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Bulgarian NDC and network – new achievements and challenges

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T4.1-P2

Abstract

The first big steps to bring Bulgarian seismology to digital age was made in the end of 2005 when first data transfer from each seismic station to Bulgarian data center was fact and the operation seismologist works directly with digital seismograms. All seismic stations were equipped with 3C broadband seismometers and digitizers DAS 130 of Reftek, brand of Trimble Inc. Automatic EQ processing is based on SNDM software package. As fast as possible location, magnitude and depth are performed within 8 minutes. Information for felt EQ as soon as possible is sent to authority, civil protection and public mas media. For seismic event of interest we provide information to IDC of CTBTO in Vienna Now the end of 2018 we started with a new step to integrate Seiscomp3 in seismic data processing in our NDC with modules - scanloc for detection clustering and association and sceval for Realtime event evaluation

Some historic notes

The beginning of the seismology in Bulgaria is 1891 when the director of the Central Meteorological Station in Sofia - Spas Vatsov organized a correspondent network for collecting information about earthquakes felt in the country. Prof Vatsov makes the first prototype of a macroseismic bulletin in Bulgaria.

The period of Bulgarian historical era ends in 1905 when the seismograph of Omorri-Boch type was installed in the first Seismological Station in the capital city of Sofia. The same year four

seismoscopes of Agamenonne type were installed in Sofia, Petrohan, Rila monastery and the town of Kazanlak.

From 1961 to 1979, six seismic stations were built in Dimitrovgrad, Pavlikeni, Musomishta, Kardjali, Preselentsi and Vitosha (DIM, PVL,MMB, KDZ, PSN and VTS)

The strong earthquake in 1977 in the region of Vrancea (Romania) and its negative impact (lost human lives) required the development of a new strategy for monitoring and study the seismicity in Bulgaria.

In 1980 a National Operative Telemetry System for Seismological Information (NOTSSI) was established. The analogue information from the stations is transferred in real time by telephone lines to the Seismological Center of NOTSSI at the Geophysical Institute. Seismic data is visualized on paper drums with two levels of amplification to achieve better dynamics.

At the end of the last century seismological observations in Bulgaria were carried out by 14 national seismic stations and 2 local networks with 7 stations

Both local seismic networks are designed to monitor the weak seismicity in the nearby areas (30 km) around NPP Kozloduy and around the salt body near the town of Provadia.

In the period 2001-2004 seismic stations Plovdiv and Yambol are equipped with the digital systems Quanterra 330 and broadband seismometers Guralp CMG40T.

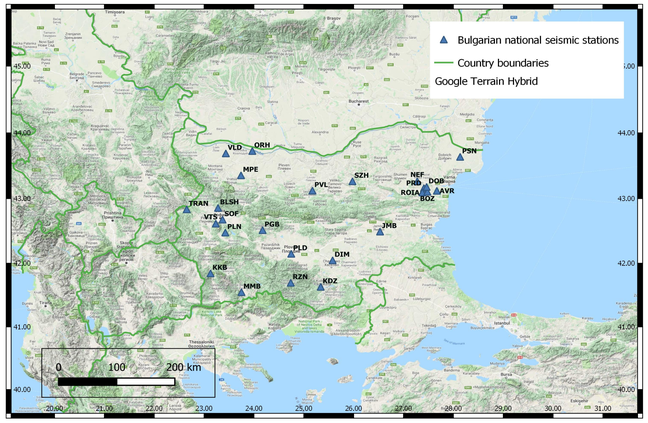
In 2005 with the financial support of the then existing Ministry of Emergency Situations, digital equipment and software was purchased from the American company "Refraction Technology" Inc.

Real-time data acquisition is performed using REFTEK's protocol RTPD. Data from the Quanterra recorders and foreign stations are fed into RTPD in real-time via SeisComP/SeedLink protocol. Data processing is performed by the Seismic Network Data Processor (SNDP) software package.

The national seismic network currently consists of 16 digital seismic permanent stations with three component broadband seismometers and 2 local networks with 8 digital seismic stations -Pic.1 and Table 1.

The main observations of the NOTSSI are:

- **Registration of earthquakes with magnitude above 3.0 realized on the territory of the country;**
- **Real-time transmission of seismic data from all permanent seismic stations to center in the former Geophysical Institute (GPhI) ;**
- **Processing of earthquake data on the territory of Bulgaria - estimations of the main earthquakes parameters (within 15-20 minutes) – Hipocenter, Origin, Magnitude ;**
- **Impact Assessment (up to 1 hour) – Macroseismicity**
- **Inform the responsible state authorities in the case of felt earthquakes;**



Picture 1. Bulgarian seismic Network with permanent stations

Station Name	Code	Sensors	Comp	Data acquisition system	Data Transfer
Dimitrovgrad	DIM	S-13	3C	Reftek 130-01/ 100 sps	RT on VPN
Yambol	JMB	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Kurdzhali	KDZ	CMG 3 ESPC/120s	3C	Reftek 130-01/ 100 sps	RT on VPN
Krupnik	KKB	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Musomishta	MMB	STS2	3C	Reftek 130-01/ 100 sps	RT on VPN
Panagyurishte	PGB	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Plovdiv	PLD	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Provadia	PRD	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Preselentsi	PSN	KS 2000/60s	3C	Reftek 130-01/ 100 sps	RT on VPN
Pavlikeni	PVL	CMG 3 ESPC/120s	3C	Reftek 130-01/ 100 sps	RT on VPN
Rozhen	RZN	GMT-40T/30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Sofia	SOF	S-13	3C	Reftek 130-01/ 100 sps	RT on VPN
Strazhitsa	SZH	CMG-3ESPC/60s	3C	Reftek 130-01/ 100 sps	RT on VPN
Vitosha	VTS	CMG-3ESPC/120s	3C	Quanterra 680/ 20sps	RT on VPN
Malo Peshtene	MPE	RefTek 151-120s	3C	Reftek 130-01/ 100 sps	RT on VPN
Plana	PLN	CMG-3ESPC/120s	3C	Reftek 130-01/ 100 sps	RT on VPN
Tran	TRAN	RefTek 151-30s	3C	Reftek 130-01/ 100 sps	RT on VPN
Orjahovo	ORH	S-13	3C	Reftek 130-01/ 100 sps	RT on VPN
Valchedram	VLD	S-13 -Borehole	1C	Reftek 130-01/ 100 sps	RT on VPN
Avren	AVR	Geophone GS 11D	3C	Reftek 130-01/ 100 sps	RT on VPN
Roiak	ROIA	Geophone GS 11D	3C	Reftek 130-01/ 100 sps	RT on VPN
Bozvelijsko	BOZ	Geophone GS 11D	3C	Reftek 130-01/ 100 sps	RT on VPN
Dobrina	DOB	Geophone GS 11D	3C	Reftek 130-01/ 100 sps	RT on VPN
Nevsha	NEF	S-13	3C	Reftek 130-01/ 100 sps	RT on VPN
Balsha	BLSH	"Reftek 151B/30s"	3C	Reftek 130-01/ 100 sps	RT on VPN

Table 1. Basic information related to Bulgarian seismic Stations

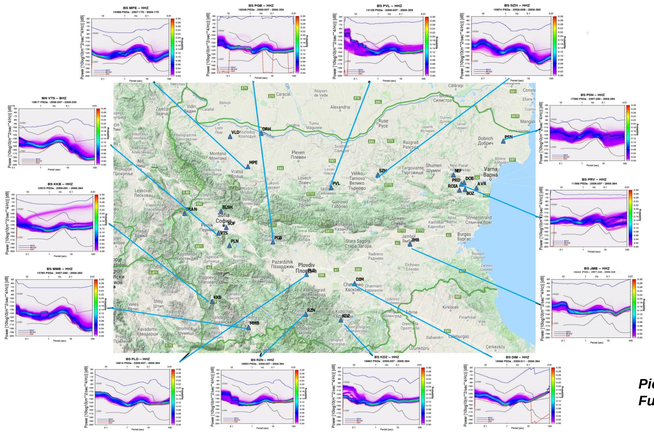
The Bulgarian National Seismological Network (BNSN) and National Data Center (NDC) are unique services providing information for earthquake parameters, Macroseismic information , etc. to public and governmental institutions such as:

- **Ministry of interior**
- **National services of civil protection**
- **Mass Media**
- **Services of earthquake disaster mitigation**

National Institute of Geophysics, Geodesy and Geography – BAS is National Data Center (NDC) of CTBTO. Bulgarian NDC is receiving seismic data from Turkish Array BRTR and in case of strong event on the territory of Bulgarian sends the necessary information to the PTS Vienna on demand.

BNSN and NDC are part of international data exchange both of real time and archive data. The exchange is performed by Seiscomp/ Seedlink protocol with several neighbor countries and International Data centers :

- ✓ **Romania**
- ✓ **Greece**
- ✓ **Serbia**
- ✓ **North Macedonia**
- ✓ **Turkey**
- ✓ **INGV Roma**
- ✓ **Orfeus**
- ✓ **Geofone**
- ✓ **NEIC**
- ✓ **NIEP EIDA NODE**



Performance of seismic stations

One of the method in the seismological practice for assessment of the performance of the seismic stations and the quality of the acquired data is the estimation of Power Spectral Density (PSD) and the Probability Density Function (PDF) of the ambient noise at seismic stations. Distribution of the PSD and the PDF at all Bulgarian stations are given on the picture 2.

The noise within the period range from 5 sec to 12 sec is produced by storms in the Black Sea and the waves breaking on the seashore. The noise below 1 sec is mainly human produced. As it is seen from the picture 2 all curves of the PSD distribution with the highest probability level are situated close to the curve of the Low Noise Model (NLNM). It proves the ability of all stations to register high quality of seismic data. The "quietest" stations are MPE and VTS. The seismological equipment of the both stations is installed on the rocks. One of the nosiest stations is PVL which is situated on the dams' banks. When the dam machinery is running the noise in the periods below 1 sec significantly increases.

Picture 2. Distribution of Power Spectral Density and Probability Density Function of the ambient noise at Bulgarian seismic stations

Seismological Data Processing

Seismic Network Data Processor is working in NOTSSI since 2005 .
SNDP includes 3 subsystems:

- **Real-time subsystem (RTS_SNDP) – for signal detection; evaluation of the signal parameters; phase identification and association; source estimation;**
- **Seismic analysis subsystem (SAS_SNDP) – for interactive data processing;**
- **Early warning subsystem (EWS_SNDP) - based on the first arrived P-phases.**

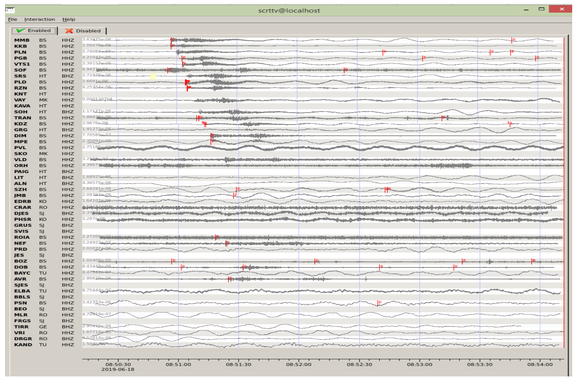
At present the manufacturer does not update the software in accordance with the requirements of modern software products. This circumstance requires implementation of alternative software with appropriate features for automatic and interactive seismic data processing for local and regional seismicity.

The best decision for the purposes of our network is SeisComP3 software package. Recently we have implemented SeisComP3 Pro with two extra modules scanloc and sceval.

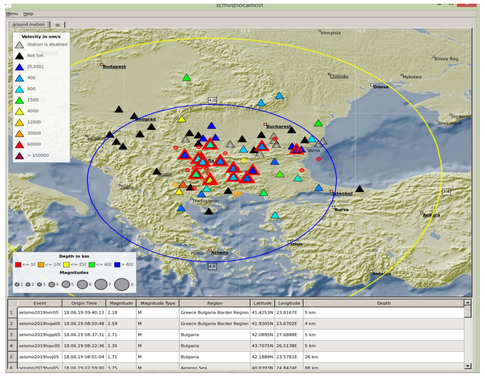
The old SNDP and the new SeisComP3 software are working in parallel in order to improve the performance of the new one.

Pictures present screenshots of automating data processing .

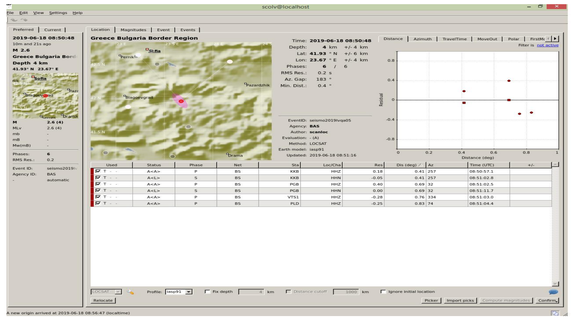
At the moment a number of fake events is large because the wrong picking of the noisy stations. We are testing different filters for correct phase picking to decrease fake events.



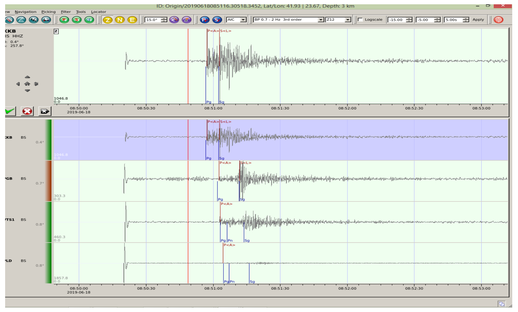
Picture 3. Screenshot from automatic data processing of scrttv module



Picture 4. Screenshot from automatic data processing of scmv module



Picture 5. Screenshot from automatic data processing of scolv module – epicenter location and phases



Picture 6. Screenshot from automatic data processing of scolv module – waveform and phases

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