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Studies of premonitory clustering of seismic events in a parameter space

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Using a newly developed technique of transformation to equivalent dimensions we study clustering of seismic events prior to great world earthquakes. The transformation to equivalent dimensions replaces the values of earthquake parameters with the values of their cumulative distributions. In this way the transformation of any earthquake parameter converts it into a variable that is uniformly distributed in [0, 1] over the whole earthquake population.

Four earthquake case are presented: M8.5 of Sumatra (12.09.2007), M8.8 of Chile (27.02.2010), M9 of Japan (03.11.2011) and M8.6 of Sumatra (11.04.2012). Analysis included time periods from 2.2 years in the case of Japan earthquake to 6.3years for Sumatra earthquake on 11.04.2012 before the onset of the main shock. All studied catalogs are declustered (Reasenberg, 1985) before the transformation to the equivalent dimensions is performed.

Earthquake clustering is studied in [dt x dr x M] space and its subspaces where dt is the time between occurrences of two subsequent earthquakes, dr is the epicentral distance between such earthquakes, and M is the magnitude of the second event from such an earthquake pair. The development of clustering is observed in a moving time window. The degree of clustering is quantified by the average distance between all earthquakes in equivalent dimension space: S=$\sqrt{\frac{2}{N(N-1)}\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}[D(i,k)]^2}$, where D(i,k) is the distance between earthquakes i and k and N is the size of catalogue.

The clustering effects are visualized by 3D probability density estimates. In all four cases the event cluster in the subspace [dt x dr] shifts towards higher magnitudes when approaching the main event. A sharp decrease of S value can be seen in 3 cases, whereas in the fourth case of Sumatra on 2012 S increases. The studied examples show that the analysis of clustering in parameter spaces can help to identify earthquake patterns preceding some strong earthquakes.

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