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Onset of circulation anomalies during stratospheric vortex weakening events: the role of planetary-scale waves

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While mounting evidence links weak polar vortex events in the stratosphere to the upward propagation of planetary-scale Rossby waves from the troposphere to the stratosphere, the causes of the accompanying tropospheric circulation anomalies remain uncertain. To highlight the details of stratosphere-troposphere dynamical coupling during the onset of events of strong vortex variability, this study identifies Stratospheric Vortex Weakening (SVW) events using rapid deceleration of polar vortex and performs composite budget analyses of the zonal wind tendency in the Transformed Eulerian Mean (TEM) framework on daily time scales.

Consistent with previous work on the variability of the Northern Annular Mode (NAM), the time evolution of zonal wind anomalies during SVW events shows a near-instantaneous vertical coupling in a time scale of only a few days which results from an anomalous upward and poleward propagation of planetary-scale waves. This coupling differs from the extended stratosphere-troposphere coupling that results from synoptic-scale eddy feedbacks. Decomposition of the eddy fields into individual wavenumber components reveals that while stratospheric deceleration is due to zonal wavenumber one and two waves, tropospheric change is dominated by the latter. It is also found that wavenumber-one disturbances in the troposphere have less geographical preference during the onset of the SVW events, whereas wavenumber-two disturbances project strongly onto the climatological pattern of planetary-scale waves in most cases. This indicates the presence of a constructive linear interference of wavenumber-two disturbances that systematically modulates vertically propagating planetary-scale waves. These results are largely insensitive to the stratospheric background flow conditions, whether events occur under strong or weak vortex regimes.

Diagnostics of finite amplitude wave activity suggest that SVW events are caused not only by planetary-scale wave breaking but also by transient wave propagation. Overall results are also compared with vertical coupling associated with weak polar vortex events such as stratospheric sudden warming events.