Gravity wave characteristics in the winter Antarctic mesosphere by a long-term numerical simulation using a non-hydrostatic general circulation model

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A long-term simulation using a high-top Non-hydrostatic ICosahedral Atmospheric Model (NICAM) is carried out to analyze mesospheric gravity waves in five months from April to August 2016 when continuous observations were made by the full system of the first Antarctic Syowa MST/IS Radar (PANSY radar) at Syowa Station (39ºE, 69ºS). The model top of the NICAM is extended to an altitude of 87 km with a vertical grid spacing in the middle atmosphere of about 300 m.

Successive runs lasting 7 days are made with the initial condition from the MERRA reanalysis data with an overlap of two days between the two consecutive runs to maintain long-term simulations sufficiently close to the reanalysis data. Analyses are made for the last five days for each run. It is confirmed by comparing with the PANSY radar observation that mesospheric wind fields simulated by NICAM are realistic, although the amplitudes of the wind disturbances seem to be slightly larger than radar observations. The latitude-height structure of the zonally-averaged zonal winds is also comparable to the MERRA reanalysis data.

The frequency spectra of zonal, meridional and vertical wind fluctuations and temperature fluctuations are obtained for the period from June to August 2016. The power spectra of zonal and meridional wind fluctuations at Syowa Station obey a power law with an exponent of approximately -5/3 in higher frequency region than the inertial frequency f (corresponding to (2π/12.7 h)), while that of vertical wind fluctuations has a flat structure (i.e., $\propto \omega^0$) at frequencies from (2π/2 h) to (2π/5 days). The power spectrum of the meridional wind fluctuations without the migrating tides has an isolated peak around frequencies slightly lower than f at latitudes from 30ºS to 75ºS. On the other hand, there are isolated spectral peaks of meridional wind fluctuations at frequencies of about (2π/8 h) for 78ºS to 90ºS, which is consistent with the lidar observation made by Chen et al. (2016).

Moreover, the frequency spectra of vertical fluxes of zonal and meridional momentum (Re[$U(\omega)W^*(\omega)$], Re[$V(\omega)W^*(\omega)$]) are obtained for the time period of JJA 2016. It seems that Re[$U(\omega)W^*(\omega)$] is mainly negative in the examined frequency range and has an isolated peak at a frequency slightly lower than f at the height of 70 km. The latitudinal structure of Re[$V(\omega)W^*(\omega)$] suggests the propagation paths of the gravity waves which focus into the regions slightly poleward of the axis of the polar night jet.

Key words: gravity wave, high-resolution modeling, MST radar observation

References

Chen, C., Chu, X., Zhao, J., Roberts, B. R., Yu, Z., Fong, W., et al. (2016). Lidar observations of persistent gravity waves with periods of 3–10 h in the Antarctic middle and upper atmosphere at McMurdo (77.83°S, 166.67°E). *Journal of Geophysical Research: Space Physics*, **121**, 1483–1502.