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PMSE OBSERVATIONS WITH EISCAT DURING SUMMER 1991

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ABSTRACT : Polar Mesosphere Summer Echos (PMSE) have been observed with the European Incoherent Scatter Radar (EISCAT) operating at 224 MHz during summer 1991. The mean height of PMSE was about 85 km during day-time and about 87 km during night-time with a markedly enhanced occurrence probability during day-time. The probalitity of occurrence of PMSE is higher during geomagnetically quiet than during disturbed periods. There are some indications of a 2day-modulation of the PMSE. Comparisons of PMSE structures derived from EISCAT-224 MHz and CUPRI-46.9 MHz radar observations demonstrate common features as well as marked differences.

1. INTRODUCTION

PMSE have been observed with radar measurements near 50 MHz [Ecklund and Balsley, 1981; Czechowsky et al., 1989] on 224 MHz [Hoppe et al., 1988] and in the UHF-range on 933 MHz [Röttger et al., 1990] as well as 1.29 GHz [Cho et al., 1992].

The reason of these PMSE is not clear in all details until now. Taking into account the common turbulence theory [Hocking, 1985] the irregularities necessary for VHF-scattering from the mesopause region should be in the viscous subrange of the neutral turbulence spectrum, and therefore strong radar backscatter should be impossible. Heavy water cluster ions, however, should shift the turbulence-driven spectrum of irregularities in the electron density to considerably shorter wavelengths than of the neutral turbulence itself [Kelley et al., 1987]. As these heavy cluster ions favourably occur near the cold polar summer mesopause region they likely play an important role in the PMSE phenomenon at least in the VHF-range. In the UHF-range enhanced Thomson scatter is discussed [Havnes et al., 1990] whereas in the MF- as well as lower part of the HF-range also partial reflections should be taken into account. A detailed review of observations and theories of PMSE is given by Röttger [1993]. In this paper some PMSE-results of EISCAT-observations at 224 MHz during summer 1991 are presented.

2. EXPERIMENTAL RESULTS

The EISCAT-observations have been carried out in Tromsø, Norway, at 16 days (8 - 17 UT) between 31 May until 17 July 1991 as well as at 12 nights (22 - 04 UT) between 25 July until 6 August 1991. During these intervals the solar and geomagnetic activity was relatively high ($F_{10.7}$ = 150...250; 5 days with Ap > 100).

The mean occurrence probability for selected values of the signal to noise ratio (SNR) of PMSE deduced from EISCAT-VHF-measurements during summer 1991 is shown in Fig. 1 for day- and night-time conditions. Whereas the PMSE occurrence distribution during day-time is relatively symmetrical with a maximum near 85 km, during night-time the distribution is broader and unsymmetrical with maximal values near 86...87.5 km. In dependence on the SNR-level PMSE are more often observed during day-time than at night by a factor of 3 to 7.

The dependence of PMSE occurrence on geomagnetic activity is shown in Fig. 2. The

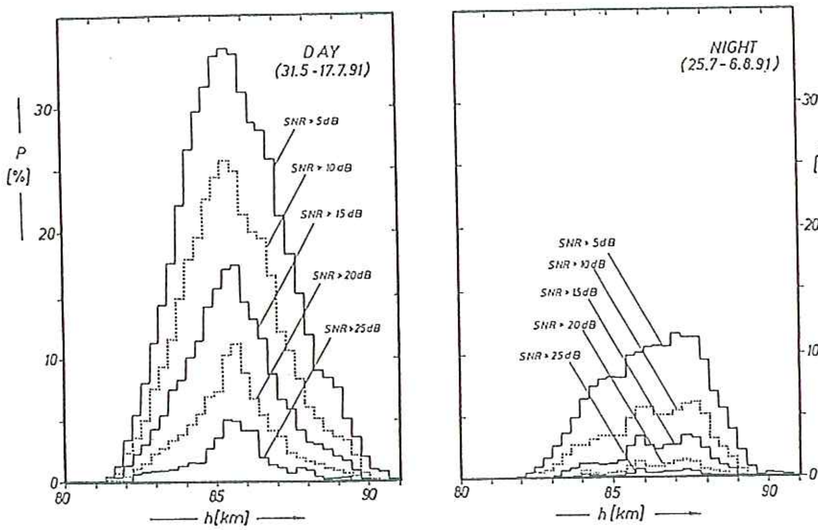

Fig. 1 : Occurrence probability of PMSE after EISCAT-observations at 224 MHz during summer 1991 in dependence on the signal to noise ratio (SNR) for day-time and night-time conditions.

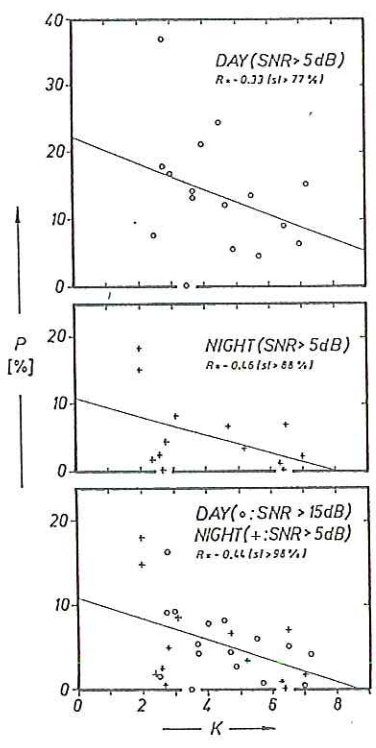

Fig. 2 : PMSE-occurrence probability derived by EISCAT-observations at 224 MHz in the height interval 80...90 km in dependence on geomagnetic activity (estimated for each measuring interval from geomagnetic K-values of Kiruna).

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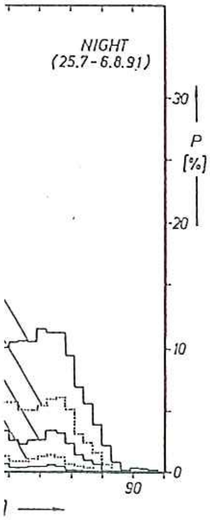

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geomagnetic activity index used here was derived from the 3-hourly K-values of Kiruna for the corresponding periods of PMSE observations. The upper panel of Fig. 2 is deduced from day-time observations, in the middle panel night-time values, and in the lower panel both data sets are combined. Here we used different SNR-values for day- and night-time PMSE observations to balance approximately the differences between day and night in the PMSE-occurrence (see Fig.1). All results shown in Fig. 2 indicate a negative correlation between PMSE occurrence and geomagnetic activity. Only a sufficient significance level with sl > 98% is obtained for the combined data (lower part of Fig. 2). As a result we can note that PMSE occurrence is higher during magnetically quiet than during disturbed periods.

There seem to be indications of a quasi- 2day -modulation of the PMSE occurrence as to be seen in Fig. 3 for a period in July / August 1991 at the high latitiudes of EISCAT (69.59°N, 19.23°E). During this period we observed a similar oscillation in the zonal component of the mesospheric wind field (89 km) with an amplitude of about 10 m/s at mid-latitudes measured by a MF-radar at Juliusruh (54.63°N; 13.38°E).

During a part of the EISCAT PMSE-measuring campaign in 1991 also observations with the CUPRI-radar at 46.9 MHz are available for Tromsø as well as Esrange, Kiruna. In Fig. 4 two examples are shown for simultaneous measurements with both radars at the same location (Tromsø). There are times when both radars detected similar structures (e.g. 12 July 1993, 13.00 - 14.30 UT). On 13 July 1991, however, marked differences between both measurements can be seen. During other periods, not shown here, we sometimes found agreement but also distinct differences.

3. DISCUSSION AND CONCLUSIONS

The height of maximum PMSE occurrence near 85 km during day-time and between 86...87.5 km during night-time agrees well with the results of other authors [Ecklund and Balsley, 1991; Czechowsky et al., 1989; Hoppe et al., 1988; Jones et al., 1989]. Also the more frequent occurrence of PMSE during day- than during night-time (see Fig. 1) are in agreement with EISCAT-VHF radar measurements in 1987 and 1988 [Hoppe et al., 1988; Jones et al., 1989].

The indication that PMSE occur more frequent during magnetically quiet periods, seems to be a new result. Rishbeth et al. [1988] found periodical variations (period near 45 min) in both PMSE and geomagnetic data whereas Röttger et al. [1990] for a singular case study did not find such a relation in the PMSE power variation. We, thus, have to discriminate between short term power variations of PMSE and their general occurrence probability. A positive correlation between Cosmic Noise Absorption and PMSE is well-known [Ecklund and Balsley, 1981; Czechowsky et al., 1989]. In general an enhancement of electron density due to particle precipitation should improve the ionospheric reflectivity [Hocking, 1985]. Precipitating high energetic particles could, however, also destroy heavy water cluster ions [Chandramma and Prasad, 1986]. This destruction reduces the effect of extension of the turbulence-driven spectrum of electron density irregularities to shorter wavelengths which was proposed by Kelley et al. [1987] to explain PMSE in the VHF-range. This effect seems to be more important at higher frequencies (e.g. 224 MHz) than in the lower part of the VHF-range (50 MHz). Therefore, the influence of particle precipitation to PMSE can be different at different radar frequencies.

The influence of atmospheric waves on PMSE has been suggested by Czechowsky et al. [1989] (semidiurnal tidal wave) as well as Williams et al. [1989] (gravity waves).Therefore, a connection between PMSE and 2day-wave could also be possible, according to the model proposed by Röttger [1993]. This fact has to be checked in more detail with common observations at the same location.

The differences of the PMSE observations at different frequencies (46.9 MHz and 224 MHz) could probably be caused by different scattering mechanisms. In the lower part of the VHF range also anisotropic scattering was reported to occur [Czechowsky et al., 1988]. Moreover the

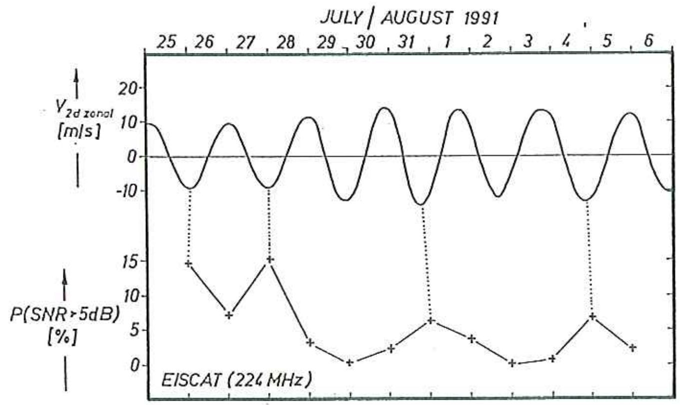

Fig. 3 : Occurrence probability of PMSE (SNR > 5dB) after EISCAT-measurements at 224 MHz and quasi- 2d -variations of the zonal wind at mid-latitudes.

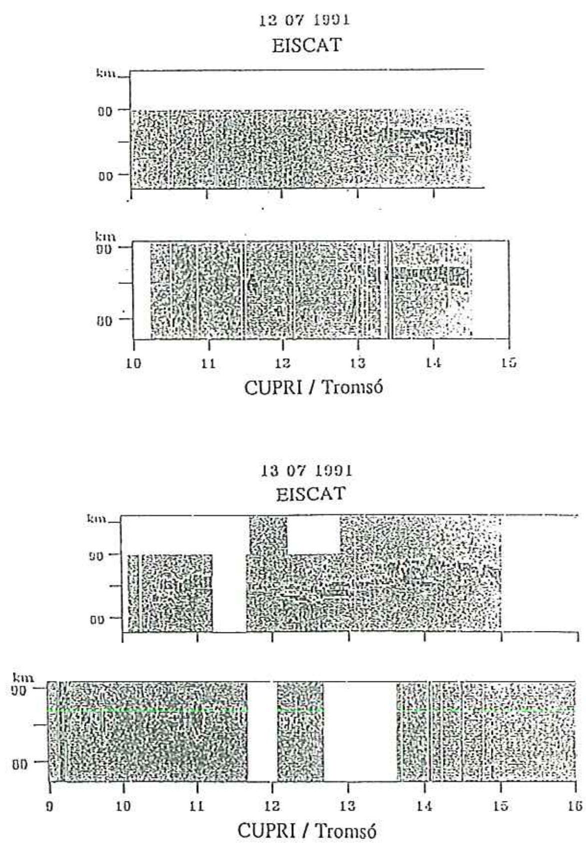

Fig. 4 : PMSE-observations with the VHF-EISCAT-radar (224 MHz) and with the CUPRI-radar (46.9 MHz) during two days in July 1991.

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