Rapid magnitude determination for Vrancea Early Warning System

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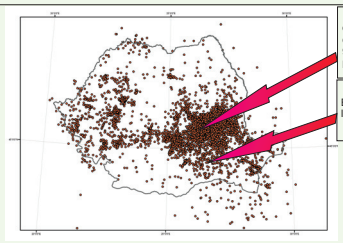
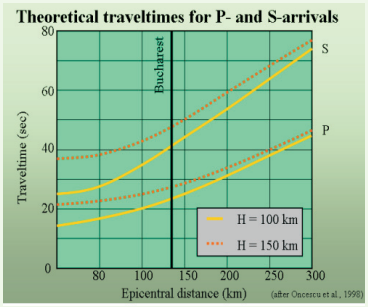


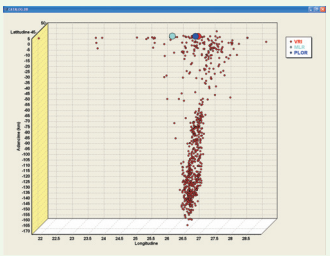
1. Seismicity of Romania (ROMPLUS catalogue 900-2008) [1]

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, **M_w=7.7**, depth 150 Km; March 4, 1977, **M_w=7.4**, depth 95 Km; August 30, 1986, **M_w=7.1**, depth 130 Km and May 30, 1990, **M_w=6.9**, depth 90 Km.

The metropolitan area of Bucharest has a population of 2.6 million people. Bucharest is the 6th largest city in the European Union by population within city limits. **Bucharest is one of the European cities with very high seismic risk**

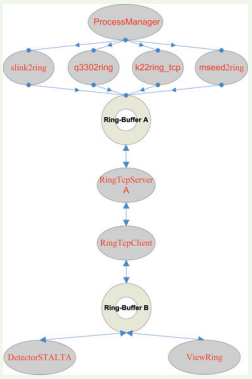


2. Warning time for Bucharest city [2]



4. Earthquakes used in this study together with the location of the seismic stations located in the epicenter area (MLR- Red Mountain station, VRI-Vrancioaia and PLOR-Plostina stations)

A set o real time applications were developed (Fig.3). This software package can be used to retrieve data in real time (1 second data packets) from Q330 (**q3302ring** module) or K2(**k22ring** module) seismic stations. Data can be retrieved from SeedLink (**slink2ring** module) data sources or any miniseed file (**mseed2ring** module) (for simulation purposes only, these are not used in the warning process). The earthquake is detected by **DetectorSTALTA** module, which is a modified STA/LTA detector. STA time interval is 1 second and LTA time interval is 10 seconds. The STA/LTA algorithm was tuned up on 2669 events with magnitude ranging from Mw=2.0 upto Mw=6.0 recorded between 1996 and 2006 at three seismic stations located in the epicentre area (MLR- Red Mountain station, VRI-Vrancioaia and PLOR-Plostina stations)(Figure 4). **ViewRing** module plots waveforms in real time. Data is stored is ring-buffers that can share data using TCP/IP protocol **(RingTcpServer** and **RingTcpClient** modules).



3. Software applications-part of the real time implementation of early warning [1]

After the STA/LTA detection, a voting scheme is used to avoid false alarms. The maximum acceleration is obtained from the vertical component of the acceleration channel and is converted to cm/s/s, by using calibration constants, then a 1 Hz LP Butterworth filter is used. A plot of maximum P wave filtered amplitude is shown of Figure 5 together with the used fit. The absolute magnitude error is shown in Fig. 6-left for all events. By making the average of local magnitudes estimated at each station, the absolute error decreases (Fig 6 right). In the first case the average error is around 0.3 magnitude degrees; by using the average it decreases to 0.21. An improvement in maximum absolute magnitude estimation error is obtained.

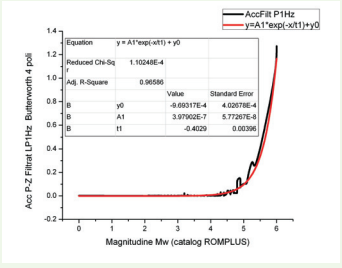


Figure 5 – Fit between maximum 1Hz LP filtered acceleration and Mw magnitude [1]

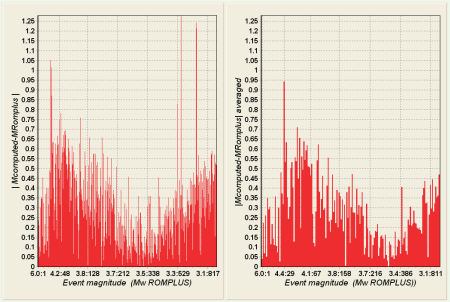


Figure 6 – Magnitude estimation absolute error (left)(for al records). Magnitude absolute errors averaged (right) (if the earhhquake is recorded on all three stations, the final magnitude is the average of all local magnitudes)

CONCLUSIONS:

The main result of this study evidences the possibility to rapidly estimate magnitude of earthquake in the first 4-5 seconds after detection of the P wave in the epicenter.

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.

Due to the relatively small amount of warning time, this system was never intended for population, but only to critical industrial facilities.

REFERENCES:

[1] A.Marmureanu Rapid magnitude determination for Vrancea Early Warning System, 2009, Romanian Journal of Physics,Vol 54,No 9-10

[2] Wenzel F.,Oncescu M.C.,Baur M.,Ionescu C.,Fiedrich F.(1999).An early warning system for Bucharest, Seismological Research Letters,70(2):161-169;