

Slovak National Network of Seismic Stations - an overview

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Introduction

The Geophysical Institute, Slovak Academy of Sciences, Bratislava Slovak Republic (GPI SAS), was founded in 1953. It consists of four scientific departments – Dept. of Gravimetry and Geodynamics, Dept. of Geomagnetism, Dept. of Seismology, and Dept. of the Physics of the Atmosphere. The institute includes 9 geophysical and 2 meteorological observatories. The institute performs a fundamental research in geophysics and meteorology with special regard to the Carpathian region.

Research activities of the Dept. of Seismology are focused on monitoring and analysis of seismic activity, analysis of historical earthquakes, seismic hazard assessment for selected sites and whole territory of Slovakia, numerical modeling of seismic waves in complex media, and analysis of effects of surface geology on earthquake ground motion.

Over several decades, the Geophysical Institute has operated the Slovak National Network of Seismic Stations, and analyzed instrumental and macroseismic data for recent earthquakes from the territory of Slovakia. The institute also participates in analysis of data from two local seismic networks deployed around the Bohunice and Mochovce Nuclear Power Plants in Slovakia. In cooperation with several Slovak and foreign geological and geophysical institutions, the institute performed the probabilistic seismic hazard assessment for the Bohunice and Mochovce Nuclear Power Plants.

Network

Tab. 1 shows basic parameters of seismic stations of the Slovak National Network of Seismic Stations – status in August 2004. Four stations are equipped with BB seismometers. Two stations are equipped with SKD seismometers (ZST, MODS), two stations are equipped with STS-2 seismometers (VYHS, CRVS), respectively. While three stations – ZST, MODS and SRO – use Lennartz PCM 5800 data acquisition systems, remaining stations use the SEMS data acquisition system. Fig. 1 shows map of the national network. Red triangles indicate the seismic stations, which are in operation. Blue triangles show location of new seismic stations, which are under construction. The new seismic stations should start their operation during the year 2004. All remaining new seismic stations should be equipped with LE3D short-period seismometers.

Name	ISC Code	Lat. [°N]	Lon. [°E]	Alt. [m]	Seismometers	DAS	Sampling freq. [sps]	Data transfer	Data format
Bratislava - _elezná Studni_ka	ZST	48.196	17.102	250	3x SM-3 3x SKD	PCM	100 20	Continuous, real time	mSEED
Modra - Piesok	MODS	48.373	17.277	520	LE3D 3x SKD	PCM	100 20	Continuous, real time	mSEED
Smolenice	SMOL	48.514	17.429	400	LE3D	SEMS	100	Continuous, real time	mSEED
Vyhne	VYHS	48.493	18.836	450	STS-2	SEMS	100 20	Continuous, real time	mSEED
_robárová	SRO	47.813	18.313	150	3x SKM-3	PCM	100 20	Continuous, real time	mSEED
Likavka	LIKS	49.050	19.106	341	LE3D	SEMS	100	Continuous, real time	mSEED
Ke_ovo	KECS	48.483	20.486	345	LE3D	SEMS	100	Continuous, real time	mSEED
_ervenica	CRVS	48.902	21.461	476	STS-2	SEMS	100	Continuous, real time	mSEED
Hurbanovo	HRB	47.873	18.192	115	2x Mainka	-	-	-	-

Tab. 1. Basic parameters of existing seismic stations of the Slovak National Network of Seismic Stations.

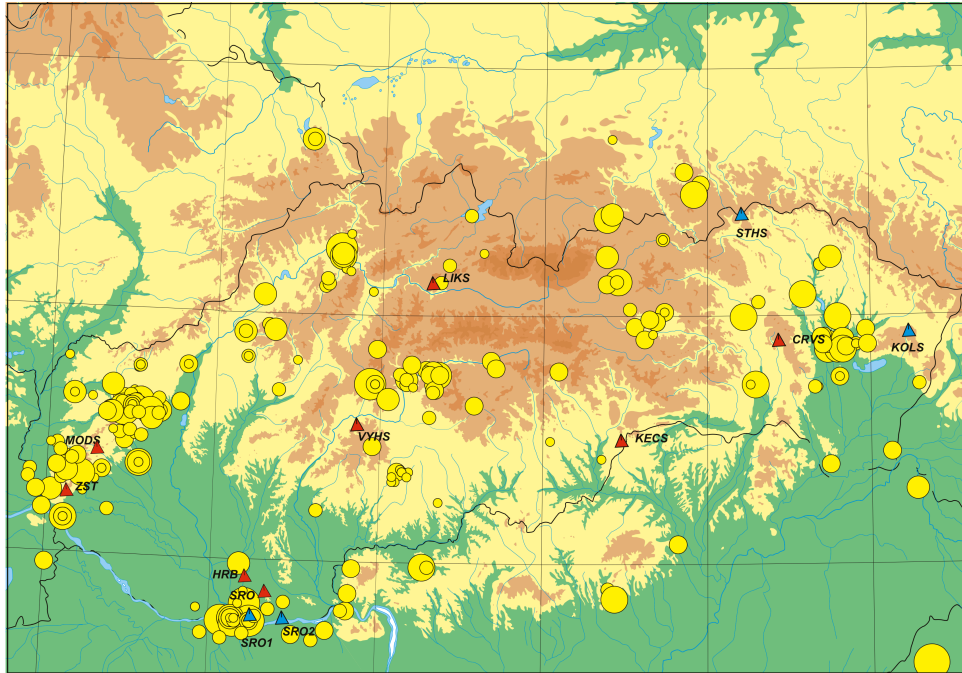


Fig. 1. National Network of Seismic Stations (red triangles – existing stations, blue triangles – stations under construction), yellow circles indicates epicenters of macroseismically felt earthquakes.

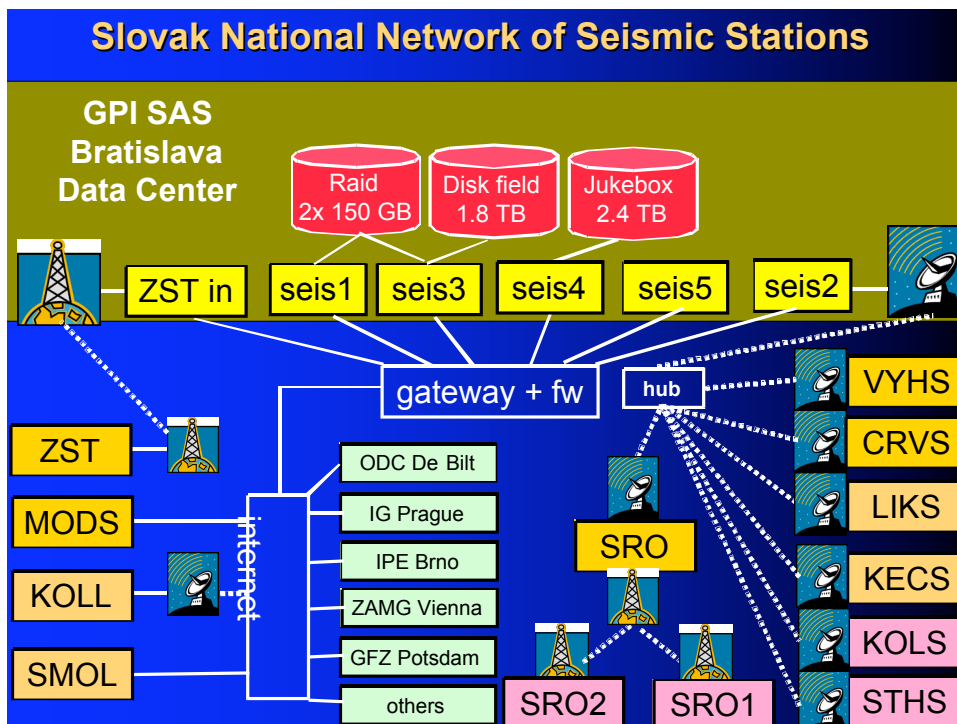


Fig. 2. Data flow between the data center in Bratislava, seismic stations of the Slovak national network and other institutions. Orange boxes indicate existing seismic stations of the national network. Pink boxes indicate seismic stations under construction. Green boxes represent cooperating institutions.

Data transfer, collection and exchange

Data center of the national network is located in the Geophysical Institute, Slovak Academy of Sciences in Bratislava. It collects waveforms from all stations of the national network and from selected seismic stations of following institutions

- Geophysical Institute, Academy of Sciences of the Czech Republic, Prague, Czech Republic,
- Institute of the Physics of the Earth, Masaryk University Brno, Czech Republic,
- Central Institute for Meteorology and Geodynamics, Vienna, Austria,
- Geoforschungszentrum, Potsdam, Germany,
- Geodetic and Geophysical Research Institute, Hungarian Academy of Sciences, Budapest, Hungary,
- Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland
- Progseis Trnava, Slovak Republic.

Data are collected in near-real time using the SeisComp/SeedLink or SEMS SeedLink software, respectively. The miniSeed format is used for both data collection and data exchange. In total, data from 26 seismic stations are collected (8 stations from the national network and 18 stations from the co-operating institutions). These 26 stations create Regional Virtual Seismic Network of the GPI SAS (Fig. 3)

Seismic waveforms are exchanged with all institutions, which supply data to the data center in Bratislava. In addition the seismic waveforms are sent also to Orfeus Data Center, De Bilt, The Netherlands. Fig. 2 shows data flow between the data center in Bratislava, seismic stations of the national network and other institutions. Fig. 4 shows equipment used in the data center in Bratislava. Live seismograms are available from the national network at the <http://ww.seismology.sk> web page. Live seismograms are archived for last 30 days.

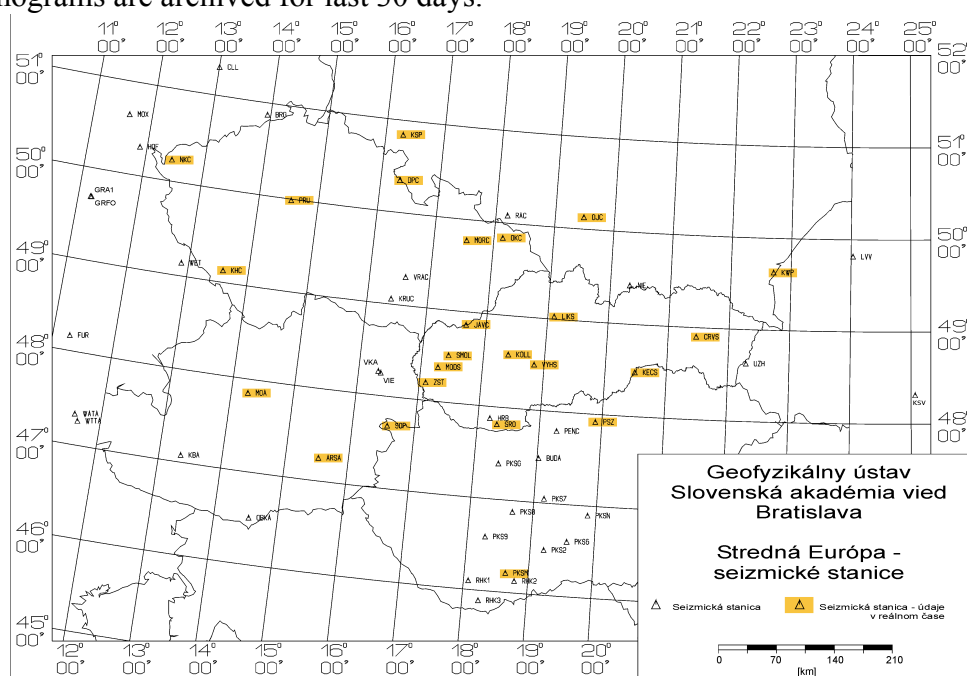


Fig. 3. Virtual Regional seismic network at the Geophysical Institute, Slovak Academy of Sciences, Bratislava (yellow diagonals) and seismic stations in Central Europe.

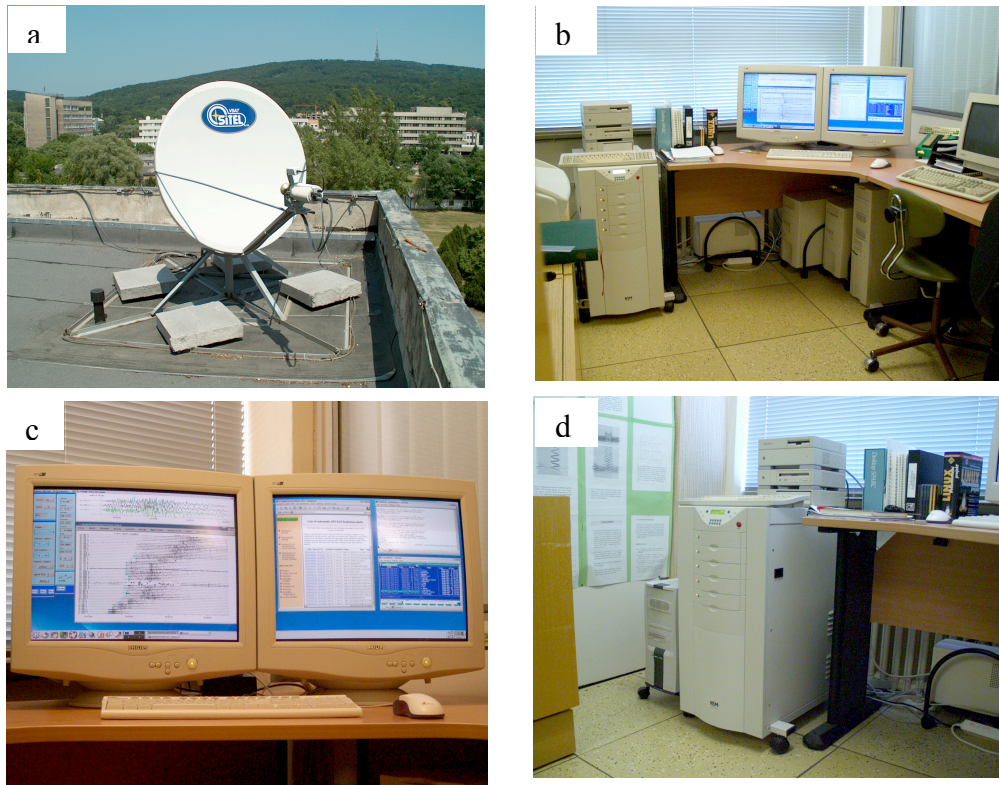


Fig. 4. Equipment used in the data center in Bratislava; a) VSAT receiver/transmitter, b) recording computers, c) analysis tools, d) archiving jukebox NSM 3000.

Name	ISC code	Period	Format	Channels
Bratislava _elezná Studni_ka	ZST	Since 2002	miniSeed	SH?, BH? EH?, HH?
Modra	MODS	Since 2002	miniSeed	SH?, BH? EH?, HH?
Vyhne	VYHS	Since 2003	miniSeed	BH? EH?, HH?
_robárová	SRO	Since 2003	miniSeed	SH? EH?
_ervenica	CRVS	Since 2003	miniSeed	BH? EH?, HH?
Ke_ovo	KECS	Since 2004	miniSeed	EH?
Likavka	LIKS	Since 2004	miniSeed	EH?
Smolenice	SMOL	Since 2004	miniSeed	EH?

Tab. 2. Availability of continuous data in the Geophysical Institute, Slovak Academy of sciences, Bratislava.

Data storage, archiving and availability

Since the national network is in the process of modernization and extension, the archiving of the waveforms was changed as well. Since July 2002 a two step procedure has been used for archiving of continuous waveforms. First, the waveforms are stored in the 1.8 TB Raid field. Then, data are moved to the 2.4 TB Jukebox NSM 3000. Tab. 2 shows availability of continuous data. In addition, digital event data are available. Tab. 3 shows availability of event data. Tab. 4 shows availability of analogue records on photo- or smoked paper, respectively.

Records of local, regional and teleseismic events are archived. All waveform data are available on request. During 2004, a new AutoDRM system should be installed. During 2004, a web page access should be available for continuous data.

Name	ISC code	Period	Format	Channels
Bratislava _elezná Studni_ka	ZST	1990-2002	ESSTF GSE2.0	SP, Z, N, E Since 1997 BB
Modra	MODS	1992-2002	ESSTF GSE2.0	SP, Z, N, E
Vyhne	VYHS	1991-2003	ESSTF GSE2.0	SP, Z, N, E
_robárová	SRO	1997-2003	ESSTF GSE2.0	SP, Z, N, E
Ko_ice	kos (local code)	1992-2002	ESSTF GSE2.0	SP, Z, N, E

Tab. 3. Availability of event data in the Geophysical Institute, Slovak Academy of sciences, Bratislava.

Name	ISC code	Period	Record type	Channels/Comp.
Bratislava	BRA	1957-1976	photo paper	SP, Z
Hurbanovo	HRB	since 1949	smoked paper	MP, N, E
Bratislava _elezná Studni_ka	ZST	1977-1999	photo paper termo papaer	SP, Z Since 1997 BB Z, N, E
_robárová	SRO	1963-1998	photo paper	SP, Z
Skalnaté Pleso	SPC	1956-1998	photo paper	SP, Z

Tab. 3. Availability of analogue records in the Geophysical Institute, Slovak Academy of sciences, Bratislava.

Data analysis

A two-step analysis of seismic waveforms is performed:

1. Automatic analysis and localization of earthquakes,
2. Manual analysis and localization.

The automatic analysis is performed by AutoLoc package of GFZ Potsdam. The package was installed in February 2003. Results of automatic localization of events are available at the <http://www.seismology.sk> web page (see example on Fig. 5).

The manual analysis is performed using the Seismic Handler package of K. Stammer since October 2003. The results of waveform interpretation and earthquake localization are stored in a database, which is in operation since 1996. Fig. 6 shows an example of event interpretation for the May 20, 2003 $M_I=4.2$ earthquake in Eastern Slovakia.

AUTOMATIC EARTHQUAKE ALERTS
Geophysical Institute SAS Bratislava

Please note that neither the Slovak National Network of Seismic Stations, nor the regional virtual network created at the GPI SAS Bratislava are not optimized to locate teleseismic events. Moreover, not all data comes in in real-time. Therefore the epicenter and magnitude estimation may be not very precise for many parts of the world and the quality of the solution may be still improved with data coming in from other stations lateron.

The files may contain data both from stations of the Slovak National Network of Seismic Stations and virtual regional network at the GPI SAS Bratislava. Usage of data from IG CAS Prague, IPE Brno, ZAMG Vienna, GFZ Potsdam, GGRI Budapest and IG PAS Warsaw is gratefully acknowledged.

The Date-Time characteristics are clickable and refer to more event location information.

Date-Time	Latitude	Longitude	Magn.	Region	Type
2004/08/25_20:56:13	50.0 N	18.2 E	ML=2.1	POLAND	L
2004/08/25_06:55:12	51.4 N	16.1 E	ML=3.4	POLAND	L
2004/08/25_05:19:52	52.4 N	142.1 E	mb=5.2	SAKHALIN ISLAND	L
2004/08/25_02:22:17	62.4 N	147.3 W	mb=5.8	CENTRAL ALASKA	L
2004/08/24_23:17:42	50.0 N	18.2 E	ML=1.5	POLAND	L
2004/08/24_10:05:39	30.8 N	89.7 E	mb=5.9	XIZANG	L
2004/08/23_15:36:17	59.5 N	177.7 E	mb=5.1	BERING SEA	L
2004/08/22_18:13:11	38.5 N	74.7 E	mb=4.4	TAJIKISTAN-XINJIANG BORDER REG.	L
2004/08/21_03:33:00	38.5 N	55.5 E	mb=4.9	TURKMENISTAN-IRAN BORDER REGION	L
2004/08/21_01:45:54	25.5 N	165.1 W	mb=6.3	HAWAII REGION	L
2004/08/20_21:19:53	35.8 N	144.1 E	mb=5.5	OFF EAST COAST OF HONSHU, JAPAN	L
2004/08/20_20:33:05	36.2 N	142.8 E	mb=5.6	OFF EAST COAST OF HONSHU, JAPAN	L
2004/08/20_17:37:51	23.8 N	123.9 E	mb=5.7	SOUTHWESTERN RYUKYU ISLANDS	L
2004/08/20_11:15:22	47.8 N	16.9 E	ML=2.4	AUSTRIA	L
2004/08/20_05:36:23	55.0 N	166.6 W	mb=5.3	FOX ISLANDS, ALEUTIAN ISLANDS	L

Fig. 5. Results of automatic localization of events using the AutoLoc package of GFZ Potsdam. All localizations are available at the <http://www.seismology.sk> web page.

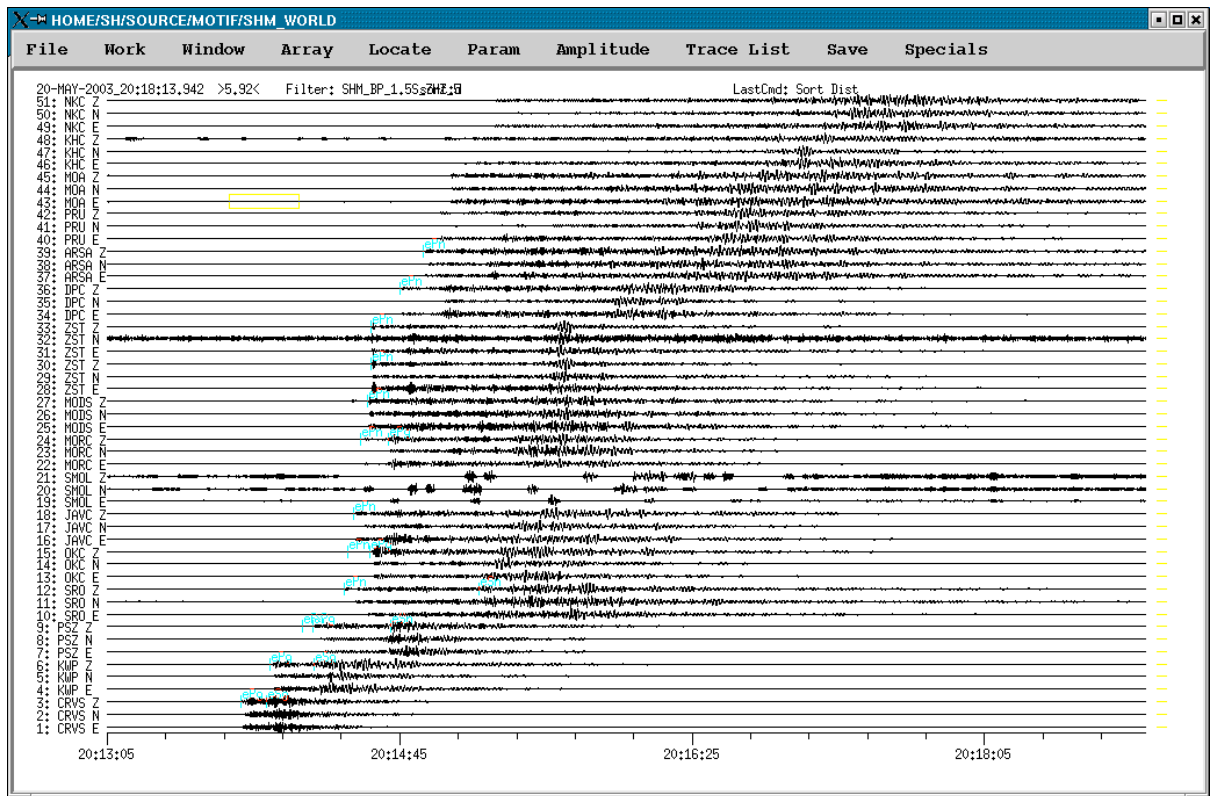


Fig. 6. Example of manual event interpretation using the Seismic Handler package. Shown traces are from the Virtual Regional Seismic Network at the GPI SAS Bratislava for the May 20, 2003 $M_L=4.2$ earthquake in Eastern Slovakia.

Published papers and conference contribution

Moczo, P., Labák, P., Cipciar, A., Kristek, J., Kristeková, M., Bielik, M., _ajgalíková, J., Rezuchová, D., 2002. 100 rokov seizmológie na Slovensku – 100 Years of Seismology in Slovakia. Geophysical Institute, Slovak Academy of Sciences Bratislava, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava.
ISBN 80-85754-11-8. (in Slovak and English)

Cipciar, A., Labák, P., Moczo, P., Kristeková, M., 2002. Monitoring of seismic events by the National Network of Seismic Stations. Geologické práce. Správy 107. Bratislava. (in Slovak).

Labák, P., 2003. National Network of Seismic Stations. Invited presentation at the 5th Slovak geophysical conference. June 12-13, 2003, Bratislava.