

REPLY TO REFEREE #3

The authors are very grateful to the editor for spending his valuable time to review the article.

This paper is a careful study comparing ozone profile measurements made at OHP with one another and with satellite measurements, over a period from 1994-2007. The results are consistent with those of previous studies; indeed, so consistent are they that there does not seem to be any new result in this paper. To proceed to publication in ACP the authors need to convince me that there are new scientific results here, and to change the abstract and conclusions accordingly.

This study presents the first elaborate quantitative bias and drift estimations using the OHP lidar ozone measurements for more than 25 years. It estimates the bias of a number of long and short-term, and ground and space-based observations, having entirely different retrieval techniques, with respect to OHP lidar. Though the data include both partial ozone columns and profile measurements on geometric altitude and pressure levels, having very low or high vertical resolutions, comparison is performed with the highly resolved lidar ozone vertical profiles in a common scale. The time series analyses help to pinpoint the bias observed in some periods due to peculiar reasons. Although there are some bias estimations from other studies, this is the first study that presents the drifts of various ground-based and satellite measurements over the whole stratosphere. The estimated instrumental drifts will help to determine the measurement validity for a successful evaluation of ozone trends. Further, our analysis discusses the possibilities of extending the SAGE II and HALOE data records with the new satellite data such as GOMOS and Aura MLS, in terms of relative offsets and drifts. With additional data from these new instruments in the next few years, the capability should exist to pursue accurate and validated long-term stratospheric ozone trends relevant for ozone recovery paths. This is also the first study using the 61 layer ozone columns from Umkehr data at OHP. Clearly, this work fulfills at least one of the main goals of NDACC i.e., the evaluation of the stability of various ground and space-based observations. In all these respects, the results of this work are quite new and would be a reference tool for the forthcoming similar scientific studies. The abstract, relevant sections and conclusions are modified accordingly. Two new Figures (Figure 7 and Figure 10 (right panel)) are also added to strengthen the discussion.

I have a number of minor comments:

p.1 col 2 l.12 :: : : measurements – (SPARC: : : :)

This has been done. Please find the revised text in Introduction, Paragraph 1, Line 12.

p.2 sec 2.1.1 l.4 :: : : : of the OHP lidar: : : : : :

This has been done. Please find the revised text in Section 2.1.1, Paragraph 1, Line 4.

p.2 sec 2.1.1 l.9 give reference for signal processing algorithm

Given the references Godin et al., (1999) and Godin-Beekmann et al., (2003). Please find it in Section 2.1.1, Paragraph 1, Line 10-11.

p.3 col 1 para 3 l.1accuracy of the lidar: : : : : : :

Changed. Please find the revised version in Section 2.1.1, Paragraph 4, Line 1.

p.3 col 1 2.1.2. l.2 (0.2km) than other measurements

This has been modified. Please see the revised version in Section 2.1.2, Paragraph 1, Line 2.

p.3 col 1 l.-3 : : : in use. The acquisition: : : : :

This has been done. Please find it in Section 2.1.2, Paragraph 1, Line 13.

p.3 col 1 l.-2 : : : ECC sondes were coupled with Vaisala: : : : (the Vaisala company does not use the Å)

This has been removed. Please find the revised version in Section 2.1.2, Paragraph 1, Line 14.

p.3 col 2 l.2 : : : radiosondes have been coupled to ECC: : : : ..

Changed. Please see the revised text in Section 2.1.2, Paragraph 1, Line 16.

p.3 sec 2.1.2 last para A better explanation is needed of the correction factor. This is the ratio of the total ozone column measured by the sonde (with an estimate of the residual above balloon-burst) to the Dobson. The last sentence should refer on to where this is discussed further.

The correction factor has been defined in Section 2.1.2, Line 32-36, and the section where correction factor is used further has been referred in Section 2.1.2, Line 44.

p.3 sect 2.1.3 l.-4 the UMK04 algorithm

This has been done. Please find the revised text in Section 2.1.3, Line 18.

p.4 l.2 : : : on the NASA () NIMBUS-7: : : : ..

This has been changed. Please see the revised version in Section 2.2.1, Line 2.

p.4 sec 2.2.4 l.7 manoeuvre

Done. Please find it in Section 2.2.4, Line 7.

p.4 sec 2.2.4 l.-2 ..MLS version in 5 from 1991-1999: : : : ..from 2004-2009

This has been modified. Please see the revised text in Section 2.2.4, Line 27-28.

p.5 sec 3.1 l.7 : : : eruption (Guirlet et al, 2000)

Changed. Please find the revised text in Section 3.1, Paragraph 1, Line 7.

p.5 sec 3.1 para 1 last sentence Here you say that Pinatubo had a big effect on SAGE-2, but that is not what fig.1 shows.

It has already been reported that SAGE II data are affected by aerosol loading from the Mount Pinatubo eruption. Therefore, those data are filtered from 1992 to 1994 as per the criteria given by SPARC (1998). This filtering is based on the pressure levels (i.e. excluding data at the affected levels. For e.g. from the ground to 14, 32, 46,... hPa from the date of Pinatubo eruption until January 1992, May 1992, January 1993, etc. respectively.) of the profiles rather than removing the complete profile. Hence, the total number of profiles do not change. Fig.1 shows the total number of profiles, which does not represent the ones with respect to altitude.

p.5 sec 3.1 para 2 l.-1 : : : ozone are excluded from the analysis for all: : : : ..

This has been done. Please see the revised version in Section 3.1, Paragraph 2, Line 13-14.

p.5 sec 3.1 para 3 What do the phrases “when the sampling of the ozone field by the satellite instrument make it possible” and “for both ground-based and space-borne measurements” mean? Both phrases appear entirely redundant.

Please find the revised sentence in Section 3.1, Paragraph 3, Line 2-3.

p.5 col 2 para 2 l.4 :: :around the OHP station: :: :

Done. Please see the revised text in Section 3.1, Paragraph 4, Line 4.

p.5 col.2 para 2 l.13 :: :onwards; the lidar provided: :: :

This has been changed in Section 3.1, Paragraph 4, Line 13-14.

p.5 col 2 para2 l.15 :: :Umkehr provided more profiles at the beginning of the observation period: :: :

This has been done in Section 3.1, Paragraph 4, Line 15.

p.5 col 2 para 2 l.20 :: :HALOE provided: :: :

Done. Please find it in Section 3.1, Paragraph 4, Line 20.

p.5 col 2 para 2 l.-4 :: :number of profiles throughout the period: :: :

Done. Please find the revised text in Section 3.1, Paragraph 4, Line 23-24.

p.6 l.1 A great show is made of lidar being measured as a function of height, yet here you introduce lidar pressure levels. What are these?

Lidar pressure levels are referred to the ones taken from the NCEP data corresponding to lidar altitudes. The sentence is reformulated. Please see Section 3.2, Paragraph 2, Line 7-8.

p.6 col 1 l.3 :: :obtain the ozone profile: :: :

This has been done in the revised manuscript in Section 3.2, Paragraph 2, Line 10-11.

p.6 col 1 l.8 (Griesfeller et al, 2010); this did not make a significant difference to the annual average

The sentence has been changed in Section 3.2, Paragraph 2, Line 16.

p.6 col 1 para 1 l.-1 AK smoothing

Done. Please find the revised version in Section 3.2, Paragraph 2, Line 20.

p.6 col 1 para 2 l.6 :: :for comparison, HALOE ozone values measured: :: :

This has been modified in Section 3.2, Paragraph 3, Line 6.

p.6 col 1 para 2 l.10using the corresponding MLS: :: :

Done. Please find it in Section 3.2, Paragraph 3, Line 9.

p.6 col 1 para 2 l.14 The difference between geopotential and geometric height is 1km at 80km; this is not "very small"

The sentence is modified in **Section 3.2, Paragraph 3, Line 10-15.**

p.6 col 1 para 2 last sentence What does this mean? What are "boundary altitudes"?

The boundary altitudes are mentioned as the extremities of the altitude ranges specified in Fig. 6. The sentence has been modified in **Section 3.2, Paragraph 3, Line 22-23.**

p.6 col 1 para 3 l.2 ..performed by convolving: ::

Done. Please find it in **Section 3.2, Paragraph 4, Line 2.**

p.6 col 1 para 3 l.6 :: ozone AKs, and the: ::

Done. Please see the revised version in **Section 3.2, Paragraph 4, Line 7.**

p.6 col 1 equation 1 Why do you use an a priori profile for lidar? Nowhere else is this mentioned

We used SBUV(/2) a priori data, not the lidar a priori. The a priori notation in Eq.(1) has been re-written.

p.6 col 2 para 2 l.9/fig 2 I do not understand fig. 2. Clear differences between the brown and blue lines are evident at 23.9mb and the point below, but this is not shown in the third panel. Instead, the largest difference is shown in the points above 23.9mb. The text says the results do not differ significantly except at 2.51 and 1.58mb, yet the error bars at 16mb are too small to plot and those at 2.51mb large enough to overlap. What is going on here? Also, what are the numbers on the third panel?

The left panel of Fig.2 is the only profile on 18 September 2007, whereas the right panel shows the relative differences of SBUV(/2) and lidar averaged over the period 1985-2007. The difference found for a single profile might not be reproduced in the whole year average. The numbers provided in the panel are the number of profiles obtained for averaging at each altitude. The errorbars below 2.51mb are very small due to large number of coincident profiles. Please find the revised paragraph in **Section 3.2, Paragraph 6.**

p.6 col 2 para 2 l.10 I can see why a smaller number of events would give a larger standard error, but not why it would give a statistically significant difference.

There are 94 profiles for the comparison of the non-convolved lidar data, whereas the convolution of the lidar data yields only 2 profiles for the analysis. This produces a statistically significant difference at 2.51 mb.

p.6 col 2 para 2 l.12 omit comma after levels

This has been removed.

p.7 col 1 para 2 The time series of the discrepancy with ozonesondes merits some discussion

Additional information is added to clarify the results in **Section 4.1.1, Paragraphs 2 and 3.**

p.7 col 1 para 3 l.4 :: HALOE provided fewer collocations: ::

This has been done.

p.7 col 1 para 4 l.4 omit “Fairly: : :1994”

This has been removed.

p.7 col 1 last para There is no sudden jump in the data at 6.3-4hPa and 4-2.51 hPa, and even at 15.8-10 hPa it is more of a systematic increase

Modified the sentence in Section 4.1.1, Paragraph 6, Line 11.

p.7 col 2 l.1 : : :the increase in 2001 found at: : :: : :profiles were compared: : :were interpolated to SBUV(/2) pressure levels, and SAGE-II ozone number density profiles analysed as discussed previously. Relative differences were determined.

The sentence is reformulated in Section 4.1.1, Paragraph 7, Line 1-7.

p.7 col 2 para 2 l.1 results were smoothed: : :

This has been done.

p.7 col 2 sec 4.1.2 l.7 Aura MLS produced: : :

This has been changed.

p.7 col 2 last line 20-40km and somewhat higher differences outside this range

Done. Please find the revised text in Section 4.2, Paragraph 1, Line 6-7.

p.8 col 1 sec 4.2.1 Line 4 and all subsequent occurrences – use “compared” not “as compared”

This has been done in Section 4.2.1, Paragraph 1, Line 5-6.

Figs. 7 and 9 Add a pressure scale as well as altitude since much of the discussion uses pressure, (eg. p.9 col 2)

Figures are modified by adding pressure levels. Please find the new Figures 8 and 10.

p.9 col 1 sect 4.3 l.2 were computed

Done.

p.9 col 2 para 4 l.2 ozonesonde – lidar comparison

This has been done.

p.9 col 2 para 4 l.5 drifts were also

Done.

p.9 col 2 para 4 l.8 slopes were computed: : :were less than: : :were more negative: : :

This has been changed in Section 4.3, Paragraph 5, Line 8-11.

p.10 sec 5 l.1040 km, because of the lower: : :

Done. Please find the revised text in Section 5, Paragraph 2, Line 11-12.

p.10 sec 5 l.20 How can a constant bias result from a change of sonde type?

The references in Section 2.1.2 recommend a change of +/-5% difference in the retrieved ozone in the long-term evolution, if sonde type changes.

p.10 sec 5 l.25 GOMOS were also

This has been done.

p.10 sec 5 l.28 relatively large: : :MLS shows good agreement

The sentence has been reformulated in Section 5, Paragraph 2, Line 29.

p.10 col 2 l.1 regressions were computed

Done. Please find the revised text in Section 5, Paragraph 3, Line 1.

p.10 col 2 l.6 2009), and are: : :./yr was calculated for SAGE: : :

This has been done.