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Wavelet analysis of ionospheric disturbances

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ABSTRACT

The satellite observation of the fluid envelopes of the planet Earth allows the study of ionospheric signatures of some telluric phenomena, such as earthquakes, tsunamis or volcanic activities. These phenomena translate a particular coupling between the solid Earth and the various fluid envelopes (atmosphere, ionosphere) which surround it.
We propose in the present work a multiscale analysis of ionospheric disturbances recorded by the microsatellite DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions). The DEMETER database includes several temporal series of measurements of various ionospheric parameters relating to certain regions, characterized by a variable seismicity. The spectral analysis of the time series obtained from measurements made by the Instrument of Plasma Analyser (IPA), recorded above Japan (subduction zone) and above Tanzania (volcanism) shows that for the seismo-electromagnetic signals, Fourier power spectra follow power law behaviour, as f- (f- frequency, - spectral exponent, typical of fractal self-affine process. Thus, the possibility that these time series show the scale invariance associated with long range correlations (LRC) led us to propose the use of Continuous Wavelets Transform as a natural tool for investigation of ionospheric disturbances. By a suitable choice of the wavelet analysis, we can overcome the regular trends and quantify the existence of correlation with long ranges associated with monofractal scale invariance properties.
The wavelet based estimator allows to locate the diverse ionospheric signatures (pre-, co- and post-seismic) produced by the seismic events represented by the precursors or the aftershocks.
For all the analyzed physico-chemical variables, the spectral exponents vary in the [1, 3] interval that characterize the fractional Brownian motions. Let us note that these observations are in perfect agreement with the elastic diffusion process involved in the ionosphere. These results confirm then the presence of long-range correlation and suggest the possibility of proposing the spectral exponent as an indication of prediction of the seismic activity.

Keywords: DEMETER, Ionosphere, continuous wavelet, spectral exponent, prediction.