Earthquake (2025) Volume 3 Issue 1 ISSN: 3029-1550 (O)
doi: 10.59429/ear.v3i1.8254

RESEARCH ARTICLE

New trends in earthquake prediction – A case study of AI performance

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ABSTRACT

The short term earthquake prediction problem is considered not solved yet. The new trends on this topic are related to the intrusion of the Artificial Intelligence (AI) with believes it can help significantly to the solution. The case study of an experiment in China during 2023 and published in BSSA (https://pubs.geoscienceworld.org/ssa/bssa/articleabstract/113/6/2461/627949/Earthquake-Forecasting-Using-Big-Data.) deals with the results critically assessed of the achievements in time, distance and magnitude of forthcoming earthquakes in a test area in China. Some other cases are also presented to help the reader to enter the last published development in the mass media of the topic and some speculations on it. The conclusions are that the proclaimed unprecedented accuracy of predicted parameters of forthcoming seismic events is strongly overestimated.

Keywords: earthquake prediction; AI; comparative case studies

1. Introduction

Recently, the mass media have intensively disseminated messages related to earthquake prediction. More precisely, it is about the so-called short-term prediction (within days to months), which is one of the most difficult problems to solve in modern seismology.

Extensive research has been done on the capabilities of modern science to achieve a relatively accurate time forecast of an approaching strong earthquake. The general strategy for solving this question is related to the study of the so-called short-term precursors of strong tremors.

The idea that the behaviour of various precursors can help in the short-term prediction of earthquakes originates in ancient times and was strongly activated in the mid-1960s of 20th century.

After the strong seismic events in the beginning of 60-ties (XX c. - Chile, 1960, M9.5; Alaska, 1964, M9.2) the intensive instrumental observations of numerous forerunners at specially equipped complex geophysical polygons in the USSR, the USA, Japan and in other countries show that there are frequent enough coincidences in the observed anomalies, preceding earthquakes of various power.

The observational polygons were located in highly active seismic regions in central Asia (Garm) and Kamchatka (in the USSR), California (USA), all of Japan archipelago, parts of China, etc. They were

ARTICLE INFO
Received: 19 December 2025 |Accepted: 3 January 2025|Available online: 22 January 2025

CITATION
Ranguelov B. New trends in earthquake prediction – A case study of AI performance. Earthqauke2025;3(1):8254.doi:10.59429/ear.v3i1.8254

equipped with various instruments – seismological, geochemical, geophysical, etc. and collected information for long time intervals (more than 40-50 years). The progress was significant, but it turns out that scientists have overestimated these possibilities, for a very simple reason. It's called "precursors' ambiguity."

Under this name lies the explanation that not always and not everywhere observed anomalies are unequivocally related to the occurrence of an earthquake. Simply said - "there are anomalies - no earthquake or there are no anomalies - there is an earthquake".

This ambiguity is proving very difficult to overcome, and finally, after the USA (Loma Prieta earthquake, M 7.0 in 1989) and Japan (Kobe strong event, 1995, M 7.3), these huge destructive earthquakes were missed to predict by the scientists. They did not issue a warning, and after that the programs for earthquake forecasting in the both leading countries – have been cancelled.

Here it should be noted that only China does not stop its program, which is based on massive and more primitive and massive measurements, including intensive observations of the behaviour of animals (wild and domestic). At present, only China can boast of a predicted strong earthquake, with a magnitude greater than 7.5 in the area of the city of Haicheng, accompanied by a mass evacuation in 1975. Just a few months later, an earthquake of similar magnitude occurred in Tangshan (M7.4), killing several hundred thousand people (one of the most devastating of human lives seismic event worldwide).

No anomalies were observed before the last one. The world seismological community agrees that the successful correct prediction in 1975 (Haicheng) was the result of a lucky coincidence and strong precursors expression of a different nature - an intensive foreshock series, a mass release in February of numerous underground animals - snakes, lizards, mice, etc., intensive changes in the level of underground water in wells located on a large territory, electromagnetic disturbances measured by local people, etc.

More recently, after the strong earthquakes near Sumatra (26th December 2004, M9.1) and Japan (11th March, 2011, M9.0) the problem of short term earthquake prediction arises again. The development of the AI during the last years is believed to help this approach.

2. Initial speculations

After the earthquake of February 6, 2023, in Turkey, with over 60,000 victims and about a million affected, there was a revival of interest to the subject related to short-term earthquake prediction. First was the Dutchman Hogerbets. Public statements were made by Frank Hogerbets that he was able to predict the massive 7.6 magnitude earthquake several days before it happened [1].

The closest look at this prediction shows that it is the result of unrelated coincidences of planetary positions and astrological signs, which has not been taken seriously by the seismological community [1].

A few months later, in August 2024, there was a "serious warning" that Japan was at risk of a mega-earthquake in the lower Nankai ridge, south of Tokyo, within the next week. In seismology, a megaearthquake is understood as a tremor with a magnitude greater than 8.0 on the Richter scale.

This prediction was accompanied by an official statement and refusal of the Japanese prime minister to attend an important international meeting under the pretext of "protecting his country". After the "alarm" period passed, nothing happened, and this raised serious questions about the competence of the scientists and authorities who issued the forecast.

The Japan Meteorological Agency is the most serious and responsible Japanese institution and one of the leading in the world. To this day, it is not clear - who issued the forecast and who took responsibility after its "non-happened" [2].

Due to their training, many Japanese cancelled or modified their vacations; many stores closed or were emptied of goods. I know from ordinary Japanese that there is a competitive struggle in this area, but which of the competing parties was wrong - it is not yet clear.

What is important to mention is the fact that before the great Tohoku earthquake (M9.1 at 11th March 2011) a foreshock of M7 was observed. Probably JMA specialists have in mind this case and as an event with M7 occurred about a week earlier when the alarm was issued, they have made an analogy with the case of 2011.

After a while, media reports about the expected strong earthquake in Istanbul were renovated, including an announcement (August 2024) that an algorithm had been created with the help of artificial intelligence. The algorithm would warn Istanbul 30 days before a strong earthquake. The algorithm was developed at the University of Georgia (UG-USA). The area of Istanbul is the most seismically threaten area in Europe, expecting a strong earthquake. This expectation has been going on for last 30-40 years, and this has again given rise to all kinds of speculation.

It is known that in Turkey, there are also two competing wings - on the one hand, there are those who constantly fuel people's fears with all kinds of statements - how much, where and how the residents of Istanbul will suffer. On the other side are those who proclaimed calm future. Of course - the truth is somewhere in the middle [6].

The strong seismic event has been expected for a long time and sooner or later it will happen. The huge population densities, the presence of an old part of the city, sometimes poor construction, are the main factors that can lead to a lot of destruction and human casualties. The program to strengthen buildings in Istanbul has been adopted, but the extent to which it is being implemented remains unclear. As they say “God (Allah) keeps the people” there.

3. AI predicts earthquakes

Attempts to use artificial intelligence in solving the problem of short term earthquake prediction are becoming more and more popular. Some time ago, in a short discussion, I wrote that artificial intelligence will become competitive with natural intelligence, if, for example, it announces the exact date of death of a famous politician, or when it get the "huge jackpot in the lottery", or when it predicts the exact time, place and power of an expected strong earthquake.

I was convinced of that because of the results by a 100 million IBM project developed in early 2000s. It was aimed to monitor data from all geophysical sensors all over the world in real time and try to solve the short-term earthquake prediction using all known earthquake precursors so far. After the expiration of the project, nothing of the kind happened, showing that humanity is still far from this possibility.

And now - a novelty appeared in the information flow:

> "Artificial intelligence predicts earthquakes with unprecedented accuracy" [3].
> The publication claims that a team from the University of Texas (UT) conducted a 30-months experiment in China (in an active seismic zone) and managed to "predict with remarkable accuracy 14 earthquakes, miss predicting 12 and miss 1."

For its achievement, the team was awarded first prize at the China Artificial Intelligence Competition, beating over 600 contestants.

A deeper look into the details of this stunning news reveals features that deserve attention.

3.1. The facts

- One year before the publication in the mass media (e.g. https://scitechdaily.com/artificial-intelligence-predicts-earthquakes-with-unprecedented-accuracy/ - August 2024 [3]) the real publication appears describing this fact - https://pubs.geoscienceworld.org/ssa/bssa/articleabstract/113/6/2461/627949/Earthquake-Forecasting-Using-Big-Data [4].

There is also data on the details: University of Texas (UT-AI team) used: training data – 2016-2020- (four years), evaluation data – during 2021, AI-Big data compression.

- The description of these details includes: (sampling from the training sample - from 2016 to 2020), data evaluation - 2021. An artificial intelligence algorithm was used – "massive data" compression (refers to input data including electromagnetic and acoustic measurements from sensors located in the experimental area).

- The explanations are again in the details: in addition to the massive data and its compression, the Principal Components method was also used (it is a statistical tool that groups the data and results according to some pre-selected criteria). Than a natural question arises - why is this achievement promoted a year after it was published?

As the authors themselves (a group of scientists from the University of Texas) claim - the task is to predict the location and magnitude of each subsequent seismic event, within a time interval of one week. The area on which the research was conducted is shown in **Figure 1**. (Directly copied from the publication)

3.2. What the analysis of the demonstrated data shows? (Cited by the researchers themselves):

- The experiment area covers an area of 12^0x14^0, which makes a size of about 2 000 000 km^2. (Area is about 20 times larger than Bulgaria) – **Figure 1**.

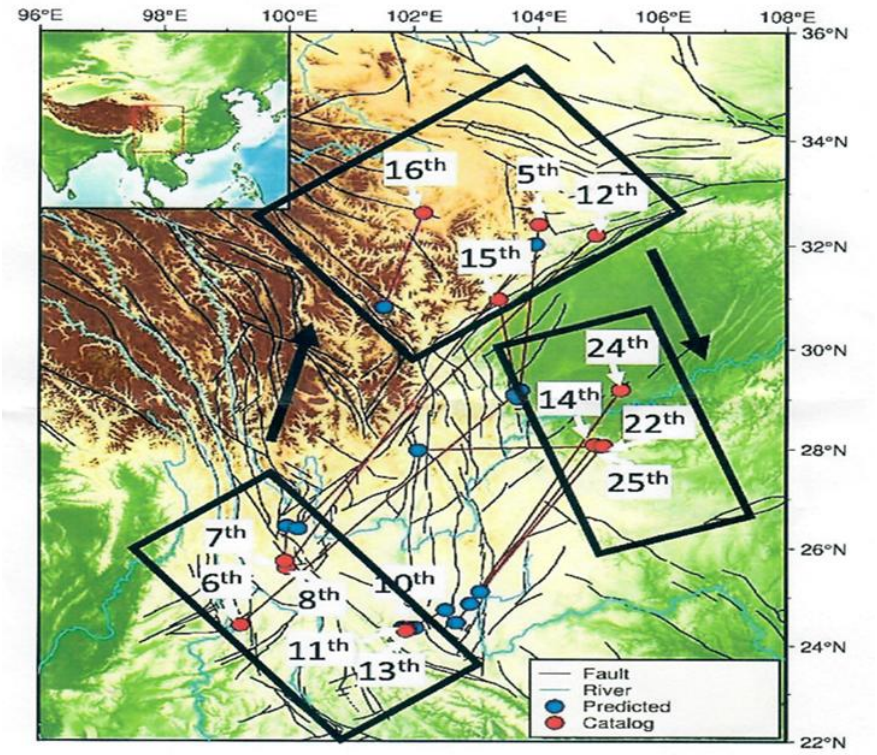

Figure 1. Area of the experiment of the team from the University of Texas. Legend: blue dots – epicenters of predicted earthquakes; red dots – earthquakes occurred (time interval – one week); white squares with numerical values – week's numbers; black rectangles – activated seismic areas; the black thin irregular lines – faults [4].

- Forecast time – 1 week

- Successful predictions – 14

- Unsuccessful predictions - 12 (1 missed)

- Or a total of over 70% successful!

- Accuracy: by distance - average error 381 km; by magnitude - 0.49 [4].

To demonstrate now these parameters fit the possible application to the earthquake prognostics on territory of Bulgaria we performed our experiment.

We delineate the seismic sources in Bulgaria used for the seismic hazard assessment in the country [5].

Than connected all sources by lines, measuring the distances between them.

Simple sketch was constructed. All Bulgarian well known seismic sources able to produce earthquakes with expected magnitude over 7.0 Richter scale, were presented on it and connected by straight lines expressing distances between all of them – **Figure 2**.

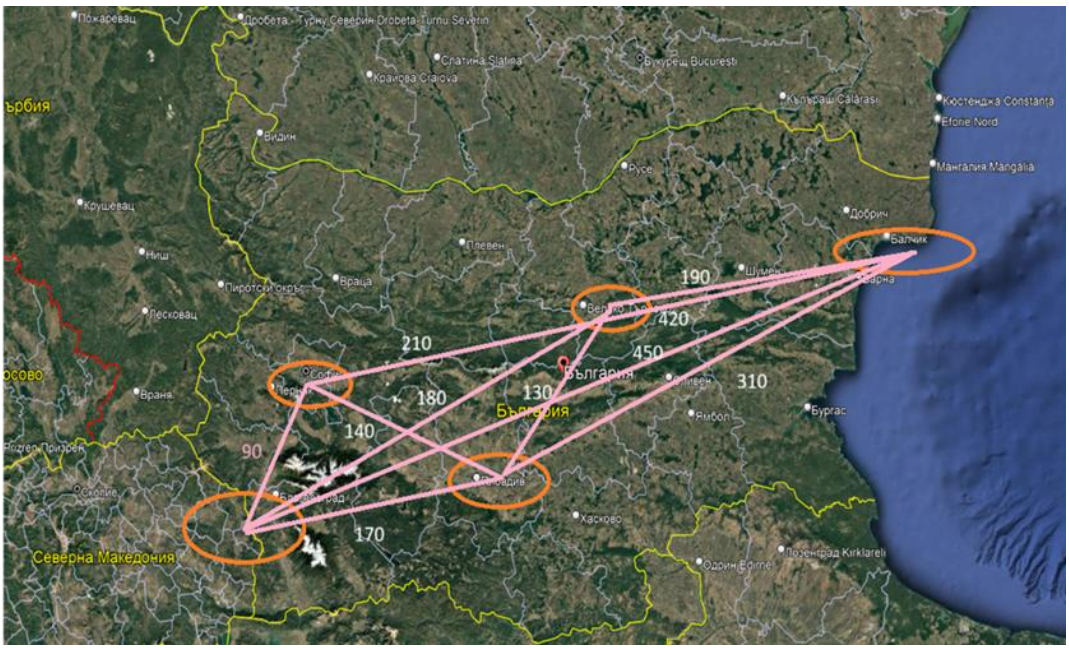

Figure 2. Main seismic sources in Bulgaria (ellipses [5]) and distances between them. Upper row – (North Bulgaria - from left to right) Sofia, Gorna Oriahovitsa, Shabla. Lower row - (South Bulgaria - from left to right) Kresna, Plovdiv.

If the above mentioned prediction algorithm could hypothetically be applied to Bulgarian seismic sources, the results would be drastically inaccurate. **Figure 2** is presented for illustration.

As can be seen from the **Figure 2**, the distances between the main seismic sources range from 130-140 km to about 420-450 km.

In practice, this means that if the described algorithm is applied with the announced accuracies (similar to those of the experiment), most often, a predicted event in one of the seismic zone (for example - the Plovdiv seismic zone) than the expected in one week strong seismic event can be expected also to be in the Sofia or GornaOriahovitsa zone, and vice versa.

The algorithm would distinguish events eventually only in the case of activation of the Shablenska separated by the Kresnenska or the Shablenska with the Sofia seismic zones. Such accuracy in distance is

completely unacceptable in practice and would only create confusion and panic if such information reached the population.

We do not like to comment on magnitude accuracy, because for stronger earthquakes a half of a magnitude unit (as mentioned 0.46) has a dramatically altered striking effect.

A comparative table about some recent cases of predictions (announced by mass media) has been created showing the location, the institution doing prediction, the method used (including AI) and the success of prediction – **Table 1**.

Table 1. Discussed predictions in the paper.

Case	Location (report)	Institution	Method	Prediction
Hogerbets (Netherlands)	Turkey 6 Feb 2023 (February 2023)	Private forecast	Astrology (rejected by science)	Post-factum
Japan	Nankai trough (August 8 2024)	JMA (?)	Possible relation with strong foreshock (M~7)	Not successful
Istanbul (Turkey)	NA Fault segment (August 2024)	UG team	Precursors + AI	Expectation (for about 30 days earlier)
China (AI experiment)	SW China (media report September 2024)	UT Team	Precursors + AI	Semi Successful in time (1 week), large errors in distance (~380 km) and magnitude (~0.5)

4. Results about the AI experiment of UT

The results that can be drawn from this highly publicized study can be formulated as follows:

- The conclusion of the authors who used AI is for "increased seismic hazard management capability" and might be acceptable. This means that the predicted activation of seismic sources in the experiment can be accepted with above mentioned accuracy. "Unprecedentedly accurate earthquake prediction" is overestimated (14/12/1). The relatively small time frame (1 week) is a positive approach and its development is better to continue.

- The recommendation to apply the method "in places with robust seismic tracking networks such as California, Italy, Japan, Greece, Turkey and Texas" [4], and that AI can improve success rates and narrow down predictions to within a few tens of miles is quite overestimated. The assessment experiment for Bulgaria shows that the accuracy of distances and magnitude are overestimated, too.

It is also important to note that Japan has a clearly delineated specificity in the occurrence of earthquakes (generally under water and at great depths) and this can certainly create difficulties with the registration of acoustic and electromagnetic signals.

5. Conclusion

The summary of what has been said so far can be reduced to several main conclusions:

1. The short-term prediction of earthquakes, both in terms of time and magnitude, remains an open question. The comparison of few cases reported during last times confirmed this issue.

2. The presence and manifestation of different precursors continues to experience difficulties regarding their ambiguity and specific manifestations in the various seismogenic areas.

3. The hope that artificial intelligence can solve this task is greatly overestimated, at least at the present time.

Acknowledgments

This paper is part of the development schedule of the Bulgarian Academy of Sciences and Arts (BANI-http://basa.bg/en/) and the Centre for Natural and Engineering Sciences https://basa.bg/index.php/otdeleniq-na-bani /nauka/ and Space Research and Technology Institute of Bulgarian Academy of Sciences https://www.bas.bg/?page_id=24455&lang=en.

Conflict of interest

The authors declare no conflict of interest.

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