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Spectral analysis tools for identifying the geomagnetic field pattern

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While the Fourier transform can not show which of the harmonic components is present at a time in the geomagnetic data series, wavelet analysis gives us information in the form of a three-dimensional graph (time, frequency, amplitude) or a two-dimensional shape, when the amplitude is encoded by color intensity levels.
A first step in the wavelet analysis is Short Time Fourier Transform, applied successively with different narrow windows, for the best accuracy of time location. Increasing the window improves the resolution in frequency but decreases the resolution in time.
Although wavelet analysis provides additional information in comparative with Fourier analysis, it should be viewed under the Heisenberg principle of uncertainty, which states that the product between time and frequency of a signal is limited to a non-zero value.
One of the advantages of wavelet analysis compared to Fourier analysis is the flexibility in choosing the mother function.
The wavelet transform is one of the ways of representing the signals in the multi-resolution analysis where the analyzed geomagnetic signal is described by a sequence of approximations that contain more and more information.
Each level of approximation contains on the one hand all the information available at the previous level plus an additional detail component.
In this paper we performed both Fourier and Wavelet analyzes on several geomagnetic record series at the Geomagnetic Surlari Observatory during intense geomagnetic disturbances. Of these, we selected a series of 729600 samples in 4 days (24-28 Aug 2018), sampled at 0.5 s.
In the study presented in this paper we used spectral analysis and wavelet tools from signal processing in Matlab.
From these types of analyzes resulted a precise localization of the times when the high frequency components represented by the pulsations were present, as well as the value of the low frequency components represented by the periodic oscillations of 8 hours, 12 hours and 24 hours. The maximum period of magnetic disturbance was manifested by a decrease or even a lack of periodic oscillations. Another advantage of wavelet analysis refer to the intervals in which sudden variations in the amplitude of the analyzed geomagnetic signal are present are unaltered.
These advantages recommend multi-resolution analysis and wavelet analysis as very effective analysis tools for studying geomagnetic storms and space weather.
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