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Atmospheric Measurement Techniques Discussions

Interactive comment on "Improving the Retrieval of XCO_2 from Total Carbon Column Network Solar Spectra" *by* Joseph Mendonca et al.

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Response to Referee 1

We thank the reviewer for the comments on our manuscript. Attached is the updated manuscript with all changes. In the manuscript highlighted text is the added text and red crossed out text is deleted text.

Please see below for our responses.

Comment 1 – In lines 55-62 authors talk about different works on the A-band and mentioning Galatry retrievals. However, for some reason the work of Drouin et al (JQSRT 2016) was not mentioned although it also employed the SDV profile.

We acknowledge that the work by Drouin et al. (2017) uses a SDV profile when fitting the A-band and have included it in the introduction of when discussing the line shape work done with the O2 A-band.

We have added the following on lines 80-82: "When fitting cavity ring-down spectra of the O2 A-band, Drouin et al. (2017) found it necessary to use a speed-dependence Voigt line shape, which takes into account different speeds at the time of collision (Shannon et al., 1986), with line mixing to properly fit the discrete spectral lines of the O2 A-band."

Comment 2 – The authors may want to mention that the HITRAN2016 parameters are very similar to those in HITRAN2012 in this particular band and the only change are improved line positions from Yu et J. Chem. Phys. 141 (2014) 174302. doi:10.1063/1.4900510.

We acknowledge that this should be included in the introductory section about the discrete O2 1.27 μm band since it is the latest version of the spectroscopic parameters used for this band.

We have added the following on lines 64-66: "Spectroscopic parameters for the discrete spectral lines of the O2 1.27 μm band from HITRAN 2016 (Gordon et al., 2017) are very similar to HITRAN 2012 except that HITRAN2016 includes improved line positions reported by Yu et al. (2014)."

Comment 3 – It is interesting that the authors do mention the line-mixing with respect to the Aband and CO2 bands but did not say about this effect in 1.27 micron band that they investigated. It is also not mentioned as potential source of remaining residuals in lines 293-303. It would be interesting to see some discussion about this.

We have added a discussion about line mixing and how it impacts some of the retrieved spectroscopic parameters as well as the remaining residuals seen when fitting the lab spectra.

We have added the following on lines 359-367: “This can be explained by the fact that line mixing, which is shown to be important for the O2 A-band, was not considered when fitting the cavity-ringdown spectra. Neglecting line mixing usually produces an asymmetric residual in the discrete lines as well as a broad residual feature associated with the fact that collisions are transferring intensity from one part of the spectrum to another. By fitting a set of Legendre polynomials for CIA we could simultaneously be fitting the broader band feature associated with line mixing while the retrieved pressure shifts, and speed-dependent pressure shifts could be compensating for the asymmetric structure one would see in the discrete lines when neglecting line mixing. The remaining structure, as seen in Figure 1c, could be due to neglecting line mixing especially in the Q-branch where the spacing between spectral lines is small (in comparison to the P and R branches) and line mixing is most likely prevalent.”

Comment 4 – Talking about the sources of the residuals and its potential relation to Dicke narrowing it would be interesting what authors think about conclusions of the Torun group (Domyslawska et al papers in JQSRT 2014-2016), that for the electronic transitions of O2 speed-dependence should have much larger effect than Dicke narrowing.

To address this comment we have added the following discussion on lines 371-383: “Domysławska et al. (2016) recommend using the qSDV to model the line shape of O2 based on multiple line shape studies of the O2 B-band. In these studies, a multispectrum fit to low pressure (0.27-5.87 kPa) cavity-ring down spectra was preformed testing multiple line shapes that took speed-dependence and Dicke narrowing into account both separately and simultaneously. They found that the line shapes that only used Dicke narrowing were not good enough to model the line shape of the O2 B-band lines, but a line shape that included either speed-dependence or both speed-dependence and Dicke narrowing produced similar quality fits, ultimately concluding that speed-dependence has a larger effect than Dicke narrowing. It was noted in the study by Wójtewicz et al., (2014) that both Dicke narrowing and speed-dependent ef-

fects might simultaneously play an important role in modeling the line shape of the O2 B-band lines. However, the speed-dependent and Dicke narrowing parameters are highly correlated at low pressures. To reduce the correlation requires either a multispectrum fit of spectra at low pressures with high enough signal to nosie ratio or spectra that cover a wide range of pressure (Wójtewicz et al., 2014). So, by combining the high-pressure spectra used in this study with low pressure spectra in a multipspectrum fit both the speed-dependence and Dicke narrowing parameters could be retrieved.”

Comment 5 – Spectral shifts in the 1.27 micron band had always been very hard to measure. See for instance discussion in Hill et al, J. Mol. Spectrosc. 221 (2003) 286–287. doi:10.1016/S0022-2852(03)00227-3 and Newman, et al, J. Chem. Phys. 110 (1999) 10749. doi:10.1063/1.479018.

The authors may want to mention this. Continuing the topic of shifts it is well known that while the widths in P and R branches for same rotational quanta should be very similar the shifts should be assymetric. Therefore I would suggest to plot these separately or using running number m, where m=-J for P lines and J+1 for R. The authors may also want to use the upper state rotational quanta because they are not split into spin components.

We have added the following on lines 356-359, to address this comment: “Accurate measurements of the pressure shifts in the 1.27 μm band have been hard to obtain as shown in Newman et al. (1999) and Hill et al., (2003). While the retrieved pressure shifts show a dependence on quantum number m (Figure 3c) as one would expect, this dependence is not as strong as the m dependence of the Lorentz widths (Figure 3b).”

We have also replotted Figures 3 and 4 to show the retrieved parameters as a function of m.

Comment 6 - Does one need to account for airglow when analysing the 1.27 TCCON spectra? See Sun et al (https://doi.org/10.1029/2018GL077823) for instance, regarding significance of airglow in oxygen’s 1.27 micron band at the top of atmosphere.

Since TCCON spectra are recorded by viewing the sun directly, airglow emission is negligible since the signal from the sun is much more intense than airglow.

We have added the following on lines 220-221: "Airglow is not considered when fitting the 1.27 μm band since the spectrometer views the sun directly, and airglow is overwhelmed by such a bright source."

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2018-62/amt-2018-62-AC1-supplement.pdf

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