GC2026-SGG056

A new approach to determine the most probable depths of earthquakes using the example of the Kuril-Kamchatka subduction zone

I. A. Vorobyova[1] , K. V. Krushelnitsky[1] , E. M. Grekov[1,2] , A. A. Skorkina[1] , S. V. Baranov[3] , P. A. Malyutin[1] , S. D. Matochkina[1] , **A. P. Molokova[1,2] ,** P. N. Shebalin[1]

[1] Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences
[2] Lomonosov Moscow State University, Moscow, Russia
[3] Unified Geophysical Service of the Russian Academy of Sciences

molokovaap@my.msu.ru

One of the key parameters of regional seismicity is the characteristic depth of recorded earthquakes. Like the parameters of the Gutenberg-Richter law or the maximum possible magnitude, depths significantly influence the resulting seismic hazard and seismic risk assessments [1].

Currently, despite the increased number of seismic stations, earthquake catalogs for the Russian Federation still frequently contain fixed depth values [2]. Clearly, this approach ultimately leads to misconceptions of depth distributions in the region. Most importantly, such values are completely unsuitable for seismic hazard assessment, synthetic catalog modeling, and other tasks aimed at obtaining the most reliable estimates of macroseismic manifestations and probable impacts on infrastructure.

This work examines the applicability of approximating earthquake depth distributions relative to the slab (according to the SLAB2.0 model [3, 4]) using two-parameter analytical functions, using the Kuril-Kamchatka subduction zone as an example, as well as the distribution of absolute earthquake depths for shallow crustal earthquakes in the Sea of Okhotsk and Pacific Ocean plates.

The Kuril–Kamchatka subduction zone consists of three segments—the Kamchatka, South Kamchatka, and Kuril segments—each with a different tectonic history and distinct geodynamic regimes [5]. Using the International Seismological Center (ISC, isc.ac.uk) catalog for 1976–2023, which contains 8,388 earthquakes, starting with a representative magnitude of 4.7 and with a depth of up to 300 km, the Kuril–Kamchatka subduction zone was analyzed separately for four segments: Hokkaido, the South Kurils, the North Kurils, and Kamchatka.

The depth distribution analysis was performed separately for each segment, as well as for each type of seismicity (interplate, intraslab, and shallow earthquakes of the Sea of Okhotsk and Pacific plates).

For interplate and intraslab earthquakes, the analysis showed that all distributions of relative depth values within their group follow a normal law. For shallow earthquakes in four segments, the distributions significantly differ. The closest approximation for the distribution of absolute depths of shallow seismicity is the Weibull distribution. Thus, for large segments and different types of seismicity, it was shown that earthquake focal depth distributions can be approximated by analytical functions with two parameters.

The main advantage of the proposed approach is the ability to fully algorithmically estimate depth distribution parameters.

References

1. Cornell C.A., Bulletin of the Seismological Society of America 58(5) (1968) 1583.
2. Malyutin P.A., Skorkina A.A., Vorobieva I.A., Baranov S.V., Matochkina S.D., Molokova A.P., Shebalin P.N., Izvestiya, Physics of the Solid Earth 4 (2024) 50.
3. Hayes G.P., Moore G.L., Portner D.E., Hearne M., Flamme H., Furtney M., Smoczyk G.M., Science 362 (20180 №6410б 58.
4. Weibull W.A., Journal of applied mechanics, 1951.
5. Avdeiko G.P., Popruzhenko S.V., Paluyeva A.A., Geodynamics and volcanism of the Kurile-Kamchatka island-arc system, Petropavlovsk-Kamchatsky, Institute of Volcanological Geology and Geochemistry of the Far

Eastern Branch of the Russian Academy of Sciences, 2001, 9.

This research has been supported by:

1. "Russian Science Foundation", grant 25-17-00094