Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-1035-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "EPP-NO_X in Antarctic springtime stratospheric column: Evidence from observations and influence of the QBO" *by* Emily Gordon et al.

Anonymous Referee #1

Received and published: 8 January 2020

This paper uses 13 years of Aura-OMI data to study the influence of energetic particle precipitation (EPP) and the QBO on the Antarctic stratospheric springtime NO2 column. The authors show that the NO2 column is positively correlated with the geomagnetic Ap index (used as proxy for EPP) until November and that the strongest correlations take place during years with easterly phase of the QBO. This is an interesting paper which should be suitable for publication after addressing my comments below, mostly dealing with the explanations provided for the encountered QBO dependence.

General comments:

(1) The title of the paper suggests that polar springtime EPP-NOx is influenced by the QBO, however, none of the suggested mechanisms results in a modulation of the EPP contribution. Specifically, the authors suggest that (i) the "amount of the primary NOx source, N2O, transported into the polar regions" is affected by the QBO, and (ii) the "QBO affects the temperature of the polar vortex and thus the amount of denitrification". (i) would affect only the background NOx concentration (produced by N2O oxidation) and not the EPP contribution. (ii) would represent a total NOy loss mechanism (independently whether produced by EPP or N2O) and hence would not alter the relative EPP-NOx contribution. In the sense a title like "Evidence for EPP and QBO modulations of the Antarctic NO2 springtime stratospheric column from OMI observations" would be more appropriate.

(2) It is suggested that, during eQBO, there is a lack of N2O transported to the polar regions which, in turn, results in a more prominent EPP-NOx contribution and hence better correlation of the observed NO2 column with Ap. This hypothesis is based on Fig 1 of Strahan et al. (2015) indicating a polar springtime N2O depletion during eQBO around 400-600 K (corresponding to approximately 15-25 km) from MLS observations. However, NOy production by N2O oxidation occurs predominantly at higher altitudes (peaking around 30 km which corresponds to a potential temperature level of around 800K) where the MLS observation analysed by Strahan et al. show a N2O increase during eQBO from the equator to around 70S. It is thus more likely that the background NO2 column is enhanced rather than decreased during eQBO because of increased N2O oxidation in the subpolar regions. Note that this is also in consonance with the results shown in Figures 3 and 4.

(3) It is further suggested that the "QBO affects the temperature of the polar vortex and thus the amount of denitrification", resulting in smaller NO2 losses and hence increased NO2 during eQBO. The authors base this explanation on MLS HNO3 observations, indicating an HNO3 increase during eQBO in the 100-10 hPa range. However, it is not clear whether this increase is caused by reduced HNO3 losses (due to a warmer

vortex and hence reduced PSC formation) or due to increased productions (e.g. by increased N2O oxidation as mentioned above). In order to proof their "denitrification" hypothesis, the authors should demonstrate that the HNO3 enhancements during eQBO are linked to temperature increases and/or PSC occurrence. In this context it is worth to mention that the link of PSC coverage and QBO modulation of polar temperature via the Holton-Tan effects is still under debate (see, e.g, Section 4 of Strahan et al., 2015).

Specific comments:

l23-25: Strahan et al. have shown that the lower stratospheric N2O anomaly at 450 K in the Antarctic polar springtime vortex correlates with the surfzone anomaly at 650 K 12 months earlier, the latter being characterized by enhanced N2O during eQBO.

l27: strictly speaking it is HNO3 (not NOx) being removed by denitrification.

l63: the major SSW occurred in January 2004 (not December 2003).

l85-86: This sentence is a repetition of what is stated in the preceding paragraph.

l87 "...whether this IS detectable...."

l147: It is the combined EPP and QBO influence which leads to the most prominent differences between H-Ap/eQBO and L-Ap/wQBO years.

l186: Figure 5 shows correlations, not NO2 column increases.

l204-205: What about wQBO? Fig 7a suggests that correlations improve also for wQBO when considering vortex-only observations.

l206: Consider to add "(see Fig. 7b)"

l215-220: see general comment (2)

l223-236: see general comment (3)

l229: QBO direction -> QBO phase

l251: "average rate" implies a time dependence. "average Ap dependence" would be clearer.

l257: Why should total EPP-NOx only be accounted for in eQBO years?

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