Electromagnetic Ion Cyclotron Waves and Geomagnetic Storms: GOES and CRRES Observations

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Abstract

Electromagnetic ion cyclotron (EMIC) waves are considered to play an important role in magnetosphere dynamics, including contributions to ring current ion losses and radiation belt electron losses. Theoretical studies suggest that some of these processes may be most effective during the main phase of geomagnetic storms. However, ground-based signatures of EMIC waves, Pc1-2 geomagnetic pulsations, are only occasionally observed during the main phase, and more frequently occur during the recovery phase.

In situ observations in the magnetosphere were undertaken to further pursue this question using GOES and CRRES satellite data. We investigated the association of EMIC waves with various storm phases in case and statistical studies of 22 geomagnetic storms over 1996–2003, with an associated Dst < −30 nT. High-resolution data from the GOES 8, 9, and 10 geosynchronous satellite magnetometers provided information on EMIC wave activity in the 0–1 Hz band over ±3 days with respect to storm onset, defined as commencement of the negative excursion of Dst. Thirteen of 22 storms showed EMIC waves occurring during the main phase. Superposed epoch analysis of the 22 storms shows 78% of wave events during the main phase occurred in the He^+ band. After storm onset the main phase contributed only 29% of events overall compared to 71% during recovery phase, up to 3 days. In case studies of two storms, waves were seen with higher intensity in the main phase in one and the recovery phase in the other.

We also studied the occurrence of EMIC waves during 119 storms occurring throughout the CRRES mission over 1990-1991. The storms were defined using the Sym-H index. The storm was divided into three phases: pre-onset, main, and recovery (80% of minimum Sym-H value). The majority, 56%, of storm time EMIC waves were found to occur during the main phase, while 36% were observed in the recovery phase. The recovery phase definition was then extended to 6 days after the minimum in order to compare with past ground studies. Although more EMIC waves were observed during this extended recovery phase, the maximum occurrence rate of EMIC waves remained in the main phase. A slight increase did appear in the 4–6 days after the minimum Sym-H value. The rise in the occurrence rate in the extended recovery phase potentially is dominated by the process of plasmaspheric expansion after the end of the storm.

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