Response to interactive comment by Anonymous Referee #2 on "OH populations and temperatures from simultaneous spectroscopic observations of 25 bands" by S. Noll et al.

General comments:
This is a well written study touching on some current and relevant issues related to the determination of mesopause temperature from ground-based measurements of the OH Meinel emissions. An extensive set of night-sky spectra measured with an astronomical spectrograph operated at the ESO in Chile and covering more than 20 OH bands is employed. The main aspects of the study are the vibrational level dependence of rotational and vibrational temperature. Nocturnal and seasonal variations in rotational temperature and vibrational population are also reported for the different vibrational levels. Most aspects of the study are not entirely new results, but the study is highly valuable for the scientific community, because a more extensive data covering more OH bands is used compared to earlier studies. I have no major objections to the publication of this manuscript, but ask the authors to consider the comments listed below.

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

Specific comments:

Page 32980, line 16: '25 bands from OH(8-2) to OH(9-7)'
This is only a really minor point, but for the inexperienced reader this order will be difficult to understand. Perhaps the wavelength ranges of the two bands can be listed in parentheses?

We have replaced the band names by the wavelength range covered by the measured lines.

Page 32980, line 21: 'show a clear trend in the change of the variability pattern.'
I'm not sure what the intended meaning of this phrase is. Can this be improved?

We have reworded the sentence.

Page 32981, line 6: 'in situ' -> 'in-situ' ?

done

Page 32981, line 8: 'emission' -> 'emissions'

done

Page 32981, line 19: 'leads to temperatures of about 10000K'
This refers to vibrational temperature, which should be stated.

done

Page 32982, line 8: 'This implies possible real temperature gradients'
It's not clear what this implication aims at. What are the effects of 'real temperature gradients'?
Same sentence: also the following sub-sentence lacks context, I think.

Emission layers with different peak altitudes probe different parts of the atmospheric temperature profile. We have rephrased the sentence.

Page 32984, line 19: ‘is operated .. since’ -> ‘has been operated .. since’ ?

We have changed it to “has been operating since”.

Page 32984, line 20: ‘We retrieved the archival data taken until March 2013.’
If the data was downloaded from a website, please provide that website. Also, does the data have a version number?

In the context of a collaboration with ESO, we obtained most data on hard discs (order of TBytes). There are only ESO-specific programme IDs. Since we used the data of many observing programmes, it does not make sense to provide the individual IDs. Note that we retrieved the raw data without any preprocessing. Therefore, version numbers are not provided.

Page 32987, line 23: ‘we only considered those observations where the temperature did not deviate by more than 3.5 25 SDs from the mean value for all considered OH bands.’
It would be interesting to learn what fraction of the spectra left does not pass this filter.
Also, although it is quite obvious, ‘SD’ should be spelled out.

19% of the VIS-arm and 4% of the NIR-arm spectra did not pass the filter. The higher fraction of VIS-arm spectra can be explained by the fainter OH lines in this wavelength regime and the corresponding higher sensitivity to disturbances. The percentage for the combined VIS- and NIR-arm spectra is 21%, which we have added to the text. Interestingly, the acronym 'SD' originates from ACP. We have changed it back to “standard deviations”.

Page 32988, line 1: ‘The deviation from the mean values of an ideal distribution is only +13 min and -4 days, respectively.’
I find this statement potentially misleading. For the first value, only the time of the day is relevant, for the second number only the day of the year.

We have rephrased the sentence to better state that there are two different averages.

Page 32988, line 5: ‘fraction .. were’ -> ‘fraction .. was’

done

Page 32988, line 19: ‘by 32 min and 6 days’
See comment above.

With the change of the first sentence related to this kind of averages (see above), this statement should also be clearer.

Page 32991, line 4: ‘First, the sky continuum was roughly determined by applying a median filter’
I don’t quite understand how this median filter is specifically applied in this case. Can you briefly explain this?

A median filter replaces the intensity of the central pixel of a range of pixels by the median intensity. The median filter included about an order of magnitude more pixels than the pixel ranges that were used for the integration of individual airglow lines. We have revised the

sentence to provide more details.

Page 32991, line 8: ‘Lines with critical continua should have been rejected’
Are they rejected or not?

If a continuum for a line measurement was critical in most sample spectra, then it is very likely that the line was rejected. However, we cannot exclude that a line continuum was problematic in a minor fraction of the sample spectra since we could not check more than 50,000 line measurements individually. We have rephrased the sentence.

Page 32992, line 8: ‘The altitude distribution of the emission with a typical FWHM of 8 km is negligible, since the correction changes by less than 1% ..’
I don’t really understand this statement. Does it mean that the correction changes by less than 1 % if the altitude profile is changed within plausible limits? It can certainly not mean that the maximum difference between I(0) and I(z) is less than 1 %, right? I also think the statement should be something like ‘the effect of the altitude distribution of the emission on the correction is negligible’ and not ‘The altitude distribution .. is negligible’. The altitude variation is certainly not negligible.

The assumption is correct. We have changed the text in the proposed way.

Page 32992, line 15: please add ‘$\Delta\lambda / \lambda$’ before ‘$\approx 10^6$’

done

Page 32992, line 22: ‘These profiles were then convolved with the transmission spectrum’
Were they really convolved? I think they just need to be multiplied by the transmission spectrum.

Indeed, the term “convolution” can be misleading since the convolution is only performed at the central line wavelengths and not for the whole spectrum. We have rephrased the sentence.

Page 32993: It would be good to mention the accuracy of the transmission correction.

This is difficult to estimate since the transmission correction is a complicated procedure with many uncertainties. However, a comparison of the scatter in the resulting level populations for lines with low and high transmission indicates an accuracy of about 10 to 20%. We have added a sentence stating these numbers.

Fig. 3: Please indicate what lines correspond to which v’.

We have labelled the lines according to their v'.

Page 32995, line 24: ‘The resulting correction was nearly 0 K .. and about +1 K’
Can you provide more accurate values for these corrections?

We have added more accurate values. They are provided separately for G98 and LG08 line parameters, which have only a minor effect. The latter was the reason for giving approximate values for each band in the previous version.

Same page, line 27: ‘These are reasonable quantities’
Unclear what you mean by ‘reasonable’ here.

Bands with the same v' behave in a similar way due to the same roto-vibrational upper states. Therefore, the corresponding mean temperatures are a physically motivated (i.e. reasonable) quantity. We have removed the "reasonable quantity" statement since it is not essential.

Page 32998, line 5: 'than reported by Beig (2003) referring to Perminov and Semenov (1992).'
What exactly do Perminov and Semenov suggest?

As reported by Beig et al. (2003), they suggest to use only lines with N' ≤ 5. We have added this limit to the sentence.

Page 32998, line 15: 'However'
This suggests a contradiction to the previous sentence, which is not the case. Suggest removing 'however'

done

Page 33000, line 10: ', the temperature decreases by 1.3 K on average.'
Suggest to state explicitly what the reference for the 1.3 K decrease is.

The average was calculated for v' = 2 to 9, which we have added to the text.

Page 33001, line 18: 'pecularities' -> 'peculiarities'

done

Page 33001, line 22: 'The process would be more efficient'
Not fully clear what 'process' refers to.

This is confusing, indeed. The whole scenario described in the first part of the paragraph was meant. We have revised the sentence by using "scenario" instead of "process".

Page 33002, line 15: 'which is caused by the O3 and O density-related collisional quenching efficiency'
Perhaps the paper by Savigny and Lednytskyy, GRL, 40, 5821 – 5825, 2013 should be cited here, because it's the first paper showing the importance of O quenching in real data.

We have added this citation. In the old version, we did not refer to this paper since the main result was reported by Kowalewski et al. (2014), which is also a paper related to C. von Savigny.

Page 33004, line 4: '(43%) .. (32%)'
Unclear what the percentages refer to. Please clarify.

The percentages indicate the overpopulation. They are directly related to the stated y differences. It now reads "(overpopulation of 43%)".

Page 3304, line 16: 'When only the vibrational levels 3 to 6 are considered, as shown in Fig. 7'
I think this should be a reference to Fig. 8, not 7?

In Fig. 7, the dotted lines are related to fits for v' = 3 to 6. Hence, the reference is correct.

Page 33005, line 3: ‘we can further constrain their origin’
‘Origin’ refers to ‘OH rotational and vibrational temperature’, which doesn’t make too much sense. Perhaps you mean the origin of variability in OH temperature?

The origin of the v'-dependent patterns discussed in Sect. 4 was meant. In this respect, the time dependence reveals the layering of the v'-related emissions, for example. We have revised the paragraph to clarify the meaning of “origin”.

Page 33008, line 4: ‘Figure 9 also indicates that structures in the variability pattern for T_rot and intensity appear to move from high emission layers ..’
Can you describe more precisely at what times, e.g. this is seen. I’m unable to see this in the intensity plot, and also in the temperature plot this effect is not very pronounced.

The observations with the minimum temperature and intensity of the time series are marked by filled circles. There is a clear trend towards later minima for lower v' (especially for low v'). We have extended the discussion related to tidal variations to better describe the observations and the corresponding interpretations.

Page 33009, section 5.2.1: ‘Nocturnal variations’
How are nocturnal variations separated from a potential semi-annual contamination? This is probably simply the case, because your measurements are nearly equally distributed in local time and day of year. Perhaps this should be mentioned here.

We have added a corresponding sentence.

Page 33010, line 16: ‘whichs’

done

Same sentence: suggest to mention that T_rot is averaged over all v’ here.

This information is given in the subsequent sentence. However, this might be too late. Therefore, we have moved this information to the proposed position.

Page 33010, line 21: ‘The slope .. derived from all v’ tends to decrease through the entire night’
Looking at Fig. 11 leads me to the conclusion that the slope increases during the night.

We agree. This is an overlooked typo. We have replaced “decrease” by “increase”.

Page 33010, line 25: ‘While the time-averaged absolute T_rot differ’
That’s the difference between odd and even v’, right? This should perhaps be mentioned at this point of the sentence already to avoid confusion.

done

Page 33012, line 15: ‘A LOWER slope of 1.0 K was found in spring’ and 2/3 lines below: ‘data of C&S (2007) for Mauna Kea ALSO indicate a STEEPER slope for spring’
This doesn’t seem to be consistent. Also in this paragraph: the difference between

‘spring’ in the NH and SH may lead to confusion.

Indeed, this is confusing and inconsistent. Thus, we have revised the related sentences by mainly stating the months. In fact, the slope changes in our data and the data of Cosby & Slanger (2007) do not agree if the same seasons are compared. For reliable conclusions, larger data sets are required. Moreover, the differences in the NH and SH intra-annual oscillations have to be understood. Just shifting one variability pattern by six months to get the pattern of the other hemisphere does not appear to be correct. For example, consider the symmetric tidal modes, which affect both hemispheres in the same way. Therefore, we just state the results for the two data sets without interpretation.

Page 33013, line 1: ‘is in good agreement’
With what? Probably Takahashi and Gelinas?

Yes. We have modified the sentence to clarify this.

Page 33017, line 26: ‘results of (Cosby and Slanger, 2007)’ -> ‘results of Cosby and Slanger (2007)’

done

Page 33030, Figure 2: The panels are barely legible on my printout. This Figure needs to cover an entire page, and even then the labels may not be legible. Please check.

We have designed the figure for an entire ACP paper page. Therefore, changing from ACPD to ACP will significantly increase the font size. However, even in this case, the font size will be smaller than for all other figures. Hence, we have revised the figure to improve the readability.

Page 33030, Caption Fig. 2: ‘The displayed spectrum is the median’
How exactly is the median determined? Is the median determined for each pixel/wavelength bin separately? I think there are different ways to determine a ‘median spectrum’

The median was calculated for each pixel independently. We have modified the figure caption and the corresponding sentence in Sect. 3.1.

Page 33032, caption, Fig. 4: Suggest to replace ‘lozenges’ by the commonly used ‘diamonds’
This comment also applies to Figs. 5, 7, 8, 11

done