Cooperation between The Albanian Seismic Network and the University of Bergen.

Report # 2

The Albanian seismic network, plans and progress towards improving data acquisition and processing. Status January 2020.

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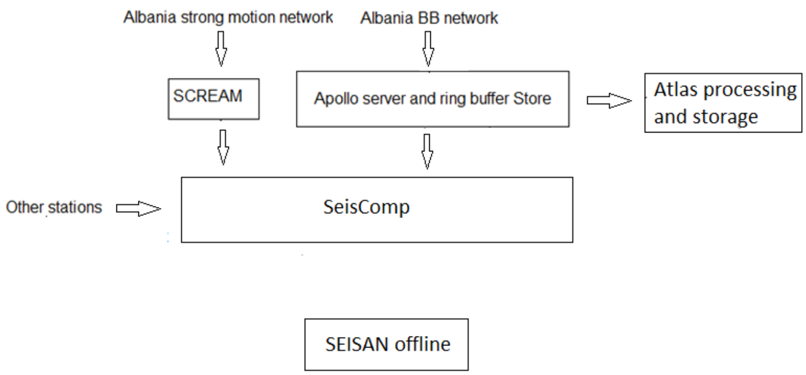
Introduction

After the disastrous earthquake in November, 2019, it is clear that the network of Albania is in need of an improvement. Similarly the data processing and storage should be improved and simplified. The current readings, locations and waveforms, are spread over different systems and it is not possible to work with the all information together. An initial evaluation with suggestions for improvements was made in October 2019 and some work started. In this second report from January 2020, more work has been done towards the goal outlined in 2019. The purpose of this report is to report on the work done and in addition give some thoughts on a future design of the network.

The current seismic network of Albania

The actual Albanian Seismic Network is composed of three sub-networks, namely:

- Albanian Weak Motion Network (AWMN)
- Albanian Strong-Motion Network (ASMN)
- GNSS Permanent Stations (AlbGNSS)



The AWMN has 8 BB stations (Fig. 2), namely sited at B. Curri (BCI), Peshkopia (PHP), Puka (PUK) and Shkodra (SDA), in northern Albania; Korça (KBN), Leskoviku (LSK), Saranda (SRN) and Vlora (VLO), in the southern Albania, as well as a MedNet central VBB (120 sec) station, located in Tirana (TIR). Thus, comprehensively 9 BB stations are operational within the Albanian territory (28000 km^2). AWMN stations are equiped with 30 sec broadband sensors mainly. The ASMN numerates 17 strong motions stations. ASMN stations are located on bedrock conditions and soft soil too. Accordingly, 2g cloping level sensors are co-installed on BCI, PHP, SDA, SRN, KBN, VLO and TIR vault basement, and the rest of them on different soil conditions (Fig. 2). The AlbGNSS sub-network has 9 permanent GPS stations, some of them located within actual seismic stations. The BB stations are sending data via VSAT communication (at least 4 of them actually) and radio link communication using internet (local provider) (Fig. 1 & 2). Some of the waveform data is received via SeedLink as well, especially from the Montenegrin Seismic Network, Aristotle University of Thessaloniki seismic network (AUTH), the Italian Institute of Geophysics and Vulcanology (INGV), the Euro-Mediterranean Seismic Network (MEDNET) and some stations from AFAD (Turkey). Other data comes through internaqs pluggin as part of the Nanometrics system. These variouse way transmitted waveform data arrive to the central data recording systems Apollo Server and Scream data Server, operating in real time. All channels, also acceleration, go into both SeisComp3 and Apollo and backup on a different computers is made of the continuous data from both systems.

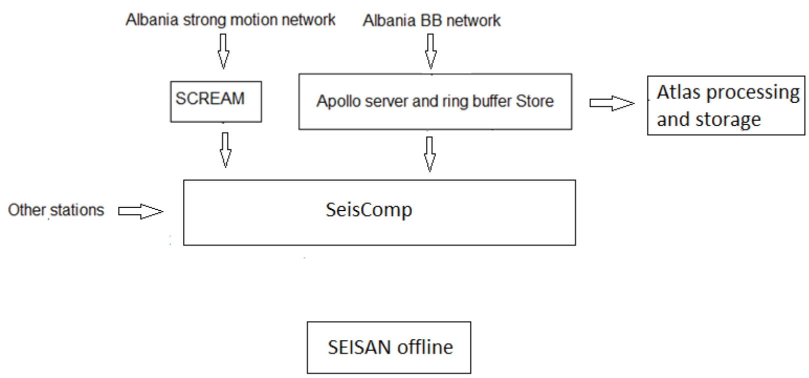


Figure 1 **Current Albanian seismic network data streams.**

Table 1 the AWMN (BB) stations and TIR (VBB), MedNet station metadata.

No.	Station Code	Latitude (degree)	Longitude (degree)	Altitude, m	Location	Sensor	Digitizer	Datalogger	Transmission
1	BCI	42.3666	20.0675	500	B. Curri	CMG-40T	Trident	Cygnus	Libra VSAT
2	PHP	41.6847	20.4408	670	Peshkopi	Trillium40	Trident	Cygnus	Radio link
3	SDA	42.0302	19.2947	67	Shkodra	Trillium40	Trident	Cygnus	Radio link
4	KBN	40.6236	20.7874	800	Korça	Trillium40	Trident	Cygnus	Radio link
5	VLO	40.4686	19.4955	80	Vlora	Trillium40	Trident	Cygnus	Radio link
6	SRN	39.8800	20.0005	20	Saranda	Trillium40	Trident	Cygnus	Libra VSAT
7	LSK	40.1499	20.5987	960	Leskoviku	CMG-40T	Trident	Cygnus	Libra VSAT
8	TIR (MN)	41.3477	19.8650	240	Tirana	STS-2	Trident	Cygnus	Opt. Fiber

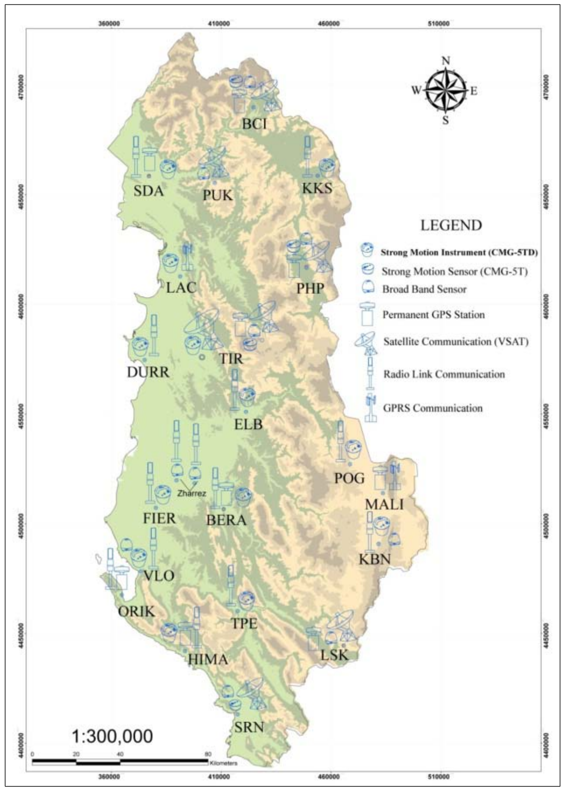


Figure 2 The Albanian Seismic Network map.

Detailed information on 8 of AWMN stations, are given on table 1 as above, excluding the PUK station, which is actually uncovered with any instrumentation and non operational.

Suggestions for a future design of the network

This section has the recommendations as outlined in the October report of which some has been done so it is partly revised.

SEISAN was installed on an independent powerful Linux server (see below). The plan is to install the Seiscomp system in the server and the continuous data in the Seiscomp system will then be directly accessible to SEISAN from the ring buffer in the Seiscomp system. When an event occurs, the MULPLT program in SEISAN can inspect the data and directly export it to the SEISAN data base from which it can be located immediately. All relevant data, including strong motion and external network data, for the event, is then in the SEISAN data base ready for other analysis like fault plane solutions and all the channels available in Seiscomp can be used. The next step is to install the SC2SEI software that automatically transfer the data from Seiscomp to SEISAN. SEISAN also has a command for sending a processed event to EMSC by mail and ISC also accepts data in SEISAN (Nordic format) so no reformatting is needed.

The strong motion data is processed in Guralp requiring GCF format. In the future it would be simpler to use a public domain software that accepts data in miniseed format or similar and access the data directly from the SEISAN database. It is also a possibility to use a software system (scwfparam, https://www.seiscomp3.org/doc/seattle/current/apps/scwfparam.html) for strong motion processing developed under the NERA project (installed in Seiscomp).

Currently Albanian data entering the Sesicomp3 system must pass through NaqsServer and SCREAM. This is an unnecessary complication for a future system which will lock the network into a particular manufacturer without any advantages. In the future all data should go directly from the field station to the Seiscomp system and a whole unnecessary and complicating layer can be eliminated. Both Guralp and Nanometrics now sell stations sending out miniseed directly so if a future replacement of Guralp and Nanometrics equipment is desired, it should be bought with this option. Having all the same digitizers in the field would greatly simplify technical maintenance. By eliminating NAQS and SCREAM, other manufactures can also provide equipment and the network becomes independent of particular manufactures. See Figure 3.

In order for this data base to be useful for future research, it is also recommended to restore as much as possible of the old data. This process has started, see below. SEISAN has many research type programs which then can be used directly.

For the near future, it is planned to put the Seiscomp system on the server. However for further simplification as outlined, funds are needed to get new digitizers or put in a small Seedlink server on the existing stations.

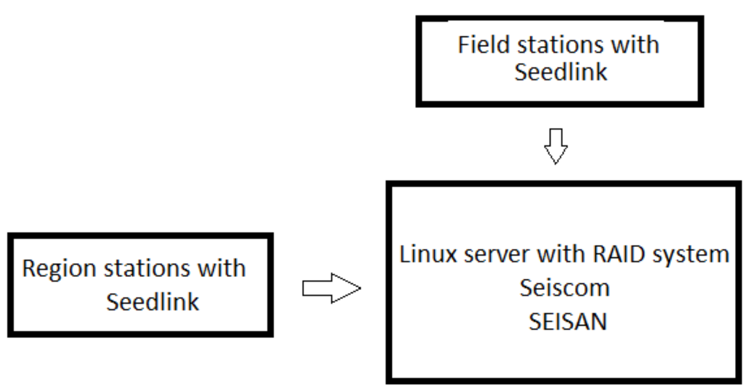


Figure 3 Suggestion for a future system.

Recovery of old readings and locations

Data resources

The institute has a larger server donated by CTBTO in 2016 and it has been decided to use that for the data base processing and the central Seiscomp3 system. SEISAN and a few other software system has been installed, however not all can be installed since the operating system has not been updated since its initial installation. The server has a large RAID system (2.8 TB) a powerful CPU with 12 processors and 32 GB of memory. The RAID can be expanded. The system seemed very fast.

Readings and hypocenters

For the older data bulletins were used and for newer data (after March 2019) output was taken from the hypocenter output. Several programs were made to convert the data to Nordic format. The amplitudes were in mm on a Wood Anderson seismogram and were converted to nm ground motion under the assumption that the WA gain is 2800 (as given in Atlas parameter file)

Some information about the original data is found in Table 2.

Table 2 information on the availability of data

Year	Format	Comment
2010	Modified Nordic	Readings several stations, no amplitude or coda
2011	Modified Nordic	Only TIR readings for most events, no amplitude or coda
2012	Modified Nordic	No coda or amplitude due to format
2013	Modified Nordic	
2014	------ and Old Hypoinverse	
2015	Old hypoinverse	
2016	Old Hypoinverse	
2017	Old Hypoinverse	
2018	Old and New Hypoinverse	
2019	New hypoinverse	

In the conversion process, all prime agencies were changed to TIR, which is the official agency reserved for Albania. The header lines were duplicated in order to keep the original locations and magnitude in case the event is relocated. The agency on the duplicated line was set to ORG to indicate the original solution. On the first header line the first magnitude was also written in the 3. Magnitude position in order to keep it on the header line if relocation is made. Many events had one of 2 stations but a location was given. In order to not lose the information in case of relocation, all events with 2 or fewer stations were set to not be relocated, see Table 3. All of the newer data was converted to Nordic format from Hypoinverse format with a program ALBNOR (now installed on server).

Table 3 Example of recovered event. Notice the two header lines and the 3. Magnitude in first header line.

```
2019  1 1 2331 17.4 L  41.983  20.298 17.1  TIR    .17 1.4LTIR 1.9CTIR 1.4LTIR1
2019  1 1 2331 17.4 L  41.983  20.298 17.1  ORG    .17 1.4LORG 1.9CORG        1
ACTION:SPL 20-01-12 17:47    jh                        ID:20190101233117 L   I
STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO AIN AR TRES W  DIS CAZ7
PUK  HZ  P       2331 24.15   20                         10   0.040   34.3 282
PUK  HN  IAML    2332 40.00       114.3 0.20             10           34.3 282
PUK  HN  S       2331 29.12                                   -.050
PHP  HZ  P       2331 24.02   22                          9   -.070   35.1 160
PHP  HN  IAML    2332 40.00        67.9 0.21              9           35.1 160
PHP  HN  S       2331 29.17                                   0.030
BCI  HE  IAML    2332 40.00        67.9 0.34              3           46.7 336
BCI  HE  S       2331 32.71                                   -.010
BCI  HN  IAML    2332 40.00        57.1 0.14              3           46.7 336
PVY  EZ  P       2331 30.71                              95   0.080   73.1 339
ULC  EZ  P       2331 33.14                              94   0.190   87.0 269
BEY  EZ  P       2331 34.68                              71   -.970    104 342
BUM  EZ  P       2331 38.56                              71   0.210    121 288
HCY  EZ  P       2331 43.83                              71   -.470    158 290
FNA  HZ  P       2331 46.67                              71    1.86    161 145
```

Table 4

An event with a location but only 2 stations so the * in front of TIR indicate that the event will not be processed. It is not know if there originally were more readings. Since there is a magnitudes, coda readings must have been available but they are not in the bulletin.

```
2012  1 9 15 7 57.8 L  41.814  20.263 8.50 *TIR  4 3.8 2.0LTIR         2.0LTIR1
ACTION:SPL 20-01-12 17:47 OP:jh   STATUS:              ID:20120109150757     I
2012  1 9 15 7 57.8 L  41.814  20.263 8.50  ORG  4 3.8 2.0LORG               1
STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO AIN AR TRES W  DIS CAZ7
PHP  SZ IPG      15 8  1.70
PUK  SZ IPG      15 8  6.00
PHP  SE ISG      15 8  5.10
PUK  SE ISG      15 8 10.71
```

Figure 4 shows the data near Albania and Figure 5 the monthly statistics.

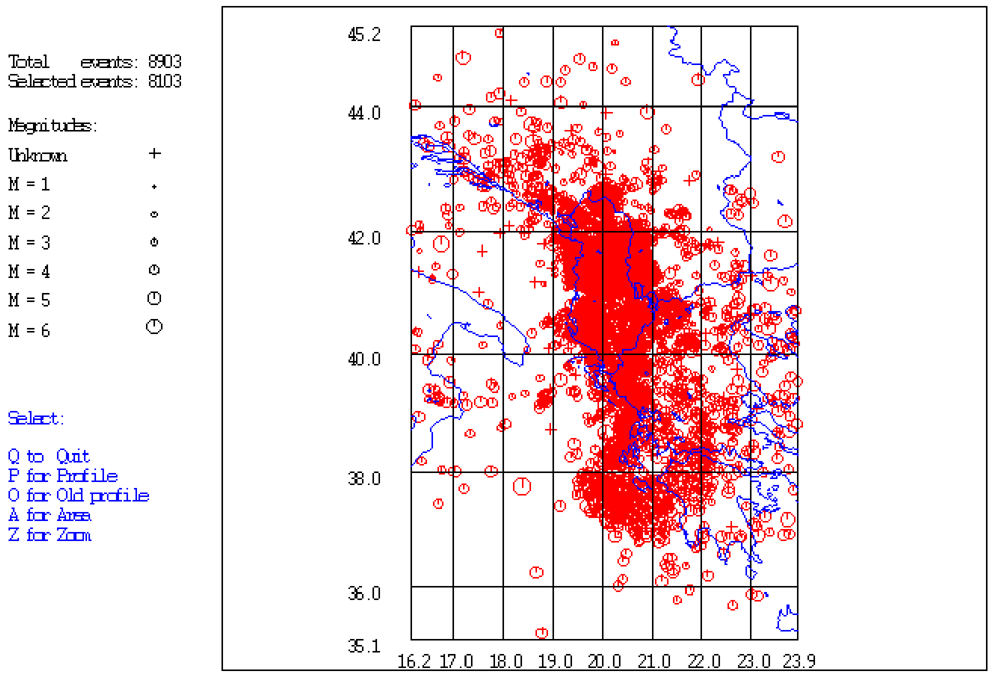


Figure 4 Recovered data from 2010-2020. A total of 8903 events were converted of which 8103 are with the limits seen in the figure.

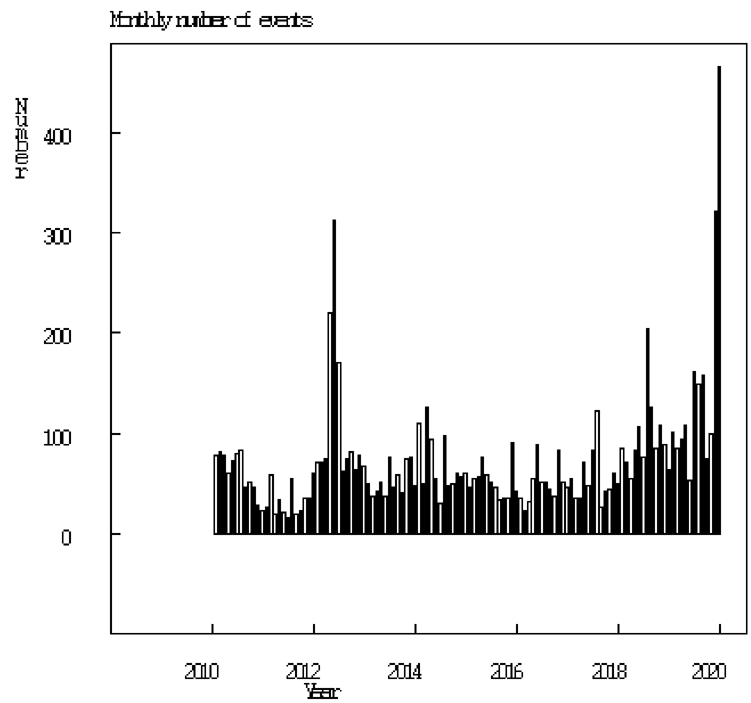


Figure 5 monthly numbers of located events with the Albanian network since 2010.

In addition to the network data, all data from the oil field injection monitoring was installed (ca 4000 events). The reading and locations (most are wrong since only using 2 stations BPA1 and

BPA1) were installed in data base BPA and all the waveform data in ..WAV/BPA/ (all in one directory).

ISC data

All prime hypocenters from ISC for the period 1900 to 2000 have been copied and put into a data base ISC, 6322 events. Only events with magnitude > 3.0 have been included. The area specified at ISC is 39-43 N and 18-22 E. However, ISC includes some events outside the specified area as well since one on the epicentres for an event can be inside, but the prime solution is outside. The first event is from 1927 but the prime solution is outside Albania. However, some agency reported it to be inside Albania.

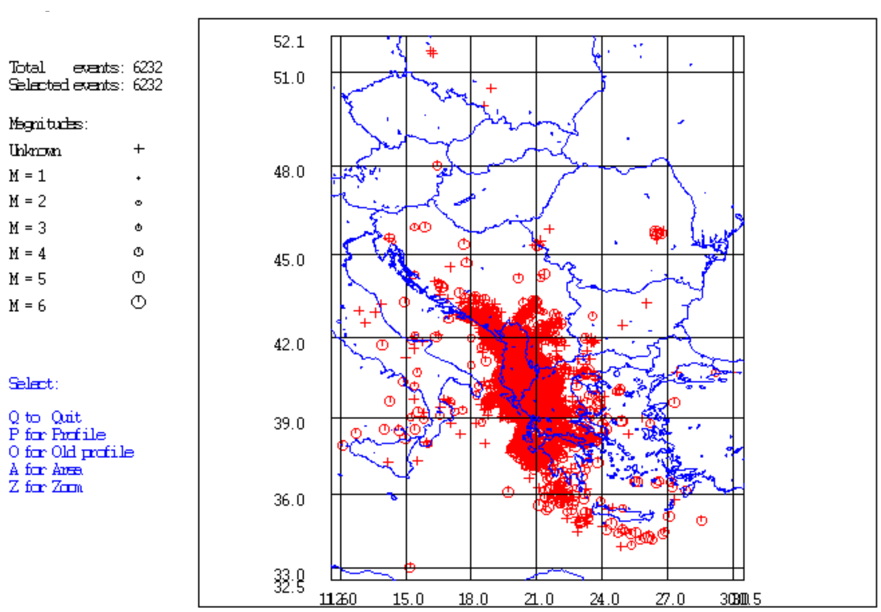


Figure 6 ISC Events with magnitude larger than 3 as installed on the server. Only hypocentral information has been downloaded.

Recovery of old waveform data

Event waveform files

Data is available since 2001. Available formats are GSR (16bit) (GeoSig), Nanometrics SEED source files which are archive files containing a large miniseed file with all the events, Nanometrics Y-files. Correspondingly to the SEED source files, data can be taken out one by one manually, but there is no tool to extract out all the events in one operation. This was confirmed by Nanomtrics. We asked Chad Trabant at IRIS if he could suggest a solution and gave us the old msrouter program which has an option to split a miniseed file in files which are continuous in time. The procedure is then:

msrouter –c **–**CDAY outputdir archive-file

where **–**c is option to split, -CDAY to write into files Net.sta.loc.chan-day files and archive file is the archive from Atlas.

An output file is e.g. MN.VLC..HHZ.2019:321:09:08:00.5

Give the files names that can be sorted according to time and station:

In outputdir, use **dirf ***

Use program **seisei** and use option **split**

This gives names like 2019-11-17-0908-00M.VLC___001_HH_1Z (input is file above)

Make **dirf** of new files like dirf 2019*

Merge files to multi channel event files with seisei, use a new agency like ALB so events can be separated from the single channel files. It seems that most single channel filer from one event is close in time so a time difference of 10s can be used.

Make a **dirf** of the ALB files

Make s-files in local directory corresponding to the ALB files using autorec

Collect the s-files to one *collect.out* with program collect.

Merge in the *s-files* with the waveform names into the data base TIR with program **associ**. Use option to merge in events from a file (*collect.out*) and make sure the *s-files* merged in comes after the s-file in data base (default option). Do some test to see what time difference to use, but around 100s seems ok.

Copy the ALB files to the WAV structure under WAV/TIR__/. This will include some files not merged in. This could be because the vent was not located or the archive has time gaps and thereby creating smaller files.

The availability of events data is given in Table 5 (under review)

Table 5 Available event data

Event Waveform Files			
Year	**Type of format**	**No. File**	**Memory**
2001	gsr	1058	58.6Mb
2002	gsr	21347	926Mb
2003	gsr	2941	115Mb
2004	gsr	4037	136Mb
2005	gsr	21347	885Mb
2006	Gsr/seed	3	1.40 MB
2007	Gsr/seed	143	414 MB
2008	Gsr/seed	1347	1.69 GB
2009	seed	22	273 MB
2010	seed	38	906 MB
2011	seed	123	715 MB
2012	seed	976	2.05 GB
2013	seed		
2014	seed	991	4.56 GB
2015	seed	383	2.32 GB
2016	seed	177	1.65 GB
2017	seed	133	1.24 GB
2018	seed	113	1.60 GB
Mixed event wf data	seed	31	472 MB
Triggered events wf data	seed	13	307 MB

Continuous data

The availability locally of continuous data was investigated, see Table 6

Table 6 Continuous data saved from the Albanian seismic network

Broad Band Stations

Year	Months	Type	Details
2014	07-12	NanometricsRingBuffer	Our Stations
2015	1-12	NanometricsRingBuffer	Our Stations
2016	1-12	NanometricsRingBuffer	Our Stations
2017	1-12	NanometricsRingBuffer	Our Stations
2018	1-12	NanometricsRingBuffer	Our Stations
2019	1-12	Seed files	Apollo Project (for December we have Regional Stations Also)
2020	…	Seed files	Apollo Project + regional Stations Also

Strong Motion

Year	Months	Type	Details
2014	7-12	Scream	Our Stations
2015	1-12	Scream	Our Stations
2016	1-12	Scream	Our Stations
2017	1-12	Scream	Our Stations
2018	1-12	Scream	Our Stations
2019	1-12	Scream	Our Stations
2020	…	Scream	Our Stations

Earthworm

Year	Months	Type	Details
2009	12	.ARC files	Back up of old events
2010	12	.ARC files	Back up of old events

It is seen that most data before July 2014 has not been backed up, however data collection started for most station in 2009 and 2010, except VLO which started in 2004. It seems that much data is available at IRIS DMC (Table 7) so it might be possible to recover from there.

Table 7 Data at IRIS

AC (2002-01-01 - 2599-12-31)

Network	AC Map DOI
Description	Albanian Seismic Network Albanian Seismological Network
Start	2002-01-01 (001)
End	2599-12-31 (365)
Data Center	INGV IRISDMC A
# Stations	9

Station	Data Center	Start	End	Site	Latitude	Longitude	Elevation
BCI	IRISDMC A	2009-12-22	2599-12-31	Bajram Curri, Albania	42.366600	20.067499	500
KBN	INGV IRISDMC A	2009-12-22	2599-12-31	Korce Korce, Albania	40.623600	20.787400 20.787399	800
LSK	IRISDMC A	2010-01-01	2599-12-31	LSK	40.149899	20.598700	960
PHP	IRISDMC A	2009-12-22	2599-12-31	Peshkopi, Albania	41.684700	20.440800	670
PUK	INGV IRISDMC A	2009-05-29	2599-12-31	Puke, Albania	42.042599	19.892599	900
SRN	INGV IRISDMC A	2003-07-22	2599-12-31	Sarande, Albania	39.880001	20.000500	20
TIR	IRISDMC A	2009-12-31	2599-12-31	Tirane, Albania	41.347691	19.865000	247
TPE	INGV IRISDMC A	2010-01-01	2599-12-31	TPE Tepelene, Albania	40.294700 40.294701	20.009400 20.009399	273
VLO	INGV IRISDMC A	2004-09-11	2599-12-31	Vlore, Albania	40.468601	19.495501	80

On request IRIS (Rick Benson) gave this information about data available:

```
393M    2009
54G     2010
1.8M    2011
??      2012      several months seed!!!
68G     2013
76G     2014
136G    2015
126G    2016
115G    2017
114G    2018
69G     2019
5.2G    2020
```

It seems that in a normal year, about 120G is stored, so by this measure 2010-2014 and 2019 are not complete. The missing data for 2019 is available from the local backup according to Table 4. It is unclear what happened in 2012. Rich Benson has suggested ways of downloading the data from IRIS.

The intention is to put all continuous data into a Seiscomp archive and this was tested with limited data using program *dataselect*. This program has been put into /seismo/PRO. A script has been made (in /seismo/COM) so to add data to the archive use command

make_archive   file

where file can be * for all files in current directory or a directory name.

Since the regional data is also used for the analysis, it must also go into the archive. Backup is now made of the regional data starting from December 2019.

Strong motion data should also go into the archive so gcf data must be converted to MiniSeed and then added. Guralp has a converter.

Strong motion data

There is continuous strong motion data available from July 2014. Before 2014 (and after) there are strong motion data in a local format for individual events. Some events were converted for testing, however not all data has absolute time. The intention is to put all event data into the data base, at least before July 2014.

Recover data before 2010 will be based mainly on GSR event files and scarce SEED file volumes covering period from 2007 to 2010, as detailed in Table 5 as above. These files are under review, checking their availability and consistency. These data are archived mainly on media such as CD-s or Floppies and need to accurately be re-collected in the same safe environment.

There are waveform event files for some years before 2010 but it is unclear if the corresponding readings are available. There exist parametric data for the period 1995-2005, saved as catalogue and phase data, separately. To be investigated. As a test, waveform data from 2019 were put in and corresponding s-files created in TIR. A total of 191 events were available.

Tasks to be done in near future

- Upgrade server to latest operating system
- Make a new seismo user which is not system
- Get access to all disks and move archive to the large RAID
- Install Seiscomp3 on the server, it must use the same archive as above
- Install 2. screen for the seismo operator
- Recover continuous data from local sources and IRIS, this includes the strong motions data
- Recover event waveform files and associate with readings if available. This includes strong motion data from before July 2014

Conclusion

It has been concluded that the future processing will take place in SEISAN as installed on the server and the daily events will be taken directly from the Seiscomp3 archive. The new way of processing can start when Seiscomp3 has been installed on an upgraded server.

Initial training in SEISAN processing has been done on the server but more is needed when the new processing starts.

The server is now the main system for the complete data base and recovery has started for data to be included in the data base. Most of the available readings from 2010 to 2020 have been converted and transferred. Tests have been made for recovery of most kinds of data so this can now continue.

In case funds will be available for upgrade of the network, a suggestion for the technical solutions has been made.