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Current state of probabilistic forecast based on seismicity analysis

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Introduction

After the disastrous earthquake of L'Aquila, Italy in 2009, the Italian government set up a committee consisting of worldwide seismologists, which summarized the current state of earthquake prediction technology and proposed guidelines to utilize the precursory information of large earthquakes. The report was also accepted by IASPEI and comes to a consensus among seismologists. In the report it is described that 'reliable and skillful deterministic earthquake prediction is not yet possible' and 'any information about the future occurrence of earthquakes contains large uncertainties and, therefore, can only be evaluated and provided in terms of probabilities'. But then how much probability can be estimated scientifically before large earthquakes? So, in my presentation I will introduce the current state of probabilistic forecast by overviewing the actually published probability values mentioned below.

Long-term probability

The long-term probabilities for major active faults and major earthquakes in the sea area have been evaluated and announced by a special governmental organization, HERP (the Headquarters for Earthquake Research Promotion). Some examples assigned relatively high probability values at the evaluation time of Jan. 1, 2013 are as follows;

- Kannawa/Kozu-Matsuda fault zone with M(magnitude)7.5: 16% at most in 30 years (= 0.005% in 3 days),
- Itoigawa-Shizuoka-kozosen fault zone with M8: 14% in 30 years (= 0.004% in 3 days),
- Tonankai with M8.1: 80% at most in 30 years (= 0.02% in 3 days),
- Sothern Kanto with M6.7~7.2: 70% in 30 years (= 0.03% in 3 days).

Here, for convenience, I also added the values in 3 days that is not published by HERP.

Aftershock probability

Aftershock probability is basically calculated by combining two empirically derived laws, an exponential law of magnitude-frequency distribution and a power law of aftershock decay rate. Statistical analysis of the past aftershock data shows that, for inland mainshocks with M around 6, the probability of aftershocks whose M difference from a mainshock is 1.0 or smaller is about 25% within 3 days after a mainshock, and for mainshocks in the sea area with M around 7, similarly defined aftershock probability is about 33%. The probability gain that is usually defined as the ratio of the specific probability to the background one during an ordinary period, is about several 100s for aftershock probabilities.

Foreshock probability

The probability, for example, that an earthquake with M5.0 or larger in inland Japan is followed by a larger one within the 50 km radius and 30 days is about 3%, and in most cases a larger one occurs within 5 days. This probability makes probability gain about several 10s. But in some specific areas where successive earthquakes tend to occur, foreshock probability rises to about several 10s %, which gives probability gain about several 100s.

Probability based on a seismic quiescence

While seismic quiescence is well known phenomenon among seismologists, it is not yet well studied to obtain the probability of mainshocks following it. However, there is a research showing that when aftershocks caused by an M6 class mainshock have a quiet period of more than three months, the probability gain of earthquake occurrence with the same or a larger one within 6 years is estimated to be about 10.

Probabilities based on other seismic phenomena

Although there are many phenomena (e.g. seismic activation, b-value change, migration, correlation with earth tide) that may have relation to a mainshock and are reported retrospectively after a mainshock occurred, little research has been conducted on the view point of a rigorous prospective forecast. Therefore, it is a future task to evaluate the probabilities based on such phenomena.

Keywords: probabilistic forecast, earthquake prediction, long-term probability, aftershock probability, probability gain