Variations of cosmic noise absorption (CNA) by energetic electron precipitation (EEP) and changes of the auroral morphology

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Temporal and spatial variations of the aurora morphology in association with substorm have been studied for more than half century. In this study we focus on pulsating aurora, which is characterized by quasi-periodic oscillations in the emission intensity at periods of a few to tens of seconds, and auroral patches observed embedding in the pulsating aurora. Both types of aurora are known as typical phenomena at the recovery phase of substorm, especially from midnight to dawn. It is known that these types of aurora are often accompanied by energetic electron precipitation (EEP) exceeding several hundreds of keV [Miyoshi et al., 2015]. Elucidation of causality to produce pulsating aurora and EEP is an important theme to understand relationships between the radiation belt and upper-middle atmosphere of the earth. Analyzing measurements from satellite observations and ground-based optical/radio technique observations, the generation mechanism is thought to be mainly attributed to wave particle interactions due to plasma wave and electrons in the magnetosphere. In this study, we study relationships between auroral morphological changes, in particular spatiotemporal evolutions of patches and coinciding precipitations of the energetic electron.

Some previous studies have presented changes in morphology from diffuse aurora to finger like structures and dependence of magnetic local time of EEP [Shiokawa et al., 2014; Hosokawa and Ogawa, 2015]. The wave-particle interaction has been widely accepted with experimental evidences to support generation of pulsating aurora and EEP [Miyoshi et al., 2015; Kasahara et al., 2018]. However, our understanding has not yet reached its maturity of presenting spatiotemporal evolutions of auroral morphology and associated electron precipitation. Oyama et al. [2017] presented enhancements of cosmic noise absorption (CNA) coinciding with appearance of the patch structure but with only two events and the horizontal area to be analyzed was relatively narrow with several hundred kilometers. In this study, we conducted observations to capture simultaneously time evolutions and spatial distributions of auroral morphology and EEP by utilizing a network of Electron Multiplying Charge Coupled Device (EMCCD) cameras operated by Japan and riometers operated by Finland in Scandinavia.

This study will present two events (March 6-7 and 29-30, 2017) with pulsating aurora and auroral patches. For the camera count of the portion where the overlapping the EMCCD camera and the field of view of the riometer, running average processing is performed to remove the luminance fluctuation with a period of 40 seconds or more. After that, frequency analysis is performed, and spectra at each time are calculated. Among the frequency components, the spectrum of the emission intensity around the main pulsation was extracted by removing the frequency component from 1 to 5 Hz corresponding to the internal modulation of the pulsating aurora, and was integrated in the frequency direction. The results were compared with the CNA. From the transmission characteristics of the optical filter attached to EMCCD, the aurora measured by EMCCD camera is considered to be emission layer around 100 km altitude represented by molecular nitrogen emission. On the other hand, although the sensitivity characteristic of the riometer has a gradual dependence on the altitude, it may be considered that the measured CNA fluctuates in accordance with the variations of the electron density around the altitude of 90 km. Thus, although the altitude represented by each device is different, the relationship between the CNA and the intensity of the main pulsation has a linear relationship of similar inclination before and after changes aurora morphology. This result indicates that the main pulsation synchronized with the precipitating electrons of several tens of keV changes the CNA.