Black: referee's comments red: authors' answers
First of all, we want to thank the referee for the detailed analysis of our paper.
For the details, please look into the paper with keeping track of changes.

Anonymous Referee #2
General comments The manuscript "A new site: ground-based FTIR XCO2, XCH4 and XCO measurements at Xianghe, China" by Yang et. al. describes a data set of total column dry air mole fractions of carbon dioxide, methane and carbon monoxide derived from near infrared, solar absorption Fourier transform spectroscopy using methods similar to those of the Total Carbon Column Observing Network (TCCON). The described dataset covers a year of measurements and therefore captures a single seasonal cycle. The manuscript follows a logical narrative, but in some areas would benefit from additional copy editing.

Data of this type, from an urban area of China, are likely to be of value to the satellite and model validation communities and I would encourage the publication of this manuscript subject to a number of clarifications and modifications as detailed below.

Specific comments
Reference is made to TCCON throughout the manuscript, however it is not made explicitly clear that the Xianghe site is not currently affiliated to TCCON. This should be stated from the start including what steps are required for the site to become affiliated with TCCON if that is the objective. Additionally, statements such as "this study shows that the Xianghe data comply with the TCCON specifications" at page 12 line 30 are considered quite strong and possibly misleading as, for example, the TCCON requirement for an in-situ validation is not covered in this work. Care should also be taken when making comparison to the TCCON accuracy/precision requirements, throughout the manuscript reference is made to "the 0.8 ppm (SZA less than 80 ◦) retrieval accuracy of TCCON XCO2." (e.g. at P4 L23), this is actually the target for site-to-site biases within the TCCON. The actual single instrument/site precision target for TCCON is 0.1% i.e. 0.4 ppm for XCO2. Precision estimates within the manuscript are based on the standard deviations of daily retrievals of each of the species. This may result in an overly pessimistic estimate as the daily means are potentially influenced by a number of factors such as a diurnal cycle, the influence of local sources in such a heavily urbanized area and a residual airmass dependence of the retrievals as pressure broadening is not accounted for in the GGG2014 spectroscopy. Better and more representative results may be obtained by limiting the windows over which standard deviations are calculated to a smaller range of solar zenith angles or shorter periods.
Thanks for the suggestions.
The aim of the study is to describe the ground-based FTIR data at Xianghe, and to show that the data quality of our FTIR XCO_2, XCH_4 and XCO measurements is comply with the TCCON requirement (except an in-situ validation). The site has not been affiliated to TCCON yet. Therefore, the main concern of this work is to demonstrate the quality of the spectra at Xianghe and to be ready to join TCCON in near future. Steps are added in the beginning to make the target of this paper clear.

We adapt the description about the precision of the TCCON XCO_2 in the revised paper. According to Pollard et al., (2017), the precision target for TCCON is 0.1% (~0.4 ppm) for XCO_2 to meet the model requirement (Olsen and Randerson, 2004). However, the precision of the TCCON XCO_2 is estimated to be 0.2% (~0.8 ppm) based on the perturbation of the GGG2014 inputs (Wunch et al., 2015).

To estimate the precision of the retrievals at Xianghe, we limit the windows over which standard deviations are calculated to a smaller range of solar zenith angle (SZA less than 30°) to reduce the potential influences, such as a diurnal cycle, the influence of local sources in such a heavily urbanized area and a residual airmass dependence of the retrievals as pressure broadening is not accounted for in the GGG2014 spectroscopy. We select all the days when at least 5 measurements are available. Table 1 is updated as follows

Table 1. The mean standard deviation (STD) of XCO_2, XCH_4 and XCO of the remaining data after solar intensity (SI) filtering for each day and the percentage of the remaining spectra amount from 14 June 2018 to 31 December 2018. Only measurements with SZA less than 30°are selected.

β (%)	γ (%)	STD(XCO_2) (ppm)	STD(XCH_4) (ppm)	STD(XCO) (ppm)	Percentage of remaining spectra (%)
85	10	0.749	0.0042	3.032	89.5
85	5	0.723	0.0036	2.954	88.9
85	0	0.667	0.0035	2.997	88.1
90	10	0.651	0.0036	2.904	86.6
90	5	0.648	0.0035	2.908	85.8
90	0	0.496	0.0035	2.559	84.7
95	10	0.450	0.0029	2.421	78.5
95	5	0.447	0.0029	2.436	77.1
95	0	0.423	0.0026	2.438	75.2

In order to reduce the variation of the measurements and to keep as many as useful measurements, we choose the β=90%， γ=0% as the criteria for the solar intensity filtering. The mean STD of XCO_2, XCH_4 and XCO are 0.496 ppm, 0.0035 ppm and 2.559 ppb, respectively, and there are 84.7% spectra remained. Note that the mean STD of XCO_2 is 0.12%, which is slightly worse than the target of the TCCON XCO_2 precision of 0.1%, but it is better than the estimated uncertainty of 0.2%. To evaluate the precision of the retrievals at Xianghe, we compare the STD of XCO_2 measurements at Xianghe with several standard TCCON sites with similar latitude (Lamont, Karlsruhe, Pasadena, Rikubetsu, Tsukuba, Saga, Orleans and Anmeyondo) in Table 2. The STD of XCO_2 at Xianghe is 0.496 ppm, which is less than most sites except Karlsruhe and Orleans. The precision of XCO_2 measured at Xianghe is comparable with other TCCON sites.

Table 2. The mean standard deviation (STD) of XCO_2 for the measurements at each day with the solar zenith angle less than 30°, together with total numbers of the days and the STD less than 0.1% for XCO_2 since January 1, 2017 at Anmeyondo, Karlsruhe, Lamont, Orleans, Pasadena, Rikubetsu, Saga, Tsukuba. At Xianghe, the measurements are between 14 June 2018 to 31 December 2018 after the SI filtering with the β=90%， γ=0%.

Sites	Latitude (N)	N (total) / N (STD < 0.1%)	Percentage (STD< 0.1%)	STD(XCO_2) (ppm)
Anmeyondo	36.5	9 / 0	0	0.925
Karlsruhe	49.1	73 / 57	78	0.311
Lamont	36.6	287 / 0	0	0.718
Orleans	48.0	49 / 41	94	0.375
Pasadena	34.1	280 / 38	14	0.524
Rikubetsu	40.0	33 / 8	24	0.507

Saga	33.2	192 / 34	18	0.589
Tsukuba	43.5	106 / 31	29	0.506
Xianghe	39.7	19 / 7	37	0.496

In addition, the table 3 is updated based on the measurements with the SZA less than 30°. For the AC+DC mode, the STD of XCO_2 with only SNR filtering is the best. If we apply both SNR filtering and SI filtering, many reasonable retrievals will be filtered out, which have bad SI flags but have been corrected by the DC correction procedure. Therefore, for the period with AC+DC mode, only the SNR filtering is applied.

Table3. Average XCO_2 daily standard deviation after (a) no filtering, (b) SNR filtering, (c) both SNR filtering and SI filtering during the AC mode and AC+DC mode periods. The unit is ppm. Only those measurements with SZA less than 30° are considered.

	AC mode	AC + DC mode
a	1.19	1.06
b	0.94	0.53
c	0.57	0.88

In sub-section 2.2 it would also be useful to present some example plots of ME and PE as a function of OPD, and as PE can have a maximum value at an OPD other than the maximum, consider presenting a time series of maximum PE. Also, LINEFIT 14.5 can be used in a number of modes, it should be explicit which mode is used.
Thanks for the suggestions.
We plot the ME and PE as a function of OPD, together with the maximum ME loss and maximum PE deviation at Xianghe in the revised version, which is showed in Figure 1. The ME has a maximum loss at the MOPD while PE has a maximum deviation at about 20 cm (positive value) or the MOPD (negative value).

These ILS parameters are retrieved by LINEFIT 14.5 using 13 HCl microwindows under non-vacuum status. The degree of freedoms for signal (DOFS) of anodization and phase are about 4.1 and 4.2, respectively.

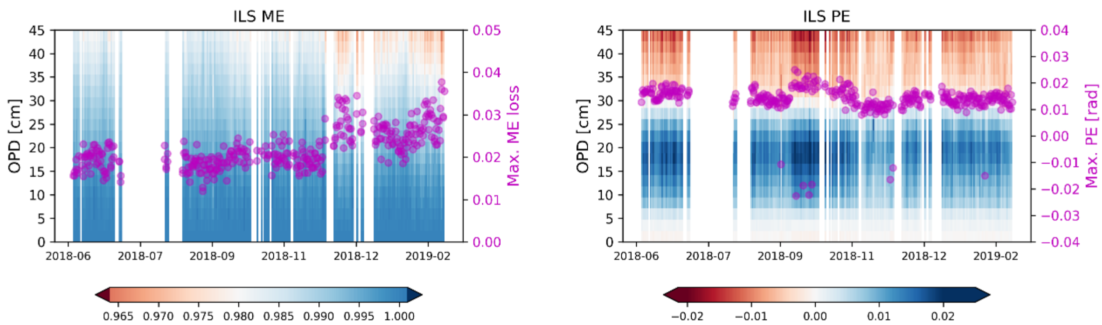

Figure 1. The modulation efficiency (ME, left panel) and phase error (PE, right panel) along the optical path difference (OPD) at Xianghe. The purple dots are the maximum ME loss (left) and the maximum PE deviation (right).
The sub-section on signal-to-noise ratio would benefit from a discussion about how SNR is calculated as there are a number of possible methods. Making this explicit would make it easier to make comparisons between sites.
Thanks for the suggestion. More information has been added in the revised paper.
We calculate SNR as the ratio between the maximum intensity of the spectrum in the spectral range of 3800-11000 cm^{-1} and the noise level. The standard deviation of the intensity

between 2350 and 2450 cm^{-1} is calculated as the noise level, since no signal is recorded in this window.

$$SNR = \max(I)\ /STD(noise).$$

In the paragraph describing satellite missions that can be validated by this type of measurement in the introduction, GOSAT is notable by its absence, and as one of the first satellites dedicated to measuring greenhouse gases probably deserves to be mentioned.
Added.

Ongoing measurements of this type are likely to be of interest to a number of users and so a statement about whether future measurements will be added to the referenced dataset, or the TCCON archive if the site should become affiliated to the network, would be useful.
Thanks for the suggestion.
The data used in this study can be accessed by the data DOI, and the public can download them for their interests, such as satellite validation and model inversions. In the near future, we hope to join the TCCON successfully via the institutional agreement and upload the ongoing measurements to the TCCON archive.

Technical corrections
P2 L4-8 Whilst not strictly necessary, it would be useful to provide more context by comparing the current values to their pre-industrial levels and/or stating the current rate of increase.
Done

P2 L10 Provide the radiative forcing of CO2 as a comparison.
Done

P2 L13-14 Try to clarify the distinction that is being made here, i.e. are the two main types of measurement in-situ and remote sensing, or ground-based and satellite?
To avoid the confusion, we remove this sentence in the revised version.

P3 L1-2 Inclusion of the sentence "To increase the precision of the retrievals, the spectra are cloud filtered based on the separate direct solar irradiation measurements." fragments the description of the manuscript outline, considering removing it.
Done.

P3 L33 After "NIR InGaAs" insert spectra or measurements.
Done

P3 L26 - P4 L7 These two paragraphs highlight the importance of consistent representation of scalars and their vectors e.g. m and meters are both used and sometimes there is a space between the scalar and vector and sometimes not.
Corrected

P5 Eq.1 Appears to have been inserted at the wrong point in the manuscript.
Corrected

P5 L16 Please give details of these sensors, particularly the type and precision/accuracy of the pressure sensor which is very important for the accuracy of trace gas retrievals.

Added

P5 L20 Does the first "a priori partial column" refer to the tropospheric component? This should be made more explicit.
Done.

P6 L10 Consider using affected instead of infected.
Done.

P9 Eq.4 The vector I is not defined.
Added

P11 L8, L14 and L31 The Landgraf et al references do not contain a year.
Corrected

Table 2. AC+DC mode column, it would be expected that additional filtering would result in a lower value for SNR+SI (row c) than for SNR (row b) on its own. This doesn't appear to be the case.
For the AC+DC mode, the STD of XCO_2 with only SNR filtering is the best. If we apply both SNR filtering and SI filtering, many reasonable retrievals will be filtered out, which have bad SI flags but have been corrected by the DC correction procedure. Therefore, for the period with AC+DC mode, only the SNR filtering is applied.

Reference:

Olsen, S. C. and Randerson, J. T.: Differences between sur-face and column atmospheric CO2and implications for car-bon cycle research, J. Geophys. Res.-Atmos., 109, D02301,https://doi.org/10.1029/2003JD003968, 2004.

Pollard, D. F. , Sherlock, V. , Robinson, J. , Deutscher, N. M. , & Shiona, H. . (2017). The total carbon column observing network site description for lauder, new zealand. Earth System Science Data, 9(2), 977-992.

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, p. 43, https://doi.org/10.14291/tccon.ggg2014.documentation.R0/122, 2015.