A seasonal dependence of the earthquake number in the Earth crust

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SUMMARY

The Northern California Earthquake Database of the USA was analyzed. The database contains about 500,000 seismic events. For depths of hypocenters up to 40 km, a statistically significant non-uniform distribution of the events number by the year periods was detected. For greater depths of hypocenters such dependence is absent.

The distribution of the number of earthquakes in the Earth crust on the year periods for different geographical zones is analyzed. Separate zones were found, both with uniform distribution and with clearly non-uniform one. All such dependences aren’t connected with action of the tidal forces from the Moon and the Sun on the Earth.
Introduction

In the previous study (Kazantsev and Kazantseva, 2019), it was found that the dependence of the earthquake number on the Moon’s phase for depths of the hypocenters up to 40 km is significantly different from the similar dependence for greater depths. It was concluded that such difference of dependencies can be explained by the different distribution of seismic events on months of the year $N(m)$ for different depths of the hypocenters. The $N(m)$ distributions for different depths are indeed noticeably different. Such difference, in one’s turn, requires a separate explanation.

In this study, the analysis of the $N(m)$ earthquake distribution both for the whole Earth and for separate zones is continued. At the same time, for each zone and at every instant the values of the tidal forces from the Moon and the Sun were calculated. A brief description of the calculation method for tidal forces is presented in (Kazantsev and Kazantseva, 2016; 2017).

The database

As before, the study used the database of the Northern California Earthquake Data Center of the US. At the end of 2017, the database contained about 500,000 seismic events with magnitude $M$ above 2.0 number, registered since 2002. The distribution of event quantity by magnitude indicates that a complete set of the events for the whole Earth begins at $M = 4.0$. Therefore, statistical constructs for the whole Earth can carry out for earthquakes with magnitude greater than 4 number. There are about 200,000 such events in the database.

The distributions of the earthquake number for different areas and for different depths

At the beginning, the $N(m)$ distributions of earthquakes with $M > 4$ for the whole Earth and for the hypocenter depths $h < 40 \text{ km}$ and $h > 40 \text{ km}$ was constructed (Figure 1). The figure shows that for smaller depths there is a clearly non-uniform $N(m)$ distribution. For greater depths, the distribution is close to uniform. In according to Kolmogorov-Smirnov test, the difference between the above dependencies is statistically significant at a level above 5σ.

![Figure 1. The $N(m)$ dependencies on for different depths](image)

The presented dependencies are not caused by the action of the tidal forces from the Moon and the Sun to the Earth. Calculations show that the values of tidal forces for depths of 40 km
and 500 km are almost equal. In addition, these forces don’t have a similar seasonal dependence.

In principle, the maximum earthquake number in the March-April period at little depths can be caused by a large number of seismic events in any one year. This is not in the case however. The dependences N(m) for different intervals of years are shows in Figure 2. In both cases, the maximum in March-April take place.

![Figure 2. The N(m) dependencies for different periods of years](image)

A certain difference in the N(m) distributions occurs not only for different depths of the hypocenters, but for different geographical zones on the Earth as well. In particular, for the northern hemisphere, the maximum in March-April is more pronounced than for the southern hemisphere. This maximum is also more pronounced for the eastern hemisphere ($\lambda = 0^\circ - 180^\circ$) in compare with the western one ($\lambda = -180^\circ - 0^\circ$). The maximum in March-April is still more pronounced for the north-eastern part ($\varphi = 0^\circ - 90^\circ$, $\lambda = 0^\circ - 180^\circ$) in compare with the south-western one ($\varphi = -90^\circ - 0^\circ$, $\lambda = -180^\circ - 0^\circ$) (Figure 3).

![Figure 3. The N(m) dependences for the north-eastern part and for the south-western](image)
In some seismic zones of the northeastern part, the \( N(m) \) distributions are also markedly different. The distribution of earthquake epicenters in the northeastern part is shown in Figure 4, where three separate seismic zones are marked.

**Figure 4.** Distribution of the earthquake epicenters in the north-eastern part.

The corresponding \( N(m) \) distributions for these zones are presented in Figure 5. Here, for a better vision, the number of earthquakes in zone 3 was increased by factor of 100.

**Figure 5.** The \( N(m) \) distributions for different seismic zones in the north-eastern part of the Earth

One can see the maximum in the \( N(m) \) distribution take place for zones 1 and zone 3, and for zone 2 it is absent.
Conclusions

There is a maximum in the March-April period in the distribution of the earthquake number in the Earth crust on months of the year. This maximum is more pronounced for the northern hemisphere and for the eastern hemisphere, and especially for the northeastern part of the Earth.

In some seismic zones of the northeastern part, the maximum in the March-April period retains, and in some seismic zones it is absent.

The presence of this maximum in the N(m) distributions is not caused by the tidal force of the Moon and the Sun to the Earth. The existence of the maximum needs a separate study.

Acknowledgements

Waveform data, metadata, or data products for this study were accessed through the Northern California Earthquake Data Center (NCEDC), doi:10.7932/NCEDC.

References

