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Interactive comment on **"Comparison of nitric oxide measurements in the mesosphere and lower thermosphere from ACE-FTS, MIPAS, SCIAMACHY, and SMR"** ***by*** **S. Bender et al.**

Anonymous Referee #2

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We thank the reviewer for his/her valuable comments which help to improve the manuscript and we address them in detail below. The original comments are black, our reply is marked green, and changed or added text is marked red.

This paper presents a comparison of nitric oxide abundances in the upper atmosphere as measured by different remote sensing instruments. NO is an important measure for the quantification of solar activity in Earth's atmosphere. The paper is well written, and the methodology and the results are described clearly. I recommend publication of this work in AMT after a few major points and some minor points are addressed.

Major points:

Altitude resolution: The altitude resolution of the datasets presented in this study differs significantly; e.g. between 5-20 km (MIPAS) and 3 km (ACE-FTS). It is essential to discuss the effect of the distinct altitude resolutions when comparing the datasets. Since most of the authors of this work are involved in retrieval activities of the instruments, averaging kernels (avk) and a-priori data should be available. The authors shall investigate the effect of the different altitude resolutions for some typical conditions, illustrated by one or two figures. Depending on the result, avk effects should be considered in the subsequent analysis or considered in the discussion, only.

In cases where data are compared which do not belong to the same geolocation, application of averaging kernels are not easily possible because the averaging kernels are time and geolocation dependent. Further, this is a "climatology" comparison and the goal here is to show how the different data sets compare **as they are**, not if they are consistent after taking into account the respective retrieval responses. We tried to make this clear with the last sentence of the second paragraph in the introduction of the original manuscript. Furthermore, the impact of the different vertical resolutions is discussed at the end of the first paragraph in the conclusions.

Systematic uncertainties: On page 12747 (line 2) and page 12755 (line 4) the authors mention "error bars" equivalent to the "95% confidence interval of the daily zonal mean". Does this mean that error bars illustrate the variance of the mean, and not systematic uncertainties of the data, such as instrument calibration or forward model uncertainties? This should be made clear. Systematic uncertainties of the various datasets should be given for a few altitudes - either in the plots or in a separate table.

The error bars indicate the statistical error and the figure captions have been changed to clearly state that. In order to make the reason clear, we added the following paragraph to the end of Sect. 4.3:
"The error bars in the figures indicate the statistical error only. Random retrieval errors are most likely much smaller than the natural variability (the latter hence dominating the standard errors of the mean) and biases are very difficult to estimate consistently for all instruments in a bottom-up manner. Here we determine biases between different instruments in a top-down approach."

Diurnal variations: NO abundance is subject to a large diurnal variation - driven by photochemistry, dynamics, and particle precipitation. Since the various instruments measure at different local times, the expected variations should be given. The authors should estimate quantitatively, to what extent the harmonic fit is biased by the different local time sampling of the various datasets.

The diurnal variation is largest when comparing day and night values. Above 100 km, MIPAS am/pm differences have already been analysed in Bermejo-Pantaleon et al., 2011. They conclude: "below about 140 km, daytime NO concentrations are about 10–50% smaller than during night." Thus, we appended the following discussion to the end of the second paragraph of the conclusions:
"Further, the NO diurnal variation affects the measurements at different local times. Taking the MIPAS am/pm (10:00/22:00) difference as an upper limit (Bermejo-Pantaleon et al., 2011) then the day and night difference between 100 km and 140 km can amount to 10–50%. The enhanced night-time NO then affects in particular the SMR measurements because of the early morning local time (06:00). Below (70–100 km), day and night differences are expected to be small since NO is controlled dynamically."

Minor points:

SMR data: Could the authors please give the altitude resolution of their data, as in the case of the other datasets?

We added the following sentence to the second paragraph in Sect. 2.4 about the SMR data:
"In the altitude range considered here, the vertical resolution is about 7 km."

Overview of dataset characteristics: I suggest to give dataset properties like altitude resolution, local time coverage, or systematic uncertainties (for 2-3 altitudes) in Table 1 as well.

The vertical resolutions have been added to Table 1 in an updated version of the manuscript.

Correlation of fitting parameters: The correlation (matrix) of the fit should be presented and/or possible dependencies of the fitting parameters should be discussed.

The correlation of the regression coefficients provides no useful information. However, we briefly discuss cross correlations between the parameters in an updated version of the manuscript. See, in particular, our reply to the next comment below.

Fitting components: I would suggest to show a plot which illustrates the magnitude of the different fitting components, e.g. in one or two additional plots or, e.g., by showing the data in Fig. 15-17 and Fig 18+19 with the same color map and color range.

Figures 16 and 17 will be changed to use the same colour scheme as Figs. 18 and 19 in an updated version of the manuscript. The coefficients in Fig. 16 differ by one order of magnitude from the other three. Using the same colour scheme for all four would result in blown out areas in one figure or in almost no differentiable colour shades in the other three figures. However, we included a new figure and the following paragraph to compare three regression coefficients on an absolute scale. Together with a short discussion of cross correlation, Fig. 18 and the following text were added at the end of Sect. 6:

"Figure 18 shows the direct comparison of three regression coefficients, d_1, b, and c, at four selected altitude–latitude points. We selected one high latitude (67.5°N) and one low latitude (2.5°N), together with one altitude in the mesosphere (85 km) and one near the maximal NO density in the lower thermosphere (105 km). Due to the nature of the ACE-FTS measurements (solar occultation), its seasonal coefficient d_1 is unreliable at high latitudes (upper row). Note that the SMR measurements at 85 km at low latitudes are too sparse (see Fig. 1) to derive significant regression coefficients. We find consistent coefficients at these four locations with some exceptions at higher altitudes. The SMR seasonal (d_1) and Kp (c) coefficients differ from the other four at 67.5°N. At 2.5°N, the notable exceptions are the SCIAMACHY seasonal coefficient and the SMR Lyman-α coefficient.
Taking into account the instrument sampling patterns, the cross correlations between these three estimators vary in general between ± 0.3. Larger (anti-)correlations were found in the Lyman-α/Kp cross correlations considering the SCIAMACHY sampling at latitudes south of 60°S and the ACE-FTS sampling between 50°N and 65°N."

General statements like: 'the NO diurnal cycle also affects the retrieved number densities' (page 12748, line 14) 'the nitric oxide densities of all four instruments are consistent during the comparison period' (page 12754, line 24) 'the remaining differences can be attributed to the different MLT measurement schedules and latitude-time coverage of

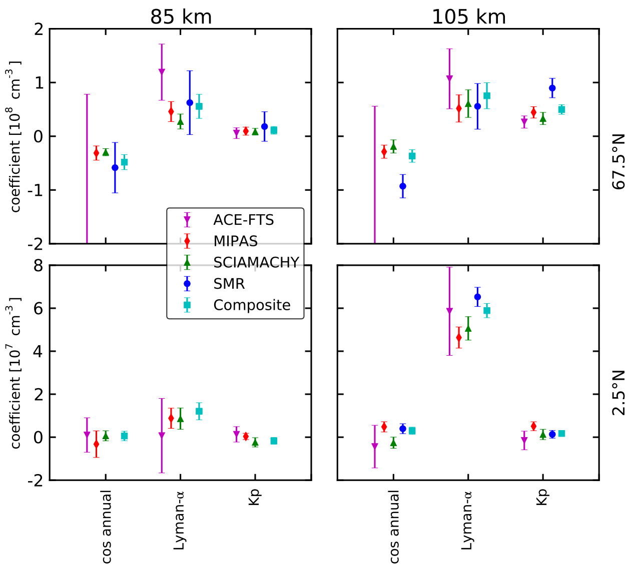

Figure 18: Direct comparison of the regression coefficients d_1, b, and c at two altitudes (85 km left column, 105 right column) and two latitudes (67.5°N upper row, 2.5°N lower row). The error bars indicate the 95% confidence interval of the coefficient calculated using the t-test.

the instruments' (page 12755, line 5) should be made more quantitatively and confirmed by /compared to model data, other measurements, etc., if possible.

The aim of this work is to compare daily zonal mean NO number densities from different instruments using different techniques on an overview scale. It is not intended as a full validation manuscript and adding more data or models to the comparison is beyond the scope of this paper. The attribution of the remaining differences has been weakened by re-phrasing the sentence in question, it now starts with:
"The remaining differences are most likely caused by the different MLT measurement schedules..."
in an updated version of the manuscript. To quantify the consistency, the following has been added to the fourth paragraph of the conclusions:
"Evaluating the residuals of the different data sets shows that the NO number densities are almost always consistent within ±30%. Single larger differences occur either at high southern latitudes (SCIAMACHY) or at altitudes close to the edge of the sensitivity range of the instrument (ACE-FTS), see Fig. 13."

Error bars in Figures 3-10: The figures are somewhat overloaded with datapoints and error bars. I suggest to plot error bars every 10th datapoint or so, only

The errors can vary substantially from data point to data point, and for Figs. 3–6 to be meaningful, we think that including all of them is justified. We have, however, removed Figs. 4 and 6 in the main text and only refer to the same figures in the appendix, also because Figs. 13 and 14 are more or less equivalent to Fig. 4.

Altitude range in Figure 7-10: ...should be reduced

The altitude range in the mentioned figures was chosen to leave room for the legend on top. If the reviewer insists on changing the scale, we will do so in an updated version of the manuscript.

Fig 11-14: I suggest to plot the mean of all datasets (versus time) into the lower panel of each plot and skip the upper panel.

One kind of useful mean of all data sets is the composite regression fit, but showing it without the data is not meaningful. We have changed the colour of the solid line for the composite fit in an updated version of the manuscript such that it is better distinguishable from the blue data points. Further, we extended the caption of Fig. 9 (Fig. 11 in the original manuscript) to end:
"The lower panel shows the individual residuals with respect to the composite fit."
Which should make clear what is shown in these figures.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 12735, 2014.