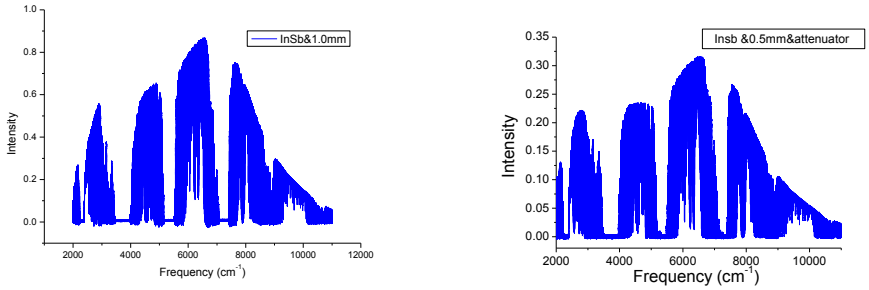
Response to comments #1

We appreciate your constructive and positive comments. The comments and proposed corrections have been taken into account and helped improving the paper. Each comment has been addressed as follows. There is an extensive discussion among the authors regarding how to revise the content. So the response is delayed, and we are sorry for this.

General comments:

1.Do your InSb spectra show any signs of nonlinearity (e.g., zero level offsets in saturated windows)? I would be surprised if there were no signs of nonlinearity using such a large wavenumber range on a single detector. There do seem to be signs of continuum curvature in your spectral fits with the InSb detector (Figs 8 and 9 especially) which could impact your retrievals. I would be cautious using the results generated from the InSb spectra in scientific analyses.

Response: We had no InGaAs detector before 2015, so we used a InSb detector to record NIR solar spectra until the end of July 2015. An InGaAs detector has been used since July 2015. The Insb spectra were collected with the 1.0mm aperture in the first 3 months, but many spectra were saturated and showed nonlinearlity (the left panel in the figure below). So we began to use the 0.5mm aperture and added two attenuators in front of the InSb detector, the spectra showed no obvious zero level offsets in saturated windows again (the right panel in the figure below).



The continuum curvature could impact our retrievals. Also, different properties of the two detectors may result in biases between the measurements. To examine the consistency between the InSb and InGaAs detector, the InSb & 0.5mm aperture and InGaAs & 1mm aperture were used alternatively to record solar spectra on a clear day on 1 April 2016.The statistical biases between the measurements of InSb & 0.5mm aperture with InGaAs & 1mm aperture are calculated. The results show that the O_2 window has a large bias ~0.6% for InSb & 0.5mm aperture compared with InGaAs & 1mm aperture, whereas the bias in each CO_2 or CH_4 window is much smaller, with mean biases of 0.129% and 0.026%, respectively. These biases are probably attributed to the response discrepancy of the two detectors. To avoid the systematic biases, the bias correction factors of 1.991ppm and 0.011ppm were applied to all XCO_2 and XCH_4 time series for InSb spectra, respectively, provided that these biases are consistent throughout the entire measurement period. We added a supplement for this paper, in which we describe the observation activities, consistency evaluation and corrections, including optical alignment evaluation, surface pressure correction, timing error

correction, and consistency between InSb and InGaAs detector. We discussed the details how to ensure the consistency between InSb and InGaAs detector in the section 3.4 of supplement.

2.I see a couple of potential problems with your tracer-tracer analysis. To look at these sorts of tracer-tracer slopes over the course of more than one day, you need to remove the seasonal cycle and long-term trends in the data, and thus most analysis of this type is done using anomalies. Furthermore, TCCON (or TCCON-like) data are subject to airmass dependencies due to spectroscopic line list inadequacies, which are removed to first order by an airmass-dependence correction. There are residual airmass dependencies that remain in the data after correction, and these can influence your tracer-tracer slopes. Computing daily anomalies by subtracting data in the morning at a given airmass from the afternoon data at the same airmass further reduces the possibility of spuriously folding airmass dependent errors into your tracer-tracer relationships. In light of this, please rework this section of the analyses.

Response: In order to reduce the airmass dependencies in tracer-tracer analysis, we calculated the daily anomalies by subtracting the morning DMF value at a particular solar zenith angle from its afternoon counterpart using the method of Wunch et al. (2009). Then we discussed the relationship between the anomalies of XCO and XCO_2 under different prevailing wind conditions, calculated the correlation slopes and discussed the influence of regional anthropogenic emissions based on the correlation slopes.

Technical comments:

1.L16-18: I' m not sure whether the two numbers are for the two seasons, or the two separate years. Please clarify: "The CO2/CO correlation slope was 126.62 and 94.32 ppm/ppm in winter and spring for 2014-2015 and 2015-2016, respectively."

Response: We changed this confusing sentence to "The correlation slope was 5.21±1.41 and 2.53±1.05 ppb/ppm for winter and spring as well as summer and autumn, respectively".

2.L61: Define all acronyms.

Response: We have defined all acronyms in the paper.

3.L62: There' s no need to mention that OCO-2 is a set of grating spectrometers when you don' t mention the instrument types of GOSAT and SCIAMACHY.

Response: We deleted the instrument type of OCO-2 as suggested.

4.L67: add (FTS) after "Fourier transform spectrometers"

Response: We added "FTS " after "Fourier transform spectrometers".

5.L75: Please explain where the 0.1% number comes from.

Response: In Olsen and Randerson (2004), they mentioned "A 1 Gt C yr-1 Northern Hemisphere carbon sink decreased the north-south column CO_2 gradient by ~0.4 ppm". The variation of the north-south column CO_2 gradient was very small, so in order to capture the carbon cycle, the CO_2 total column data resulting from the TCCON sites require a precision of better than 0.1%(0.4ppm).

6.L77: Where is the accuracy claimed to be 1%? Is this before bias correction or after?

Response: In the study of Toon et al. (2009), they mentioned that "the absolute accuracy

is limited by spectroscopic inadequacies (~1% for CO_2, ~2% for CH_4), but this can be substantially reduced by validation, i.e., airborne profiling using accurate in situ sensors". In the study of Deutscher et al. (2010), the FTS measured CO_2 columns were calibrated against integrated aircraft profiles and the 1% negative bias existed in the FTS XCO_2 relative to the World Meteorological Organization (WMO) calibrated in situ scale. In Wunch et al. (2010), they said that "due to systematic biases in the spectroscopy, the absolute accuracy of the column measurements is 1%, which is inadequate for use in combination with in situ measurements for carbon cycle science". In Messerschmidt et al. (2011), they summarized that "The findings show that the TCCON standard XCO2 product can be measured by instruments using the standard GFIT a priori profiles with a bias of 1.1%±0.2% with respect to WMO standards and a precision of 0.25% (1σ)". This 1% accuracy is before bias correction.

In Wunch et al. (2011a), they said "With stringent requirements on the instrumentation, acquisition procedures, data processing and calibration, the Total Carbon Column Observing Network (TCCON) achieves an accuracy and precision in total column measurements that is unprecedented for remote sensing observations (better than 0.25% for CO2)". So we changed this sentence to "the claimed accuracy and precision of column averaged dry air mole fraction of CO_2 is better than 0.25% (1 ppm for CO_2) (Messerschmidt et al. 2011; Wunch et al., 2011a)".

7.L90: I agree that a TCCON station in China would be very helpful, but you aren't claiming your data are "TCCON" data in this paper. For your data to be considered to be part of the TCCON dataset, your data must be delivered to the TCCON archive, inspected to ensure the dataset is of high quality and distributed freely to the public. I strongly suggest that you take these additional steps - it would strengthen the paper and make the dataset much more scientifically valuable.

Response: We would like to be one of the TCCON site and deliver our data to TCCON archive regularly. But at present there are limitations for data-share from the Chinese academy of Sciences. We once applied for data-share for our data, but there are limitations especially for data those haven't been published. After we will have publications using our data for scientific research, it is easier for us to be allowed to share the data publicly. We will take steps to deliver our data to TCCON archive and make them publicly available as soon as possible.

8.L127: How frequently is "regularly"? How many lamp spectra are recorded for each cell measurement? Is the HCl cell in the solar beam as well (as strongly recommended by the TCCON data protocol: https://tcconwiki.caltech.edu/Network_Policy/Data_Protocol#Requirements)? Did you take lamp measurements with the HCl cell in place with the InSb detector? Those results would be interesting as well.

Response: We take cell measurements once a month except during the scanner failure or NIR source failure. We usually collect 100 lamp spectra and used the last 60 spectra to analyze the ILS for each cell measurement. The routine procedures for monitoring instrument line shape meet the requirements of TCCON protocol.

We also took lamp measurements with the HCl cell in place with the Insb detector, and the results are described in Section 3.1 "Optical alignment evaluation" of supplement.

9.L128: The latest version of LINEFIT that I' m aware of is LINEFIT 14.5. I suggest you redo your ILS analysis with LINEFIT 14.5 to ensure that the results are consistent with your LINEFIT12 results, unless you have a reason to believe the LINEFIT12 results are superior.

Response: We redid the ILS analysis with LINEFIT14.5, and found that the results are consistent with the LINEFIT 12 results. We changed this sentence to "The cell measurements are performed once a month except during the instrument mechanical failure or NIR source failure. The ILS retrievals are done using LINEFIT 14.5."

10.L136: Are these forward and backward scans averaged together or processed separately (as recommended)?

Response: These forward and backward scans are processed separately using the software package "I2S" as recommended by GGG2014.

11.L159: Explain what you mean by "O_2 as an internal standard".

Response: In the equation (2) of section 4 in the paper, the total column of dry air is measured by the total column of O_2 divided by the known DMF of O_2 (0.2095). The description "O_2 as an internal standard" is not correct here, we should say O_2 is a reference. We changed this sentence to "using the column abundance of O_2 as a reference".

12.L168-169: I hope you are using the GGG2014 software suite; please state this clearly. In the GGG2014 software, the "calibration factor" is 0.9898 for XCO2. What factor did you use for XCO?

Response: We are using the GGG2014 software suite to retrieve gases from the NIR spectra. We used the sentence "We used GGG2014 to retrieve the columns of greenhouse gases. The TCCON calibration factors applied for XCO_2, XCO and XCH_4 are 0.989,1.067 and 0.977, respectively (Wunch et al., 2010; Messerschmidt, et al., 2011)." to replace the sentence "We applied the TCCON calibration factors of 0.989 for XCO_2 (Wunch et al., 2010; Messerschmidt, et al., 2011)".

13.L212: The phrase "scanner failure" is a technical term that is likely understandable only to those who use FTS instruments regularly. I recommend either defining what a "scanner failure" means, or just saying "instrument mechanical failure".

Response: We changed "scanner failure" to "instrument mechanical failure" as suggested.

14.S5.2: I' m not sure why you are showing columns in molecules/cm^2 instead of Xgas amounts. What additional point are you trying to make that could not be made showing Xgas and Xair?

Response: We showed the total columns of CO, CO_2 and O_2 in addition to Xgas and Xair, just to show the variation of the total columns of gases with time. Some information in this section are repeated with those in section 5.3, so we deleted the contents about the total columns of CO and CO_2 in section 5.2, and put the results of Xair into section 5.3.

15.S5.3: This section needs editing for grammar.

Response: We improved the grammar in this section as suggested.

16.L232-233: Please include uncertainty estimates on these numbers.

Response: We added the uncertainty estimates to the daily average values.

17.L234-243: This is a confusing set of sentences. Please rework. The XCO_2 measurements

are sensitive at the scale of hundreds to thousands of kilometres, and thus the local growing season is not the only driver of the seasonal cycle. Respiration occurs at all times of the year. That the site may be influenced by regional anthropogenic emissions is interesting, and can be tested using CO2/CO anomaly analysis under the correct prevailing wind directions.

Response: We rewrote these sentences as follows:

Biosphere-atmosphere exchange has effect on the atmospheric constituents at such low altitude locations as Hefei site. Photosynthesis results in the decrease of CO_2 in the local growing season, whereas photosynthesis gradually ceases and CO_2 builds up in winter and spring. However, the XCO_2 measurements are sensitive at the scale of hundreds to thousands of kilometers, and thus the local growing season is not the only driver of the seasonal cycle. The site is influenced by regional anthropogenic emissions under the southeast wind directions, because it is about 10km northwest of the Hefei urban area (population 7.7 million). The CO/CO_2 anomaly analysis under the prevailing wind directions are used to discuss the influence of the regional anthropogenic emissions later in this section.

18.L259: Why is the seasonal amplitude larger in your measurements than in other TCCON stations at similar latitudes? It seems comparable to the Tsukuba station (L319), so please clarify this statement. Have you compared with the Pasadena (urban, 34N) and Dryden (rural, 34N) TCCON data?

Response: We changed this sentence to "In our observations, the seasonal amplitude is comparable to the results of other areas" as suggested.

When we used the TCCON's observations to compare with our data, we chose Tsukuba station because it is the nearest station and at similar latitude. Other stations with similar latitude lacked the updated data in half a year at that time. So we didn't compare our data with the Pasadena and Dryden TCCON data. Of course it's interesting to do it, we will do this work, but this time we maybe have no chance to put the results to this paper, because the paper seems too long after we have added one new section about comparison with EM27/SUN as one referee suggested

19.L300: What does the 23-38 ppm/ppm indicate about the relative contributions of anthropogenic emissions and biospheric activities? How do I interpret the 107 ppm/ppm number in light of the previous studies?

Response: The correlation slope of CO_2/CO gives the emission ratio of CO_2 to CO, which varies with the sources of CO_2, depending on different combustion types and biospheric activity. So the correlation slope of CO_2/CO provides a characteristic signature of source regions and source type. The large correlation slope means the small relative contributions of anthropogenic emissions, so the relative contributions of anthropogenic emissions of CO_2 in Hefei area is smaller than those in Beijing.

We changed "the correlation slope of CO_2/CO" to "the correlation slope of the anomalies of XCO to XCO_2" based on the anomaly analysis, and changed the corresponding discussions about the influence of regional anthropogenic emissions accordingly.

20.S5.4: It would be helpful to see two additional plots with the Tsukuba and Hefei daily mean time series on the same axes. One plot for XCO2, the other for XCO.

Response: We added the two plots with the Tsukuba and Hefei daily mean time series

on the same axes in section 5.5 “Comparison with nearby TCCON's observations”. One plot is for XCO_2, and the other is for XCO. We added the corresponding discussions accordingly.

21.L370: Clarify the phrase: "Although not all FTS spectra were collected for GOSAT overpass"

Response: We changed the phrase to "Although there are not a lot of data according to coincidence criteria " as suggested.

22.L371: Are you comparing the GOSAT data with the daily mean ground-based data? This may not be the best choice, since the GOSAT orbit is sun-synchronous with an equator crossing time of 1 pm local (Morino et al., 2011). A near-1pm or at least daily median value may be a better choice. Why do you not include a comparison of XCH4 with GOSAT?

Response: Our site is not the target site of GOSAT, so the near-1pm GOSAT data are relatively scarce in the site. We used the daily median value to replace the daily average as suggested.

We added the daily, monthly and annual variability of XCH_4 and the corresponding discussions in section 5.3 “Daily, monthly and annual variability of XCO_2, XCO and XCH_4”. One of my colleagues are writing a manuscript about the comparison of XCH_4 data with surface in situ data, model data and GOSAT data. So this paper didn’t include a comparison of XCH_4 with GOSAT to avoid repetition.

23.L407: Is your coincidence criteria the same for OCO-2 as it is for GOSAT? Which Warn Level data did you select?

Response: Our coincidence criteria are the same for OCO-2 as for GOSAT. GOSAT Level 2 and OCO-2 Light File product data within 4° latitude/longitude radius of Hefei station were adopted. We set the collocation time to 1 day. We select Warn Level 14 as the OCO2 data filtered criteria. We described the coincidence criteria and Warn Level data in the paper.

24.L420: This does not seem like a significant result, given that your error bars are so much larger than your biases. Unless I am missing something, I would suggest removing the analyses with the uncorrected OCO-2 data.

Response: We removed the analyses with the uncorrected OCO-2 data as suggested.

25.References: The Tsukuba TCCON data should be properly cited: Morino, I., Matsuzaki, T., and Shishime, A.: TCCON data from Tsukuba, Ibaraki, Japan, 125HR, Release GGG2014R1, TCCON data archive, hosted by CDIAC, http://dx.doi.org/10.14291/tccon.ggg2014.tsukuba02.R1/1241486, doi:10.14291/tccon.ggg2014.tsukuba02.R1/1241486, 2014

Response: We added this reference in section 5.6.

26.Fig 12: In 150330-150930 time range, there are some significant outliers in Xair from the daily mean. What is the cause of those outliers?

Response: We operated the weather station for monitoring surface pressure, surface temperature, relative humidity, wind speed, wind direction, and other meteorological parameters from Sep 18, 2015. The time sampling interval is 10 seconds. We used the meteorological parameters from a weather station about 1km away from our laboratory before Sep 18, 2015. The time sampling interval is 10 minutes. We applied interpolation

to the low time resolution data for fitting the spectra. So the meteorological data before Sep 18, 2015 may have no higher precision than the data after Sep 18, 2015. This may cause many outliers to Xair during this period.

27.Figs 18-19: Tsukuba should have a "b" in the name.

Response: We added “b” in the captions of the two Figures.

28.References:Morino, I. et al. (2011), Preliminary validation of column-averaged volume mixing ratios of carbon dioxide and methane retrieved from GOSAT short-wavelength infrared spectra, Atmos. Meas. Tech., 4(6), 1061–1076, doi:10.5194/amt-4-1061-2011.

Response: We have cited this reference in the paper.