Fine structure of the tropopause revealed by the PANSY radar at Syowa Station in the Antarctic

Masatoshi Mizukoshi[1], Masashi Kohma[1], Kaoru Sato[1],and Masaki Tsutsumi[2]
[1]*Department of Earth and Planetary Science, The University of Tokyo*
[2]*National Institute of Polar Research and The Graduate University for Advanced Studies (SOKENDAI)*

Rapid and deep descent in the tropopause (the so-called tropopause folding) is often observed in association with the strong cyclonic disturbances in the extratropics. It is considered that such tropopause folding significantly contributes to the stratosphere-troposphere exchange. The tropopause height is conventionally defined as the temperature lapse rate. Based on the definition, the climatology and variability of the thermal tropopause heights were investigated in previous studies. However, the determination of the tropopause based on the lapse rate is inadequate during Antarctic winter and spring when the lower stratosphere is cold due to low solar radiation. In the present study, characteristics of the Antarctic tropopause are examined using echo power from PANSY radar observations at Syowa Station (39.6°E, 69.0°S) and potential vorticity (PV) from the state-of-art reanalysis data (ERA5) in October 2015 through September 2016.

Figure 1 shows a time-height section of the echo power in July 2016 together with the dynamical tropopause, z_{PV}, which is defined as the PV surface of -2 PVU. It is found that the z_{PV} accords well with a sharp vertical gradient of the echo power. The sharp gradient of the echo power is associated with a jump in the Brunt-Väisälä frequency from the reanalysis. In contrast, the vertical structure of the water vapor mixing ratio does not always correspond to the sharp gradient of the radar echo. In the following, the radar-based tropopause height (z_{radar}) is defined as the height where the vertical gradient of the echo power is maximized in the height range within 300 m above and below z_{PV}.

The vertical distributions of z_{radar} and z_{PV} for each month are shown in Figure 2. Both tropopauses range from 4–13 km. The monthly average of z_{radar} is high in late winter and spring and lowest in February. It is noticeable that the bimodal distribution of the tropopause heights is observed in August and November. The frequency spectrum of z_{radar} is shown in Figure 3. The spectrum has a peak at a wave period of 3-4 days and obeys a power law of ω^{-1} for $2\pi/(3\text{day})<\omega<2\pi/(13\text{h})$.

We will also show the results of a detailed analysis of the several significant events such that the tropopause height descends to near the surface.

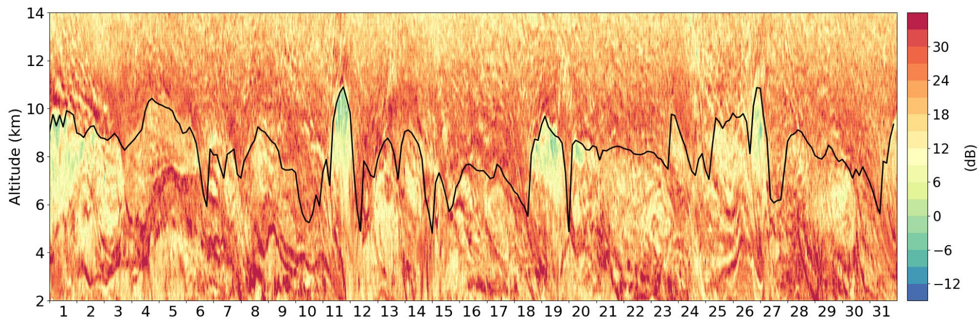

Fig. 1 A time-height section of the echo power observed by the PANSY radar in July 2016. The black curve shows z_{PV}.

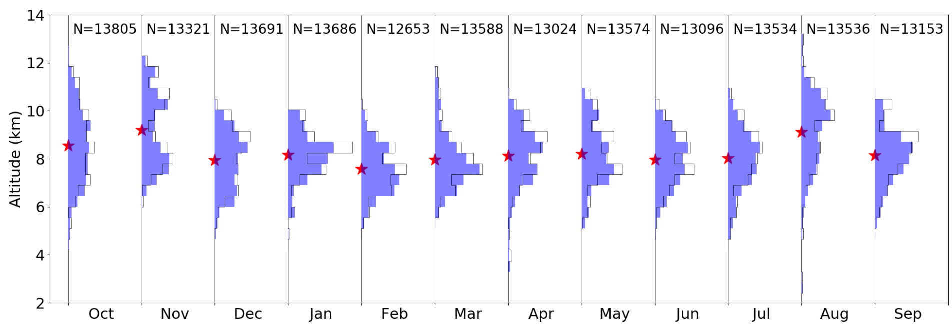

Fig. 2 The vertical distributions of z_{radar} (blue) and z_{PV} (black line) for each month. The monthly mean z_{radar} is indicated by red stars.

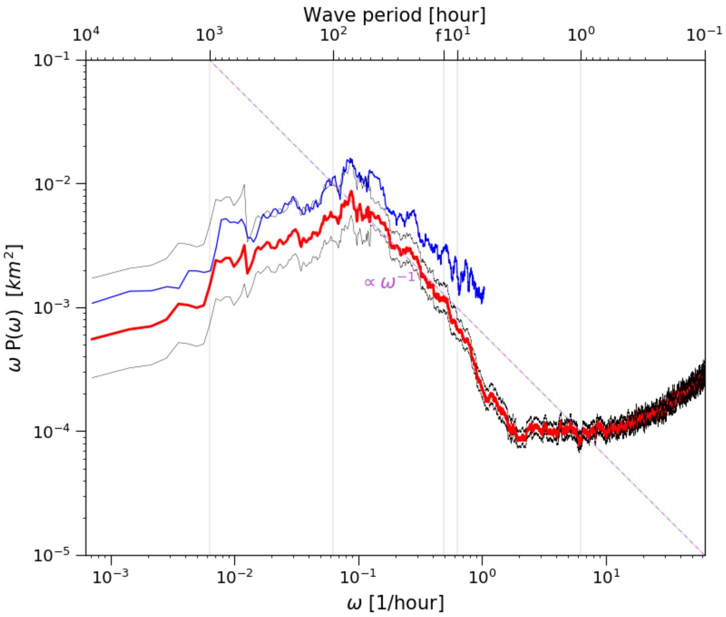

Fig.3 Frequency power spectra of z_{radar} (red curve) and z_{PV} (blue curve). The 95% confidence interval for z_{radar} is shown by gray line. A purple line indicates the slopes of ω^{-1}.