Response to interactive comment by Anonymous Referee #2 on "Comparison of VLT/X-shooter OH and O_2 rotational temperatures with consideration of TIMED/SABER emission and temperature profiles" by S. Noll et al.

Review

This manuscript is an interesting study dealing with the comparison of ground-based measurements of OH and O2 rotational temperatures – based on VLT/X-shooter observations – complemented by kinetic temperature and OH emission profile observations carried with the SABER instrument on the TIMED spacecraft. The manuscript deals with several issues important for ground-based rotational temperature measurements and is therefore worth publishing.

However, the paper contains quite a number of misleading or unclear statements that should be adjusted before the paper should be accepted, in my opinion. I think I am well familiar with the overall topic of the manuscript, but I had a hard time understanding many of the sentences. In many cases I think I know what the intended meaning of the statements is, but the sentence actually states something else. Particularly section 3.3 is difficult to follow. I ask the authors to go through the paper carefully and make the statements as clear as possible. Again, I think this paper is very relevant, but some of its messages should be conveyed more clearly.

We thank the anonymous reviewer for the thorough reading of the paper and the detailed suggestions for improvements.

Specific comments:

Page 30794, line 5: " .. has to be achieved"
I find this phrase somewhat misleading, because it suggests that a Boltzmann distribution can be "achieved" by some means. I suggest something like., e.g.: "To measure realistic temperatures, the rotational population has to be in LTE".

done

Page 30795, line27: "and makes the initial T_{rot} higher for lower \nu"
This is certainly a valid point, but I suggest removing it here. It may confuse the inexperienced reader, because this sentence is the argument for higher T_{rot} at higher (not lower) \nu as stated in the previous sentence.

Since this statement is an important argument for the different T_{rot} found for OH bands with odd and even v', we have moved it to the subsequent sentence, where it fits better and is less confusing.

Page 30798, line 7: this is only a minor point, but I thought that \lambda/\Delta\lambda is the "resolving power", while \Delta \lambda is the "resolution". But perhaps the latter term is also used for \lambda/\Delta\lambda.

Indeed, "resolution" is often used for both quantities. This can cause ambiguities if numbers are given without adding λ/Δλ or Δλ. Therefore, we agree that it would be safer to also use different words. We have substituted "resolution" by "resolving power" at the indicated position and in several other cases where numbers are discussed (see below).

Page 30800, line 7: resolving power vs. resolution (see point above)

We have not touched the corresponding sentence since it only contains "λ/Δλ" without the word "resolution" .

Page 30800, line 21: "We retrieved VER profiles"
I suggest writing "We used VER profiles", because in satellite remote sensing "retrieval" usually refers to applying a numerical scheme to the raw data to infer the parameter wanted. For a satellite person your statement suggests, that you actually performed this retrieval, which is not the case.

We agree that "retrieval" has a very specific meaning in the context of satellite data. To avoid any confusion, we have replaced it at the given and several other positions where SABER data are discussed.

Page 30800, line 22: "We took the "unfiltered" VERs, which are corrected for the emission of the targeted molecular band(s) outside the filter"
I'm not sure I really understand this statement. The statement doesn't clearly say, whether this correction was performed by you or whether it has already been applied to the data you use. Does the correction mean, that, e.g., the parts of the OH(4-2) and OH(5-3) bands not covered by the SABER 1.6 micron channel are added to the measured radiances?

The "unfiltered" VERs are regular data products provided in the SABER data archive. Your interpretation is correct. We have modified the sentence to make it clearer.

Page 30803, lines 21 -26: I read these sentences several times, but I don't really get the intended meaning, particularly of "Taking the most reliable bands with at least five measurements, the T_{rot} were converted to a reference line set consisting of the three . . ." What conversion is meant here? I think I know what's done, but I think this is not well explained.

T_{rot} changes due to the use of a different line set. The temperature differences for the transition from the actual to the reference line set were calculated based on the sample mean T_{rot} for the 16 most reliable bands. We have rephrased the text in a similar way. We have removed "with at least five measured lines" since this statement could be confusing. In any case, the details can be found in Noll et al. (2015).

Page 30804, line 25: resolving power vs. resolution

Done. See comment on Page 30798, line 7.

Page 30806, line 27: "Taking the resulting temperatures as reference, we decreased the T_{rot} of the whole sample by 0.4 K"
Again, I don't understand the reasoning or logic behind this and the previous sentence. My understanding is that you determined the temperature difference between two cases with difference continuum windows and obtained 0.4 K. Then the temperatures were corrected by 0.4 K. I'm sorry if I appear somewhat picky, but in my opinion the text does not clearly describe what was actually done.

Your interpretation is correct. We have replaced the corresponding sentences by a more accurate description.

Page 30807, line 8: resolving power vs. resolution

Done. See comment on Page 30798, line 7.

Page 30810, line 14: "see Baker et al."
I think it's more appropriate to cite "Russell et al. (1999)" here

We have added Russell et al. (1999). However, we also keep Baker et al. (2007) since the Russell et al. paper does not show the filter curves.

Page 30812, line 23: "a ppears" -> "appears"

done

Page 30813, line 18/19: "which shows the best agreement"
Agreement in terms of what? Probably the mean emission altitude?

Your interpretation is correct. The sentence has been revised.

Page 30813, line 20: "(4.6 vs. 2.3 km for the first and the last period in comparison)"
These values do certainly not correspond to the emission profile widths, as the sentence suggests.

These values show the lowering of the FWHM of $O_2a(0-0)$ and OH during the night. We have rephrased the sentence to avoid any confusion.

Page 30814, section 3.3, Temperature corrections: This is in my opinion the section of the paper which is most difficult to understand and which required some text adjustments.

We agree that Sect. 3.3 is the most challenging. It is not easy to describe the very complex analysis in a concise way. Guided by the subsequent comments, we have therefore revised the section to improve the comprehensibility.

Page 30814, line 21: Suggest to replace "of 2 to 3 K, i.e. 2.5 K" to simply " of 2.5 K"

done

Page 30814, line 23: "The old T_{kin} show deviations between .."
This statement is not entirely precise. I assume the deviations refer to differences in T_{kin} between the two SABER data versions? This is, however, not explicitly stated.

We have rephrased the sentence to clarify that the differences between the old and new T_{kin} are given.

Page 30815, line 2: "With the band-dependent T_{eff}, the emission profile correction can be performed by calculating a temperature shift from the T_{eff} for a given band and the desired reference profile"
I read this statement many times, but I still don't fully understand its intended meaning. Please rephrase to make it easier to understand.

We have modified this sentence together with the beginning of the next paragraph to better explain how the emission profile correction is performed.

Page 30815, line 15: "In particular, the yaw cycle of the TIMED satellite lasting about 60 days .. results in a very narrow range of times for a certain DOY"
I don't think the logic of this sentence is correct. It's not the specific yaw cycle of TIMED that causes these problems. A yaw cycle of 50 or 40 days would be essentially associated with the same

problem, and so would a sun-synchronous orbit, right?

The specific yaw cycle does not cause the limitations in global and time coverage. This is inherent to any satellite mission. We agree. However, the kind of gaps in the time coverage for a certain location depends on the satellite orbit and operation mode of the instrument. We have removed the yaw cycle argument. Instead, we have added that the time coverage depends on the selected area and refer to Sect. 2.2 for more details.

Page 30816, line 4: "Within the 1-\sigma radius around .."
What exactly do you mean by "1-\sigma radius" ?

The area within the 1σ perimeter of the 2D Gaussian was meant. We have changed the sentence accordingly.

Page 30816, line 23: I'm not sure, what "interval-specific" refers to here? The five nighttime periods?

You are right. We have rephrased the sentence.

Page 30816, line 26: "The resulting errors"
Perhaps better "differences" rather than "errors"?

In fact, these are standard deviations derived from the temperature differences for the five nighttime bins. This is an error measure. In order to make this clearer, we now use "standard deviation" instead of "error".

Page 30817: I find many statements on this page difficult to follow. I always have a rough idea what the intended meaning is, but this is in many cases not what the sentences state. I would like to ask you to go through this page again carefully and explain things as plainly as possible. For example line 26: "For the correction to the reference profile, we find average errors of 1.2 . . ." What do you mean by "For the correction TO the reference profile"?

It seems that the main problem on this page is to understand the meaning of the discussed errors. Phrases like "for the correction to the reference profile" do not appear to be sufficient in this respect. Therefore, we have especially revised those parts where the errors are described. On page 30817, the errors are mostly related to systematic uncertainties in the differences of the true effective temperatures (no non-LTE effects) for airglow emission bands measured by X-shooter and an artificial reference emission profile. Since these temperature differences are estimated based on SABER data, discrepancies in the temperature variability of the SABER and X-shooter data cause the reported errors.

Page 30818, line 6: "It is possible to check the reliability of these data by comparing the sample means of h_{eff} differences with correlation coefficients r for the selected bands derived from the T_{rot} data of the same data set"
I'm sorry, but I have no clue what this statement means. What correlation coefficients are these. What's correlated with what? Please clarify.

The correlation coefficients were calculated for the correlation of the T_{rot} of the selected emissions and a reference band. For this purpose, the same data set was used as for the derivation of the band-dependent h_{eff} sample means. We have modified the sentence accordingly.

Page 30819, line 1: "There is an almost perfect linear relation of h_{eff} and r for these data, which confirms the found equidistance of the OH layers and . . ."
I can see that the equidistance and the linear relation of h_{eff} and r are not entirely unrelated, but I don't see such a clear connection that justifies the conclusions that the one confirms the other. Perhaps I'm missing a point?

Indeed, "confirms" does not appear to fit in this context. We have substituted it by "is in good agreement".

Page 30820, line 27: "By calculating the T_{eff} differences involving the reference profiles"
Please explain better what you mean here.

We have rephrased this statement. With the revised discussion in Sect. 3.3, the procedure should be comprehensible.

Page 30822, line18: "Nevertheless, values of more than 10K for \nu' = 8 are plausible"
It's not clear what "values" refers to here. Please clarify.

The word "values" refers to $\Delta T_{non-LTE}$, which we now use in the text.

Page 30823, line 19: "based on OH(\nu'=2) instead of O2 .."
Please mention that the corresponding emission profiles are meant here (right?)

done

Page 30824, line 28: ", it is not clear how this distribution is modified by collisional quenching"
I'm not sure what the intended meaning of this statement is. There are several OH modelling studies taking collisional quenching into account (based on the best or plausible knowledge of the relevant rate constants). Does the statement refer to the issue that some of this rate constants are highly uncertain?

Indeed, there are several models that try to explain the population distribution over the vibrational levels. However, the statement is related to the population distribution over the rotational levels of the different vibrational levels, as mentioned in the first part of the sentence. Here, we have not seen a suitable model so far. However, such a model is required to explain the v'-dependent T_{rot} non-LTE effects. We have slightly changed the sentence.

Page 30827, line 22: "LTE dynamics"
This is not a frequently used term, please specify

We have replaced "LTE dynamics in the mesopause region" by "changes in the emission and mesopause kinetic temperature profiles".