成層圏突然昇温に伴う成層圏重力波励起機構の変化

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Gravity Wave Source Variations during the 2009 Stratospheric Sudden Warming

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Gravity waves are a key element for driving the atmospheric coupling from the stratosphere to the thermosphere during stratospheric sudden warmings (SSWs). The limited knowledge of gravity wave variations and their source distribution leads model uncertainties in SSW simulations. In this study, the high-resolution ECMWF-T799 (25km horizontal resolution and 91 vertical levels up to 0.01 hPa) is used to study the physical mechanisms of gravity wave variations associated with the 2009 SSW.

ECMWF results indicate that gravity wave activities enhance at the edge of the polar jet prior to the 2009 SSW. The magnitudes and occurrences of gravity waves correlate well with the location and strength of the polar vortex that is strongly distorted by planetary wave growth. During the development and onset of SSW, the zonal-mean gravity wave potential energy density (GW-Ep) increases prior to the peak SSW in association with the growth of planetary wave wavenumber 1 and wavenumber 2, respectively, and significantly weakens after the SSW. These variations are confirmed by COSMIC/GPS observations. Two different physical mechanisms play important roles on these variations. GW-Ep enhancements prior to the SSW correspond well with the positive vertical gradient of total perturbation energy flux (F_E) indicating that the in-situ energy sources cause the enhancements of GW-Ep. To identify the in-situ energy source, the residual tendency is used to examine the locations of unbalanced flow that can excite gravity waves through spontaneous adjustment process. The temporal and spatial variations of residual tendency correspond well with the strong gravity wave activities. Therefore, two peaks of gravity wave activity are strongly tied to the increase of in-situ spontaneous adjustment gravity wave source that is not included in most of gravity wave parameterization scheme. Sudden decay of gravity wave activities correlates well with the variations of probabilities of gravity wave propagations from the troposphere to the stratosphere obtained from the GROGRAT ray-tracing model. In addition, the vertical derivatives of F_E show the decay after January 22. These results indicate that decay of gravity waves after wind reversal is likely due to changes of gravity wave propagations along with the weakens of in-situ spontaneous adjustment process.