Statistical analysis of Electromagnetic Ion Cyclotron (EMIC) waves and their correlation to the 11 year solar cycle

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Introduction

Proton temperature anisotropy in the magnetosphere causes unstable, energetic proton distributions to generate EMIC waves in the equatorial plane. EMIC waves are hydromagnetic and travel along the magnetic field lines, and are therefore examples of Alfvén waves. Since the EMIC waves travel along the magnetic field lines, precipitation of the waves can be measured by ground based instruments at high latitudes. The EMIC waves have frequencies below the local proton gyrofrequencies, which in the magnetosphere corresponds to the Ultra Low Frequency (ULF) range: 0.1-5 Hz.

Measurements waves in the ULF range have been conducted at the Halley Research Station in Antarctica (fig. 1) since February 17th, 2005. This presentation shows a statistical analysis of EMIC waves at Halley from 2008 throughout 2012. In this presentation, "above 1 Hz" means that the maximum frequency of the wave reached above 1 Hz. See figures 2 and 3 for examples of EMIC waves.

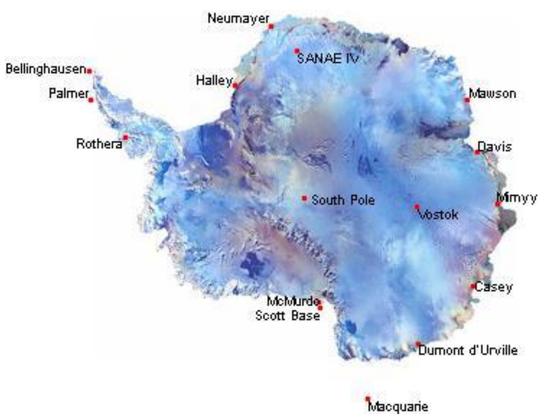

Figure 1 Map of Antarctica showing the location of Halley Research Station

Sample Events

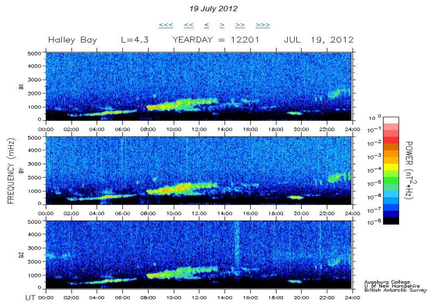

Figure 2 Example of a day with several EMIC waves above 1 Hz

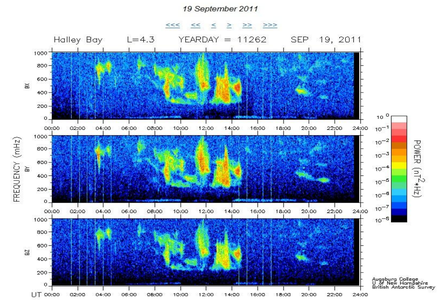

Figure 3 Example of a day with several EMIC waves below 1 Hz

Statistical Results

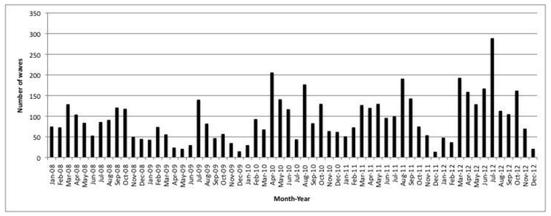

Figure 4 Total number of EMIC waves for each month during the 5 year period

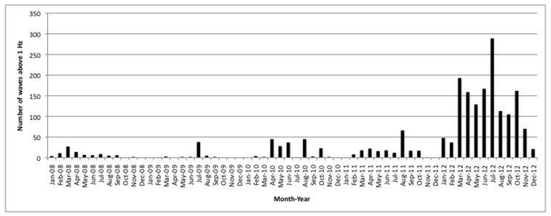

Figure 5 Number of EMIC waves above 1 Hz for each month

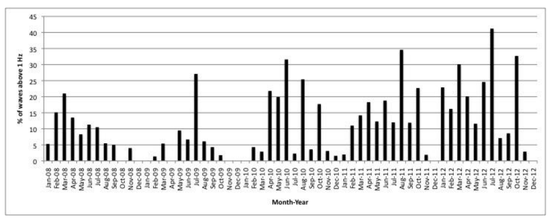

Figure 6 Percent of EMIC waves above 1 Hz for each month

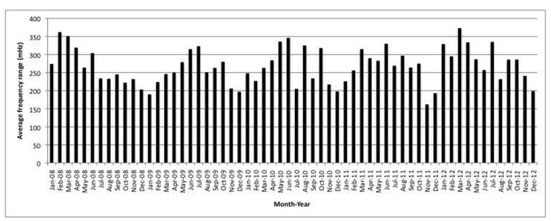

Figure 7 Average frequency range of EMIC waves for each month

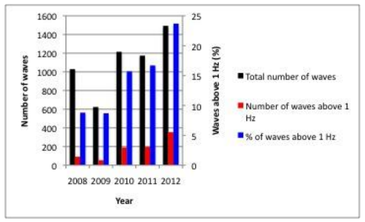

Figure 8 Shows total number of EMIC waves, number of events above 1 Hz and percent of waves above 1 Hz for each year

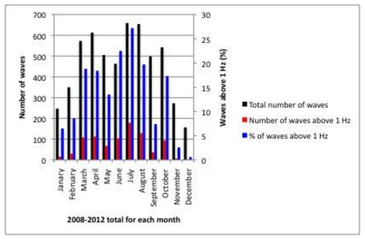

Figure 9 Shows total number of EMIC waves, number of events above 1 Hz and percent of waves above 1 Hz for each month, summed over all months 2008-2012

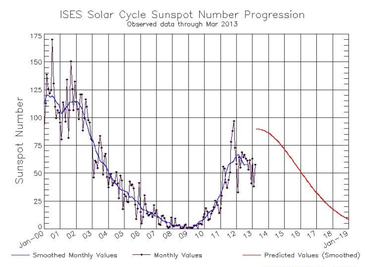

Figure 10 Solar activity as measured by sunspot count [1]

Discussion

The data from Halley shows an increase in the total number of events as well as number and proportion of waves above 1 Hz during the five year period (fig. 4, 5, 6 and 8), with maxima in 2012 and minima in 2009 for the total number of waves and number and proportion of waves above 1 Hz (fig. 8). The increasing trends coincide with the recent rise in solar activity, and the solar minimum in 2009 (fig. 10). There is no clear increasing or decreasing trend in the frequency range (max frequency – min frequency) of the EMIC waves during the five year period (fig. 7).

EMIC waves show a seasonal dependence (fig. 7 and 9). The number of EMIC waves, number and proportion of waves above 1 Hz, and wave frequency range all show minima during the austral summer months, while the corresponding maxima occur during the fall, winter and spring months. This is possibly due to the Russell-McPherron effect which predicts a better coupling between the solar wind and the magnetosphere during the fall and spring months [2]. However, this effect does not explain the maxima that can be seen in the winter months.

Conclusions

- The number of EMIC waves, number of EMIC waves above 1 Hz and proportion of EMIC waves above 1 Hz has increased from 2008 until 2012, reaching minima in 2009 and maxima in 2012. This coincides with the 2009 solar minimum and the recent rise in solar activity.
- The number of EMIC waves, number and proportion of waves above 1 Hz, and wave frequency range all show minima during the austral summer months and maxima during the spring, winter and fall months.
- There is no clear increasing or decreasing trend in EMIC wave frequency range during the five year period.

References

1. *Solar Cycle Progression*, Space Weather Prediction Center, 8 April 2013. Web. 22 April 2013.
2. Russell, C.T., McPherron, R.L. *Semiannual Variation of Geomagnetic Activity*, J. Geophys. Res., 78(1), 92, 1973.