Continuous precipitation of low-energy electrons associated with pulsating aurora obtained by the Reimei satellite

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We report the results of event and statistical analyses on continuous precipitation of low-energy electrons associated with pulsating aurora using the data taken by the Reimei satellite. From recent data obtained with a magnetospheric satellite like Arase, it is widely supported that chorus waves interact with plasma sheet electrons that produce diffuse aurora mainly in the post-midnight to morning sectors. In addition, temporal (a few Hz) variation of lower band chorus waves cause modulation of pitch-angle scattering of keV-range electrons that generate pulsating aurora in the ionosphere. On the other hand, such temporal variation is not commonly seen in upper band chorus and electrostatic electron cyclotron harmonic (ECH) waves that expected to interact with lower-energy electrons. However, the characteristics of such low-energy electrons and their relationship to pulsating aurora are not understood.
Reimei is a polar-orbiting sun-synchronous satellite at an altitude of 650 km and obtained simultaneous image and particle data with high-time and spatial resolutions. Thanks to its orbit, Reimei covers wide L-value ranges and measures velocity-dispersed electrons travelling from magnetospheric source region to ionosphere. Miyoshi et al. [2015] showed an event that Reimei observed continuous precipitation of low-energy electrons (mainly in the energy range of hundreds eV) in addition to high energy (more than a few keV) temporal electrons that caused pulsating auroral emission. Here, we investigated the characteristics and generation mechanism of continuous low-energy electron precipitation using all of the electron data (5150 paths) taken by Reimei/ESA from November 2005 to August 2008, and compared the data with simulation results. Event selection criteria are 1) existence of continuous precipitation of low-energy electrons below a few keV range, and 2) high-energy (more than a few keV) electrons that distinguished from the continuous low-energy electrons. We also examined simultaneous auroral image data obtained with Reimei/MAC. Using the criteria, we found 155 events of continuous low-energy electron band. From statistical analysis, the continuous low-energy electron evens occurred in 11 % of total observation paths in the nightside sector, while temporal precipitation of high-energy electrons that produced pulsating aurora appeared in 36 % of total observation paths in the nightside sector. From event analysis for several cases, we found in most cases that energy of continuous low-energy electrons increased from ~200 eV to a few keV as the latitude decreased. However, the electron energy decreased near the lower boundary of plasma sheet. In some cases, multiple electron band structures were seen in the low-latitude region. To understand the characteristics and mechanisms of continuous precipitation of low-energy electrons, we carried out simulations of electron pitch angle scattering with chorus waves and ECH waves, respectively. For the simulation of ECH wave resonance, we calculated wavenumber at ECH wave frequency (e.g., 1.6 fce(cyclotron frequency)) based on the Bernstein mode dispersion relation, and estimated electron energy by the cyclotron resonance equation assuming the electron density with GCPM model and magnetic field with IGRF model. From the comparison between the Reimei data with simulation results, we suggest that latitudinal dependence of low-energy electrons can probably be explained with the chorus wave resonance. The decrease of electron energy near the low-latitude boundary is likely to be caused with decrease of plasma density outside of the plamsapause. On the other hand, we showed the possibility for some cases that low-energy electron precipitations were generated by ECH waves.

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