The Kelvin-Helmholtz billows in the Antarctic troposphere and lower stratosphere captured by the PANSY radar at Syowa Station (69.0°S, 39.6°E)

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Atmospheric turbulence plays a role in mixing and irreversible transport of heat, momentum, and various materials. Due to its small spatial and temporal scales, it is difficult to observe its structure directly and the entire time evolution from its onset to disappearance. Therefore, the role of turbulence is not well understood qualitatively. Kelvin-Helmholtz instabilities (KHIs) resulted from enhanced vertical shear in the atmosphere, are one of the major sources of atmospheric turbulence; when KHI occurs, it generates Kelvin-Helmholtz waves (KH waves), which mix heat and materials up and down. They are small-scale phenomena with a duration as long as 30 minutes and depth smaller than 2.5 km (Fukao *et al.*, 2011). The purpose of this study is to elucidate the dynamical structure and formation mechanism of KH waves in the Antarctic troposphere and lower stratosphere using the PANSY radar observation (installed at Syowa Station [69.0°S, 39.6°E]) using the frequency-domain interferometry (FDI) technique which enables the observation with the high-resolution in both temporal and spatial directions.

In the standard observation mode, The PANSY radar has temporal and vertical resolutions of 200 seconds and 150 m, respectively. On the other hand, in the FDI observation mode using five different frequencies of transmitted waves, an echo power which suggests that Bragg scattering from isotropic turbulence is obtained with a resolution higher than the transmitted pulse width. The campaign focused on atmospheric microstructure in the troposphere and lower stratosphere are performed from March 14-24 and August 2-12, 2019 (20 days in total). During the campaign, the FDI mode observations (~22 minutes) and the standard mode observations (~ 7 minutes) were repeated. In the campaign, radiosonde observations were also carried out every 4 hours. The FDI mode provides vertical profiles of the vertical wind as well as the echo power, while the standard observation mode provides vertical profiles of the three-dimensional wind including vertical wind and echo power. Vertical profiles of horizontal winds, temperature, and humidity were also obtained from radiosonde observations.

During the campaign, structures which appear to be KH waves were captured several times. In this presentation, we focus on the KH waves captured at (a) 1230UT-1430UT on 21 March around the height of 9.0 km and (b) 1130UT-1230UT on 22 March around the height of 7.0 km. In case (a), a wave-like structure evident in the horizontal winds having a period shorter than 1 day was associated with KH waves. A hodograph analysis conducted for this wave-like structure has shown that it has a northeast- or southwestward wave vector and upward group velocity. Its vertical and horizontal wavelengths were also estimated to be about 1.7 km and 132.9 km, respectively. The long ground-based period of about 55.5 hours suggests that the wave-like structure is a topographic gravity wave (GW). These mechanical properties are consistent with a northeasterly wind of about 15 m s^{-1} near the surface during this period. It is also found that the large part of the vertical shear in this height region is accounted for by the shera associated with the GW. In case (b), a wave-like structure localized around the height of 7.0 km was found to form an enhanced vertical shear. A hodograph analysis was performed and the parameters of the wave-like structure were estimated; the structure has a southeast or northwest wave vector, an upward group velocity, vertical and horizontal wavelengths of about 1.6 km and 90.8 km, respectively, and a ground-based period of about 3.3 hours, which is short for a topographic GW. The wave-like structure may be a non-orographic wave excited from a developed trough in the vicinity of the Syowa Station. We will also present the results based on both our observational data and the results of the numerical model simulations using the Nonhydrostatic ICosahedral Atmospheric Model (NICAM).

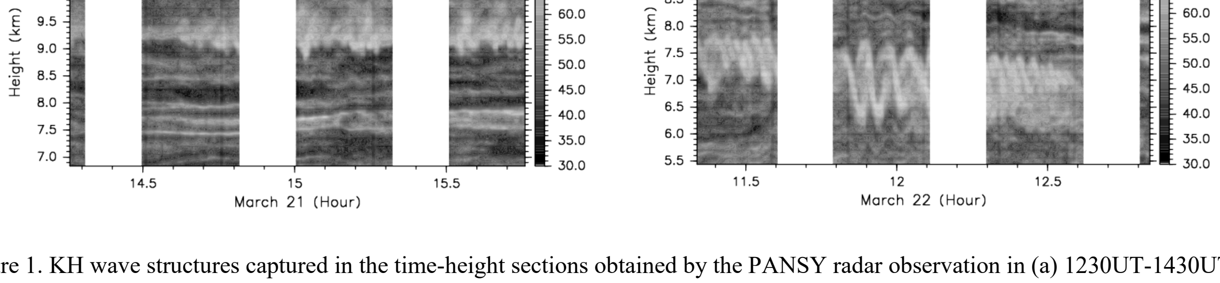

Figure 1. KH wave structures captured in the time-height sections obtained by the PANSY radar observation in (a) 1230UT-1430UT on 21 March around the height of 9.0 km and (b) 1130UT-1230UT on 22 March around the height of 7.0 km.