

## **Author's reply to anonymous Referee #2:**

First of all, we would like to thank the referee for the help in further improving the manuscript and the identification of possible misleading statements. We will adopt most of the comments in the final version of the manuscript.

### **Point-by-point response to major Comments:**

**Referee:** The paper could be shortened. Many details are well known or described by others. Describing all details, and repeating what is already published causes the danger that the paper will not be read by others.

**Author:** We will shorten the abstract and remove that the new Karlsruhe data is available through CDIAC (see below). We will shift parts of section 2 into section 3 and remove section 2 completely. We consider to remove the paragraph about LSE corrections (Page 3 L21ff.) since it is not important for our study. We will remove tables 1 and 3 since the content is already included in table 4 (see below). We will remove Figure 6 and 8 (see below).

**Referee:** Page 2, line 19: It is not necessary to mention in the abstract that the new Karlsruhe data are available through CDIAC. The paper should concentrate on the general retrieval technique and not highlight the results from one site.

**Author:** We will remove Page 2, line 19-21 from the abstract and shift it into the conclusions section.

**Referee:** Page 6, line 8: The spectra measured by the Si-diode are also necessary to study aerosols, and the oxygen band is necessary for comparison with satellites, which cannot use the oxygen band at 7885 cm<sup>-1</sup>.

**Author:** We will change Page 6, line 8 to: "The spectra from the Si detector are important, however, because they are used to calculate and correct for any LSE in the system (Wunch et al., 2015), to study aerosols and the oxygen A- and B- band is necessary for comparison with satellites, which cannot use the oxygen band at 7885 cm<sup>-1</sup>."

**Referee:** Page 11, line 18 and Fig. 7 and 8. This chapter gives the impression as if this kind of plot is first published here. This is wrong, the correlation plots have been shown and discussed already in detail by others (e.g. Wunch et al., Geibel et al., Messerschmidt et al.). Therefore it is not correct to write that: Numerous CO<sub>2</sub> in-situ profiles were obtained via instruments on an aircraft and compared to CO<sub>2</sub> column amounts from TCCON spectrometers. Further details and instrument descriptions are given in Messerschmidt et al. (2011) and Geibel et al. (2012). The results from Kiel et al. yield an update of what has been done before.

**Author:** To avoid the impression that this kind of plot is first published here, we will emphasize that the CO<sub>2</sub> calibration curves were initially published in e.g. Wunch et al. (2010), Messerschmidt et al. (2011) and Geibel et al. (2012) and will adapt the caption of Figure 7 (see below, Figure 8 will be removed). We will rephrase section 6 to (major changes are highlighted bold):

*We compare Karlsruhe TCCON data to aircraft overflights recorded as part of the EU project Infrastructure for Measurement of the European Carbon Cycle (IMECC) in 2009 to provide evidence that the higher order continuum level fit option improves the consistency of the Karlsruhe dataset with other TCCON sites. IMECC was the first airborne campaign to calibrate the European TCCON FTIR sites with respect to the WMO standards.*

***For our comparison we rely on IMECC and TCCON data which were presented in detail in e.g. Wunch et al. (2010), Messerschmidt et al. (2011) and Geibel et al. (2012) where numerous CO<sub>2</sub> in-situ profiles were obtained via instruments on an aircraft and compared***

**to CO<sub>2</sub> column amounts from TCCON spectrometers. An update of the calibration curve which already has been discussed in the aforementioned publications with combined results using the IMECC campaign and other aircraft profiles is shown in Fig. 7.** The calibration curve contains North American, Australian, Asian, and European TCCON sites (see legend within Fig. 7). There is no significant bias between the Karlsruhe data and the aircraft data when comparing the integrated in-situ profiles and the Karlsruhe TCCON data (with the higher order continuum fit option). Karlsruhe data are in good agreement with the other geographically nearby TCCON stations Orleans (France), Bialystok (Poland), Jena and Garmisch-Partenkirchen (both Germany). Without the higher order continuum fit, Karlsruhe data is slightly elevated and exhibits an overestimation with respect to the best fit as seen in Fig. 9.

**In addition, to test how DMFs from other sites are affected when a higher order continuum fit in the retrieval strategy is applied, we update the calibration curve from e.g. Wunch et al. (2010), Messerschmidt et al. (2011) and Geibel et al. (2012) using the Karlsruhe retrieval approach to process data of the other TCCON stations which contribute to the TCCON XCO<sub>2</sub> calibration curve (of the particular day of the aircraft overflight).**

The differences between XCO<sub>2</sub> retrieved from both retrieval strategies are depicted in Fig. 10. The change in XCO<sub>2</sub> for Karlsruhe is about three times larger than for the other TCCON sites. This shows that a continuum fit...

**Referee:** Page 16, line 15: Co-authors should not show up in the acknowledgement. Delete either as co-author or in the acknowledgment.

**Author:** The Caltech/JPL scientists remain as co-authors and will be removed from the acknowledgements section. If convenient, we will thank the entire Caltech/JPL Team for making the Author's stay at Caltech/JPL possible.

#### **Point-by-point response to minor Comments:**

**Referee:** I am not sure whether tables 1, 3 and 4 are necessary. The results depend on the specific instrumental setup, and will not help other groups if they plan to perform this kind of strategy.

**Author:** The content of tables 1 and 3 is included in table 4, therefore we will remove tables 1 and 3. Although the number of continuum basis functions is specific for the Karlsruhe instrument, we think that the content of table 4 can be used as a rough guide for other groups which also experience similar features.

**Referee:** Figure 2-4: The three Figures can be summarized in one.

**Author:** If Figures 2-4 are summarized in one, the figure does not fit in one column of the journal format and would need to be split up. Therefore, we consider to remain Figures 2-4 as standalone Figures.

**Referee:** Figure 5-6: One figure showing the differences is sufficient.

**Author:** We will remove figure 6.

**Referee:** Figure 7-8: One Figure is enough. See also my comment above, the caption is not acceptable.

**Author:** We will remove Figure 8 and change the caption of Figure 7 and 9 to:

Caption Figure 7: Update of the XCO<sub>2</sub> calibration curve which is discussed in detail in e.g. Wunch et al. (2010), Messerschmidt et al. (2011) and Geibel et al. (2012) using the continuum fit option for the Karlsruhe TCCON data.

Caption Figure 9: Same as Fig. 7 but using the standard GGG2014 TCCON retrieval strategy for Karlsruhe spectra.