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Modulation of the Northern Polar Vortex by Particle Precipitation, QBO Phase and Sudden Stratospheric Warmings

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Energetic particles, especially electrons, regularly precipitate to the upper atmosphere forming odd nitrogen oxides (NO_x), which can catalytically destroy ozone. 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. Polar vortex is a jet of strong westerly winds in the stratosphere that develops each winter around the winter pole. It experiences considerable inter-annual variability, which is also reflected on tropospheric weather as the NAO/NAM weather pattern. Recent studies have shown that the positive phase of the NAO/NAM pattern is strongly favored during the declining phase of the solar cycle. This gives evidence for a significant modulation of the polar vortex by high-speed solar winds. High-speed winds are known to be most effective in accelerating magnetospheric particle that can precipitate into the upper atmosphere. The related increase in energetic electron precipitation (EEP) enhances the polar vortex, most likely due to associated ozone loss. Moreover, the EEP effect on polar vortex and NAM has been found to be modulated by the phase of Quasi-Biennial Oscillation (QBO). EEP-related variations to the polar vortex in late winter are predominantly observed only in the easterly phase of the QBO, and the effect enhances with a few months lag is QBO phase definition. Sudden stratospheric warmings (SSW) are a quasi-regular phenomenon that disrupt the northern polar vortex typically every second winter. Here we study the interrelations between these middle-atmospheric forcings (EEP, QBO, SSW) and discuss how the EEP can dynamically affect the northern polar vortex.