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Probability of strong seismic events occurrence and its relationship with self-similarity of seismicity

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The aim of this investigation is determination of probability of strong seismic event (with magnitude more then M_{pr}) occurrence in a certain point for certain time interval (t_1, t_2).

This task is solved by means of determination of expression for probability P_s of strong seismic event occurrence around each event from magnitude interval (M_{tr}, M_{pr}), where M_{tr} is threshold magnitude. The probability P_s depends on parameters M, r and t, where M is magnitude of considered event, r is distance from it and t is time past after its occurrence.

Investigation of a stochastic variable R allows to determine the probability P_s. Here R is distance from considered event to the nearest (in space) strong event, which occurred in time interval with duration t after considered event. If for considered event with magnitude M for fixed values of t and M_{pr} R is equal r then it means that area around this event defined by parameters r, t and M was "forbidden" for strong events. Furthermore the value of distribution function of R: $F(r) = P(R < r)$ corresponds to probability that radius of "forbidden" area (disk or ball) will be less then r. In other words $F(r) = P_s$ is probability that in area with radius r around considered event for time t at least one strong event occur. Thus information about background seismicity and the distribution function $F(r)$ allows to determine the probability of strong seismic event occurring.

It was found that the distribution function $F(r)$ for different M, r, t and M_{pr} has a stable shape and can be obtained by means of scaling of base function F_0:

P_s = $F(r)$ = $F_0(r/< R >)$, where the scale parameter $< R >$ is average of variable R. To determine the probability P_s = $P_s(r,\ t,\ M_{pr})$ of strong seismic event occurrence in certain magnitude-space-time interval it is enough to find function F_0 and relationship between $< R >$ and parameters M, r, t and M_{pr} (P_s and $< R >$ are near independent from M).

When we know $P_s(r, t, M_{pr})$ we can determine the probability density $f(r, t, M_{pr})$ of strong events occurrence in time interval (t_1, t_2), in a point remote from the considered event to distance r: $f_s(r, t_1, t_2, M_{pr}) = \frac{1}{2\pi r}\frac{\partial}{\partial r}\left(P_s(r, t_2, M_{pr}) - P_s(r, t_1, M_{pr})\right)$.

The described approach was applied for seismicity of southern California (USA), and Toktogul region (Kirgizia) and Welkom gold fields (RSA).

It was found that $F_0(r)$ is well fitted by function 1 – [1+$(r/r_0)^2$]$^{-\alpha}$, and $< R >$ – by function $Ct^{-\beta}10^{\gamma\ M_{pr}}$ (other variants of fitting are also possible). For such fitting $f_s(r, t_{1,} t_2, K_{pr}) = \frac{\alpha}{\pi r_2^2}\left(1+\left(\frac{r}{r_2}\right)^2\right)^{-(\alpha+1)} - \frac{\alpha}{\pi r_1^2}\left(1+\left(\frac{r}{r_1}\right)^2\right)^{-(\alpha+1)}$, where $r_2 = r_0 C t_2^{-\beta} 10^{\gamma\ M_{pr}}$ and $r_1 = r_0 C t_1^{-\beta} 10^{\gamma\ M_{pr}}$.

The parameters α, r_0, C, β, and γ can be easy obtained from experimental relationships. They completely define $P_s(r,\ t,\ M_{pr})$ and $f(r,\ t,\ M_{pr})$ and allow to estimate probability of strong seismic event (with magnitude more then M_{pr}) occurrence in a certain point for certain time interval $(t_1,\ t_2)$.