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# Stratospheric cooling and downward planetary-wave propagation in the lowermost stratosphere during the 2010-11 winter

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Dynamical cooling in the polar stratosphere is induced by weakening of E-P flux convergence (i.e. anomalous divergence) in the stratosphere. As the E-P flux convergence is mainly contributed to by upward planetary-wave (PW) propagation from the troposphere, the intensity of its propagation is well correlated with the E-P flux convergence and the polar stratospheric temperature. Recent studies (Orsolini et al. 2009, QJRMS; Nishii et al. 2010, GRL) pointed out that a tropospheric blocking high over the western Pacific, whose anomalous circulation is projected strongly onto the Western Pacific (WP) teleconnection pattern, tends to weaken the upward PW propagation and thus lower the polar stratospheric temperature. In this study, we present a possibility that downward PW propagation in the lowermost stratosphere can also cause the E-P flux divergence in the polar stratosphere and thereby the stratospheric cooling.
On the basis of prominent downward events of the 100-hPa E-P flux averaged over the mid- to high-latitudes in the northern hemisphere, we performed a lag composite analysis for each of the terms of the transformed Eulerian mean (TEM) equation. In the composite time evolution, downward E-P flux in the lowermost stratosphere and the E-P flux divergence aloft are evident around the reference date, followed by persistent cooling of the polar stratosphere for more than two weeks. About one week before the reference date, enhanced upward E-P flux and its convergence lead to the deceleration of upper-stratospheric zonal winds and thus the weakening of their vertical shear , which may result in the formation of a turning surface for upward-propagating PWs. Our results are overall consistent with Harnik (2009, JGR), who showed that a short pulse of upward-propagating PWs forms a turning surface in the upper stratosphere, where the PWs that subsequently propagate upward can be reflected back.
By taking above results into consideration, we analyzed the prolonged cold 2010-11 winter. We found that while three cooling events in December and January were accompanied by tropospheric WP pattern events, cooling in February and March was led by downward-propagating PW events.