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Asymmetries in seasonal stratosphere-troposphere interaction

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While a large body of studies has indicated a significant statistical relationship between episodes of strong (weak) polar stratospheric vortex in winter with positive (negative) phases of the North Atlantic Oscillation (NAO) or Arctic Oscillation and, consequently, weather and climate over the North Atlantic, Europe and large parts of Siberia, aspects of the mechanisms involved remain unclear. Statistical inferences based on seasonal anomalies are complicated by (causal or coincident) interferences from additional lower frequency processes like the phase of the Quasi Biennial Oscillation (QBO) and of the El Niño Southern Oscillation (ENSO).
Taking these additional phenomena into account, we present an analysis based on reanalysis data since 1948 of climate anomalies during extremely strong and weak midwinter polar vortex. We find that nearly all extremely strong stratospheric polar vortices took place during cold to neutral ENSO and westerly QBO phases, while extremely weak polar vortices were observed during both warm and cold ENSO and during both phases of the QBO. Interestingly, and different from previous suggestions, the NAO is barely impacted by very strong polar vortices, while for very weak polar vortices a strong negative NAO and very cold winter conditions over midlatitude Eurasia are found. The latter anomalies are enhanced during warm ENSO episodes, which are all characterized, in weak polar vortex winters, by Central Pacific Warming and an active upper tropospheric subtropical bridge between the Pacific and the Atlantic.
We show differences in the seasonal evolution of very strong and weak polar vortices and highlight that different mechanisms are responsible for tropospheric climate anomalies during strong and weak polar vortex winters. We suggest that the statistics of previous seasonal analyses of the dynamical coupling between stratosphere and troposphere were dominated by the effects observed during weak polar vortex and that the state of ENSO, especially during Central Pacific Warming, has a bigger impact on climate anomalies over Eurasia than anticipated so far.