Atmos. Meas. Tech. Discuss., 6, C3568–C3573, 2013
www.atmos-meas-tech-discuss.net/6/C3568/2013/

Atmospheric Measurement Techniques
Discussions

Interactive comment on "Tropospheric column amount of ozone retrieved from SCIAMACHY limb-nadir-matching observations" *by* F. Ebojie et al.

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Received and published: 5 December 2013

Author comment on "Tropospheric column amount of ozone retrieved from SCIAMACHY limb-nadir-matching observations" by F. Ebojie et al. doi:10.5194/amtd-6-7811-2013.

Response to anonymous reviewer #2 (C3001)

We thank the anonymous reviewer #2 for his/her valuable comments, most of which we agree with. We believe that this review has helped us to improve our paper.

Reviewer #2 (Comments to Author):

This study presents a residual method of subtracting stratospheric column ozone from total column ozone to derive tropospheric column ozone. What makes this particular residual method unique is that these two measurements are made by the same satellite instrument. Residual ozone is derived by subtracting nadir total column minus limb viewing stratospheric column. To my knowledge this single instrument method is currently only possible with SCIAMACHY measurements; however, the new NPP OMPS instrument can also do this using a nadir scan instrument measurement minus limb slit instrument measurement, but the OMPS data are not yet publicly available. Time lag between the SCIAMACHY total and limb measurements as noted by the authors is about 7 minutes which is as good as can be obtained with current instruments. I like this paper and suggest publication subject to relatively small improvement changes to the current version. Below are listed some comments which the authors may want to implement:

Reply: We thank the reviewer for his/her encouraging comments.

General comments: 1. Page 7822, Section 3.1: Just to clarify in the text regarding the original ozone retrieval by SCIAMACHY – by "ozone profile" you are referring to SCIAMACHY measuring ozone number density on fixed altitude surfaces at 1 km vertical sampling? In comparison, ozone profiles from the Aura MLS instrument are ozone volume mixing ratios measured on constant pressure surfaces. Equation (5) suggests that it is number density on fixed altitude surfaces unless some conversion was made from mixing ratios on fixed pressure surfaces. Also, with your optimization method employed for retrieving stratospheric ozone profiles, aren't the ozone profiles in the lower (upper) stratosphere below some altitude originating from the visible (UV) wavelengths? About what would this altitude be and is it much different between the tropics and extra-tropics?

Reply: Thank you for the question. We added in sections 3.1 and 3.3 that the quantity directly retrieved from the SCIAMACHY limb measurements is ozone number density on a fixed 1 km altitude grid. The stratospheric ozone retrievals involve the combination of visible and UV wavelengths. Between 35 and 40 km overlapping information from both spectral regions is used at all latitudes.

2. Figures 6-13: It is likely that the differences between the tropospheric column ozone measurements in these figures come largely from differences in the tropopause pressures that they each employ. Differences in column ozone between them would be larger in the extra-tropics compared to tropics and sensitive to the highly localized nature of the sonde station locations depending on tropopause definition.

Reply: Yes, the reviewer is certainly right. We discussed that in section 5.1 of the revised manuscript. We have also discussed in sections 5.1 and 5.2 of the updated manuscript that the differences might also come from retrieval algorithms in terms of a-priori value, cloud treatment and air mass factors employed by the different satellite instruments. Comparison of tropospheric ozone columns values from satellites with the values from ozonesonde, which are sparse, are prone to noise mostly in dynamically active subtropics where rapid fluctuation in the tropopause heights occurs. Such comparisons exhibit a lot of scatter and the regression line deviates from the line of unity. The aim of the plots 6 – 13 in the original manuscript was to show how well the tropospheric ozone columns from SCIAMACHY can be related to tropospheric ozone columns from other instruments within the above mentioned uncertainty. The plots have been replaced with the monthly tropospheric ozone columns anomaly in Dobson Units (figures 6 – 11) as suggested by anonymous review #3.

3. The basic spatial features with season in Figure 15 look to be generally consistent between the three different tropospheric ozone products but there are some inconsistencies that stand out. One puzzling feature is smaller zonal variation in the tropics for SCIAMACHY including almost no evidence of an Atlantic relative maximum during DJF and MAM. Also, the tropical Pacific ozone for SCIAMACHY appears much larger than both TES and OMI/MLS during DJF. On a different subject, Lelieveld et al. [2002, Science] discuss a pollution “crossroads” in the Mediterranean during northern summer months (JJA) which TES and OMI/MLS ozone seem to show but not SCIAMACHY.

Reply: Thank you for pointing this out, we have added in section 5.2 of the revised manuscript that some of the features that are not clearly seen might be due to the resolution or changes in color scale, which may hide or amplify some of the features. As shown in figure 15, over the tropical southern Atlantic SCIAMACHY tropospheric ozone values lie in the range of 25-35 DU and 10 – 25 DU in DJF and MAM months, respectively, OMI/MLS tropospheric ozone values lie in the range of 30 - 38 DU and 25 – 30 DU in DJF and MAM months, respectively, while TES tropospheric ozone values lie in the range of 35 - 45 DU and 25 – 35 DU in DJF and MAM months, respectively.

With regards to the discussion on the pollution crossroads in the Mediterranean during northern summer months (JJA), the different instruments show pollution plumes, although SCIAMACHY values are lower than the values from the other instruments in this region during JJA. TES tropospheric ozone column values over the Mediterranean are above 55DU, OMI/MLS values ranges from about 45 – 50 DU while SCIAMACHY values lie between 35 and 40 DU. We have added the above statement to section 5.2 of the revised manuscript.

4. It is clear from Figure 15 that OMI/MLS is smaller overall relative to either SCIAMACHY or TES, but there is also indication that spatial variability may be most similar between TES and OMI/MLS despite their offset differences. The problem with color plots is that small changes in color scale can either hide or amplify certain features. It would be very useful for directly comparing the spatial variability of these three tropospheric ozone products by including some simple longitude line plots of the three ozone measurements averaged within different latitude bands (e.g., perhaps 20S-20N, 40S-60S, 40N-60N, etc.?).

Reply: Thank you for pointing this out, we have included the line plots on the tropospheric ozone columns for different seasons from December 2005 to November 2011 on latitude bands of 40S-60S, 20S-20N and 40N-60N from the satellite instruments. These figures reveal the spatial variability, seasonally as well as annually reoccurring features present in global tropospheric ozone (please see Fig. 14)

5. It could be that the major differences between the tropospheric ozone products from SCIAMACHY and OMI/MLS originate largely from differences in their total column ozone measurements (independent of tropopause pressure). If space permits, it would be useful to say or show something in the paper about their total column ozone differences.

Reply: We are thankful to the reviewer for the above statement. We have included in the revised manuscript zonal climatology plots of tropospheric ozone column, stratospheric ozone column and total ozone column (please see Fig. 12) We have also added in section 3.2 of the revised manuscript that WFDOAS total ozone from GOME and SCIAMACHY is mature and agrees with other total ozone datasets to within 1% (e.g. Bracher et al. 2005, Weber et al., 2005, 2013) . For OMI TOC we cite Balis et al. (2007), for the validation of SCIAMACHY stratospheric ozone, we cite Mieruch et al. (2012) for the validation of MLS stratospheric ozone we cite Froidevaux et al., (2006) and Froidevaux et al, (2008)

We also mentioned in sections 2.2 and 5.2 that the low bias in the AURA tropospheric ozone is mostly due to MLS ozone being high biased in the lowermost stratosphere (e.g. Livesey et al., 2011).

Some small comments: 6. Page 7825, line 13: "...from ozonesonde climatological: : :"

Reply:We have modified the statement as suggested.

7. Page 7830, line 3 ": : :ozonesonde: : :"

Reply: We have modified the word as suggested.

8. Page 7834, line 2: ": : :TES are slightly: : :"

Reply: We have changed the statement as suggested.

9. Page 7834, line 6: ": : :in these regions: : :"

Reply: We have modified the statement as suggested.

10. Page 7835, line 29: ": : :no ozonesonde stations: : :"

Reply: The statement has been changed as suggested.

11. I had some other comments regarding sectional content and improving the clarity of figures (such as currently small text/numbers in some of them), but these are only very small subjective comments and not really worth bringing up.

Reply: We have increased the size of the fonts in the figures and also worked on the section content.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 7811, 2013.