The authors like to thank Referee#1 for his comments and suggestions. The Referee's comments and questions are bold, the authors' replies are formatted as plain text, and excerpts from the manuscript as well as changes to the manuscript are given in italics.

Reply to Anonymous Referee #1

While CO_2 is the most important greenhouse gas, its sources and sinks are still not well understood. Studies of the carbon cycle require qualitatively good and long-term measurements. Beside in-situ observations remote sensing observations have become an important tool to study the carbon cycle. This paper forms an important contribution for such studies. While so far most remote sensing observations are performed in the near-infrared spectral region, organize in TCCON, this paper presents observations in the mid-infrared, organized in the NDACC. Since most NDACC observations cover a longer-time span, it makes sense to perform such studies also in the mid-infrared. This holds especially for the Jungfraujoch site, where, together with the Kitt-Peak studies in the US, the longest mid-infrared observations exist. The long-term data set presented, and especially the studies of the seasonality together with the footprint analysis are important and new scientific contributions.

The paper is well written and I have only a few comments.

Major comments:

The results of the paper depend on the comparability of near-infrared with mid-infrared observations. This needs to be studied in much more detail. Great care has to be taken in order to consider the different sensitivities of both infrared techniques to understand differences and potential biases.

The goal of this study is to compare in-situ measurements of a NonDispersive InfraRed analyzer (NDIR) with column measurements from a Fourier Transform InfraRed (FTIR, mid infrared) system, and to find out whether their different samples (surface air vs. column above the station) provide similar results for the annual CO_2 change, the seasonality or even shorter-lived CO_2 signals, or not. The physical characteristics of the CO_2 adsorption of both methods is not subject of the present study and would be beyond the scope of this publication.

Recently two papers have been published where these differences are studied in detail. Barthlott et al, AMT, 2015 and Buschmann et al., AMT, 2016. The authors mention shortly the paper by Barthlott, but do not mention the paper by Buschmann et al.

Buschman et al., (2016) was added to the references and page 9, line 7 was changed from:

"With a Monte Carlo algorithm, the values of the annual change of the CO_2 mole fraction of the two datasets were calculated. Despite the shift between the two datasets of roughly 13 ppm (i.e. about 3%, in line with the systematic uncertainty affecting the FTIR measurement; see section 2.3) and the different measurement techniques the annual CO_2 increase is quite similar. The FTIR slope is 2.04 ± 0.07 ppm yr^{-1} and the NDIR dataset shows a slope of 1.97 ± 0.05 ppm yr^{-1}, so they are equal within their uncertainties (Figure 4)."

to:

"With a Monte Carlo algorithm, the values of the annual change of the CO_2 mole fraction of the two datasets were calculated. Despite the shift between the two datasets of roughly 13 ppm and the different measurement techniques the annual CO_2 increase is quite similar. The FTIR slope is 2.04 ± 0.07 ppm yr^{-1} and the NDIR dataset shows a slope of 1.97 ± 0.05 ppm yr^{-1}, so they are equal within their uncertainties (Figure 4). The observed offset between the FTIR (NDACC) and in-situ records at Jungfraujoch contrasts the comparison of NDACC and TCCON records as determined at Ny-Ålesund which do not show any offset at all when using several individual CO_2 lines for the mid-IR (Buschmann et al., 2016). However, the FTIR/NDIR offset of about 3% is commensurate with the systematic uncertainty affecting the FTIR measurement; see section 2.3."

Since the study of the comparability of the mid-infrared data set from Jungfraujoch with near-infrared observations, as performed within TCCON, are extremely important, the results should be discussed and interpreted with respect to both papers.

Unfortunately, there are no TCCON measurements at Jungfraujoch to compare with.

Besides the presentation of the CO_2-data, section 2.3 of the manuscript form the most important part of the paper, and much more details on the analysis should be given.

In our opinion, the two measurement systems are equally important. Both measurement systems provide an independent, valuable data set, which we compared.

We added some more detail to the section 2.3. It was changed at page 5, line 3 from:

"The uncertainty on the main CO_2 line strength is estimated at 2 to less than 5% in the HITRAN compilation (Rothman et al., 2005), leading to a systematic error on the retrieved total column of the same magnitude. In the meantime, the data set has been consistently updated, still using the SFIT-1 algorithm (version 1.09c) and a single microwindow spanning the 2024.3 – 2024.7 cm^{-1} spectral interval, whose main spectral line is coming from $^{13}CO_2$. The single CO_2 a priori vertical distribution used in all retrievals is characterized by a constant mixing ratio of 338 ppm from the surface up to the tropopause, then slightly decreasing to stabilize at 330 ppm at 20 km and above. A simple scaling retrieval is performed, and the mixing ratio derived for the troposphere is used in the present comparisons. Note that the representativeness of this unique profile is not optimal for all seasons and may lead to an underestimation of the seasonal amplitude (see Fig. 1 in Barthlott et al., 2015), because of a non-optimum vertical sensitivity of the FTIR retrieval. Indeed, typical values of the total column averaging kernel – indicative of the fraction of information coming from retrieval rather than from the a priori (e.g. Vigouroux et al., 2015) – are in the 0.5 – 1 range between the ground and 10 km altitude, in line with Fig. 4 of Barthlott et al. (2015)."

to:

"In the meantime, the data set has been consistently updated, still using the SFIT-1 algorithm (version 1.09c) and a single microwindow spanning the 2024.3 – 2024.7 cm^{-1} spectral interval, whose main spectral line at 2024.564 cm^{-1} is coming from $^{13}CO_2$. The uncertainty range on the strength of this CO_2 line is estimated at 2 to less than 5 % in the HITRAN compilation (Rothman

et al., 2005), leading to a systematic error on the retrieved total column of the same magnitude. The single CO_2 a priori vertical distribution used in all retrievals is characterized by a constant mixing ratio of 338 ppm from the surface up to the tropopause, then slightly decreasing to stabilize at 330 ppm at 20 km and above. During the retrieval process, a simple scaling of the whole vertical profile is performed, accounting for interferences by weak ozone and water vapor lines, and the mixing ratio derived for CO_2 in the troposphere is used in the present comparisons. Note that the representativeness of this unique profile is not optimal for all seasons and may lead to an underestimation of the seasonal amplitude (see Fig. 1 in Barthlott et al., 2015), because of a non-optimum vertical sensitivity of the FTIR retrieval. Indeed, typical values of the total column averaging kernel – indicative of the fraction of information coming from retrieval rather than from the a priori (e.g. Vigouroux et al., 2015) – are in the 0.5 – 1 range between the ground and 10 km altitude, in line with Fig. 4 of Barthlott et al. (2015). Over all the standard deviation of multiple measurements over the course of a single day corresponds to less than one ppm, which is significantly smaller than the observed seasonal cycle."

Minor comments:

The introduction is quite interesting and detailed, but very long. To me, many details about the carbon cycle are not worth mentioning here, this part should be shortened.

The part about the carbon cycle in the introduction was shortened, it reads now from page 2, line 16 to page 3, line 4:

"CO_2 is the most important anthropogenic greenhouse gas, with a large contribution to the greenhouse effect (Arrhenius, 1896) and an additional radiative forcing of the atmosphere currently evaluated at 1.68 Wm-2 (IPCC, 2013). The strength of the forcing is depending on its atmospheric mole fraction which is ruled by the processes of the carbon cycle as well as by anthropogenic CO_2 emissions from fossil fuel combustion and land use change. The major reservoirs of the carbon cycle besides the lithosphere are the soils, the ocean, the biosphere and the atmosphere, where the latter is also acting as the main link between the biosphere and the ocean. The linking process between the atmosphere and the ocean is dissolution of CO_2 in oceanic water, where it is subsequently chemically bound to bicarbonate and carbonate and therefore removed from the carbon cycle on a longer timescale (Broecker and Peng, 1982;Feely et al., 2004;Heinze et al., 1991;Sillén, 1966). The processes coupling the biosphere with the atmosphere are photosynthesis, where CO_2 is taken up by plants, and respiration, where CO_2 is released back to the atmosphere. Photosynthesis and respiration are mainly driven by climatic conditions of the environment. In the northern hemisphere, especially in the extratropics with distinct seasons, the dominating process in late spring, summer and fall is photosynthesis and thereby the uptake of CO_2 from the atmosphere. In autumn respiration and with it the release of CO_2 from the biosphere into the atmosphere starts to take over and is the ruling process in winter until spring when photosynthesis becomes the dominating process again. Due to these alternating processes, the CO_2 mole fraction in the atmosphere shows a seasonal cycle with its maximum generally in early spring and its minimum in fall (Halloran, 2012;Keeling et al., 1976;Keeling et al., 2001;Machida et al., 2002)."

For me the Figures 10, 11 and 12 do not tell important new findings. I suggest skipping these Figures, or showing only one instead.

We disagree because if there were significant changes of the correlations with increasing time shifts, increasing widths of the running mean or a combination of the two, these figures would be extremely important because they would show it clearly. However, the lack of clear changes in the correlation in combination with the sensitivity plots indicates that the short term variability of the two signals can't be compared. Therefore we like to keep these figures.

Page 7, line 1: The seasonality is also influenced by fossil fuel combustion, not only by respiration and photosynthesis.

We changed the sentence:

"One is the linear increase due to fossil fuel combustion (trend) and one is the annual in- and decrease due to respiration and photosynthesis (seasonality)."

to:

"One is the linear increase due to fossil fuel combustion (trend) and one is the annual in- and decrease due to respiration and photosynthesis, and to a lesser degree due to fossil fuel combustion (seasonality)."