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Case study about PMSE intensity affected by high energy particle precipitation

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An unexpected strong radar echoes are observed from polar mesospheric heights between about 80 and 90 km at local summer, and is called polar mesosphere summer echoes (PMSE). These radar echoes are generated by inhomogeneities of the refractive index of the mesospheric plasma which are mainly caused by irregularities in electron density with scales of the half radar wavelength. The reason of the existence of such electron density irregularities is not quite clear in all details. But the large charged particles (ice particles, aerosols or water cluster ions), which preferably exists at low temperatures may play an essential role for the existence of such irregularities. The detailed physical background of PMSE is comprehensively described more recently by Rapp and Lübken [1].

The ionization generating free electrons necessary for creating radar echoes may play an important role for the existence of PMSE. The ionization in the polar mesosphere is controlled by solar EUV radiation (mainly Lyman α line at 121.5nm) and the precipitation of high energetic particles. Several studies have investigated the diurnal and annual variations of PMSE with precipitation measures such as cosmic noise absorption (CNA), the K-index and the F10.7 flux. In general, the studies find weak positive correlation factors between CNA and PMSE strength [2]. If there have close relationship between PMSE strength and particle precipitation have been studied for many years, and still is one open question. Here we try to find one different way to analyze the relationship.

We have studied the effect of variation in PMSE intensity due to variation in the strength of high energy particle precipitation. Observations of polar mesosphere summer echoes (PMSE) were carried out with the EISCAT VHF radar located near Tromsø, Norway (69°35′ N, 19°14′ E). The experimental data analyzed here was collected at 20:00 - 20:59:55 UT on 10 July 2013. Radar echoes were assumed to be present when the average apparent electron density exceeds the background density. We judge if there have strong precipitation reaching down into the mesosphere by the experimental results observed with EISCAT VHF radar, and the precipitation strength at altitude of 90 km are chosen to analyze the relationship between precipitation and PMSE strength. We have computed the Spearman rank correlation coefficient between the average apparent electron density at precipitation altitude of 90 km and PMSE altitude between about 80 and 90 km. For the time interval of (20:14:57–20:22:57), we found the Spearman rank correlation coefficient r = 0.80, indicating the strong positive correlation. The result shown in Figure 1 indicates that 64% of the variation in PMSE intensity can be explained by the variation in high energy particle precipitation, but in most cases, they do not show strong correlation, therefore, statistical investigation will play an important role for obtaining convincing result in the future.

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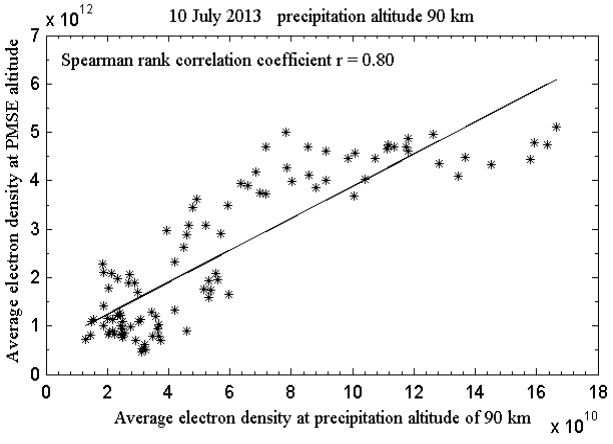

Figure 1. Scatter plot of average apparent electron density, at precipitation altitude of 90 km versus PMSE altitude of (80.9–85.9 km) for time interval of (20:14:57–20:22:57)