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Report from visit to Sudan, 17.04 – 26.04, 2007

Cooperation in Seismology

by

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Introduction

As part of the cooperation between the University of Bergen, Faculty of Natural Sciences and research institutions in Sudan, the University of Bergen has allocated funds to initiate the cooperation and several minor seed projects have been approved (see www.sudan.mnfa.uib.no). Cooperation in seismology started with a workshop in April 2006 which was followed by another workshop in December 2006. During those visits, several minor activities were started up. The intention with this visit was to follow up on general activities in seismology, work on a paper on Khartoum seismicity and collect data for soil structure. In addition a lecture was given at the University of Juba. Meetings were made with people from University of Khartoum and University of Juba.

Content

Meetings

University of Juba, at Juba Campus

Participants: Salim Gibril Ahmed (dean of College of Natural Resources and Environmental Studies), Faiza Ahmed Ali (deputy dean of College of Applied and Industrial Science) and Ibrahim Abdu (professor of Geology and Geophysics). This was a small informal meeting after the lecture where possible collaboration was discussed. Also Faiza Ahmed confirmed her interest in coming to Bergen this spring.

University of Juba, Acropole hotel

Participants: Dr Ahmed K. Yagoub, College of Applied and Industrial Science and Faiza Ahmed Ali (deputy dean of College of Applied and Industrial Science). Further discussion of possibility of funding. Apparently the Norwegian Government has now released some funds for the collaboration, however no details of how to apply for funds has been given. Yougoub is also interested in a short visit to Bergen, so possibilities should be investigated. The visit of Faiza was fixed to the end of June in agreement with Nils-Kåre Birkeland.

University of Khartoum

Meeting with El Nadi (deputy dean of Faculy of Science) and Salah Abdalla (director of Geology). Discussion about forthcoming visit of Abdalla and a possible visit of El Nadi to Bergen.

GRAS

Dr. Abed Elrazig Obeid (Director of GRAS), Dr. El Sheikh M. Abed Elrahman (Director of Integrated Geological Survey), Mr. Faisal El Zebair (Head of the Geophysics department), Mr. Abrahim Saror (Head of the seismological department) and Mr. El Hadi Ebrahim (Head of the instrument department).

The status of the network was discussed. In generally the operation works well except for continuous recording. There was a general agreement that in the future, all 3 LP station will work continuously. It was also agreed to try to make an institutional agreement between GRAS and the University of Bergen. This is particularly needed for the acceptance of future MSc students from GRAS. In the near term, short visits to UiB will be considered. Different possibilities for modernizing the network was discussed.

Field work

Noise data was recorded on 2 geophones at distance of 10 to 200 m at GRAS and at a field site near Khartoum, Abu Halima. The purpose is to test if a new method of noise correlation can be used to determine the near surface structure. Result of this will be available later.

The SSN and data from the network

The Network

The network has improved performance and is currently recording on 2 stations using the radio lines. Station SLAT has serious communication problems and test has shown that there seems to be something blocking the way. Therefore SLAT is recording continuously on a field recorder.
The system has now been set up to transmit all triggers from both stations and if only one station trigger, the same time interval from the other station is also transmitted. This seems to have significantly improved the data retrieval.

The continuous recording has only been working part of the time. For station SLAT and MRKH, data have been collected for 8 months, respectively. However almost all MRKH data has been lost. Considering that continuous data recording stated in August 2006 and recording could have been made on all 3 stations, only 12% of the data potentially available has been recovered (see Appendix 1).

Statistics was made for the potential operating time of the network since November 2003. Since no logs are available, this is, for most of the time, based on available data. It is estimated that in total, the network has operated 49 % of the time.
SSN is now a full member of the International Seismological Center (ISC) and sends data to the ISC on a regular basis.

Data

For the period December 2006 to and including March 2007, 24 events have been recorded (22 distant and 2 local). This is 6 per month and thus similar to the previous period. However it is still well below what the network is expected to be able to record, see Appendix 2.

All continuous data recorded until now has been processed. This confirms that there is very little local data. A routine was set up to store and process the continuous data in a systematic way in a SEISAN data base and all continuous data available was transferred to the SEISAN data base. It is however recommend that the raw data is stored on a backup system.

GMT (Generic Mapping Tools) was installed on several Linux systems and tested. This should make it easy to make GMT plots.

The local data was all revised in order to be used for the paper on Khartoum seismicity (see Appendix 2). Part of the distant events ware also revised.
On November 5, 2003, an earthquake was felt about 150 km east of Khartoum. Unfortunately, the digital data was lost. The Seismological Research Center made a report at the time giving macroseismic area with a maximum intensity (V) and an estimate of the epicentre. Paper seismograms were available. The data was reprocessed (Appendix 2) and the instrumental location was very close to the macroseismic location which indicate that the crustal model is reasonable accurate.

New data is now available for the Sudan area form ISC. Since many more networks report to ISC now, there are too many small events to all be included in the SSN data base. It was therefore decided to reduce the basic are to 0-25 deg north and 20-40 deg East. For events outside this area, only events with magnitude larger than 4 should be included.

New projects not mentioned earlier

- Data from old seismograms

Several seismograms exist for the period that the digitial data is lost. (before November 2003). The phase arrival can be read and entered into the data base. The arrival times can be useful for global studies and local crustal travel time deviation studies.

- Macroseismic study of the 1993 event

Some information might exist in GRAS and information can also be found in local newspapers. Making a macroseismic map will indicate how far event was felt and also give indication of local attenuation. The 2003 event should also have a revised macroseismic map.

- Revise data base for Sudan interior

This are has between 50 and 100 events. It is also the area of highest economical significance. The catlog should therefore be very reliable and continuous revision and check is needed.

Recommendations for network operation

Since the most important is to get data, it is recommended that:

- The MARS field recorders are moved to the field stations and connected to the broad band sensors.
- The 1 HZ sensors are connected to the MARS88 recorders at stations with communication.
- Data is collected and analyzed every 2 weeks from all stations.

In this way no data will be missed and also a good record is obtained of the distant earthquakes which cannot be collected completely by the radio network.

Data completeness

- The continuous data must all be stored. This amounts to about 60 GB a year so a new internal hard disk must be bought. Backup can be done on an additional disk or DVD.
- Regular backup on CD of event data.
- Regular running reports of
  - Number of events detected
  - Availability of continues data, if none available, reason for lack of data
  - Number of detected events (noise and earthquakes) per day from radio network, this will give a log of how system is working and how noise level is changing
  - Trigger parameters used

New equipment

The most important is still to get continuous recording on the existing stations. The current Mars88 station are no longer produced and cannot be used for continues recording, so the MarsLite are used. However this is not a long term solution and newer generation equipment is needed. There are several alternatives:

Lennarts M24/net: For permanent deployment, power about 12 W, price ca EU 14000
Nanometrics recorder: For both permanent and portable use, power ca 1 W, ca EU 8000
SARA recorder : For both portable and stationary used, power ca 2W, ca EU 2000

All units can be connected to internet.

The best all-round recorder is the Nanometrics

If a new broad band station are to be acquired, Nanometrics is also recommended. The current Lennartz sensors are not really broad band and a real broad band sensor from Nanometrics cost about the same as the Lennartz long period sensor.

Acknowledgements

GRAS provided very good support during the stay, offered transport to the field. GRAS also paid my living costs while in Sudan. B. M. Storheim read and corrected this report. The University of Bergen provided support for the travel to Sudan.

Appendix 1

Report No. 11

Technical Report

Data Base status Until April 2007

By

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And
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Geological Research Authority Of Sudan

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April 2007

Data Base Status

1. Introduction:

Since last technical report was done in May 2006, many earthquakes have been added to our database either by recording from network triggers and continuous mode operation or by adding events from different agencies which belong to our prime area. One important event added is the 5th November 2003 event which has been reprocessed. The number of local events increased and a composite fault plane solution will be made.
The purpose of this report is to show results of processing the new data and update the data base.

2. Quality Control:

The quality control has been performed in terms of cleaning the duplications and relocation for all local events recorded by SSN.
Some data recorded with continuous recording had used a wrong response file. A correction was made for (SLAT SP) and amplitudes recalculated see technical repot no. 10.

3. Statistic of the Sudan Seismic Network (SSN):

The content of the data base is summarized in table 1. On the other hand comparisons between previous and new data are also shown the table. Figure 1 and 2 show the events in the local area (Sudan) and Figure 3 and 4 show the distant events in our prime area. Global events are shown in Figure 5.

Table 1. Table summarized events in the period 1850-200704 recorded either by SSN or other sources in our data base.

Period	**Total events in the data base**	**Local (Sudan) Long. (21-39) Latit. (3-23)**	**Local in central Sudan by SSN**	**Distant (Prime) Long. (15-45) Latit. (-2-25)**	**Global by SSN**
1850-2006	1142	158	8	984	157
1850-2007	1174	172	14	1002	171

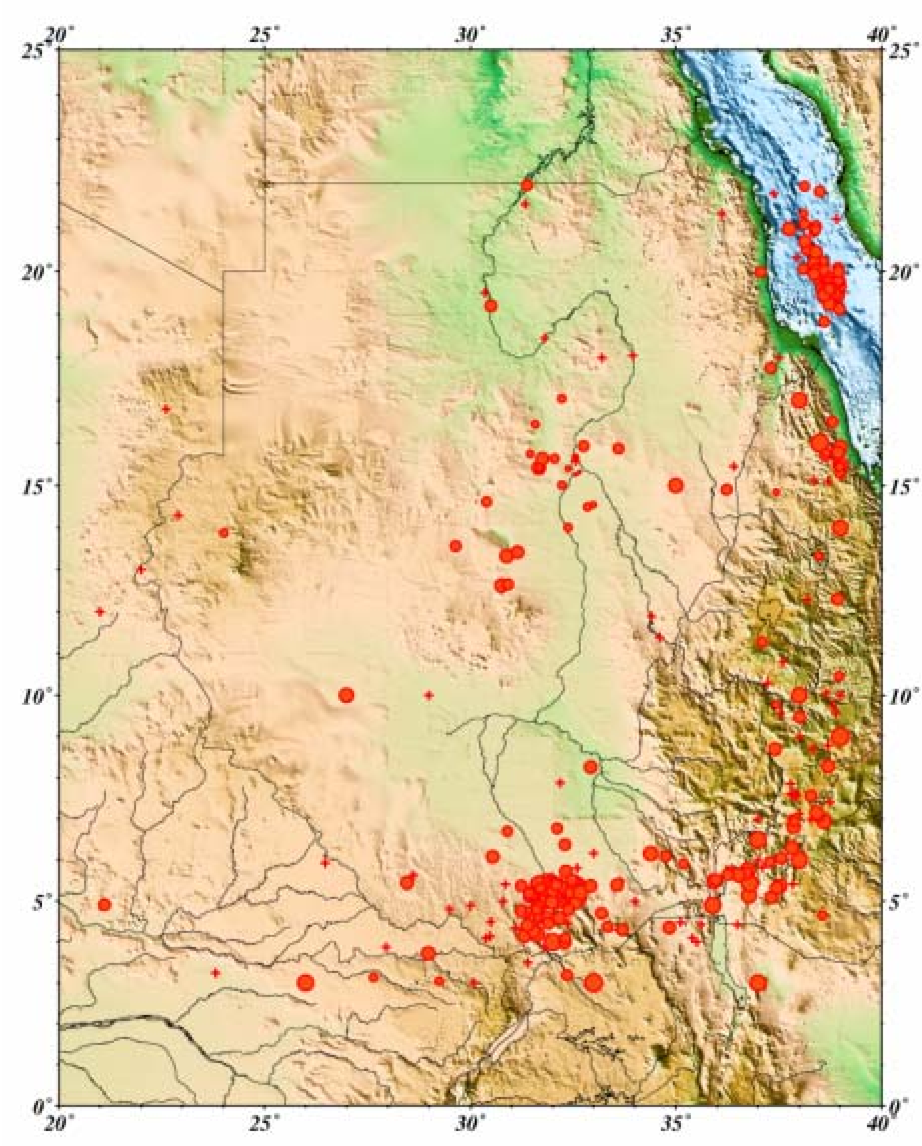

Figure 1. Seismicity for local (Sudan) area for the time period 1850 to April 2007. A total of 172 events are shown. Magnitude symbols are proportional to size.

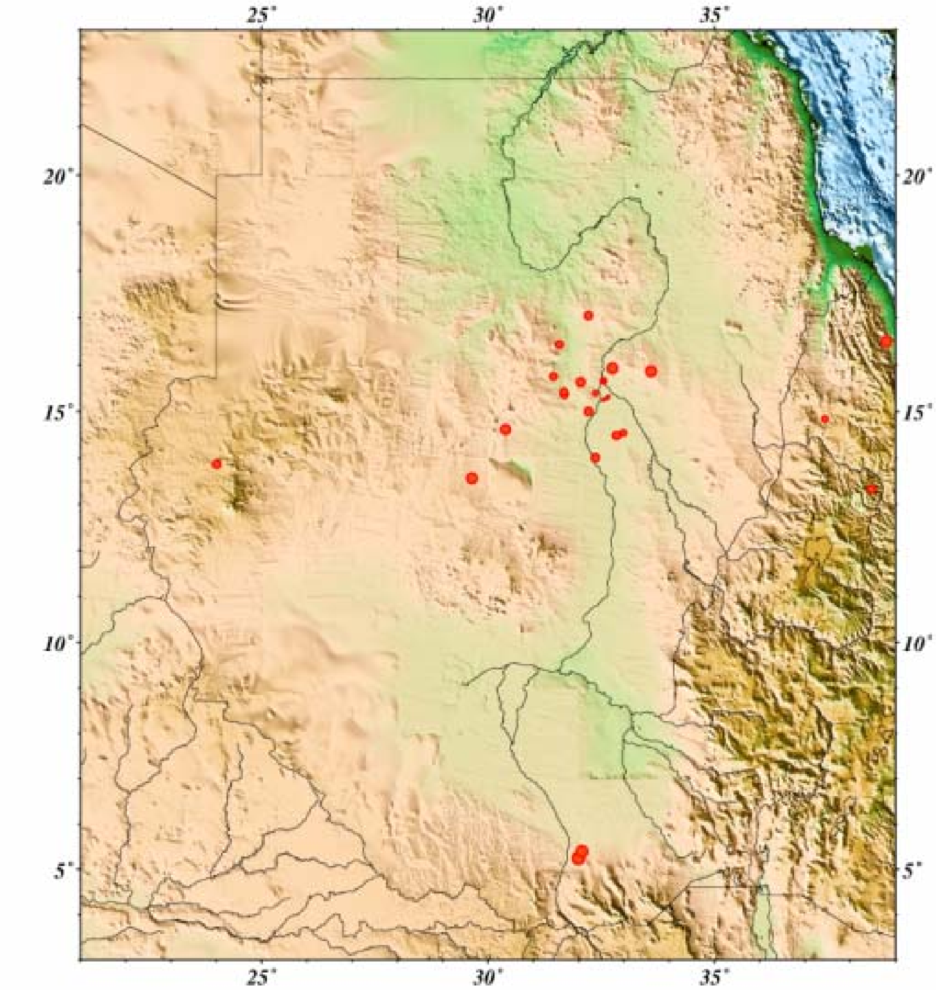

Figure 2. Seismicity for local (Sudan) for the time period November 2003 to April 2007. The data comes from SSN.A total of 17 events are shown. Magnitude symbols are proportional to size.

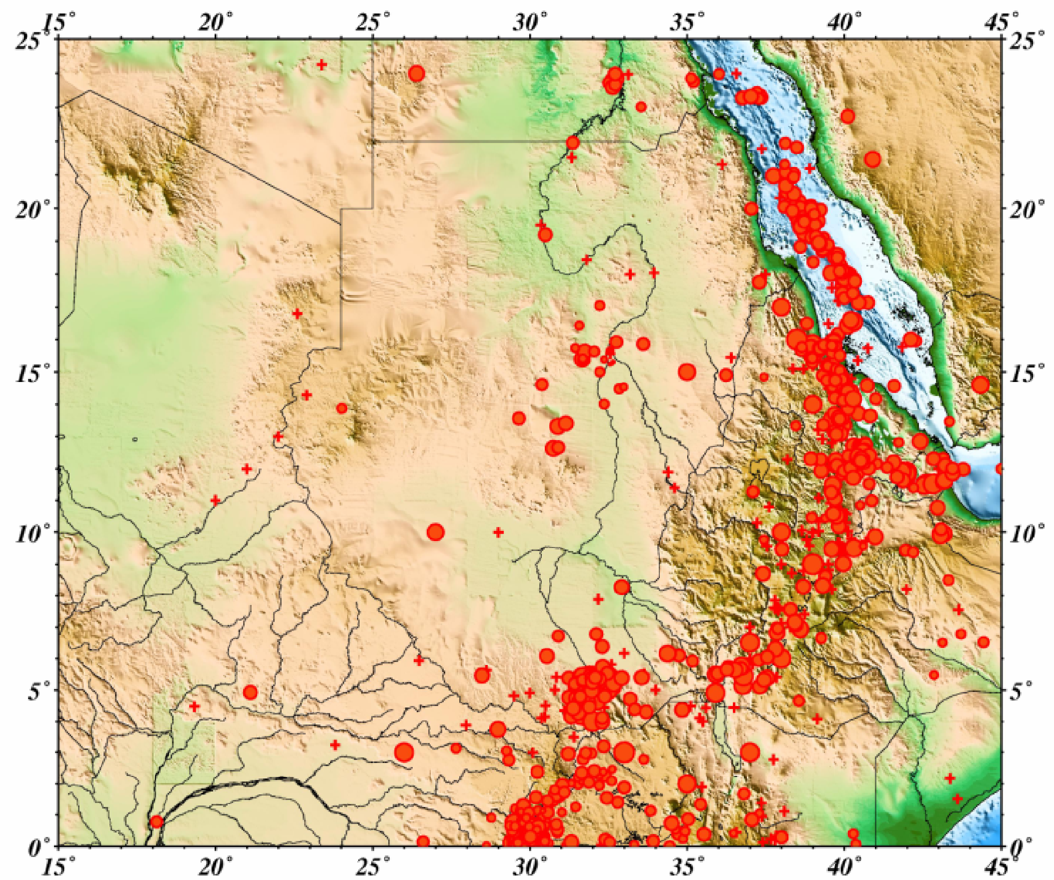

Figure 3. Seismicity for Sudan prime area for the time period 1850 to April 2007. A total of 1021 events are shown. Magnitude symbols are proportional to size.

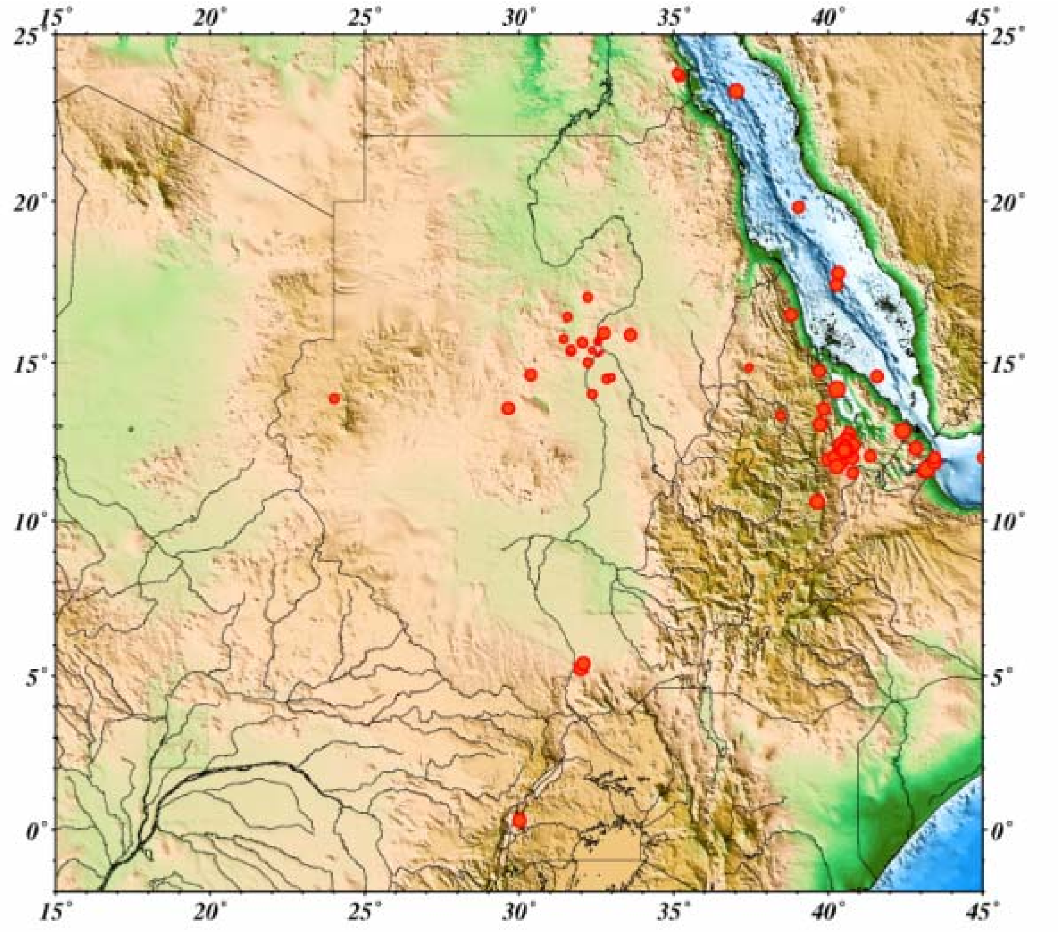

Figure 4 Seismicity for Sudan prime area for the time period November 2003 to April 2007 .A total of 65 events are shown. Magnitude symbols are proportional to size.

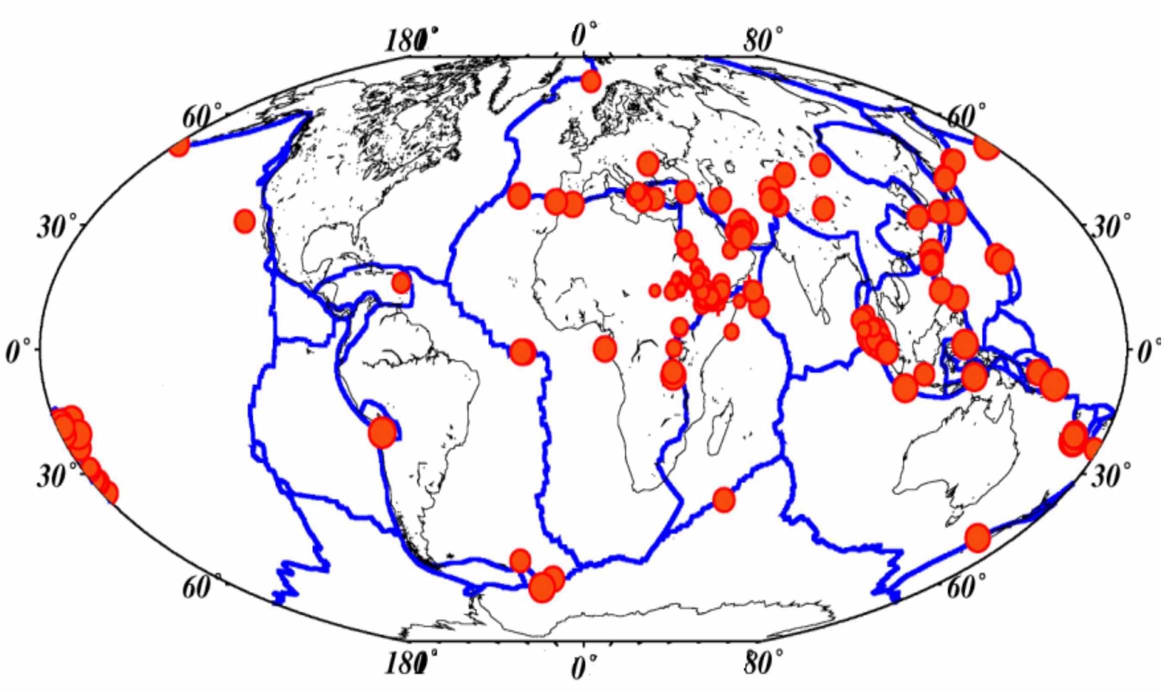

Figure 5. Seismicity for the global for the time period November 2003 to April 2007. The data comes from SSN. A total of 185 events are available. Magnitude symbols are proportional to size.

4. Local Seismicity of central part of Sudan:

A total number of 17 vents were recorded in Sudan, all of them were checked carefully, relocated and recalculated the magnitude See Figure 2. From the figure the epicenters of two of them were located in southern Sudan and one event located far to west Sudan whilst the 14 events were distributed around Khartoum area. On the other all explosions were excluded. The largest of these events around Khartoum occurred in Abu Deileg area NE Khartoum with magnitude 3.9. See section 6 on Abu Deileg event.

Table 2. Details of the local events used in the study

Year	Date	HRMM	Sec	L	Latitude	Longitude	Depth	Mc	Ml
2003	11 5	1020	17.4	L	15.86	33.598	10	3.9	-
2003	1114	1754	33.2	L	15.37	31.688	22	2.8	3
2004	112	1245	27.0	L	15.42	31.677	15	2.5	2.5
2004	214	1004	40.3	L	15.75	31.448	10	2.7	2.5
2004	321	801	46.8	L	15.4	32.37	4	2	1.9
2004	516	1730	6.8	L	15	32.225	5	2.4	2.4
2004	516	1821	36.8	L	17.04	32.221	15	2.9	2
2004	917	1753	57.7	L	14.61	30.39	15	3.7	3.2
2006	5 5	1658	50.2	L	15.63	32.048	4	2.2	2.2
2006	5 6	1853	33.6	L	14.01	32.373	0.1	-	3
2006	623	911	13.9	L	13.56	29.652	15	3.9	4
2006	9 4	241	21.4	L	16.44	31.58	15	2.6	2.4
2007	1 8	1715	11.9	L	14.49	32.843	15	3.2	2.1
2007	311	1821	29.9	L	14.54	32.989	15	2.4	2.5

5. Composite Fault Plane Solution:

In order to figure out the focal mechanism around Khartoum, a composite fault plane solution was made for the 14 events located around Khartoum Table 2.
Polarities used were 14 and 2 errors were allowed in the solution.
From the plot shown in Figure 6 obviously the tension axis in the NE direction which consistent very well with focal mechanisms for the significant earthquakes occurred in central Sudan the in 1966 (Fig. 7) and 1993 (Fig. 8) respectively.
Central Sudan is transversed by NW-SE trending faults bounding Mesozoic and early tertiary rift basins (Bosworth, 1992). Considering the general tectonics in Sudan region NE-SW extension is expected and the stress field observed is could be probably is due to influence of forces from outside the region.

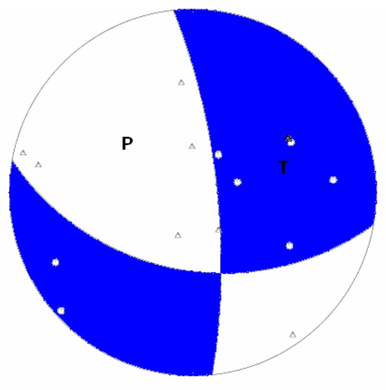

Figure 6. A composite fault pane solution for the local events in the central Sudan around Khartoum. The triangles are P axis while the circles are T axis

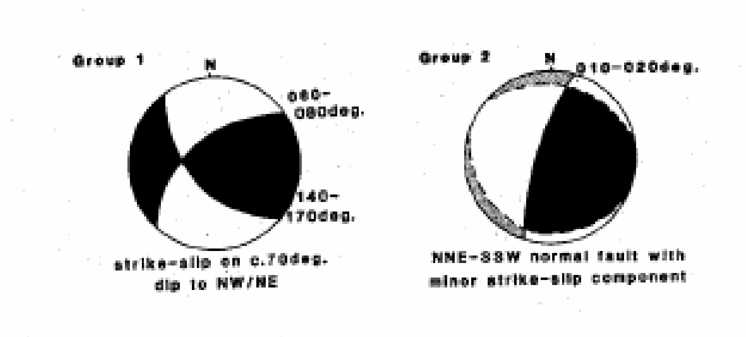

Figure 7. A fault pane solution for the local events in 1966 in central Sudan , the event resolved by use of P/P P/Ps relative amplitude method.(Clark and Brown, 1987)

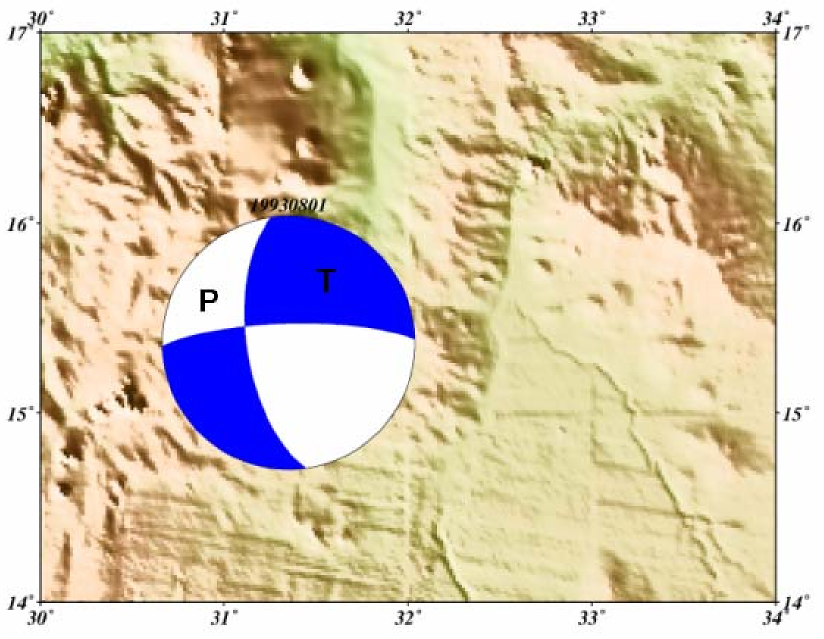

Figure 8. A fault pane solution for the 1993 event SW Khartoum. The T axis in the NE direction. The solution was adopted from Harvard.

6. Location and Magnitude of Abu Delig Earthquake in Central Sudan

6.1 Introduction

On 5th of November 2003 an earthquake was felt in and around Abu Delig area eastern Khartoum and recorded by the SSN seismic network at GRAS. This is the largest event in the Khartoum area since the Ms=5.5 event in 1993.This event is important because it occurred close to Khartoum capital city where the major infrastructure for instance electricity stations, oil pipe lines and the refinery station, beside the major population are concentrated.

6.2 Data Analysis

The earthquake was felt in Abu Delig area and recorded by SSN seismic network. Unfortunately the stations at that specific time were not in triggering mode, so only a paper plot with low resolution were available from the two the operating stations, El Merkheyat and El Seliet stations (Fig. 9). The arrival time of P and S waves were determined from the seismograms and used to locate the event with the two operating stations. In order to avoid ambiguity, an azimuth to the known epicenter was used. The epicenter was found to be 15.51 E and 33.35 N.
The magnitude was found to be 3.9 using coda duration magnitude and the SSN magnitude scale. The Seismological Research Institute (January 2004) gathered information about the felt area through questionnaire Table 3. Consequently, isoseismic map (Fig. 10) has been made for affected area. From the information shown in table 3, the maximum recorded intensity is V of Mercalli Intensity Scale MMS.

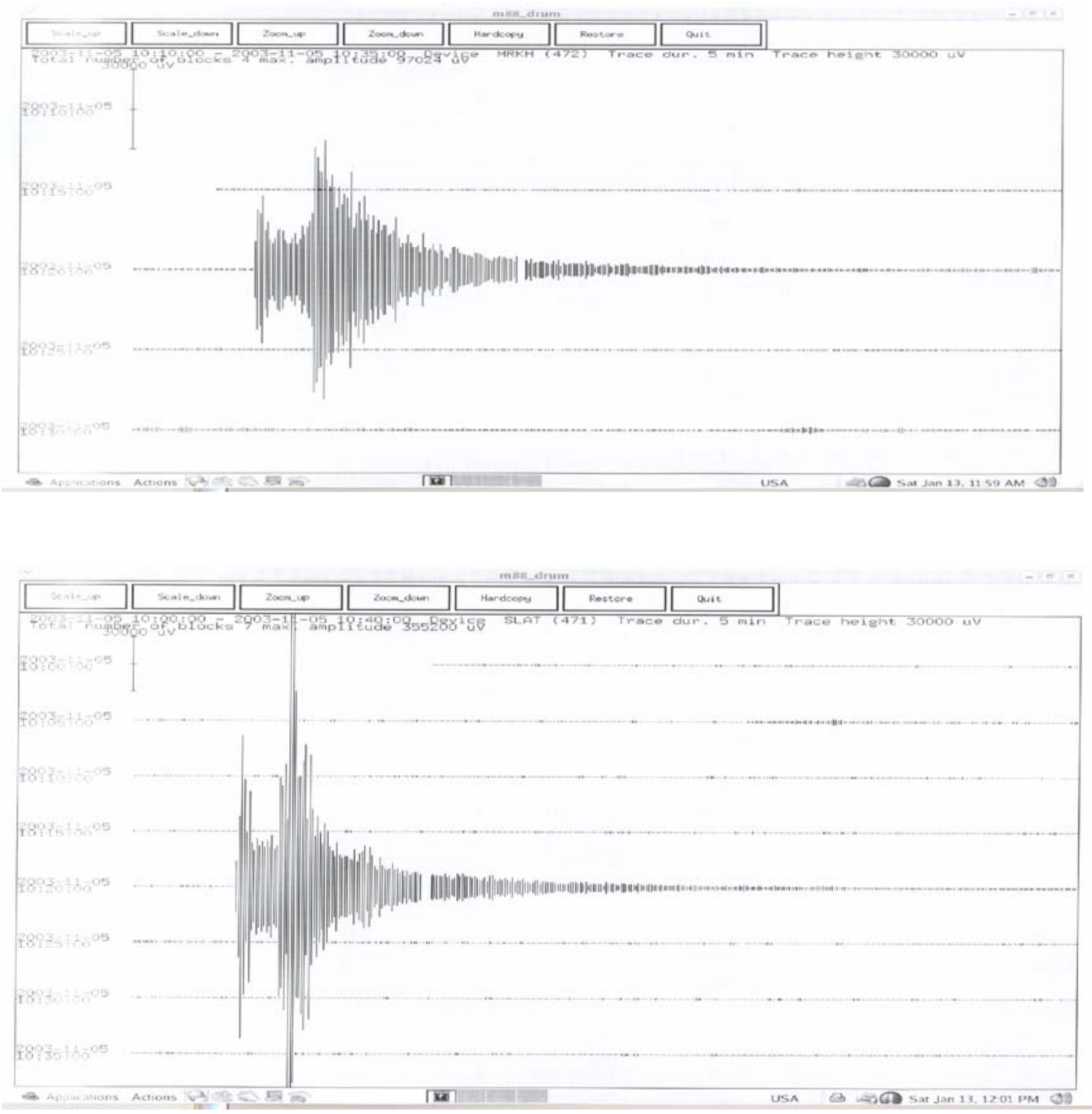

Figure 9. Seismograms of Abu Delig area in by the SSN seismic network the top trace shows El Selit station and a lower trace shows El Merkheiat station. The scale duration for both traces is 5 minutes.

Names	Longitude	Latitude	Intensity
El Tekeyab	15.76	33.37	I
El Khalwat	15.89	33.75	IV
El Khlwat	15.89	33.76	IV
Wadi EL Talih	15.90	33.64	IV
Khawat Wad Sheikh Idriss	15.89	33.75	IV
Wad EL Kadak	15.90	33.71	IV
EL Khalwat	15.55	33.77	IV
El Khalwat	15.90	33.81	IV
Abu Delieg	15.90	33.77	IV
EL Hamrab	15.91	33.82	IV
Abu Delieg	15.90	33.80	V
Abu Delieg	15.91	33.80	IV
Adu Delieg –Elsuq	15.90	33.81	IV
Adu Delieg –Elsuq	15.92	33.84	V
Adu Delieg- the mosque	15.89	33.77	V
Adu Delieg	15.90	33.77	V
Adu Delieg	15.90	33.77	V
Sheikh Talha	15.91	33.84	V
Abu Delieg	15.90	33.80	V
Adu Delieg –Elsuq	15.90	33.81	V
Adu Delieg	15.89	33.82	V
Adu Delieg –E of the mosque	15.92	33.84	IV
Adu Delieg –Elsuq	15.90	33.81	IV
Adu Delieg –Elsuq	15.90	33.81	IV
The Hospital	15.90	33.81	V
Umm Shalkha	15.93	33.84	V
Khor Abu Delieg	15.90	33.80	IV
Khor Abu Delieg	15.90	33.81	IV
NE- Abu Delieg Wad Farag	15.91	33.79	IV
Temer EL Nafa`p	15.94	33.91	III
W- Umm Seneit	15.90	34.07	III

Table 3. Estimation of the Intensity of Abu Delig Earthquake

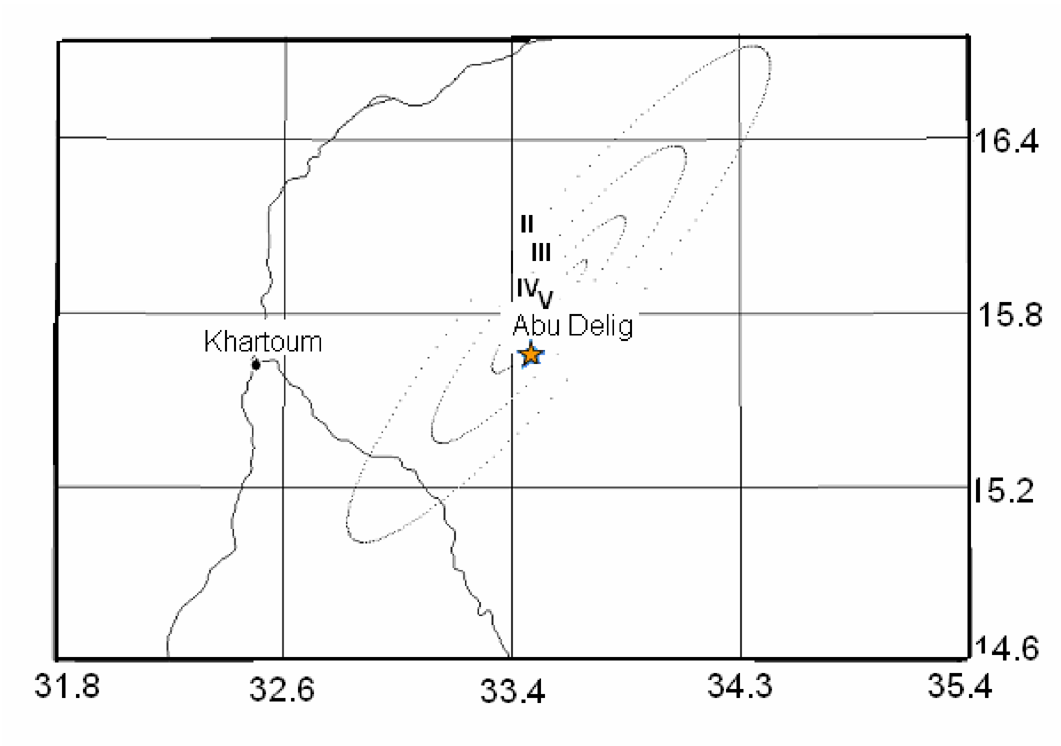

Figure 10. The isoseismal map of Abu Delig earthquake. The star shows the instruments location.

6.3 Conclusion

Despite the event was not available in digital form, the location was calculated using the seismogram paper. The location was calculated and compared to the isoseismic map. The epicenter calculated by SSN consistent very well with area showing the maximum intensity. This could indicate that the crustal model used was good for the Khartoum area.
Detailed crustal structure study for Sudan would be of great important in locating earthquakes.

References

1. Bosworth, W., 1992: Mesozoic and early Tertiary rift basins in East Africa. Tectonophy. 209, 115 137.

2. Clark, R. A., and Brown, S. E. (1987). The Kordofan earthquake, central Sudan, Journal of African Earth Science, Vol. 6, No. 4, pp. 573-581.

3. Seismological Research Institute (2004). The Determination of Abu Delig Earthquake Intensity.

Appendix 2

Technical Report No. 10

Statistical Overview of SSN Operation From Nov. 2003 to Apr. 2007

By

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April 2007

STATISTICAL OVERVIEW OF SSN OPERATION
FROM NOVMBER. 2003 TO APRIL. 2007

1 - THE NETWORK OPERATION

Introduction

The essential motivation for this study is the fact that, it is already known that there are some lost data. This can be attributed to many factors among them are; limited number of working hours during certain periods of time (as it will be described later), low speed of radio communication, stations that are stopped and sometimes the setting of non-optimum triggering parameters.

Aim

To make an attempt to have an assessment of the operational time of SSN

Procedure

In this part of the report, the only controlling guide which was adopted in order to achieve the aim of the study is the triggered data detected by the network.

For every period of one month, the SELECT Program has been used, taking the station code as the selection criteria to find the number of recordings for each station. From those numbers certain percentages operation time has been calculated as it will be shown later in the results section.

Moreover, the CATSTAT Program has also been applied for a more comprehensive view of the data status, obtaining diagrams for yearly, monthly and time of day distribution of events. Those diagrams are displayed and discussed later within the text.

Operational Mechanism of the Network

In the 3 field stations, the data are stored in the data buffer. When the data buffer is full, it is overwritten. The data remains at the field stations until the central workstation requests it.
The central workstation is responsible for requesting data from the field stations and arranging them in the database. First the trigger times from all field stations are transferred. Once the trigger times from three stations have been received, then these times will be inspected for coincidence within a time window. If 2 out of 3 field stations trigger within this window (usually around 60 secs.), then the trigger criteria satisfied and a network event is declared and the central station will collect corresponding waveform data in high resolution and ready to be analyzed

Known Operational Status

- Starting from November, 2003 to December 2003, the working hours for the central station were more or less 24 hours (including the holidays).

- Starting from January, 2004, the working hours for the central station were more or less about 9 hours (excluding the holidays).
- For the month July, 2005, all stations were down.
- During the period from November, 2005 to March 2006, JAWL was down.
- Starting from April.2006 up to date, the working hours for the central station is 24 hours (including the holidays).
- During the period from July, 2006 to Feb 2007, JAWL was down.
- For the month August 2006 all stations were down
- Starting from Sep.2006 up to date, SLAT was down
- For the month of December, 2006 all stations were down
- Starting from March, 2007 up to date, JAWL Started to record again in relatively good %

Effect of Central Station Down - Time

A diagram has been plotted for the period from Jan, 2004 to March, 2006, using CATSTAT Program. The time of day distribution of events was taken into consideration and the diagram is represented by figure (1.1).

From the diagram it can be observed that the recoded events are distributed through the whole 24 hours of the day more or less symmetrically, that is to say that there is no obvious or sharp gabs of recordings during the night times and this is to some extent different from it was expected. This can be explained partially by the large enough buffer memory at the field stations. On the other hand still there is the possibility that some data has been lost during long weekends and holidays. But as a general view, it seems that not as much data as expected has actually been lost.

From all of the above it can be concluded that, there is no proven evidence that the shutting of the central station has a significant influence on the data losing matter, however there is a remarkable notice that the period within the day where there is the minimum data recordings is found between 2 am - 6 am (GMT), equivalent to 5 am - 9 am (Sudan Local Time) as it could be seen from figure (1.1). This could largely be explained by the fact that there were long periods of time when some of the field stations had problems with their battery charging capacity, it might be that there was no enough power to operate the stations, and this would have toke several hours, till the sun is rising up and the solar panel starts to charge again.

Results

The total number of events recorded by SSN for each month has been obtained and it was found to be 192 events, indicating an average of 4.6 events per month. In addition to that, the total number of events has been detected by each station whether alone or by other station(s), has been calculated.

For SLAT, MRKH and JAWL, the numbers were found to be132, 138 and 132 respectively, showing averages of 3.1, 3.3 and 3.1 events per month.

The symbol “C” appears in table (1.1), indicates that those event(s) was detected when station was set on continues mode, and consequently, they were not counted when statistics were made.
Then to make the results more realistic, and in order to estimate the percentages of recording capacities of the stations, an assumption has been made. That is that if any station recodes 4 events or more per month, this will be taken as 100% recording capacity, if it recorded 3 events this indicates 75% recording capacity, while 2 events refers to 50% and 1 event indicates 25%.

On the basis of the above mentioned assumption, and during the period from November, 2003 up to April, 2007, SLAT shows an overall uptime of 44% of recording capacity per month, MRKH indicates an average of 56% and JAWL refers to an average of 47% recording capacity per month. All of the above calculated and estimated figures are shown in table (1.1).

Moreover, the CATSTAT Program has also been applied for the selection of yearly distribution of events for the whole period. The diagram showing the results is illustrated by figure (1.2)

In the diagram the remarkably limited number of events appears for the year 2003 can be explained by the fact that only about 1.7 months of data are available for this year. The same holds true for the year 2007 where only 3.5 months are available for this year. Moreover, the diagram indicates that the year 2004 scored the maximum number of events recoded per year which is about 61events, and this could be mainly attributed due the large number of Ethiopian events detected during that period.

Figure (1.3) represents the monthly number of events for the period from Nov, 2003 to April, 2007. The diagram is considered to be well correlated with the statistics shown in table (1.1), indicating that for the year 2004, those Ethiopian events were particularly recorded during the months of March and October of this year

For the period from January, 2005 to December, 2005, the diagram pointed out that the maximum number of events recoded during this year is related to the month of September and it was found to be 20 events and, remarkably, all of them are Ethiopian events.

For the period from January, 2006 to December, 2006, the diagram reveals that the recording capacity percentages started to increase remarkably from April to July and this is coincide with the fact that the working hours for the Network during that period of time were 24 hours including the holidays. The maximum number of events recoded during that period was 17 events recorded in June. This is in addition to the fact that during this month all stations show 100% of recording capacity.

Moreover, it can also be observed from figure (1.3), and for the years 2005 and 2006, months showing a complete absence of data are coincide with the fact that all stations were down at that period of time. July 2004, August and December, 2006 are perfect examples of such a case as it can be seen from table (1.1).

Furthermore, it can be deduced from figure (1.3) that there are some periods showing relatively clear decrease in data recording, periods from October, 2005 to December, 2005 and from January, 2006 to March 2006, have been taken as examples.

Table 1.1: Statistical Overview on the Network Recording Capacity

Year	Month	Total No. Of Events	Stations SLAT	MRKH	JWAL	Stations SLAT%	MRKH%	JWAL%	Comments
2003	NOV	14	12	14	10	100	100	100	Starting from Nov.2003 to Dec.2003, the working hours
2003	DEC	11	4	11	7	100	100	100	For the Radio network is 24 hours including the holidays.
2004	JAN	7	6	7	7	100	100	100	Starting from Jan.2004, the working hours for Network
2004	FEB	6	5	5	6	100	100	100	were more or less about 9 hours (excluding the holidays)
2004	MAR	10	10	10	10	100	100	100	
2004	APR	5	5	5	4	100	100	100	
2004	MAY	4	4	2	4	100	50	100	
2004	JUN	4	3	3	4	75	75	100	
2004	JUL	2	1	2	1	25	50	25	
2004	AUG	1	1	1	1	25	25	25	
2004	SEP	3	3	3	3	75	75	75	
2004	OCT	10	10	9	10	100	100	100	
2004	NOV	7	7	6	6	100	100	100	
2004	DEC	1	1	1	1	25	25	25	
2005	JAN	3	1	3	1	75	25	75	
2005	FEB	3	3	3	3	75	75	75	
2005	MAR	4	3	2	1	75	50	25	
2005	APR	1	0	0	1	0	0	25	
2005	MAY	4	4	4	4	100	100	100	
2005	JUN	2	1	2	1	25	50	25	
2005	JUL	0	0	0	0	0	0	0	Stations all down
2005	AUG	1	1	0	1	25	0	25	
2005	SEP	20	19	20	20	100	100	100	
2005	OCT	1	1	1	1	25	25	25	
2005	NOV	1	1	1	0	25	25	0	During the period from Nov.2005 to March 2006, JAWL
2005	DEC	1	0	1	0	0	25	0	Is down
2006	JAN	1	0	1	0	0	25	0	
2006	FEB	2	2	2	0	50	50	0	
2006	MAR	1	1	1	0	25	25	0	
2006	APR	3	3	2	1	75	50	25	Starting from Apr.2006 up to date, the working hours for
2006	MAY	7	1	4	3	25	100	75	the Radio network is 24 hours including the holidays.
2006	JUN	17	14	11	10	100	100	100	
2006	JUL	6	5	1	0	100	25	0	Starting from Jul.2006 to Feb 2007, JAWL is down
2006	AUG	0	0	0	0	0	0	0	Stations all down
2006	SEP	3C	0	0	0	0	0	0	"C" indicates that event(s) was detected when station was
2006	OCT	3C	0	0	0	0	0	0	Set on continues mode.
2006	NOV	1C	0	0	0	0	0	0	Starting from Sep.2006 up to date, SLAT is down
2006	DEC	0	0	0	0	0	0	0	Stations all down
2007	JAN	4+2C	0	4	0	0	100	0	
2007	FEB	7	0	7	0	0	100	0	
2007	MAR	11	0	11	7	0	100	100	From March2006 up to date, JAWL Started to record
2007	APR	7	0	7	4	0	100	100	again in relatively good %
AVERAGE		4.6	3.1	3.3	3.1	44	56	47	Figures indicate average percentages per month

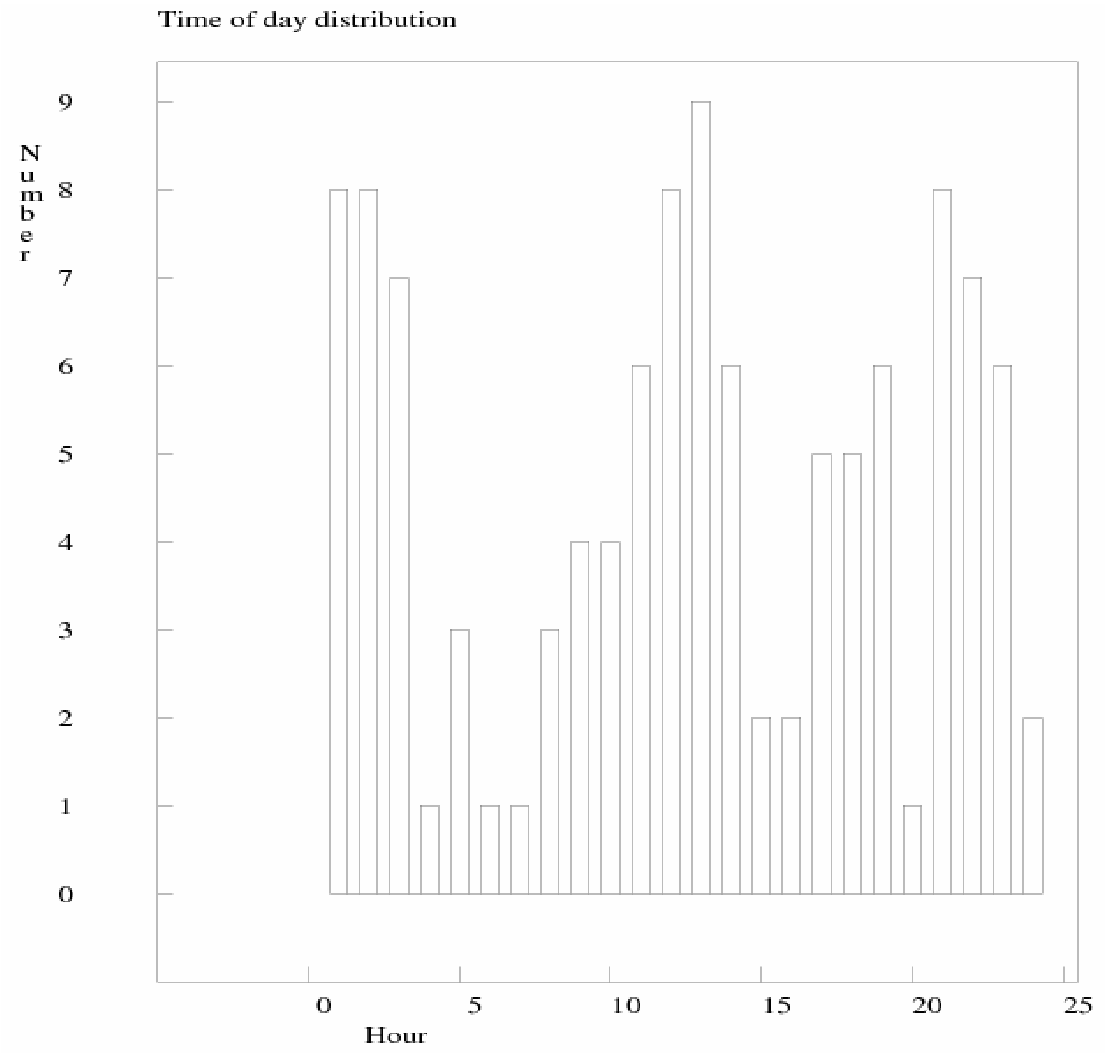

Figure 1.1 : Shows the Time of Day Distribution of Events for the Period from Jan. 2004 to March 2006.

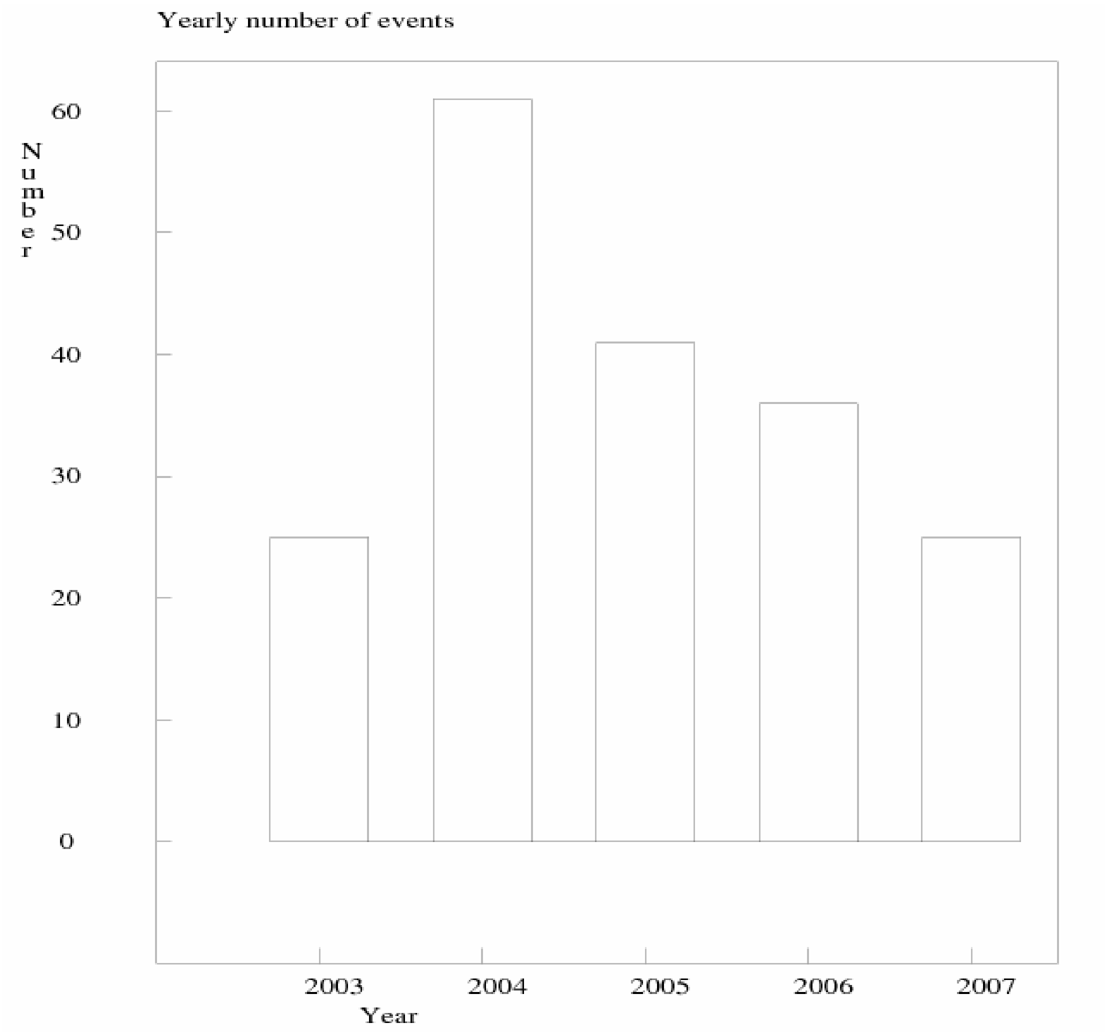

Figure 1.2 : Shows the Yearly Number of Events through the Period from Nov. 2003 to April 2007.

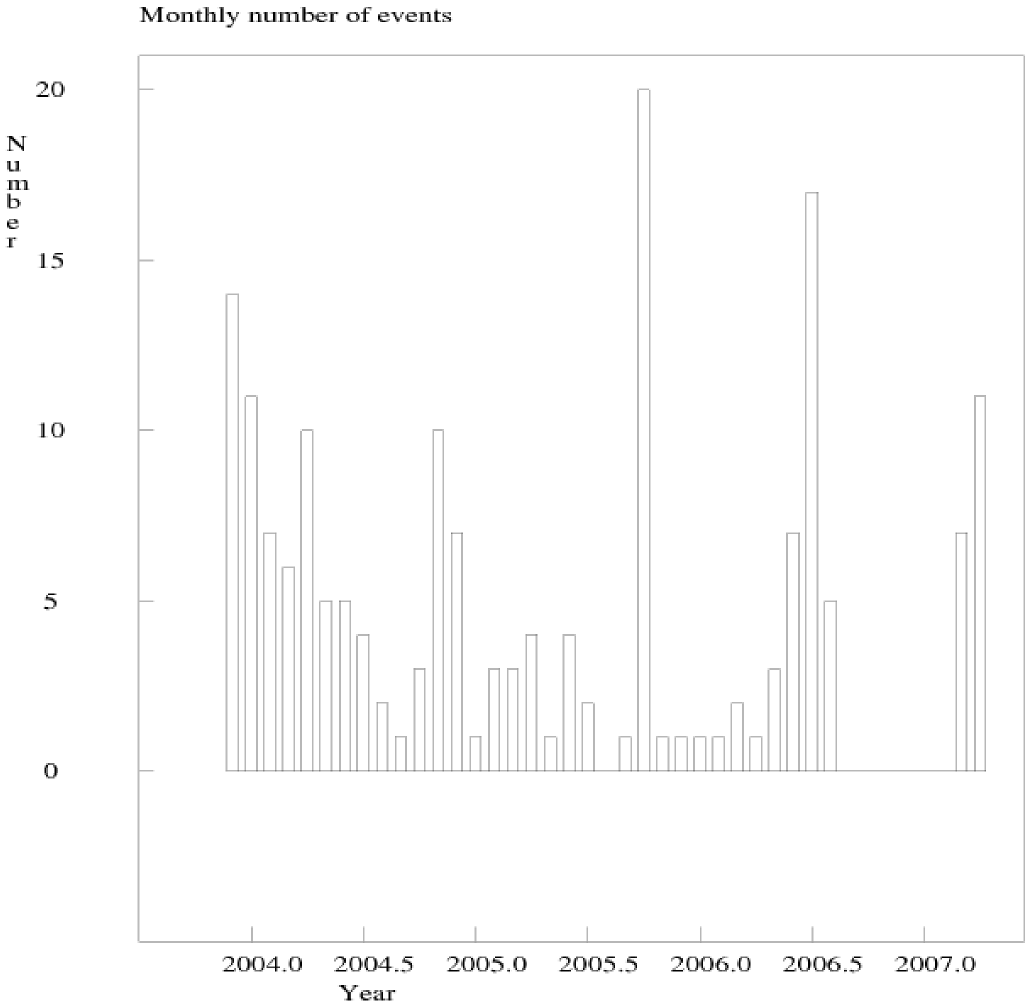

Figure 1.3 : Shows the Monthly Number of Events through the Period from Nov. 2003 to April 2007.

2- CONTINUOUS DATA RECORDING

Introduction

The SSN network does not work properly due to problems with radio communication and difficulties in setting optimal trigger parameters. In addition, the network only has limited capacity to transmit events with long duration.
For all these reasons we decided to put two MARSLITE stations in continuous mode at SLAT station and MRKH stations.

Data Collection

The continuous data has been gathered from the remote stations every 10 days in average but some times, for some problems, the period was exceeded to more than one month, and the data has been lost due to the limit of the memory and overwriting of data has taken place so, the data can not be retrieved. For example data from Jan. 18, 2007 to Feb. 28, 2007. See table (2.1)

- SLAT station:

Continuous data available from SLAT station started from 22 Augst.2006 up to now, see table1. All these data has been checked for events and stored in external hard disk.

- MRKH station:

Continuous data available from MRKH station started from August. 22. 2006 till December 2006, but unfortunately these data was lost after checking for events.

Data Processing

To put continuous data that was recorded by MARSLITE into SEISAN format the following Procedure are followed:

- Export 60 minute length of data to GSE2 using m88_select program.
- Run WAVETOOL program to convert GSE2 format to SEISAN format.
- Run WAVFIX program to change the agency name, station code and components.
- Run SEISEI program to merge each of three components in three different files into one file.
- Finally, putting the converted continuous data into the SSN database. That has been done as follows:

- Run SEICUT program to choose a certain limit of time (3600 seconds) to avoid the
Overlapping.
- Run AUTOREG program to register the continuous data into the database.
- Finally copy waveform file to WAV /SLAT/2006/…. directory

Differentiation between SP and LP Sensors

Sometimes it was not clear which type of sensor was used, because of both of the short period and long period sensors have been used in collecting continuous data.

In order to find out which sensor was used a spectrum of the noise was made of each type of sensor see figure (2.1 and 2.2). It is clearly seen that the LP sensor has higher amplitude at low frequencies than the SP sensor this differences was used to identify the sensor.

The two parameter that affecting on the response file which is used in SEISAN program in calculating the magnitudes are the sensitivity of the sensor and the MARSLITE digitizer.

Sensitivity of MARSLITE

Since it was not known if the sensitivity of the MARSLITE is the same as the MARS88, a comparison of noise signals for the two recorders was made. In both cases, the LP sensor was used. Since no recording existed simultaneously, noise signals from different time periods were used.

The data has been checked for its amplitude using different filters. Especially the low frequencies (0.1-1.0 Hz and 0.1-0.01 Hz) show stable results, see table (2.2).

Since the amplitudes at these low frequencies are very similar, it is assumed that the gain of the MARS88 and MARSLITE is the same. A summary of calibration parameters used is given in table (2.3). The response file for short period sensors was made.

All triggers recorded by short period sensors in continuous mode from August 22, 2006 till December 31, 2006, must be checked and recalculate the amplitude and the magnitude.

Conclusion

The working days for SLAT station are 82 days from 22 August. 2006 up to 31 March 2007 which supposed to be 222 days, so the average percentage is only 37%, on the other hand for MRKH station is zero since no data is available in this moment. The average percentage of continuous data available is 37% divided by 3 stations that should be working is equal 12.3%.

All continuous data available has been converted to SEISAN format and put into SSN database. The data was checked for which type of sensor was used and finally the data was investigated for events and processed.

Table 2.1: Continuous Data available from SLAT Station from Aug.2006 to Apr.2007

SLAT Station

Year	Month	Day	Total working days	Data %	Type of Sensor	comments
2006	Aug	22-31	10	100 %	SP	The continuous mode Started on Aug 22
2006	Sep	1-22	23	76.7 %	SP	
2006	Oct	8-10 19-31	16	51.6 %	SP	
2006	Nov	1-9	11	36.7 %	SP	
2006	Dec	6-17	12	38.7 %	SP	
2007	Jan	-		0 %	LP	Data from 18.1 till end of the month are lost
2007	Feb	-		0 %	LP	All data of this month are lost
2007	Mar	1-3 25 -31	10	32.3 %	LP	
Average	222		82	37 %		

MRKH Station

All Continuous data collected from MRKH station from Aug. 2006 till Dec. 2006 is lost after checking for events.

Table 2.2 : Differentiation between LP and SP

MARSLITE

	Without Filter	Filter (0.1 to 1.0)	Filter (0.01 to 0.1)	Interval in Sec
2007	10000	2000	1350	90
	22000	2500	900	90
	31000	3100	3300	90
	50000	3100	2100	90
	7000	6000	1300	90
	5000	2600	1200	90
	3700	2400	900	30

MARS 88

	Without Filter	Filter (0.1 to 1.0)	Filter (0.01 to 0.1)	Interval in Sec
2003	4000	3200	1100	25
	3000	1900	800	30
	600	2100	420	35
2005	6000	1800	700	25
2006	6500	4700	628	50
	3200	1800	1100	90
	4500	2100	1100	90

Table 2.3: Specification of LP and SP Sensors and Parameters that used in Making Response File for SP Sensor.

Specification	LP Sensor	SP Sensor
Sensitivity	1000 V/m/s	400 V/m/s
Damping	0.707 critical	0.707 critical
Natural Frequency	0.05 Hz	1 Hz
Digitizer gain	$16X10^6$ c/v	$16X10^6$ c/v

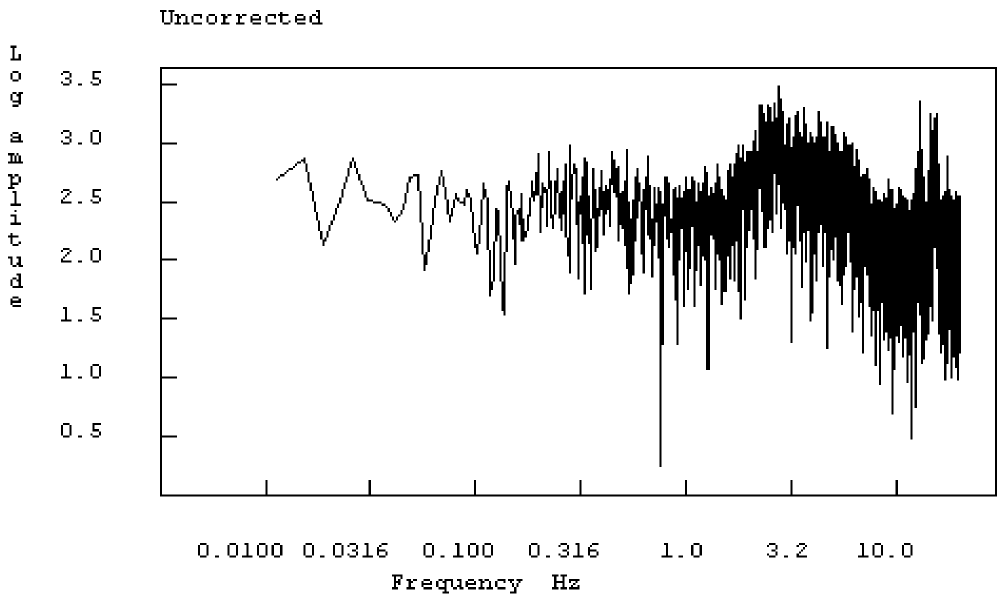

Figure 2.1 : Spectrum of Continuous Signal from SLAT Station For November 2, 2006 using SP Sensor

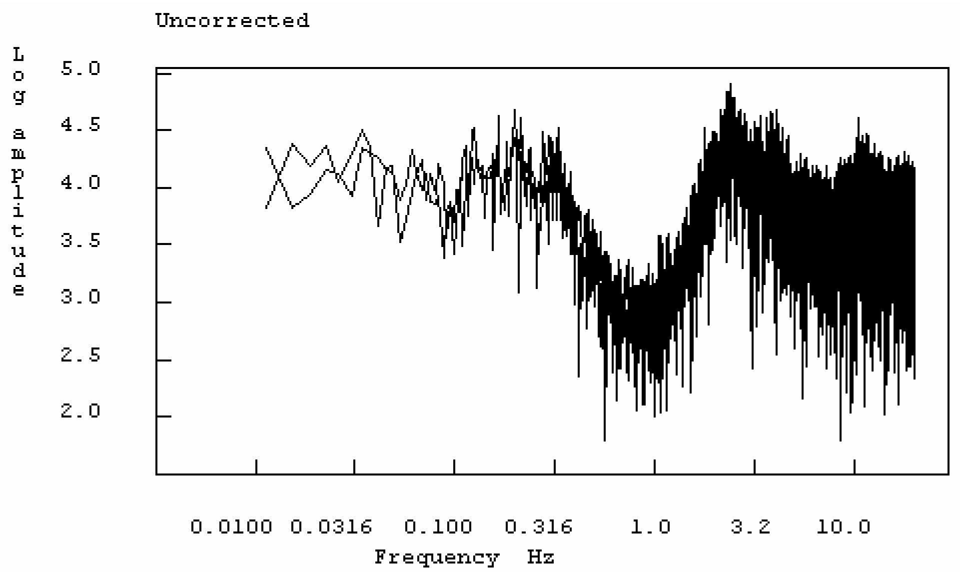

Figure 2.2: Spectrum of Continuous Signal from SLAT Station For March 25, 2007 using LP sensor

3- ESTIMATION OF NETWORK OPERATIONAL TIME DURING THE PERIOD FROM JANUARY TO APRIL 2007

Motivation

The SSN network experiences many periods without data, however no log exits of network operation, so it is difficult to find out if the network was in operation at one particularly time. In order to estimate seismcity rate it is important to have a network operational log. It could easily be obtained on daily basics using the real time transmission of events. The purpose of this study is to create an operational log for 2007 based on available trigger information.

Method of preparing statistics

Statistics was collected on daily basis for the two stations in operation. The data was taken together in one table for each month for example table 1 include for data log MRKH and JAWL counting started on 1st Jan 2007 up to now. Sometime the registration of data was not regular, as it is clearly shown in tables below.

The two stations should daily have the same number of trigger. Since the system it set up to retrieve the same data from both stations in case any of time trigger. If one station then has fewer triggers than the other, it is assumed that the operational time is proportionally smaller. The % operational time is then calculated as the ratio of number of trigger to maximum number of triggers
.
Table (3.1) Shows the number of triggers during Jan 2007 and includes MRKH and JAWL stations as there was no recording of triggers for JAWL station while MRKH station recorded regular information. The average estimate operational time was 100% in MRKH station

Table (3.2) 25 th of Feb. JAWL station started recording. The average estimate operational time was 39.3% in MRKH station while for JAWL station it was 6.6%.

Table (3.3) For the both stations. Each in this month. The average was 97% in MRKH station, 46% in JAWL station.

Table (3.4) The operational time was made regular in both stations. The average estimated operational time was 61% in MRKH station 24% in JAWL station.

Table 3.1: <u>Shows the number of triggers during Jan 2007 and includes MRKH and JAWL stations</u>

Month	Day	MRKH Station		JAWL Station		Real event	comment
		Tri No	%	Tri No	%		JAWL had no reading MRKH had many
Jan	8	63	100%	0	0	3	
Jan	9	106	100%	0	0	0	
Jan	10	113	100%	0	0	0	
Jan	11	92	100%	0	0	0	
Jan	12	06	100%	0	0	0	
Jan	13	03	100%	0	0	0	
Jan	14	18	100%	0	0	0	
Jan	15	02	100%	0	0	0	
Jan	16	06	100%	0	0	1	
Jan	17	04	100%	0	0	0	
Jan	18	19	100%	0	0	0	
Jan	19	07	100%	0	0	0	
Jan	20	22	100%	0	0	1	
Jan	21	29	100%	0	0	0	
Jan	22	15	100%	0	0	0	
Jan	23	13	100%	0	0	0	
Jan	24	14	100%	0	0	1	
Jan	25	12	100%	0	0	0	
Jan	26	13	100%	0	0	0	
Jan	27	13	100%	0	0	0	
Jan	28	09	100%	0	0	0	
Jan	29	14	100%	0	0	0	
Jan	30	17	100%	0	0	1	
Jan	31	13	100%	0	0	0	
			Ave. 100%		**Ave.** 0 %		
Total average = 50%							

Table 3.2 : <u>Shows the Number of Triggers During Feb. 2007 and includes MRKH and JAWL Stations</u>

Month	Day	MRKH Station		JAWL Station		Real event	Comment
		Tri No	%	Tri No	%		JAWL had no power 1 -24 MRKH had many
.Feb	1	0	0	0	0	0	
Feb.	2	0	0	0	0	0	
Feb.	3	11	100	0	0	1	
Feb.	4	0	0	0	0	0	
Feb.	5	0	0	0	0	0	
Feb.	6	0	0	0	0	0	
Feb.	7	0	0	0	0	0	
Feb.	8	0	0	0	0	0	
Feb.	9	0	0	0	0	0	
Feb.	10	0	0	0	0	0	
Feb.	11	9	100	0	0	1	
Feb.	12	0	0	0	0	0	
Feb.	13	0	0	0	0	0	
Feb.	14	0	0	0	0	0	
Feb.	15	0	0	0	0	0	
Feb.	16	6	100	0	0	1	
Feb.	17	0	0	0	0	0	
Feb.	18	0	0	0	0	0	
Feb.	19	0	0	0	0	0	
Feb.	20	25	100	0	0	1	
Feb.	21	0	0	0	0	0	
Feb.	22	28	100	0	0	0	
Feb.	23	1	100	0	0	0	
Feb.	24	28	100	0	0	0	
Feb.	25	19	100	9	47	1	
Feb.	26	32	100	9	28	1	
Feb.	27	3	100	8	88	0	
Feb.	28	18	100	4	22	1	
			Ave 39.3%		**Ave** 6.6%		
Total average = 22.9%							

Table 3.3 : Shows the Number of Triggers During March 2007 and includes MRKH and JAWL Stations

Month	Day	MRKH Station		JAWL Station		Real event	Comment
		Tri No	%	Tri No	%		JAWL and MRKH had many in the whole month
March	1	20	100	9	45	0	
March	2	11	100	10	90	0	
March	3	22	100	4	18	1	
March	4	4	57	7	100	0	
March	5	17	100	9	52	0	
March	6	6	100	1	16	2	
March	7	20	100	3	15	0	
March	8	47	100	45	95	1	
March	9	45	100	45	100	1	
March	10	29	87	33	78	1	
March	11	39	100	29	74	0	
March	12	37	100	35	94	0	
March	13	36	100	35	97	0	
March	14	21	100	11	51	0	
March	15	32	100	2	2	0	
March	16	27	100	16	59	0	
March	17	33	100	5	15	0	
March	18	43	100	5	11	0	
March	19	63	100	6	9	0	
March	20	30	75	40	100	0	
March	21	36	100	23	63	0	
March	22	35	100	22	62	0	
March	23	20	100	11	55	0	
March	24	75	100	42	56	0	
March	25	68	100	60	88	3	
March	26	35	100	11	31	0	
March	27	27	100	0	0	1	
March	28	38	100	0	0	0	
March	29	32	100	0	0	0	
March	30	24	100	4	16	0	
March	31	36	100	0	0	0	
			Ave. 97%		**Ave. 46%**		
Total average 72%							

Table 3.4 : Shows the Number of Triggers During April. 2007 and includes MRKH and JAWL Stations

Month	Day	MRKH Station		JAWL Station		Real event	comment
		Tri No	%	Tri No	%		JAWL and MRKH had many in the whole month
April	1	3	75	4	100	1	
April	2	0	100	47	100	0	
April	3	9	19	47	100	1	
April	4	28	001	0	0	1	
April	5	18	100	8	44	1	
April	6	26	100	14	53	0	
April	7	73	100	71	97	1	
April	8	54	60	90	100	0	
April	9	40	100	19	47	0	
April	10	42	100	25	59	0	
April	11	24	100	0	0	0	
April	12	31	100	2	6	0	
April	13	22	100	01	22	0	
April	14	0	0	46	0	10	
April	15	0	0	0	0	0	
April	16	07	100	07	100	1	
April	17	44	100	16	36	1	
April	18	27	100	17	62	0	
April	19	33	100	13	39	0	
April	20	30	100	29	96	0	
April	21	22	100	19	68	0	
April	22	27	100	27	100	0	
April	23	28	84	33	100	0	
April	24	3	75	4	100	0	
April	25					0	
April	26					0	
			Ave 79.7%	**Ave 63.7%**			
total Average =71.7%							

Conclusion

From the above information we can conclude the MRKH station was recording well over the time period from Jan to April.
The JAWL station only recorded during the period from end Feb to April, this was party cased complete failure but also many days it only worked partially.
The average operational time for both stations for the 3 months has 45%.For all 3 stations it was 36%.