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Effect of energetic electron precipitation on the northern polar vortex and its modulation by QBO and meridional circulation

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Energetic electron precipitation (EEP) forms odd nitrogen oxides (NO_x) in the mesosphere, which can catalytically destroy ozone. Such ozone loss happens directly in the mesosphere and indirectly in the stratosphere, where the EEP created NO_x can descend over the winter in polar darkness. Earlier studies have shown that increased EEP activity enhances the stratospheric polar vortex, most likely due to EEP associated ozone loss. The EEP effect on atmospheric dynamics propagates to the surface level, as indicated by a significant correlation of the Northern Annular Mode (NAM) weather pattern with EEP activity. Recently, the EEP effect on polar vortex and NAM has been found to be modulated by Quasi-Biennial Oscillation (QBO). However, the cause of this QBO modulation has remained unresolved. Here we study the EEP effect on the northern polar vortex and how it depends on the QBO phase. We use corrected satellite measurements of precipitating electron fluxes from POES satellites and the ERA-Interim re-analysis data to study the EEP effect on zonal wind, temperature and ozone mass mixing ratio during 1979-2016. We show that the EEP effect on polar vortex is stronger and more significant in the easterly QBO phase (at 30 hPa) compared to westerly phase. Using the ozone mass mixing ratio as a rough proxy for the strength of the Brewer-Dobson circulation (BDC) we show that the EEP effect on the polar vortex is modulated by the BDC.