Energetic Electron Precipitation and its relation to IPDP type EMIC waves

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Electromagnetic ion cyclotron (EMIC) waves are excited by the ion cyclotron instability in the equatorial region of the magnetosphere. EMIC waves propagate along the magnetic field line to the ground and are observed as the Pc1- Pc2 pulsations. Pitch angle scattering due to EMIC waves is considered to be an important loss mechanism of relativistic electrons. As evidence of its contribution to the loss of radiation belt electrons, we previously reported a good correspondence between the time variation of energetic electron precipitation (EEP) and the intensity of EMIC waves during the main phase of a geomagnetic storm on 27 March, 2017 (Hirai et al., AOGS2018).

In this paper, we enhanced this result with more temporal and spatial correspondences of EMIC waves with EEP, through their statistical analyses from 1 November 2016 to 30 June 2018. We used induction magnetometers at Athabasca (latitude: 54.7 deg, longitude: 246.7 deg, L: 4.45) for the detection of EMIC waves. The artificial radio waves received at Athabasca were also used for the detection of the ionization caused by EEP with typical energies higher than 100 keV, which propagated in the subionospheric waveguide from the transmitters located at NDK (latitude: 46.4, longitude: 261.5, L: 2.98, 25.2 kHz) and NLK (latitude: 48.2, Longitude: 238.1, L: 2.85, 24.79 kHz).

Simultaneous data of the magnetometer and the radio wave receiver were obtained on 289 days. This data set included 395 EMIC wave events, and 55 had the IPDP (Interval of Pulsations of Diminishing Period) type (14%). In this data set, we investigated 20 clear EEP events with simultaneous EMIC wave events. Among them, 16 EMIC wave events were IPDP type. 19 events occurred in duskside and only one event in post-midnight. The IPDP type EMIC event is characterized by an increase in wave frequency over 30-60 min and is observed in the evening sector accompanied by a substorm. When energetic protons are injected into the inner magnetosphere and drift westward during the expansion phase of substorm, IPDP waves are generated. The local time dependence of IPDP found in this study is consistent with this picture. The result suggests that the IPDP type EMIC wave event is closely related with the precipitation of energetic electrons into the atmosphere, a different mechanism than those causing other types of EMIC waves.