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An approach to automatic prediction of earthquakes: techniques, tools, and case studies

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We suggest a technology for automatic prediction of earthquakes based on assumption that strong earthquakes are preceded by anomalous processes in their vicinity. We construct spatio-temporal grid-based fields (fields-features) and determine abnormal nodes as the nodes with values close either to the highest or to the lowest values of the fields.
For a single field-feature the earthquake forecast is carried out according to a threshold decision rule. Alarm area is a union of alarm cylinders with bases centered at abnormal nodes and elements gone along the time axis. The forecast is successful if the epicenter enters the alarm area. The earthquake with the epicenter coordinates (x, y, t) will be forecasted if the cylinder with the base center in (x, y, t-T) and the element [(x, y, t-T), (x, y, t)] (so-called precursor cylinder) contains at least one grid node with the feature-field value greater than the threshold. The threshold value is selected with the help of training set. The forecast quality is determined on a test set.
For several fields-features, the idea of the forecast algorithm is as follows. We consider epicenters of strong events and construct precursor cylinders for each of them. In every precursor cylinder we choose K nodes, abnormal with respect to all fields-features. Given these nodes, the algorithm calculates a normalized vector of parameters of the forecast that gives the maximum number of predicted events while the alarm volume is limited. Further, we construct the predictive field as linear combination of the initial fields-features with coefficients equal to the coordinates of this vector. Finally, we apply a threshold decision rule to the predictive field.
Simulation of the technology of automatic earthquake prediction is performed by means of GIS GeoTime 3 (www.geo.iitp.ru/GT3). The initial data are the earthquake catalogues for the period of 25 years, available from the sites of ISC, NEI and Kamchatka Branch of the Geophysical Service RAS. Ten year interval is used for estimating the predictive function, computing the forecast field and finding the threshold. The following 3 year interval is used for testing. Next, the experiment is repeated with a shift of 3 years.
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