Electrostatic electron cyclotron harmonic waves as a candidate to cause pulsating auroras

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Pulsating auroras (PsAs) are classified as diffuse auroras, which show quasi-periodic (2-20 s or longer) temporal fluctuations. They typically appear during the recovery phase of substorms. Observations by sounding rockets and low-altitude satellites have confirmed that pulsating auroras are caused by quasi-periodic precipitation of electrons with energies from a few to tens of keV. The electron energy spectra associated with pulsating auroras are primarily Maxwellian and do not contain signs of acceleration by electrostatic parallel fields. It suggests that electrons are precipitated from the magnetosphere into the ionosphere by pitch angle scattering. Candidate waves to scatter electrons are lower-band chorus (LBC) and electrostatic electron cyclotron harmonic (ECH) waves. They can resonate with more than and less than a few keV electrons through cyclotron resonance, respectively. One-to-one correlation between LBC wave intensity and PsA intensity has been reported in a number of previous studies [Nishimura et al., 2010, 2011]. However, direct correlation between ECH and PsA has not been reported. In this study, using a coordinated satellite and ground-based imager observation, we aim to understand the correlation between the temporal variations of PsA and ECH in addition to LBC.

The Exploration of energization and Radiation in Geospace (ERG, also called Arase) satellite was launched in December 2016. The first campaign observation between the Arase satellite and ground-based optical imager was conducted in March 2017. The optical auroral observation used in this study is from the all-sky imager installed at Sodankyla (67.37 degrees geographic latitude, 26.63 degrees geographic longitude, 64.14 degrees geomagnetic latitude, 106.59 degrees geomagnetic longitude). The sampling rate is 100 Hz and long-pass filter, whose cut-off frequency is 665 nm, is attached to mainly observe N2 1PG emissions, whose life time is very short (~10^{-6} s) and emission height is ~110 km. We calculated cross-correlation coefficients between the wave intensity observed by the Arase satellite and the auroral emission intensity at each pixel on image frame to find the high correlation region between them. Though several pulsating auroral patches were observed within the field of view of the imager, high correlation regions were localized near the footprint of the Arase satellite. We estimated the precipitating electron energy by assuming that the time lag when the cross-correlation coefficient became the highest was travel time of electrons from the modulation region. We found that it was almost consistent with the cyclotron resonance energy of each wave. From a statistical analysis, ECH waves with a similar period of their intensity variations with PsA have been frequently observed by Arase around the magnetic equator. We used data observed by Arase in the 00-06 MLT region from 23 March to 31 May 2017. Combined effect of LBC and ECH waves may be relevant to explain the complex behavior and great diversity in the morphological characteristics of PsA. To confirm whether wave-particle interactions indeed occurred or not, we will compare each wave intensity and loss cone electron flux measured by Low-Energy Particle Experiments - Electron Analyzer (LEP-e) and Medium-Energy Particle Experiments - Electron Analyzer (MEP-e) onboard the Arase satellite.