AMT Manuscript Title: Retrieval and validation of carbon dioxide, methane and water vapor for the Canary Islands IR-laser occultation experiment

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Response to Reviewer #3

We thank the Reviewer #3 for his/her constructive and helpful comments. We carefully considered all comments and accounted for them in our paper as stated below.
The original comments of the Reviewer are cited in *italic font*, our response is put below each comment in standard font. The changes stated below are also yellow-highlighted in the Revised Manuscript.

General comments:

The manuscript is rather difficult to follow, with 15 sections. I suggest to move some discussions into an appendix, e.g. parts of the validation data set and potentially others (maybe parts of the uncertainty corrections?).

We carefully considered this option, discussed it with main co-authors, but at the end we decided to stay at our version. We found the structure with six main sections, and the respective subsections, a reasonable logical flow, which was quite broken when trying to reorganize/reshuffle. In particular, putting parts such as the uncertainty correction into an appendix to come at cross purpose with the clarity of the results discussion afterwards, since the uncertainties play a significant role for the interpretation of the retrieved data. Therefore we thought it is better to accept it being a longer paper, leaving it to the (more casual) reader which particular sections to skip if one decides so, but with the whole paper as it stands having a clear flow.

Major comments:

- with spectroscopic parameters posing such an issue, I would have expected a more thorough investigation into available information. Is e.g. Hitran 2012 providing more accurate values? Are other laboratory or data bases available to obtain more accurate information?

Yes, we checked for improvements on the uncertainties of the HITRAN 2012 to the HITRAN 2008 data base and found for our particular lines no improvements on the line parameters, the differences, if any, where very small in fact. And unfortunately there are currently also no other data bases with more accurate data than HITRAN for our purposes. For example, the spectroscopic data base GEISA (e.g., used for IASI) did not give any uncertainties in its data sheets. But as we point out and recommend/explain in the manuscript, single line spectroscopy is the needed next steps in order

to fulfill the spectroscopic requirements for an ACCURATE-type infrared-laser occultation mission. See also the response to Editor comments, where there was a related spectroscopic question.

- with such a small area sampled, wouldn't it be better to have a local model with a high resolution providing meteorological data, instead of a global one (ECMWF)?

We agree with the reviewer that an (even) higher resolution model would have been preferable if it would have been available, and known to provide better performance than ECMWF in this a little bit remote Atlantic Island region. However, the T1299L91 ECMWF fields (used at their full resolution of about 14 km) were indeed the most suitable dataset that we could find for this remote region.

Specific comments:

- Abstract: this is not really a measurement in July 2011, but rather 2 nights, please clarify this

Ok, to make these just two nights explicit we changed on page 11595 line 10 in the abstract from "The experiment delivered..." to "For two nights from 21st to 22nd July 2011 the experiment delivered..."

- Page 11602, Line 17: Don't understand why a bias is identified in the weather station data, just because the CRDS has no drift. Did you also confirm the accuracy?

Ok, we have been a bit misleading here with our formulation and improved to "...since the CRDS measurements underwent calibrations before and after the campaign, confirming their high accuracy as stated above."

- Page 11607: what kind of moving average filter has been applied?

We used a box-car moving average filter. We now added this on page 11607 line 15: "...we applied a box-car moving average filter..."

- Page 11607: when estimating the Delta Tau_sc, has that been applied only on the reference frequency side of the target line? What happens if that is done on the other side, in particular for fairly symmetric lines (e.g. CH_4-2, $^{12}CO_2$-2 in figure 4)? And why is there an offset estimated, not a broadening, which might better fit the observation?

Yes, the correction has been applied on the reference frequency side. For clearly symmetric lines not much would change in the result if estimated against the other wing of the line. In general, as Figs 4 and 5 illustrate and as explained in the text, the chosen estimation approach is clearly a most convenient way to unambiguously align the spectra at the target absorption line peak and then estimate the correction term as the transmission

difference at the ref channel. Other variants (such as broadening instead of offset etc.) would be less well defined and less robust as we found out as part of the comprehensive sensitivity tests mentioned on page 11608, lines 8-11.

- Figure 4, bottom: some lines show a full mismatch between measured and calculated, e.g. around 4347 cm^{-1}, and these seem to be CH_4 as well, which show a better fit for other CH_4 lines. Why is that?

As discussed in the text, and more so in the Brooke et al. (2012) reference, the quality of the CH_4 spectra was unfortunately not very good. Therefore we had many unusable spectra and those which are clearly robust were found reliable also in certain wavelength subranges only. Therefore, as shown in Fig 4 bottom, we only used the absorption lines near 4348 cm^{-1} and 4347 cm^{-1}. So the core reason for parts of "full mismatch" is the degraded data quality.

- Figure 5: the gray lines are typical measured spectra, and the cyan are some sort of average, but e.g. around 4346 cm^{-1}, all gray lines are below the cyan. Shouldn't the cyan be somewhere in the center?

This comes due to the fact that the alignment process is done separately for each target absorption line and in this plot this target line is the CH_4-2 line near 4348 cm^{-1}. This effect below 4346,5 cm^{-1} is therefore a "far field effect" since the fit focuses on the target line and its wings.
To make this clear we added to the Figure 4 caption as follows: "....The transmission alignment of the measured and simulated spectra is done in these panels for the $C^{18}OO$-2, $^{12}CO_2$-2, and CH_4-2 absorption peaks, respectively."
And into the Figure 5 caption we inserted: "...illustrating the spectral broadening correction, are aligned and marked in the same way as in Fig. 4."

- Table 5: the Delta Tau_sc value seems to vary still a lot between different files, e.g. $^{13}CO_2$-1 F12 to F13 shows a large jump, as do the other lines. Any explanation?

Yes, as explained in the text (e.g.. on page 11608 line 19 onwards), the readjustment of the equipment between the scans, changes in calibration and available SNR etc, made it challenging during the experiment to record under stable conditions over longer times (despite we did put quite an effort behind this). So the explanation is as briefly described and as visible from Table 5; there is a robust picture of how the correction term (and therefore the underlying setup) was stable over certain cycles of observation setup but it clearly changed over others. So there was clear lessons learned for a follow-on experiment but for this initial experiment it was the best to get.

Editorial:

- The LMIO in the abstract comes a bit surprising, with no indication what it means.

Ok, the acronym does indeed not fit here so we removed it from the abstract. The acronym is properly introduced in the introduction section.

- *Page 11596: suggest to add to e.g. SCIAMACHY that this is no longer working*

Ok, we improved to: "...or SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric ChartographY) on Envisat until 2012 and missions like..."

- *Page 11602: staion – station*

Ok, corrected.

- *Suggest to shorten Brooke 2012 and not use the full reference every time*

Ok, yes we cited this quite often so we agree. We added on page 11597 line 7 "...Brooke et al. (2012) (referred to as Betal2012 hereafter)..." and changed all subsequent citations to "Betal2012".

- *Page 11606: please use cm^{-1} if you refer to figures with this unit, not um*

Ok, we changed to: "...by laser L3 in the 4346 cm^{-1} to 4349 cm^{-1} wavenumber range suffered..."

- *Page 11621: particularynarrow typo*

Ok, corrected.

- *Figure 2, top plot: the legend is rather unclear, it would be better to put just Tx in green letters, Rx in blue letters without a line, and then just in black the cycles and the dots (since there are also blue triangles, green dots in the plot). Although there are so many dots/circles that they are no longer visible.*

Ok, we carefully modified Fig 2. We reduced the size of the symbols for a clearer distinction, colored the Tx Meteo and Rx Meteo in the legend to the colors green and blue, respectively, and changed the Temperature and Pressure symbol color to black. In this way the logic of visualizing the information is more clear, we agree.

Many thanks to Reviewer #3 again for his/her valuable comments that helped us to further improve our manuscript.