EVALUATION OF CURRENT STATUS OF THE UNIVERSITY SEISMIC NETWORK IN SRI LANKA AND PROPOSAL OF ITS UPGRADE

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ABSTRACT

In order to investigate the current status of the University Seismic Network in Sri Lanka, which was funded by Japan International Cooperation Agency (JICA) and is operating since 2003, data availability, detectability and P, S arrival times were checked. The results indicate that system is able to detect events with magnitude greater than 6, within the epicentral distance up to 20 degrees. Due to low S/N ratio, it is difficult to detect smaller events in regional scale and local events. There is a good agreement between the observed P arrival time and the theoretical P arrival time but systematic decrease in S-P time difference. Communication problem and poor site selection are the major problems. An upgrade plan of the current network consisting of relocation of the sensors and establishing real time data communication. It is desirable to combine data from the University Seismic Network and data from the PALK broadband station for earthquake monitoring and tsunami alert for Sri Lanka. Broadband moment magnitude, M_{wp} was calculated using data for PALK station to find that it is possible to obtain relatively reliable magnitude estimates using data from single station.

Keywords: Seismic Network, Earthquake/Tsunami Monitoring, Sri Lanka

INTRODUCTION

As Sri Lanka is placed well inside the Indo-Australian plate far away from an active plate margins, it is very unlikely to experience any substantial damage from a direct impact of earthquake. The closest active plate margin is Sunda Trench and is located around 1200km away from the island. However, secondary events such as tsunami can cause extensive damage as we already got similar experience in the year 2004. In 2004 Indian Ocean Tsunami, the large causalities were caused because of no experience and incapability in the issuance of tsunami warning as well as lack of tsunami awareness. In this context it is necessary to develop and strengthen the seismic/tsunami monitoring system with earthquake locating and rapid magnitude determination in the earliest possible time to minimize the risk of earthquakes damages. In this paper, the utility the existing Local University Seismic Network and GSN Station in seismic studies, rapid determinations of earthquakes and especially in the tsunami warning are discussed and also this is the first attempt to analyze the data from University Seismic Network. The objectives of this study are: (1) Study the current status of University Seismic Network and preliminary analysis of data (2) Proposal for upgrading Earthquake/Tsunami Monitoring System in Sri Lanka. Data used in this study is provided by University Seismic Network which consists of four short period seismometers and the PALK, GSN broad band station. Finally a plan which could be implemented for the network upgrading is discussed, so that its capacity and reliability in Earthquake/Tsunami Monitoring can be enhanced.

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SEISMIC OBSERVATION IN SRI LANKA

The University of Peradeniya operates University Seismic Network which contains four seismological stations with short period sensors and Geological Survey and Mines Bureau together with University of California, San Diego operate PALK–GSN broadband station. The Government of Japan through Japan International Corporation Agency (JICA) donated University Seismic Network to the Department of Geology, University of Peradeniya for teaching and research purposes. It was operated since May, 2003. Four seismometers which are able to receive seismic signals of regional and local earthquakes are stationed at Matara (RHN), Mihintale(RJR), Olluvil(EST), and Peradeniya(PRD) within university premises. The each station is equipped with Short period seismometer (GS-1), Force balance servo Accelerometer (Episensor), Data logger (K2) and relevant infrastructure facilities.

INVESTIGATION OF THE CURRENT STATUS OF UNIVERSITY SEISMIC NETWORK

The data availability and detectability of the events greater than magnitude 5.5 using the data available (transferred to central station) at Central Station at Peradeniya (PRD) within the 01/05/2005 and 30/04/2006 was investigated. The original data obtained from the University Seismic Network is in ".evt" (Kinematrics K2) format and the data obtained were prepared to read in SEISAN. First the events were selected using USGS/NEIC data base and the travel time was calculated using Taup_Time. Then the availability of relevant events was checked in the triggered data base at Central Station with reference to each station. Finally among those records, seven events near the Andaman Region were selected for further analysis. The theoretical travel time calculated using Taup toolkit and the time observed by University Network and the theoretical S-P time difference were compared

Availability of Data

Availability of the data from all the stations at central station, from May 05, 2005 to April 30, 2005 (as shown in the Table 1) was checked and the available data were categorized basically in to three categories. Category A includes the records which are detected and can be used for phase picking and hypocenter determinations. It is seems that only S arrival was recorded in some cases and those cases were categorized into category B. Category C represents the records which are very difficult to read even related to large events. Availability of the data from all the stations at central station indicates relatively higher number of records is available for station PRD and RJR.

Table 1. Data Availability at Central Station

Date			Origin Time			Lat	Lon	Mag	Depth	PRD	RJR	RHN	EST
2005	6	26	8	23	3.87	1.77	125.82	6.0	91	**C**			**D**
2005	7	13	0	29	29.81	10.35	92.00	5.5	49	**A**	**A**		
2005	7	23	7	34	56.77	35.50	139.98	6.1	61	**D**			
2005	7	23	22	53	35.08	5.11	94.80	5.6	48	**B**	**B**		
2005	7	24	15	42	6.21	7.92	92.19	7.5	16	**A**	**A**		
2005	7	29	20	33	40.03	2.86	93.56	5.8	32	**A**			
2005	7	30	11	3	49.12	-61.47	154.25	6.0	10	**C**	**C**		
2005	7	30	15	13	20.12	5.18	94.48	5.8	38	**B**			
2005	8	2	8	39	51.70	-4.00	128.82	5.6	10	**D**			
2005	8	4	9	26	52.81	-3.66	140.18	5.8	40	**C**			
2005	8	9	5	26	17.53	-20.94	173.82	6.1	23	**D**	**D**		
2005	8	13	7	36	52.77	20.13	145.80	6.0	48	**C**	**C**		
2005	9	10	16	57	47.27	4.86	95.04	5.8	41		**B**		
2005	9	13	14	32	57.82	8.07	91.91	5.5	30		**A**		
2005	10	11	3	37	56.85	10.89	92.30	5.5	22	**C**			
2005	10	15	15	51	8.13	25.31	123.35	6.4	192	**A**			
2006	2	3	4	47	36.36	36.16	141.45	5.7	28		**C**		

2006	2	3	20	34	12.71	11.90	92.41	6.1	30	A		
2006	2	28	7	31	0.65	28.12	56.87	6.2	18	D		
2006	3	9	17	55	55.40	0.79	-26.12	6.0	10	D	D	
2006	4	19	20	36	48.30	2.65	93.24	6.2	30			B
2006	4	20	23	28	3.90	60.87	167.01	6.1	10			D

A	detected and readable	C	triggered but difficult to read
B	Only S arrival	D	not detected

Earthquake Detectability

First the earthquake detectability by these short period sensors was checked using the data of Station, PRD and the Station RJR as those stations have relatively large number of records. The results as shown in the following graphs (Fig.1) indicate that this short period sensor can detect readable events even with magnitude greater than 6 and also the distance around 20 degrees.

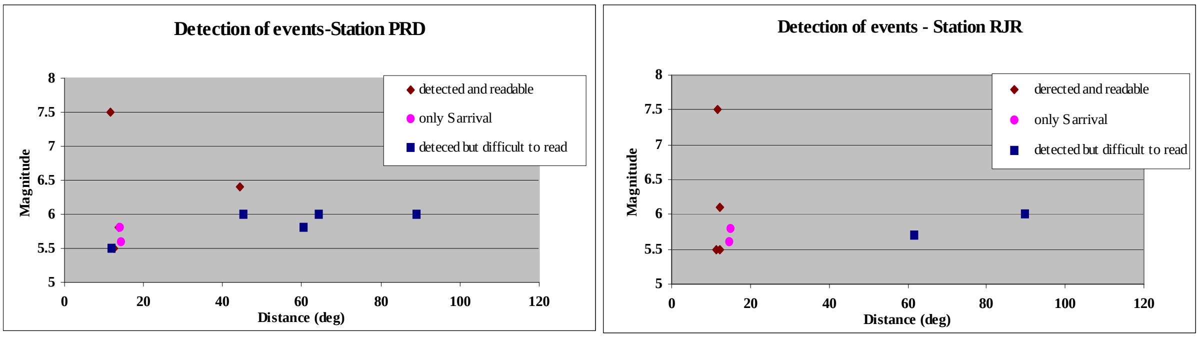


Figure 1. Graphs showing the Detectability by (a) Station PRD (b) Station RJR

Arrival Times of P and S waves

Seven events, magnitude greater than 5.5 were selected among the available data and used for further analysis. The P and S were picked to calculate S-P interval. The theoretical travel time for relative events were calculated using the Taup-kit (based on IASP91 model). Finally the both theoretical and observed results were compared to find the accuracy of the observations.

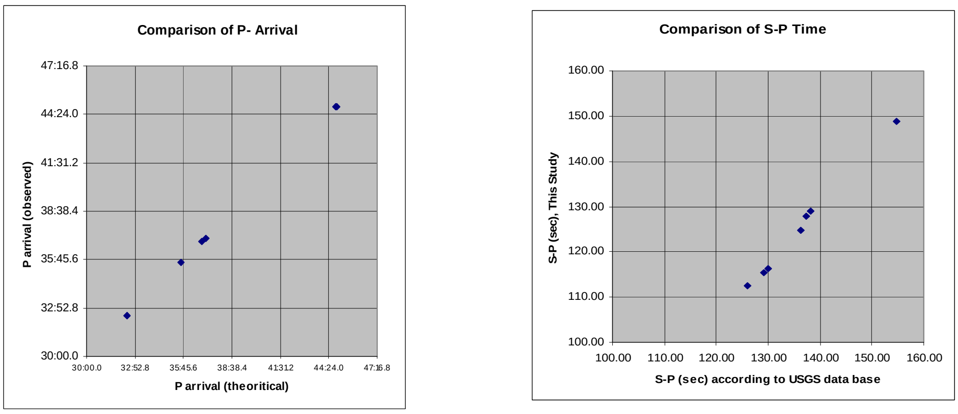


Figure 2. (a) Comparison of P-arrival (observed) with P-arrival (theoretical)
(b) Comparison of S-P time (observed) with S-P (theoretical)

Results in the Figure 2 show those theoretical and observed P-arrival times are almost identical but there is a significant decrease in S-P time difference.

PROPOSAL FOR UPGRADING
TSUNAMI/EARTHQUAKES MONITORING SYSTEM IN SRI LANKA

In this chapter, the current problems of the University Seismic Network and the proposals of its upgrade are discussed in detailed.

Problems of current University Seismic Network

The result of the study on the current status of the University Seismic Network in Sri Lanka has shown that this network can detect events with magnitude greater than 6, the epicentral distance up to 20 degrees. The ability to detect such large events in the Sumatra Andaman region is useful for Tsunami Alert in Sri Lanka. Because Sri Lanka has a risk of tsunami which will originate from the Sunda trench located around 1000-1700km away from the Island. However, there are two major problems that are highly desirable to the solved to improve and enhance earthquake monitoring in Sri Lanka. One of these problems is the low S/N ratio. At present, it is difficult to detect local events as well as events with M<5.5 in the Sumatra – Andaman Region. The other problem is bad communication links between the Central Station and four stations. Due to this problem the system did not function well.

Upgrade Plan for Earthquake/Tsunami Monitoring in Sri Lanka

Relocation - Because of the low S/N ratio, the system is unable to detect smaller events in regional scale and local events. However Over the past few years, tremors have been reported within the country (for example recent earth tremors occurred in Tissamaharama area, South-Eastern part of Sri Lanka in July 2007) by the general public in frequent manner. Most of these tremors were very, local, confined to particular region within the island and these events were not registered in any Global Seismic Network. Local scientists were also unable to determine under the present conditions of seismic monitoring. As most of those events are not registered in Global Network, the monitoring of seismic activities by local seismic network is uttermost important. The sensors should be relocated with appropriate noise survey to enhance the data quality and get high quality data for early warning and research purpose. Relocation is one of the major important points otherwise this system can not be used in hypocenter determination of local events.

Real Time Data Transferring - The observations indicate that there haven't been any serious hardware problems with the sensor and recording equipments. The lack of availability is mainly caused by bad communication link. The modems are breakdown easily due to the interrupted power supply and thundering and it stop the data transfer between the data center and seismic stations. In the current system, data is not transferred on real time basis. The data communication links within the system are as follows. At each station, continuous data consisting of one minute data segments are kept for one month. When it detects an arrival of seismic signal, that information is sent from station to the Data Center every 20 minutes. Then the program at Data Center sends a batch file for retrieval of event data to each station every 20 minutes. At each station, the continuous data files are copied from the directory where continuous data are kept to the directory where the event data files are kept (in the current system, an actual event file is not created. Instead, series of continuous data segments which are expected to contain seismic signals are kept). Then the data collection program running at the Data Center retrieve event data every 40 minutes. After event data are collected at the Data Center, the file conversion program converts ".evt" files to SEISAN files. This program also creates event files (S-files in SEISAN file system).

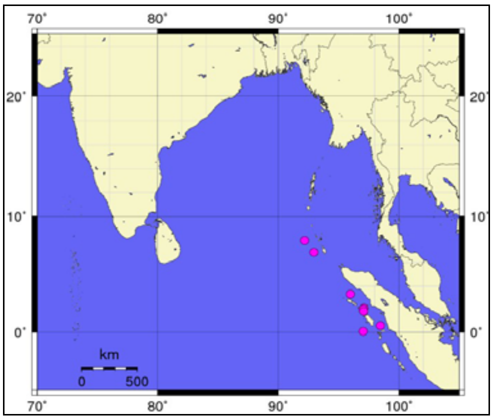
These three communication steps should be carried out properly between each station and the data center for event triggering and registration. Due to the bad communication and often power supply failure, these steps have not been properly completed. For continuous monitoring of large earthquakes in regional distance range and small events in the island it is necessary to link all of the stations to the data center to collect data on a real time basis through a dedicated line instead of dial up phone connection. Since the current system is complicated and since one or some data transfer procedure have not worked properly event files are not available. And also the data transfer takes long time. It is too slow for tsunami alert. It is essential to data transfer on real time basis for tsunami monitoring and alert. In addition to making the data transfer of the University Network on a real time basis, it is necessary to receive broadband waveform data from PALK on a real time basis to establish proper monitoring system.

Establishment of National Data Center - According to the National Disaster management System in Sri Lanka, Geological Survey and Mines Bureau (GSMB) is responsible for monitoring of seismic activities, especially the micro-seismic activity within the country and GSMB also advises the Department of Meteorology on possible tsunami threats of seismic origin. The GSMB has now established a National Data Centre for seismic information. Therefore, it is essential to transfer the near real time data to the National Data Center at the Geological Survey and Mines Bureau. In future, existing broadband station and another two proposed broadband stations which will be installed with the assistance of the German Government as well as a University Seismic Network maintained by the University of Peradeniya are to be gathered and analyzed at this Data Centre. To achieve this target, personnel training are needed specially in hardware and network to face the problems with the breakdown or maintenance of the equipments and also training on data processing. If this integration is realized, it is possible to determine hypocenters and earthquake magnitudes (M_{wp}) for 24 hours a day. Before it, still it is possible to determine epicentral distance using S-P. In 2004, Indian Ocean Tsunami killed around 36 000 people because of lack of experience in tsunami issuance and also lack of awareness. Therefore it is necessary to prepare to avoid such kind of disaster in future. In such a case accuracy as well as rapidness is important. Therefore in this study, M_{wp} using the data from PALK station was determined as shown in another chapter to check the reliability of calculation of M_{wp} using single station. The result of determination of M_{wp} even using single station is acceptable. This integrated basic information is useful for making decision on tsunami warning. The data can be verified with the linkage of PTWC and JMA.

In this study, a good agreement between the observed P arrival time and the theoretical P arrival time was observed but there is a systematic decrease in S-P time difference. It is important to carry out further detailed study on this regard and also it may be interesting to try to determine the mb using the currently available data.

DETERMINATION OF M_{wp} USING PALK BROADBAND DATA

I propose above real time data transfer from PALK station, and M_{wp} for some events were determined to investigate the accuracy of magnitude estimates using single station within this system.



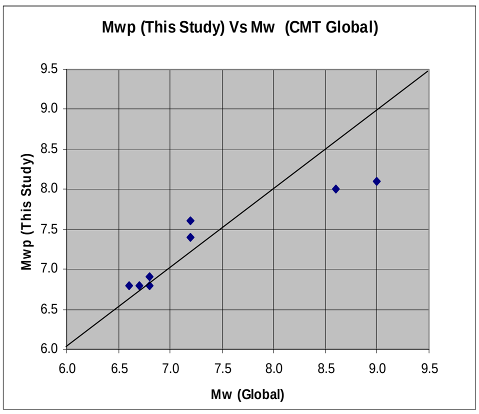


Figure 3. Events used for M_{wp}, Comparison of M_{wp} (This Study) and Mw (Global CMT)

The procedure by Tsuboi *et al*. (1995, 1999) was followed. Tsuboi *et al*. (1995) introduced broadband moment magnitude $M_{wp.}$ Determination of the Moment Magnitude (M_{wp}) from the digital waveform by

PALK GSN station was done using the method described in Tsuboi *et al*. (1995, 1999) which uses the broadband seismograms for calculating broadband moment magnitude M_{wp}. The P-wave moment magnitude, M_{wp} is calculated from the vertical component of far-field P wave displacement. Eight events were selected from the USGS/NEIC catalog from 2004 to 2007 within the 25 degrees from the station and the hypocenter depth is less than 100km. The hypocenter parameters were taken from USGS database. Distribution of the events and the location of the station are shown in Fig.4. The results obtained by this study were compared with the moment magnitude determined by the Global CMT solutions and the results are shown in Figure 3 up to magnitude 7.5. Results are within a less uncertainty except two events (M>8)) which suggests that it is possible to obtain relatively reliable M_{wp} by analyzing even single station. Result has shown that the M_{Wp} is reliable up to around 7.2 while it is under estimate for large earthquakes. In this case December 26, 2004 Sumatra earthquake (M_w9.0) and the March 28, 2005 Northern Sumatra earthquake (Mw8.6) are probably out of the range of the applicability of M_{wp} calculation.

CONCLUSION

The investigation on data availability, detectability and P, S arrival times reviled that there is no major hardware problem with sensors and recording instruments. Poor site selection, improper communication links are the major drawbacks. The results show that many records of events are missing at the Central Station due to the communication problem and the unstable power supply. The system is able to detect events with magnitude greater than 6, within the epicentral distance up to 20 degrees. Due to low S/N ratio, it is difficult to detect smaller evens and local events. I found a good agreement between the observed P arrival time and the theoretical P arrival time. It is possible to obtain rough guesses on the epicentral distance using S-P times although there is a systematic decrease in S-P time difference. Based on these results, I propose an upgrade plan of the current network consisting of relocation of the sensors and establish real time data communication. As monitoring of local events is an important and a primary issue, it is necessary to relocate the sensors and real time data transferring is needed for quick decision making on Tsunami alert. It is desirable to combine data from the University Seismic Network and data from the PALK broadband station for earthquake monitoring and tsunami alert for Sri Lanka. I calculated broadband moment magnitude to check the reliability of use of single station data for M_{wp} calculations and it is found that this procedure can be used to determine relatively reliable magnitude estimates.

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