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Evolution of multifractal singularities spectra of geophysical time series: applications for detecting periodic and synchronization effects.

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Estimates of fractal dimension of the sets of time moments of the signal, having the same Hölder-Lipschitz singularity value α is known as multifractal singularities spectra ***F(***α) and this function is an important tool for analyzing stochastic properties of time series in different applications of fractal analysis of wide-banded signals: from finance and turbulence research till meteorology and climate sciences. The peculiarities of the function ***F(***α): minimum α_{min} and maximum α_{max} values of singularity values α, the width of the support interval $\Delta\alpha = \alpha_{max}$- α_{min}, the value α******* of the index α, providing the maximum value of ***F(***α) and this maximum value ***F(***α****)*** itself are important statistics for characterizing self-similar properties of the signal. The vector ξ of these values:

$$\xi = (F(\alpha^*), \alpha^*, \Delta\alpha, \alpha_{min})$$

could be regarded as the result of nonlinear transform of time series. If the time series is long enough then singularities spectrum ***F(***α) could be estimated within moving time window of the certain length ***L*** and this function and the vector ξ became dependent on the right-hand time coordinate τ of the moving time window: ***F=F(***τ***,***$\alpha|$***L)***. Thus, it is possible consider variations of $\xi(\tau)$ instead of variations of initial signals.

Report presents experience of using estimates of function ***F(***τ***,***$\alpha|$***L)*** for the analysis of various geophysical signals. Singularity spectra were estimated using deflection fluctuation analysis (DFA) and skeleton chains of continuous wavelet transform maximum modulus (WTMM) approach. The following time series are considered: background microseismic oscillations, underground water well levels variations, cumulative values of the released seismic energy, rivers runoff time series, tree rings. The $\boldsymbol{F(\tau,\alpha|L)}$-estimates turn to be a powerful tool for detecting hidden non-stationary properties of long geophysical records (such as periodic structure) and help to find synchronization effects between different signals.