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# Rapid magnitude determination in maximum 5 seconds for Vrancea early warning system

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The Romanian territory is exposed to high seismic risk associated to earthquakes occurring in Vrancea area. Major earthquakes occurred in this area in the last century: November 10, 1940, (Mw=7.7; h=140 km); March 4, 1977(Mw=7.4; h= 95 km); August 30, 1986(Mw=7.1; h=130 km) and May 30, 1990(Mw=6.9;h=90 km). The deep earthquakes (MW =7.9) generated in Vrancea area are particularly of interest for many countries in Europe since they cause destructive effects at large distances from Moscow to Rome. EWS made by NIEP uses the time interval (28-32 sec.) between the moment when earthquake is detected by the local accelerometers array network installed in epicenter area (Vrancea) and the arrival time of the seismic waves in the protected area, for example, Bucharest. Due to the huge amount of recorded data(nearly 3,000 recorded events and over 16,000 acceleration and velocity waveforms) were used in this analysis, an automatic procedure was developed and used to test different methods to rapidly evaluate earthquake magnitude from the first seconds of the P wave. A method to rapidly estimate magnitude in 4-5 seconds from detection of P wave in the epicenter was obtained. There were used data from 3 seismic stations located in Vrancea-Romania area to test the accuracy of quick magnitude determination using P-wave arrivals only and a special voting scheme was developed in order to avoid false alarms. This early warning system consists of several different parts: a dedicated acquisition system, algorithms to rapidly detect seismic events, algorithms that eliminate false detections and alarms and methods to estimate the earthquake magnitude and to send the warning to the users. All of these parts have to work automatically, in real time, without interruption for a long period of time. Real-time software permits minimum communication latencies and proper detection of earthquakes. This detector uses a voting scheme for the event detection and validation; namely each channel has a vote assigned to it. If the sum of votes exceeds a preset voting threshold in a certain amount of time, the application considers that an event occurred and the magnitude estimation procedure starts. The detector was tuned used continuous data recorded on three stations placed in the epicenter area (MLR, PLOR, VRI) and of recorded events since 1996 (nearly 800GB of data). The software is able to run the detection on a very large number of channels in real time.
The software developed by NIEP was tested at last Vrancea earthquake on April 25, 2009 when the magnitude (Mw =5.7) of the Vrancea earthquake was computed in the first 5 seconds and it was an accurate value.
The ability to rapidly estimate the earthquake magnitude combined with powerful real-time software, as parts of an early warning system, could reduce the seismic risk.