>-1</sup>, thus retrieving C<sub>3</sub>H<sub>8</sub> is challenging. Although the authors conducted uncertainty analysis, I still have some concerns about the accuracy and importance of the C<sub>3</sub>H<sub>8</sub> retrievals.

**First of all, we would like to thank you for the comments and suggestions.**

Specific comments:

1. Due to the weak absorption of C<sub>3</sub>H<sub>8</sub>, I suspect that the a posteriori C<sub>3</sub>H<sub>8</sub> strongly depends on a priori C<sub>3</sub>H<sub>8</sub>. Figure 6 shows the seasonal variation of FTIR C<sub>3</sub>H<sub>8</sub> is different from the two model simulations. How is the monthly variation of the a priori C<sub>3</sub>H<sub>8</sub>? Is it similar to the FTIR retrieval? It would be interesting to see to how the a posteriori C<sub>3</sub>H<sub>8</sub> vary if different a priori profile (for example, using profiles from CAMS and WACCM as a priori) is used.

**Thanks for the suggestion and comment. In this study, the a priori profile of C<sub>3</sub>H<sub>8</sub> is derived from the mean of WACCM model simulations between 1980 and 2040. The a priori mole fraction profile is fixed, which does not vary with time. By using a fixed a priori profile, the retrieved C<sub>3</sub>H<sub>8</sub> mole fraction is less affected by the a priori variation. More information is added in the revised version. In addition, we added the a priori C<sub>3</sub>H<sub>8</sub> columns in the left panel of Figure 5. Note that the a priori mole fraction is fixed, while the a priori columns vary with surface pressure, with a maximum in winter and minimum in summer.**

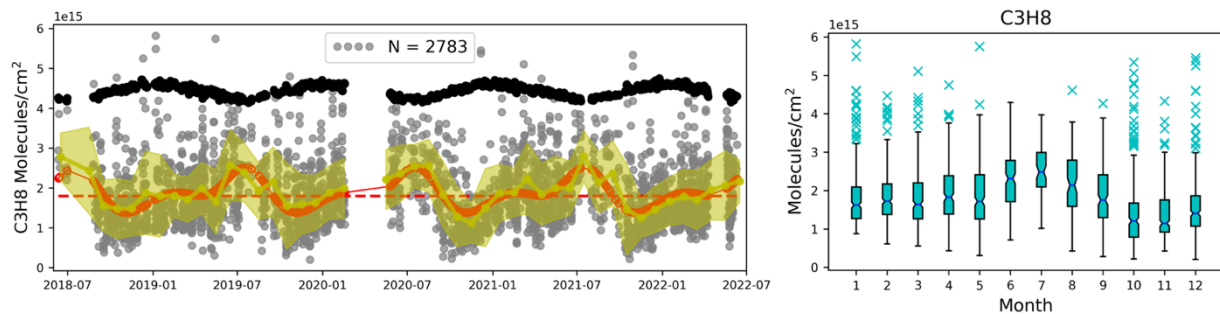


Figure 5. Left panel shows the time series of FTIR a priori columns (black dots), individual C3H8 column measurements (grey dots), monthly means (yellow line), monthly stds (yellow shade), and periodic function fitting (red solid line) and the fitted offset (red dashed line). Right panel: the monthly box plot of the FTIR retrieved C3H8 columns. The bottom and top bars represent the 10% and 90% percentiles of the datasets and the blue crosses are the extremely high values above 90%.

2. As CH4 and H2O have stronger absorption than C3H8, and CH4 and H2O absorption lines are not perfectly fitted, how it will affect the accuracy of C3H8 retrieval should be discussed.

Thanks for the comment. More discussion about CH4 and H2O impacts are added in the revised version. Particularly, the retrieval error of the C3H8 column from the CH4 and H2O spectroscopy uncertainty are re-calculated and added in Table 3.

3. In Sect. 2.4, how uncertainty is calculated? Apparently, we cannot get  $x_i$  and  $b_i$ . More details are needed.

Thanks for the comment. More information about the uncertainties are added in the revised version.

It is assumed that 10% of the a priori profile is used to derive the diagonal values of the systematic covariance matrix  $S_a^{sys} = \sigma_i^2$ , and the off-diagonal values of  $S_a^{sys}$  are calculated as  $S_a^{sys} = \sigma_i \sigma_j$  (von Clarmann 2014 AMT). The covariance matrix derived from the WACCM 61-years' monthly means are set to the random covariance matrix  $S_a^{ran}$ .

Regarding the model parameter uncertainties in the Table 3, the systematic/random  $S_b$  matrix was created by the mean/standard deviation of the differences between NCEP and ERA5 at Xianghe. The random deviation is about 2K, and the systematic deviation is about 1.5K for the whole vertical range. For the target spectroscopic parameters, the relative uncertainties of C3H8 is set to 4% according to the PLL database. For the CH4 and H2O spectroscopy parameters, the relative uncertainty of 5% is derived from the HITRAN 2020 dataset. For the uncertainties of curvature, zshift, and SZA, we use the values provided by the SFIT4 algorithm (<https://wiki.ucar.edu/display/sfit4/SFIT4+Version+1.0.xx+Release>), which is recommended by the NDACC-IRWG community.

Toon, G. C., Blavier, J.-F. L., Sung, K., and Yu, K.: Spectrometric measurements of atmospheric propane (C<sub>3</sub>H<sub>8</sub>), *Atmos. Chem. Phys.*, 21, 10727–10743, <https://doi.org/10.5194/acp-21-10727-2021>, 2021. should be cited. It used observation around 2967 cm<sup>-1</sup> to retrieve C<sub>3</sub>H<sub>8</sub>.

**References:**

von Clarmann, T.: *Smoothing error pitfalls*, *Atmos. Meas. Tech.*, 7, 3023-3034, doi:10.5194/amt-7-3023-2014, 2014.