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# THE POLAR MESOSPHERIC MF ECHOES

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**Abstract.** Seasonal and diurnal behavior of high-latitude mesospheric MF echoes was studied using PGI radar of vertical radiation at Tumanny (69.0° N, 35.7° E).

## Introduction

It is well known that very strong backscatter echoes from mesosphere are observed by 50 MHz radar in summer at polar latitudes [see for example, Cho and Röttger, 1997]. These echoes were christened polar mesosphere summer echoes (PMSE). They are observed also at higher frequencies, including 224, 933 and 1200 MHz. Until recently it has been very difficult to detect PMSE in the MF range. The first abnormally strong MF radar echoes from polar mesopause region have been observed with PGI facility on 2.72 MHz at Tumanny only in summer 1999 [Tereshchenko et al., 2001]. The measurements indicated the presence of strong radar returns from altitudes between 74 and 99 km with features very similar to VHF radioreflections.

These PMSE imply the existence of large electrically charged particles (water cluster ions, aerosols or ice particles) in cold summer mesopause region. The generation of such particles are presumably necessary to cause inhomogeneities in the electron density of the radar Bragg scale, which is one-half the probing wavelength. For the 2.7 MHz radar this scale size is 55 m, much less than the radar scattering volume dimensions.

Another mechanism is related with the excitation of plasma turbulence by the noncompressible turbulence of neutral gas at mesospheric altitudes [Gurevich et al., 1997]. The compressible plasma turbulence in the lower ionosphere can be described as the superposition of the linear low frequency plasma waves, excited by turbulent motions of neutral gas. The key role in the induced turbulence is played by drift mode, as well as and in the gradient drift instability.

In general, MF radar echoes in the atmosphere can originate from either a turbulent or a nonturbulent medium. These two scattering mechanisms can both produce echoes of comparable power. In order to determined which mechanism dominates in a particular region of the atmosphere, additional information about the properties of the medium is required. For example, we need to have information about the full three-dimensional nature of the scatters in the mesosphere [Alcala and Kelly, 2001], i.e. to look more closely inside the radar scattering volume.

The simultaneous rocket and 50 MHz radar measurements in Andenes, Norway during a polar mesosphere summer echo event showed strong fluctuations and sharp gradients of electron density at the altitudes where the radar echoes were strongest [Alcala et al., 2001]. Comparison of the electron density profiles, found by a standard method of differential absorption, with the PGI radar observations of radar reflectivity, showed the same result. In this paper similar investigations will be extended in other seasons.

## Experimental results and calculations

The typical days of mesospheric scattering are summurized in Fig. 1 and 2 in the different times of year. The amplitude of the returned power of ordinary wave is shown as function of scattering height and time of day for a 24-hours period. The colour variations from light to dark agree with the signal amplitude range 0 – 2400 mV. The observations demonstrations the presence of intensive radioreflections from mesospheric layers at the altitude range of 74-99 km.

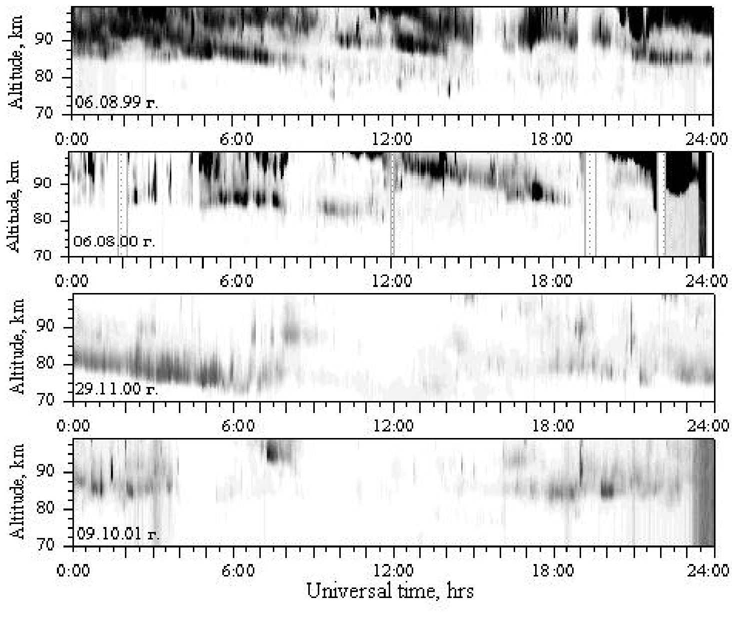


Fig. 1. Amplitude of a ordinary wave as function of time and height in the summer and autumn

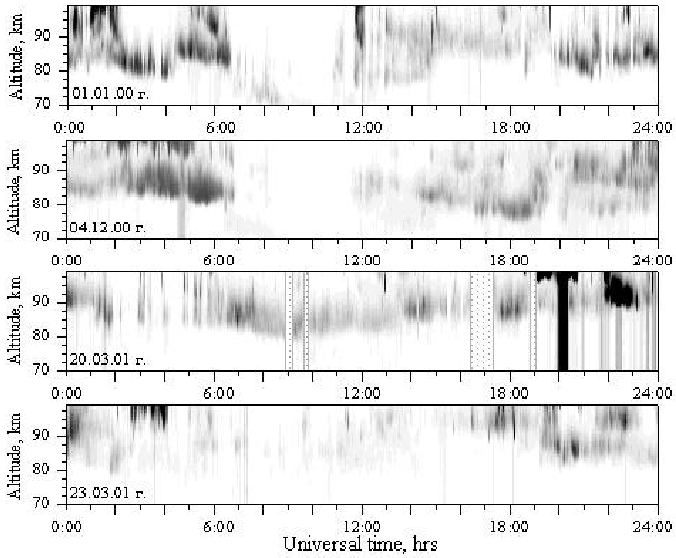


Fig. 2. Similar to Fig. 1, but in the winter and spring

An interesting feature seen in Fig. 1 (the event of August 06.1999) is the apparent wave-like variation of power with altitude between 10:00 UT and 24:00 UT. The similar changes are developed during events of January 01.2000 between 00:00 UT and 07:00 UT and March 20.2001 from 00:00 UT until 24:00 UT (see Fig. 2). Such a variation is what might be expected from a region of particularly strong scatter moving spatially under influence of a periodic neutral wind motion caused, for example, by an atmospheric gravity wave.

The occurrence statistics for the MF echoes show that they are observed at any times of day with a bias toward semidiurnal enhancements at 00:00 – 07:00 UT and 18:00 – 24:00 UT. Changes in the echo amplitudes is thought to be related to enhancements of tidal winds which predominate in this region of atmosphere [Jones et al., 1997].

Fig 3 and 4 illustrate the time-altitude variations of the electron density received by method of differential absorption.

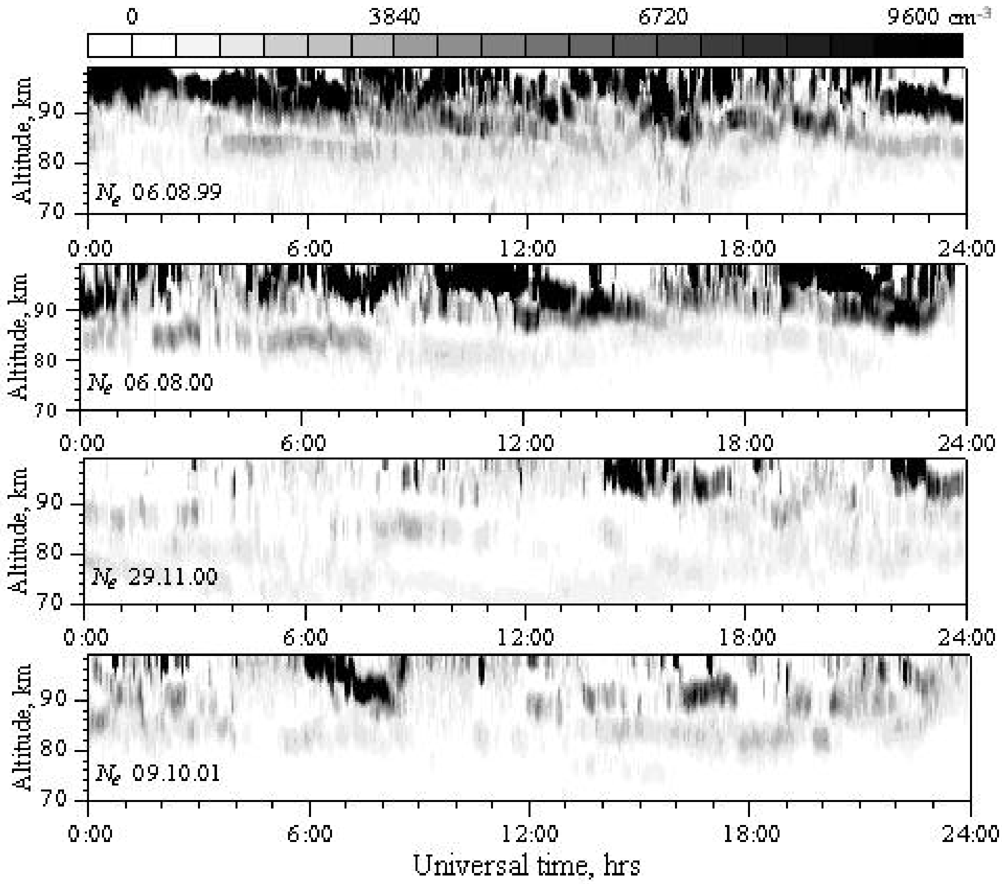


Fig. 3. Time-altitude picture of the electron density in the summer and autumn

The distinctive feature of these observations is a registration of areas of the lowered electron density in the polar mesosphere at heights close to the mesopause. Radio-echoes from these areas have the increased intensity (Figs. 1 and 2). Existence of areas of the lowered electron density may last from one minute till several hours. Earlier the minimum of electron concentration in a vicinity of the polar mesopause was fixed only in very short-term rocket experiments.

Observations of the MF echo in absence of direct solar illumination intensity were earlier conducted on dynasonde at Hally, Antarctica (75.6° S, 26.8° W) [Jones et al., 1997]. From a data analysis follows, that PME at arctic and antarctic latitudes have a different statistician of occurrence. The observed differences in PME occurrence and intensity in northern and southern hemispheres are most likely due to interhemispheric differences in the thermal structure of mesopause regions.

The present of strong and long lasting PMSE events coincide with the lowest seasonal temperatures around 85 km. Therefore the main features of the seasonal and diurnal variations of PME can at least qualitatively be explained by temperatures variations in the polar mesosphere.

## Conclusions

In this paper we reported on PME observations during 1999-2001 with PGI MF-radar at Tumanny (near Murmansk). The observational data indicated the presence of intensive radioreflections from mesospheric layers and a significant level of electron density changes at the same ionospheric heights, where reflections were more intensive.

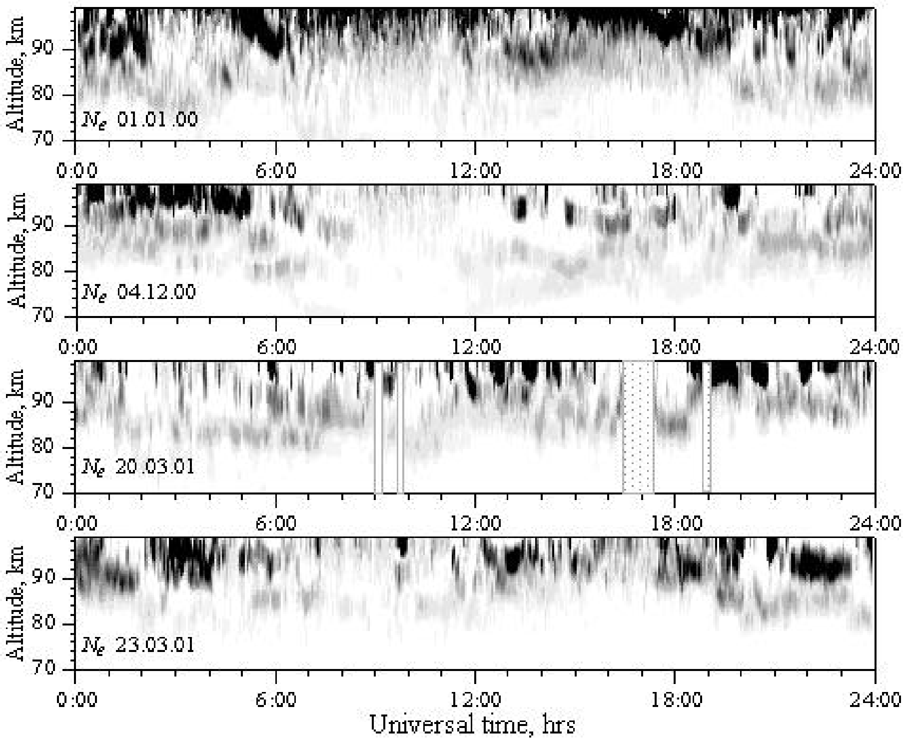


Fig. 4. Similar to Fig. 3, but in the winter and spring

The initial results showed that suitable scatter can be recorded from a wide range of mesospheric heights at all times of day. The questions concerning the nature of PME that make up these layers persist, including questions about their formation and dissipation processes, their interactions with the surrounding ionospheric plasma and their global coverage are remained wide open at the present moment.

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