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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of tropospheric column densities of NO_2 from combined SCIAMACHY nadir/limb measurements" *by* S. Beirle et al.

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We thank the reviewer for his/her positive feedback and constructive comments. Below we respond to the specific/technical comments point-by-point.

Specific Comments

1. For given latitude, the RLC scheme basically takes the differences between limbmeasured stratospheric columns around the world and limb-measured columns in the RS and adds those differences to nadir-measured stratospheric columns in the RS. This introduces longitudinal variation into the RSM while eliminating any additive biases between the nadir- and limb-type

measurements. Using only limb-measured columns (the ALC method) would not eliminate biases, as the authors show. However, they have not shown why these biases are necessarily additive (the effect of an error in tropopause height on limb columns – an additive bias – is negligible). For a multiplicative bias (e.g. limb columns at a given latitude might be systematically 20% larger than nadir columns), the ratios (not differences) of limb-measured columns should be multiplied by (not added to) nadir columns in the RS.
The assumption of multiplicative rather additive errors might not make much difference in the final results, but I think the authors should explore this possibility, or at least be explicit about their assumptions and why they chose to make them.

Reply: We agree that the aspect of possible multiplicative biasses should be discussed in the manuscript. We thus added a paragraph on this issue to the discussions.
The RSM is per definition an additive correction: The RS VCDs are subtracted from the observed VCDs, thereby removing the stratosphere and possible additive biases (like spectral structures caused by the diffusor plates, affecting the NO2 SCD; such an additive bias in SCDs is also additive in VCDs for a given AMF, i.e. approx. additive for a given latitude). In analogy, we applied an additive RSM also to the limb data to define the LLV (see eq. 5), and use this LLV to define the RLC (eq. 6). In our point of view, this is the most simple and straightforward approach.
The reviewer is right in saying that a possible systematic multiplicative bias of limb or nadir measurements would have to be corrected with a kind of multiplicative RLC. At the moment, we can only speculate about reasons for the deviations of nadir and limb VCDs over the RS, wich makes the ALC inappropriate (see p. 3003-3004). We thus cannot decide, from a theoretical point of view, whether an additive or a multiplicative approach is advisable (probably a combination of both).
However, as long as the absolute values of nadir- and limb VCDs are of the same order of magnitude, both approaches give similar results. Since the deviations of V^*_{RS} and L_{RS} are less than 10% for high latitudes (see Fig. 3 and Fig. S10 in the supplements), the effect of a multpiplicative bias approach on LLV is small. On the other hand, for low latitudes, where deviations V^*_{RS} and L_{RS} can be up to 50% (Fig. S10 in the supplements,

July), the LLV itself is small (<2e14 molec/cm2 for LLV).

2. On p. 3004, it is stated that no correlation was found between clouds and TSCDs over the reference sector. Is this based only on an average over all latitudes in January? For example, I have seen statistical evidence presented of enhanced total slant column NO2 near convective clouds in the tropics.

Reply: The mentioned correlation coefficient of R=-0.01 refers to the correlation of all TSCDs in the RS with the respective cloud fraction on 28 January, 2006. We checked also for correlations for the other days presented in the supplements and found values of R close to 0 in all cases. We conclude that our fitted NO2 SCDs do not suffer from spectral interference with clouds. This is not necessarily a contradiction to other studies reporting on correlations for specific subsets (like high clouds for tropical latitudes) over long time-periods. However, from our experience with modifying fit parameters, we found that correlations of SCDs with clouds might be fit artefacts due to spectral interferences of NO2 cross-sections with Ring effect, spectral ground albedo, or polarization.

3. Referring to the TRSM and TRLC tropospheres as "relative" and the TALC troposphere as "absolute" is somewhat confusing, for example on page 2997 lines 12-14 just before Sec. 2.6. Actually all three are relative to some assumed stratosphere. It's just that in the TRSM and TRLC cases, you believe the assumed stratosphere might contain a small amount of tropospheric contamination (as explained on page 3006, lines 11-17). If that is what you mean, maybe this should be clarified.

Reply: We skip p. 2997, lines 12-14, and instead extend the discussion of tropospheric excess columns (T_{RSM} and T_{RLC}), in contrast to tropospheric columns from T_{ALC}, on p. 3006, lines 11ff., to avoid misunderstandings.

Technical Corrections

The list below contains a few suggestions for improving grammar, etc. I think the paper would

benefit from a thorough overview by a copy editor (although it is certainly understandable as is).

Reply: We thank the reviewer for the detailed suggestions for improving English grammar. In addition, we will have an additional proof-reading of the manuscript, hoping to improve the overall level of English.

1. In the Abstract: Line 2: "As the only instrument of its kind,..." Line 13-14: "Thus a relative limb correction scheme was also defined,..."

Reply: Done.

2. Page 2985: Line 10: "...numerous scientific applications in recent years..."

Reply: Done.

3. Page 2986: Line 17: "...CDs are not independent..."

Reply: Done.

4. Page 2987: Line 17: "The viewing geometry alternates between nadir and limb..."

Reply: Done.

5. Page 2989: Line 2: "...as well as systematic errors..." Line 17-18: "...geometries, including nadir, limb and solar/lunar occultation"

Reply: Done.

6. Page 2990: Line 21-22: "...related to this study in that large parts of the chosen..." Line 26: "...measurements from the descending part of the orbit..."

Reply: Done.

7. Page 2991: Line 22: "...due to the viewing geometry and narrow vertical resolution..."(?)

Reply: We changed the respective sentence to "...due to the limb viewing geometry and the narrow field of view..."

Line 25-26: "...retrieval are on the order of several percent in the upper ..."

Reply: We changed the respective sentence to "... are on the order of a few percent."

8. Page 2992: Line 12: Please define "LZA" (look zenith angle?)

Reply: The meaning of LZA (Line-of-sight Zenith Angle) is added.

9. Page 2996: Line 12: "With any of these estimates of W (i.e. WRSM, WALC, WRLC) ..."

Reply: Done.

10.Page 2998: Line 8-9: "...can be derived, mainly in cases of strong temporal..." Line 18-19: "...where the shortcomings of RSM become particularly evident."

Reply: Done.

11.Page 3000: Line 25-26: "...in contrast to..."

Reply: Done.

12.Page 3001: Line 19: "...sometimes reduced, rather than completely eliminated the..."

Reply: Done.

13.Page 3007: Line 2: "This also affects studies on relative..." Line 24: "...and suggest using this scheme..."

Reply: Done.

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 2983, 2009.