Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS22-06 Room:301B Time:May 20 10:15-10:30

Gravity waves associated with an extratropical cyclone and possible role in the formation of tropopause inversion layer

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We perform a numerical simulation on the generation of gravity waves associated with an extratropical cyclone and investigate its possible role in the formation of tropopause inversion layer (TIL), which is a persistent layer with high static stability (Birner, 2002). We use a JMA regional non-hydrostatic model (NHM), which has 200 layers in the vertical from the surface to 25 km in altitude, and the horizontal domain is 4140 km x 4000 km around Japan with a horizontal resolution of 20 km. The time integration period is 72 hours from 19th to 22nd in February, 2009, during which a typical explosive cyclogenesis was observed. For the initial and boundary conditions, we use NCEP FNL.

An arc-shaped wave packet propagating northward from a jet streak associated with the extratropical cyclone is identified during its developing stage, and the wave packet satisfies the dispersion relation of inertia-gravity wave with a period of about 300 minutes. Histograms of N^2 at the TIL classified by d^2w/dz^2 and dw/dz at the TIL show that enhancement of d^2w/dz^2 by vertically-propagating gravity waves have a significant impact on the strength of the TIL. The effect of gravity waves on the TIL is clearer in the regions where relative vorticity at the tropopause is negative. This result implies that gravity waves may have an important role in making the negative correlation between the strength of the TIL and relative vorticity at the tropopause.

Keywords: gravity waves, extratropical cyclone, tropopause, inversion layer, numerical simulation