Dear Editor,

With regard to the manuscript:

MS-NR: acpd-2010-0522
Title: NDACC UV-visible total ozone measurements: improved retrieval and comparison with correlative satellite and ground-based observations
Author(s): F. Hendrick, et al.

Please find below the replies to Referee #1 comments.

Sincerely yours,

F. Hendrick (**franch@oma.be**)

Anonymous Referee #1

First, we would like to thank Anonymous Referee #1 for his/her helpful comments.

The manuscript discusses the recommendations made by the NDACC WG for the analysis of ground-based zenith sky UV-visible observations and AMF calculations for the conversion of slant into vertical columns. These recommendations aim at improving the homogeneity of the data submitted to the NDACC data base. The details of the analysis recommendations and AMF look-up table calculations are discussed. The impact of the analysis suggestions regarding the retrieved ozone columns are investigated using measurements made as part of the SAOZ network. The revised SAOZ ozone data is then compared to satellite overpass observations and a collocated Dobson and Brewer instrument, and the findings based on the observed differences are discussed in detail.

One general concern here is the question of suitability of these observations for monitoring the total ozone columns (and this is used as the overall motivation in the manuscript!) given that these observations provide little sensitivity to tropospheric ozone. This is stated clearly in the text e.g. "the seasonal variation of the tropospheric column to which SAOZ is little sensitive" or "provides measurements of stratospheric ozone with little sensitivity to tropospheric ozone and clouds". Given these statements, how effective can the SAOZ observations really be in accurately measuring the long-term changes in total column ozone?? This needs to be clearly addressed before the manuscript can be published.

We have added a Section 2.2 called "Sensitivity analysis" (see page 6 of the revised manuscript) which describes the sensitivity of the SAOZ measurements to stratospheric and tropospheric ozone. In this Section, we have plotted a typical

column averaging kernel corresponding to SAOZ ozone measurements at mid-latitude at 90°SZA. As can be seen, the sensitivity to tropospheric ozone is low, with averaging kernel values smaller than 0.5 below 10 km of altitude while the sensitivity to the stratosphere is larger (averaging kernel values close or larger than 1 in the 18-30 km altitude range). This is because at the wavelength of 500 nm the sunlight scattering layer is located around 14 km of altitude at 90° SZA. It also explains the limited sensitivity to tropospheric clouds (now also explained in the manuscript). It should be noted that nadir-viewing satellite instruments also show reduced sensitivity in the troposphere, especially towards the surface. The height dependent sensitivity of these sensors is a function of the SZA which might explain the observed SZA dependences in comparison to SAOZ, if not adequately accounted for in the retrievals (this effect is now also investigated in the revised paper). SAOZ, like other remote-sensing measurement systems based on scattered light observations (including UV nadir backscatter satellite sensors) require the use of appropriate AMFs to convert the slant columns into total ozone. The final product is nevertheless the total column, although it is clear that the measurements are not equally sensitive to all atmospheric layers. Asides from the temperature dependence of the ozone cross-sections, this may explain the differences between SAOZ and satellites as well as differences between satellites.
It is clear that SAOZ total column measurements are strongly weighted by the contribution of the stratosphere and since the tropospheric column represents only 10% of the total column in an altitude range where the measurement sensitivity is also smallest, a trend of even 10% in tropospheric ozone would be hardly detectable in the total column.

Given these explanations, we decided to keep the terms “total column ozone” in the text.

Scientific comments:

Page 20407, line 19/20 (abstract): the SAOZ data is only compared to one Dobson and Brewer instrument, not several as indicated by using the plural.

We have replaced “….as well as those of collocated Dobson and Brewer Instruments.” by “…as well as those of collocated Dobson and Brewer instruments at Observatoire de Haute Provence (44°N, 5.5°E) and Sodankyla (67°N, 27°E), respectively.

Page 20408, line 17: “. . . with moreover little sensitivity to the cloud cover.” Can you please very briefly explain why that is.

Zenith-sky UV-vis ozone measurements at twilight have limited sensitivity to clouds (see reply to first comment) but the latter contribute largely to the

uncertainty on the O3 AMFs, as shown in Section 3.2. We have added the following paragraph in Section 3.2:

"The small impact of clouds on zenith-sky ozone UV-vis measurements at twilight is due to the fact that the mean scattering layer is generally located at higher altitude than that of the clouds. However, there are two exceptions: in the tropics where thunderstorms accompanied by heavy rainfall can reach 15-16 km, and at high latitude in the winter where Polar Stratospheric Clouds (PSC) are sometimes present, disturbing the ozone measurements. These episodes are easily removed from the ground-based data series by detecting the large enhancements of 70% or more of the absorption by O_4 and H_2O in the tropics in the presence of thick clouds and rainfall, and by the use of a color index (ratio between irradiances at 550 and 350 nm) in case of PSC (Sarkissian et al., 1991)."

Page 20412, lines 17-19: similar comment as above, please explain somewhere in the text briefly why. Also - and more importantly - this begs the questions if it is then such a good technique for measuring total ozone columns if it is indeed little sensitive to tropospheric ozone (see also general comment above).

See above our reply to the general concern of Referee #1 about the suitability of the SAOZ observations for monitoring the total ozone column.

Page 20415, lines 12/15: " . . . the three groups . . ." The three groups or retrieval teams should be briefly described somewhere.

Section 3.1 (see page 11 of the revised manuscript) has been completely modified, so this comment is not relevant anymore.

Page 20420: V2 SAOZ data performs better in many cases but not all (as shown in Table 6) – any thoughts about why not in some cases?

a) There was an error in the calculation of these seasonal cycles. Although some satellites data (TOMS, SCIAMACHY, OMI-TOMS) are limited to SZA<84° in their respective databases, others like GOME and OMI-DOAS are including measurements at all SZAs (also those during the pm descending orbit at high latitude in the summer). These data sets are showing large uncertainties at large SZA in the winter at high latitude (note that DDU, missing in the discussion paper, is now added). In the revised manuscript, all measurements SZA>84° are now ignored, reducing the amplitude of the seasonal cycle with V1 as well as with V2 for GOME and OMI-DOAS.
b) However there are still satellites for which the change from V1 to V2 increases the amplitude of the seasonal cycle, particularly with SCIA-TOSOMI and OMI-

DOAS at high latitude. This comes again from measurements at large SZA at the beginning and the end of the winter period, for which large deviations are observed, compared to SAOZ. It is not clear that all satellites (or retrieval algorithms) can perform correctly up to 84° but for homogeneity reason we decided to take the same SZA limit for all.

Page 20421, lines 26-28: "Figure 8 shows . . ." It should be pointed out that the satellite– SAOZ V2 differences discussed here are only investigated for one station each per geographic area and not several, e.g. the Arctic is represented by Sodankyla only and not also by other Arctic stations such as Thule, Ny-Alesund etc. – why??

We have selected stations for each latitude bands (Northern and Southern polar, mid-latitude and tropical regions) where the longest time-series are available (since the early nineties for some of them) and measurements can be performed throughout the year. Stations like Ny-Alesund or Thule have not been chosen because measurements around 90°SZA are not available throughout the year due to the limitation of the SZA coverage in both the summer and the winter. We have also removed from Table 5 the stations which are not used in the study to avoid any confusion (see page 44 of the revised manuscript)..

Page 20422, line 26: ". . . for all stations .." But not for all 16 stations listed in Table 5, right? At least it doesn't quite look like this to me. But it is also not just the subset used in Figure 8; please clarify.

In order to avoid any confusion, we have removed from Table 5 the stations which are not used in the study (see page 44 of the revised manuscript).

Technical comments:

Page 20408, line 5: replace "the first . . .. and the last" with "the former . . . and the latter"

This sentence has been removed in the revised version of the manuscript. So this comment is not relevant anymore.

Page 20414, line 23: ". . . uncertainties in . . ." not on

Section 3.1 (see page 11 of the revised manuscript) has been completely modified, so this comment is not relevant anymore.

Figures: most of the figures should be enlarged, in particular Figures 1, 3, 4 and 8 are difficult to read in their current size.

Figures are readable in the web version of the paper but maybe not in the print-friendly version. We think that it is an edition issue and as solution for the final version of the paper, we recommend to plot Figures 1, 3, 4, and 8 over two columns instead of limiting them to the one-column size.

Page 20415, line 1: replace "Beyond this issue, . . ." with "In addition to this issue,"

Section 3.1 (see page 11 of the revised manuscript) has been completely modified, so this comment is not relevant anymore.

Page 20415, line 5: better: "This is achieved through . . ."

Section 3.1 (see page 11 of the revised manuscript) has been completely modified, so this comment is not relevant anymore.