The role of gravity waves in the evolution of the vortex-splitting stratospheric sudden warming in January 2009

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The role of gravity waves (GWs) in the evolution of the stratospheric sudden warming (SSW) is investigated for a SSW event occurred on 24 January 2009 with the strongest warming and a clear polar vortex splitting, using a MERRA-2 reanalysis data set including parameterized GW drag (GWD) data. At 5 days before the central date of the SSW of which the zonal-mean zonal wind at 10 hPa and 60^{o}N first becomes negative, planetary waves (PWs) of zonal wavenumber (ZWN)-2 in the high-latitude stratosphere are enhanced while PWs of ZWN-1 are weakened. During the SSW evolution, westward GWD in the high-latitude is enhanced in the upper stratosphere and the mid-stratosphere nearly 2 weeks prior to the central date. Statistically significant lagged correlation between GWD and the amplitude of PWs of ZWN-2 at 10 hPa occurs at nearly two weeks in the upper stratosphere and the mid-stratosphere. To examine the relationship between the planetary waves and GWs precisely, a non-conservative GWD forcing term (source term) of the quasi-geostrophic potential vorticity (QGPV) equation is considered. Surprisingly, a ZWN-2 pattern of the non-conservative GWD forcing is developed about 2–3 weeks before the central date of the SSW in the upper stratosphere and near 10 hPa, and its correlation with PWs of ZWN-2 at 10 hPa is largest from about 5 days before the central date to the central date. This implies that amplification of PWs of ZWN-2 in the stratosphere before the SSW occurrence is related to generation by GWs, by the non-conservative forcing term in the QGPV equation in the stratosphere.