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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Retrieval of nitrogen dioxide stratospheric profiles from ground-based zenith-sky UV-visible observations: validation of the technique through correlative comparisons" *by* F. Hendrick et al.

F. Hendrick et al.

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We would like to thank Anonymous Referee #2 for his/her helpful comments and suggestions.

Referee comment: From the title I was expecting that profiles retrieved from GB slant columns were to be validated by balloons and satellites measurements but when reading the manuscript, it is unclear who is validating who.

Reply: We fully agree. We have corrected the whole manuscript including the abstract taking this comment into account. Also, the relative differences between GB profile retrievals and correlative data are now calculated as (GB-correlative)/correlative instead

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of (correlative-GB)/GB.

Referee comment: When discrepancies are found between satellite and GB, the authors attribute the differences to limitation in the solar occultation technique below 25 km but they don't provide any explanation on the causes. Even though that could be the case, a description of the possible satellite limitations would help to support the statement.

Reply: Since a good agreement has been found in the 20-30 km range with balloon measurements, we think that the discrepancies between satellite and GB below 25 km would be more likely due to a limitation of both satellite solar occultation instruments at these low altitude levels. The possible error sources on the HALOE and POAM III data are described in detail in Gordley et al. (1996) and Randall et al. (2002). A source of systematic error is the strong variations of NO2 along a solar occultation measurement line of sight. Neglecting a correction for the line of sight variations can result in a systematic overestimation in NO2 below 25 km. According to Randall et al. (2002) and Newchurch et al. (1996), this overestimation is ˜20% at 20 km whereas Roscoe and Pyle (1987) estimate it to maximum 1% for the conditions of the present comparisons. The uncertainty on the diurnal effect correction is therefore very large, mainly because this correction strongly depends on the photochemical model used for calculating it. Nevertheless, the absence of such a correction in the POAM III retrievals could at least partly explain the large discrepancies systematically observed between the GB profile retrievals and POAM III below 25 km since this explanation is consistent with the significantly better agreement observed with HALOE - which includes a correction for the diurnal effect - than with POAM III in sunset spring and summer conditions. The comparison of the relative differences in these conditions (below 20% for HALOE and comprised between 20% and 40% for POAM III) suggests that the magnitude of the diurnal effect correction could reach at least 10%. This effect could also play a significant role in the difference observed between sunrise and sunset in the agreement between GB retrievals and HALOE data (larger discrepancies at sunrise than at sunset) since

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the uncertainty on it can be 2 to 3 times larger at sunrise than at sunset (Gordley et al., 1996). More investigations - which are beyond the scope of the present study - are required to go one step further in the determination of the exact impact of this error source as well as others (e.g., the errors due to interfering absorbers and uncertainties on spectral parameters) on the agreement between GB retrievals and satellite instruments.

Referee comment: Figures 6 to 8 and comparison sections. There must be a problem with smoothing (SAOZ, DOAS, POAM III) since smoothed profiles do not match the unsmoothed ones. The discrepancy is particularly obvious in Fig 6 Harestua 13.8.98 and the top of Andoya 27.3.03 but it can be seen in all plots. This has an obvious implication in the degree of agreement (tables 1 and 2) that should be modified when corrected.

Reply: The correlative profiles cover a limited altitude range (e.g., 13-29 km for the SAOZ balloon) but according to the smoothing method, they have to be extended over the same altitude grid as the averaging kernels. For all the results presented in the manuscript, the correlative profiles have been completed below and above their covered altitude range by the a priori profile. As noted by Dr H. K. Roscoe and Referee #2, this is unsatisfactory because the smoothed correlative profiles are biased downwards since the a priori profiles are generally less than the correlative profiles, which makes the comparison with ground-based data look better than it should be. In the revised version of the manuscript, the correlative profiles are completed below and above their covered altitude range by the a priori profile scaled by the ratios between the correlative and a priori profiles at the lower and upper altitude limits of the correlative profile, respectively; e.g., a SAOZ balloon profile is completed below 13 km by the a priori profile scaled by the ratio between the SAOZ balloon and a priori profiles at 13 km, and above 29 km by the a priori profile scaled by the ratio of the SAOZ balloon and a priori profiles at 29 km. This scaling avoids the presence of large discontinuities at the lower and upper limits of the original altitude range of the correlative profile and

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results in higher smoothed correlative profiles than previously, especially for the SAOZ balloon profiles. Due to these changes, all the Figures and Tables are updated in the revised manuscript. The scaling also generally improves the agreement between smoothed and unsmoothed correlative profiles. However, low biases in the smoothed correlative profiles can still be observed as in Figure 6 for the Harestua 13.8.98 and Andoya 27.3.03 cases at low and high altitudes, respectively. The fact that the smoothed profile does not match the unsmoothed one is inherent to the smoothing method and observational technique used: the information content retrieved from the GB UV-visible measurements becoming significantly lower below 20km and above 30km, the second term of the Eq. 9 (p2880) is smaller at these altitudes due to the low values of the corresponding elements in the A matrix, resulting in an increase of the weight of the a priori profile in the smoothed correlative profile. This behaviour can be amplified in some cases, e.g. when the SZA sampling of the measurements is not optimal (low SZA upper limit and/or large SZA intervals above 90° SZA).

Referee comment: Page 2886, Lines 1 to 20. It is mentioned in the text that according to Gordley et al 1996, orbital instruments yield lower columns than GB since there is a layer below 80 hPa not seen by the occultation technique spectrometers. The authors claim this is in agreement with their results, but according to figure 12, HALOE smoothed profiles yield larger, not lower, values than GB ones. The magnitude of the differences are about the same but of opposite sign.

Reply: We have performed comparisons as Gordley et al. (1996) (comparison between GB total and HALOE partial columns) in addition to the comparisons shown in the manuscript (comparisons between GB and HALOE partial columns calculated in the same altitude range). The results of these additional comparisons are not shown in the manuscript because we found that comparing columns calculated using different altitude ranges is not appropriate. We just mentioned them to tell that results consistent with those of Gordley et al. (1996) can be obtained if we use their method of comparison. To avoid any confusion, we have rephrased this part.

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Referee comment: Page 2872. Noxon, 1975.

Reply: The error appears on page 2871. We have corrected this.

Referee comment: There is something wrong with the section numbering: Page 2872 line 25. Section 3.2 does not exist. Page 2876, line 9 Sec. 5.4 does not exist (is section 11 in the manuscript), etc.

Reply: The numbering of the sections and subsections has been modified during the production process at the EGU Office and we did not detect the changes when we proofread the manuscript. So the right Sections numbering is the following: Section 3.2 instead of Section 4; Section 4 instead of Section 5; Section 4.1 instead of Section 5.1; Section 4.2 instead of Section 6; Section 5 instead of Section 7; Section 5.1 instead of Section 8; Section 5.2 instead of Section 9; Section 5.3 instead of Section 10; Section 5.4 instead of Section 11; Section 6 instead of Section 12.

Referee comment: Page 2882. line 22. 'A good agreement is observed since both instruments' is somewhat misunderstanding. It would be better to say '... between balloon and GB profile inversion', since the profile obtained from slant GB are not direct measurements and a model and the a priori play a role.

Reply: 'Ĕ. since both instrumentsĔ' is replaced by 'Ĕsince balloon and GB profile inversionĔ'

Referee comment: Page 2883. line 8. <decreases> instead of <increases>

Reply: We have corrected this.

Referee comment: Page 2883. lines 21-23. The sentence introducing the figure 9, is not enough clear. The authors intend to show that the differences are seasonal dependent but they don't mention it until later in the manuscript. Explanation of the reason why the fig. 9 is introduced would clarify.

Reply: Figure 9, which shows comparisons of mean profiles, is introduced in order to

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illustrate that the underestimation of the POAM III data by the GB retrievals is not only observed is some particular cases but is a systematic behaviour. Averages for spring and summer conditions have been plotted separately because of the difference in the polar vortex conditions between both seasons at Harestua (possible presence and absence of the polar vortex in spring and summer, respectively). However, a seasonal dependence is not present since the magnitude of the underestimation below 25 km is similar in both spring and summer.

Referee comment: Page 2884, lines 10-14 and figure 10. From figure 10 it cannot be concluded that there is a seasonal dependence. In 1998 there are no data in spring. In 1999 relative differences are of the same order in spring and summer.

Reply: We agree with Referee #2 that it cannot be concluded that there is a seasonal dependence. Therefore, this point is cancelled.

Referee comment: It is hard to see (at least in my printing from the pdf file) all light gray lines: Fig. 1. Curve NO2 natural variability Fig. 2. Curve 5 km. Fig. 9. Right plot. Summer curve. Fig. 11. right plots. Sunset curves.

Reply: To avoid any confusion, the grey lines are replaced either by black dashed lines, or either by color lines, depending on the Figures.

References

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Interactive comment on Atmos. Chem. Phys. Discuss., 4, 2867, 2004.