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Multi-Fractal Modelling the Hydrological Systems (On Example Of Danube River): Spectral Hierarchy And Self-Scaling

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The multi-fractal approach (MFA) gives an opportunity to describe extremely compactly hydrological and other processes and systems. In the applied hydrology and generally geophysical sciences the MFA for description of various objects and processes develops actively. A set of most important results is as follows: a concept of scale self-similarity for the topography of Earth's surface (Mandelbrot, 1967; Menabde et al.,2001), the hydraulic-geometric similarity of river system and floods forced by the heavy rain (Lovejoy-Schertzer, 1992; Burlando-Rosso,1996), Deidda et al,1998; Loboda-Glushkov,2003,2004), etc. Here a generalized version of the MFA is numerically realized to investigate the annual runoff for the Danube river and reveal scale invariance for distribution of this variable by using statistical parameters such as arithmetic average, coefficients of variation, skewness, and auto-correlation. Investigations of the annual runoff for indicated rivers using standard fluctuation analysis show that both in spatial distribution and in time one of the runoff's characteristics the self-affine scaling behaviours exist. The fractal dimension d = 1.8 for long-term annual runoff and d= 1.6 for variation coefficient. Spatial correlation between these parameters is found at distance up to 400 and 200 km respectively. If distance increases ($s = L$) then these characteristics become uncorrelated. The statistical parameters such as the skewness C and the auto correlation coefficient r have a randomicity of distribution in the space; a "satiation" of spatial structure function occurs at very short S. We may recommend a zoning for the spatial generalization of C and r. The use of multifractal approach to the first component of decomposition on the empirical orthogonal functions for annual runoff has an advantage over the use of observational time series. First component of decomposition and its components represent large-scale forcing of generating process for the annual run-off. At the same time the influence of water-related activities and surface factors are eliminated. Furthermore, the time components (amplitude functions) are general for all hydrological objects, i.e. they characterize the fluctuation of runoff in time. In addition, this fluctuation is averaged for whole territory. The time part of first component describes most general patterns for the annual runoff fluctuations of rivers. Namely this variable is subject to the fractal analysis. Here the variational function $F(s) \quad \sim \quad s*(H)$is used as a property of spatial-time variation for the annual runoff (H is the exponent of scaling identical with the fractal dimension). It is determined that H = 0.8 and this agrees to the hypothesis of Hurst's universal exponent.

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