Multifractal Spectrum of Time Series of Earthquakes by Use of Wavelet Analysis-Introduction and preliminary results-

Bogdan Enescu[1], Kiyoshi Ito[2]

[1] RCEP, DPRI, Kyoto Univ., [2] Disas. Prev. Res. Inst, Kyoto Univ.

http://www.rcep.dpri.kyoto-u.ac.jp/~benescu/

Multifractality-Intro. Multifractal structures have been found in various contexts, as for example in the study of turbulence, stock market exchange rates and network data traffic. The idea of using multifractal measures in geophysics is not new, as it has been pioneered by Mandelbrot (1989). Multifractal analysis is especially well suited for dealing with multiplicative, cascades-like processes, where the use of traditional statistical methods is not good enough. For example, how you can describe a process where the local density of its associated signal goes to zero or to infinity? Earthquakes are also such cascade-like processes, with one 'main' shock followed by many aftershocks, having their own aftershocks and so on... ETAS model (Ogata, 1988, 1989, 1992), for example, was especially designed to deal with the multiplicative character of seismicity.

Multifractality and earthquakes. Geilikman et al (1990), Hirabayashi et al. (1992) or Goltz (1997) have all employed a multifractal approach for characterising the earthquake spatial, temporal or energy distribution. Their results clearly suggest that seismicity is an inhomogeneous fractal process.

Wavelet analysis and the multifractal spectrum. The wavelet transform proves to be a very good tool for characterising the local properties of a signal or function, as it gives a local time-frequency decomposition of it. The application of the wavelet transform (modulus maxima) to multifractal analysis has been developed by Arneodo et al., in the early nineties, and has been extensively used to test many natural phenomena. The method has been found superior to more traditional approaches used for the computation of the multifractal spectrum (dimensions), like the box-counting method, which are very sensitive to finite-size effects. Struzik (1999, 2001, 2002) extends the methodology and shows some very interesting applications at characterising the human heart beat dynamics or financial time series.

Aim of this work. Data used. Method. The goal of this work is to apply the wavelet analysis for the computation of the multifractal spectrum of the occurrence times of earthquakes. In the future, we would like to extend the application of the method to characterise the spatial distribution of seismicity. We use as data the aftershocks of the 2000 Western Tottori earthquake, in particular the inter-event time between two successive aftershocks. The method consists in wavelet transforming the data and then finding its modulus maxima. The maxima lines thus obtained are 'filtered' to eliminate the weak, noisy signals and then used for the computation of the partition functions, obtained by summing the maxima at different scales. After choosing an appropriate scaling range, the fractal dimensions (Dq) are determined from the slopes of the partition functions.

Preliminary results. The wavelet analysis of the inter-arrival times reveals a clear multifractal pattern. There is a clear scaling range for the partition functions, but we are still working to find the best way for filtering the maxima lines and improving the results. The method seems to be a valuable alternative for the characterisation of the multifractal pattern of seismicity.