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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measuring FeO variation using astronomical spectroscopic observations" *by* Stefanie Unterguggenberger et al.

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Response to interactive comment by T. P. Viehl

General comments *The paper presents spectroscopic observations of FeO and Na nightglow emissions by the X-shooter instrument at the VLT / Paranal Observatory, Chile. The observations are analysed on diurnal as well as seasonal scales and compared to theoretical considerations. The seasonal variation of the emissions is very satisfactorily reproduced by an atmospheric chemistry model. This analysis reveals new insights about FeO in the MLT and the quantum yields of the relevant emissions.*

The paper presents new data and insights which are relevant to the field and well suited for publication in ACP. The methods and assumptions are valid and clearly

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outlined. In general, the experiment and the calculations are sufficiently described. Some suggestions are given below to improve the description further. The authors give proper credit to related work and clearly indicate their own contribution. The overall presentation is well structured and clear. Some suggestions to improve the presentation further are given below. The title reflects the contents of the paper and the abstract provides a concise and complete summary.
I recommend publication of this interesting manuscript after minor revision and ask the authors to address the following comments and suggestions.

Specific comments and suggestions

Page 2, line 24: Suggestion: change "source of THE metals" to simply "source of metals", "source of metal layers", "source of meteoric metals" or similar, as this is the first account of mentioning "the metals"
Thanks for the suggestions. The phrase was changed to 'source of metal layers'.

Page 3, line 12: It appears slightly odd to me to refer to sodium as "a good CANDIDATE" since observations of Na are well established and not only theoretically considered. Suggestion: "a good candidate" -> "well established", "commonly used", or similar
'A good candidate' was meant with respect to astronomical techniques since the Na doublet can already be detected with small telescopes and low-to-medium resolution spectrographs. The phrase was changed to 'commonly used'.

Page 5, line 16: Can you provide more information about the criteria of the "additional quality checks" applied to the data? Are these implemented in the pipeline (Modigliani et al., 2010) or are additional reductions performed, e.g., by discarding spectra with obvious distortions through technical problems?
The spectra were furthermore checked for residuals introduced by the pipeline reduc-

tion (residuals related to higher orders, mentioned in the paper), contamination of the continuum by astronomical objects as well as a check on the reliability of the OH(9-4) intensity measurement. Furthermore, the continuum was checked for unreasonable behaviour like steep sudden steps in the spectrum. A paragraph with this information was added to the manuscript.

Page 5, lines 19/20: "...an adapted version of pipeline v2.6.8 of the ESO public pipeline..." Suggestion: change to "...an adapted version of the public ESO pipeline v2.6.8..."
The suggested change was implemented.

Page 5, line 28: I'm not familiar with the term "echelle orders". I suggest changing to "higher diffraction orders of the echelle spectrometer" if this is what is meant. Furthermore, can it be easily explained how the pipeline (i.e., data processing) introduces these as opposed to the instrument? It might be worthwhile adding a further short explanatory sentence, since this influence does not seem to have been covered in the cited literature.
Echelle order is indeed an astronomical term. At the position of its first occurrence it is now changed to the more detailed '...high diffraction orders of the echelle spectrograph...'
The main issue was the separation of sky and astronomical object. Applying different extraction methods implemented in the pipeline led to different results. X-shooter either traces the light profile of the astronomical source to separate the object from the sky or uses a predefined window to distinguish between sky and object.
We found that the difference between the spectra for the latter and the former method can be used to construct a template for the order-related contamination (periodic wave pattern). This template could then be scaled to the individual contamination patterns and finally be subtracted. Here we only considered the sky spectra obtained with the second approach which is more reliable for line emission.

This information was also added to the manuscript: 'Comparing different extraction routines we found a systematic variation in flux with wavelength that shows minima at the central positions of the different echelle orders and maxima in the overlapping regions. A correction spectrum was determined by comparing differently extracted spectra. This spectrum was then scaled to the observation and subtracted. In addition, we checked for continuum contribution by astronomical objects, the reliability of the intensities of various OH lines and for unreasonable behaviour like sudden steps in the spectrum.'

Page 6, line 12: "FeO is only a faint pseudo continuum component": this doesn't really make sense to me. Suggestion: change to "FeO has only a faint pseudo continuum component" or "the component of FeO to the observed pseudo continuum is only faint" depending on what you want to say here.
The phrase was changed to '...FeO contributes to the airglow as a faint pseudo-continuum'.

Page 6, lines 23&24 and Figure 2: In the text you refer to the exposure time as "roughly 1 hour" and the resolving power as " approx 7450". In the caption of Figure 2, however, the exposure time is given as precisely "3600 sec" and the resolving power as "7450" (without approx). Please clarify, e.g., by choosing either "roughly 1 hour" or "3600 sec", whichever is correct.
It is indeed exactly an hour of observation time and a resolving power of approx 7450. The values are correct and the text changed accordingly.

Page 7, line 2: Recommendation: change "this interval" to "the interval" as it is not referred to in the previous sentence.
The suggested change was applied.

Page 7, line 14: "which IS according to Gattinger et al. [2011] defined at" ->

"which according to Gattinger et al. [2011] IS defined at" ?
The suggested change was applied.

Page 7, line 14: "FROM their selected wavelength range" -> "IN their selected wave- length range" ?
The suggested change was applied.

Page 7, lines 13/14: Here and throughout the manuscript there are several personal references to studies (i.e., "They found..." instead of "That study found...). This very much is a stylistic choice of the authors, but I suggest to change those occurrences to the more neutral, impersonal form. In this example, I suggest changing "from their selected wavelength range" to "in the wavelength range of that study" or similar.
Thank you very much for the comment. We left the text as it was in the original manuscript.

Page 7, line 15: I recommend placing "of 6%" between "an error" and "for the FeO main peak"
The suggested change was applied.

Page 8, line 24: While the observed FeO spectra indeed match the theoretical work of Gattinger et al. with "good overall agreement", I recommend to add a note that some parts show a difference in relative intensity of more than 50% (in particular at around 590 nm and 600 nm, well within the main peak).
With this sentence we referred to the agreement of the five quintile spectra with each other. For clarification we added '. . . with each other ...'
Also your suggestion on the differences between the spectra was implemented.

Page 10, line 2/3: "...we obtain a value of 3.9%" ...of what? Do you mean to

say "...we find that FeO contributes 3.9% to the overall spectrum." ?
Due to other airglow contamination like different OH bands, NiO and NO+O it is difficult to measure the FeO spectrum. The most reliable part is the main peak. Since we wanted to see how much of the total FeO intensity is contained within the main peak, we took the the theoretical FeO spectrum from Gattinger et al. (2011) and scaled it to the total FeO flux. Hence, the 3.9% refer to the contribution of the main peak to the total FeO spectrum. '. . . FeO pseudo-continuum...' was added for clarification.

Page 10, line 27: "...are the low statistic bins." Suggestion: change to "...have the lowest statistic." or "...contribute the fewest data points." or similar.
The text was changed to 'contain the fewest data points'.

Page 11, line 6/7: "show A similar" or "show similar ... variationS" ?
The text was changed to '. . . show similar variations'.

Page 11, lines 11-15: This description is not very clear to me. If 2010 shows a different behaviour than 2011&2012, does this mean the effect in those years would be even stronger than in the combined data shown or was 2010 excluded from the plot? Similarly, were the data from September and November 2011 excluded for the reason given or does this imply that the data from these months decreases the effect shown?
For Fig. 4 all data points were used. Fig. 4 shows the average diurnal behaviour for the respective seasons in a time span of 3.5 years.
We also wanted to discuss the behaviour for the different years. However, the corresponding results are not as reliable as the complete picture since the sample size is much smaller.

Page 14, line 10: Suggestion: "...rates were using the..." -> "...rates were CALCULATED / ESTIMATED using the..."

The text was changed to '...rates were calculated using the . . .'.

Page 16, line 7: "The shape of the quintile spectra is almost identical." Identical to what or during which periods? I assume it is meant identical to each other. Indeed, we referred to the similarities of the quintile spectra among each other.
The phrase 'to each other' was added for clarification.

Figure 3: Please use a lighter shade of grey for regions where the correction might not have been performed accurately. The contrast of the black and blue curves to the grey shaded areas is very low. It is furthermore slightly distracting to have features as prominent as the dark grey areas in the figure without a description in the figure or its caption.
The shades were changed to a lighter grey.

Technical comments

Page 6, line 6: "and as well as": choose either "and" or "as well as"
The 'and' was eliminated.

Page 7, line 28: "are discussed" -> "is discussed" ?
The phrase was changed to 'is discussed'.

Page 8, line 6: "merge" -> "merged" or "merging"
The tense was changed.

Page 8, line 15: "normalize" -> "normalized"
The tense was changed.

Page 8, line 1516: Throughout the manuscript, you seem to prefer British En-

glish over American English. While "normalized" is probably acceptable in BE, you might consider changing to "normalised" for consistency here.
The correction for British English was applied.

Page 12, lines 4/5: "...between 0 and 0.65 x the maximum intensity" Change to "...be- tween 0 and 0.65 OF the maximum intensity" or consider using percentages as done previously
The suggestion was included in the manuscript.

Page 12, line 20: "...squareS the Bayesian..."
The s was added.

Some comma errors, e.g. Page 16, line 6: "...with intensity, median..." Page 16, line 12/13: "...pointed out that..."
The suggestion was included in the manuscript.

Figure 4(d): "Okt" -> "Oct" The figure was changed.

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