Statistical properties of Polar Mesosphere Summer Echoes as detected with the Super Dual Auroral Radar Network

K. Hosokawa[1], T. Ogawa[2], A. S. Yukimatu[3], and N. Sato[3]

1. The Univ. of Electro-Communications, Tokyo, Japan
2. Solar-Terrestorial Environment Lab., Nagoya Univ., Toyokawa, Aichi, Japan
3. National Institute of Polar Research, Tokyo, Japan

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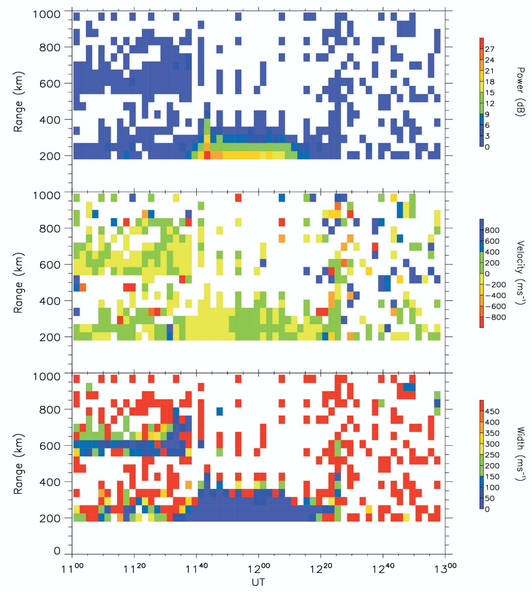
Abstract

Polar Mesosphere Summer Echoes (PMSE), which are regularly observed in summer months at polar latitudes, are strong radar backscatter from the upper mesosphere. Recently, peculiar echos, which are interpreted as PMSE, were found appear in the near range observation of the SuperDARN radars. This suggests a possibility that SuperDARN becomes a powerful tool for studying PMSE as a global scale phenomenon. In the present paper, we statistically analysed occurrence probabilities of the first range gate (180 km) backscatter echoes using 6-years measurements of the SuperDARN radars at Syowa Station, Antarctica (69.0 S) and Pykkvibaer, Iceland (63.8 N). As a result, occurrence percentage of the near range backscatter is enhanced considerably in summer months. Maximum is located at summer solstice, where occurrence percentage reaches 80-90% near noon meridian. Local time distribution of the echo occurrence has its maximum around local noon and minimum at 20LT. These fundamental characteristics of the echoes are quite similar to those of VHF-PMSE, which again implies that near range observation of SuperDARN contains significant amount of PMSE. Interhemispheric asymmetry of the echo occurrence probabilities are also estimated. Occurrence percentage averaged over summer months is 72% in the Northern Hemisphere and 50% in the Southern Hemisphere, suggesting that occurrence of PMSE has an interhemispheric difference.

What is PMSE?

Polar Mesosphere Summer Echoes



Morphological features:

- strong radar backscatter
- height range : around 86km
- in summer polar region
- low Doppler velocity
- narrow spectral width

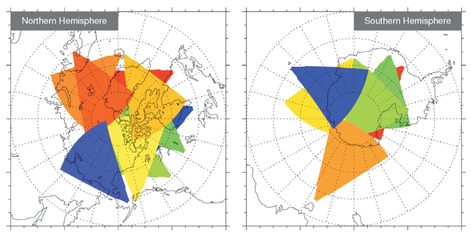
Generation mechanism:

In the summer mesosphere, water vapor is iced because of low temperature. These iced particles reduce diffusivity of plasma, and small-scale density fluctuations can survive.

How to extract PMSE from SuperDARN

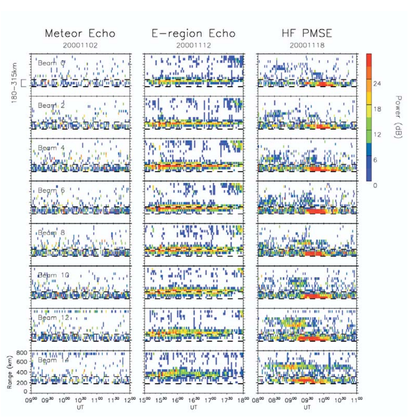
Super Dual Auroral Radar Network

International network of 15 coherent HF radars in the Northern & Southern Hemi.
Field-of-view coverage:
16 beams x 3550 km
≒ 6×10^6 km^2 / radar



Near Range Echoes of SuperDARN

PMSE, meteor echoes and E-region irregularities appear at similar range gates very near to the radar site.

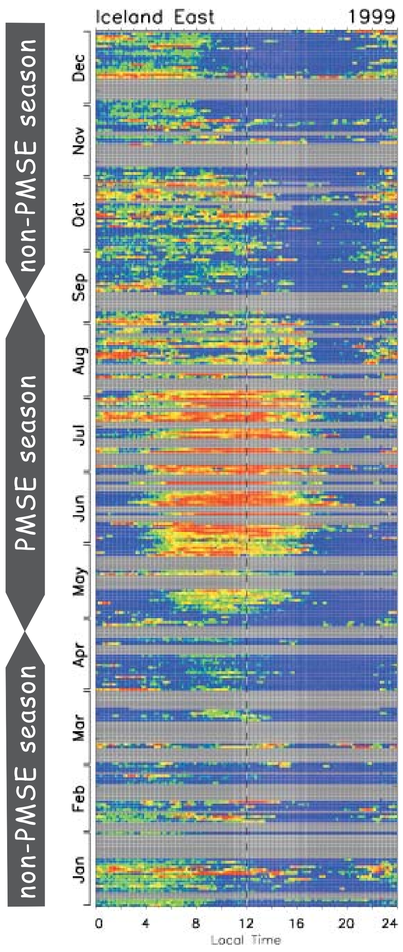


In order to distinguish PMSE from other backscatter targets (E-region FAIs and meteor) correctly, the following selection criteria were employed.

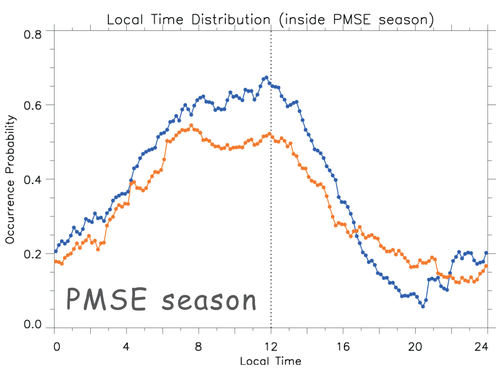
1. pwr_l > 6dB
2. -50 m s^{-1} < vel < 50 m s^{-1}
3. width_l < 50 m s^{-1}

Seasonal Variation of the Near Range Echoes

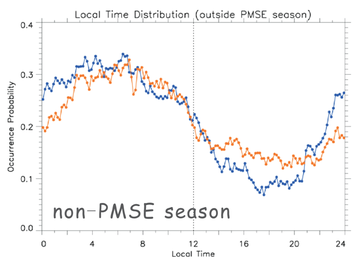
Echo occurrence rate is greatly enhanced during summer months.
Strong seasonal variation is consistent with the previous PMSE studies.



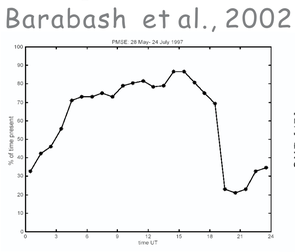
Local Time Distribution



LT distribution has a maximum near noon and minimum at 20LT, which is also consistent with the local time distribution of PMSE.

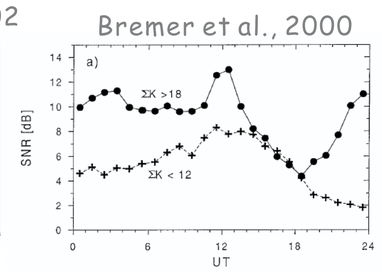


Esrange 67.5N 52MHz
Barabash et al., 2002

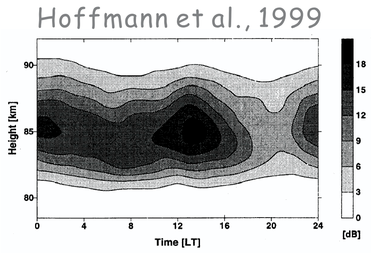


Andenes 69.3N 53.5MHz

Bremer et al., 2000



Hoffmann et al., 1999



Step A: An Interhemispheric Comparison of PMSE Activities

N–S Asymmetry of PMSE activities

First observation of PMSE in the S.H.
(50MHz VHF radar @ 62S, Woodman et al., 1999)

34dB - 44dB weaker echo power
- Is Antarctic PMSE weaker than Arctic PMSE?

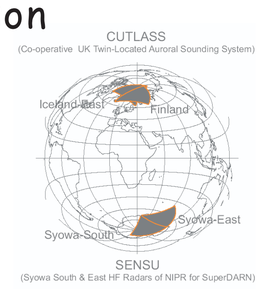
Is the Antarctic mesosphere warmer than the Arctic mesosphere?
- Difference in AGW activities?
  (Huaman and Balsley, 1999)
- No outstanding interhemispheric difference in mesospheric temperature (Lubken et al., 1999)

Strictly speaking, method of the interhemispheric comparison was not fair
- Operating frequency is roughly the same, but different radar system
- Comparison was made by using data in different time interval

Interhemispheric Comparison

Iceland (63.8N) vs Syowa (69.0S)

Syowa & Iceland pair is magnetically conjugate, but their geographical latitudes are different (about 5deg)



The interhemispheric asymmetry of PMSE occurrence is found to be 1.5 times higher in the N.H. than in the S.H.
Thus, N-S asymmetry in PMSE occurrence appears to exist, but is much weaker than that predicted previously based on VHF radar observations.