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Atmospheric Measurement Techniques Discussions

Interactive comment on "MAX-DOAS measurements of HONO slant column densities during the MAD-CAT Campaign: inter-comparison and sensitivity studies on spectral analysis settings" *by* Y. Wang et al.

Anonymous Referee #3

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The study by Y. Wang et al. reports on a detailed evaluation of state-of-science retrievals of HONO column densities from MAX-DOAS measurements of scattered UV radiation during an intensive measurement campaign in 2013 in Mainz, Germany. Following a comparison of HONO columns retrieved by 11 different groups, the authors present an in-depth analysis of the retrieval settings required for optimal fitting. This analysis also allows them to present a characterization and breakdown of the error budget of the HONO retrievals. Both aspects of the paper are scientifically important, very suitable for AMT, and in my opinion help to improve and better understand the

MAX-DOAS HONO retrievals.

Strong about this manuscript is that a substantial number of dedicated and relevant sensitivity tests have been carried out to improve the fitting approach, and at the same time characterize the fitting errors. The team makes a strong case that using sequential reference spectra instead of once-per-day noontime reference spectra works best, that water vapour absorption should be accounted for in the fit, and that the 335-373 nm fitting window gives most robust retrieval results. The comparison between the sensitivity study results and the discrepancies between HONO columns observed by different groups provides excellent potential to interpret theoretical and practical uncertainties in the retrievals.

I recommend that the paper is published in AMT, but the authors should first clarify a number of issues listed below, and make the manuscript much better readable.

Major issues

1. The title does not cover the aspect of error analysis that is certainly an important component of this paper. I suggest modifying the title accordingly.

2. The paper is too long. In many places too much information is provided. There are too many references in the text to the Supplementary Material and such interruptions prevent a smooth read. The manuscript should be streamlined in many places. As an example, on page 8, L31-32 and P9, L1-15, much of the text is about supplementary figures supporting the material in Figs. 4 and 5. Isn't the material presented in Figs. 5 and 5 convincing enough to stand on its own? It would be more logical to discuss the results shown in Fig. 4 and 5 more extensively and only at the last instance mention that there is support to be found in the supplementary figures. Another option to make the manuscript more concise is to refrain from giving all of the available information for both the FRS and noontime reference spectrum once the recommendation is given to prefer the FRS method. The same holds for the fitting windows that are ultimately not used.

3. I'm not sure if the order of the sections is optimal. If I'm correct, the 11 retrieval groups use the optimal fitting window (335-373 nm) and settings to obtain their results presented in section 3, but the motivation for this is only given in section 4. Isn't it better to present the sensitivity studies and corresponding recommendations before the actual intercomparison? This would also prevent the need to point forward to sections still to come (e.g. on P6, L14-15 "see Section 4.1")

4. The text in the manuscript is sometimes too vague. For instance in the abstract, the last sentence reads "However, systematic uncertainties limit the reliability of the results." Since you have a pretty decent quantitative estimate of the systematic error of the HONO columns, please indicate what you think is the detection limit, and how frequently you think this is being exceeded in practice. This gives potential users of the data a sense of the usefulness of the HONO retrievals, for instance in the context of the diurnal cycle of HONO columns. Also, see many minor comments below, asking for clarifications.

5. The role of clouds in the retrieval remains under-exposed. It would be interesting to distinguish the quality of the spectral fits under cloudy and clear-sky conditions.

Minor issues

P2, L14: "of the fitted from the simulated real HONO delta SCDs". Hard to follow, please rephrase.

P2, L21: "tropospheric atmosphere" → troposphere

P3, L26: I think it would be appropriate to introduce the 11 groups participating in the MAD-CAT campaign here.

P4, L22: "seven of all of the eleven" → Seven of the eleven . . .

P4, L30: repetitive to mention the 12 June – 5 July period here since it was in 2.1

P5, L15: it is unclear at this stage what sigma^2 NO2 represents and what it is used

for. This has to do with the ordering of the section (were section 3 and 4 reversed at the last minute?)

P6, L29-30: is there any physical or chemical reason why HONO dSCDs are high on 3 July 2013?

P7, L31-32: please clarify what 0.01 means here. How should the number be interpreted?

End of P9, lines 1-3 op P10: difficult to follow. I think section 3.3 is in need of a clear conclusion on what we have learned from the statistical comparison. Instead, we end with a quite detailed, unsatisfying comment on something that could be wrong with one particular instrument.

P10, L5-6: "real atmospheric values for real MAX-DOAS measurements"?

P10, L30: "than the half of that"→ than half of that

P11, L17-18: nonlinear fits . . . were not included

P12, L14: can you elaborate on the increase in HONO with an increase in H2O delta SCDs? Is there a good reason to expect this?

P12, L24: peek→peak

P12, L26-27: this has been said already.

P12, L29: "bands" or are they rather lines?

P14, L27: dependence of the Ring spectrum

P15, L6-7: it would be helpful to quantify here what variations you think are due to different Ring settings. This helps is evaluating the overall error budget of the HONO retrievals.

P16, L7: non-linear

P16, L15-16: same as for section 4.5: please quantify the error associated with the intensity offset uncertainty, and conclude as to its relevance.

P16, L25: “instrumental function”→ instrument transfer function or slit function?

P17, L4: “noises” → noise

P18, L8: please calrify what the correlation coefficients refer to.

P18, L10: it would be useful here to explain the typical diurnal variation in HONO, and make clear that the retrievals are able to capture the temporal changes to large extent. Perhaps also indicate when (what column densities, those typically around noon?) the retrievals are running into detection limit issues.

P18, L15: before the paragraph ends, I think

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