EPSC Abstracts
Vol. 5, EPSC2010-923, 2010
European Planetary Science Congress 2010

On the application of the Wigner-Ville distribution to the identification and analysis of Pc 5 waves events

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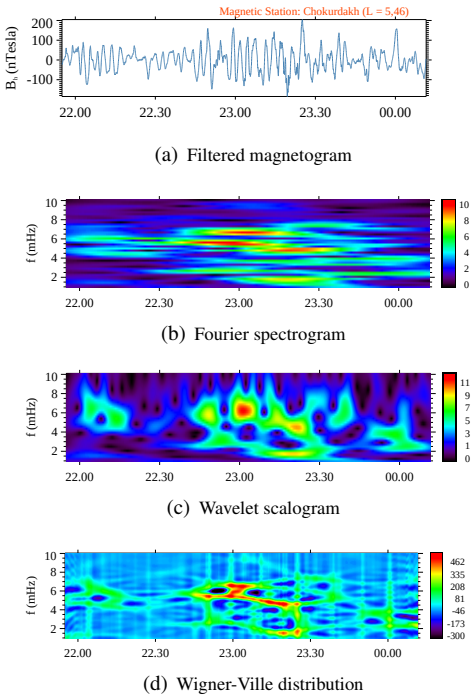
Abstract

Magnetospheric ultra low frequency (ULF) waves with frequencies ranging from $f = 1\,mHz$ to $1\,Hz$ are intimately related to shear instabilities at the magnetopause flanks and compressions of the dayside magnetopause due to quasi-periodic variations in the solar wind dynamic pressure. The observation of Pc 5 waves with remarkably stable frequencies of $1.3\,mHz$, $1.9\,mHz$, $2.8\,mHz$ and $3.4\,mHz$ provide strong evidence for the existence of MHD waveguide or cavity modes in the magnetosphere. However, their properties and in particular their frequencies may vary with structural changes of the magnetosphere during intense magnetic storms [1].

Pc 5 wave events, all occurring during major geomagnetic storms of the declining phase of solar cycle 23, have been studied with the use of measurements of the terrestrial magnetic field covering low and mid latitudes and the Wigner-Ville distribution. This approach has unique advantages over the Fourier spectrograms and wavelet scalograms which are traditionally used for the time-frequency analysis of triaxial magnetometic field data [2, 3]. With the use of the Wigner-ville distribution not only the start and end time of each wave packet, but also the frequency and phase could be more accurately defined.

The characteristics of low latitude Pc 5 wave are visible in the response of the Earth's magnetic field the magnetic storm that occurred in January 2005, when the Dst index reached a minimum value of $-105\,nTesla$ (Figure 1). Although in this case, Pc 5 power enhancements are observed at the frequencies of $1.9\,mHz$ and $3.4\,mHz$, even at the low latitudes that the Chokurdakh station of the 210^o Magnetic Meridian chain [4, 5] is located, these apparently stable frequencies do not seem to be distinguished from other frequencies of the Pc 5 waves.



(a) Filtered magnetogram

(b) Fourier spectrogram

(c) Wavelet scalogram

(d) Wigner-Ville distribution

Figure 1: The magnetic field of the pulsation observed by Chokurdakh station of the 210^o Magnetic Meridian chain during the magnetic storm on 21 January 2005, when the Dst index reached a minimum value of $-105\,nTesla$. The dynamic power spectra of the horizontal component (eastward) has been plotted in color for frequencies up to $10\,mHz$ (Pc 5 range). The color scale of the Fourier spectrogram and the wavelet scalogram correspond to the logarithm of the power, in nT^2/Hz.

In view of the highly dynamic nature of the magnetosphere, in particular during magnetic storms, these Pc 5 frequencies widely distributed throughout the $f = 1\,mHz$ to $10\,mHz$ band suggest the existence of alternative sources, from which they draw their energy,

such as low frequency instabilities of the ring current plasma.

References

[1] Lee, E. A., Mann, I. R., Loto'aniu, T. M., and Dent, Z. C.: Global Pc5 pulsations observed at unusually low L during the great magnetic storm of 24 March 1991, Journal of Geophysical Research, Vol. 112, A05208.1-A05208.12, 2007

[2] Chi, P. J., and Russell, C. T.: Use of the Wigner-Ville distribution in interpreting and identifying ULF waves in triaxial magnetic records, Journal of Geophysical Research, Vol. 113, pp. A01218.1-A01218.11, 2008

[3] Boudouridis, A. and Zesta, E.: Comparison of Fourier and wavelet techniques in the determination of geomagnetic field line resonances, Journal of Geophysical Research, Vol. 112, pp. A08205.1-A08205.8, 2007

[4] Yumoto, K.H. and the 210^o MM Magnetic Observation Group: The STEP Magnetic Meridian network project, Journal of Geomagnetism and Geoelectricity, Vol. 48, pp. 1297-1309, 1996

[5] Yumoto, K. H. and the 210^o MM Magnetic Observation Group: Globally coordinated magnetic observations along 210^o Magnetic Meridian during STEP period: 1. Preliminary results of low latitude Pc3's, Journal of Geomagnetism and Geolectricity, Vol. 44, pp. 261-276, 1992