Response to anonymous Referee #1

Main comments:

REFEREE COMMENT:

1) Correction of local sources for the surface observations:

a) Can you describe in more detail how the local source component is corrected in the in-situ observations of CO2 from the Delta13 values for Ascension island and Ragged point.

b) Is the Paramaribo measurement after correction of local sources any different to the observations of Ascension Island or Ragged point?

c) The surface fluxes used in the TM3 model calculation

are most likely based on these in-situ observations so that it is not surprising that the calculations match these observations well.

AUTHOR RESPONSE:

a)

In the modified manuscript we have included the following equations to describe the correction:

$$\delta^{13}C^{meas} = m\frac{1}{CO_2^{meas}} + \delta^{13}C^{source}$$

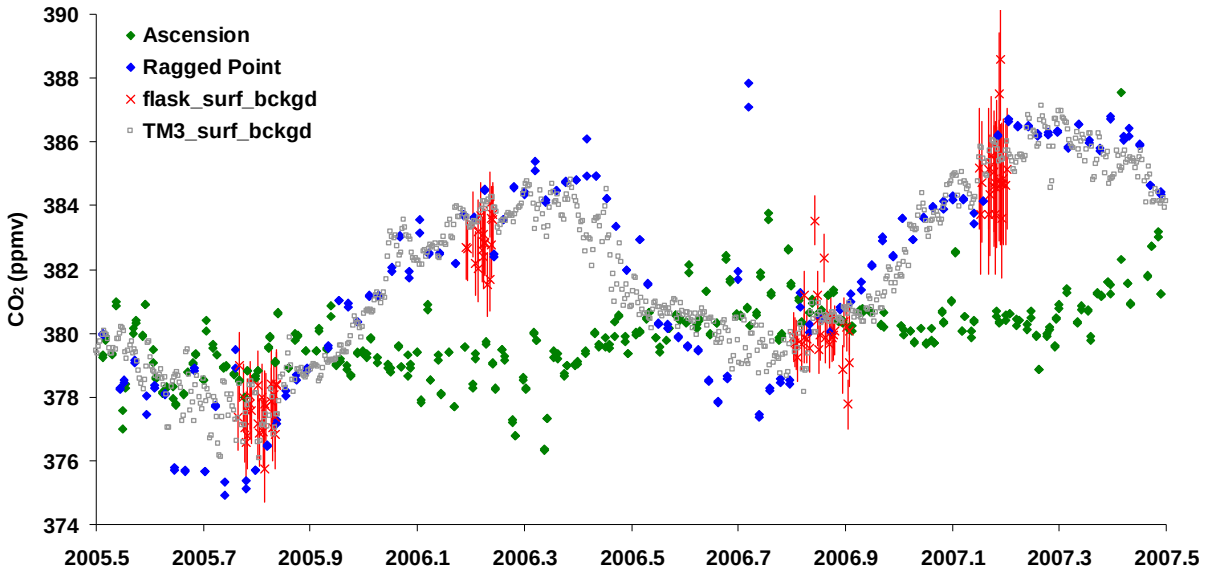
$$m = \frac{\delta^{13}C^{backgnd} - \delta^{13}C^{source}}{\frac{1}{CO_2^{backgnd}} - \frac{1}{CO_2^{source}}}, \text{ where } \frac{1}{CO_2^{source}} = 0$$

$$\delta^{13}C^{meas} = \frac{\delta^{13}C^{backgnd} - \delta^{13}C^{source}}{\frac{1}{CO_2^{backgnd}}}\frac{1}{CO_2^{meas}} + \delta^{13}C^{source}$$

$$CO_2^{backgnd} = \frac{\delta^{13}C^{meas} - \delta^{13}C^{source}}{\delta^{13}C^{backgnd} - \delta^{13}C^{source}}CO_2^{meas}$$

b)

In the plot below the Paramaribo measurement after correction of local sources is compared to observations at Ascension Island and Ragged point. The model data used in figure 2 in the manuscript is also included. It can be seen that the Paramaribo measurement after correction can differ from the observations at Ascension Island and Ragged point.



c)

Yes, the surface observations are used in the model, but the model data for the ocean-pixel close to the Surinamese coast does neither agree with the NOAA-data from Ascension nor with the data from Ragged Point.

REFEREE COMMENT:

2) FTS Observations: The column observations have been scaled with 1.018 to match the TM3 calculations for Spitsbergen.

a) Is this a correction factor needed to compensate a constant spectroscopic offset? If so, how does it compare to correction factors inferred from aircraft comparisons for other FTS sites? How do you know that the same scaling factor applies to a tropical site?

b) Since the FTS columns have been scaled to match the TM3 calculation. Does this mean that the main focus of the column-model comparison should be rather on the seasonal differences than the absolute values?

AUTHOR RESPONSE:

a)

It is well known that the spectroscopic data of CO2 and O2 have an offset. A scaling factor is required to compensate this. The aircraft measurements performed at the TCCON sites so far demonstrate that the scaling factor is instrument-independent and one scaling factor can be applied for the different TCCON-sites (Deutscher et al., AMTD 2010, Messerschmidt et al, in preparation).

However, this single scaling factor can only be applied when using the 125HR instrument. In Paramarobo we use the 120M spectrometer. This instrument type has neither been part of an aircraft calibration campaign nor compared to an TCCON instrument during a side-by-side intercomparison. Hence it cannot be assured that the scaling is the same as for the TCCON instruments. In our study we are interested in the seasonal variability, and do not use our data together with other TCCON data, which would require an absolute calibration. Therefore we determined the scaling factor in the way that the differences between model and measurements are most clearly visible, corresponding to a scaling factor of 1.018. However, we must state that by using the TCCON scaling factor our data would be by 0.7% lower This is significant, but does

not change the results of our paper. Therefore we added the following paragraph to our manuscript:

“

Previous studies have shown that the spectroscopic data of CO_2 and O_2 have an offset and a scaling factor is required to compensate this. To determine this scaling factor aircraft in situ measurements have been performed at several TCCON sites, demonstrating that the scaling factor is instrument-independent and one scaling factor can be applied for the different TCCON-sites (Deutscher et al., AMTD 2010, Messerschmidt et al, in preparation).

However, this single scaling factor can only be applied when using the Bruker 120/125HR instrument. In Paramaribo we use the Bruker 120M spectrometer. Since this instrument type has never been compared to the TCCON measurements instrumental artifacts might impact the measurements, which can be compensated by a different, unknown, scaling factor. The measurements at Paramaribo could not be calibrated against in situ measurements. Therefore these measurements cannot compared to the XCO_2 measured at the TCCON sites and cannot be used for inversions. However, since the focus of our study is the comparison of the variabilities between measurements and model, we have choosen the scaling factor in the way that the comparison between measurement and model is most easily visible. For this comparison a scaling factor of 1.018 has been used to match the model simulations. This scaling factor results in 0.7% higher XCO_2 values compared to the scaling used in TCCON. It is important to assume that the scaling factor is constant throughout the measurement period, but this can be assured with our regular instrumental line shape measurements. In the future we plan to exchange the instrument and perform an side-by-side measurements with a TCCON spectrometer prior the exchange.

“

In the future we plan to exchange the Paramaribo FTS with a similar instrument that allows DC recording (mainly to resolve the problem of source brightness fluctuations due to cirrus clouds). Before shipping this instrument to Paramaribo we plan to perform a side-by-side measurements with the TCCON spectrometer in Bremen.

b) See a)

REFEREE COMMENT:

3) Column-surface-model comparison

a) The FTS-model comparison is for Paramaribo itself without any correction for local effects. The surface data is corrected for local effects and then compared to a TM3 model grid point hundreds of kilometer away from Paramaribo. I wonder if the in-situ-model and FTS-model comparison really represent the same thing.

b) The column seasonal cycle is roughly +/-2 ppm (again assuming that we should focus on the seasonal amplitude rather than absolute values). The standard deviation for the column observations is 0.9ppm so that the relative error in the model can still be rather large. Since the column observation is an average over the atmospheric CO2, there could still be a large error in the free-tropospheric CO2 from the model.

c) This study seems to contradict earlier studies that found that models have difficulties in reproducing the vertical distribution measured by aircrafts. Could you please discuss your findings with respect to those findings? Will column observations with a standard deviation of 0.9ppm have enough sensitive to observe discrepancies observed by aircrafts?

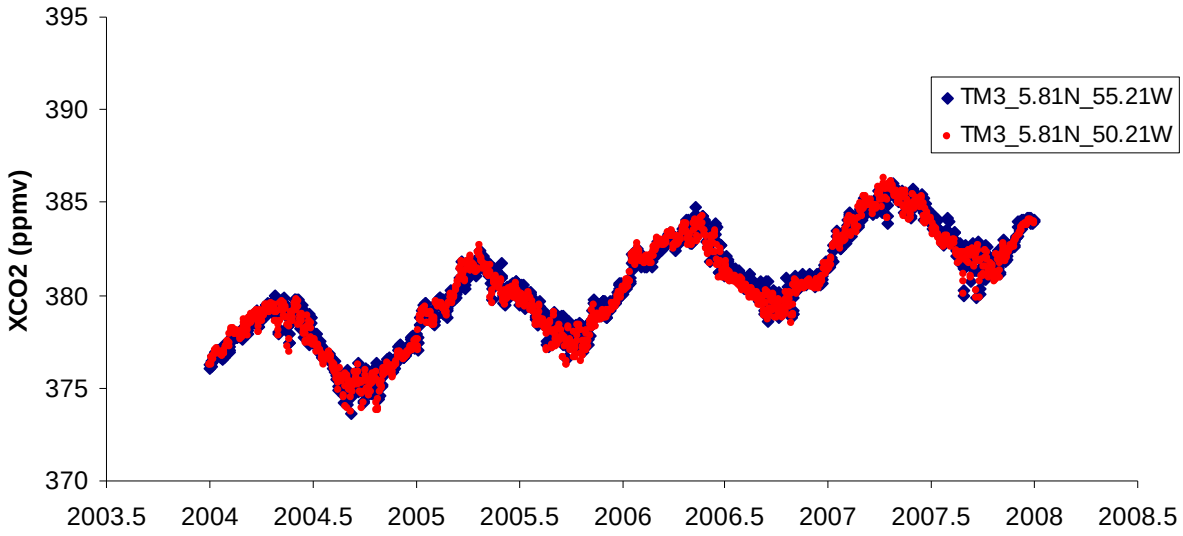
AUTHOR RESPONSE:

a) The modeled XCO_2 is almost identical for the two model grid cells (figure below). The following sentence has been added to the paper:

“

For XCO_2 the difference between the ocean grid cell used for the in situ comparison and the grid cell containing Paramaribo is small and therefore it is not relevant, which model grid is used for the XCO_2 comparison.

“



b) This is true, but we are limited by our precision. However, this does not influence our conclusions.

c) The precision of the measurements is currently not high enough to decide if tropical uptake balances deforestation like suggested Stephens et al. (2007) or if the previous studies are correct that predict the tropics as a net source. This is now mentioned in the manuscript.

Minor comments:

REFEREE COMMENT:

p.3174 Overall the comparison demonstrates that the TM3 model is capable to simulate surface concentrations as well as column densities of CO2 correctly at the same location. -> it should be stated that this is for one tropical site only so that it cannot be concluded in a general sense

AUTHOR RESPONSE: done

REFEREE COMMENT:

p. 3175 This is especially important in the tropics since a spatial bias is likely to arise from (a) the frequent occurrence of (subvisual) cirrus clouds, which are suggested to be a significant error source in CO2 retrievals from SCIAMACHY (Schneising et al., 2008) and (b) the high abundance of water vapour, an inferring gas in the spectral region of the satellite retrievals, which has shown to have a strong impact on the CH4 retrievals from SCIAMACHY in the tropics (Frankenberg et al., 2008). -> This is somewhat an overstatement. Bias might or might not arise in the Tropics. Schneising et al. found biases due to cirrus clouds when cirrus clouds are not taken into account in the retrieval algorithm. However, most current algorithms used for GOSAT retrievals have an explicit treatment cirrus clouds so that potentially biases should be much smaller. Furthermore, Frankenberg et al. has found that the H2O spectroscopy had been insufficient in the HITRAN database and that updates to the spectroscopy have largely removed such biases.

AUTHOR RESPONSE: This statement was used to illustrate the problems occurring for satellite retrievals specifically in the tropics. Water vapor as well as cirrus cloud will be potential

problems in the greenhouse gas satellite retrievals in the future. The sentences has been re-written in the follwing way:

“The high abundance of water vapour as well as the frequent occurrence of (subvisual) cirrus clouds have previously caused problems in tropical satellite retrievals of greenhouse gases (Frankenberg et al., 2008, Schneising et al., 2008).

“

REFEREE COMMENT:

p. 3176 Spectral line parameters for the O2 retrieval were taken from an updated version (December 2006) of the ATMOS database (Brown et al., 1996). -> How does this compare to the current HITRAN database?

AUTHOR RESPONSE:

These spectroscopic parameters for O2 used within TCCON are different from the HITRAN 2008 database. The linelist is documented in the GFIT package. The following has been extracted from the documentation:

“ Discrete Lines: Linelist created by Andrew Orr-Ewing using the PGOPHER code, based on lab seasurements of S.M. Newman et al. [1999]. The widths were subsequently modified to be 1.5% larger than those in Yang et al. [2005] in order to minimize the airmass dependence of retrieved XO_2, as described by Washenfelder et al. [2006]. O2 quadrupoles lines are from Gordon et al. [2010].

Collision induced absorption (CIA): This is represented by a pseudo-linelist based on fits to lab spectra described by Smith and Newnham [2000]. The CIA is not used in the determination of the O_2 column. It is fitted only to minimize its impact on the discrete O_2 lines.”

REFEREE COMMENT:

p. 3176: The initial vmr-profiles are taken from the GFIT-package and are based on balloon observations at Ft Sumner (35_ N, 104_W) using the JPL MkIV Interferometer. -> Is this a good representation of the CO2 profiles for Paramaribo?

AUTHOR RESPONSE: We now compared different vmr apriori files and the difference was insignificant.

REFEREE COMMENT:

p. 3178 The isotopic signature of the local source component as well as that the calculated CO2 for the local source does not correlate with the measured CO in the flasks (not shown) suggests that the measurements are not strongly influenced by urban pollution and the local source component is the terrestrial biosphere. -> . . .as well as the calculated CO2 . . . -> . . .CO in the flasks (not shown) suggesting that . . .

AUTHOR RESPONSE: done

REFEREE COMMENT:

p. 3179 . . . modeled values are within the errors of the corrected vmrs. -> How are these errors for the data corrected for local sources calculated?

AUTHOR RESPONSE: We have calculated that using error propagation laws: delta_f = sqrt(sum $(df/dx_i * delta\_x_i)^2$)

REFEREE COMMENT:

p. 3180 requires the DC recording. . . -> Define DC

AUTHOR RESPONSE: done

REFEREE COMMENT:

p. 3180 Only spectra with an O2 vmr within 2.5% of the mean retrieved vmr of O2 were used for this study. -> Would it not be better to compare it to the observed surface pressure (corrected for the H2O column)?

AUTHOR RESPONSE: Systematic errors (e.g. airmass from wrong solar pointing) partially cancel in the ratio CO2/O2. This procedure has been found suitable within TCCON and we followed that approach.

REFEREE COMMENT:

p. 3181 The measurements agree very well with the model simulations for the SDS and LDS in 2006 -> Does this take into account the averaging kernel of the measurement?

AUTHOR RESPONSE: yes

REFEREE COMMENT:

p. 3186: Figure 2 – Upper panel. From the cloud of the individual dots it is very hard to see something. Maybe a correlation plot would show it better?

AUTHOR RESPONSE: A correlation plot has been added to the revised manuscript.