Poster # 59

The geomagnetic condition dependence of the spatial distributions of EMIC waves observed by the Van Allen Probes

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Abstract

Electromagnetic ion cyclotron (EMIC) waves play an important role in the overall dynamics of the Earth's magnetosphere, including the energization and loss of particles. We perform a statistical study of EMIC waves detected by the Van Allen Probes mission to investigate their spatial distributions under different geomagnetic activity levels, gauged by the AE index. The Van Allen Probes allow us to explore the inner magnetosphere (1.1 to 5.8 R_e) while providing better resolution of the lower frequencies (Pc 1-2 pulsations) where O^+-band EMIC waves can occur. Magnetic field measurements from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) onboard Van Allen Probes are used to identify EMIC wave events from the first 22 months of the mission operation. EMIC waves are examined in H^+-, He^+- and O^+-bands. Throughout the first 22 months of the Van Allen Probes mission, the majority of the data coverage has been during quiet (AE < 100) conditions. Results show that as AE increases, the spatial distributions of EMIC waves converges to the afternoon sector. Disturbed conditions yielded stronger H^+- and He^+-band EMIC waves. The afternoon sector featured higher occurrence rates for He^+-band EMIC waves. Weaker H^+- and He^+-band EMIC waves tend to be located in the pre-noon sector occurring more prominently under quiet conditions.

Motivation

1.) Since EMIC waves can affect their nearby environment and particle dynamics (through pitch angle scattering of relativistic electrons from the outer radiation belt [*Thorne and Kennel*, 1971; *Lyons and Thorne*, 1972; *Jordanova et al*., 2008; *Miyoshi et al*., 2008], energy excitation of heavy ions [*Zhang et al*., 2010; 2011], and subauroral proton precipitation [*Sakaguchi et al*., 2008; *Yahnin et al*., 2009]), *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 O^+-band EMIC waves since previous mission have often been contaminated with noise at lower frequencies. The Van Allen Probes have also completed a full precession allowing for complete Magnetic Local Time (MLT) data coverage.

3.) This study serves as an extension of a recently published GRL paper by *Zhang et al*. [2014], in which EMIC wave events on April 28 2013 were focused on, and a statistical EMIC wave survey paper, already submitted by *Saikin et al.* [2015].

4.) AE has been shown to be well correlated with EMIC wave occurrence in the afternoon sector with CRRES [*Meredith et al.,* 2014]. However, an analysis including the pre-noon MLT sector (due to the halted operation of CRRES) and the O^+-band EMIC waves has not been performed.

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.

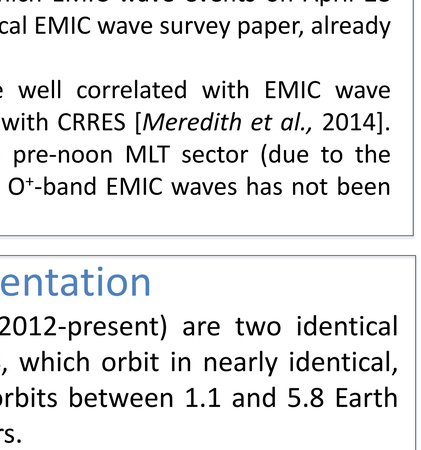
2.) Each probe carries the EMFISIS fluxgate magnetometer which collects magnetic field data used in this study. The magnetometer provides high resolution (64 vectors/second) magnetic field data which allows us to examine EMIC wave activity.

3.) AE were obtained through the OMNIWeb.

Sample EMIC Wave Events

1) Wave power spectra of three sample EMIC waves. The black lines represent local ion gyrofrequencies.

a.) H^+-band event (top)
b.) He^+-band event (middle)
c.) O^+-band event (bottom)



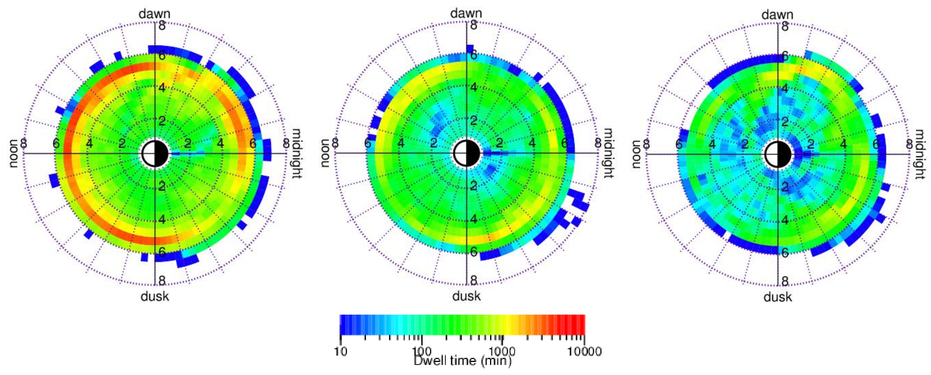
2) EMIC wave event selection criteria:

-Each event was observed for at least 5 minutes.
-Power cutoff for wave activity was set at 0.01 nT^2/Hz.
-Local gyrofrequencies were used to distinguish between bands.
-Events over multiple bands were counted separately in band.
-Events from both Probes, A and B, were used.

3) Events were categorized by the maximum AE value during each event.

Van Allen Probes Data Coverage by AE

Quiet AE ≤ 100 | Moderate 100 < AE < 300 | Disturbed AE ≥ 300

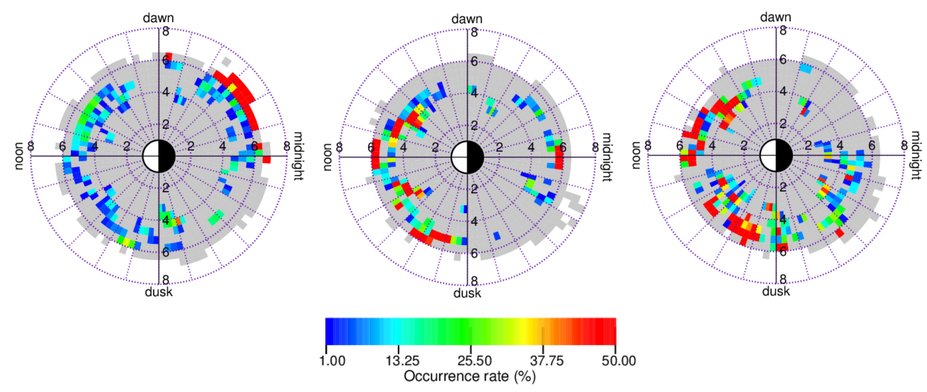


- Data coverage of the Van Allen Probes (in L* vs. MLT).
- Data used from the *first* 22 months of the Van Allen Probes mission (8 September 2012 – 30 June 2014).
- All bins represent 15 minutes of MLT per 0.5 L*.
- A Majority of data coverage is during quiet conditions.
- Disturbed conditions have lowest data coverage in the afternoon sector.

Spatial Distribution of EMIC Waves by band and AE

H^+-band

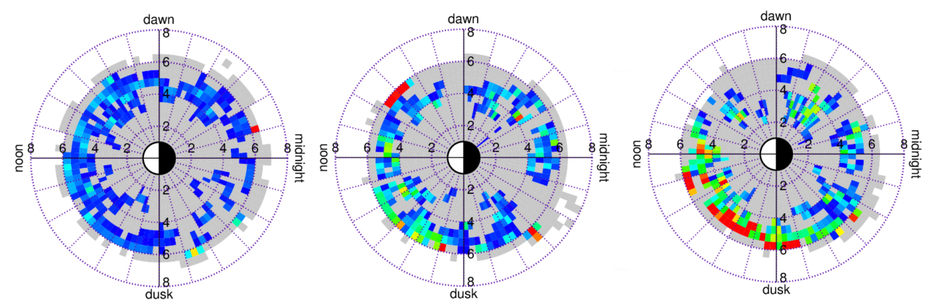
Quiet | Moderate | Disturbed



- As AE increases, fewer EMIC wave events are observed in the post midnight sector, but more are in other sectors.

He^+-band

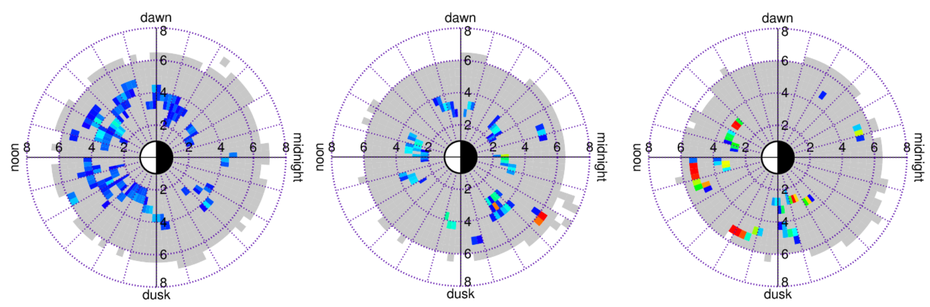
Quiet | Moderate | Disturbed



- Both moderate and disturbed conditions feature high occurrence rates in afternoon sector.
- Disturbed condition features higher low L* shell occurrence rates.

O^+-band

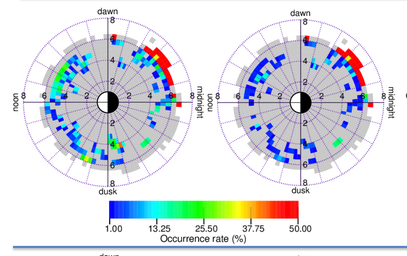
Quiet | Moderate | Disturbed



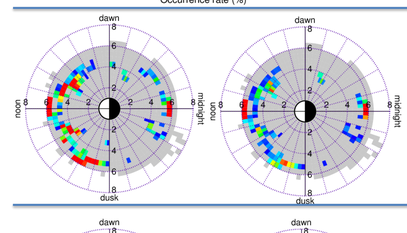
- Quiet condition features most extended spatial distribution.
- Higher geomagnetic disturbances result in higher wave occurrences, but the events are too few to make the result statistically significant.

EMIC Wave Power vs. AE

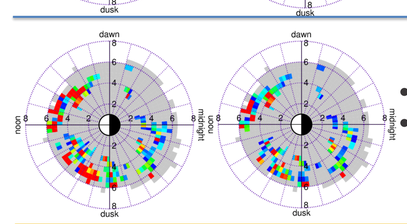
Each plot shows 0.01 nT^2/Hz threshold (left) and the 0.1 nT^2/Hz (right) threshold occurrence rates. All plots are on the same color scale.



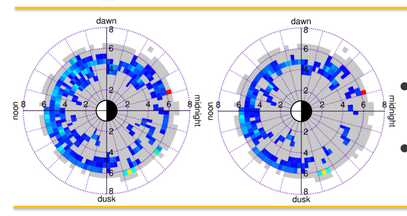
Quiet H^+-band
- Occurrence rates on the dayside have dropped.



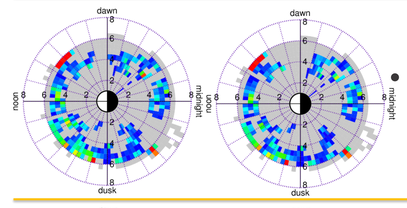
Moderate H^+-band
- Overall dayside decreases.



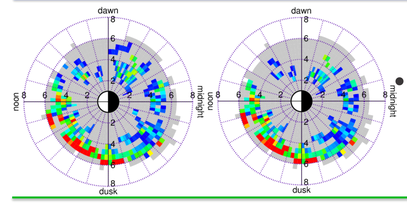
Disturbed H^+-band
- Dayside decreases.
- Peak H^+-band occurrence regions stay the same.



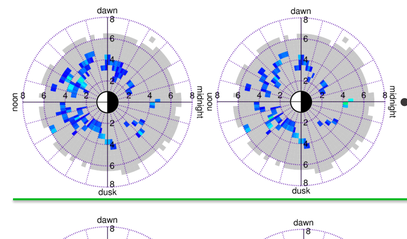
Quiet He^+-band
- Occurrence rates on the dayside decrease.
- Weaker waves located in this sector.



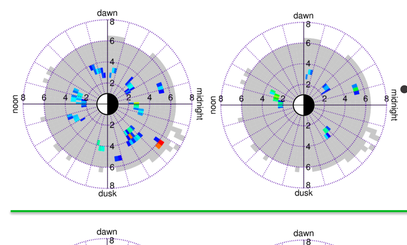
Moderate He^+-band
- Afternoon sector rates have not diminished.



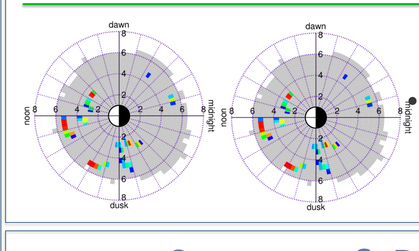
Disturbed He^+-band
- Post-midnight sector rates fall slightly. Afternoon sector still preferred wave occurrence region.



Quiet O^+-band
- Rates are fairly consistent.



Moderate O^+-band
- Significant decrease in afternoon and pre-midnight sector.



Disturbed O^+-band
- Rates are consistent. Few waves observed during pre-midnight sector.

Summary & Discussion

1.) The spatial distributions of EMIC wave events observed by the Van Allen Probes were examined. A majority of the Van Allen Probes data coverage was during quiet conditions.

2.) As AE increases, the spatial distribution of EMIC waves converges to the afternoon sector. This is consistent with results by *Meredith et al.* [2014]. Despite lower data coverage (especially for O^+-band waves), the afternoon sector yielded high occurrence rates under disturbed conditions.

3.) The number of quiet condition EMIC wave events experienced a greater loss of events with an increased wave power threshold than compared to the moderate and disturbed conditions.

4.) As the wave power threshold is increased, the occurrence of EMIC waves on the dayside decreases. More intense H^+- and He^+-band waves were observed in the afternoon sector, this is consistent with the well known enhanced EMIC wave region described by *Thorne* [2010]. Overall there were stronger He^+-band EMIC waves than the other wave bands as also reported by *Meredith et al.* [2014].

EMIC Wave Power vs. AE

EMIC events wave power ≥ 0.01 nT^2/Hz

Band	Quiet	Moderate	Disturbed
H^+	66	46	68
He^+	154	115	122
O^+	32	17	13

EMIC events wave power ≥ 0.1 nT^2/Hz

Band	Quiet	Moderate	Disturbed
H^+	40	36	55
He^+	94	88	100
O^+	21	8	13

- This analysis has been performed for two minimum wave power thresholds: 0.01 nT^2/Hz (left) and 0.1 nT^2/Hz (right).
- More stronger H^+- and He^+-band EMIC waves occurred under disturbed conditions.
- Weaker waves are associated with quiet conditions.

Future Work

1.) To examine the spatial distribution of EMIC waves with respect to solar wind conditions.

2.) To investigate excitation conditions and particle energization and loss effects of all EMIC wave events.

References

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Miyoshi *et al*., 2008
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Thorne, 2010
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Zhang *et al.,* 2011
Zhang *et al.,* 2014

Acknowledgements

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