Short-Term Advance Prediction of the Large Hokkaido Earthquake, September 25, 2003, magnitude 8.1: A Case History

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SUMMARY

Here we report a successful advance prediction of the major earthquake on Hokkaido, Japan, on September 25, 2003, with the magnitude 8.1. The prediction was made during the recently initiated test of the new methodology for short-term earthquake prediction developed by the group we belong to; the test covers the territories of Japan, California, and Eastern Mediterranean. These results were reported during the XXIII Assembly of the International Union of Geodesy and Geophysics (IUGG), at the Hagiwara Symposium on earthquake prediction, on July 2, 2003.

While the test of the new methodology is by no means complete, the first results are highly promising and might be of interest to the scientists working on earthquake prediction and to the disaster preparedness authorities.

1. Introduction. Earthquakes remain one of the larges natural disasters that threaten the humankind. Today a single earthquake might cause million of casualties, trigger a global economic depression, ecological catastrophe, or a major military conflict. Development of successful earthquake prediction is necessary to cope with the unacceptable and rapidly growing threat of the earthquakes.

Short-term earthquake prediction (months or less in advance) is commonly regarded as an exceedingly important but virtually unattainable goal; the US National Research Council has recently dubbed this goal the “Holy Grail of earthquake science”. Numerous studies have described hundreds of short-term earthquake precursors, but no short-term prediction algorithm has been validated as yet, and the possibility of such prediction is often regarded with fatalism or skepticism.

The prediction described here is based on a new approach rooted in non-linear dynamics, geodynamics, and pattern recognition.

2. Case History

July 2, 2003: precursor is put on record. In the report at the XXIII Assembly of IUGG (Sapporo, Japan) the precursor of a large earthquake with a magnitude of 7 or more in Northern and Central Japan was put on record. This precursor is formally defined as a dense sequence of small earthquakes that had quickly extended over a long distance; such precursors, termed “chains” reflect increase of correlation range between small earthquakes. The chain predicting the Hokkaido earthquake is shown in Fig. 1. A large earthquake was expected during nine months after the chain emerged in its vicinity, shown in gray in Fig. 1. Territory where the testing of the prediction methodology has started is shown in Fig. 2. Comparing to the report at the IUGG Assembly the epicenter of the subsequent Hokkaido earthquake has been added for convenience to both figures.

September 25, 2003: Hokkaido earthquake, magnitude 8.1 occurred in the vicinity of the chain shown in Fig. 1, almost six months after this chain emerged

3. Methodology. This precursory chain was detected by a recently introduced methodology named “Reverse Detection of Precursors” (*RDP*), in which short-term precursors are considered in conjunction with intermediate-term ones (appearing years in advance), in the reverse order of their appearance. *RDP* allows detecting precursors not detectable in direct analysis. This methodology is based on the concept of self-organization of the fault network culminated by a strong earthquake. Possible outcomes of such predictions are illustrated in Fig. 3.

4. Supporting results. This is the first advance prediction in the recently initiated tests of *RDP* methodology in the territories of California, Japan, and Eastern Mediterranean. Retrospectively, 22 more large earthquakes occurred during the time periods considered; 20 were predicted; two were missed; and nine false alarms were issued.

These results are encouraging and set up a base for testing this prediction methodology by further predictions in advance.

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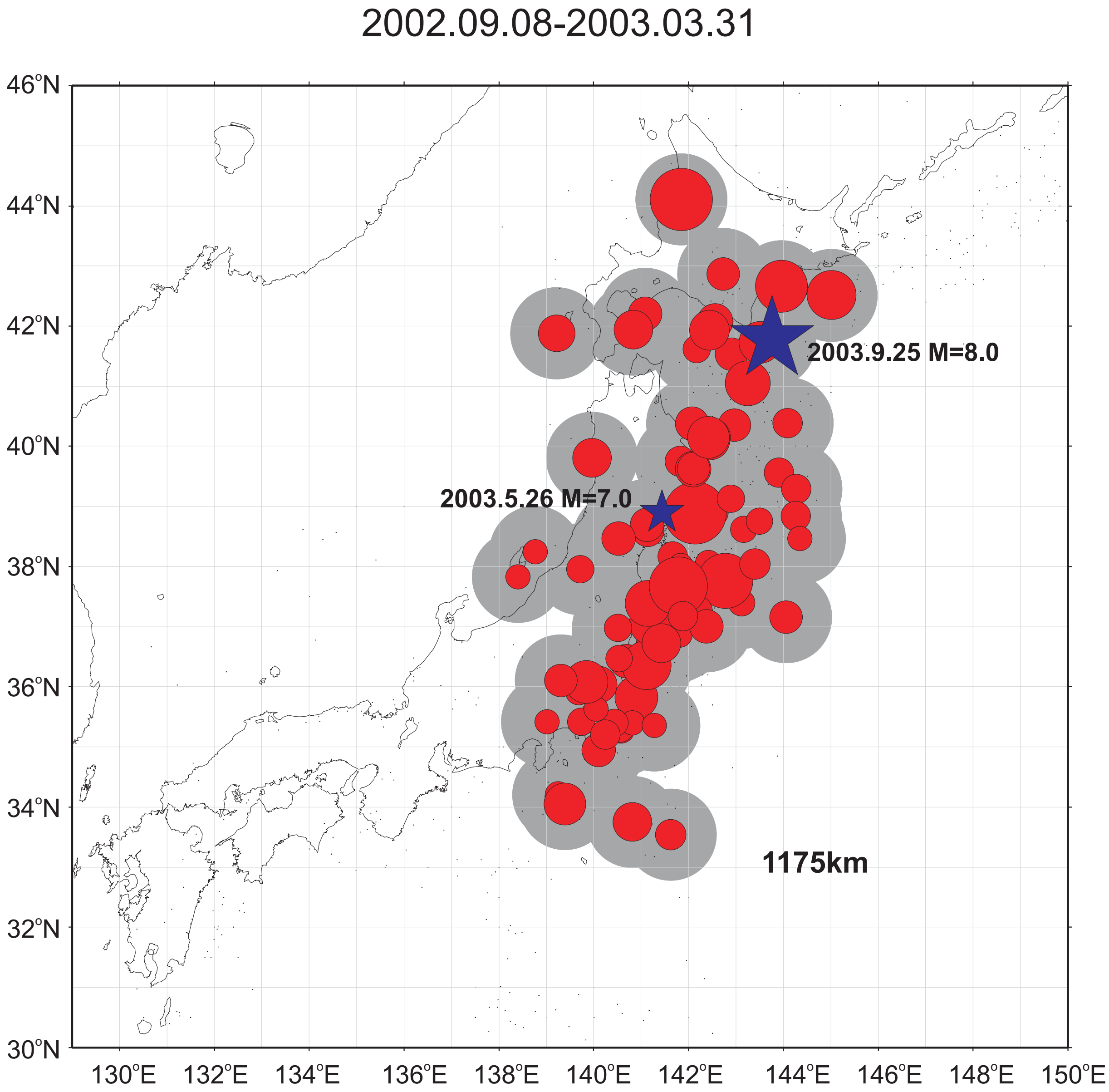

Fig. 1. The precursory chain reported on July 2, 2003. Red circles show epicenters of the earthquakes that form this chain; size of the circles is proportional to the magnitude. The gray area shows formally defined vicinity of the chain; strong earthquakes, magnitude 7 or more, are expected there during 9 months after the chain emerged. Stars show epicenters of two strong earthquakes that followed the chain within the above limits; large star corresponds to the Hokkaido earthquake, September 25, 2003, magnitude 8.1.

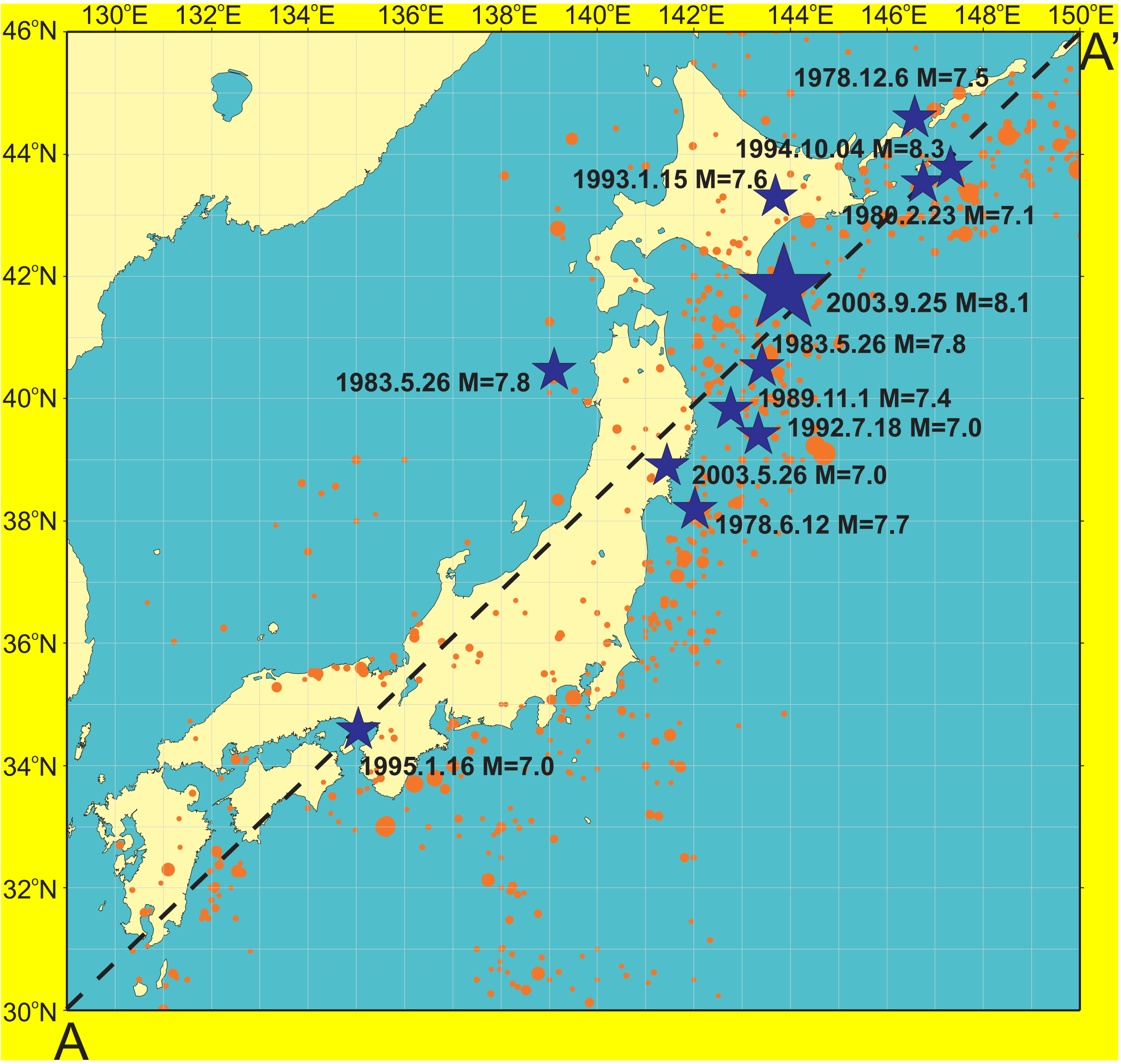

Fig. 2. The territory covered by testing prediction methodology in Japan region, 1975 – 2003. Dots show background seismicity for the time period considered: epicenters of earthquakes with magnitude 5 or more, with aftershocks eliminated. Large star is the epicenter of Hokkaido earthquake, predicted in advance by the precursory chain, shown in Fig. 1. Small stars show epicenters of strong earthquakes, magnitude 7 or more, targeted for prediction in retrospective analysis.

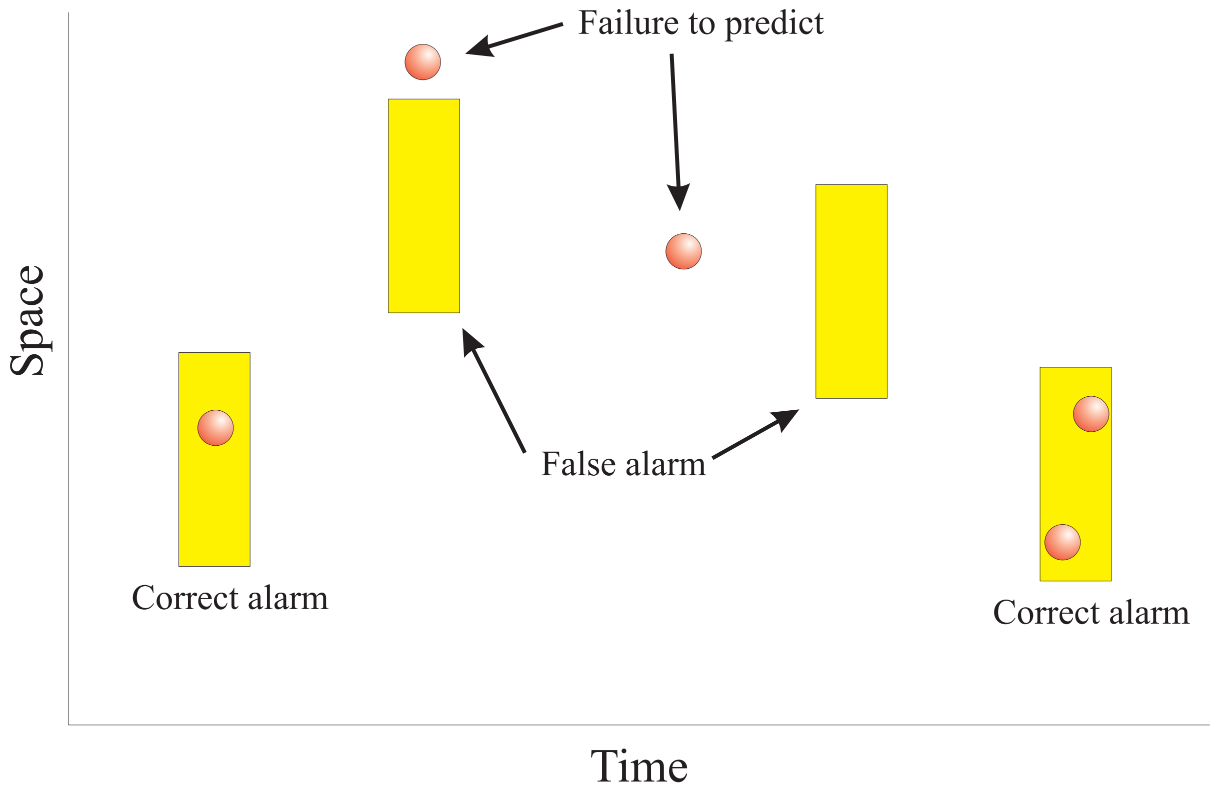

Fig. 3. Possible outcomes of prediction. Circles mark strong earthquakes, targeted by prediction. A box represents the time - space covered by an alarm. A prediction is correct if a strong earthquake occurs within an alarm. Otherwise, this is a false alarm. Failure to predict is the case when a strong earthquake occurs outside of an alarm. Probabilistic component of prediction is represented by the score of errors [Molchan, 2003].