南極における慣性重力波による多重圏界面の研究

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A study of multiple tropopause structures caused by inertia-gravity waves in the Antarctic

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Multiple tropopauses (MT) defined by the World Meteorological Organization are frequently detected in autumn to spring at Syowa Station (69.0°S, 39.6°E). The dynamical mechanism of MT events was examined by observations of the PANSY radar, the first Mesosphere-Stratosphere-Troposphere radar in the Antarctic, and of radiosondes on 8–11 April 2013 (Fig. 1). The MT structure above the first tropopause is composed of strong temperature fluctuations. By a detailed analysis of observed three-dimensional wind and temperature fluctuation components, it is shown that the phase and amplitude relations between these components are consistent with the theoretical characteristics of linear inertia-gravity waves (IGWs).

Numerical simulations were performed by using a non-hydrostatic model. The simulated MT structures and IGW parameters agree well with the observation. In the analysis using the numerical simulation data, it is seen that IGWs were generated around (15°E, 65°S) and around (15°E, 70°S), propagated eastward, and reached the region above Syowa Station when the MT event was observed (Fig.2). These IGWs were likely radiated spontaneously from the upper tropospheric flow around (15°E, 65°S) and were forced by strong southerly surface winds over steep topography (15°E, 70°S). The MT occurrence is attributable to strong IGWs with low static stability in the polar winter lower stratosphere.

It is also shown that non-orographic gravity waves associated with the tropopause folding event contribute to 40% of the momentum fluxes, as shown by a gravity-wave resolving general circulation model in the lower stratosphere around 65°S. This result indicates that they are one of the key components for solving the cold-bias problem found in most climate models.

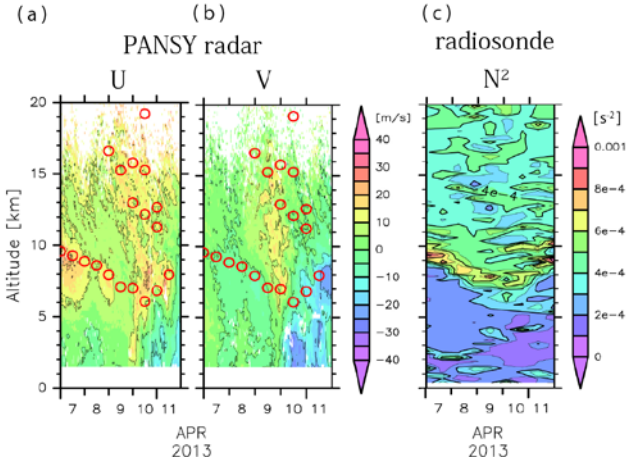

Fig.1: Time-altitude cross sections of (a) zonal wind velocity and (b) meridional wind velocity (contour interval 10 m s^{-1}) from the PANSY radar observations and (c) Brunt-Väisälä frequency from twice daily operational radiosonde observations (contour interval 1.0×10^{-4} s^{-2}).

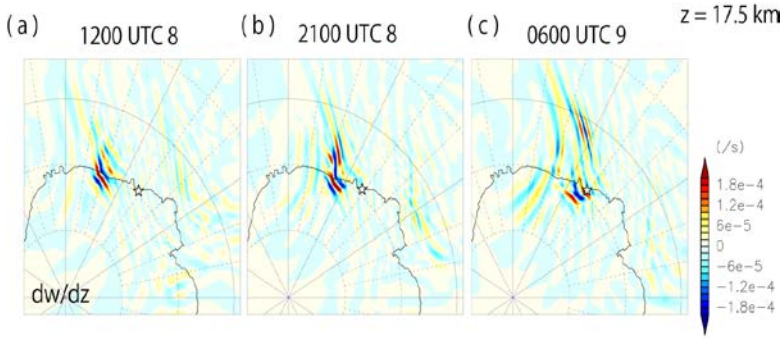

Fig.2: Snapshots of horizontal maps of vertical gradient of vertical wind components at (a) 1200 UTC 8, (b) at 2100 UTC 8 and (c) at 0600 UTC 9 April 2013 at z =17.5 km. A star mark denotes the location of Syowa Station (69°S, 39.6°E).