

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 Editor

We thank the Editor for his helpful comments. We carefully considered all comments and accounted for them in our paper as stated below.

The original comments of the Editor 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.

Here are some comments that I noted down when reading the paper. Figure, page, and line numbers refer to the original submission, so may deviate from the AMTD version.

1. Figures 4 and 5: Near 4772.0 cm^{-1} there seems to be a quite strong H_2O line in the simulated data that seems to be completely missing in the measurement. Even in the filtered simulated data in Figure 5 this line is still clearly visible. Can this apparent discrepancy be explained?

This relates to the middle panel of Figs 4 and 5 and, yes, we think this discrepancy mainly occurs since we focused in this particular wavenumber range fully on the $^{12}\text{CO}_2$ line. We likely did not fit the (unknown) H_2O concentration very well, which was not critical because the $^{12}\text{CO}_2$ -line differential transmission is rather insensitive to H_2O for this particular line (cf. also Table 6, with just 0.5% H_2O uncertainty for this line). Therefore in the simulated spectra we likely have used too much H_2O abundance in this case. Part of the effect, specifically near 4772 cm^{-1} , may also come from some raw processing adjustment along wavelength (sub)ranges. We have seen, from time to time, that some lines were not resolved well in the measurements and we discarded such spectral subranges from target line selection, or spectra with too low SNR completely (see also the related data quality discussion in the manuscript). So, as we explain in section 3, we had to be careful and use several reasonable criteria to select clearly robust lines and wavelength subranges for the data analysis of this first demonstration experiment.

To this end, we added at page 11606, line 14“...or even negligibly small. An example is the weak influence of H_2O on the $^{12}\text{CO}_2$ -2 channels (middle panel) so that the fairly uncertain H_2O concentration needs not to be simulated accurately in this case. On the other hand, an example for a noticeable influence is provided by the...”

2. Page 15, line 502 (in the AMTD online version it is page 11615, line 29): "This would enable to reduce this uncertainty component in a follow-on experiment to smaller than 0.2%." I think this number needs some justification. Reducing the spectroscopic uncertainty component from now 10% to 0.2% seems to require a reduction in spectroscopic parameter uncertainty (line intensity and line broadening) by a factor of 50. It is not self-evident that such a large improvement is feasible, given the usual systematic errors in laboratory spectroscopy measurements, particularly for the broadening parameter.

We are aware that the reduction of the spectroscopic uncertainty is substantial compared to the uncertainties given from the spectroscopic data base so far. We see as the main reason that targeted single-line (laser) spectroscopy was not a really urgent need for supporting remote sensing techniques so far. And it indeed seems only worth the effort for a fairly limited number of selected single lines (and their immediate neighborhood), such as the target lines that would be used for an IR-laser occultation mission.

We therefore provide from AMTD page 11615 line 25 to page 11616 line 2 a recommendation plus references to the spectroscopy feasibility work so far, in particular the work of Harrison et al. (2011). Also in the AMTD paper we write, as a somewhat weaker formulation, "This could reduce..." instead of "This would enable to reduce..."

We have now further improved the sentence to: "As discussed by Harrison et al. (2011), this could reduce..."

3. Page 15, lines 513-515 (in the AMTD online version it is page 11616, line 13): "Table 6 (fourth column) shows that this fairly limited knowledge on H₂O that we could get during the campaign strongly governs the uncertainty that we need to conservatively attribute to the H₂O retrieval results." I do not understand the logic here. I thought Table 6 lists retrieval errors, not validation data uncertainty. Why does the limited validation data accuracy for H₂O lead to a higher retrieval error?

Ok, we have not been optimal in terminology here. Indeed for H₂O we felt it clearly needed to account also for the validation data uncertainty (and this is what we meant by "conservatively attribute"), which is of course formally not due to retrieval error. In the above sentence we now improved the terminology in saying "...governs the combined uncertainty conservatively attributed to the H₂O volume mixing ratio." In other parts of the manuscript we correctly pointed out that the H₂O uncertainty is mostly overlapped by the 50 % knowledge of the H₂O validation data which we thus determined conservatively as the H₂O uncertainty, comprising the validation data uncertainty (since there is such a strong variation along the ray-path). We point this out at page 11613 line 14 and explained it further in section 4.3 how the error of 50 % is composed of.