Statistical study of cosmic noise absorption (CNA) observed at six stations at subauroral latitudes: Relation to ELF/VLF waves and substorms

*加藤 悠斗[1]、塩川 和夫[1]、田中 良昌[2,3,4]、尾崎 光紀[5]、門倉 昭[2,3,4]、大山 伸一郎[1]、西谷 望[1]、Oinats Alexey[6]、Kurkin Vladimir[6]、Connors Martin[7]、Baishev Dmitry[8]
*Yuto Kato[1], Kazuo Shiokawa[1], Yoshimasa Tanaka[2,3,4], Mitsunori Ozaki[5], Akira Kadokura[2,3,4], Shin-ichiro Oyama[1], Nozomu Nishitani[1], Alexey Oinats[6], Vladimir Kurkin[6], Martin G Connors[7], Dmitry Baishev[8]

1. 名古屋大学宇宙地球環境研究所、2. データサイエンス共同利用基盤施設/極域環境データサイエンスセンター、3. 総合研究大学院大学、4. 国立極地研究所、5. 金沢大学、6. Institute of Solar-Terrestrial Physics, Irkutsk, Russia、7. Athabasca University、8. SHICRA SB RAS, YaSC SB RAS, Yakutsk, Russia
1. Institute for Space-Earth Environmental Research, Nagoya University, 2. ROIS-DS/PEDSC, 3. SOKENDAI, 4. NIPR, 5. Kanazawa University, 6. Institute of Solar-Terrestrial Physics, Irkutsk, Russia, 7. Athabasca University, 8. SHICRA SB RAS, YaSC SB RAS, Yakutsk, Russia

High energy electrons (>30 keV) penetrate to the atmosphere below 90 km without causing significant optical emissions [Wilson and Stoker, 2002; Baker et al., 1982]. The electron density in the D-region, which is enhanced by the precipitation of high-energy electrons, has been observed by using ground-based riometers as increase in cosmic radio noise absorption (CNA). CNA is the absorption of radio waves (cosmic noise) from galaxies and radio stars in the Earth's lower ionosphere (D-region) [Hargreaves et al, 1969]. Therefore, CNA is a good indicator to identify the electron density enhancement in the D region ionosphere.
The precipitation of high energy electrons is attributed to the electron-cyclotron resonance involving electromagnetic waves in the ELF/VLF wave bands and subsequent pitch angle diffusion in the magnetosphere [Kennel and Petschek, 1966; Tsurutani and Lakhina, 1977]. Pitch angle scattering populates the electron loss cone, with an accompanying growth in wave energy giving rise to the generation of chorus and plasmaspheric hiss [Thorne et al., 1973]. Therefore, there might be a strong correlation between the high energy electron precipitation and the magnetospheric ELF/VLF wave intensity. Rosenberg and Dudeney (1986) investigated the relationship between CNA and intensity of 2-4 kHz emissions using one-year data obtained at Siple and Halley in Antarctica located at L=4. Ozaki et al. (2014) conducted a correlation analysis between the ELF/VLF wave power averaged over 1–3 kHz and CNA intensity at Athabasca and Meanook, Canada. In these previous studies, ELF/VLF waves at specific frequencies were compared with CNA, but it is still unclear on which frequency band the wave power has a strong correlation with CNA. In this study, we investigated the dependence of CNA on ELF/VLF waves, solar wind parameters, and geomagnetic indices by using six ground stations at subauroral latitudes with superposed epoch analyses. We defined the CNA enhancement onset time as the zero epoch. During the period of increased CNA, the ELF/VLF wave power decreases, indicating a negative correlation. This result suggests that the increase in the ionospheric electron density attenuated the power of the ELF/VLF waves propagating from the magnetosphere are attenuated. We also investigated the local time dependence of the correlation between CNA and ELF/VLF wave power and the time difference between substorm onset and CNA onset by sorting CNA events by local time. In this presentation, based on these observations, we will discuss the dynamics of high-energy precipitating electrons and magnetospheric ELF/VLF waves.

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