

***Interactive comment on “Retrieval of tropospheric
NO₂ columns from SCIAMACHY combining
measurements from limb and nadir geometries”
by A. Hilboll et al.***

Anonymous Referee #3

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***** General Comments *****

The authors have described their method for using limb measurements of NO₂ from SCIAMACHY to estimate the stratospheric column at the location of SCIAMACHY nadir pixels. They compare these columns with those obtained directly from nadir measurements, and with stratospheric NO₂ columns estimated by the reference sector method as well as the Oslo CTM2 model.

This study is valuable because, as the authors state, the SCIAMACHY limb data provide more detailed information about global stratospheric NO₂ than any other type

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of measurement. The method described here for spatially interpolating these data to use with nadir measurements seems reasonable, and the comparisons with nadir and model columns are useful and informative. My main concerns involve the descriptions of the method for dealing with the tropospheric contribution to the nadir columns. A related issue is the description of the matching (via additive offsets) of the different column types.

In most cases, the modifications needed are clarifications of the methods, but some sections will require more substantial rewriting. A minor criticism is that some editing for language/grammar is also needed.

When these concerns are addressed, I feel the manuscript can be a valuable publication in AMT and a useful contribution to the field of satellite NO₂ retrievals.

***** Specific Comments *****

(1) The title of the paper is misleading, since the retrievals, comparisons, figures and discussions involve mainly stratospheric NO₂. I suggest modifying it to better reflect the scope of this study.

(2) In general, I found the nadir-limb-CTM2 comparisons in the paper somewhat confusing, since the nadir measurements contain tropospheric NO₂, but limb and CTM2 do not. When the limb and CTM2 columns are corrected by an additive offset to match the nadir columns over the Pacific, they are effectively contaminated by the small amount of trop NO₂ in that region. At that point, they are no longer purely stratospheric estimates. (From my reading of the manuscript, it seems the Pacific background correction described in section 2.3.5 has not been applied in most of the figures.)

The zonal plots of stratospheric VCD (Figures 9 to 13) would be easier to interpret if the authors provided an estimate of the magnitude of the tropospheric contamination in the Pacific and showed it in the zonal plots if possible. The amount should be SCDtrop/AMFstrat (which is not the amount shown in Fig. 20). Is this contamination

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ever comparable to the differences shown between limb, nadir and CTM?

(3) Equations would be very helpful to show explicitly how/where the various corrections and offsets are added the column amounts.

(4) In section 2.1, the authors say their method has an advantage over that of Beirle et al [2010], since it does not require averaging several days of stratospheric measurements. However, the figures here show only monthly mean results, and the methods for dealing with NO₂ over the Pacific seem appropriate only for multi-day averages.

Specifically, the tropospheric AMFs used to correct for the small Pacific background are monthly means, as stated in 2.3.5. For daily retrievals, cloud amounts can significantly affect the visibility of trop NO₂. Also, in the reference sector method (2.3.6), the very narrow (0.125 deg) latitude bands could exacerbate errors and create latitude-dependent noise in the stratospheric estimate unless multi-day averaging is done.

These effects might well be small, but please add some comments on these retrieval-parameter choices and the size of the potential errors they could introduce. This might be done by referring to section 3.5.3 and adding some words there.

I also recommend addition of a figure showing stratospheric and tropospheric retrievals for a single day. This would help demonstrate the effectiveness of the limb-nadir interpolation procedure presented in this study.

(5) Regarding the discussion of Figure 6 in section 3.2.2, why would the smaller nadir SCDs (relative to limb) in the tropics be the result of upper-tropospheric lightning or biomass-burning NO₂? The AMF in the upper troposphere is similar to that in the stratosphere, so wouldn't the resulting contributions of upper trop NO₂ to nadir and limb SCDs be similar?

(6) In the final paragraph of section 3.5.3 (page 21), the authors correctly state that tropospheric AMFs are larger in cleaner regions than in polluted ones. But the error contribution to the stratospheric correction depends on the magnitude and uncertainty

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in the tropospheric slant column. Because of the small NO₂ amounts in clean regions, this uncertainty is likely to be smaller than in polluted regions, regardless of the AMF (an exception would be totally cloudy scenes, where low clouds could completely mask boundary layer pollution, but enhance the visibility of trop NO₂ in clean regions). I suggest some rewording of this paragraph.

***** Technical Corrections *****

Although the meaning of the text is generally understandable throughout the manuscript, there are several instances of awkward grammar and cases where rewording would make the meaning clearer. A few examples are given below, but I recommend additional editing by a native English speaker.

1. Page 3 Line 58: "...necessitates additional information..."

2. Page 4 Line 117-118: "...the total nadir slant columns are calculated using the DOAS procedure."

3. Page 5 Line 129: "...the stratospheric NO₂ profiles must be extrapolated down to the tropopause when the tropopause is below 11 km." Line 150: "...the limb stratospheric slant columns are matched to the SCD_{tot} from nadir measurements over clean (unpolluted) regions."

4. Page 6 Line 186: "Where measurements are not available, model simulations are used to obtain atmospheric quantities needed in the analysis."

5. Page 7 Line 227: "...by linearly interpolating along track in latitude, that is along each limb state i."

6. Page 8 Line 231: "...we consider the stratospheric NO₂ column to be a function of the line of sight (azimuth angle)..."

7. Page 9 Line 274-275: "By applying the aforementioned offset to the retrieved limb SCD_{strat}, we have incorrectly assumed that there is no significant tropospheric NO₂ in

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the reference sector."

8. Page 11 Lines 338-339: "The months November to March are an exception to this pattern..."

9. Page 12 Lines 363-364: "...ocean regions might often be devoid of tropospheric NO₂..."

10. Page 13 Lines 443-444: "...modulated by lee waves..."

11. Page 15 Lines 468-469: "As seen in Fig. 13, the VCD_{strat} between 90 deg and 130 deg W estimated from nadir measurements are lower than those from limb measurements and model simulations..."

12. Page 16 Line 525: "As seen in Fig. 17,..."

13. Page 17 Lines 562-563: "...independently of the method used to correct the stratosphere."

14. Page 19 Lines 608-609: "...fitting procedure, including errors in the estimation..."
Also, please clarify what is meant by "water leaving radiance".

15. Page 21 Lines 702-703: "However, neither the limb measurements nor the modeled columns can be applied as an absolute correction."

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 5043, 2012.