A Study of Gravity Waves in the Antarctic Troposphere and Lower Stratosphere Observed by the PANSY Radar

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Gravity waves (GWs) mainly generated in the troposphere propagate into the middle atmosphere, deposit momentum, and drive the material circulation in the middle atmosphere (e.g. Plumb, 2002). The necessity of a quantitative analysis of GWs in the polar region based on observations has been widely recognized (cf. Geller et al., 2013). The PANSY (Program of the Antarctic Syowa MST/IS) radar installed at Syowa Station (39.59°E, 69.01°S) is the first MST radar in the Antarctic. The MST radar is a powerful observational instrument providing vertical profiles of vertical and horizontal winds with high time and height resolutions and good accuracy. From October 2015 to September 2016, continuous observations by the full system of the PANSY radar were conducted. Such a long-period continuous observation is unprecedented as MST radar observations even including those at low and middle latitudes. The time series with such a high time resolution over a long time period allow us to analyze almost full frequency range of inertial GWs from the inertial frequency [2π/(13 h) at Syowa Station] to the Brunt-Väisälä frequency [typically, 2π/(10 min) in the troposphere] in case of negligible Doppler shift by the background wind. The purpose of this study is to examine statistical characteristics of GWs in the troposphere and lower stratosphere in the Antarctic utilizing the data over a year.

The frequency power spectra of horizontal wind fluctuations have an isolated peak around f in the lower stratosphere (Fig. 1). The zonal momentum flux spectra ($\omega \mathrm{Re}[U(\omega)W^{*}(\omega)]$) are also largely negative around f. Sato et al. (1999) showed using a GW-permitting GCM that power spectra of horizontal wind fluctuations have an isolated peak near f of each latitude in the lower stratosphere. It is considered that the waves having a quasi-inertial frequency observed by the PANSY radar are likely one of such inertia-GWs.

A hodograph analysis is performed and results are statistically examined by focusing on the GWs with a quasi-inertial frequency (QIGWs) in the lower stratosphere. A striking feature is that the percentage of QIGWs propagating energy downward is significantly large above the height of z ~ 15 km in the winter stratosphere, although that of QIGWs propagating energy upward is still more than half. These results suggest that the sources of QIGWs propagating energy downward exist in the stratosphere and/or above in winter. The distribution of ground-based phase velocities (c) is much different between the QIGWs propagating energy upward and downward. A significant proportion of QIGWs propagating energy downward have large c pointing to the east, whereas most QIGWs propagating energy upward have c around 0 $\mathrm{m\ s^{-1}}$. This result supports that the origins are different between the upward and downward propagating QIGWs. The most likely candidates are the Antarctic topography for upward propagating waves and the polar night jet for downward waves.

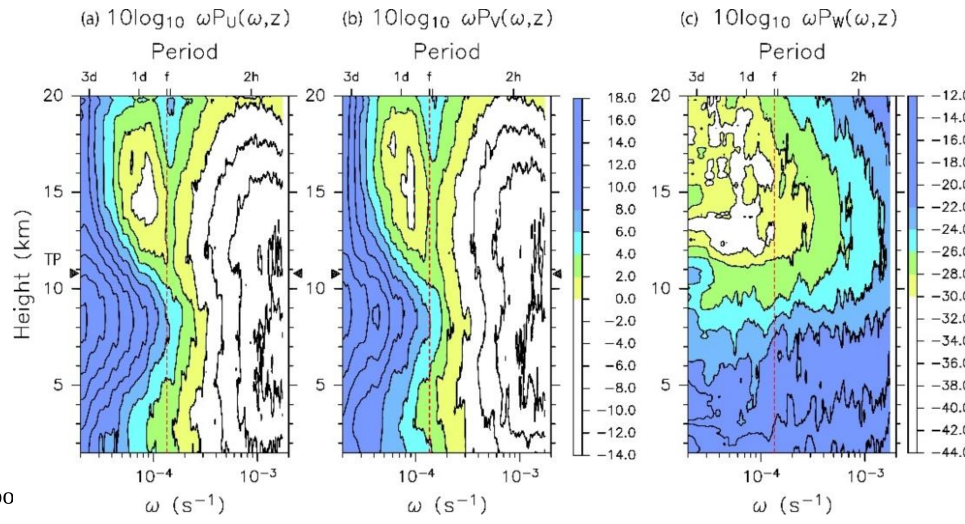

Fig1. Frequency po … ember 2016.

Figures are shown in energy content form as a function of height and frequency.