

Response to anonymous reviewer #1 (C2185)

Andreas Hilboll et al.

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We thank the anonymous referee #1 for the valuable comments.

A paragraph should be added that summarizes the limb retrievals of NO₂. The complexity of these retrievals needs to be conveyed to the reader.

To include this information, Section 2.1.2 has been rewritten in the revised manuscript.

It was surprising to see no mention of the Network for the Detection of Atmospheric Composition Change (NDACC) or solar occultation measurements as a means to understand differences between the Oslo CTM2 and SCIAMACHY. Often differences between SCIAMACHY and the CTM were attributed to errors in the CTM because they disagreed with SCIAMACHY (for example in the discussion of the slope of F7). Errors in the SCIAMACHY retrieval could also be responsible. A validation dataset is needed to correctly attribute these differences. This is already a lengthy manuscript. It is understandable that there is insufficient space to introduce a third dataset for comparison. But then the attribution of differences to errors in the CTM should be softened. It would be more accurate to simply state that differences exist.

We agree that comparison with an independent, third dataset would be interesting to further investigate possible reasons for individual differences between model simulations and SCIAMACHY measurements. This would, however, be better suited in a comparison study of the different available stratospheric NO₂ data products. Direct comparison between NDACC and SCIAMACHY measurements is not straight forward, as photochemical corrections are needed which introduces additional complexity (Dirksen et al., 2011).

To express the uncertainty of which stratospheric NO₂ dataset better represents the atmosphere's true state, we have softened the attributions of the errors in several places to simply state that differences between the two datasets do exist.

Many of the differences in F8 follow the pattern of surface reflectance. SCIAMACHY NO₂ tends to exceed that in the Oslo CTM2 over bright surfaces, e.g. snow covered regions in Feb, deserts in July. Could errors in the SCIAMACHY NO₂ retrieval be responsible?

The effect of clouds lower than 10 km on the limb retrieval is basically comparable to an enhanced surface reflectivity, as both effects lead to an increased number of upwelling photons which might get scattered into the instrument's direction. Bauer et al. (2012) have investigated the influence of clouds on the limb retrieval. They show their results in Figs. 5-7. While the relative impact of clouds on the retrieved number concentrations can be as large as 10% for low clouds (pink curves), this is only in altitude regions where absolute NO₂ concentrations are so low that this comparably large relative error does not significantly impact retrieved stratospheric column densities. We therefore conclude that the influence of the surface reflectivity on the limb retrieval is negligibly small. The impact of surface reflectance on the sensitivity of nadir measurements is very small ($< 2\%$) for purely stratospheric profiles and can therefore also be neglected. There could in principle also be a systematic error in SCIAMACHY measurements over bright surfaces from calibration issues, but we do not have any indication that this is actually the case.

References

- Bauer, R., Rozanov, A., McLinden, C. A., Gordley, L. L., Lotz, W., Russell III, J. M., Walker, K. A., Zawodny, J. M., Ladstätter-Weissenmayer, A., Bovensmann, H., and Burrows, J. P.: Validation of SCIAMACHY limb NO₂ profiles using solar occultation measurements, *Atmos. Meas. Tech.*, 5, 1059–1084, doi:10.5194/amt-5-1059-2012, 2012.
- Dirksen, R. J., Boersma, K. F., Eskes, H. J., Ionov, D. V., Bucsela, E. J., Levelt, P. F., and Kelder, H. M.: Evaluation of stratospheric NO₂ retrieved from the ozone monitoring instrument: intercomparison, diurnal cycle, and trending, *J. Geophys. Res.*, 116, D08305, doi:10.1029/2010JD014943, 2011.