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Characteristics of gravity waves revealed in a high-resolution baroclinic wave simulation

Young-Ha Kim (1), Hye-Yeong Chun (1), Sang-Hun Park (2), Hyun-Joo Choi (3), and In-Sun Song (3)

(1) Yonsei University, Seoul, Korea, Republic Of, (2) National Center for Atmospheric Research, Boulder, CO, (3) Korea Institute of Atmospheric Prediction Systems, Seoul, Korea, Republic Of

Mesoscale modeling results from an idealized baroclinic wave simulation are used to investigate gravity waves associated with jet and frontal systems. The simulation is conducted using the global Weather Research and Forecasting (WRF) model with a horizontal resolution of $\sim$0.09°, based on the balanced initial conditions proposed by Jablonowski and Williamson and a baroclinic wave disturbance with a zonal wavenumber 9. In the simulation, the mesoscale gravity waves begin to appear around 55°N when and where the baroclinic wave disturbance is well developed. These gravity waves (G1) are identified by three wave packets in the upper troposphere propagating eastward, southeastward, and northeastward, which are advected by the background westerly jet. They have horizontal wavelengths of 50–600 km at 300 hPa, with a peak of approximately 110 km. Their phase speed ranges from 10 to 23 m s^{-1}. About one day after the G1 appears, a secondary cyclone is developed in the lower troposphere around 45°N according to the development of baroclinic waves, and mesoscale gravity waves distinct from G1 appear (G2) above this cyclone. The G2 is quasi-stationary, with a peak wavelength of about 360 km at 300 hPa. For both G1 and G2, the zonal momentum flux is negative, implying that upward-propagating mode is dominant. In the lower stratosphere, the magnitude of G1 decreases significantly because the waves are largely filtered above the jet, whereas the quasi-stationary G2 propagates into the stratosphere with substantial amplitudes.