

R006-22

B 会場 : 11/27 AM2 (11:05-12:35)

11:35~11:50:00

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Hardness of precipitating particle energy spectrum revealed by spectral riometer: May 2024 storm event

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Spectral riometers in Finland observe cosmic noise in the frequency range of 20 – 55 MHz, and the frequency spectra of cosmic noise absorption (CNA) derived from the observations are expected to provide estimates of the altitude distribution of electron density enhancements in the ~50 – 100 km region. However, only one case study has attempted to derive altitude distributions of electron density enhancements using a spectral riometer, in which the results during an electron precipitation event showed good agreement with simultaneous EISCAT radar observations. This indicates that, although the spectral riometer has sufficient capability to capture the characteristics and temporal variations of mesospheric electron density enhancements, our understanding of these processes remains limited.

In May 2024, an extreme magnetic storm occurred, during which the Dst index reached – 400 nT. During the 16-day period from May 1, which included this storm, frequent enhancements of mesospheric electron density were observed by the spectral riometer at Kilpisjärvi, Finland. These enhancements were caused by phenomena such as high-energy electron precipitation associated with substorms, X-ray emissions associated with solar flares, and high-energy proton precipitation during proton events.

In this study, we focused on the fact that the slope of the CNA frequency spectrum obtained by the spectral riometer is expected to serve as an indicator of the hardness of the energy spectrum of precipitating particles, i.e., the characteristic altitude of electron density enhancements. More specifically, the key parameter is the spectral index, defined as the absolute value of the slope in the relation $\text{CNA} \propto f^{-n}$, where f is the frequency of cosmic radio noise and n is the spectral index. The CNA spectrum is known to follow a curve with $n = 2$ when electron density enhancements occur only above an altitude of 70 km. In contrast, when enhancements occur below 70 km, the spectral index decreases toward 0 as the characteristic altitude becomes lower.

In this presentation, we will show that the temporal variation of the spectral index during proton and electron precipitation events agreed well with the features expected from other observations and previous studies. For proton precipitation events, the spectral index became smaller when the flux of >10 MeV protons relative to >50 MeV protons observed by the GOES-18 satellite was smaller, i.e., when the precipitating proton energy spectrum was harder. For electron precipitation events associated with substorms, the MLT distribution of the spectral index showed that the value was around 2 near midnight, while it tended to be smaller than 2 in the morning side. This tendency is consistent with previous studies reporting that precipitating electron spectra become harder in the morning side. In contrast, the number of flare events was too small to obtain sufficient results.

These results demonstrate that the spectral index can serve as an indicator of the hardness of the energy spectrum of precipitating particles and suggests that the spectral riometer is a useful tool for elucidating the characteristics of mesospheric electron density enhancements.