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Effects of energetic particle precipitation and Quasi-Biennial Oscillation on polar ozone and polar vortex

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Energetic particle precipitation (EPP) has been shown to cause indirect ozone loss in the stratosphere during polar winter when long-lived nitric oxide (NO_x) molecules created by EPP are transported down from the mesosphere to the stratosphere. This has been suggested to enhance polar vortex with the effect propagating even to ground level, where it is observed as a more positive phase of the Northern Annular Mode (NAM), the dominant ground circulation pattern in the winter time at high latitudes. Recent research has also shown that the Quasi-Biennial Oscillation (QBO) modulates the relationship between NAM and EPP so that the positive correlation between the two is more clearly seen in the easterly phase of QBO measured at 30 hPa height especially during the late winter season. The cause for this QBO modulation is presently not well understood.

Here we elaborate the QBO modulated connection between EPP and NAM by studying how the EPP affects the stratospheric polar vortex in the two phases of the QBO. Since the EPP presumably affects the polar stratosphere via indirect ozone loss we will study how the EPP modulates the amount of ozone, the stratospheric temperatures and zonal winds in the two QBO phases. We show that the EPP related ozone loss and consequent enhancement of polar vortex is significantly stronger in the easterly QBO phase than in the westerly phase. To understand this difference we consider the effects of QBO on the Brewer-Dobson circulation which transports both ozone and NO_x into the polar stratosphere.