General part

We thank the anonymous reviewer for his/her constructive feedback. Benefitting from his/her expertise, the manuscript has undergone some critical revision. The text is shortened and compacted where appropriate and some figures have been modified and/or combined. After reconsidering their relevance with respect to key questions addressed in the article, trends in total and integrated limb ozone have been removed. The structure of the article has been improved by rearranging some sections. The trend analysis has been extended to account for the El Niño Southern Oscillation (ENSO) in addition to the terms considered so far.

Some lists of citations have been shortened or removed completely, e.g. page 11271: lines 8-11, lines 18-21, page 11272: lines 25-26 and lines 26-3(next page). This allows further for a considerable shortening of the list of references. Section 3.2 and 3.3, in which the fitting of QBO and solar cycle terms (in the revised article also ENSO terms) is introduced, are now joined into one section. Some points on the QBO and solar cycle response of ozone and their proxies are now described in a less detailed manner.

The structure of the article has been reorganised. Section 5.1 and parts of Section 5.2. are now joined into one small section which presents the results from SCIAMACHY. This is now followed by a combined section (Section 6 and 7 before) which provides inter-instrumental comparisons. Subsequently, a separate section discusses potential reasons for the observed ozone trends.

The sequence of figures shown in the article is now improved to better illustrate key points discussed in the text. Figures 1-4 are now complemented by two additional figures showing time series and their regression models for the altitude of 21 km. Figures 10-12 are now combined into one figure. Figures 14 and 15 have been removed.

The method of trend determination is extended to handle ENSO signatures in ozone as well. The anomaly of the Niño 3.4 index, as previously used in Oman et al.(2013), serves as ENSO proxy. It is now included into the regression model at tropical latitudes (20°N-20°S) at altitudes up to 25 km. Possible time lags between the proxy and ENSO signatures in ozone are accounted for. The inclusion of ENSO into the regression model affects tropical ozone trends within the 15-25 km range (in the discussion paper, these trends were reported to be clearly positive). These trends are somewhat mitigated, but still discernibly positive. In the lowermost tropical stratosphere, this tendency towards positive trends is not conform with Randel and Thompson either. Independent of our study, similar findings have meanwhile been reported by Eckert et al.(2013).

Detailed points

(1) Abstract / line 2: also give the time period over which the trend was calculated (presumably 09/2002 to 03/2012)

The period under investigation is now given in the text: 08/2002-04/2012.

(2) pg. 11270, line 18: I don't think that "the earth . . . is shielded by ozone absorption . . ." Rephrase, e.g. "The stratospheric ozone layer shields the earth from UVB and UVC radiation in the 240 to 320 nm range. The absorbed energy . . ."

Changed.

(3) pg. 11274, line 12: It would also be fair to admit that SCIAMACHY does not measure polewards of 60° in winter. So maybe add "and the lack of SCIAMACHY measurements in the absence of sunlight" after "polar vortex"

We have added after "polar vortex": "and because of gaps in the SCIAMACHY sampling in the high latitude winter."

(4) Figs. 1 to 4: I think these Figures are good and important. One important panel, however, is missing in all panels (in my opinion). This additional panel should show the linear trend underlaid by the times series with seasonal, QBO, and solar terms removed. Since the rest of the paper largely discusses the trend, I feel it would be fair and very necessary to clearly show the trend part of the time series as well. I am still wondering where these large decadal trends come from – and other readers will wonder too. It would be very important to see the underlying data, i.e. time series with seasonal, QBO and solar terms removed.

Also Figs. 1 to 4: I think adding a title line giving the altitude and latitude band to each Figure, and labeling each panel (e.g. with data+fit, residual, seasonal, QBO, solar) would help the reader a lot. I realize that this information is also given in the legend, but having it in the Figure would help.

Figure 1-4 are now improved by adding a panel which shows the linear part of the fit and the time series with all other parts of the fit removed. In each panel, the part of the fit shown is now overlaid by the time series with all others parts removed. Labels are added to each of the panels. A title giving altitude and latitude is added.

(5) Pg. 11280, line 25 to page 11281, line 13: Ok, indeed these investigations show ozone decreases in a "narrow" layer around 35 km due to increasing N2O/NOX. However, the estimated ozone trends are 0.5% per decade maximum, NOT 5 to 20% per decade as seen here. This factor 10 or more difference needs to be mentioned and discussed. Also, I don't see the narrow maximum response near the equator for 2005 to 2095 in Fleming et al. Fig. 4. I see the same shape as for 1979 to 1996, but a weaker response. This should be checked. The text should be corrected.

We were not able to sort out each of the points, particularly the factor 10 or more difference with respect to Fleming et al.(2011). For this reason, the reference of Nevison et al.(1999) has been given priority in the text and further references have been omitted.

(6) Pg. 11281, lines lines 25 to 27: if this is true for 60° to 70°, where clouds and tropopause are below 10 km, it must be true even more in the tropics, where clouds may reach up to 16 or 18 km.

As now mentioned in Section 2, SCIAMACHY may have not enough measurements poleward of 60N and 60S during winter months due to the lack of sunlight. The trends shown are now limited to 60N-60S and this sentence is left out accordingly.

(7) Pg. 11282, lines 9 to 15: Which Figure of Stiller et al. are the authors referring to? Please clarify. I would expect to find an age-of-air pattern somewhat similar to the decadal change pattern of the authors Fig. 7. However I did not find that in the Stiller et al. paper. Figs. 10/11 of the Stiller et al. paper, e.g., show large negative age-of-air decadal changes near 35 km in the tropics and around 50°N (reminiscent of the current Fig. 7), but they also show a large positive decadal change near 35 km around 25°N and 50°S – in contrast to the current Fig. 7. So the current statements should be qualified a bit. Overall, my impression is that there is a few ideas, but no really very plausible explanation for the current large decadal changes in certain layers. This should probably stated in the text.

a) It has been clarified in the text that there is presently no comprehensive explanation for the observed trends in ozone. In our study, we give attempts of explanation for isolated parts of the overall pattern of trends only.

b) A Figure to be referred to can meanwhile been found in Eckert et al.(2013) which is based on MIPAS ozone data. Their figure 14 resembles largely the hemispheric asymmetry of extratropical ozone trends seen by SCIAMACHY in the 25-35 km range: Eckert et al.(2013) obtained similar negative ozone trends in the northern extratropics between 25 and 30 km and similar positive ozone trends in the southern extratropics between 25 and 35 km. The hemispheric asymmetry of extratropical ozone trends is now discussed referencing Eckert et al. (2013). Other references are omitted.

(8) (a) Pg. 11284, lines 19 to 21: I would disagree, comparison with OSIRIS and SHADOZ indicates that the higher MLS decadal changes are correct (Figs. 10 to 13, MLS +20% decade near 18 km, OSIRIS +15 to +20% per decade near 18 km, SHADOZ + 20% per decade near 16 km), and the lower SCIAMACHY decadal change (0% per decade near 17 km) is probably not correct.

(b) Pg. 11285, line 14: As does SHADOZ !!

(a) The hint on vertical oscillations in the MLS ozone retrieval being possibly reflected by trends has been removed.

(b) The tendency of OSIRIS and MLS towards positive trends in the lowermost tropical stratosphere is now revisited when discussing the trend comparison between SCIAMACHY and SHADOZ.

(9) pg. 11285 line 15: As said above, I would suggest to combine sections 6 and 7 into one section. The section title is not correct as well: MLS and OSIRIS are just as independent from SCIAMACHY as SHADOZ is. And I would expect that the GOME/SCIA/GOME2 combined nadir decadal change is less independent from the SCIAMACHY limb decadal change, since both use them same instrument, ancillary data, . . . MLS, OSIRIS and SHADOZ are all completely different instruments from SCIAMACHY.

As already mentioned in the general part, Sections 6 and 7 are now combined. The title of the combined section is: “Comparisons of trends from SCIAMACHY with those from other instruments”.

(10) Pg. 11285 lines 23, 24: I would change the 30 km to 35 km, as most balloons will reach above 30 km (except maybe for the polar winter stratosphere). Apart from balloon-burst, evaporation and/or freezing of the wet-chemical sensing solution used in the sondes also limits the reachable altitude range to 35 km (triple point of water is at 6 hPa). This could be mentioned as well.

The text is now changed into "*The altitude range of the balloon sonde O3 data is limited to 30-35 km by different factors like balloon burst and evaporation and/or freezing of the wet-chemical sensing solution used in the sondes.*".

(11) Pg. 11288, line 11: I think it would be fair to add that below 20 km, SCIAMACHY shows smaller / more negative decadal changes than the other instruments.

It is now added "*In the lowermost tropical stratosphere below 20 km, SCIAMACHY and the comparison instruments see non-negative trends, but don't agree in detail. The other instruments show higher positive trends than SCIAMACHY.*".

References

Eckert, E., von Clarmann, T., Kiefer, M., Stiller, G. P., Lossow, S., Glatthor, N., Degenstein, D. A., Froidevaux, L., Godin-Beekmann, S., Leblanc, T., McDermid, S., Pastel, M., Steinbrecht, W., Swart, D. P. J., Walker, K. A., and Bernath, P. F.: Drift-corrected trends and periodic variations in MIPAS IMK/IAA ozone measurements, Atmos. Chem. Phys. Discuss., 13, 17849-17900, doi:10.5194/acpd-13-17849-2013, 2013.

Fleming, E. L., Jackman, C. H., Stolarski, R. S., and Douglass, A. R.: A model study of the impact of source gas changes on the stratosphere for 1850–2100, Atmos. Chem. Phys., 11, 8515–8541, doi: 10.5194/acp-11-8515-2011, 2011.

Nevison, C. D., Solomon, S., and Gao, R. S.: Buffering interactions in the modeled response of stratospheric O3 to increased NOX and HOX, J. Geophys. Res., 104, 3741-3754,doi:10.1029/1998JD100018, 1999.

Oman, L. D., Douglass, A. R., Ziemke, J. R., Rodriguez, J. M., Waugh, D. W., and Nielsen, J. E.: The ozone response to ENSO in Aura satellite measurements and a chemistry-climate simulation, J. Geophys. Res., 118(2), 965976, doi:10.1029/2012JD018546, 2013.