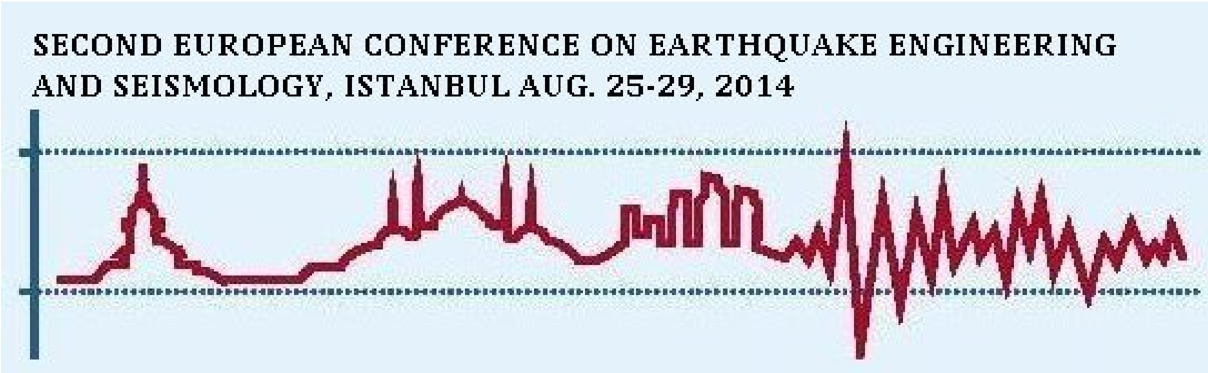

REAL-TIME SEISMIC PROCESSING SYSTEM FOR THE NORTHERN CAUCASUS

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The Northern Caucasus is one of the most seismically active regions of the Russian Federation. The monitoring of earthquakes is of importance here because of the high density of population and industrial enterprises.

The system of seismological monitoring of the Northern Caucasus region includes 51 seismic stations equipped mainly by Russian UGRA and SDAS data loggers. Seven of these stations are equipped with broadband sensors STS-2 and SM3-OS, and the remaining – with short-period seismometers SM3-KV.

The recorded seismograms are initially transferred in the near real-time mode to three regional processing centers and after that to a united center of data acquisition, processing and storage in the Geophysical Survey of RAS (Obninsk, Russia).

The system of automated data processing based on the *SeisComP3* software platform was tested for Northern Caucasus network in 2012 – 2014. This software package is an advanced system of acquisition, processing and storage of seismic data with extensive configuration features. SeisComP3 is characterized by high efficiency of incoming data processing. It also represents the convenient tool for information management and quality control. This package consists of separate modules interacting with each other via *TCP/IP*. It allows to distribute the computational load across multiple servers using the remote connection to the operation and management. *SeisComP3* is available for most Linux-based operating systems.

The data from the Northern Caucasus seismic network are collecting via the *isi* protocol from two NRTS-servers located in the Kislovodsk and Obninsk cities. Distribution of the stations between the NRTS-servers was made possible evenly (in both quantity and spatial location). Firstly it makes it possible to lower the load on each of the NRTS-servers. Secondly it guarantees the functionality of the *SeisComP3* system in case of the connection with one of the data sources is lost. In addition, the data acquisition and processing system are connected to 15 seismic stations located in adjacent regions - Georgia, Armenia, Turkey, Kazakhstan and Romania. The data from these stations are receiving via *SeedLink* protocol from server of Incorporated Research Institute for Seismology (IRIS), USA.

To optimize the operation of the *SeisComP3* package in the limits of the relatively small region certain changes were made in the settings of “associator”. In particular, for the Caucasus region the step of grid used for the initial search for a possible earthquake hypocenter was reduced from 5 to 0.5°. The default depth value was decreased from 33 to 10 km. Minimum number of stations required for forming “origin” was reduced to 7. Therefore, the following parameters were set to create a new “event”: the minimum number of used phases = 7, the minimum number of defined magnitudes = 3.

Analysis of the level of background seismic noise at all seismic stations was performed in order to correctly assess sensitivity of the network for regional earthquakes. The majority of seismic stations are installed in areas with high population density that leads to the high noise level. Analysis of seismograms showed that only 5 stations installed in places that can be considered as quiet: noise level is close to the lower boundary of the Peterson’s model (Peterson, 1993). For 17 stations the noise level

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can be estimated as the average and for others it is high or very high. In some cases the noises can be almost completely excluded by band-pass prefiltering, but for most stations they have a wide spectrum and cannot be effectively suppressed.

Earthquake catalog including more than 300 earthquakes with magnitudes M_L in the range from 1.5 to 5.7 was generate during 1,5 year period operation of the system of automatic processing. The catalog can be used to evaluate the performance of the monitoring system.

Firstly the analysis of system response speed was done. It showed that first solution for the vast majority (89%) of earthquakes is obtained in the range from 2 to 5 minutes after their initiation. This delay is due to a rather complicated scheme of data transfer, including several intermediate points, as well as internal caching and format conversion. Histogram showing the distribution of the number of solutions in time intervals is presented in Fig. 1.

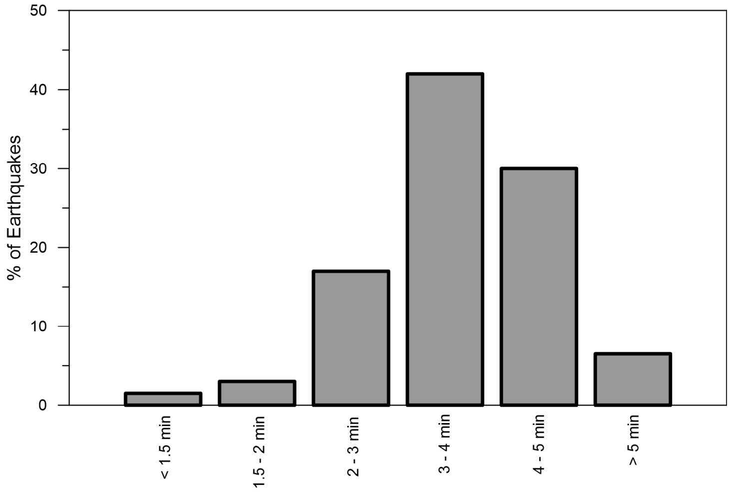

Figure 1. Time delay between the origin time and the first location result

Furthermore, sensitivity of the monitoring system was assessed. Since the density of the seismic network in the Caucasus region is not uniform and different stations are characterized by different levels of seismic noise, for the analysis all considered territory was divided into 3 parts: western, central and east. The highest density of seismic stations is provided in the central part of the Caucasus (40° - 45° N; 42° - 46° E). In the western (42° - 46° N; 36° - 42° E) and eastern (40° - 44° N; 46° - 50° E) parts density of the seismic network is lower and most of them are characterized by high levels of noise. The plots of frequency-magnitude relation (Gutenberg-Richter law) for all 3 parts are shown on fig. 2. As seen from this figure, the operating system in an automatic mode ensures the minimum representatively registered magnitude 2.5 in the central part of the Caucasian region and 3.0 - in its western and east parts.

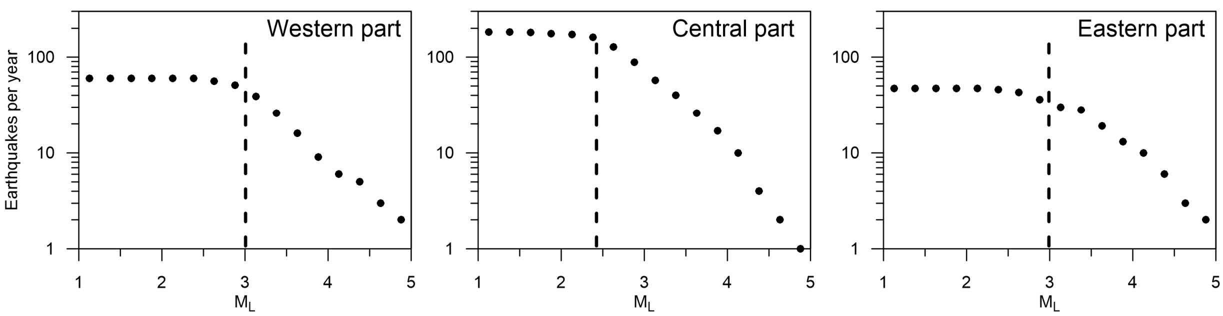

Figure 2. Determination of the minimal representatively registered magnitude by frequency-magnitude relation

At the moment, operations on the selection of optimal filters for signal detection with STA/LTA algorithm are underway. This will allow, on the one hand, to increase the accuracy of evaluationof the hypocenters, and on the other hand, to decrease the minimum representatively registered magnitude.

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