LONG-TERM EARTHQUAKE FORECAST FOR IRAN

Mohammad TALEBI
PhD Student, IIEES, Tehran, Iran
m.talebi@iiees.ac.ir

Mehdi ZARE
Associate Professor, IIEES, Tehran, Iran
mzare@iiees.ac.ir

Anooshiravan ANSARI
Assistant Professor, IIEES, Tehran, Iran
a.ansari@iiees.ac.ir

Keywords: Probabilistic Earthquake Forecasting, Adaptive Kernel, Iran

We present a model of forecasting of earthquakes in Iran to assess the Long-term probabilities of future earthquakes of moderate magnitudes. The model estimates a decoupled rate of magnitude, space and time for future seismicity (Helmstetter et al., 2007) using a spatial-temporal Poisson process.

Within the selected region, latitude limits 25- 41° and longitude limits 43.5- 64°, we applied the ISC bulletin in the period of 1980 to 2014. Here, we simply considered the local magnitude (M_l) and body wave magnitude (M_b) of M<6 as well as surface wave magnitude (M_S) of M>6 as moment magnitude.

Firstly, in order to remove large obscures of seismic activity, the applied catalog was declustered by the Reasenberg's algorithm (1985) as modified by Helmstetter et al. (2007). Then, based on the magnitude completeness of the catalog, spatial density of seismicity was estimated by smoothing the locations of magnitude $M \geq 4.3$ earthquakes in the training catalog. We used an isotropic adaptive kernel for smoothing past earthquake locations. As it is used in several studies (e.g. Helmstetter et al., 2007; Werner et al., 2011), a power-law type kernel was used as follows:

$$K_d(r) = \frac{C(d)}{\left(|r|^2 + d^2\right)^{1.5}} \quad (1)$$

Where r is epicentral distance of i-th event for each grid point, d is the adaptive scale parameter, and $C(d)$ is normalization constant set so that the integral of kernel over an infinite area equals 1.0. In Figure (1), we illustrate the use of the kernel to evaluate the smoothened rate of earthquakes.

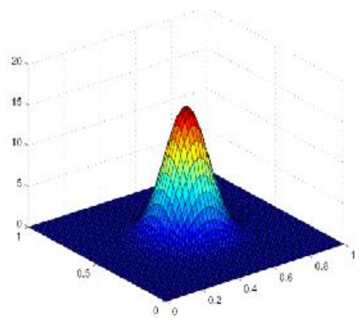

Figure 1. Schematic diagram of an isotropic power-law kernel

The density (λ) at each point was estimated by summing the portion of all past earthquakes (N) as follows:

$$\lambda = \sum_{i=1}^{N} K_d(r) \quad (2)$$

The bandwidth (d) of the kernel was adjusted regarding the horizontal distance of n-th nearest neighbor of each earthquake. The number n was an adaptable parameter that was evaluated by optimizing the model. The bandwidth decreased if the spatial seismic distribution was large in size around the location of the i-th earthquake, so that we had better resolution where the density was higher.

We optimized the model by computing the likelihood of the model. Accordingly, we used a Jackknife-like procedure (Kagan and Jackson, 1994) in which the catalog was divided into 2 sub-catalogs. We applied the first sub-catalog, as learning catalog, to forecast the second sub-catalog, as test catalog.

The spatial density was scaled to the number of expected earthquakes by using expected number of earthquakes over a year. Then, to estimate a magnitude-dependent rate, we multiplied the scaled spatial density by a tapered Gutenberg-Richter magnitude frequency distribution. Finally, to obtain the long-term forecast, we scaled the calculated rate by the number of years.

Figure (2) shows the forecasted seismicity rate map of Iran for five-year period from January 1, 2013, based on the ISC catalog.

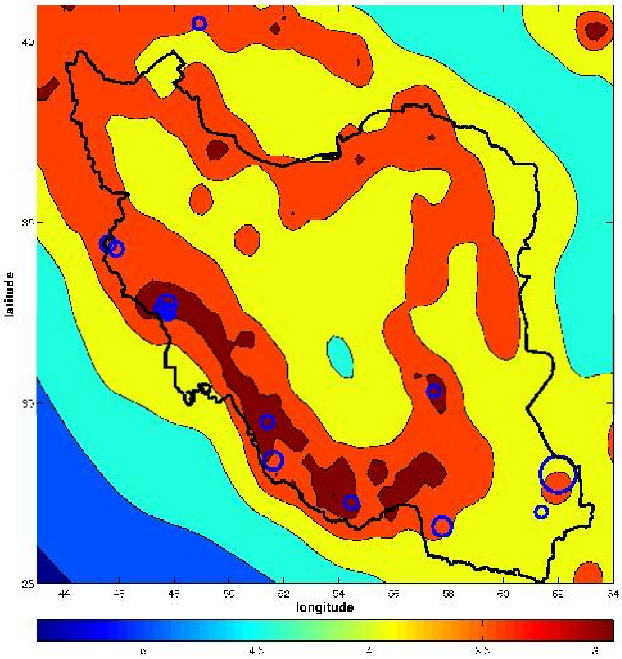

Figure 2. The base 10 logarithm of expected number of earthquakes of M >5.5 over the five-year period from January 1, 2013 based on smoothing the locations of earthquakes of M >4.3 in the ISC catalog from 1980 to 2013. Black line shows Iran border and circles are M ≥ 5.5 earthquakes that occurred between 1 January 2013 and 27 September 2014

REFERENCES

Helmstetter A, Kagan YY and Jackson DD (2007) High resolution time-independent grid-based forecast for M >= 5 earthquakes in California. *Seism. Res. Lett., 78(1)*: 78-86

Kagan YY and Jackson DD (1994) Long-term probabilistic forecasting of earthquakes, *J. Geophys. Res.*, 99, 13685-13700

Reasenberg P (1985) Second-order moment of central California seismicity, 1969-82, *J. Geophys. Res.*, 90, 5479-5495

Werner MJ, Helmstetter A, Jackson DD and Kagan YY (2011) High resolution long- and short-term earthquake forecasts for California, *Bull. Seism. Soc. Am.*, 101(4):1630–1648, doi:10.1785/0120090340