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The source region and its characteristics of pulsating auroras based on Reimei observations

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Pulsating aurora is a phenomenon which shows periodic changes of emission intensity in the diffuse aurora. The emission is characterized by not sinusoidal change but pulsation, and its typical period is from a few seconds to a few tens of seconds [e.g., Oguti et al., 1981; Yamamoto, 1988; Nemzek et al., 1995]. Precipitating electrons which generate pulsating aurora were observed with 3 Hz modulations by rockets and low-altitude satellites and the energy ranges from a few keV to a few tens keV [Sandahl et al., 1980; Yau et al., 1981; Sato et al., 2004]. Since pulsating aurora appears in diffuse aurora, electrons are thought to undergo cyclotron resonance with whistler mode waves in the equatorial region of the magnetosphere and to precipitate into the Earth's upper atmosphere by pitch angle scattering. This idea is widely accepted, but there is few observations demonstrating this idea. Sato et al. [2004] recently suggested that the source region of pulsating aurora is located earthward, raising a question about a source region and the mechanism of pulsating aurora.
The purpose of this study is to search for the source regions and the mechanism of pulsating aurora using simultaneous image and particle observation data from the Reimei satellite in statistical basis. We used mainly MAC and Electron/Ion energy Spectrum Analyzer (E/ISA) in this study. MAC takes an image at three wavelengths; 427.8 nm (N_2^+ 1st Negative Band), 557.7 nm (O Green line) and 670.0 nm (N_2 1st Positive Band). The field of view is 7.6 degrees and the temporal and spatial resolutions are 120 ms and 1 km, respectively. E/ISA is a tophat type electrostatic analyzer with an energy range from 10 eV/q to 12 keV/q and temporal resolution of 40 ms.
We used image and particle dataset for 29 pulsating aurora events obtained from Reimei observations and carried out two Time-Of-Flight (TOF) analysis methods in order to restrict source regions and production mechanism based on observations. The one is the analysis method that takes the wave-particle interactions with propagating whistler mode waves into account, the other is the traditional TOF analysis. The sources' location were mapped onto the magnetosphere using a magnetic field model [Tsyganenko and Sitnov, 2005] and discussed a possible mechanism which generates pulsating auroras in the source regions obtained from two TOF-analyses.
As a result, while the sources identified by traditional TOF model are distributed continuously from magnetic latitude of 50 degrees to -20 degrees, the sources obtained from TOF model taking account of whistler wave propagation are confined to the equatorial region up to about 11 degrees. The source distribution obtained with the latter method corresponds to the frequent occurrence region of chorus emission and, therefore, pitch angle scattering through wave-particle interactions with chorus is assumed to be one of main production mechanisms for pulsating aurora. It is also revealed that all 29 events occurred outside of the plasmapause.
In addition, cold plasma density inside the source regions of pulsating aurora and wave frequencies propagating along a field line are obtained as secondary products in the latter TOF analysis. Cold plasma density ranges from 1.0 to 14.2 cm^{-3}. The result also suggests that the density has the tendency to increase as the source region is closer to the Earth, although the density has large variance. Wave frequency normalized by a cyclotron frequency is in a range of 0.22 to 0.82. These

values are also consistent with empirical plasma density model and a typical frequency of the chorus wave. It is clearly showed that the frequency gets higher corresponding to upper band chorus in closer to the Earth.

By improving our model, it will become possible to monitor plasma environment inside an individual source region such as cold plasma density and whistler wave frequency, through observations of pulsating auroras.

Keywords: pulsating aurora, Reimei, wave-particle interaction, whistler mode wave,
the inner magnetosphere