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A review of the Egyptian National Seismological Network after 20 years of operation

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ABSTRACT
On 12 October 1992, a moderate earthquake with magnitude, Mw 5.8 was occurred in Cairo; the epicentre is located 25 km south west of Cairo, resulted in great damage in the surrounding area and extended 300 km away from the epicentre. Subsequently, the government established Egyptian National Seismological Network (ENSN) under the supervision of National Research Institute of Astronomy and Geophysics (NRIAG) with 66 stations of different recording bands (e.g. short period, broadband) for monitoring the seismic activity in and around Egypt. The network started operation since mid-1997 up till now, consider revising 20 years of operation, a lot of changes were done (sensors, digitisers, station locations and even stations name), there is still the absence of adequate documentation of the type of changes made. This article is the first attempt to study the recorded data to track all changes done in the network, as a first step towards a different studies regarding determination of the detection capabilities of ENSN's stations and proposed an optimisation solutions for the current faced problems. A software code was designed under Matlab programme to read around 55,000 recorded events and track different changes that took place during the operational time. The output of this study will affect all related research work including magnitude determination and hazard analysis.

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Seismological network; data analysis; seismic detectability; matlab codesENSN

1. Introduction

The present active seismicity in the world is the result of active tectonics that takes place in certain zones on the earth's surface. On 12 October 1992, a moderate earthquake with magnitude, Mw 5.8 occurred in Dahshour seismic zone south west of Cairo Egypt; this earthquake is considered as one of the most destructive events in recent time in Egypt, although its magnitude was moderate size but due to cultural behaviour, building types, the damage was reported to be around 10,000 persons between died and injured while the cost of the damaged generated surpasses 35 Million US Dollars. The Egyptian government established the Egyptian National Seismological Network (ENSN) for monitoring the seismic activity after this important event and scientific research on diverse seismology problems started flourishing. Over the years of ENSN's operation, a lot of changes have been made to the stations, some stations locations were changed, while for others, the sensors and digitisers were replaced, even in some cases, stations names were changed. Through a funded project to study the detection capability of ENSN seismologic stations, the authors started to track various changes done on the network as a first step to determine the network's recording performance and quality of the data used in research work.

The area of the 1992 earthquake is located at the Western Desert west of the Nile Valley, about 25 km southwest of Cairo. It is a NE-extending ridge that represents the northern escarpment of the Faiyum depression (Bown et al. 1988). The exposed rock units at Gebel Qatrani are represented by the sandstones of the Oligocene Qatrani Formation as well as Tertiary basalt sheets and flows. The Qatrani Formation is overlain by The Miocene sediments and underlain by the Eocene rocks of the Faiyum depression. The Gebel Qatrani is marked by ENE-striking faults along its northern margin. These faults are parallel to similar faults of the Syrian arc fold belt, which includes a group of related faults, folds, push-up structures and basins. The E–W structures are probably related to the relative motion between Eurasian and African Plates and closure of the Neotethys (Kusky et al. 2011).

Abd El-Nabi et al. (1993) interpreted the magnetic data acquired at the epicentral area of the 1992, Dahshour earthquake and concluded that the isolated magnetic anomalies are aligned nearly in the E–W direction at shallow sources and this trend matches the surface E–W structural features. At the deeper sources, they are aligned in the E–W and ENE–WSW directions. Also, they concluded that most of the area is occupied by a major structural controlled basin, which coincides with El-Gindy basin. The above mentioned magnetic study also deduced that the area is dissected

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by major transverse faults trending ENE–WSW to E–W and minor longitudinal faults trending nearly N–S, and as the intersection points of these two faulting sets deteriorate, the crust in this area which in turn become tectonically as weak as the epicentral area.

ENSN started operation in September 1997 with 66 stations distributed all over Egyptian territory, and five sub centres which received the data from the surrounding stations and transmit it to the main centre in Helwan area (Figure 1). Initially, the network stations transferred the recorded data mostly through telephone line, while a few stations were sent the data via telemetry to the nearest sub-centre and then to the main centre in Helwan. Nowadays all stations are connected to a satellite channel carrying the data directly to the main centre. Different studies nowadays need to have a clear figure about the changes done in the data during operational time, also different methods are used recently to determine the detection capabilities of the seismological network; generally, these methods can be classified into three main categories. The methods of the first category depend on studying the background noise recorded by the seismological stations and detect the best method to reduce its effect (Peterson 1993; McNamara and Buland 2004), the methods of the second category depend on statistical analysis of the recorded catalogue of the network and determine the magnitude and location of completeness of the network (Mignan and Woessner 2012), while the methods of the third category depend on studying the seismological network stations using waveform data (Schorlemmer and Woessner 2008).

The above methods are utilised when the data is well recorded and controlled, some research work have already done based on using limited period of recorded data (Abdel Hafiez 2015a, 2015b; Abd EL-Aziz et al. 2018; Abd EL-Aziz and Abdel Hafiez 2019; Abdel Hafiez and Toni 2019); but to have a well complete catalogue of all previous recorded data, a review to all network's stations should be done, a deep review of the network changes (hardware components, data recorded) should be done. This includes determination of any location changes, hardware change and type of sensors with time of these changes. Most of these information were not documented during network operation, which can result in fatal problem when using the recorded data for any research work. This is the main motive of this article, the impact of the results is to document the changes done all stations type.

2. Project items

The ENSN has been in operation for more than 20 years, and as such there is an urgent need to evaluate the recording performance of the individual stations. This is in order to suggest possible

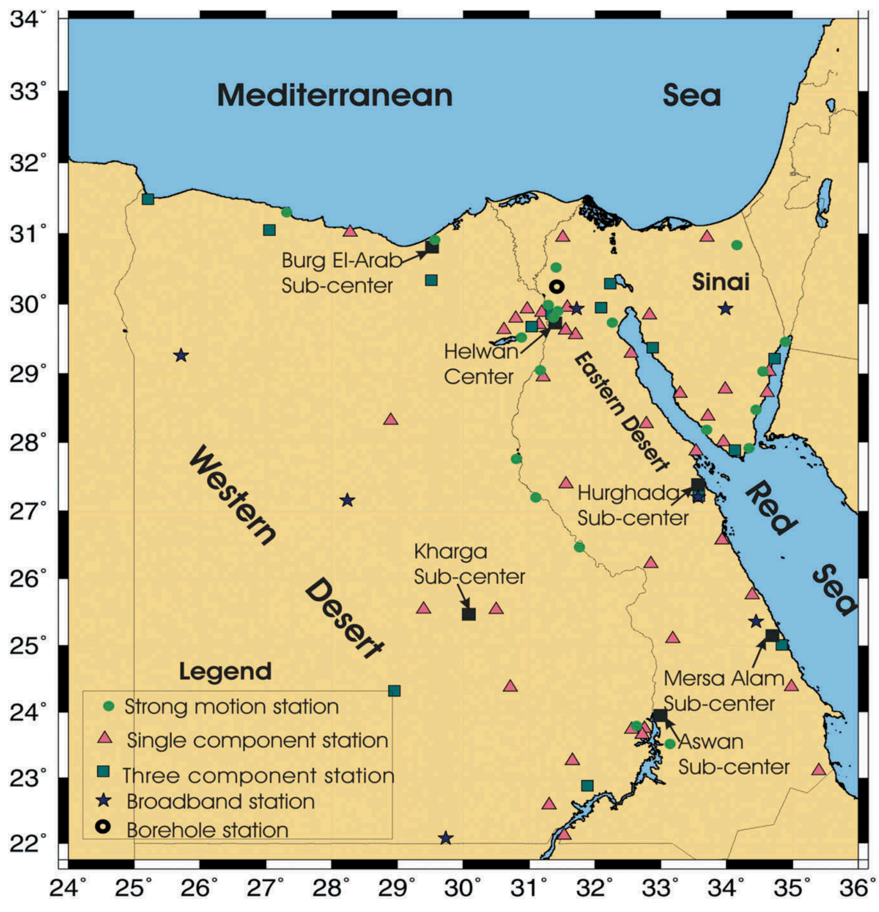

Figure 1. ENSN seismological stations.

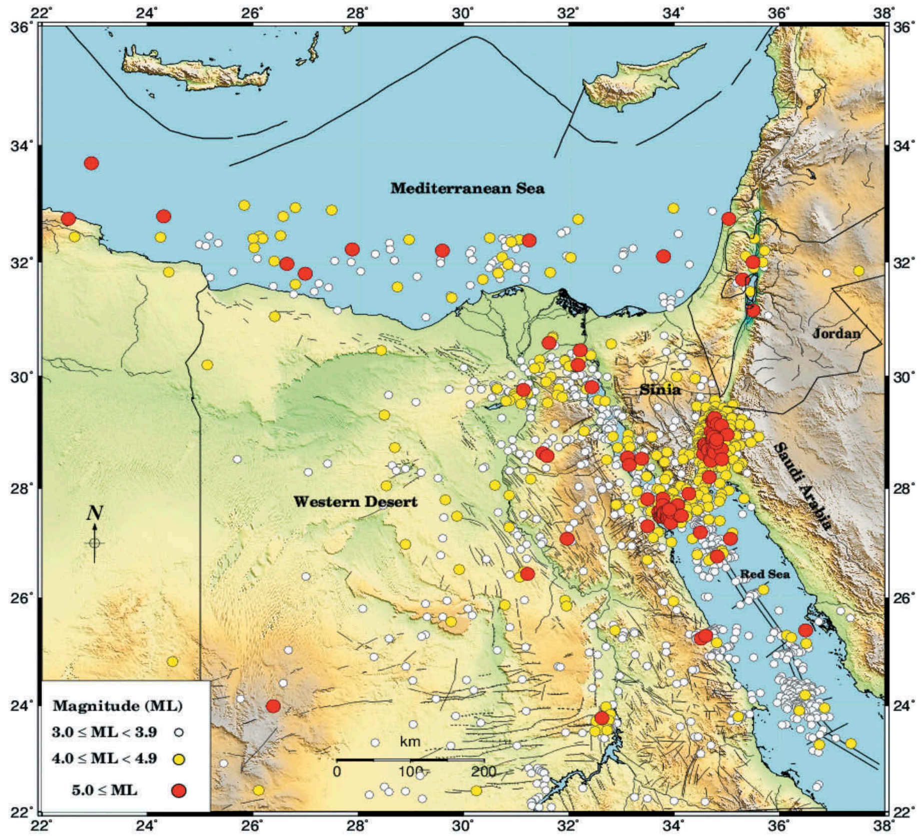

Figure 2. The distribution of recorded earthquakes ($M > 3$) by ENSN (1997–2018).

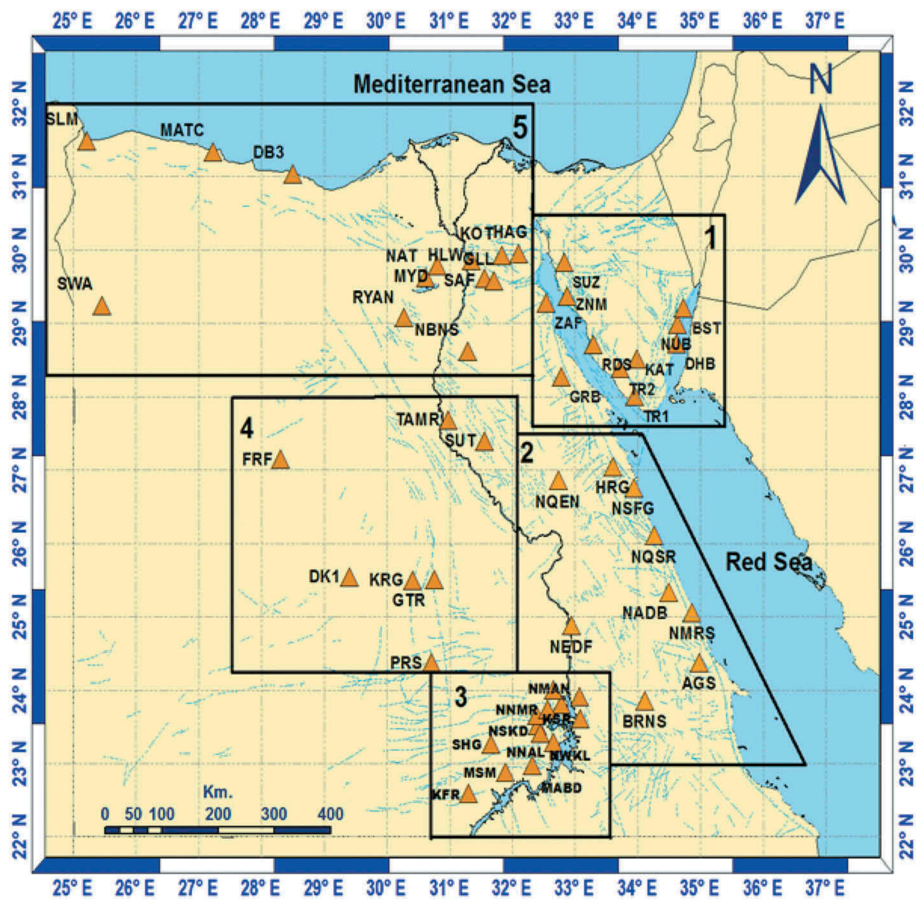

Figure 3. The divided zones of ENSN for this study.

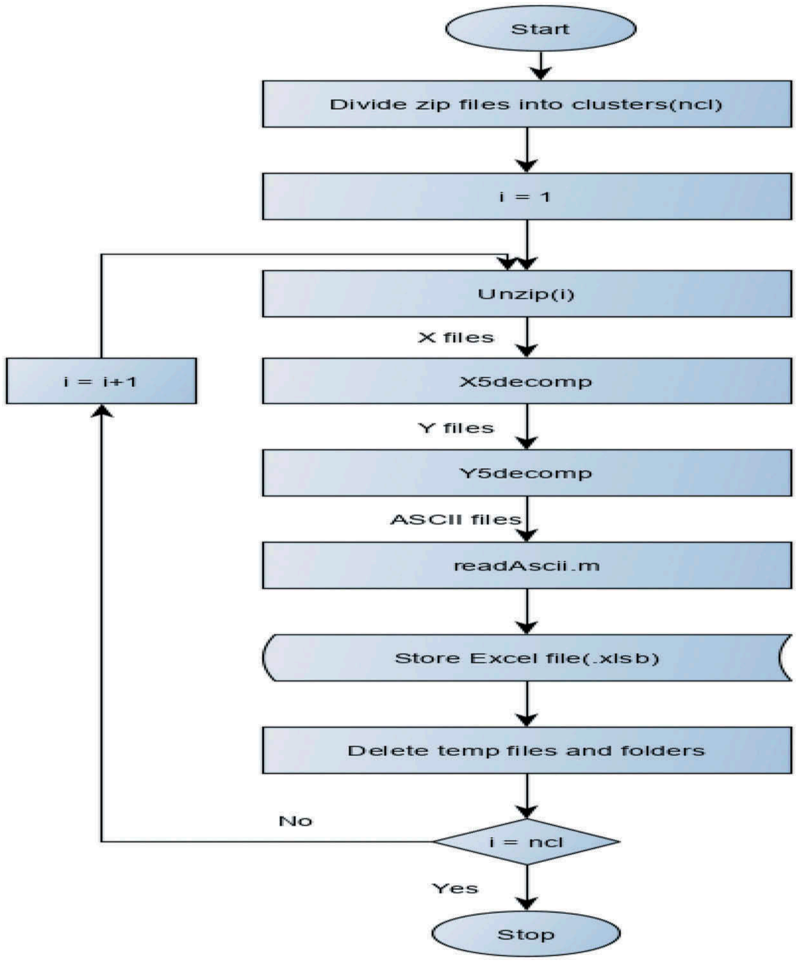

Figure 4. Flow chart for the data analysis (method 1).

solution to any problem that appeared due to change in the conditions surrounding each seismic station. A funded project was initiated between the Science and Technology Development Fund (STDF) authority and National Research Institute of Astronomy and Geophysics (NRIAG) to study the performance and ability for recording events and the accuracy of these records. Studying the real situation of the station nowadays will be the first target of the project and this is the motive of the current article; then based on the output, studying station's quality for recording earthquakes and its contribution for recent research topics will be the next target. The re-evaluation process will follow the most recent and standard techniques used in the evaluation of seismological networks.

The government development plan for the country relies on many residential projects, which based geotechnically in calculation of the seismic hazard and microzonation. The basis of these studies is the recorded data from the ENSN. Hence the main target of the article can be summarised as tracking the changes to the ENSN during last time, which is the base for checking the recorded data.

3. Data used and methodology

Through the last time of ENSN recording (1997–2017), around 55,000 events were recorded. Figure 2 shows the locations of the events in and around Egypt. In this study, we divided the seismological stations in whole Egypt into five zones to be able

Table 1. Description of the first analysis method.

1	The total number of zip files have been divided into clusters, with each one having 1000 files; where ncl is the number of clusters = (zip files [478,460]/cluster size [1000]).
2	set *i* = 1(first cluster of zipped files)
3	unzip(i) to extract the zip files of cluster i; which will produce a group of X-files (store them in a temp folder X_Temp)
4	***X5decomp*** is a programme used to convert X-files into Y-files format (store them in a temp folder Y_Temp)
5	***Y5Dump*** is a programme used to convert Y-files into ASCII files format (store them into temp folder ASCII_Temp)
6	***readAscii.m*** procedure is used to get the useful information (for the purpose of this work) from ASCII files.
7	Store the resultant information (such as sampling rates, sensor types, ...etc.) in spreadsheet file format (.xlsb) for each cluster.
8	Delete temp files and folders
9	Check if we finished all clusters (i = ncl)

1 If true stop
2 Else update cluster number (i = i + 1) and repeat again the same steps
Note: The processing time of this first group is about 48 days using two servers

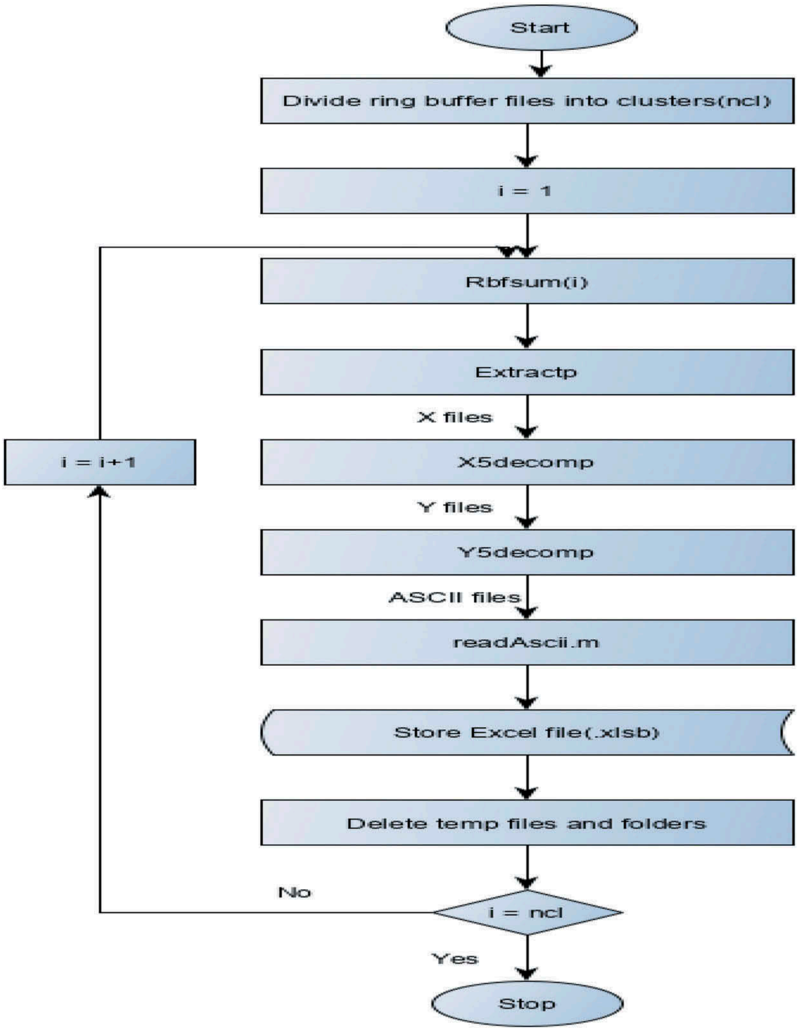

Figure 5. Flow chart for the data analysis (method 2).

to carefully track minor changes (Figure 3). We used all the archived data for the 20 years; for this purpose, we designed a software programme under (MATLAB and Statistics Toolbox Release 2016) to read this large amount of data together with tracking any change that occurred either in sensors (which reflected in station name), or station location, or even the station name (with the same fixed location).

3.1. First group

Data stored in compressed file (zip format) with a total number of 478,460 files from 9 October 1997 to 2 July 2007; each file is a record of multiple stations (the number varies from one file to another based on how many stations were available at that time) with a duration of 10 minutes for each file.

3.2. Second group

Data stored in ring buffer format in a huge data server with total number of 132,045 files; each file is the recording of one station but with different time durations (usually 1 day). Based on the nature of the used data, we had to adopt different procedures to get most useful information about each station from the enormous amount of data files. In this section, we will explain the utilised methods.

For the written code, we divided all the archived data into two groups:

First Procedure: the flowchart of this procedure is shown in Table 1 and described in Figure 4.

Second Procedure: the flow chart of this procedure is shown in Figure 5 and Table 2.

The rest of this second process is similar to first one. After combining the results from the first and second method, another designed code was used to separate each station information in one excel file (xlsm), the output files (xlsm) files are further processed to separate

Table 2. Description of the second analysis method.

10	The total number of ring buffer files have been divided into clusters, each one has 1000 files; where ncl is the number of clusters = (ring buffer files [132,045]/cluster size [1000]).
11	set *i* = 1 (first cluster of ring buffer files)
12	*Rbfsum* is a programme to check the data availability in each ring buffer file
13	*Extractp* is a programme used to produce X-files based on the available data in each ring buffer file.

Note: The processing time for this method is about 6 days.

Table 3. Different changes occurred for ENSN stations during its operation between 1997 and 2018.

		Location		Sensor			Components			Sampling Rate			
Code	Station Name	Latitude (Degree)	Longitude (Degree)	Type	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Comments
ADB	Abo Dabab	25.351	34.623798	SS1	1/16/2003	6/3/2013	1	1/16/2003	6/3/2013	100	1/16/2003	9/5/2003	Not working (Stolen)
										50	9/5/2003	6/17/2004	
										100	6/21/2004	6/3/2013	
ADN	Adendan	22.1224	31.530701	SS1	10/7/2001	6/6/2013	1	10/7/2001	6/6/2013	100	10/7/2001	6/6/2013	Not working (Repeater Stolen)
AGS	Abo Ghoson	24.3794	34.986599	SS1	1/26/2003	9/22/2017	1	1/26/2003	1/26/2003	100	1/26/2003	9/4/2003	Working
										50	9/4/2003	4/12/2004	
				TRILLIUM-120 C	9/22/2017	1/4/2018	3	9/22/2017	1/4/2018	100	4/12/2004	1/4/2018	
AHD	Abo Hadeed	23.7474	32.751	SS1	10/7/2001	7/22/2011	1	10/7/2001	7/22/2011	100	10/7/2001	9/14/2003	Not working (Stolen)
										50	9/14/2003	2/21/2005	
										100	2/21/2005	7/22/2011	
ANS	Anshas	30.290899	31.399799	CMG40 T	6/28/2003	12/24/2003	3	6/28/2003	9/8/2009	50	6/28/2003	6/30/2003	Not working (Abandoned)
				CMG3 T	12/24/2003	9/8/2009				100	6/30/2003	9/8/2009	
AYT	Al Ayat	29.704	31.153	SS1	10/8/1997	8/29/2011	1	10/8/1997	8/29/2011	100	10/8/1997	8/29/2011	Not working (Stolen)
BNS	Beni Soueef	28.9517	31.212601	SS1	10/20/1999	7/15/2013	1	10/20/1999	7/15/2013	100	10/20/1999	7/15/2013	Not working (Stolen)
BRG	Borg Al Alrab	30.574301	29.8393	SS1	9/24/2001	10/7/2001	3	9/24/2001	9/18/2014	100	9/24/2001	9/18/2014	Not working (Stolen)
				SS1	2/26/2002	6/14/2011							
				TRILLIUM-120 C	10/22/2012	9/18/2014							
BRNS	Barnees	23.8559	34.1143	TRILLIUM-240	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
BST	Basata	29.2166	34.7327	SS1	9/24/2001	1/4/2018	3	9/24/2001	1/4/2018	100	9/24/2001	11/17/2003	Working
										50	11/17/2003	6/7/2004	
										100	6/7/2004	1/4/2018	
DAB	Al Dabaa	31.0098	28.2815	SS1	2/26/2002	12/3/2006	1	2/26/2002	12/3/2006	100	2/26/2002	12/3/2006	Not working (Stolen)
DB2	Al Dabaa 2	31.047001	28.503901	STS-2	1/15/2007	1/11/2012	3	1/15/2007	1/11/2012	200	1/15/2007	7/2/2007	Not working (Stolen)
										100	7/21/2007	7/22/2007	
										200	7/22/2007	1/11/2012	
DB3	Al Dabaa 3	31.04	28.5	TRILLIUM-240	3/29/2016	1/4/2018	3	3/29/2016	1/4/2018	100	3/29/2016	1/4/2018	Working
DHB	Dahab	28.722099	34.618801	SS1	2/26/2002	1/4/2018	1	2/26/2002	1/4/2018	100	2/26/2002	6/24/2003	Working
										50	6/24/2003	1/4/2018	
DK1	Al Dakhla 1	25.5432	29.4028	SS1	12/24/2003	1/4/2018	1	12/24/2003	1/4/2018	50	12/24/2003	1/16/2005	Working
										100	1/16/2005	1/4/2018	
DK2	Al Dakhla 2	24.3195	28.954599	SS1	6/9/2002	3/29/2016	3	6/9/2002	3/29/2016	100	6/9/2002	3/29/2016	Not working (Stolen)
EDF	Edfu	25.0945	33.181801	SS1	12/28/2001	3/15/2015	1	12/28/2001	3/15/2015	100	12/28/2001	2/26/2002	Not working (Stolen)
										50	3/19/2003	2/28/2005	
										100	2/28/2005	3/15/2015	
FRF	Al Farafrah	27.148399	28.310499	SS1	2/8/2003	2/23/2008	1	2/8/2003	6/19/2008	100	2/8/2003	7/6/2008	Working
				L4 C	2/24/2008	6/19/2008				40	7/6/2008	12/22/2008	
				TRILLIUM-240	6/19/2008	1/4/2018	3	6/19/2008	1/4/2018	100	12/22/2008	1/4/2018	
FYD	Fayed	30.2929	32.2309	SS1	10/20/1999	3/21/2007	3	10/20/1999	3/21/2007	100	10/20/1999	12/23/2004	Not working (Abandoned)
										200	3/20/2007	3/21/2007	
FYM	Al Fyoum	29.692301	31.042999	SS1	10/8/1997	2/23/2008	3	10/8/1997	5/24/2011	100	10/8/1997	5/24/2011	Not working (Stolen)
				TRILLIUM-40	5/26/2010	5/24/2011							
GLL	Gabl Algalalah	29.5772	31.7081	SS1	10/8/1997	10/29/2017	1	10/8/1997	10/29/2017	100	10/8/1997	10/29/2017	Not working (Stolen)
GRB	Ras Ghareb	28.2705	32.7859	SS1	10/20/1999	1/4/2018	1	10/20/1999	1/4/2018	100	10/20/1999	1/4/2018	Working
GTR	Gabl Altyer	25.5096	30.5595	SS1	8/22/2003	1/4/2018	1	8/22/2003	1/4/2018	100	8/22/2003	1/4/2018	Working

(*Continued*)

Table 3. (Continued).

		Location		Sensor			Components			Sampling Rate			
Code	Station Name	Latitude (Degree)	Longitude (Degree)	Type	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Comments
HAG	Hagoul	29.952999	32.098999	SS1	10/8/1997	2/12/2000	3	10/8/1997	1/4/2018	100	10/8/1997	1/4/2018	Working
				STS-2	2/16/2000	1/11/2001							
				SS1	1/30/2001	4/29/2014							
				TRILLIUM-40	5/5/2014	1/4/2018							
HLW	Helwan	29.8585	31.343201							40	4/26/1998	5/15/2004	Working
										100	12/14/2004	12/22/2004	
										40	12/22/2004	1/11/2007	
										50	3/27/2007	5/24/2007	
										100	2/16/2008	4/7/2013	
										200	6/4/2013	6/19/2013	
										100	6/19/2013	1/4/2018	
HRG	Hurgada	27.219299	33.569099	SS1	2/29/2000	10/4/2006	3	2/29/2000	1/4/2018	100	2/29/2000	1/4/2018	Working
		27.051701	33.608101	STS-2	10/5/2006	7/11/2008							
				TRILLIUM-240	11/24/2008	1/4/2018							
KAT	Sant Kathreen	28.5229	33.992802	SS1	4/25/2002	4/11/2011	1	4/25/2002	4/11/2011	100	4/25/2002	5/28/2003	Working
				TRILLIUM-40	1/1/2012	1/4/2018	3	1/1/2012	1/4/2018	50	7/26/2003	1/20/2006	
										100	1/20/2006	1/4/2018	
KFR	Khafra	22.5891	31.304701	SS1	10/7/2001	1/4/2018	1	10/7/2001	1/4/2018	100	10/7/2001	9/11/2003	Working
										50	9/11/2003	2/24/2005	
										100	2/2/2005	1/4/2018	
KHB	Gabl Alkhashab	29.928301	30.9746	SS1	10/8/1999	4/9/2005	1	10/8/1999	4/9/2005	100	10/8/1999	4/9/2005	Not working (Stolen)
KOT	Al Kotamya	29.927601	31.829201	SS1	10/8/1997	1/8/2001	3	10/8/1997	1/4/2018	100	10/8/1997	12/14/2004	Working
				STS-2	1/12/2001	3/13/2007				40	12/15/2004	12/22/2004	
				SS1	3/22/2007	6/5/2007				100	12/22/2004	1/4/2018	
				STS-2	6/5/2007	1/4/2018							
KRG	Al Kharga	25.503201	30.498501	SS1	2/24/2003	1/4/2018	1	2/24/2003	1/4/2018	100	2/24/2003	8/20/2003	Working
										50	8/21/2003	1/15/2005	
										100	1/15/2005	1/4/2018	
KRL	Khor Ramla	23.663401	32.7211	SS1	10/7/2001	12/6/2010	1	10/7/2001	12/6/2010	100	10/7/2001	9/14/2003	Not working (Stolen)
										50	9/14/2003	2/20/2005	
										100	2/20/2005	12/6/2010	
KSR	Khor Saqr	25.5096	30.5595	TRILLIUM-40	6/15/2014	1/4/2018	3	6/15/2014	1/4/2018	100	6/15/2014	1/4/2018	Working
MABD	Al Maabed	22.972601	32.325802	TRILLIUM-240	5/21/2010	5/7/2017	3	5/21/2010	5/7/2017	100	5/21/2010	1/4/2018	Working
MAG	Gabl Almaghara	30.643	33.208199	SS1	2/4/2003	10/28/2010	1	2/4/2003	10/28/2010	50	2/4/2003	2/28/2006	Not working (Stolen)
										100	3/1/2006	10/28/2010	
MAT	Matrouh	31.094	27.096399	SS1	2/26/2002	6/14/2011	3	2/26/2002	6/14/2011	100	2/26/2002	6/14/2011	Not working (Stolen)
MATC	Matrouh Centre	31.345699	27.230499	SS1	5/21/2010	11/10/2012	1	5/21/2010	11/10/2012	100	5/21/2010	1/4/2018	Working
				TRILLIUM-120	12/9/2012	1/4/2018	3	12/9/2012	1/4/2018				
MNS	Al Mansoura	30.9564	31.5187	SS1	8/11/2000	11/3/2003	1	8/11/2000	11/3/2003	100	8/11/2000	8/3/2003	Not working (Abandoned)
										50	10/26/2003	11/3/2003	
MRS	Marsa Alam	25.0131	34.838699	SS1	4/25/2002	6/20/2013	3	4/25/2002	6/20/2013	100	4/25/2002	9/5/2003	Not working (Stolen)
										50	9/5/2003	4/30/2004	
										100	4/30/2004	6/20/2013	
MSM	Masmas	22.881399	31.889	SS1	10/7/2001	1/4/2018	3	10/7/2001	1/4/2018	100	10/7/2001	10/26/2003	Working
										50	12/16/2003	2/23/2005	
										100	2/23/2005	1/4/2018	

(*Continued*)

Table 3. (Continued).

		Location		Sensor			Components			Sampling Rate			
Code	Station Name	Latitude (Degree)	Longitude (Degree)	Type	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Comments
MYD	Al Mayadeen	29.795799	30.8009	SS1	10/8/1997	3/28/2007	1	10/8/1997	1/4/2018	100	10/8/1997	1/4/2018	Working
				L4 C	3/29/2007	1/4/2018							
NADB	New Abo Dabab	25.3405	34.502102	TRILLIUM-240	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NAHD	New Abo Hadeed	23.8022	32.778	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NAT	Al Natroun	29.6329	30.617201	SS1	6/15/2000	6/13/2011	1	6/15/2000	6/13/2011	100	6/15/2000	1/4/2018	Working
				TRILLIUM-120	10/22/2012	9/15/2014	3	10/22/2012	1/4/2018				
				TRILLIUM-120 C	9/16/2014	1/4/2018							
NBNS	New Beni Souef	28.622601	31.2945	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NGAL	New Gabl Alysa	23.419081	32.732941	TRILLIUM-40	4/15/2012	2/13/2016	3	4/15/2012	2/13/2016	100	4/15/2012	2/13/2016	Not working (Stolen)
NGMR	New Gabl Marawa	23.5217	32.4074	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NGRW		23.6684	32.791199	TRILLIUM-40	11/5/2010	6/25/2016	3	11/5/2010	6/25/2016	100	11/5/2010	6/25/2016	Not working (Stolen)
NKL	Nekhel	29.9293	33.9804	STS-2	10/7/2001	3/23/2007	3	10/7/2001	2/18/2013	100	10/7/2001	2/18/2013	Not working (Stolen)
				TRILLIUM-240	3/24/2007	2/18/2013							
NKUR	New Kurkur	24.0042	32.651402	TRILLIUM-40	11/6/2010	1/4/2018	3	11/6/2010	1/4/2018	100	11/6/2010	1/4/2018	Working
NMAN	New Man	23.916901	33.0737	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NMR	North Marawa	23.733999	32.562599	SS1	10/7/2001	3/10/2016	1	10/7/2001	3/10/2016	100	10/7/2001	9/14/2003	Not working (Stolen)
										50	9/14/2003	2/23/2005	
										100	2/23/2005	3/10/2016	
NMRS	New Marsa Alam	25.063	34.868	TRILLIUM-120 QA	9/21/2017	1/4/2018	3	9/21/2017	1/4/2018	100	9/21/2017	1/4/2018	Working
NNAL		23.2931	32.6647	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NNMR	New North Marawa	23.7379	32.562099	TRILLIUM-40	4/14/2012	1/4/2018	3	4/14/2012	1/4/2018	100	4/14/2012	1/4/2018	Working
NQEN	New Qena	26.1107	32.4418	TRILLIUM-120 QA	9/21/2017	1/4/2018	3	9/21/2017	1/4/2018	100	9/21/2017	1/4/2018	Working
NQSR	New Quseer	26.11	34.264	TRILLIUM-120 QA	9/21/2017	1/4/2018	3	9/21/2017	1/4/2018	100	9/21/2017	1/4/2018	Working
NSFG	New Safaga	26.763	33.938	TRILLIUM-120 QA	9/21/2017	1/4/2018	3	9/21/2017	1/4/2018	100	9/21/2017	1/4/2018	Working
NSKD	New Sen Alkadab	23.659901	32.386002	TRILLIUM-40	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
NUB	Nubeaa	29.027599	34.6474	SS1	2/26/2002	1/4/2018	1	2/26/2002	1/4/2018	100	2/26/2002	1/4/2018	Working
		28.9893	34.639599										
NWAL		23.3829	32.5779	TRILLIUM-40	6/23/2011	12/22/2014	3	6/23/2011	12/22/2014	100	6/23/2011	12/22/2014	Not working (Stolen)
NWKL	New Wadi Kalabsha	23.413099	32.448898	TRILLIUM-40	6/22/2011	1/4/2018	3	6/22/2011	1/4/2018	100	6/22/2011	1/4/2018	Working
PRS	Parees	24.371799	30.712601	SS1	8/22/2003	1/4/2018	1	8/22/2003	1/4/2018	50	8/22/2003	5/20/2004	Working
										100	5/26/2004	1/4/2018	
QEN	Qena	23.1068	35.399899	SS1	4/16/2003	12/9/2004	1	4/16/2003	12/9/2004	50	4/16/2003	12/9/2004	Not working (Stolen)
QSR	Al Quseer	25.7554	34.3871	SS1	1/13/2003	12/13/2012	1	1/13/2003	12/13/2012	100	1/13/2003	9/2/2003	Not working (Stolen)
										50	9/2/2003	4/14/2004	
										100	4/14/2004	12/13/2012	
RDS	Abo Redees	28.712	33.297501	SS1	10/26/1999	1/4/2018	1	10/26/1999	1/4/2018	100	10/26/1999	1/4/2018	Working
RSH	Al Areesh	30.9601	33.721901	SS1	10/20/1999	12/22/2014	1	10/20/1999	12/22/2014	100	10/20/1999	12/22/2014	Not working (Stolen)
RYAN	Wadi Alrayan	29.082001	30.2775	TRILLIUM-120 C	9/1/2014	1/4/2018	3	9/1/2014	1/4/2018	100	9/1/2014	1/4/2018	Working
SAF	Al Saf	29.6187	31.553801	SS1	9/10/2002	11/14/2017	1	9/10/2002	11/14/2017	100	9/10/2002	11/14/2017	Not working (Stolen)
SFG	Safaga	26.567499	33.929199	SS1	1/12/2003	9/1/2012	1	1/12/2003	9/1/2012	100	1/12/2003	9/5/2003	Not working (Stolen)
										50	9/5/2003	4/13/2004	
										100	4/13/2004	9/1/2012	
SH2	Sharm Alshekh 2	27.881701	34.083302	TRILLIUM-240	6/30/2010	6/6/2013	3	6/30/2010	6/6/2013	100	6/30/2010	6/6/2013	Not working – Stolen
SHG	Om Shagher	23.2655	31.6577	SS1	10/7/2001	1/4/2018	1	10/7/2001	1/4/2018	100	10/7/2001	10/26/2003	Working
										50	12/16/2003	2/23/2005	
										100	2/23/2005	1/4/2018	

(*Continued*)

Table 3. (Continued).

		Location		Sensor			Components			Sampling Rate			
Code	Station Name	Latitude (Degree)	Longitude (Degree)	Type	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Value	From (Y-M-D)	To (Y-M-D)	Comments
SHL	Shalateen	23.1068	35.3998	SS1	1/17/2003	9/26/2013	1	1/17/2003	9/26/2013	100	1/26/2003	9/3/2003	Not working (Stolen)
										50	9/3/2003	4/12/2004	
										100	4/12/2004	9/26/2013	
SHR	Sharm Alshekh	27.8925	34.132198	SS1	2/29/2000	6/2/2010	3	2/29/2000	6/30/2010	100	2/29/2000	1/19/2004	Not working (Stolen)
				TRILLIUM-240	6/22/2010	6/30/2010				50	2/12/2004	6/3/2004	
										100	6/10/2004	6/30/2010	
SLM	Al Saloum	31.4916	25.212299	SS1	2/26/2002	4/21/2007	3	2/26/2002	1/4/2018	100	2/26/2002	11/8/2012	Working
				TRILLIUM-240	4/21/2007	1/4/2018				500	11/14/2012	11/18/2012	
										100	11/18/2012	1/4/2018	
SQR	Squaraa	29.8813	31.1959	SS1	1/30/1999	1/7/2013	1	1/30/1999	1/7/2013	100	1/30/1999	1/7/2013	Not working (Stolen)
SUT	Asyot	27.3967	31.562599	SS1	12/24/2003	3/26/2016	1	12/24/2003	3/26/2016	50	12/24/2003	1/12/2005	Working
				TRILLIUM-120 C	4/13/2016	1/4/2018	3	4/13/2016	1/4/2018	100	1/12/2005	1/4/2018	
SUZ	Suez	29.840599	32.832199	SS1	11/15/1999	1/4/2018	1	11/15/1999	1/4/2018	100	11/15/1999	1/4/2018	Working
SWA1	Siwa 1	29.263201	25.709801	STS-2	10/7/2001	7/26/2003	3	10/7/2001	2/23/2008	100	10/7/2001	2/23/2008	Not working (Abandoned)
				CMG40 T	7/26/2003	12/23/2003							
				STS-2	12/23/2003	6/20/2007							
				TRILLIUM-240	6/20/2007	2/23/2008							
SWA2	Siwa 2	29.243299	25.455601	SS1	10/7/2001	6/6/2007	1	10/7/2001	6/6/2007	100	10/7/2001	1/4/2018	Working
				TRILLIUM-240	2/23/2008	1/4/2018	3	2/23/2008	1/4/2018				
TAMR	Tal Al Amarna	27.6821	30.9175	TRILLIUM-240	5/21/2010	1/4/2018	3	5/21/2010	1/4/2018	100	5/21/2010	1/4/2018	Working
TR1	Tor Sainai 1	28.0068	33.952	SS1	10/26/1999	1/4/2018	1	10/26/1999	1/4/2018	100	10/26/1999	1/4/2018	Working
TR2	Tor Sainai 2	28.3853	33.722698	SS1	10/26/1999	1/4/2018	1	10/26/1999	1/4/2018	100	10/26/1999	1/4/2018	Working
WBH	Al Wahat Al Baharya	28.320801	28.903799	SS1	2/8/2003	7/16/2011	1	2/8/2003	7/16/2011	100	2/8/2003	9/10/2003	Not working (Stolen)
										50	9/10/2003	1/30/2005	
										100	1/30/2005	7/16/2011	
ZAF	Al Zafarana	29.2819	32.548698	SS1	10/24/1999	5/9/2014	1	10/24/1999	5/9/2014	100	10/24/1999	1/4/2018	Working
				TRILLIUM-120	5/12/2014	1/4/2018	3	5/12/2014	1/4/2018				
ZET	Gabl Al Zeet	27.8699	33.5387	SS1	10/26/1999	12/14/2005	1	10/26/1999	12/14/2005	100	10/26/1999	12/14/2005	Not working (Abandoned)
ZGZ	Al Zagazeeg	30.9735	31.8828	SS1	8/30/2000	9/28/2000	3	8/30/2000	9/28/2000	100	8/30/2000	9/28/2000	Not working (Abandoned)
ZNM	Abo Zonymah	29.376101	32.875198	SS1	10/24/1999	1/4/2018	3	10/24/1999	1/4/2018	100	10/24/1999	1/4/2018	Working

and store the information of each station in one table as shown in Table 3 (Note: The processing time took about 3 days). Table 3 shows 49 stations, while the rest of the stations (17 stations) were not working as some of their components were stolen or the site occupied with some force majeure conditions. Regarding the research papers, the authors gathered most of the research done based on data from ENSN. The total number of papers gathered was 125, distributed across all branches of seismology, 30% of these papers studied the seismic hazard in and around Egypt, 30% focused on tectonics studies, and the rest distributed among the different seismology disciplines.

4. Results

The following are the results of the application of our designed code on the recorded data. Table 3 includes the first attempt for tracking the changes that occurred in ENSN during last time of operation. Some stations were added after the commencement of the network, while others were removed. Around 88 stations were working together at some time of operation, while nowadays (i.e. 2020) only 50 stations are working (35 stations are three component and 15 stations are one component) and all the rest (38 stations) were stop working for different reasons.

5. Summary and conclusion

The motivation of this study comes from the great efforts done by the Egyptian seismologists for more than 20 years, after the occurrence of Cairo earthquake in 1992, and establishment of the ENSN, to understand the seismicity behaviour together with the tectonics regime in Egypt which are essential for understanding the earthquake hazards. Following up the status of the recorded data is essential to be used in different research studies (i.e. checking the detectability performance, magnitude scale and seismic hazard studies). A programme code was designed under Matlab software to analyse the recorded huge amount of data since start recording of the data by ENSN in 1997 that are stored using different formats, to track the changes happened through last 20 years of operations of the network which mostly were not documented, these changes include hardware change, sensor and digitiser type, location of the stations, sampling rate and even the station's name itself. The designed code we succeeded to read all the recorded data (around 55,000 events) and track the time of change at any stations, the results show many change happened for the sensor time (e.g. KAT, MATC, KOT), while other station change its location (e.g. HRG), sampling rate (e.g. SHG, SLM).

The second suggested future phase after this study is to check the site conditions change for each station, and applying different tools for determine the performance of recordings in different stations (network detectability) for suggestion of any modifications needed to improve the recorded data. Tracking of the changes that occurred in the stations of ENSN is successful for the first time through the output of this study (Table 3). It was motivated by the importance of making a quality estimation of the recorded data and instrument change documentations after 20 years of operation of the network. It is now available for different branches of research to use the recorded data from the past time with a clear figure about any change in the data type.

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