Response to interactive comment by Anonymous Referee #1 on "OH populations and temperatures from simultaneous spectroscopic observations of 25 bands" by S. Noll et al.

This is an excellent and exhaustive paper, and carries with it the bottom line that previous attempts to use the OH rotational distributions as an indication of mesospheric temperature are incorrect and should not be pursued. The actual causes of these distributions are complicated, and there is still much to be learned, but the approach of using the first few rotational levels of various OH bands to define a temperature is an over-simplification. The quality and spectral range of astronomical sky spectra is such that one may conclude that the typical ground-based experiment of using a single OH band to extract a Boltzmann distribution and then a local temperature is very misleading. Previously, there was uncertainty in data quality, so that the question of variation of rotational temperature with different vibrational levels was difficult to pin down. We now find that two distinct data sets reproduce rather well the dependence of "rotational temperature" on vibrational level, and these findings should guide further research. Below are some typos, and further discussion.

We thank the reviewer for the detailed and very helpful comments.

32980/5 "as many OH bands as possible" is desirable.

done

32980/16 The given range presupposes that the reader understands the sequence of OH bands. "OH(8-2) to OH(9-7)" could imply that only v = 8 and 9 are investigated. It's much better to give the wavelength range, stating that this includes v = 2-9.

We have replaced the band names by the wavelength range covered by the measured lines. The v' range is already given in the abstract. Therefore, we have not added it again.

32980/19 "discrepancy" is not the right word here

We have rephrased the sentence to avoid "discrepancy".

32980/23 I don't think that you want to pursue the idea of "vibrational temperature". More on this below.

The vibrational temperature indicates the slope of the vibrational level population distribution and is therefore a handy measure of the characteristics of this distribution. It is clear that the vibrational temperature is just a pseudo temperature without any relation to a real temperature. Nevertheless, this quantity can be well understood since it is derived in a similar way as the rotational temperature. According to the OH-related results of this paper, the latter is also a pseudo temperature. Finally, the Russian community frequently uses vibrational temperatures (see Khomich et al. 2008). Therefore, we wanted to provide results that can be compared. Consequently, we would like to keep the quantity in the paper. However, we have shortened the related discussion (see comment 33003).

32981/6 "and satellites"

In our opinion, satellites need a stable orbit, which is not possible at about 90 km because of the air density. Moreover, everything that has to be brought to the upper atmosphere and beyond requires a rocket. Therefore, we think that our statement is sufficient.

32981/14 Is v = 9 the ninth or the tenth vibrational level?

Indeed, the term “ninth” can be confusing. Now, we directly give v = 9. We have also changed the subsequent sentence in a similar way.

32981/(17-25) This section is murky, because of the introduction of vibrational temperature.

As motivated above, we would like to keep the vibrational temperature in the paper. However, we have rephrased the corresponding paragraph to more emphasise that it is a pseudo temperature.

32982/9 “high-altitude layers”

Now, it reads: “high emission altitudes”. This is more precise than “layer”, which has a certain width.

32982/14 “uncertainties still present”

done

32983/23 I think “unusual plain” is better defined as “ordinary”

For an astronomer, an observation of the plain night sky without an astronomical target is unusual. Such observations are mostly performed to obtain calibration frames for the sky subtraction. This explains the term “unusual plain”. Nevertheless, since this might be misunderstood without a detailed explanation, we have removed “unusual”.

32984/12 delete “will”

done

32984/19 “has operated”

We have changed it to “has been operating” to more emphasise that X-shooter is still working.

32985/10 “is necessary to apply”

done

32986/2 “in an adequate way”

done

32987/25 “for all OH bands considered”

done

32989/1 use wavelength range, not band range

done

32989/3 “except for the 7-1 band”

done

32989/4 what is a median spectrum?

It now reads “spectrum of the median pixel intensities of the K-band sample”.

32989/7 many OH bands are in the optical range

We agree.

32995/7 “to” here makes no sense, maybe a comma

The “to” meant: all measured bands in between in terms of wavelength. As this seems to be confusing (see comment 32980/16), we now list all bands individually.

32995/8 OH(2-0) is not a “neglected” band – it’s the only one you have for v’ = 2

The selected 16 bands were used to quantify the effect of the line set on the derived temperatures. The corrections were calculated independent of v'. Therefore, OH(2-0) could be excluded. We have changed “neglected” to “not used”.

32995/13 “required” instead of “necessary”

done

One needs a band table arranged by wavelength, to clarify how the bands appear in the nightglow

Figure 2 already provides this information. To easier find a band listed in Table 1 in this figure, we have added a column to Table 1 that provides the label letter of the subfigure with the corresponding spectrum.

32997/25 “of the Δy pattern observed”

done

32999/(21-27) another explanation could be that there are two distributions, v = 7-9 and v = 2-6.

As it is discussed later in this section, the nascent population of the high v and the population of the low v by radiation processes and collisions are important ingredients for the explanation of the T_{rot}(v') pattern. However, apart from differences in the T_{rot} for high and low v', this also results in differences between odd and even v'. In this context, the T_{rot} for v' = 5 tend to be lower than the ones for v' = 4. Therefore, the assumption of two separate distributions does not appear to be sufficient.

33002/top It could be that OH is not a good choice at all for measuring mesospheric temperatures. As I understand it, temperatures determined from the O2(b-X) 0-1 band tend to be lower than any OH “temperature”, which suggests that we don’t understand the OH system well enough yet.

We agree that OH rotational temperatures are significantly affected by non-LTE contributions. In this respect, the discussion in Sect. 4.2 could have been too optimistic in terms of the use of OH for mesopause temperature retrievals. We have changed this by modifying the last two paragraphs of this section. Now, we clearly state that OH-related mesopause temperature gradients are unrealistic.

33003 I don't understand the significance of a determination of Tvib. The initial v distribution is a consequence of the reaction dynamics of H + O3 →OH(v) + O2. The initial levels are v = 7-9, with a small amount of v = 6. Any lower v comes from relaxation, so what is observed is mainly related to altitude, i.e. the number of collisions and the radiative lifetime of OH(v). So it seems to me that a vibrational temperature has little meaning. The initial vibrational distribution has no population in v = 0-5 – so what then is the vibrational temperature? What would be useful is the total emission from each vibrational level. I think there's enough data to compile that.

T_{vib} is a measure for the vibrational level population distribution (see also comment 32980/23) and is therefore an indicator of the state of the vibrational relaxation, which in turn depends on the altitude. Therefore, we think T_{vib} is a very useful quantity. Moreover, by comparing e.g. T_{vib} for the v' ranges 2 to 6 and 2 to 9, one can learn something about the contribution of the overpopulation at high v to the v population distribution. However, we agree that T_{vib} related to narrow v' ranges are relatively abstract and difficult to interpret. Moreover, their discussion is not essential for the paper. Therefore, we have decided to shorten the T_{vib}-related discussion. We have removed everything related to T_{vib} derived from three or two v'. This has significantly shrinked the last paragraphs of Sects. 4.3 and 5.1. Moreover, Fig. 8 has been removed, Fig. 9 has been modified, and the conclusions have been slightly shortened.

The temporal changes in the population of the different v' are discussed in Sect. 5.2. Therefore, we do not think that showing the same in Sect. 5.1 would significantly improve the discussion. Instead, the discussion of relative intensities and T_{vib} provides complementary information. In particular, the variability correlations for the different OH bands are well illustrated.

33004/25 "OH lines and bands considered"

The corresponding sentence has been removed.

33008/28 "on", not "in"

We think that "in the order" also works. Nevertheless, we have changed all occurrences of this expression.

33012/23 "As for Trot"

done

33013/8 "We considered the (Trot(v')) already discussed"

done

33017/18 "observed", not "found"

done

33029/F1 what does “see legend” in the caption mean?

At the bottom of the figure, different symbols and colours are assigned to single years of the data set. This is the legend. To make it clearer, we have extended the text in parentheses.

It strikes me that it would be useful to add the Cosby and Slanger data to Fig. 13.
This would show how reproducible the structure of the “spectrum” is, and it would be interesting to compare their March/October data with the seasonal data in the figure, because the seasons are reversed between Mauna Kea and the VLT.

As proposed, we have added these data to the figure. In fact, there is a better agreement of the Cerro Paranal and Mauna Kea data if similar months are compared. If true, this could be related to the symmetric diurnal tide. However, the data sets are relatively small. For more robust results, more data are required. We have revised the discussion on this topic.