Response to referee #3

We appreciate the positive analysis of the reviewer and his constructive recommendations which contributed to improve the quality of the manuscript. We comment below all of them and have modified the manuscript accordingly when required

This paper describes Antarctic ozone variability based on ozonesonde observations at Belgrano II station over 13 years and discusses possible mechanisms causing the variability. As Belgrano II station is located at a quite high latitude (78S) compared with most Antarctic stations, the climatology and variation of stratospheric ozone obtained from the ozonesonde data are quite valuable. However, it is difficult to understand from this manuscript what is new knowledge on the Antarctic ozone obtained from this study. Most discussion is simply descriptive by referring to previous studies. I think that more quantitative estimates from viewpoints of dynamics and/or chemistry is needed. For example, it should be more informative to show how different the ozone variabilities in the regions inside and outside the polar vortex are. For this, it is better to analyze data not only at Belgrano II and South Pole stations but also other Antarctic stations located at lower latitudes. In summary, I suggest that the manuscript should be significantly revised before publication for Atmospheric Chemistry and Physics. Other comments are listed below.

Variability in ozone loss rates from different regions has already been done by Kuttippurath et al (2010). This work has been referenced in the manuscript to compare some of our results from two stations well inside of the polar vortex. Our study aims to go into detail about the ozone behaviour in the inner side of the polar vortex in terms of differences in ozone loss rates and transport for the vortex edge to the SPS. In fact, our results provide an experimental support to the previous modelling studies on transport of ozone depleted air from the edge to the core (Lee et al., 2001). The referee suggestion, while interesting, is out of the scope of the work since it requires a different approach. In particular, our methodology to calculate ozone loss rate is only valid for stations inside the vortex.

p.15665 ll.19-20: Salby et al. (2012) showed an evidence of ozone rebound from the analysis of satellite and reanalysis data.

We have included the nice work on rebound by Salby et al 2012. The text is now as follows:

Models predict that these changes will probably reverse due to the ozone recovery (Son et al., 2009). Thus, in recent years, great attention has been paid to the timing of ozone recovery. First convincing evidence of the rebound has been recently provided by Salby et al (2012). Chemistry climate models are an excellent tool to investigate how the decreasing in *atmospheric halogen compounds loading to natural "background" levels, will lead to stratospheric ozone recovery in the near future (Austin et al., 2010).*

2. p.15664 l.20: The authors define two ozone loss rates, i.e., one determined for August (Figs. 4, 5, and 7) and another for September (Fig. 8). According to Fig. 9, the ozone loss rate at SPS is smaller than that at Belgrano II in August but not in September. However, it may be natural that the ozone loss rate at SPS in September is larger because the sunrise is later at SPS. It should be described why it is "not expected".

We have removed this sentence since the time evolution of accumulated hours of light in SP is faster than in Belgrano. In addition, it is shown by Lee et al. that a significant part of the O3 reduction in the pole is not due to "on site" chemical ozone depletion but to meridional transport of low-O3 airmasses from the vortex edge. Lee et al. 2001 (fig. 5) nicely shows that OLR is larger at the Pole than at 78º and that the maximum accumulated losses are reached simultaneously at all latitudes poleward of 75º, which is exactly what we have found.

3. p.15668 Section 3.1: Please define here "Region I, II and III" which are used in later paragraphs.

According with referee I, the word region has been changed to layer when we are referring to the vertical extension parts. We have added a new paragraph explaining that the ozone loss rates have been calculated in the three layers, and a deep analysis has been done in layer II

4. p. 15670 ll. 8-9: As the partial pressure is not a conservative quantity, the descent rate observed in the partial pressure may not be attributed to the downward motion associated with the Brewer-Dobson circulation. The discussion here should be made using mixing ratio which is a conservative quantity when irreversible mixing and chemical production and loss are absent.

We do not claim that the observed descent is the rate of air subsidence. We use "descent of the O_3 maximum" which is what can be seen when using absolute concentration units. However, as outlined in the text, the rate of the observed O_3 maximum descent is in agreement with the Rosenfield et al. calculations for the rate of air subsidence, providing hints that summer and autumn air downwelling near the pole play a role in the ozone distribution.

Partial pressure can be converted to volume mixing ratio since pressure and temperature are simultaneously recorded by the radiosonde. However, deriving of air descent rates on long periods of time from O_3 profiles of a single station is not straightforward. For the main objectives of the paper we prefer to continue using absolute units.

5. p. 15671 ll. 7-8: A similar indication was already made by Sato et al. (2009).

The reference has been included

6. p. 15672 l.27: Please note that the ozone loss rate described here is for August, as the authors use another ozone loss rate in September later. Similar description should be made in the captions of Figs. 4, 5, 7, and 8.

Ozone loss rates show in figure 5 are calculated for the period covering from mid-August and September, we have added a sentence for clarification. In the captions of the figures period of the study has been specified as well.

7. p. 15674 ll.6-8: This point is interesting. Please describe what the definition of "initial" ozone is. Is it the ozone partial column on the 1st of August? Moreover, please describe possible mechanisms how the "initial" ozone controls the ozone loss rate.

In this study we have considered initial ozone in layer II as the integrated ozone amount the 1st of August. Obviously, an ozone vertical profile is not available all years for this specific day. To solve the fact, the initial ozone has been estimated by a linear interpolation using vertical profiles the days before and after the 1 of August.

We clarify this definition in the manuscript.

For a reference, the integrated ozone amount the 1st of August was used as initial ozone. On years when no data were available for that day, interpolation from closest sounding were performed.

The explanation on how this initial ozone controls the ozone loss rate is the following:

Winter ozone is determined by dynamics through planetary wave forcing of the mean meridional circulation. This relation has been quantified by the correlation between the Eliassen–Palm (EP) flux anomalies entering the lower stratosphere with the ozone anomalies at high latitudes of Southern Hemisphere (Salby et al., 2011). The high correlation means that years with larger poleward transport are related to a positive anomaly in ozone (Weber et al., 2011). On these years larger amounts of reservoirs (HCl and ClONO2) reach the polar stratosphere, then activating in spring increasing the OLR as compared to years of lesser transport. On these years larger amounts of reservoirs (HCl and ClONO2) reach the polar stratosphere. In spring, these molecules are converted into active radicals, leading larger OLR as compared to years of lesser meridional transport..

On the other hand, as long as there are plenty halogen compounds activated, the more ozone present in the atmosphere the more severe the ozone destruction will be.

8. p. 15674 ll.19-20: The stratospheric temperature and the strength of polar vortex are strongly related to the planetary wave activity.

That is clear. We have taken into account this suggestion, and the sentence is now:

The stratospheric temperature and the strength of polar vortex which are strongly related to the planetary wave activity, play major roles in the amount of ozone and the rate of depletion

9. p. 15675 l. 19: It is better to specify which days of which month corresponding to the 16-17 Weeks

We have incorporated in the text the days corresponding to this period and the sentence is now:

The difference in time between the two stations is too small compared to the overall period of potential PSCs over continental Antarctica from the end of May to beginning of October (about 16-17 weeks)

10. p. 15676 ll.1-3: This sentence is not very clear. Is "the first four weeks" (and "in four weeks" in the same sentence) means the first four weeks after sunrise? Please specify.

Yes, in both cases the four weeks cover the period after sunrise, we have modified this sentence for clarification.

Accumulated solar radiation during the first four weeks after sunrise in both stations is quite different. In Belgrano is about 200 hours leading to activate less ODS than in SPS (688 hours)

11. p.15676 l. 22: Please specify the altitude corresponding to 475K.

The altitude corresponding to the isentropic level of 475 K varies along the year from 20.5 km to 16.8 km. For November and December the mean altitudes are 17.8 and 17.2 km respectively. These data are included in the text.

12. Fig. 3: The size and seasonal variation of the polar vortex largely depend on the year. Inter-annual variability should be shown for the daily mean distance from the vortex edge to Belgrano II together with the climatology.

Standard deviations for the daily mean distance from the vortex edge are shown in the complementary figure A. We consider there are many data in figure 3 to include this information as well.