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2010-2011 冬季における寒冷な極域成層圏と惑星波の下向き伝播
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 E-P flux convergence and the polar stratospheric temperature. Several studies (Orsolini et al. 2009, QJRMS; Nishii et al. 2010, GRL) pointed out a tropospheric blocking high over the western Pacific, whose circulation pattern has projection onto the Western Pacific (WP) teleconnection pattern, tend to weaken the upward PW propagation and to lower the polar stratospheric temperature. In this study, we investigate a possibility that downward PW propagation in the lowermost stratosphere also causes the E-P flux divergence in the polar stratosphere and leads to stratospheric cooling.

Based on prominent negative events of vertical 100-hPa E-P flux averaged over the mid- to high-latitudes in the northern hemisphere, we performed composite analyses for each term of a transformed Eulerian mean (TEM) equation. Downward E-P flux in the lowermost stratosphere and divergence of E-P flux in the stratosphere are observed around the reference date, which is followed by persistent cooling of the polar stratosphere more than two weeks. About one week before the reference date, enhanced upward E-P flux and its convergence lead to deceleration of upper stratospheric zonal wind. This deceleration results in weakening of vertical sheer of zonal wind at the level, which hints at a turning surface for vertically-propagating PWs there (Harnik 2009, JGR). Our results are mostly consistent with Harnik (2009, JGR) who showed that a short pulse of upward-propagating PW forms a turning surface in the upper stratosphere, where the PW is 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 was led by downward-propagating PW events. Cooling in March is accompanied both by WP and downward-propagating PW events.

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