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Anomalies of RTL function and Gutenberg-Richter parameter preceding earthquakes in California

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Seismicity anomalies are characteristic changes in the distribution of earthquakes in the spatiotemporal domain and their energy spectrum. To detect anomalies preceding strong earthquakes, parameters of the seismicity are analyzed, each corresponding to a precursor pattern – a specific behavior of values over time, accompanying the process of earthquake source preparation.

The present study investigates seismicity anomalies preceding the 15 largest earthquakes in California (with magnitudes M>6.5) from 1984 to 2023. Two parameters were selected for the analysis: the RTL function, sensitive to stages of seismic quiescence and foreshock activation, and exponent of the energy spectrum of seismicity (Gutenberg-Richter parameter, or b-value), reflecting the ratio of frequencies of earthquakes with different magnitudes. These statistical parameters have been previously used by the authors to search for and analyze seismicity anomalies in subduction zones (Kamchatka, Japan) and in the rift zone (Iceland) [1].

For all investigated earthquakes anomaly characteristics were determined: duration, spatial size, distance from the earthquake epicentre. The values of tuning parameters for the algorithms are presented. The durations of the identified anomalies correspond to typical values for mid-term precursor anomalies [2, 3]. The average (median) duration of RTL and b-value anomalies in California was found to be shorter than the durations of such anomalies in the subduction zone in Kamchatka [1]. Regarding the comparison of RTL anomaly durations in California, Kamchatka, and Japan, [4] notes the same relationships but with a smaller event statistic than ours.

It was found that for 12 out of 15 earthquakes, RTL parameter anomalies are registered earlier than anomalies of b-value. The obtained staging of anomaly occurrence differs from the staging found by the authors previously when analyzing strong earthquakes in subduction zones and the rift zone [1]. This may be related to differences in earthquake depths in California and in subduction zones, as well as differences in earthquake preparation processes in strike-slip zones, subduction zones in Kamchatka, and transitional zones from ocean to continent [4]. Most of the studied earthquakes occur with a delay after the end of RTL anomalies, reflecting the completion of the formation of a metastable area. The nature of this delay remains unclear, and the time of earthquake occurrence in such situations is associated, in particular, with triggering mechanisms [3, 5].

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