Response to the comments of referee #2

We thank the referee for their helpful comments. With the revised version, we tried to incorporate the reviewer's comments into the revised manuscript. We have addressed all of them one by one in detail as listed below. The reviewer's comments are in bold, and our replies are in regular font. The line numbers indicated in our replies are given with respect to the track change manuscript and may differ from the revised manuscript.

General issues:

Lines 147-149: HITRAN does not give you the emission spectra. HITRAN only gives you the line strengths and parameters at 296 K. You then need to scale those to the line strengths for different temperatures (the equation for which, unless I'm mistaken, is not in the Gordon et al paper you reference). But more importantly, you then need to convert the temperature dependent line strength values into an actual emission energy spectrum. If you are only using HITRAN line strengths, you have not calculated proper emission spectra, see Babcock and Herzberg (1948) doi:10.1086/145062, and references therein (esp. Herzberg, 1939).

We agree with the referee that the previous text lacked clarity in conveying the intended information. As a response, we have made revisions to the relevant section. Furthermore, we have incorporated a reference to an equation that outlines the calculation for relative line strength. This calculation utilizes spectroscopic parameters of each emission line, which are taken from the HITRAN data set. The revised version can be found in line 161–163, which now reads as follows: 'Instead of calculating the full radiative transfer equation, it calculates the relative distribution of the oxygen A-band emission lines for a given temperature following Song et al. (2017), where the required spectroscopic parameters of the emission lines are taken from the HITRAN data set.'

Minor issues:

Line 26: missing "et al." in the reference

We would like to point out, that the reference is a PhD thesis and therefore is only written by one author.

Lines 33-40: This section still is confusing, and I think it's because the instrument doesn't have a name. I think the solution is to describe the instrument in the first sentence. Please be very specific as to what kind of limb instrument was built and for what purpose in the first sentence. It would also help to make this a separate paragraph from the preceding sentences.

This comment is addressed in accordance with the subsequent comment. The changes are described below the next comment.

Line 46: What do you mean by "Our instrument"? Have you built an instrument? Please be clearer before talking about "your instrument" whether it's one you've built, or one you've designed and planning to build, or whether you're simply talking about the same instrument from Chen et al. If this is in fact your instrument, I'd highly recommend giving it a name in order to clear up some of this confusion.

To address the latter two comments, we have restructured the entire section, retaining the same content as previously presented. However, we have relocated certain parts to enhance comprehension. Additionally, we have introduced paragraphs to enhance readability. Furthermore, we have included the instrument's name to provide readers with a reference point. You can review the revised section in line 35–64.

Line 55: What kind of resolution?

The references used single sided interferogram to enhance spectral resolution. The revised version has been changed accordingly by adding the word 'spectral' in line 68.

Figure 1 caption: "SHS" should be "SHI"

We thank the reviewer to spot this error. The caption of Figure 1 has been changed accordingly in the revised version.

Line 101-102: This sentence makes it sound like only HITRAN can be used to calculate the absorption and emission spectra. I'd suggest making it two sentences, and have the second start with something like, "In order to calculate the emission energies between rotational states, . . . "

We welcome the referees suggestion and changed the text in the revised version accordingly in line 115–116, which now reads as follows: 'The band consists of multiple emission lines due to the transition of multiple rotational states. In order to calculate the emission energies between the rotational states, the HITRAN database can be used (Gordon et al., 2022).'

Line 103: There are many different excited O2 states. Please be specific and replace "excited O_2" with "$O_2(^1\Sigma)$" (or another common notation) here and throughout the manuscript.

The text in the revised version has been changed accordingly in line 116 and line 118.

Line 109: A-band "emissions" should probably be "volume emission rates" as to not be confused with emission energies.

The referee is correct and the text in the revised version has been changed accordingly in line 123.

Line 136: Please be a bit more specific with altitude range, I'd highly recommend, ". . . the lowermost tangent altitudes, below 85 km, need to be treated with reservation."

The text in the revised version has been changed accordingly in line 150.

Line 149: Why are the spectra scaled and what are they scaled to?

In the Forward model, the spectrum is scaled with a scaling factor to match the output spectrum from the Fourier transform. In this context, the factor is a retrieval parameter and corresponds to the number density of excited $O_2(^1\Sigma)$ molecules. This information has been added to the revised manuscript in line 164–165, which now reads as follows: 'Subsequently, it convolves the emissions with a given instrument line shape (ILS) and scales the total spectrum with a scaling factor to match the output spectrum from the Fourier transform. In this context, the factor corresponds to the number density of excited $O_2(^1\Sigma)$ molecules.'.

References

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