Reviewer #1

General comments

The manuscript "Validation of XCO_2 and XCH_4 retrieved from a portable Fourier trans-form spectrometer with those from in-situ profiles from aircraft borne instruments" by Hirofumi Ohyama et al. describes the validation of retrievals of the column averaged dry air mole fractions of CO_2 and CH_4 from a single portable, low-resolution near infrared solar absorption EM27/SUN Fourier transform spectrometer at the Rikubetsu and Burgos total carbon column observing network (TCCON) sites with in situ aircraft measurements.

The presented work represents one of the first documented examples of in situ validation of greenhouse gas measurements from a portable spectrometer of this type and therefore contributes significantly to the value of such measurement techniques. The Authors have taken rigorous steps to ensure the robustness of the comparisons by demonstrating the stability of the portable instrument in terms of its instrument line shape and comparison of retrievals to the Tsukuba TCCON site, and by choosing which aircraft data to compare to, informed by the effect of large scale dynamics on the tropopause height in the case of the Rikubetsu comparison and by transport of regional emissions for Burgos. The manuscript is well written and follows a logical narrative. All important steps are outlined, and assumptions appropriately justified. I would strongly recommend publication of the manuscript subject to some minor alterations outlined below.

We thank you for reading our paper carefully and providing valuable comments. We have added some descriptions for clarification and revised our manuscript according to your comments. Please see our specific responses below.

Specific comments

At the end of sections 3.1 and 3.2, and elsewhere in the manuscript particularly Table 2, the terms uncertainty and error are used interchangeably. The error in a measurement should refer to the difference between that measurement and the true value of the measurand whereas the uncertainty describes the range about the measurement in which the true value most likely lies. In the context of this work, the term uncertainty should be used. For further information I refer the authors to the BIPM Guide to the Expression of Uncertainty in Measurement.

We have revised the text to exclusively use the term uncertainty, unifying the two terms (i.e., uncertainty and error).

To aid with the understanding of the choice of aircraft profile used for the Rikubetsu comparison it would be helpful if the radiosonde lapse rate derived tropopause heights (or a subset thereof) and the GGG derived value were plotted on Figs 1 (b) and (c) or Fig 2 (a), and the GGG determined tropopause height included in Table 1.

We have added the tropopause heights from the radiosonde lapse rate and the GGG2014 in Figs. 1b and 1c. In addition, the tropopause height from the GGG2014 has been included in Table 1.

Figure 1 (b) seems to be missing data from the ascent profile between just above the surface and approximately 3 km. It would also aid the interpretation if Figures 1 and 2, (b) and (c) included an indication of the transition from aircraft data to a priori in the composite profile.

As you pointed out, there is no description of the missing data from the ascent profile. We have added the following sentence in Sect. 3.1 (lines 190–191): "There are missing data due to instrumental calibrations, especially between 0.24 and 2.78 km of the CO_2 ascent profile (Fig. 1b)." Additionally, we have added the following sentences in Sect. 3.4 (lines 412–416): "When calculating aircraft XCO_2 and XCH_4 values, the missing data were linearly interpolated. We note that, provided that the missing data between 0.24 and 2.78 km of the CO_2 ascent profile were substituted by the descent profile in the corresponding altitude range, the difference between the XCO_2 values from the linear interpolation and the substitution was less than 0.1 ppm."

Regarding the transition from aircraft data to the a priori profile, we have added the composite profiles in Figs. 1b, 1c, 3b, and 3c.

It should be made clearer that the EM27 results presented in Table 4 are before the derived airmass independent correction factor has been applied.

We have added the following sentence in the caption of Table 4: “The air mass independent correction factors derived in this study are not yet applied to the EM27/SUN data.”

Has the GGG2014 airmass dependent correction factor also been applied to the EM27 retrievals presented?

Yes. We have revised the description related to the correction factors in Sect. 2.1 (lines 143–148) as follows: “The GGG2014 software includes air mass independent and air mass dependent correction factors for the TCCON data. The air mass independent correction factors (AICFs) were not utilized (i.e., they were set to one) because we separately determined them for EM27/SUN in this study. Meanwhile, we used the same air mass dependent correction factors (ADCFs) as those applied to the TCCON data, and their validity is evaluated in Sect. 3.3.”

In addition, we have added the following sentences in Sect. 3.3 (lines 370–386): “As described in Sect. 2.1, we applied the GGG2014 ADCFs to the EM27/SUN retrievals. The ADCF is a coefficient tied to a symmetric basis function (Eq. A12 in Wunch et al. (2011a)) representing spurious diurnal variation, and the values derived from the TCCON data at multiple sites are -0.0068 ± 0.0050 for XCO_2 and 0.0053 ± 0.0080 for XCH_4 (Wunch et al., 2015). To assess the relevance of applying the ADCFs derived from the TCCON data to the EM27/SUN data, we derived the ADCF for our EM27/SUN, such that the difference between the EM27/SUN and TCCON retrievals in Burgos that were individually averaged into 10 min bins is minimized while taking into account a coefficient for correcting the mean bias between EM27/SUN and the TCCON data. The derived ADCFs are -0.0064 ± 0.0004 for XCO_2 and 0.0034 ± 0.0007 for XCH_4 (the uncertainties were estimated as 1σ standard deviations of daily ADCFs derived from four days side by side observations in Burgos). The ADCFs for XCO_2 show good agreement between the EM27/SUN and the TCCON, while those for XCH_4 show a slightly larger difference. Considering that the ADCFs for our instrument are consistent with those for the TCCON data within the uncertainties and that the ADCFs have the possibility to vary with the seasons and sites (Wunch et al., 2015), we conclude that the use of the mean ADCFs derived from the TCCON data is a reasonable choice.”

References:

Wunch, D., Toon, G. C., Blavier, J. F., Washenfelder, R. A., Notholt, J., Connor, B. J., Griffith, D. W., Sherlock, V., and Wennberg, P. O.: The total carbon column observing network, Philos. Trans. A Math. Phys. Eng. Sci., 369, 2087–2112, https://doi.org/10.1098/rsta.2010.0240, 2011a.

Wunch, D., Toon, G. C., Sherlock, V., Deutscher, N. M., Liu, C., Feist, D. G., and Wennberg, P. O.: The Total Carbon Column Observing Network's GGG2014 Data Version, Tech. rep., California Institute of Technology, Pasadena, CA, https://doi.org/10.14291/tccon.ggg2014.documentation.R0/1221662, 2015.

Past and present tenses are used inconsistently through the manuscript, this should be rectified.

We have revised the manuscript based on the following basis. We used the past tense to describe measurements and analyses that have already been completed at the time of writing of the paper, while we used the present tense to interpret the results and discuss the significance of the findings.

Page 6, line 195 insert CO_2 before profiles when referencing figure 2 (a).

We have revised accordingly.