Long-term earthquake forecast based on the seismic quiescence: trials in the Kurile, the Tohoku, and the Izu-Bonin subduction zones

Kei Katsumata (Institute of Seismology and Volcanology, Hokkaido University)
Masao Nakatani (Earthquake Research Institute, University of Tokyo)

We forecasted large earthquakes retrospectively by using the long-term seismic quiescence and found that the forecast is significantly better than the one based on random guess. The method is as follows. First, earthquakes between 1964 and 2014 with a body-wave magnitude mb >= 5.0 and with a depth H <= 60 km were downloaded from an earthquake database provided by the International Seismological Center. Second, thirty short lists were produced from the data downloaded. All the short lists had the same length of 22 years: the 1st list covers earthquakes from 1964 to 1985, the 2nd list covers earthquakes from 1965 to 1986, the 3rd list covers earthquakes from 1966 to 1987, and so on. A declustering procedure (Zhuang et al., 2002) was applied to each shot list. Third, seismic quiescence as of 1985 was explored using the 1st list. The study area extends along the Kurile, the Tohoku, and the Izu-Bonin subduction zones and was divided into a grid spacing of 0.1 X 0.1 degrees. Around each node, 10 nearest earthquakes were selected and the time dT between the last earthquake among the 10 events and the end of the 1st list, that is, 31 December 1985, was calculated. When there were less than 10 earthquakes within a 100 km radius from the node, the region around that node was excluded from the analysis and the performance evaluation. If the dT was equal to 10.8 years or longer, the alarm was set ON for 4 years from 1986 to 1989 within 100 km around the node. Finally, this procedure was applied to all nodes in the study area and to all of the short lists, to produce 25 annual updates of the forecasting map for 1990-2015. According to the Global CMT catalog, large earthquakes with Mw>=7.5 and shallower than 80 km occurred 10 times in this period in the study area, including three M8-class earthquakes and one M9-class earthquake. Seven of the ten earthquakes occurred in the alarm ON area and the remaining three earthquakes occurred in the alarm OFF area. Therefore, the alarm rate was 7/10 = 70 %. On the other hand, the alarm fraction was 24 %, and hence the forecast gain was 70%/24% = 2.9. The probability P that seven of ten earthquakes occur in the alarm ON area by chance is 0.24**7 X (1-0.24)**3 X 10C7 = 0.24 %. Since the P value is smaller than 1 %, we conclude that the long-term earthquake forecast based on the seismic quiescence is significantly better than the one based on random guess.