Response to referee #2

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

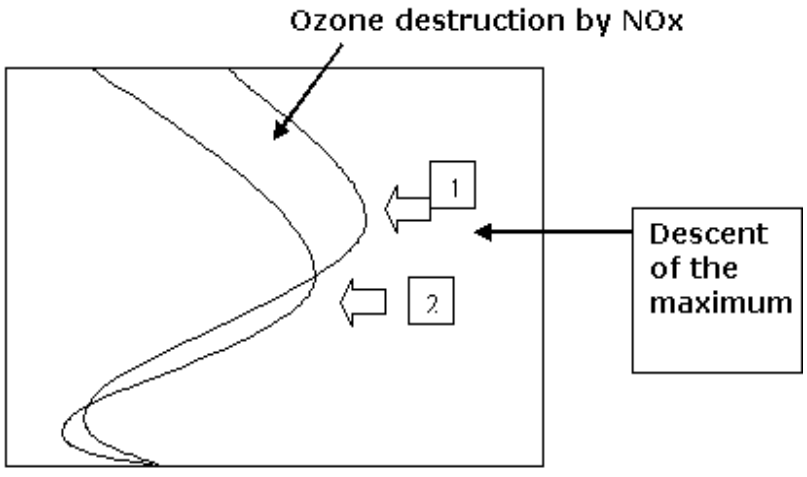
Comments:

At page 15671+, lines 28+, the effect of ozone depleted air masses transported to higher latitudes is mentioned. However, this argument is seldom or not at all used in later discussions, e.g. when reduced ozone values are measured at SPS before the sun light period. The knowledge of the Eulerian view of station data and the corresponding specific differences between Belgrano and SPS are helpful in interpreting the data and have in general to be discussed much more.

Section 4.4 has been rewritten including the effect of transport processes in the core of the vortex to explain the differences between both stations.

Page 15670, Lines 10-15: How can the lowering in the height of the maximum at 20 or 22 km be influenced by chemistry in the 25-38 km region above?

O_3 destroyed by NO_x catalytic cycles in the upper stratosphere is a well described feature (see references in the manuscript). Part of the observed lowering in the O_3 maximum from January to August is just a geometric effect of the O_3 depletion at higher altitudes (see picture).



p 15673, l 4-7: The contribution of the 2002 event to the variability is largest in region III. Therefore, I assume that the explanation dealing with minor warmings is less important.

We have clarified this point in the text

The largest relative variability observed in layer III (84%) is explained by the contribution of the 2002 event. When the anomalous year 2002 is not taken into account this coefficient

is reduced in all layers, as it'd beds expected. In layer III, the relative variability is less than half of the previous value (41%), while in the layers II and I, the coefficient is reduced by 15% and 20%, respectively. This fact indicates a higher contribution of 2002 event in layer III. On the other hand, the largest relative variability in layer III, when 2002 in not included might be related to larger temperature variations at higher altitudes resulted from stratospheric minor warmings occurred in 2004 and 2010. In fact, when these two years are excluded, relative variability in layer III is reduced to 19% and shows similar values than in layers II and I.

Minor comments
Some of the figures, at least Figs. 2 and 3 have presentation problems. In those two figures the data (isolines) at the right border should coincide with the data at the left border, which is in fact not the case. In addition, the numbering of the isolines in the upper panel of Fig. 2 mismatch with the numbers of the colour legend on the right side, at least for the number 14. These problems may cause some of the following comments.

p 15665, l 12+: I recommend to acknowledge the first article dealing with this issue: Thompson and Solomon, Science 296, 895, 2002, DOI: 10.1126/science.1069270.

We thank the referee for the reference supplied, which has been included in the text.

p 15668, l 3+: Are there any known biases between the different references?

The biases between the references used are well known. Kroon et al., 2008 have estimated that uncertainty of ozone column from TOMS data is 3.3 %. The OMI data are continuation of the TOMS series and its uncertainty for the ozone column is 2–5% for SZA<84_ (Levelt et al., 2006). For the Brewer instrument, the total error is of 2.5% according to (Scarnato et al., 2010; Kerr and McElroy, 1995).

Taken into account these data we can assume differences about -2-3% when we are using different references.

p 15668, l 15-17: I understand that one profile per year, i.e. 13 profiles in total, contributes to the mean minimum profile. The time of a minimum in a single season can be altitude dependant. What was the definition of a minimum profile in a single season?

The mean minimum ozone profile is obtained as the mean from each of the minimum profile registered every year. It has been considered the minimum profile in a single season as the ozone profile registered the day of the minimum total ozone column, generally observed by the end of September or early October.

p 15670, l 8: I see the maximum at 20 km not at 22 km in January.

In January the ozone maximum is observed at 20 km.

p 15670, l 15: The rather large range of 3-7 km of descent is due to a height dependance. I recommend to compare the values in the same relavant height region.

We do not claim that the observed descent is the rate of air subsidence. We use “descent of the O3 maximum” which can be seen when using absolute concentration units. However, as outlined in the text, the rate of the observed O3 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

p 15671, l 7-8: Please make more clear that the downward propagation rate as well as the end time is your result (and not that of Miyazaki et al.). Please specify the time period, where the downward propagation was 74 m per day.

The ozone enriched air resulting from poleward eddy transport (Miyazaki et al., 2005) arrives to the polar region when the vortex edge barrier disappears and propagates downwards. The height of maximum ozone concentration descents at a rate of 38 m/day from October to January.

p 15671, l 12-13: I don’t understand the need and significance in mentioning "covering a 58% of the ..."

The objective for including this magnitude is to emphasize the large extension in time and height with potential existence of Polar Stratospheric of Clouds.

The have rewritten the paragraph.

The temperature structure is dominated by the winter radiative cooling, reaching minimum temperatures at 21 km. Height and time of Polar Stratospheric Clouds (PSC) Presence, approximately defined by the -78º isotherm (figure 2, lower panel) as threshold temperature for the existence of nitric acid trihydrate (NAT) (Hanson and Mauersberger, 1988), extends from May to late October with a large vertical extension of over 15 km. The area below -78º in the height-time plot covers a 58% of the area limited by 12–30 km in height (low and mid stratospheric region) and by May to October in time. Minimum temperature takes place by the end of July at 21 km. As spring proceeds, heating at upper levels propagates downwards, quite in coincidence with ozone increase at a mean rate about 0.5ºC.day−1.

p 15672, l 12: The approx. height of 475 K is dependant on season. During the vortex season as it is of interest here, the approx. height is higher up, presumably 19-20 km.

The altitude corresponding to the isentropic level of 475 K varies along the year from 20.5 km to 16.8 km. A mean data of 18 km has been considered in the manuscript.

p 15672, section 4.3: The definition of the ozone loss rate should be given in detail. Obviously, means are taken and plotted. This should be mentioned in the text and in the caption of the Fig. 4. What are the time periods where the means are taken? Why should relative ozone reductions be interesting to show??

For any unknown reason, the explanation on how ozone loss rates are calculated was removed in the last version of the manuscript. We have now included it as a new section in the methodology. We do not calculate a daily ozone loss rate, a single ozone loss rate is obtained for each year and for the time window considered. The ozone loss for a single is not a mean value. In figure 4 the time period covers from day 220 to 273. Relative ozone reduction provides an indication on the severity of the ozone loss in total column each year.

Caption for Figure 4 has been modified

Fig 4. Time series of ozone loss rate during phase II (red line and right scale) for the total ozone column and ozone reduction with respect to ozone in August in percent (left scale). The total amount of ozone depleted (DU) is written on the top of the bars

p 15675, 13-14 & Fig. 8: Obviously different time periods are chosen to define ozone loss rates at Belgrano and SPS. Please specify.

We have specified in the text how the comparison has done. We had calculated the ozone loss rate in Belgrano for the period from day 220 to 273, when the ozone decrease is nearly linear in time. In order to compare ozone loss with those obtained for SPS, we have recalculated the ozone loss rates for September as in Hofmann et al., (2009) . The sentence now stands as:

Ozone loss rates from Belgrano have been compared with those obtained for SPS (Hofmann et al., 2009) in order to examine the vortex spatial homogeneity. Calculations have been carried out for the month of September to make data directly comparable.

p 15675, l 18: Too small for what??

We have changed the adjective small by “not significant”, as we meant that the difference in time between the two stations was not enough to justify the differences in ozone loss rates found.

p 15676, l 2: Man-made compounds like CFCs and halons are called ODS. However, the reservoir gases like HCl and ClONO2 and Clx are not named ODS. Please substitute "ODS" by "chlorine".

We have substituted ODS by Halogen compounds

Technical issues
p 15664, l 14: "warm" instead of "warms" Done

p 15664, l 25: "longest vortex": I assume longest in time. Please specify.

We meant longest in time. To avoid confusion the sentence is now:

Minimum ozone concentration of 57 DU in the 12-24 km layer remained in November when the vortex is more persistent.

p 15665, l 2: "mid 1980s" instead of "late 1980s" Done
p 15666, l 16: "both polar vortices": I assume the Antarctic and the Arctic polar vortices are meant. Please mention the word Arctic. Done
p 15667, l 5-7: "... of 2 profiles per month during summer and autumn and up to 6-10 profiles per month in winter and spring on Wednesdays ..." instead of "... of 2 profiles per month during summer and autumn months and up to 6-10 profiles in winter and spring months on Wednesdays ..."Done
p 15670, l 12: "Bhrul"? Corrected by Brühl
p 15670, l 19: "evolution during summer" instead of "evolution summer" Done
p 15671, l 15: "rate of about" instead of "rate about" Done
p 15672, l 21: "in the coldest" instead of "in coldest Done "
p 15672, l 26-27: "details on inter-annual variability of the ozone loss rate can" instead of "details on ozone loss rate inter-annual variability can" Done
p 15675, l 1: "in the rate of" instead of "in rate of" Done
p 15677, l 22 "mean rate of about" instead of "mean rate about". Done
Figs. 4 and 5: Mention the corresponding phase in the captions. We have included this information
Fig. 4: "with respect to ozone in" instead of "with respect the ozone in". Done
Fig. 7: Mention in the caption that the 2002 event was excluded for the calculation of the correlation. Done
Figs. 8 and 10: Why are there boxes around the plot symbols of South Pole data (upper left corner) and of PV criterium (lower right corner), respectively? It was just a problem with the software that has been solved
Fig. 9: "590 hours" can be placed nearer to days 275-280. Done
In my printed version of the manuscript some figures show one or more thin horizontal lines, which are not visible in the online and PDF versions.
Recommended phrasing:
p 15673, l 16-17: "In year 2010 ozone loss rate ... top layer it is even positive." Instead of "Year 2010 is also an interesting case. Ozone loss rate ... top layer is even positive." Done