A METHOD OF LARGE SHALLOW-FOCUS EARTHQUAKE PERIODICITIES REVEALING AND OF PREDICTION SEISMICALLY HAZARDOUS TIME INTERVALS

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A technique of general solution of the problem of revealing of statistically significant, informative and stable in time periodicities of shallow-focus earthquake occurrences has been suggested in the report. The found out periodicities are used for evaluation of time intervals with higher probability of occurrence of large seismic events. Catalog data of large earthquakes are the initial data for calculations. Search for periodicities is made in maximum wide range of periods from parts of days to scores of years. The following stages of processing are executed for each period $T_i$:

Stage 1. Conversion of the catalog events into a point over a ring, i.e. half-interval $[0,1)$ with the identified ends. This stage is realized for three steps by means of: (1) formation of reamers of $T_i$ duration from the beginning to the end of observation time in the earthquake catalog; (2) evaluation of the residual between origin time in the earthquake source and the beginning (end) of the corresponding reamer; (3) conversion of the residual into a point over the ring $[0,1)$, i.e. calculation of the conditional cycle phase as of the moment of a strong shock occurrence. On completion of this stage we obtain distribution of earthquakes over the ring.

Stage 2. The calculation on the basis of the obtained distribution of two parameters: Kuiper’s statistics $K(T_i)$ and informative characteristics $S(T_i)$ which define maximum distance between the events on the ring. Below this distance is called «calm window». It plays an important role by prediction of periods of the higher probability of large earthquake occurrences. As a result we obtain two rows of values $K(T_i), S(T_i)$ ($i = 1,\ldots, n$).

Stage 3. Choice of periods most informative for prediction of large earthquakes. The problem is reduced to evaluation of the anomalous values of local maxima of row $S(T_i)$ ($i = 1,\ldots, n$). Maxima $S(T_i) \geq U$, where $U = \mu + 3 \sigma$ is threshold level and $\mu$ and $\sigma$ are average and root mean square deviation of values of row $S(T_i)$, are considered to be anomalous. As a result we form a combination of the most informative periodicities $T_j$ ($j = 1,\ldots, m$).

Stage 4. Evaluation of a degree of uniformity of event distributions over the ring for combination of the most informative periodicities. The problem of verification of $H_0$ hypothesis on uniformity of $F = F_0$ distributions versus $H_1$: $F \neq F_0$ alternative is solved. During the verification Kuiper’s statistics $K(T_j)$ and the criterion of the same name, which is the analog of Kolmogorov-Smirnov’s criterion, were used. As a result we have a set of statistically significant and at the same time most informative periodicities $T_k$ ($k = 1,\ldots, l$).

Stage 5. The analysis of stability in time of $T_k$ periods. Their stability is checked by means of the repetition of calculations in terms of the first two above-mentioned stages by variation of the volume of earthquakes selection from 50% to 100%. A set of stable periodicities, for which variations of positions of local maxima with variation of the sample volume are not beyond the permissible values depending on the period value, is established on the basis of these calculations.

Stage 6. The calculation of mobility of the calm window boundaries on the ring for the given period. Choice of tolerances to the calm window boundaries. Value of tolerances must be chosen taking into account the importance of errors of the first (goal omission) and second (false alarm) kinds. In this case negative after-effects from the goal omission is much greater than from the false alarm. Therefore choice of tolerances is made in such a way as the error probability of the first kind was close to zero. When we choose tolerances for a separate periodicity we take into account both stability of the period and degree of mobility (variation) of calm window boundaries depending on filling of the sample of large earthquakes.

Stage 7. (final). The calculation of time intervals with the higher probability of large earthquake occurrences (alarm periods) in the study area from total statistically significant, informative and stable periodicities.