Answer to comments from Anonymous Referee #1: Validation of SCIAMACHY limb NO_2 profiles using solar occultation measurements by Ralf Bauer et al

January 9, 2012

About general comment #1

We can only agree to the conclusion, that one has to to be very careful with the yearly NO_2 global mean plots, as averaging over seasons results in potentially misleading or even erroneous results.

We followed the suggestion and created new scatter-plots, with four seasons and 3 altitude regions, see Figure 1. To avoid misunderstandings, the seasons are marked by their months (MAM = "March, April, May", i.e. spring in the Northern hemisphere). Instead of discrete altitudes, partial vertical columns are calculated to deemphasize fluctuations in single altitudes in some profiles and to counter influences from altitude changes in the NO_2 maximum - although this cannot be avoided completely. In the scatter plots, the latitude regions are color-coded.

In the revised version of the paper, the global mean plots are no longer useful and thus removed. Additionally, to give the reader an idea of the actual profile shapes for the validation efforts, averaged profiles are calculated for each latitudinal and seasonal bin, see Figure 2.

Since the data is now divided into new bins, the diurnal effect error correction has also been recalculated with interesting results, see Fig. 3. As suggested by referee #2, sunset and sunrise are now discussed more separately, which is especially important for SAGE II.

About general comment #2

Most of this is answered for general comment #1. The Southern Hemisphere is now also included in the results.

About general comment #3

This figure is not kept.

About general comment #4

Unfortunately, the referee did not provide any further information regarding the missing issues in our retrieval description. It is difficult to improve the retrieval description without this knowledge.

About general comment #5

This particular figure is now longer included. However, when standard deviations are mentioned, the new descriptions are now hopefully less confusing for the reader.

About general comment #6

Each reference in the text is screened and improved as necessary, to provide a better introduction to each figure.

About general comment #7

The manuscript is searched for these qualitative slogans and corrected.

Detailed comments

Each item not discussed here is just changed in the manuscript without further notice.

P4755, line 7/8 : N2O is the major source for stratospheric NO2, but this does not make it the major cause for ozone depletion ! The next sentence is (more) correct. However, the term ozone depleting gas should be replaced by the more commonly used ozone depleting substance.

ANSWER: The wording of that sentence might be misleading. The Montreal protocol does not cover all ozone depleting substances, and of those not covered N_2O is the most important. It is of course not the major cause of ozone depletion in the stratosphere. The sentence is changed to avoid further confusion.

P4757, line 28 : While not part of the NO2 retrieval ... : please motivate why the information about the SCODA cloud product is given here.

ANSWER: The sentence is now moved up one paragraph. The cloud product is included in the NO_2 data product and should be mentioned. However, mentioning the cloud product as part of the retrieval description is confusing, as it is not a part of the current NO_2 retrieval approach.

P4758, line 8 : ... spectral information from all spectral points ... : skip one spectral Same sentence: The data vector y ... makes use of a technique similar to DOAS. How can a data vector make use of a technique ? Please rephrase. And what is the difference to DOAS ?

ANSWER: The DOAS technique is now mentioned one sentence later. It is stated here, as the usage of a reference tangent height in the way described in the paper is best known from DOAS.

P4762, line 4: ... at high latitudes, it is about 3.0x10^9 molec/cm^{-3} at about 20 km altitude These values should be given more accurate: the peak is clearly above 20 km, the maximum value is approx. 2.8x10^9 molec/cm^{-3} Maybe more important: NO2 at high latitudes is strongly variable due to seasonal effects. The value given here may be correct for summer but not for the other seasons. Also, this example for 77.5°N can not be generalized, since number densities of NO2 vary strongly within the region of the high latitudes (60 to 90°) also for one season.

ANSWER: The generalization problem is difficult to avoid, as only a limited number of profiles can be analyzed in this level of detail. Even a limited selection (say, one profile for each season) would be an arbitrary choice, as the variability of NO_2 is too high. The most feasible way to deal with this problem seems to avoid generalization and to discuss a "high latitudes/ tropics example". An additional sentence now explains, that individual profiles can be quite different from these examples.

P 4763, line 11: ... near the measurement tangent heights. where are they ?

ANSWER: New version: "As expected, the spread profiles seen in panel (d) show the best vertical resolution near the measurement tangent heights, which are indicated as black horizontal lines at the righthand side of panel (c)."

P4771, line5: Thus, seasonal differences might dominate in these comparisons. No, it is vice versa. When you perform the comparison for one season then there are no seasonal differences for this comparison. Instead, when comparing the annual mean, then this value is dominated by the averaging out of the seasonal differences. So, this argument is not valid for excluding the results for the first half of year 2005.

ANSWER: This is true. Therefore, the argument is removed from the manuscript.

P4772, line 5: ... it worsens for the tropics in this case for all altitudes.

Please explain how this is possible. Does this indicate an error in the model for the diurnal effect error or its application on the comparison ? I think this point is very interesting and should be studied and explained. Also, remember that you are looking at seasonal means. Thus it is possible that the agreement for the mean gets worse, while the agreement for every season or every collocation in fact improves with the diurnal effect correction (compare the two examples

in the general comment) ! It seems it is not unlikely that this is what happens here, but without the full seasonal and latitudinal resolved comparison one can not say this surely. However, the possibility of such an effect shows, how dangerous conclusions based on the mean profile for all seasons can be !

ANSWER: This is certainly true. As a side effect of the new latitudinal and seasonal bins, the reason for this discrepancy is revealed in the new plots analyzing the diurnal effect error. In fact, the agreement is improved for the tropics, but only for sunset measurements (SAGE II). It is this discrepancy of SAGE II sunrise and sunset comparisons, that is the most important reason for the different results in the tropics and middle latitudes in the older figures, which are now replaced.

Suggestions regarding Figures:

Since the figures mentioned here are replaced, these suggestions can not be applied. However, we try to avoid the same problems in the new plots.

Suggestion regarding Abstract and Conclusion:

Conclusion and Abstract are partly rewritten as a consequence of these changes.

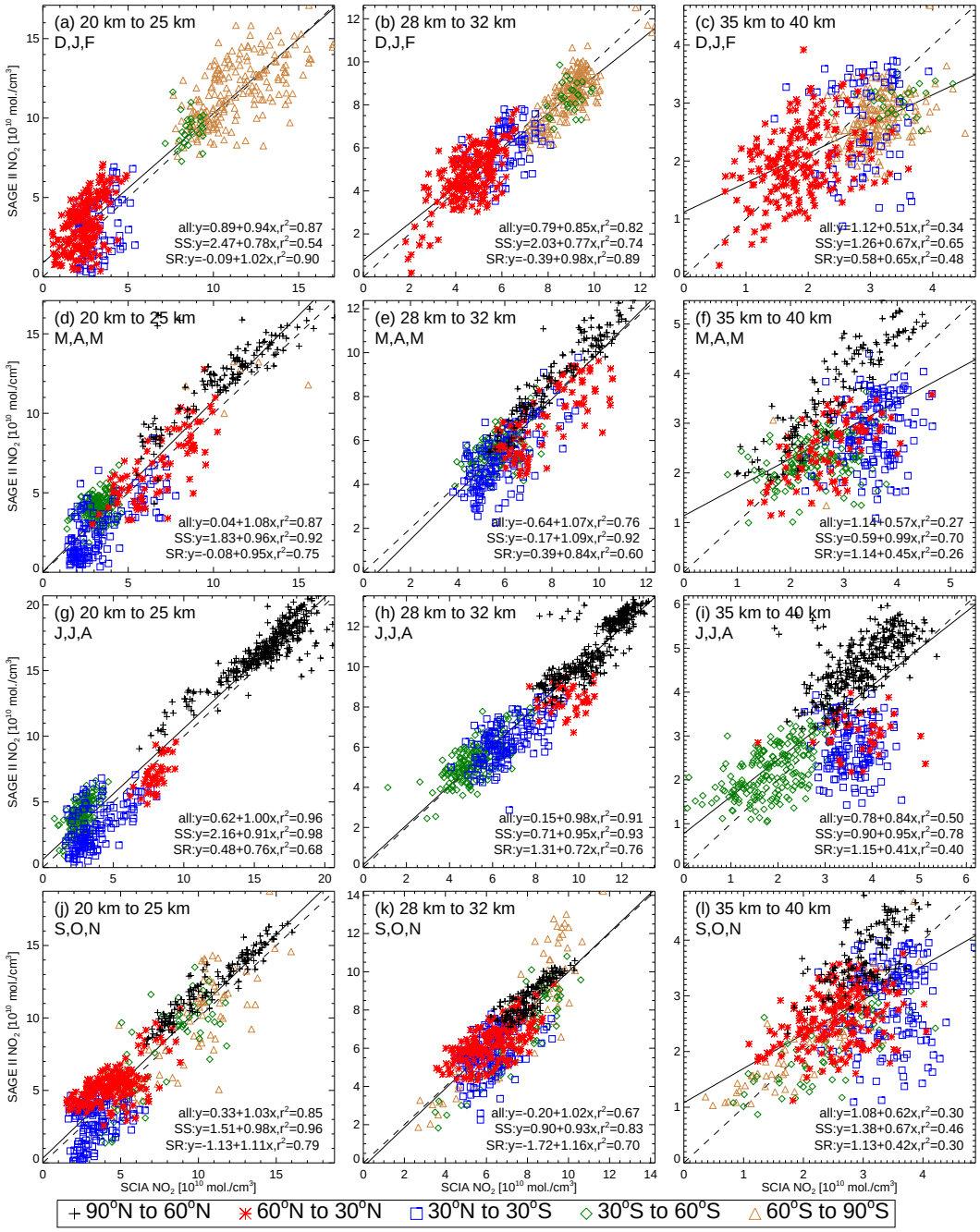

Figure 1: Scatterplots of collocated SCIAMACHY and photochemically corrected SAGE II NO_2 results for the years 2003 and 2004 are given for partial vertical columns and grouped in 4 seasonal and 3 altitude ranges (20 to 25 km, 28 to 32 km, and 35 to 40 km). In each panel, collocated pairs from different latitude regions are shown with different colors (black for 90°N to 60°N, red for 60°N to 30°N, blue for 30°N to 30°S, green for 30°S to 60°S, and brown for 60°S to 90°S).

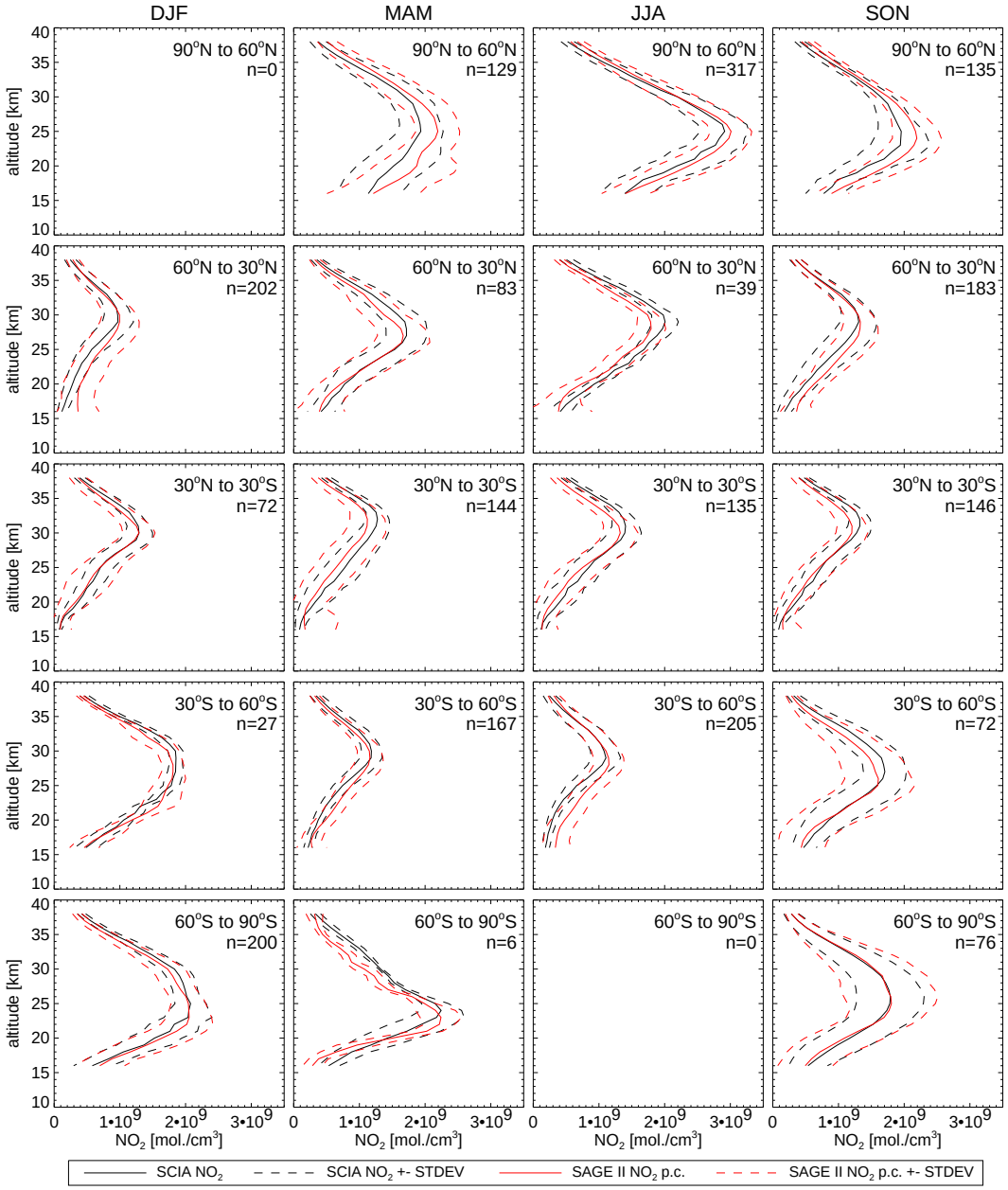

Figure 2: From the SCIAMACHY and SAGE II collocation pairs for 2003 and 2004, vertical NO_2 profiles are averaged for collocation subsets of different latitude ranges and seasons. The panels are ordered from top to bottom depending on latitude range, with northern latitudes on top. The panels are also ordered from left to right depending on season. In each panel, the NO_2 profiles are averaged for SCIAMACHY (black line) and photochemically corrected SAGE II NO_2 profiles (red). The standard deviations for both subsets are given as dashed lines in the respective color and added/subtracted from the averaged profiles.

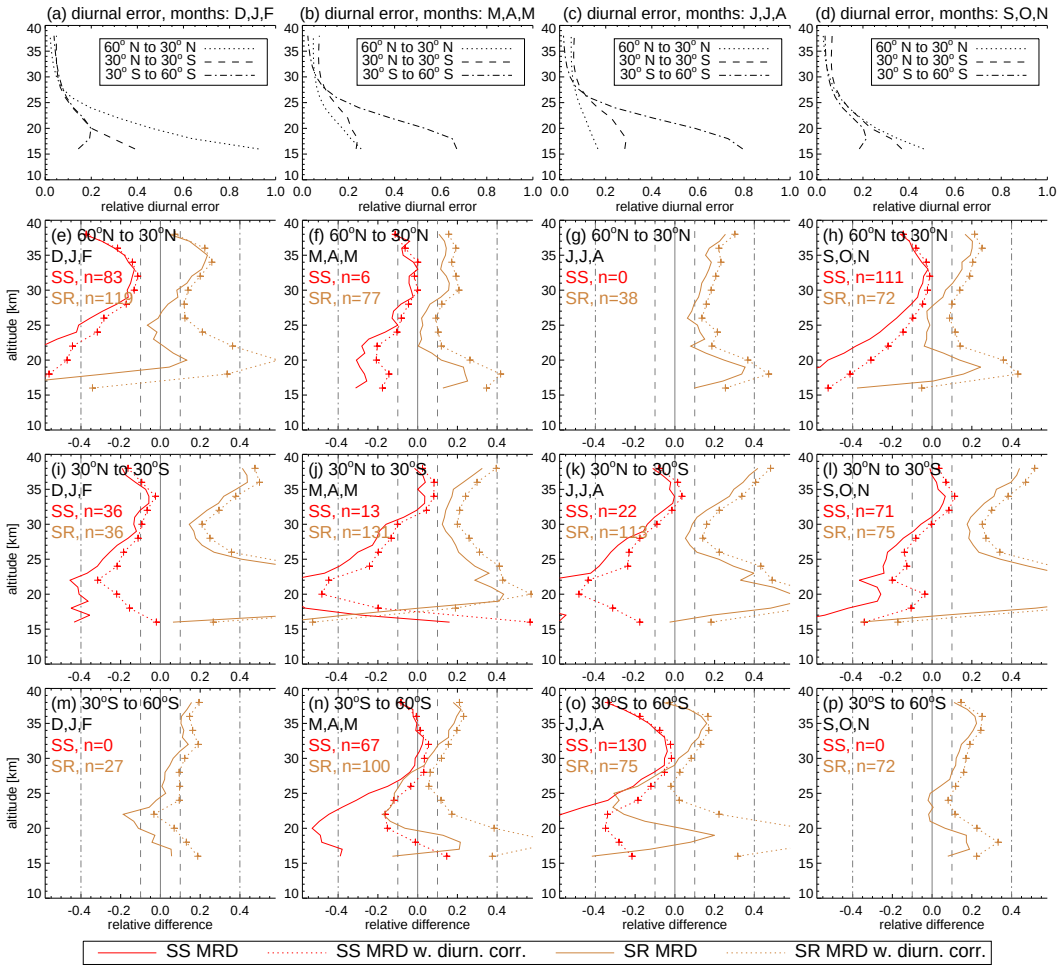

Figure 3: Panels **(a)** to **(c)**: Relative diurnal effect errors for the SAGE II profiles shown in Fig. 2. A model was used to estimate the diurnal effect error for each SAGE II occultation. These represent the mean errors over the latitude/seasonal bin. The influence of this error on the agreement between the SAGE II and SCIAMACHY is estimated in panels **(e)** to **(p)** for each latitude and season. MRDs with photochemical corrections and without diurnal scaling are displayed as red (sunset) and orange (sunrise) solid lines. MRDs with consideration of the diurnal effect are given as dashed lines with the same color-coding.