Abstract

Presented here is a statistical study of EMIC waves observed by the Van Allen Probes mission. Magnetic field measurements from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) onboard Van Allen Probe A have been used to identify EMIC wave events from the beginning of the mission (September, 2012) to February, 2014. Statistical studies using in situ observations from other missions have been conducted, however the Van Allen Probes Mission allows much better resolution of lower frequencies (0.2-0.9 Hz), within which oxygen-band EMIC waves can occur in the inner magnetosphere. This allows us greater insight into the characteristics of this previously largely unavailable band of EMIC waves, and for the comparisons of the occurrence and spatial distribution of EMIC waves in different bands. Hydrogen, helium and oxygen bands of EMIC waves are examined with respect to their occurrence in the coordinates of L-values (L) and Magnetic Local Times (MLT).

Motivation

1.) Since EMIC waves can affect their nearby environment and particle dynamics (through energy excitation of heavy ions [Zhang et al., 2010; 2011], cause dropouts of relativistic electrons from the radiation belt [Thorne and Kennel, 1971; Lyons and Thorne, 1972; Jordanova et al., 2008; Miyoshi et al., 2008], auroral proton precipitation [Sakaguchi et al., 2008; Yahhn et al., 2009], and cause traveling convection vortices inside the magnetosphere [Lockwood et al., 1990; Engebretson et al., 2013]), in situ observations throughout the magnetosphere are needed.

2.) The Van Allen Probes allow us to perform a statistical study of EMIC waves occurring in the radiation belts. Particularly, in this study, it is possible to statistically examine oxygen-band EMIC waves for the first time since previous mission have often been contaminated with noise at lower frequencies.

3.) This study serves as an extension of a recently accepted GRL paper by Zhang et al. [2014], in which EMIC wave events on April 28, 2013 were focused.

Instrumentation

1.) The Van Allen Probes (2012-present) are two identical spacecraft, denoted as A and B, which orbit in nearly identical, low inclination (10°), elliptical orbits between 1.1 and 5.8 Earth radii approximately every 9 hours.

2.) Each probe carries the EMFISIS fluxgate magnetometer which collects magnetic field data used in this study. The magnetometer takes high resolution (64 vectors/second) magnetic field data which allows us to examine frequencies between ~0-30 Hz.

Spatial distributions of EMIC waves by band

1.) Proton-band waves (left):
   -Wave occurrence peaks during the dusk sector. Dawn, midnight, and noon sectors (MLT = 0-12) are barren.
   -Majority of waves occur at approximately L = 5-6. Hallford et al. [2010] (CRRES data) observed a mean L = 6.07 and a mean MLT = 15.
   -Min et al. [2012] (THEMIS data) and Allen et al. [2014] (Cluster data) show peak proton-band occurrence in the dusk sector at approximately L=10.

2.) Helium-band waves (middle):
   -Wave occurrence is symmetric in MLT.
   -Majority of waves occur at approximately L = 5-6. Hallford et al. [2010] (CRRES data) observed a mean L = 6.07 and a mean MLT = 15.
   -Min et al. [2012] (THEMIS data) and Allen et al. [2014] (Cluster data) show peak helium-band occurrence in the dusk sector at approximately L = 10.

3.) Oxygen-band waves (right):
   -Waves occur mostly at L = 5.
   -Half the noon sector (MLT = 12-16) and midnight regions haven’t observed EMIC waves despite proper coverage.

Spatial distributions of EMIC waves observed by Van Allen Probe A

Proton-band EMIC Waves

Helium-band EMIC Waves

Oxygen-band EMIC Waves

Band
Number of waves observed
Proton 79 (53)
Helium 169 (129)
Oxygen 30 (27)

References


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Future Work

1.) To further examine the spatial distribution and temporal evolution of EMIC waves by combining wave observations on Van Allen Probe B
2.) To determine the wave properties for all EMIC wave events (normal angle, ellipticity, polarization, etc.)
3.) To analyze plasma conditions associated with these events
4.) To cross check all wave events with solar wind conditions
5.) To perform a Poynting vector analysis for observed EMIC waves during which high-resolution electric field measurements are available