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Earthquake prediction: paradigms and opening possibilities

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This paper reviews earthquake prediction studies, integrating (i) modeling of development of strong earthquakes, as an intrinsic component of tectonic development of the Earth; (ii) statistical physics-type modeling of development of critical transitions in hierarchical complex systems (which allows to cope with multiplicity of scales, driving forces, and instability mechanisms involved in tectonics); and (iii) exploratory data analysis. Problem considered is different from classical Kolmogorov-Wiener prediction of continuous functions. We consider prediction of extreme point events distinct by small probability and large consequences. Prediction is formulated as a discrete sequence of alarms i.e. time-, space-, and energy volumes where such an event should be expected. Linking a prediction with disaster preparedness is based on the theory of optimal control. New paradigms in predictive understanding seismicity are established by these approaches. Accuracy of respective prediction algorithms already validated by extensive tests is limited, but allows a considerable reduction of damage, Most importantly, these results open new possibilities for further improvements of prediction methodology based on the already available data and models. This review summarizes results of the broad international collaboration, multi-institutional and multidisciplinary.