Application of Simulation Methods to Understand Tsunami Processes Around the Coastal Region of Sri Lanka

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Abstract Tsunami is one of the most devastating natural disasters which cannot be prevented or precisely predicted even with the modern advanced technology. One of the best solutions for prediction as well as for the risk analysis of this natural disaster is Numerical Modelling. Present study focuses on the generation of earthquake induced different Tsunami scenarios from the potentially high amplitude earthquake generation zones in the Indian Ocean using Tsunami numerical modelling. Simulation modelling for different scenarios was carried out for source, propagation and inundation using UNESCO/IOC recommended interfaces of AVI NAMI and ComMIT, which uses TUNAMI N2 model. Etopo 2, JEBCO (combine SRTM, ETOP2 and Sea Map data) were used for bathymetry analysis. Distribution of wave heights, run up heights for given locations and arrival times of the waves were simulated as output data. Different Tsunamis were simulated, taking Java Sumathra and Macrum zones as Tsunami sources. Wave heights and propagation of Tsunami waves around twelve locations of Sri Lanka were analysed and vulnerable areas for different scenarios were identified. Results further indicated that if a Tsunami is triggered at Java-Sumatra, Southern part of Sri-Lanka will be severely affected, and particularly the Yala region, because of the direct hit of the Tsunami waves. ComMIT simulation results showed strong coupling to Tsunami sediment data and actual tidal records for 26th December 2004 Tsunami. Therefore, ComMIT seems to be one of the best models for Tsunami warning and forecasting in Sri Lanka.

Keywords: Numerical Modeling, Propagation, Topography, Tsunami

1. Introduction

The earthquake of Sumatra on 26th December 2004 earthquake had triggered a giant Tsunami and the Tsunami waves that propagated throughout the Indian Ocean caused extreme inundation, extensive damage and loss of property and lives along the coasts of 12 surrounding countries in the

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Indian Ocean. The loss of lives has also been extended to the people from totally 27 countries from other parts of the world. The number of casualties and missing personals from the countries bordering Indian Ocean were more than thousands.

Sri Lanka is one of the countries which was badly affected by the devastating Tsunami in 2004.

The Tsunami source was located near Java-Sumatra islands. The earthquake had a magnitude of 9.3 in Richter scale. The focal depth was 30 km and rupture zone was 1200 km long. In the past, people believed that Tsunami is an event, which occurs once in a 100 years. But during last 2 years there were 3 major earthquake generated Tsunamis. Because these earthquakes occurred in the Indian Ocean, there is a probability for more Tsunamis to affect Sri Lanka in the future. So, Sri Lankan people have a question which lies with in their mind as to whether they are capable of facing this natural disaster or not? The focus of this project is to find a way to face this event. There are solutions like permanently removing people from the coastal areas or building structures that can withstand the Tsunami waves. But socio-economically, it is not a good solution. Tsunami Numerical modelling which can be used to forecast tsunami is one of the most important tools for risk analysis and evacuation plans. In Tsunami Numerical modelling, solitary wave equation derived for the tsunami wave equation is simulated by computer softwares to create artificial Tsunamis. There are 3 main steps in Tsunami Numerical Modelling. They are source, propagation and inundation modelling. Main objective of this project is to create artificial Tsunamis from Indian Ocean Tsunami sources, which are Java Sumatra and Macrum zone, and how it can affect Sri Lanka. This study would give insight into tsunami forecasting in the future scenarios.

2. Methodology

Tsunami earthquake sources for different scenarios were identified by analysing 100 years of earthquakes which had a magnitude more than 7.0 and focal depth less than 70 km. Different scenarios are selected based on magnitude, focal depth, slip angle, dip angle and locations. TUNAMI N2 model which uses the solitary wave equation is used for the simulations. Bathymetry data were prepared using the ETOPO 2, JEBCO and Sea Maps. Source parameters were taken based on past earthquake data and UNESCO/IOC data base. Avi Nami and ComMIT models (Source code TUNAMI N2), which are recommended by UNESCO/IOC, were used to create artificial Tsunamis for different sources and for different source parameters for both Java-Sumathra subduction zone and Macrum Subduction zone.

4. Results

4.1 Numerical Modelling using Avi Nami

From Avi Nami the first wave arrived to Galle after 171.2 mins up to 0.045m height. But in ComMIT the initial wave arrived after 132 mins and up to 0.12m. But from both softwares second wave is the highest wave reached to Galle. It arrived there in Avi Nami after 230.5 mins and in ComMIT after 162 mins. The third and fourth waves from Avi Nami arrived after 304.8 and 337.3 mins up to 0.061m and 0.063m high. In ComMIT they arrived at 198 and 222 minutes after up to 0.13 and 0.15 m high, respectively.

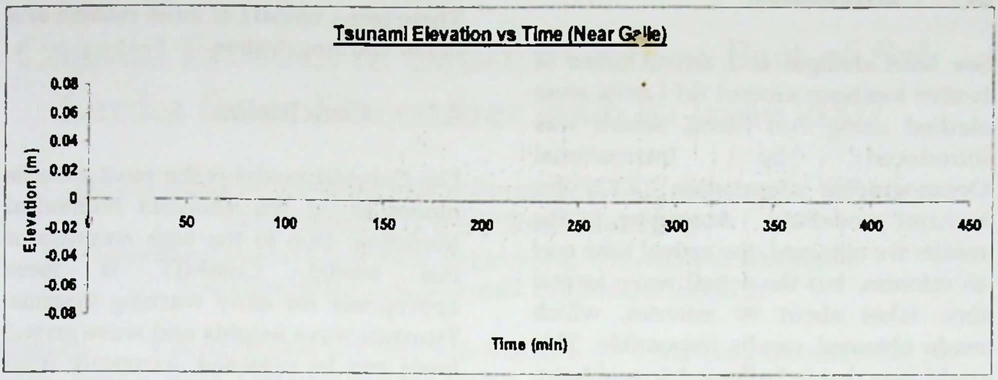

Figure 1. Tsunami wave height variation with time near Galle area

Table 1. Major Tsunami wave arrival times and wave heights using Avi Nami

Wave	Elevation (m)	Time (min)
First wave	0.045	171.2
Second wave	0.062	230.5
Third wave	0.061	304.8
Fourth wave	0.061	337.3

Table 2. Major Tsunami wave arrival times and wave heights using ComMIT

Wave	Elevation (m)	Time (min)
First wave	0.12	132
Second wave	0.35	162
Third wave	0.13	198
Fourth wave	0.15	222

4.2 Numerical Modeling Using ComMIT

Results obtained from Galle area are presented in Figure 2 and Table 2.

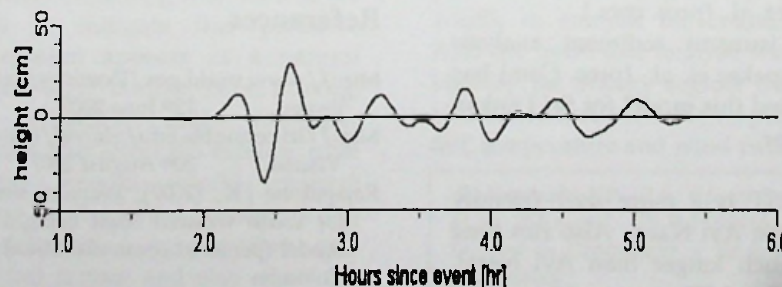

Figure 2. Tsunami wave height variation with time near Galle area

5. Discussion

Sea level changes and arrival times of twelve locations around Sri Lanka were studied using Avi Nami, which was introduced by International Oceanographic Committee (IOC) for tsunami modelling. According to the results we obtained, the arrival time was 45 minutes, but the actual wave arrival time takes about 90 minutes, which made obtained results impossible. This could may due to bathymetric problems, which arise due to the low resolution of ETOPO 2. Deep water bathymetry is not complex and smooth variation can be seen, but in continental shelf the bathymetry is much complex. For confirmation of this problem, the model was run to the tsunami data buoy located near Java Sumatra. After run the model for 12th September 2007 Tsunami, it indicated a zero wave height, eventhough actual results were shown 10 cm wave height. According to the above mentioned results, it indicated that reliability was quite questionable in this Avi Nami model.

Model results from the ComMIT shows reliable arrival time for the Galle region. Further it shows predominant tsunami wave was the second wave. Sediment analysis south western coast of Sri Lanka indicates that second wave was always the predominant wave. Ratnayake et. al., (pres. com.)
. Further tsunami sediment analysis shows Rajapakse et. al., (pres. Com) has also validated this model for Sri Lankan coastal water.

The ComMIT is a more user friendly software than Avi Nami. Also run time was not much longer than Avi Nami. There fore ComMIT is more time saving software. Actually for numerical modelling results within very short time duration is required, because there should be enough time to give warnings. There fore ComMIT is more reliable as a better warning system.

4. Conclusion

The ComMIt model is the most suitable model to do the Tsunami Numerical Modeling. Due to the high accuracy of this model, ComMIT is more appropriate for early warning systems. Tsunami wave heights and wave arrival times can be obtained accurately from ComMIT model. Therefore The Disaster Management Centre (DMC) can use this model for risk analysis and inundation mapping.

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