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Interactive comment on "Observational evidence of EPP–NO_x interaction with chlorine curbing Antarctic ozone loss" *by* Emily M. Gordon et al.

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1 Summary

This paper reports on the connection between energetic particle precipitation (EPP) and various trace gases like chlorine substances (ClO and $ClONO_2$) and ozone during Antarctic winter/spring season. Their main finding is that ozone increases with elevated EPP, which is on first sight in contrast to expected decreases mainly due to enhanced NO_x levels directly destroying ozone. The explanation for the ozone increases is the reduction in active chlorine by additional conversion into reservoir species due to elevated NO_2 that inhibits additional ozone loss. This is, however, only statistically significant in winter/spring seasons during QBO east phases.

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Discussion paper

The analysis methods and results are well described in this study and publication is highly recommended. Nevertheless the papers lacks detailed discussion on the interpretation of the findings.

2 More discussion needed

I miss in this paper a discussion on the possible reasons why the correlation with A_p (the proxy for EPP) are only statistically significant during eastern QBO phase. In a brief statement the authors refer to the Holton-Tan mechanism (l. 376ff) but do not elucidate further on it. No explicit explanation is given why eQBO and not wQBO shows more significant result.

An important driver for polar ozone losses are stratospheric temperatures being sufficiently low. eQBO phases favors planetary wave propagation to be directed towards higher latitudes (see e.g. Baldwin et al. 2001) thus leading to higher stratospheric temperatures, higher ozone (NOy) transport and weaker polar vortices and less polar ozone loss. Consequently more ozone and NO_x (less denitrification) are then available (see for instance Sonkaew et al., doi: doi:10.5194/acp-13-1809-2013, and references therein). The warmer the polar stratosphere the stronger the diabatic descent inside the polar vortex becomes which makes the downward transport of EPP NO_x possibly more efficient during eQBO. So this could be potential mechanism that could explain the better statistics during eQBO.

Another point is that most of the (anti-)-correlation between A_p and the trace gases investigated show the highest statistical significance mostly in the upper (late winter) and middle stratosphere (spring) which is above the lower stratosphere where most of the polar ozone loss occurs. This would suggest that polar ozone loss may be less affected by EPP, but the dissolution of the ozone hole over late spring may be accelerated by a faster back conversion of active chlorine into their reservoirs due to excess NO_2 from EPP.

I think these points need be addressed in more detail in this paper.

3 Minor issues

line 5: omit "overall"

line 21: here you have a comma/semi-colon separated list, so each item should not start with capital letters, i.e. "the Brewer-Dobson circulation ...; the strong polar vortex ...; polar stratospheric clouds ..."

line 26ff: the phrase on PSC and Cl_x catalytic cycle is muddied. first: PSCs convert reservoir gases into active chlorine (mainly C_2), the sun then activates Cl_x from photolysis of Cl_2. The breakdown of CFCs (into reservoir gases) is mainly occurring outside the Antarctic vortex. Reaction R1 and R2 are not the main reactions in the lower stratosphere (mainly due to lack of atomic oxygen), so here the role of the ClO dimer is more relevant here.

l. 140: "anomaly study" –> "anomalies"

l. 141: line 149 "We exclude 2002 due to the sudden stratospheric warming that occurred in the SH that spring, disrupting the polar stratosphere therefore any NO_x descent." During that winter there were particularly high amounts of NO_x available and also strongly descended as in other winters, so there is not necessarily a disrupted NO_x descent. I suggest to make a more general statement that winter/spring seasons with abrupt surges in EPP in the middle of the winter/spring (Halloween 2013) and other perturbances that lead to sudden changes in or in-situ production of NO_x in the course of the winter seasons (like major warmings) were excluded from this study and that the focus is here on NO_x from EPP coming from higher altitudes and descending into the stratosphere over the winter season.

l. 153: "EPP effects from the previous winter". Does that mean that the A_p average from May to August (Section 2.5) is a proxy for EPP a year before. Please clarify.

Table 1: suggest to mention in the table caption the delimiter value which separates low and high A_p values.

line 210: "As in Figure 1, ozone is cos(latitude) weighted zonal mean average over 60S to 82S. Note that for all correlation analyses presented here, the data has been linearly detrended to avoid misattribution from linear increases or 215 decreases from reduced EESC since 2005." This has been already stated before and does not need to be repeated here again.

Figure 4: Why is there a data gap in OMI near October 1. By averaging many years there should be no gaps.

Figure 5: In panel (a) there are two data points from wQBO that rather fit to eQBO and one from eQBO to wQBO regression line. Some comments on that. Are there winter/spring seasons with QBO phase changes in the middle of the season? Can they cause outliers? What about years where A_p changes strongly from May to August?

Figure 5: "Recall eQBO years are [2005 2007 2009 2010 2012 2014 2017]." I would rather refer to Table 1 and omit this.

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