

Seasonal variation of Polar Mesosphere Winter Echo (PMWE) observed by PANSY radar

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In the lower thermosphere at the altitude of around 100 km, both neutral turbulence and ionization of atmosphere due to solar radiations cause irregularities of reflective index, and as a result back scatter echoes from that altitude are frequently observed by radars on the ground. In the mesosphere, Polar Mesosphere Summer Echo (PMSE) is reported to be a strong echo associated with ice particles, which are produced around the coldest mesopause region in the polar summer, by a number of past radar observations [Cho and Rottger, 1997; Rapp and Lübken, 2004]. It should be also noted that occurrence rate of PMSE is very high (80-90%) [Bremer *et al.*, 2003]. On the other hand, Polar Mesosphere Winter Echo (PMWE) is also known as back scatter echo from 55 to 85 km in the mesosphere, and it has been observed by MST and IS radar in polar region during winter [e.g., Ecklund and Balsley, 1981; Czechowsky *et al.*, 1989; Lübken *et al.*, 2006; Strelnikova and Rapp, 2013]. Due to the lack of free electrons and ice particles in the dark and warm mesosphere during winter, it is suggested that PMWE requires strong ionization of neutral atmosphere associated with precipitations of Solar Energetic Particles (SEPs) during geomagnetically disturbed periods [Kirkwood *et al.*, 2002; Zeller *et al.*, 2006]. However, the detailed generation process of PMWE has not been identified yet, partly because the reported PMWE occurrence rate was quite low (2.9%) [Zeller *et al.*, 2006].

In the VIII-th six-year project of the Japanese Antarctic Research Expedition (JARE) from 2010, the middle and upper atmosphere research is one of the sub-projects of the prioritized research project entitled 'Global warming revealed from the Antarctic', and comprehensive ground based observations with various remote sensing instruments for the middle and upper atmosphere have been operating continuously in Syowa station. We analyzed data obtained by PANSY (Program of the Antarctic Syowa MST/IS) radar, which is the core instrument of the project, focusing on PMWE in the context of neutral-plasma atmospheric coupling process between the middle and upper atmosphere. PANSY radar is a 47 MHz VHF radar with 125 kW (full system 500 kW) output power, and it is the largest MST radar composed 5,000 m² (full system 20,000 m²) antenna array in Antarctica at the moment. PANSY has already identified a number of PMWE near local noon since operation of mesosphere observation mode was started in June 2012.

We would like to show seasonal variations of occurrence characteristics of PMWE between June 2012 and July 2013. Taking full advantage of PANSY radar's detectability, we calculated monthly-averaged height-time section of backscatter echo power in austral winter between 2012 and 2013. The result demonstrated that durations of PMWE strongly depended on hours of sunlight, although occurrence heights of PMWE, which range from 60 to 80 km, were fixed on every month and year. These statistical characteristics of PMWE were consistent with previous studies suggesting ionization at the PMWE height due to solar radiation play a dominant role in generation of PMWE [Zeller *et al.*, 2006; Lübken *et al.*, 2006]. However, the mean occurrence rate of PMWE estimated by our study was 20-30%, which was considerably higher than that of previous studies. It implies that atmospheric turbulence in the mesosphere would be driven by breakings of atmospheric gravity waves more frequently than past observations, especially in Antarctica, and the role of atmospheric gravity waves cannot be ignored when considering the long-termed climate changes.

Keywords: Polar Mesosphere Winter Echo, PANSY radar, Atmospheric gravity wave, Neutral-plasma interaction