Statistical relationships between the fractal dimensions computed for the seismicity of the southern slope of the Greater Caucasus

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The fractal scaling parameters of the seismicity of the southern slope of the Greater Caucasus are examined by analysing the distribution of earthquakes recorded in this region in 1902-2016. The southern slope of the Greater Caucasus is a collision zone with a wide earthquake magnitude range. Four seismic zones have been identified within this region based on gravimetric measurements and analysis of GPS-velocities, energy distribution, and the fractal properties of the region [Kadirov et al., 2013].

The scaling parameters of earthquake energy and epicentre distribution are computed both for the region of study and for earthquakes recorded in the territory of Azerbaijan.

In particular, the Gutenberg-Richter b-values and the fractal dimensions of earthquake energy distribution are estimated for the southern slope of the Greater Caucasus as well as for the four seismic zones within this region.

To compute a fractal dimension of earthquake energy distribution, we use the Gutenberg-Richter magnitude-frequency relationship and the equation $lgE=\alpha + \beta M$ showing how magnitude relates to the logarithmic energy of an earthquake. Combining them yields the equation $N = 10^v E^{-d}$ which represents a power-law relationship, where d is a fractal dimension of earthquake energy distribution corresponding to b/β (the empirical coefficient β is assumed on average to be 1.5). Hence, the fractal dimension of earthquake energy distribution for the southern slope of the Greater Caucasus is 0.53. The highest fractal dimension of energy distribution (0.59) within the region of study is observed in the Sheki-Gabala zone, while the lowest one (0.39) in the Gobustan-Absheron zone.

The fractal dimension of epicentre distribution (D_e) for earthquake records of the southern slope of the Greater Caucasus is calculated by the box-counting method [Angulo-Brown et al., 1998; Caneva and Smirnov, 2004]. The computed fractal indicator equals 1.33 and reflects heterogeneity in the spatial distribution of earthquake epicentres. The fractal dimensions of epicentre distribution calculated for the four seismic zones within the region range from 1.03 to 1.30, averaging 1.20.

To examine the statistical relationships between estimated fractal dimensions, the equation $D = 2 * b$ [Turcotte, 1997; Aki, 1981], which relates the b-value and a seismic fractal dimension, is employed. Combining it with the formula $d=b/\beta$ gives the following relation $D_e = 3 * d$. This theoretical relation shows how fractal dimensions of earthquake energy and epicentre distribution are approximately correlated. Such correlations, however, vary in regions with different seismotectonic regimes.

Our research has found that the coefficient connecting the D_e and d values calculated for the southern slope of the Greater Caucasus is 2.51, whereas the highest rate of correspondence (2.97) is observed in one of the seismic zones (Gobustan-Absheron) located within the studied region. Meanwhile, the coefficient which connects the fractal dimensions of epicentre and energy distribution computed for earthquakes recorded in Azerbaijan's territory during the instrumental period equals 2.91 and approximately fulfils the relation $D_e = 3 * d$.