

Author response

We thank the reviewer for taking the time to evaluate the manuscript thoroughly and for giving the valuable comments that helped to improve the method and the manuscript. Below we answer the comments in detail, our response is marked in green and changes to the text in blue. Some larger changes are not repeated in detail here, but we refer to the relevant places in the updated manuscript as detailed as possible.

Review of SCIAMACHY nominal mode NO

Review of: "Retrieval of nitric oxide in the mesosphere from SCIAMACHY nominal limb spectra", by Stefan Bender, Miriam Sinnhuber, Martin Langowski, and John P. Burrows

The paper is clear and well written, and promises to deliver a data set that is timely and important for the community. There are several minor comments that are included below. There are only two major comments.

Major comments

With regard to the procedure of halving the a priori values mentioned on page 11, line 9.

Firstly, has the value 0.5 been optimized in some way?

The factor 0.5 was empirically determined and considered only the MLT time period (2008–2012). We have extended the retrieval algorithm to simultaneously fit an additional scale factor for the a priori values. We have updated the manuscript Sect. 3.2 with the improved method (page 4 lines 28–30 and page 5 lines 1–10), the results section (pages 10–12) and the conclusions (page 14 lines 9–14) with our new findings.

What is the justification for fixing this value? I understand having an a priori that varies as little as possible, but here you are using a highly variable model a priori, so allowing this value to vary would not seem to be a problem. It would seem that halving the NOEM values based on the fact that they were taken during solar maximum would indicate that this factor should vary with respect to the point in the solar cycle at which you are retrieving the SCIAMACHY results. You do not mention if there is any overlap in solar conditions between SNOE and SCIAMACHY. If there is, should the factor not be one during these conditions?

Finally, why would this scaling be justified for the regression model which should not have this effect? It seems as if there is some other effect occurring here.

Both points are valid and even the authors were surprised that scaling by 0.5 seemed to work that well. Even with the long-running nominal mode, SCIAMACHY (2002–2012) has no time overlap with SNOE (03/1998–09/2000). The solar conditions at the end of the SCIAMACHY period (2011–2012) may be comparable to SNOE solar conditions.

The regression model a priori was determined from the multi-instrument daily zonal mean data (SMR, MIPAS, SCIAMACHY MLT, and ACE-FTS) which results in slightly larger values compared to using only SCIAMACHY. We tried to lessen any circular reasoning this way and therefore the scaling factor may be different from one. It is also true that this scaling should be different between using the NOEM model and the regression model as priors. However, as mentioned above, we extended the retrieval algorithm such that the a priori scale is no longer fixed. It is retrieved alongside the number densities and thus accounts for different solar conditions automatically.

A second major comment regards contamination issues:

The high latitude data during the summer will contain contamination from Polar Mesospheric Clouds (PMC). Has this been taken into account in the analysis?

Indeed, PMCs enhance the back-scattered light substantially and therefore may pose a problem for the retrieval. However, this affects the spectrum uniformly, and we subtract the Rayleigh background over a wavelength range that encompasses all three used gamma bands. Thus, the higher background is taken into account before fitting the NO gamma bands which removes the need to detect and treat PMCs separately. We added the following paragraph to the end of Sect. 3.1 (page 4 lines 13–14 in the updated manuscript): We subtract the Rayleigh background before the spectral fit. This enables NO number densities to be retrieved for cases where the spectra are contaminated by Polar Mesospheric Clouds (PMC), also known as Noctilucent Clouds (NLC).

Minor comments

Page 1 lines 1 and 16: Though there are a number of chemical names for NO that are technically correct, I agree with reviewer 1, "nitric monoxide" should be changed to "nitric oxide" for consistency with the title and common usage in the literature.

We changed the text to use "nitric oxide" throughout the manuscript.

Page 1 line 7: Spell out Nitric Oxide Empirical Model (NOEM) in the first appearance in the abstract (Page 1 line 7) and article body (Page 5 line 14).

We spell those out in the updated version of the manuscript.

Page 1 line 10: "misinterpretation" might be better as "attribution" or "incorrect attribution".

We replaced it with "incorrect attribution" which matches the intended meaning.

Page 2 line 12: "SubMillimetre" (which would be a tiny hat for a bishop), should be "Submillimetre".

Thank you for the catch, it slipped through the internal proof-reading and was corrected.

Page 4 line 16. The phrase "Here we use both, that is, we use prior input and regularise vertically and horizontally" could perhaps be expressed more clearly as: "Here we use

both prior input as well as vertical and horizontal regularization.”

Changed as suggested.

Page 4 line 20: Again, “...for the a priori covariances, the vertical, and the horizontal regularisation” could be expressed more clearly as: “...for the a priori covariances, and the vertical and horizontal regularisation.

Again, changed as suggested.

Page 5 line 12: The phrase: “...get correct number densities, also below 100 km”, might be more clearly expressed as: “...to get correct number densities below 100 km”, or “...to get correct number densities, especially below 100 km”.

We changed the sentence using the first suggestion.

Page 5 line 15: One should spell out “Student Nitric Oxide Experiment (SNOE)”.

Done.

Page 6 line 10: “Equivalently to the MLT...” might be better expressed as: “As in the MLT...”.

Changed as suggested.

Page 7 line 13: “smaller then” should be “smaller than”.

Done.

Page 8 lines 23: Since you have explained which tangent points are affected in the previous sentence, would the phrase: “no slant column densities from dedicated limb tangent points.” be better as: “no slant column densities from these limb tangent points.”

We changed this sentence to end in (page 8 lines 6–7 in the updated manuscript):

“...no slant column densities available.”

Page 8 line 7: Again, the word “dedicated” is not necessary.

Removed.

Page 8 line 8: “To compensate these enhanced values” should be “To compensate for these enhanced values”.

Changed.

Page 8 line 10: “Similar” should be “Similarly”.

Done.

Page 8 line 21–22: The sentence: “The median of the number densities retrieved from the restricted MLT scans in these three latitude bands compared to the results from the full MLT retrieval are shown in the top panel of Fig. 6”, is unclear. I would suggest this be rewritten as: “The zonal median number densities retrieved from the full MLT scan as well as the restricted MLT scans with and without a priori information above 90 km

are shown in the top panel of figure 6 for the three latitude bands.” This is because the retrieved values are being presented and these MAY be compared on the graph, but what is presented is not the comparison to the full MLT retrieval. The latter implies they have been ratioed or subtracted. One should also mention that negative number densities can result from the retrievals of the restricted scans using a priori information above 90 km.

We changed this sentence as suggested.

Page 11 line 8: "...using the a priori values seem to overcorrect" should be "using the a priori values seems to overcorrect"

Changed.