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Influence of energetic particle precipitation on polar vortex mediated by planetary wave activity

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The northern polar vortex experiences considerable inter-annual variability, which is also reflected to tropospheric weather. Recent research has established a link between polar vortex variations and energetic electron precipitation (EEP) from the near-Earth space into the polar atmosphere, which is mediated by EEP-induced chemical changes causing ozone loss in the mesosphere and stratosphere. However, the most dramatic changes in the polar vortex are due to strong enhancements of planetary wave activity, which typically result in a sudden stratospheric warming (SSW), a momentary breakdown of the polar vortex. Here we use the SSWs as an indicator of high planetary wave activity and consider their influence of SSWs on the atmospheric response to EEP in 1957-2017 using combined ERA-40 and ERA-Interim re-analysis data and geomagnetic activity as a proxy of EEP. We find that the EEP-related enhancement of the polar vortex and other associated dynamical responses are seen only during winters when a SSW occurs, and that the EEP-related changes take place slightly before the SSW onset. We show that the atmospheric conditions preceding SSWs favor enhanced wave-mean-flow interaction, which can dynamically amplify the initial polar vortex enhancement caused by ozone loss. These results highlight the importance of considering SSWs and sufficient level of planetary wave activity as a necessary condition for observing the effects of EEP on the polar vortex dynamics.