EMIC waves observed by MMS and the Van Allen Probes

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Abstract

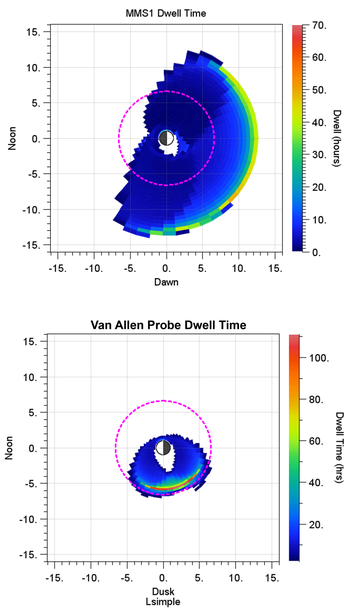
We present here a selection of electromagnetic ion cyclotron (EMIC) wave activity observed using the Van Allen Probes and the recently launched MMS satellite constellation. The equatorial orbital configurations of these missions are ideal for observation of the theoretical source region of EMIC waves. From the launch of MMS in early March of 2015, both missions have observed a similar region of MLT across the dusk, though the differences in apogee allow a larger span of coverage in L. The spatial configuration of the MMS constellation will allow for full wave number solutions to an unprecedented degree of accuracy. This, coupled with the temporal separation of the Van Allen Probes, will allow us to define the size and persistence of observed wave regions, and directly measure the propagation characteristics of these waves.

EMIC Waves

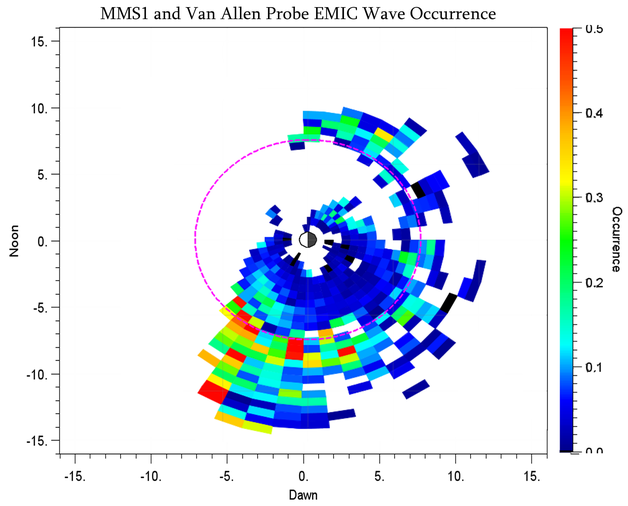
- Left-hand circularly polarized field-aligned wave mode
- Generated near magnetic equator by hot ion temperature anisotropy
- Can heat thermal ions and scatter relativistic electrons
- Frequency stop bands at ion gyrofrequency lines
- Subsets of this wave category include rising-tone triggered emissions and time-moduated Pc1 pearl pulsations

Instrumentation

- MMS is made up of four identical spacecraft in a tetrahedral configuration. They undergo a highly elliptical orbit near the equatorial plane with an apogee of 11 Re.
- The Van Allen Probes constitute two identical spacecraft in a similarly elliptical orbit in the equatorial plane out to an apogee of 5.8 Re.
- During the period of this study, from 2015-03-18 through 2015-08-31, both missions covered areas spanning the night side into the dusk region, where EMIC waves are predicted to be strongest.

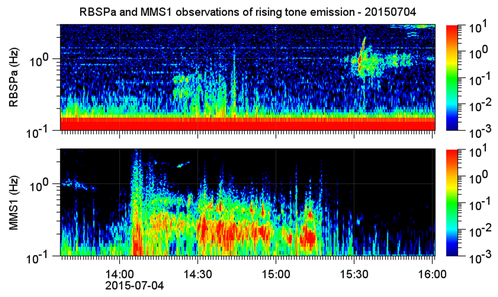


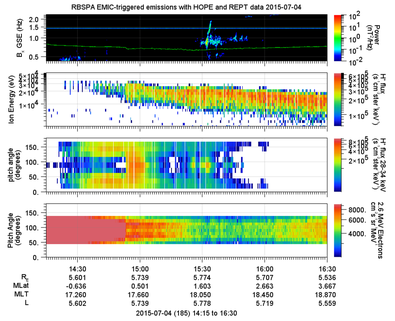
Occurrence Distribution



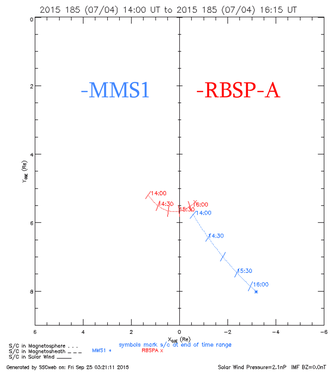
- By combining MMS and Van Allen Probe data we are able to construct an occurrence distribution of the entire equatorial plane.
- The duskside enhancement is much more pronounced in the outer magnetosphere.
- Little to no wave activity between local midnight and 3:00 MLT beyond 7 Re.
- MMS observes rising triggered emissions more often than the Van Allen Probes, but observes Pc1 pearl pulsations much less often.

2015-07-04 Event



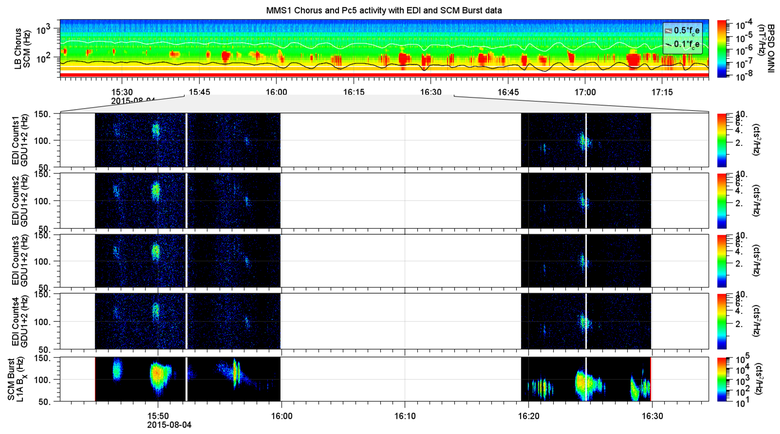


- On 2015-07-04, the four MMS spacecraft and Van Allen Probe A observed several strong rising tone EMIC-triggered emission in the Hydrogen excitation band.
- These rising tones are thought to very efficiently trap and scatter ultrarelativistic electrons. Above and to the right, RBSP-A observed a strongly anisotropic H+ population transfer their energy into the triggered emission. We do see a small depletion in high-energy electrons, but will have to examine phase space density parameters to conclude this was due to wave interactions.
- This region spanned 18:00 to 21:00 MLT and L=5-7, and was active over a period of 1-2 hours. Van Allen Probe B crossed the same area 3 hours later but did not observe the activity.



Pc5 Modulation

- On outbound passes, the MMS spacecraft often observe a region of EMIC activity followed by a region of large amplitude (10s of nT) Pc5 waves.
- Pc5 modulation has recently been proposed as a driver of time-modulated EMIC waves (Pc1 pearl pulsations) but we have not seen this behavior in the overlap between these regions.
- Instead, we see strong modulation of lower band chorus activity by these Pc5 waves (visible in the top panel of plot below).
- Additionally, we find elevated count rate fluctuations in the 500ev electron flux measurements made by the EDI instrument at the same frquency and time as these lower band chorus bursts, demonstrating direct measurements of wave-particle interactions



Conclusions

The MMS spacecraft will provide an excellent opportunity to observe EMIC wave activity in the outer magnetosphere throughout the duration of its mission. By combining these observations with those of the Van Allen Probes, we can construct a full dynamic map of areas of wave activity. The different regions sampled result in measurements of different subsets of EMIC waves, triggered emissions in the outer magnetosphere and Pc1 pearl pulsations in the inner magnetosphere, implying spatially-dependent generation mechanisms.

The high sampling rates of EDI's particle detection mode have allowed us to observe in situ scattering of electrons by wave processes. The outer magnetospheric region is dominated by Pc5 wave activity, but this region does not seem to encourage EMIC wave growth.

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