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Atmospheric Measurement Techniques Discussions

Interactive comment on "Nitrogen dioxide stratospheric column at the subtropical NDACC station of Izaña from DOAS, FTIR and satellite instrumentation" *by* Cristina Robles-Gonzalez et al.

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Interactive comment on "Nitrogen dioxide stratospheric column at the subtropical NDACC station of Izaña from DOAS, FTIR and satellite instrumentation" by Cristina Robles-Gonzalez et al. Anonymous Referee #1 Received and published: 10 May 2016

The author's reply does not address my initial concern regarding the effective SZA correction: - The proposed ESZA correction is meritorious for species with relatively short photochemical lifetimes, NO2 in particular. Considering the sensitivity of the issue (e.g., about 30% NO2 changes between SZA=90 and SZA=86.8 cases around

the winter solstice), there is a lack of detail about the ESZA evaluation. Using some overly simplistic assumptions, one may arrive at EZSA of about 85 instead of the used ESZA=86.8. Unless all the underlying details and assumptions are explicitly mentioned by the authors, it is impossible to judge validity of the approach. - The same applies to the effective (projected) DOAS pathway used in the DOAS satellite collocations. Why the authors arrive at the 300 km estimate instead of, e.g., about 360 km (again, using, for a sake of argument, overly simplistic, purely geometric assumptions and ESZA=86.8)? Is there some optical-pathway weighting applied by the authors? [There should be some.] Please provide more details.

The selection of a single point as representative of the layer is a simplification since that "effective point" changes with the sza, the day of the year and the dynamics (through vertical displacement of the layer). We have made use of the Lambert-99 climatology for the latitude based on HALOEv19 and POAM-II data to establish the height of the bulk of the layer, or more precisely, the effective height as the mean height weighted by the NO2 concentration using a annual mean profile. In the Northern Subtropical region the "effective height" does not vary much and so the "effective sza", either. In figure 2c the effect of the height assumption on the effective sza is shown. A change of 5 km in height of the bulk of the layer (25km to 30 km) at sza 90° over the station makes the "effective sza" to change from 86.4° to 87.2°. (We don't see how the reviewer arrives to 85°). The error due to such a change would be $\pm$ 0.4°, that means 1.4-1.5% in the column, depending on the season.

The same applies for the scanned airmass projection. Following our "best geometric estimation" for the NO2 distribution over the station, we reach to approximately 300 km radius. Whether it is 300 or 360 km has a negligible meaning for the purpose of the work, in a Subtropical station. We have, nevertheless computed such a difference providing that it is expected some NO2 column increase around the archipelago due to human activities than in the areas outside their influence.

We will clarify this issue by changing the text in the manuscript ". Line 245. "As the stratospheric NO2 layer is centered at about 25-30 km height (orange layer in figure 2a),. . .”

Line 270. “To compute it, the mean height of the NO2 layer weighted by the concentration in a mean NO2 profile has been used. The mean vertical distribution above 17 km was obtained by annual averaging of mean morning profiles from the HALOE and POAM-II data (Lambert 1999) whereas for lower latitudes the output of the SLIMCAT boxmodel was used (Denis et al., 2005). No tropospheric NO2 has been considered. In the Northern Subtropical region the “effective height” does not vary much and so the “effective sza”, either. In figure 2c the effect of the height assumption on the effective sza is shown. A change of 5 km in height of the bulk of the layer (25km to 30 km) at sza 90° over the station makes the “effective sza” to change from 86.4° to 87.2°. The error due to such a change would be ± 0.4°, which means 1.4-1.5% in the column, depending on the season. We estimate this error as the upper limit.

Ref: Denis, L., Roscoe, H. K., Chipperfield, M. P., Van Roozendael, M., and Goutail, F.: A new software suite for NO2 vertical profile retrieval from ground-based zenith-sky spectrometers’, J. Quant. Spectrosc. Ra., 92, 321–333, 2005

Additional remarks: - Figure 4, bottom-left panel: Why the DOAS-FTIR SZA=90 difference is negative? I see a positive shift in the upper-left panel. Two panels contradict each other. Now, going to Table 2, I also see the negative SZA=90 DOAS-FTIR shift. The negative sign also quoted in the text (Section 7) and reconfirmed in Figure 6. This contradiction must be resolved. What FTIR and DOAS data are used in the plot and the stats (Table 2)? AM? PM? Both?

We thanks the reviewer for noticing the mistake. There was a wrong sign in the plot in both the DOAS and the FTIR data. Only AM data were used here.

- Please clarify the AM/PM split in the FTIR data (Fig. 5). Is this related to how the FTIR data are referenced to the either DOAS-AM or DOAS-PM observations? Or you really subdivide the FTIR records into the AM and PM parts? If the latter is true, then

Fig. 6 should have two FTIR points. So does Table 3. Please be explicit in description of the data sets in Table 3: e.g., does the OMI-DOAS mean OMI-DOAS(AM), or OMIDOAS(PM), or something else?

For the comparison of the DOAS-FTIR data records are subdivided into the AM and PM values while OMI-DOAS and SCIA-DOAS are refereed only to the DOAS AM data. The data values used in Figure 4 for the comparison of DOAS and FTIR are only AM data. This issue will be clarify in the text, in line 290 we will changed the text by this one: “In our work the stratospheric NO2 from FTIR AM data, SCIAMACHY and OMI instruments has been photochemically corrected to the DOAS AM measurement time while FTIR PM data has been corrected to the DOAS PM using the BIRA-IASB (Belgian Institute for Space Aeronomy). . .” And in line 306 we will replace the sentence “Figure 4 displays the cross-correlation of FTIR, SCIAMACHY and OMI data” with this one “Figure 4 displays the cross-correlation of FTIR (AM data), SCIAMACHY and OMI data”

- The caption of Figure 10 mentions two panels, (a) and (b). I see only one. The part (b) has been eliminated.

The comments about panel (b) has been eliminated.

- Lines 400-405. The more pronounced NO2 trends seen in the DOAS observations are ascribed to the relatively higher DOAS sensitivity to the lower-stratospheric NO2 concentrations. How does this questionable conclusion come along with the factor-of three lower changes detected by SCIAMACHY and OMI, despite their comparatively high strat-trop sensitivity (cf. the DOAS and satellite AVKs in Fig.1)? It seems, in this respect the DOAS observations are the only outstanding category, since both FTIR and satellites deliver comparable results, despite their different sensitivity to various stratospheric NO2 layers.

We accept the reviewer comment on the explanation provided in the manuscript. At the moment we have no solid explanation for the large differences in trends between DOAS and FTIR, SCIA and GOME and as a consequence the following paragraph starting in line 605 will be removed from the manuscript: Figure 11 shows the ratio of sensitivities in the stratosphere between DOAS and FTIR, weighted by the concentration at each height. It is found that DOAS sensitivity is higher than FTIR in the lower stratosphere (below 28 km) whereas the opposite is true above that region. Larger trends in DOAS mean that the increase takes place in the layer in which NOx is dynamically controlled, also playing in favor of the above mentioned explanation.

We would like to mention, however, that NO2 trends observed by DOAS are very similar to NOy trends measured by MIPAS, and also calculated by the WCAAM model (+8.5%/decade, and over 20%/decade at 25 km). These trends have been shown in meetings but not yet published in a peer review paper (Funke et al., 2015). The trend section will be object of a future dedicated paper. Ref: Funke, B., Lopez-Puertas, M., Stiller, G., von Clarmann, T. and Gacia, R.: Stratospheric NOy: global budget and vaiability in 2002-2012 from MIPAS observations, in Regional SPARC workshop, Granada, Spain

Funke, B. Stratospheric NOy: Global budget and variability in 2002-2012 from MIPAS observations, 26th IUGG General Assembly 2015, June 22-July 2, 2015, Prague, Czech Republic, Symp. 14 (Middle Atmosphere Science), available at http://www.czech-in.org/cmdownload/IUGG2015/presentations/IUGG-1701.pdf.

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