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11. Abstract

Aftermath of the Indian Ocean Tsunami of December 26, 2004, which caused approximately 230 000 fatalities, the Ministry of Earth Sciences (MoES) has taken up the responsibility to establish the National Tsunami Early Warning System at Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. The Indian Tsunami Early Warning System (ITEWS) is operational since October, 2007 and comprises of a real-time network of Seismic Stations, Bottom Pressure Recorders (BPR) and Tide gauges to detect Tsunamigenic earthquakes and to monitor tsunamis. A state-of-the-art early warning centre was developed with all the necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure.

This report describes about the various components of the ITEWS, provides a glimpse of the standard operating procedure followed for dissemination of the advisories, the types of products generated and the action to be taken for different threat status of the advisories.

12. Keywords: **Indian Tsunami Early Warning system, Standard Operating Procedure, Coastal Forecast Zones, Decision Support System, Tsunami Advisories**

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Technical Report Report No. INCOIS-ASG-TR-2011-04

National Tsunami Warning Centre (NTWC) services of the Indian Tsunami Early Warning Centre

Indian National Centre for Ocean Information Services
Ocean Valley, Pragathi Nagar (B.O), Nizampet (S.O)
Hyderabad- 500090

August, 2011

Acknowledgements

We are grateful to eminent Scientists and Administrators in the various Ministries and Departments of Government of India for their insights in establishing world-class Tsunami Early Warning Centre at INCOIS, Hyderabad. Our sincere thanks to former secretaries Dr. H.K. Gupta, Dr. P.S. Goel and former directors of INCOIS Dr. K. Radhakrishnan, Dr. Shailesh Nayak and current director Dr. S.S.C. Shenoi for their approach and valuable guidance in establishing and commissioning the Tsunami Early Warning System as a very sophisticated advanced system in the Indian Ocean region.

NTWC services of the Indian Tsunami Early Warning Centre

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National Tsunami Warning Centre (NTWC) services of the Indian Tsunami Early Warning Centre

1. Introduction

The great Sumatra earthquake (Mw 9.3) of 26th December, 2004, was rated as the world's second largest recorded earthquake. This earthquake generated a devastating tsunami, which caused unprecedented loss of life and damage to property in the Indian Ocean rim countries. The tsunami was considered as one of the deadliest natural hazards in the history, killing over 230,000 people in fourteen countries. In India it claimed 10,745 lives according to official estimates. In response to this disaster, the government of India took up the task of establishing an Early Warning System for Tsunamis and Storm surges. The Ministry of Earth Sciences (MoES) has taken up the responsibility of establishing the Indian Tsunami Early Warning System (ITEWS) and is based at & operated by Indian National Center for Ocean Information Services (INCOIS), Hyderabad. The Indian Tsunami early warning system is an integrated effort of different organizations under MoES along with the Department of Space (DOS), Department of Science and Technology (DST), the Council of Scientific and Industrial Research (CSIR), Survey of India (SOI) and National Institute of Ocean Technology (NIOT).

The major objective of Indian Tsunami Early Warning Centre (ITEWC) is to detect, locate, and determine the magnitude of potentially tsunamigenic earthquakes occurring in the Indian Ocean Basin. A database of all possible earthquake scenarios for the Indian Ocean is used to identify the regions under risk at the time of event. Significant changes in Sea Level are monitored at the time of occurrence of tsunamigenic earthquakes. Timely tsunami advisories (Warning/ Alert/ Watch) are disseminated to the vulnerable community following a Standard Operating Procedure (SOP) by means of various available communication methods.

The National Tsunami Early Warning Centre at INCOIS is operational since October 2007 and has been issuing accurate tsunami advisories for all under-sea earthquakes of $\geq$ 6.5 M. The warning system has been undergoing constant improvements incorporating the latest developments in tsunami science as well as Information and Communication Technology (ICT). This document provides latest details of the tsunami early warning services provided by INCOIS, such as the observation network, modelling, operating procedures, products, dissemination methods, etc., and is intended to serve as a user guide to the national disaster management agencies.

2. ITEWS Components

The ITEWS comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR), tide gauges and 24 X 7 operational tsunami warning centre to detect tsunamigenic earthquakes, to monitor tsunamis and to provide timely advisories to vulnerable community by means of latest communication methods with back-end support of a pre-run scenario database and Decision Support System (DSS).

2.1. Seismic Network

As part of the Indian Tsunami Early Warning System, a Real Time Seismic Monitoring Network (RTSMN) has been established by India Meteorological Department (IMD). The network comprises of 17 Broadband seismic field stations transmitting real time data through V-SAT communication to the Central Receiving Stations (CRSs) located at IMD at New Delhi and INCOIS, Hyderabad simultaneously for processing and interpretation. In addition to this, data from around 300 global seismic stations is received at INCOIS in near-real time. Most of these data are provided by IRIS Global Seismographic Network and GEOFON Extended Virtual Network. These datasets form the basis for determining preliminary earthquake epicenters and magnitudes. The location of current network of stations is as shown in the figure-1. For determining tsunamigenic potential of an earthquake moment magnitude, Mw, is useful. It is computed based on the long-period components of the seismic signal and is more accurate for very large earthquakes. INCOIS uses Response Hydra and Seiscomp for autolocation of earthquakes. All earthquakes of >5 M are autolocated within 5 – 10 minutes of occurrence.

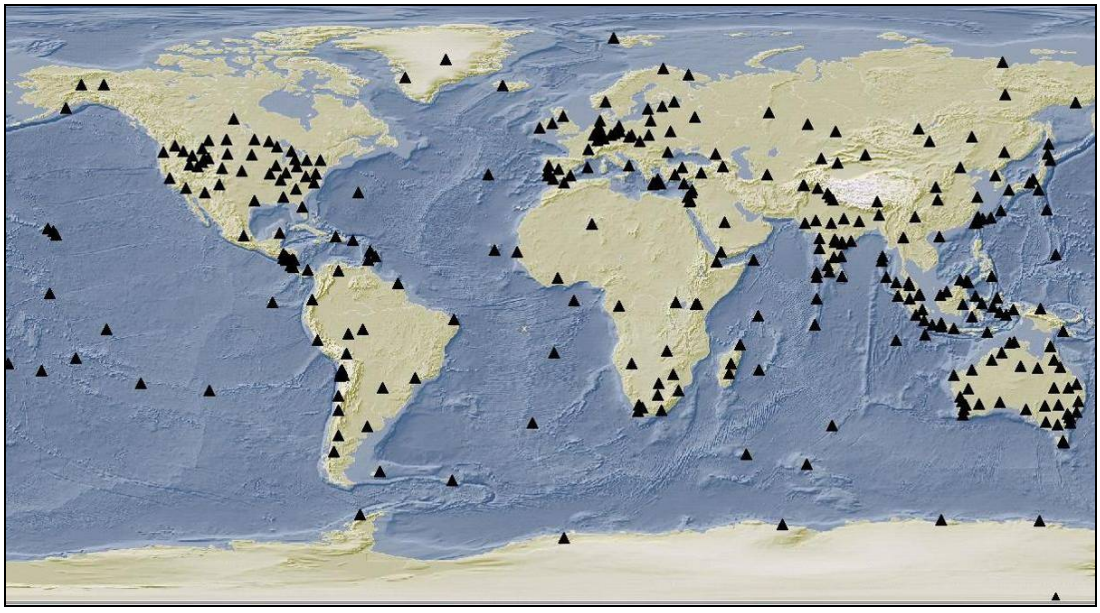

Figure 1: Real Time Seismic Monitoring Network, INDIA

2.2. Modelling

The use of numerical modeling to determine the potential run-ups and inundation from a local or distant tsunami is recognized as useful and important tool, since data from past tsunamis are usually insufficient to plan future disaster mitigation and management plans. Models can be initialized with potential worst case scenarios for the tsunami sources or for the waves just offshore to determine corresponding impact on near by coast. Models can also be initialized with smaller sources to understand the severity of the hazard for the less extreme but more frequent events. This information then forms the basis for creating tsunami evacuation maps and procedures.

At INCOIS a finite difference code of TUNAMI N2 (Imamura, 1996) is employed to study the tsunami. The TUNAMI N2 model basically takes the seismic deformation as input to predict the run-up heights and inundation levels at coastal regions for a given tsunamigenic earthquake. The seismic deformation for an earthquake has been computed using Smylie and Mansinha, (1971) formulation using the earthquake parameters like location, focal depth, strike, dip and rake angles, length, width and slip of the fault plane. At the time of earthquake, only location, magnitude and focal depth are available immediately. For operational quantitative tsunami forecast, there needs to be a method to quickly estimate the travel times and run up based on the above available parameters. For this purpose, all the other input parameters such as length, width and slip are calculated from the magnitude using global relations. strike angle, dip angle and slip angle are considered for worst case scenario (strike angle parallel to trench or coast, dip angle 45 deg, slip angle 90 deg).

2.2.1. Pre-run Model Scenario Database

A "scenario" is a single tsunami model simulation that is calculated from the required initial seismic deformation condition with the pre-defined input fault geometry parameters of earthquake rupture, i.e., Fault Location, Depth, Length, Width, Displacement, Strike angle, Dip angle and Slip angle. Each Scenario output contains the expected tsunami wave travel times, run-up heights and directivity maps.

The scenario database of pre-computed scenarios is generated with the objective to use available real time seismic information to provide an immediate forecast of tsunami height at the coast. The database is developed for different levels of depth (10, 20, 33, 40, 60, 80 & 100 km) and magnitudes (6.5, 7.0, 7.5, 8.0, 8.5, 9.0 & 9.5), for 975 “simulations points”, each with separation of half a degree, covering all tsunamigenic sources in the Indian Ocean. The Model Domain that has been setup for Indian Ocean covers 30 N to 40 S latitude and 30 E to 130 E longitudes with a grid spacing 0.0450 degrees approximately (5.01km). Each simulation covers the entire Indian Ocean domain with 15 hours simulation time and a time step of 5 seconds. The tsunami profiles of 15 hours for every 15 seconds are saved at coastal forecast points for each scenario. The coastal forecast points are selected at 30 m bathymetry assuming that till such depth, the computation is linear. About 1800 CFPs are selected for the tsunami domain separated by ~50 km apart covering the entire Indian Ocean rim countries. Arrival times and wave heights at these coastal forecast points for each scenario are stored in a database. Travel times and Surge heights on 30 m bathymetry are interpolated to get the values at Coast. Whenever an earthquake occurs, the closest scenario to the event is extracted from the scenario database based on magnitude and hypocenter location to identify the regions at risk.

Further, as an improvement to the scenario database only Mw 7.5 is considered as the basis for 1000 unit sources covering all the tsunamigenic sources. In this database each unit source has a length of 100 km and width of 50 km that represents a rupture caused by a Mw 7.5 magnitude earthquake with a slip of 1m. During any earthquake event, the basic unit source open ocean propagation scenario is selected from the scenario database and depending on earthquake’s location and magnitude these basic unit source open ocean

propagation scenarios are either scaled up or down using scaling relations for any level of depth, eliminating the need for accessing huge database for matching scenario. The main advantage with this kind of approach is, for higher magnitudes such as 9.0, the rupture can be represented more realistically with multiple rupture zones of Mw 7.5, instead of a single uniform rupture zone. Further, real time observations of sea level will be used to "invert" for slip parameter. This information can be used to update the forecast.

2.2.2. Coastal Forecast Zones

The spatial dataset of coastal forecast zones, generated using Geographic Information system (GIS), forms the basis for translating the model simulation results into an actionable advisory covering a geographical section of the coastline. For practical purposes, it was decided that every 100 Km stretch of coastline should be represented by one coastal forecast zone.

Accordingly, each coastal forecast zone is represented by a rectangular box extending 100 km in length (along the coast) and 50 Km in width (across the coast). The box starts from a depth of 30 M bathymetry line to ensure that there are sufficient numbers of wet grids in the model simulations. The buffer of 50 km towards offshore was drawn for this 30m bathymetry line. The results of the model simulations from within the 100 x 50 km boxes are extrapolated to the adjacent districts (Figure 2).

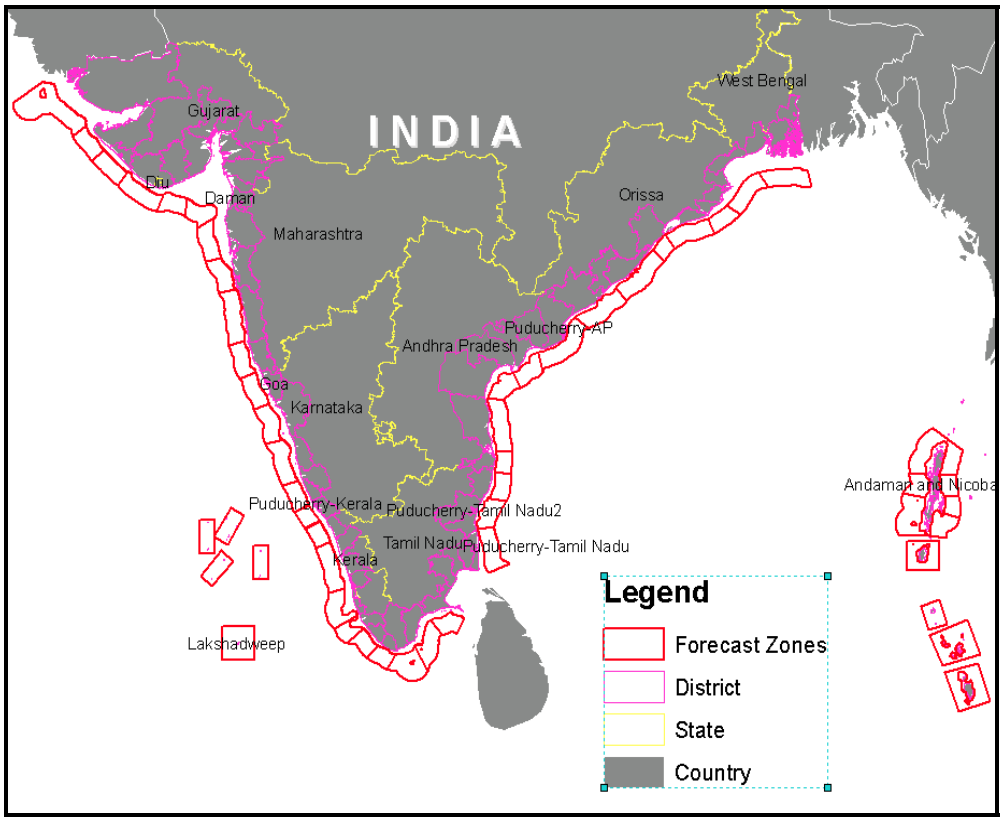

Figure 2: Map depicting the coastal boxes for ITEWC Products

Wherever possible, the coastal forecast zones are reappropriated to match one or a group of coastal districts to enable easy use at the local administrative level. While districts large enough have been represented in one coastal forecast zone, in case of smaller districts & gulfs, a group of districts have been clubbed into one coastal forecast zone. For example Vizianagaram district coast line is very small, so it is combined with the Visakhapatnam district and these two are represent as a coastal forecast zone. Similarly in case of Gulf, a group of five districts (Bhavanagar, Khada, Baruch, Surat & Valsad) is considered as a one forecast zone (Figure 3).

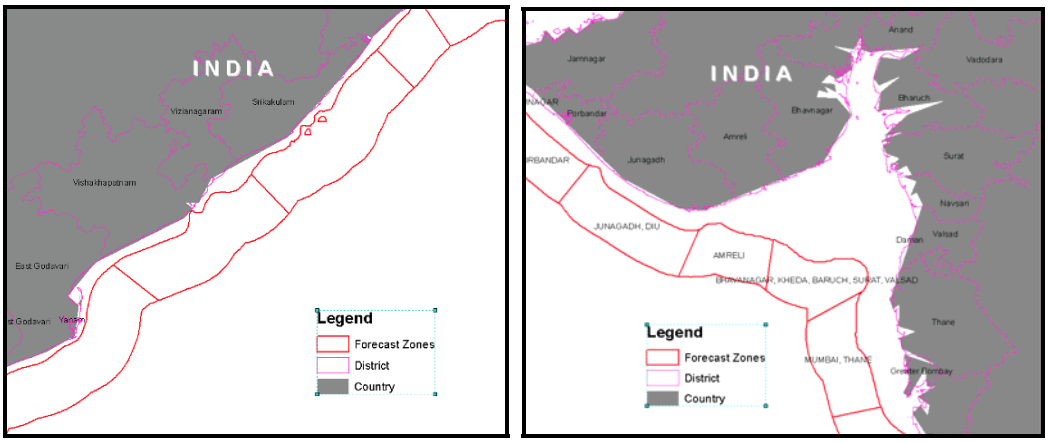

Figure 3: In the case of small district, group of districts clubbed in to one forecast zone

Each coastal forecast zone is associated with quantitative information extracted from numerical model simulations as listed in Table 1 below, based on which action could be initiated by the local administrators.

S.No.	Fields	Details
1	District/Region Name	Name of the District
2	State/Territory	Name of the State/Territory
3	ETA	Estimated Time of Wave Arrival in IST
4	EWA	Estimated Maximum Wave Amplitude in meters
5	Status	Areas under Warning/Alert/Watch/

Table 1: Attribute Table of the Bulletins

2.3. Sea-level Network

In order to confirm whether the earthquake has actually triggered a tsunami, it is essential to measure the change in water level as near to the fault zone with high accuracy. There are two basic types of sea level gages: coastal tide gages and open ocean buoys. Tide gages are generally located at the land-sea interface, usually in locations somewhat protected from the heavy seas that are occasionally created by storm systems. Tide gages that initially detect tsunami waves provide little advance warning at the actual location of the gage, but can provide coastal residents where the waves have not yet reached an indication that a tsunami does exist, its speed, and its approximate strength.

Open ocean tsunami buoy systems equipped with bottom pressure sensors are now a reliable technology that can provide advance warning to coastal areas that will be first impacted by a teletsunami, before the waves reach them and nearby tide gages. Since the tsunami waves will not yet be modified by local bathymetry, Open Ocean buoys often provide a better forecast of the tsunami strength than tide gages at distant locations.

The ITEWC's planned sea level network compromise of 7 tsunami buoys (5 in Bay of Bengal & 2 in North Arabian Sea) to be installed by NIOT and Tide gauge stations at 36 locations to be installed by SOI & INCOIS. The location of the BPRs and Tide Gauges is given in figure 4. Currently, 4 tsunami buoys (3 in Bay of Bengal & 1 in North Arabian Sea) and Tide Gauges at 25 locations are operational. Near-real time data is also being received from international stations. Necessary software for real-time reception, display and archiving of tide gauge data has been developed.

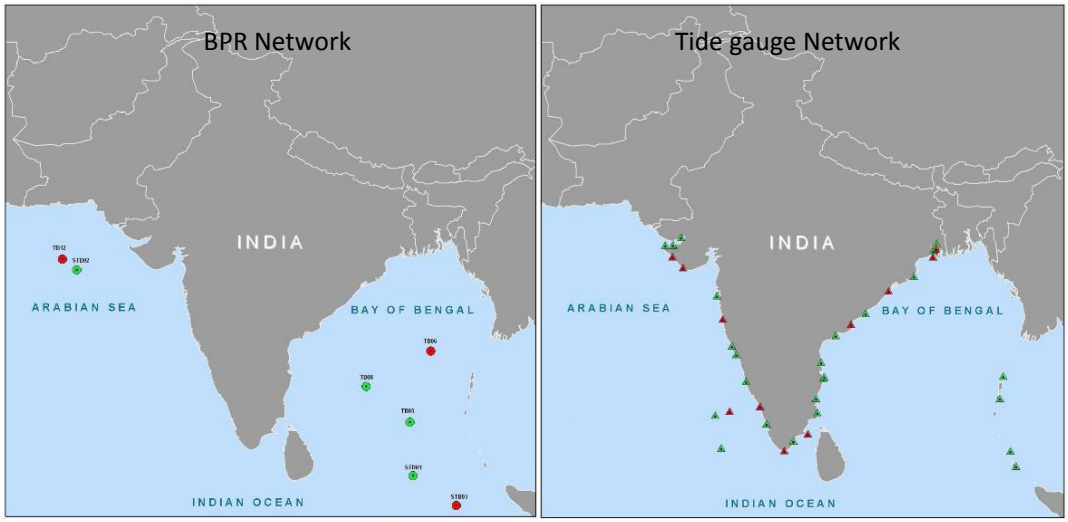

Figure 4: Tsunami Buoy Network and Indian Tide gauge

2.4. Decision Support System (DSS)

The Decision Support System is intended to (i) Monitor the online input data from individual sensors, (ii) Generate automatic alarms based on preset decision rules for one or many of the input parameters and (iii) Carry out criteria-based analysis for one or many input parameters to generate online advisories. Automated DSS software has been developed and deployed at the ITEWC that enables the operator to make quick decisions and generate advisories based on pre-defined decision rules following the SOP. Few snapshots of the DSS are given in figure-5.

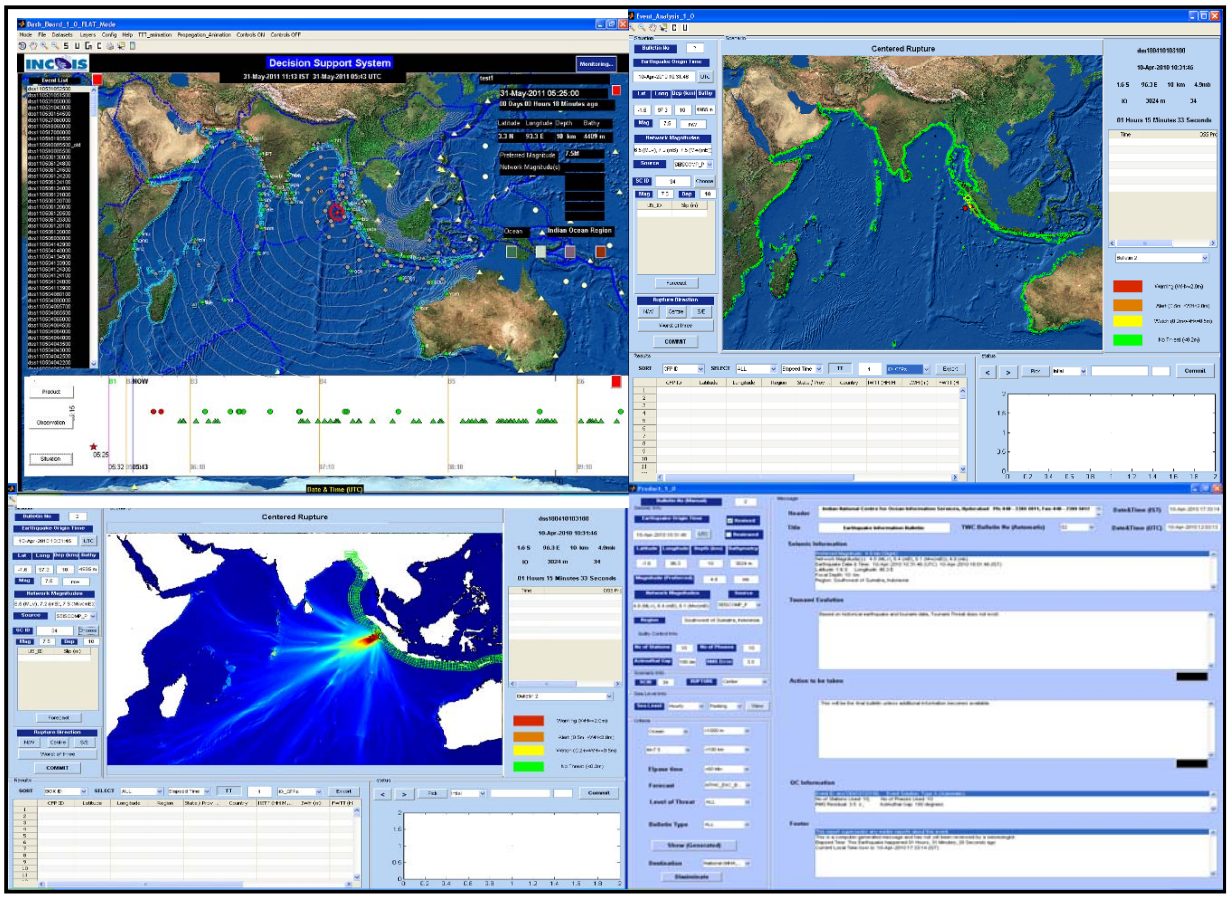

Figure 5: DSS system

2.5. Computational & Communication Facilities

A state-of-the-art data centre has been established at INCOIS with all the necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, analysis of the data, generation and dissemination of warnings following a standard operating procedure. Necessary redundancies are planned to ensure fault tolerance of the entire system configuration. All hardware elements are scalable. The entire warning centre infrastructure is hosted on highly reliable hardware designed for mission critical applications with necessary redundancies.

2.6. Manpower

The functions at the Tsunami Early Warning Centre are varied and require the expertise of multi-disciplinary group of scientists to perform 24 x 7 functions for routine monitoring, bulletin generation and dissemination, maintenance, etc. In addition, there is a large component of Research and Development to improve the system. The Tsunami Early Warning Centre currently has 14 Scientific / Technical Personnel working on a full time basis and 8 personnel contributing on a part-time / on-call basis. This team comprises of Geophysicists, Oceanographers, Marine Scientists, Electronics Engineers, Communication Engineers, Computer Engineers, Spatial Information Technologists, etc. The centre operates on a round-the-clock basis with three shifts of 8 hours in a day. The

centre is always manned by a shift in-charge, preferably a geo-physicist, who is assisted by two scientific personnel. In addition a senior geo-physicist is designated as scientist-on-call to be available at the warning centre within 15 minutes of any major earthquake. One scientist each is made functionally responsible to oversee different subsystems such as seismic, tide gauges, BPRs, modeling, computational facilities, communication facilities, application software, R&D, capacity building, etc. who will act as the single-point contact for that subsystem and will ensure effective operation and maintenance. All the personnel report to the warning centre in-charge who is the overall in-charge of the operations of the tsunami warning system and reports to Director, INCOIS.

3. ITEWC Service

3.1. Area of Responsibility

India

3.2. Types of Products:

The ITEWC services comprise two types of products:

3.2.1. Public Products: These products, released publicly, consist of easily understandable and actionable tsunami forecast information. Every coastal forecast zone in the spatial data (representing a district / group of islands) is provided with attributes such as Estimated time of arrival (ETA), Estimate Maximum Wave Amplitude (EWA) and Threat Category. Observations of positive wave amplitude and time (IST) at tideguage stations are also included in the bulletins. BPRs will be listed as having observed a tsunami, but no numerical height values will be provided.

3.2.2. Exchange Products: These products, released only to authorized nodal agencies involved in tsunami disaster mitigation, consist of detailed tsunami forecast information that needs expert interpretation. Every coastal forecast zone in the spatial data (representing a district / group of islands) is provided with attributes such as max_beach, max_deep, depth, travel times (T1, T2, T3, T4) and threat category. These products, which could facilitate advance actions by nodal agencies, are shared through password protected websites and other secure means.

3.3. Operational Procedures & Types of Bulletins

ITEWC services for an earthquake event commence whenever earthquakes are recorded with magnitudes ≥ 6.5 within Indian Ocean and magnitudes > 8.0 outside Indian Ocean. Duty officers respond immediately and begin their analysis of the event. The analysis includes automatic and interactive processes for determining the earthquake's epicenter, depth, and origin time, as well as its magnitude.

3.3.1. Notification Messages

The ITEWC issues brief Notification Messages alerting the recipients as and when a bulletin is issued. The notification messages contain earthquake parameters as well as web links to the detailed Bulletins. An example of the Notification message is given below:

```
TSUNAMI BULLETIN NOTIFICATION MESSAGE NUMBER 1
Indian Tsunami Early Warning Center (ITEWC)
Indian National Centre for Ocean Information Services (INCOIS)
      issued at: 27-May-2011 11:33:24 (IST)
ITEWC INCOIS detected an earthquake with the following preliminary
information
Magnitude:          9.0 M
Depth:              10  km
Date:               27 May 2011
Origin Time:        1130 IST
Latitude:           7.2 N
Longitude:          92.9 E
Location:           Nicobar Islands

NTWC BULLETIN 1 is now issued and is available at
www.incois.gov.in/Incois/tsunami/Login.jsp?dssid=dss110527060000&amp;pid=NTWC

NTWC is a service of ITEWC, INCOIS for providing Tsunami Advisories
for India.
You are receiving this "Notification Message" via Dss_1_0 (Automatic
S_PRIMARY_NEW)) configured to send mail from  tsunami@incois.gov.in
```

3.3.2. Bulletin Types

Following is brief description about Types of Bulletins issued by Warning Centre. The bulletins/notifications issued for an event are numbered sequentially. The bulletins are identified by the header **"NTWC-INCOIS-yyyymmdd-hhmm-bulletin number (TYPE-X)"**.

For Indian Ocean earthquakes, Warning Centre issues **Type -I** bulletin that contains preliminary earthquake information & a qualitative statement on its tsunamigenic potential based on the following criteria:

Magnitude (Mw)	Product Type
$6.5 \geq M \leq 7.0$	Earthquakes of this size sometimes have small potential to generate tsunamis.
≥ 7.1	Earthquakes of this size sometimes have potential to generate tsunamis.

Table 3: Criteria for Tsunamigenic potential based on preliminary earthquake parameters

Based on preliminary earthquake parameters, the nearest matching scenario from pre-run model scenario database is selected. If pre-run model scenario indicates Estimated Wave Amplitude (EWA) < 0.2 m then **Type-II** is issued with **NO THREAT** information. However, the monitoring of sea-level observations continues.

If the Estimated Wave Amplitude > 0.2 m, then **Type-II** is issued with Estimated Time of Wave Arrival (ETA), Estimated Maximum Wave Amplitude (EWA) and Threat Category **(WARNING / ALERT / WATCH)** for each of the coastal forecast zones.

The criteria for generation of different threat types (WARNING / ALERT / WATCH) for a particular region of the coast are based on the available warning time (i.e. time taken by the tsunami wave to reach the particular coast). The threat criteria are based on the premise that coastal areas falling within 60 minutes travel time from a tsunamigenic earthquake source need to be warned based solely on earthquake information, since enough time will not be available for confirmation of water levels from BPRs and tide gauges. Those coastal areas falling outside the 60 minutes travel time from a tsunamigenic earthquake source could be put under a Alert/Watch status and upgraded to a Warning/Alert only upon confirmation from water-level data.

The criteria for considering an area under different Threat level (WARNING / ALERT / WATCH) are as follows:

Pre-run Model Scenario Results			
ETA ≤ 60 mins		**ETA > 60 mins**	
EWA (M)	**Threat Status**	**EWA (M)**	**Threat Status**
> 2	**WARNING**	**> 2**	**ALERT**
0.5 to 2	**ALERT**	**0.5 to 2**	**WATCH**
0.2 to 0.5	**WATCH**	**0.2 to 0.5**	**WATCH**

Table 4: Threat Level Status Criteria

As and when the revised earthquake parameters become available, or else if earthquake elapsed time exceeds > 60 mins, before the realtime sea-level data becomes available, then a supplementary to the Type-II (**Type-II Supplementary-xx**) is issued with revised Threat (WARNING / ALERT / WATCH) information.

If a Threat (WARNING / ALERT / WATCH) is issued or if there is otherwise the possibility that a tsunami may has been generated, Warning Centre monitors the sea level gauges such as open ocean BPRs and coastal tide gauges near to the epicenter.

If the readings from sea level gauges confirm generation of tsunami, Warning Centre issues **Type-III** with Threat (WARNING / ALERT / WATCH) information from model

scenario as well as observed water levels. As and when subsequent real-time observations become available or after 60 mins from the time of previous bulletin issuance, **Type-III Supplementary-xx** is issued. Type-III Supplementary-xx messages also contain Threat Passed information for individual Zones.

The **FINAL bulletin** is issued when there are no significant water level changes from multiple sea level gauges or 120 mins after the last exceedance of 0.5 M threat threshold at last Indian coast.

However, as local conditions would cause a wide variation in tsunami wave action the ALL CLEAR determination is made by local authorities.

The following table defines the bulletin types issued by the ITEWC & the timelines

Bulletin type	Information	Time of issue (Earthquake Origin time as T_0) mins
Type -I	Preliminary EQ Parameters and LAND / NO THREAT Information based on EQ Location, Magnitude & Depth.	T_0 + 20
	Preliminary EQ Parameters and Qualitative Tsunamigenic potential based on EQ Location, Magnitude & Depth	
Type-II	Preliminary EQ Parameters and NO THREAT Information from Model Scenarios	T_0 + 30
	Preliminary EQ Parameters and Quantitative Tsunami Threat (WARNING / ALERT / WATCH) Information from Model Scenarios	
Type-II Supplementary - xx	Revised EQ Parameters and Quantitative Tsunami Threat (WARNING / ALERT / WATCH) Information from Model Scenarios - If revised EQ Parameters are available much before the real-time water level observations are reported.	as and when revised earthquake parameters are available or after Earthquake Elapsed Time + 60 mins
Type-III	Revised EQ Parameters and Quantitative Tsunami Threat (WARNING / ALERT / WATCH) Information from Model Scenarios and Real-time water level observations indicating Tsunami Generation.	as and when the first real-time water level observation is available
Type-III Supplementary – xx	Revised EQ Parameters and Quantitative Tsunami Threat (WARNING / ALERT / WATCH) Information from Model Scenarios and Real-time water level observations indicating Tsunami Generation Threat PASSED information for individual Zones	Hourly update / as and when the subsequent real-time water level observations are available
Final Bulletin	Issued when water levels from multiple gauges confirm that no significant tsunami was generated.	
	120 minutes after a significant tsunami passes the last Indian threat zone.	

Table 4: Types of Bulletins

The DSS flow chart followed by ITEWC for its NTWC operations is as follows:

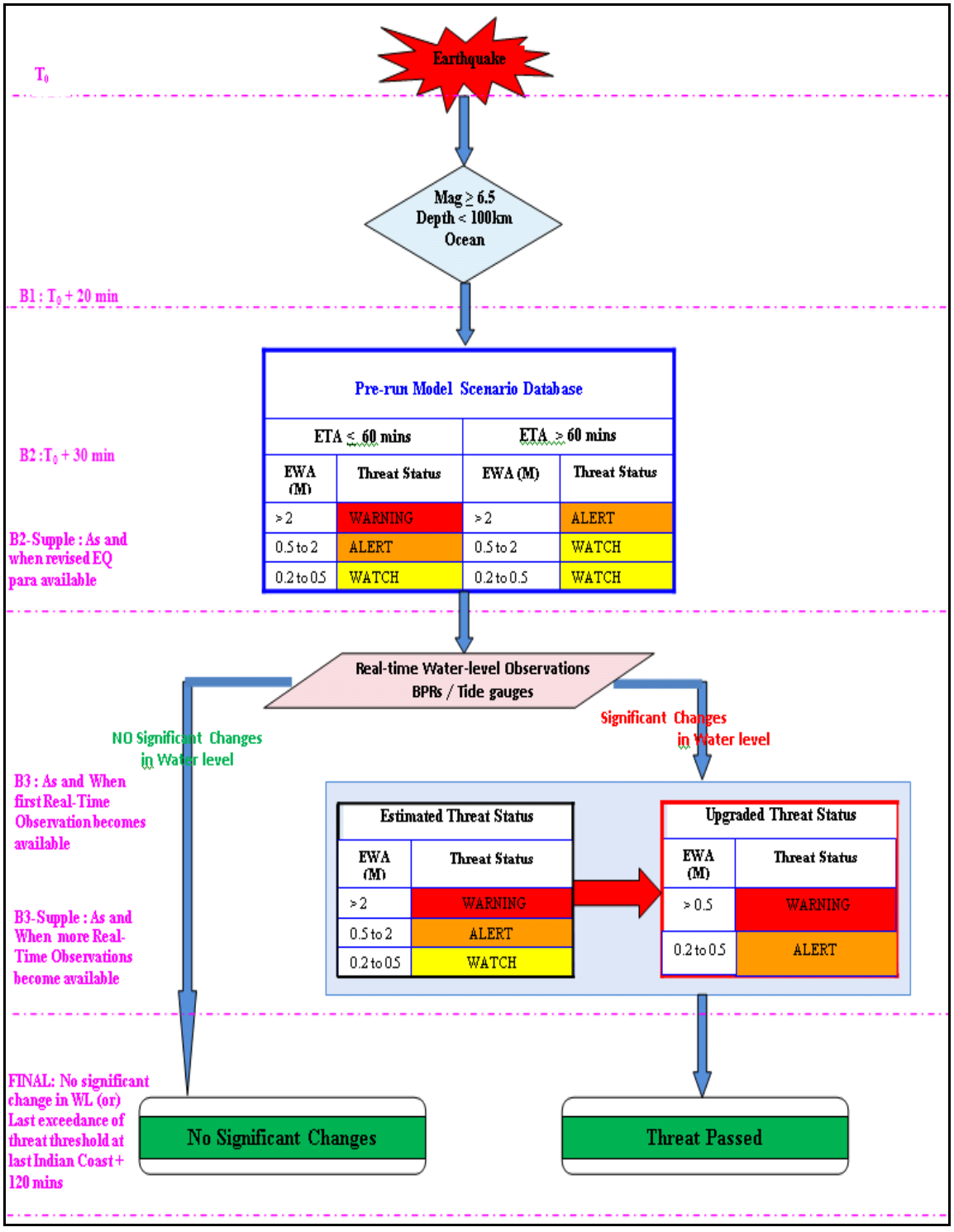

Figure 6: DSS Flow chart for NTWC Services

Actions Based on Threat Status (WARNING / ALERT / WATCH)

Threat Status	Action to be taken	Dissemination To
WARNING	Public should be advised to move in-land towards higher grounds. Vessels should move into deep Ocean	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media
ALERT	Public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into deep Ocean	MoES, MHA, MEDIA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media
WATCH	No immediate action is required	MoES, MHA MoES, MHA, MEDIA, NCMC, NDRF Battalions, SEOC, DEOC
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media

Table 5: Actions Based on Threat Status

4. Bulletin Content

The different sections in an NTWC bulletin are detailed below

4.1.1. Product Header

Product Header has four lines. The first line represents issuing authority followed by earthquake origin time in IST, bulletin number and type of the bulletin. The second line indicates tsunami bulletin number which is sequential, third line is issuing authority and fourth line indicates date and time in IST that the bulletin was issued.

Sample Header:

NTWC-INCOIS-20110527-1130-001 (TYPE - I)

TSUNAMI BULLETIN NUMBER 1

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1133 IST Friday 27 May 2011

4.1.2. Earthquake Parameters

Earthquake parameters are listed under “Earthquake Information”. These are preliminary parameters determined from very early data available from seismic data for tsunami

purposes. They may get revised following the initial bulletin as and when more stations data becomes available.

Sample Earthquake Parameters

EARTHQUAKE INFORMATION

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

4.1.3. Tsunami Evaluation Statement

Based on preliminary earthquake parameters, the first bulletin contains the information on tsunamigenic potential of the earthquake (local / regional / ocean-wide) according to range of the magnitude. If pre-run model results indicate a Threat (WARNING / ALERT / WATCH), the evaluation message indicates currently investigation is underway in second bulletin. Meanwhile if any sea level gauge indicates any significant change in water level that is listed from third bulletin onwards.

Sample Tsunami Evaluation Statement -1 ($6.5 \geq M \leq 7.0$**)**

Earthquakes of this size sometimes have small potential to generate tsunamis. However, so far there is no confirmation about the triggering of a tsunami. An investigation is under way to determine if a tsunami has been triggered. ITEWC INCOIS will monitor sea level gauges near epicenter and report if any tsunami wave activity has occurred.

Sample Tsunami Evaluation Statement - 2 (≥ 7.1**)**

Earthquakes of this size sometimes have potential to generate tsunamis. However, so far there is no confirmation about the triggering of a tsunami. An investigation is under way to determine if a tsunami has been triggered. ITEWC INCOIS will monitor sea level gauges near epicenter and report if any tsunami wave activity has occurred.

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of "Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the

zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by country (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

LITTLE ANDAMAN	1141IST 27 May 2011	11.9 m	Warning
NICOBAR	1131IST 27 May 2011	21.7 m	Warning

Sample Tsunami Evaluation Statement – 3 (No significant sea-level changes**)**

Real-time measurements of wave activity indicated that no significant tsunami was generated. When no major waves have occurred at least for two hours after the estimated arrival time then local authorities can assume that the threat is passed. As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities.

4.1.4.Advice

Following the headline is the Authority Statement. It indicates that the bulletin is issued as an advice only and that the condition of the alert and determination of action based on threat status is up to national or local authorities. The threat level definitions also included.

Sample Advice 1:

This is only a Heads-up message to the national/state/local authorities and disaster management offices. No immediate public action is required. This Bulletin is being issued as an advice. Only national/state/local authorities and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

Sample Advice 2:

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into Deep Ocean

For regions under WATCH (Yellow), no immediate action is required

When no major waves have occurred at least for two hours after the estimated arrival time then local authorities can assume the threat is passed. As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities..

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

4.1.5.Product Schedule

At the end of the bulletin is a statement regarding future bulletins. Threat (WARNING / ALERT / WATCH) bulletins are issued at an hourly schedule or as and when real-time water level observations become available. The FINAL bulletin is issued only when no significant water level changes are confirmed from the readings of multiple sea level gauges or else after 120 mins after the last exceedance of 0.5 M threat threshold at last Indian Coast which was under Threat.

Sample Product Schedule Statement

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

Sample bulletin formats are given as ANNEXURE -1.

5. Bulletin Formats & modes of dissemination:

- Notification Messages are issued in text format through email, Fax, SMS & GTS, as and when a tsunami bulletin is issued
- Bulletins are issued in both text and html formats through email, fax and website
- Graphic products such as Directivity maps, Travel Time maps and Threat status maps are made available in jpg or png format on the website
- Spatial data is made available in dbf format through the ftp site

6. Dissemination of Tsunami Bulletins:

Tsunami management guidelines issued by the National Disaster Management Authority (NDMA) in August 2010 mandates that ITEWC disseminates all tsunami bulletins to Ministry of Home Affairs (MHA), NDMA, National Crisis Management Committee (NCMC) and National Disaster Response Force (NDRF) battalions for taking appropriate action. In case of confirmed threat (ALERT/WARNING), the bulletins should also be disseminated to National Emergency Operations Centre (NEOC), State Emergency Operations Centres (SEOC), District Emergency Operations Centres (DEOC), public and media through all possible modes of dissemination.

Warning Time Line & Dissemination Actions

T_0	Earthquake Occurrence
T_0 + 20	Detection of Tsunamigenic Earthquake: Earthquake Information Bulletin: • A ROUTINE Tsunami Information Bulletin to be issued by NEWC to MHA, NDMA, NCMC, NDRF Battalions and MoES. This also contains preliminary evaluation of tsunami potential based on the magnitude. • (Regular status reports may be issued to MHA, NDMA, NCMC, MoES as required by NEWC).
T_0 + 30	*Earthquake expected to generate Tsunami, (on ocean, >6.5 Richter magnitude, <100 km Depth):* • A Warning/Alert/Watch will be issued by the NEWC based on scenario database results • Near Coastal Areas (< 60 min travel time of waves). o Warning: > 2 M Expected Run-up - FLASH - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media o Alert: 0.5 - 2M Expected Run-up - Emergency - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media o Watch: < 0.5 M Expected Run-up - Ops - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC • Far Coastal Areas (> 60 min travel time of waves). o Alert: > 2M Expected Run-up - Emergency - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC o Watch: 0.5 - 2 M Expected Run-up - Ops - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC
T_0 + 30 - T_0 + 120	Confirmation of Tsunami Generation *Tsunami not Triggered* • NEWC to withdraw Tsunami Alert and Tsunami Watch Bulletins and issue Tsunami Cancellation Bulletin to NEOC, MHA, NDMA, NCMC, NDRF Battalions, MoES and concerned near area SEOCs and DEOCs, public and media.
T_0 + 30 - T_0 + 120	*Tsunami Triggered* • NEWC to issue upgraded Tsunami Bulletins to various coastal regions. • Upgrade Tsunami Advisory Bulletin to Tsunami Watch Bulletin and Tsunami Watch Bulletins to Tsunami Alert Bulletin to NEOC, MHA, NDMA, NCMC, NDRF Battalions, MoES and concerned SEOCs and DEOCs.

Table 6: NDMA guidelines for Dissemination of Tsunami Bulletins

The tsunami early warning centre is equipped with latest dissemination facilities such as SMS, E-mail, Fax, Phone, Website, FTP, Electronic Display Boards (EDB) and a satellite-based Virtual Private Network for Disaster Management Support (VPN-DMS) to disseminate the tsunami advisories to various stakeholders.

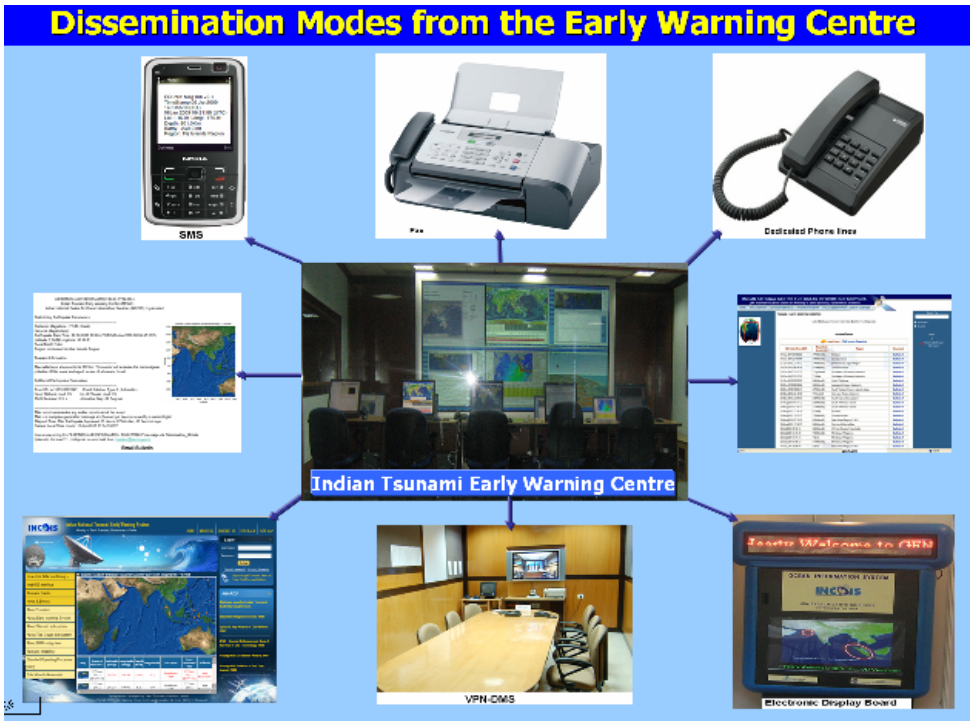

Figure 7: ITEWC dissemination modes

Presently ITEWC disseminates tsunami bulletins to the Ministry of Home Affairs (MHA) control room, Ministry of Earth Sciences (MoES), National Disaster Management Authority (NDMA) as well as Andaman & Nicobar Administration through Fax, Phone and Emails. Considering that A&N islands are close to the tsunamigenic zones, special priority is given to disseminate tsunami bulletins to the concerned authorities during an event through multiple dissemination modes. For instance, tsunami bulletins are also disseminated through four Electronic Display Boards installed in A&N Islands. Earthquake information, tsunami bulletins as well as real-time sea level observations are also made available on a dedicated website for officials, public and media. Users can also register on the website for receiving earthquake alerts and tsunami bulletins through emails and SMS. While currently, MHA & NDMA pass on the tsunami bulletins to NCMC, NDRF, SEOCs & DEOCs, future efforts will be focussed towards dissemination of bulletins directly from INCOIS.

7. RTSP Service for International Community

ITEWC has also set up the warning centre infrastructure so as to have the capabilities of a Regional Tsunami Advisory Service Provider (RTSP). The ITEWC RTSP service comprises two types of products:

7.1.Public Products: These products, released publicly, consist of Type-I (earthquake information), tsunami-genesis potential and an NTWC warning summary. Observations of positive wave amplitude and time (UTC) at tide gauge stations are also included in the bulletins. BPRs will be listed as having observed a tsunami, but no numerical height values will be provided.

7.2. Exchange Products: These products, released only to NTWCs, consist of detailed tsunami forecast information that needs expert interpretation. Every coastal forecast zone in the spatial data is provided with attributes such as max_beach, max_deep, depth, travel times (T1, T2, T3, T4) and threat category. These products, which could facilitate advance actions by nodal agencies, are shared through password protected websites and other secure means requested by the NTWCs.

For Indian Ocean earthquakes, ITEWC issues Type-I that contains preliminary earthquake information & a qualitative statement on its tsunamigenic potential based on the preliminary earthquake parameters, the nearest matching scenario from pre-run model scenario database is selected and the Type-II is issued with THREAT information. The agreed THREAT threshold for considering a country under threat is when the predicted positive wave amplitude is ≥ 0.5 meter at any location in that country. If pre-run model scenario indicates Estimated Wave Amplitude < 0.5 m then Type-II is issued with NO THREAT information. However, the monitoring of sea-level observations continues. As and when the revised earthquake parameters become available (before the availability of sea-level data), then a supplementary to the Type-II (Type-II Supplementary-xx) is issued with revised THREAT information based on updated parameters. If the readings from sea level gauges confirm generation of tsunami, ITEWC issues Type-III with Threat information from model scenario as well as observed water levels. As and when subsequent real-time observations become available or after 60 mins from the time of previous bulletin issuance, Type-III Supplementary-xx is issued. Type-III Supplementary-xx messages also contain Threat Passed information for individual Zones. The FINAL bulletin is issued when there are no significant water level changes from multiple sea level gauges or 120 mins after the last exceedance of 0.5 M threat threshold at last Indian Ocean member state coast.

8. Contact Details for the ITEWC

24 x 7 Monitoring Room Contact No. : + **91 40 23895011**

24 x 7 Monitoring Room Fax No. : **+91 40 23895012**

Email id: **tsunami@incois.gov.in**

Website Address: **http://www.tsunami.incois.gov.in**

http://www.incois.gov.in

Warning centre In-charge

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In-charge, National Tsunami Early Warning System (NTEWS)
Head, Advisory Services and Satellite Oceanography Group (ASG)

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Email: director@incois.gov.in

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10. Glossary of Tsunami Terms relevant for NTWC Operations

Tsunami Warning (RED): Highest level of tsunami threat assigned to coastal forecast zones with estimated wave amplitude of > 2 metres and estimated wave arrival of < 60 minutes. In such cases, Public should be advised to move in-land towards higher grounds and vessels should move into deep Ocean.

Tsunami Alert (ORANGE): Medium level of tsunami threat assigned to coastal forecast zones with (i) estimated wave amplitude of > 2 metres and estimated wave arrival of > 60 minutes or (ii) estimated wave amplitude between 0.5 and 2 metres and estimated wave arrival < 60 minutes. In such cases, Public should be advised to avoid beaches as well as low-lying coastal areas and vessels should move into deep Ocean.

Tsunami Watch (YELLOW): Low level of tsunami threat assigned to coastal forecast zones with (i) estimated wave amplitude between 0.5 and 2 metres and estimated wave arrival of > 60 minutes or (ii) estimated wave amplitude between 0.2 and 0.5 metres. In such cases, no immediate public action is required.

No Threat: Indicates that the coastal forecast zone is not under tsunami threat. No action is required.

Threat Passed (GREEN): Issued 120 minutes after the last exceedance of the threat threshold (50 cm for areas under Warning/Alert or 20 cm for areas under Watch). All clear determination to be made by the local authorities.

Tsunami Arrival Time: Time when the tsunami appears on the record.

Time of the Measurement: Time when the centre measured tsunami amplitude showed in its bulletin.

Period: Period of time in minutes from one crest to the next.

Amplitude: For the PTWC and WC/ATWC tsunami amplitude is measured relative to normal sea level. On the other hand, the NWPTAC reports amplitude in 0.1 meter unit by measuring half of trough to crest height.

Tsunami Height: Amplitude from predicted tide level to the crest of the maximum wave.

Initial Estimated Arrival Times: Computed from the epicenter of the earthquake to each forecast point using the physics principle that a wave will travel from point A to point B over whatever path in the ocean gets it there the fastest.

Warning area: Near beach or surrounding low-lying area

Earthquake magnitude: The magnitude used by PTWC is the moment magnitude, Mw. It is more accurate for large earthquakes than the more common Richter magnitude. The

moment magnitude determined by PTWC for initial products is Mwp, based on the first arriving seismic P waves. Subsequent estimates of Mw may be made by methods based on later arriving seismic waves.

Depth: Focal depth of the earthquake. Seismogically, earthquakes occurring at a depth of 100km or more considered not to generate tsunami regardless of its magnitude.

Location: Latitude and longitude of the earthquake. Tsunami is not generated by earthquakes occurring in inland areas. However, possibilities are not excluded if its epicenter is located very close to the sea.

Local tsunamis are those with destructive effects generally limited to within 100 km of their source. Destructive local tsunamis with runups tens of meters above normal sea level are possible.

Regional tsunamis are those with destructive effects generally limited to within 1000 km of their source. This is because either because the energy released was not sufficient to generate destructive ocean-wide tsunami, or because the source was within a confined sea.

Ocean-wide tsunamis are much less frequent, but still occur a few times each century, mostly in the Pacific. Such tsunamis can have disastrous consequences because their source area is large, initial wave heights are great, and even distant coastal areas are subject to destructive impacts.

Coastal Forecast Zones: To ensure interoperability between the RTSPs and NTWCs, it was decided that all the RTSPs will use a common spatial data set of specific "coastal forecast zones" for providing tsunami advisories. Every **coastal forecast zone** in the spatial data shall be provided with attributes such as max_beach, max_deep, depth, threat category, travel times (T1, T2, T3, T4). (Proposed IOTWS Service)

Max_beach: Maximum positive wave amplitude at the shore-line (Proposed IOTWS Service)

Max_deep: Maximum positive wave amplitude in deep water in each coastal zone (Proposed IOTWS Service)

T1: Time of arrival of the minimum detectable positive amplitude wave (Proposed IOTWS Service)

T2: First exceedance of the threat threshold (Proposed IOTWS Service)

T3: Time of arrival of max_beach (Proposed IOTWS Service)

T4: Time when the last exceedance of the Threat Threshold is forecast (Proposed IOTWS Service)

MoES – Ministry of Earth Sciences

MHA – Ministry of Home Affairs

NDMA – National Disaster Management Authority

NCMC - National Crisis Management Committee

NDRF - National Disaster Response Force

NEOC – National Emergency Operations Centres

SEOC - State Emergency Operations Centres

DEOC - District Emergency Operations Centres

ICG Intergovernmental Coordination Group

PTWS Pacific Tsunami Warning and Mitigation System (formerly ITSU)

IOTWS Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System

JMA Japan Meteorological Agency

GTS Global Telecommunication System

NTWC National Tsunami Warning Center

NTWFP National Tsunami Warning Focal Point

RTSP Regional Tsunami Advisory Service Provider

TOWS-WG Working Group on Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems

TWFP Tsunami Warning Focal Point

TWS Tsunami Warning System

ANNEXURE – I

Sample Bulletins

TYPE I: Preliminary EQ Parameters and NO THREAT Information based on EQ Location, Magnitude & Depth - within T + 10 Min

NTWC-INCOIS-20110527-1130-001 (TYPE - I)

TSUNAMI BULLETIN NUMBER 1

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1133 IST Friday 27 May 2011

... EARTHQUAKE INFORMATION BULLETIN ...

1. EARTHQUAKE INFORMATION

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	7.2 M (Great)
Depth:	200 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

The water column height at epicenter location is: 1781 m. Based on historical earthquake and tsunami data, Tsunami Threat does not exist for India.

3. ADVICE

This Bulletin is being issued as an advice. Only national, state, district administrators and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

4. UPDATES

No further bulletins will be issued by ITEWC INCOIS for this event unless additional information becomes available.

5. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21, IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE I: Preliminary EQ Information with Qualitative Tsunami Threat Information

NTWC-INCOIS-20110527-1130-001 (TYPE - I)

TSUNAMI BULLETIN NUMBER 1

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1133 IST Friday 27 May 2011

... EARTHQUAKE INFORMATION BULLETIN...

1. EARTHQUAKE INFORMATION

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Magnitude Range 6.5 ≤ M ≥ 7.0

Earthquakes of this size sometimes have small potential to generate tsunamis. However, so far there is no confirmation about the triggering of a tsunami. An investigation is under way to determine if a tsunami has been triggered. ITEWC INCOIS will monitor sea level gauges near epicenter and report if any tsunami wave activity has occurred.

Magnitude Range M ≥ 7.1

Earthquakes of this size sometimes have potential to generate tsunamis. However, so far there is no confirmation about the triggering of a tsunami. An investigation is under way to determine if a tsunami has been triggered. ITEWC INCOIS will monitor sea level gauges near epicenter and report if any tsunami wave activity has occurred.

3. ADVICE

This is only a Heads-up message to the national/state/local authorities and disaster management offices. No immediate public action is required. This Bulletin is being issued as an advice. Only

national/state/local authorities and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

4. UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

5. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21,IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE II: Preliminary EQ Information with NO THREAT Information from Modeled Scenarios – T + 15

NTWC-INCOIS-20110527-1130-002 (TYPE - II)

TSUNAMI BULLETIN NUMBER 2

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1135 IST Friday 27 May 2011

... POTENTIAL TSUNAMI THREAT FOR INDIAN COAST ...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	7.4 (Major)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Based on historical earthquake and tsunami data, Tsunami Threat does not exist for India.

3. ADVICE

This Bulletin is being issued as an advice. Only national, state, district administrators and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

4. UPDATES

No further bulletins will be issued by ITEWC INCOIS for this event unless additional information becomes available.

5. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

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Website: www.incois.gov.in

END OF BULLETIN

TYPE II: Preliminary EQ Information with Quantitative Tsunami Threat (WARNING / ALERT / WATCH) Information from Modeled Scenarios – T + 15

NTWC-INCOIS-20110527-1130-002 (TYPE - II)

TSUNAMI BULLETIN NUMBER 2

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1135 IST Friday 27 May 2011

... POTENTIAL TSUNAMI THREAT FOR INDIAN COAST ...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	8.8 (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E

Location: Nicobar Islands

2. EVALUATION

Earthquakes of this size are capable of generating tsunamis. However, so far there is no confirmation about the triggering of a tsunami.

An investigation is under way to determine if a tsunami has been triggered. ITEWC will monitor sea level gauges and report if any tsunami wave activity has occurred.

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of "Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by country (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

NICOBAR	1131IST 27 May 2011	21.7 m	Warning
LITTLE ANDAMAN	1141IST 27 May 2011	11.9 m	Warning
PORT BLAIR	1157IST 27 May 2011	8.8 m	Warning
HAVELOCK	1210IST 27 May 2011	5.2 m	Warning

4. ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into Deep Ocean

For regions under WATCH (Yellow), no immediate action is required

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

6. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)
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Email: tsunami@incois.gov.in
Website: www.incois.gov.in

END OF BULLETIN

TYPE II Supplementary XX: Revised EQ Information with Revised Quantitative Tsunami Threat (WARNING / ALERT / WATCH)Information from Modeled Scenarios - If revised EQ information is available much before the real-time water level observations are available - as and when revised earthquake parameters are available

NTWC-INCOIS-20110527-1130-003 (TYPE - II Supplementary 1)

TSUNAMI BULLETIN NUMBER 3

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1145 IST Friday 27 May 2011

... POTENTIAL TSUNAMI THREAT FOR INDIAN COAST ...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	9.0 (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Earthquakes of this size are capable of generating tsunamis. However, so far there is no confirmation about the triggering of a tsunami.

An investigation is under way to determine if a tsunami has been triggered. ITEWC will monitor sea level gauges and report if any tsunami wave activity has occurred.

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of “Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by country (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

NICOBAR	1131IST 27 May 2011	21.7 m	Warning
LITTLE ANDAMAN	1141IST 27 May 2011	11.9 m	Warning
PORT BLAIR	1157IST 27 May 2011	8.8 m	Warning
HAVELOCK	1210IST 27 May 2011	5.2 m	Warning

4. ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into Deep Ocean

For regions under WATCH (Yellow), no immediate action is required

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

6. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21, IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE III: includes real-time water level observations and threat status - As and when the first real-time water level observation is available

NTWC-INCOIS-20110527-1130-004 (TYPE - III)

TSUNAMI BULLETIN NUMBER 4

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 1154 IST Friday 27 May 2011

... CONFIRMED TSUNAMI THREAT IN THE INDIAN COAST ...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Sea level observations have confirmed that a TSUNAMI WAS GENERATED.

Maximum wave amplitudes observed so far:

CAMPBELLBAY (India)	6.9	93.7	1135IST 27 May 2011	12.5m
NANCOWRY (India)	8.0	93.5	1144IST 27 May 2011	13.0m

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of "Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by State or UT (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave

action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

NORTH SENTINEL ISLAND	1157IST 27 May 2011	7.2 m	Warning
PORT BLAIR	1157IST 27 May 2011	8.8 m	Warning
FLAT ISLAND	1222IST 27 May 2011	6.1 m	Warning
RANGATH BAY	1225IST 27 May 2011	6.5 m	Warning
DIGLIPUR	1226IST 27 May 2011	5.3 m	Warning
AGATTI	1526IST 27 May 2011	1.4 m	Watch
AMINI	1528IST 27 May 2011	1.3 m	Watch
AVARATTI	1519IST 27 May 2011	1.4 m	Watch
ANDROTH	1506IST 27 May 2011	1.4 m	Watch

4. ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into Deep Ocean

For regions under WATCH (Yellow), no immediate action is required

When no major waves have occurred at least for two hours after the estimated arrival time then local authorities can assume the threat is passed. As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities.

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

6. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21, IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE III Supplementary XX: includes real-time water level observations and updated threat status - Hourly update / as and when the subsequent real-time water level observations are available

NTWC-INCOIS-20110527-1130-013 (TYPE - III Supplementary 13)

TSUNAMI BULLETIN NUMBER 13

INDIAN TSUNAMI EARLY WARNING CENTRE – INCOIS HYDERABAD (ITEWC)

issued at: 2029 IST Friday 27 May 2011

... CONFIRMED TSUNAMI THREAT IN THE INDIAN COAST ...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following preliminary information:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Sea level observations have confirmed that a TSUNAMI WAS GENERATED.

Maximum wave amplitudes observed so far:

CAMPBELLBAY(India)	6.9	93.7	1135IST 27 May 2011	12.5m
NANCOWRY(India)	8.0	93.5	1144IST 27 May 2011	13.0m
SABANG (Indonesia)	5.8	95.3	1157IST 27 May 2011	8.5m
PORTBLAIR (India)	11.7	92.8	1208IST 27 May 2011	3.4m
Meulaboh (Indonesia)	4.3	96.2	1208IST 27 May 2011	7.3m

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of "Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by State or UT (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

NORTH SENTINEL ISLAND	1157IST 27 May 2011	7.2 m	Threat Passed
PORT BLAIR	1157IST 27 May 2011	8.8 m	Threat Passed
FLAT ISLAND	1222IST 27 May 2011	6.1 m	Threat Passed
RANGATH BAY	1225IST 27 May 2011	6.5 m	Threat Passed
DIGLIPUR	1226IST 27 May 2011	5.3 m	Threat Passed
AGATTI	1526IST 27 May 2011	1.4 m	Alert
AMINI	1528IST 27 May 2011	1.3 m	Alert
AVARATTI	1519IST 27 May 2011	1.4 m	Alert
ANDROTH	1506IST 27 May 2011	1.4 m	Alert

4. ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into Deep Ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into Deep Ocean

For regions under WATCH (Yellow), no immediate action is required

When no major waves have occurred at least for two hours after the estimated arrival time then local authorities can assume the threat is passed. As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities.

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

6. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21, IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE IV- FINAL BULLETIN: Issued when water levels from multiple gauges confirm that no significant tsunami was generated

NTWC-INCOIS-20110527-1130-015

TSUNAMI BULLETIN NUMBER 15

INDIAN TSUNAMI EARLY WARNING CENTRE, INCOIS (ITEWC)

issued at: 2304 IST Friday 27 May 2011

... FINAL TSUNAMI BULLETIN FOR THE INDIAN COAST...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following parameters:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Real-time measurements of wave activity indicated that no significant tsunami was generated. When no major waves have occurred at least for two hours after the estimated arrival time then local authorities can assume that the threat is passed. As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities.

3. ADVICE

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

4. UPDATES

No further bulletins will be issued by ITEWC INCOIS for this event unless additional information becomes available.

5. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)

Indian National Centre for Ocean Information Services (INCOIS)

Address:"Ocean Valley", P.B No.21, IDA Jeedimetla P.O,

Hyderabad - 500 055, India.

Tel: 91-40-23895011

Fax: 91-40-23895012

Email: tsunami@incois.gov.in

Website: www.incois.gov.in

END OF BULLETIN

TYPE IV- FINAL BULLETIN: After 120 minutes after threat passed the last Indian threat zone

NTWC-INCOIS-20110527-1130-015

TSUNAMI BULLETIN NUMBER 15

INDIAN TSUNAMI EARLY WARNING CENTRE, INCOIS (ITEWC)

issued at: 2304 IST Friday 27 May 2011

... FINAL TSUNAMI BULLETIN FOR THE INDIAN COAST...

1. EARTHQUAKE INFORMATION (Revised)

ITEWC INCOIS detected an earthquake with the following parameters:

Magnitude:	9.0 M (Great)
Depth:	10 km
Date:	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Nicobar Islands

2. EVALUATION

Data from sea-level gauges confirmed that a tsunami was generated. The expected period of significant tsunami waves is now over for all threatened Indian coastal regions, based on ITEWC INCOIS modelling.

Because local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities. Please be aware that dangerous currents can continue for several hours after the main tsunami waves have passed.

3. ADVICE

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

4. UPDATES

No further bulletins will be issued by ITEWC INCOIS for this event unless additional information becomes available.

5. CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)
Indian National Centre for Ocean Information Services (INCOIS)
Address:"Ocean Valley", P.B No.21,IDA Jeedimetla P.O,
Hyderabad - 500 055, India.
Tel: 91-40-23895011
Fax: 91-40-23895012
Email: tsunami@incois.gov.in
Website: www.incois.gov.in

END OF BULLETIN

Sample HTML Bulletins

Bulletin-1 with Preliminary Earthquake Parameters and Map

INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(An Autonomous Body under the Ministry of Earth Sciences, Government of India)
Indian Tsunami Early Warning Centre (ITEWC)

Current Date &Time : 01 Jun, 2011 5:33

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NTWC-INCOIS-20110527-1130-001 (TYPE - I)

TSUNAMI BULLETIN NUMBER 1

INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 1133 IST Friday 27 May 2011

Location Map | Earthquake Information

EARTHQUAKE INFORMATION

Magnitude (Preferred) :	9.0 M (Great)
Network Magnitude(s):	9.0 (M)
Depth:	10 km
Date :	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Desktop Exercise (DE 1105270600)
Land/Ocean:	Ocean part
Water Level Depth (if Ocean):	2163 m

EVALUATION

Earthquakes of this size sometimes have potential to generate tsunamis. However, so far there is no confirmation about the triggering of a tsunami. An investigation is under way to determine if a tsunami has been triggered.

ITEWC INCOIS will monitor sea level gauges near epicenter and report if any tsunami wave activity has occurred.

ADVICE

This is only a Heads-up message to the national/state/local authorities and disaster management offices. No immediate public action is required. This Bulletin is being issued as an advice. Only national/state/local authorities and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

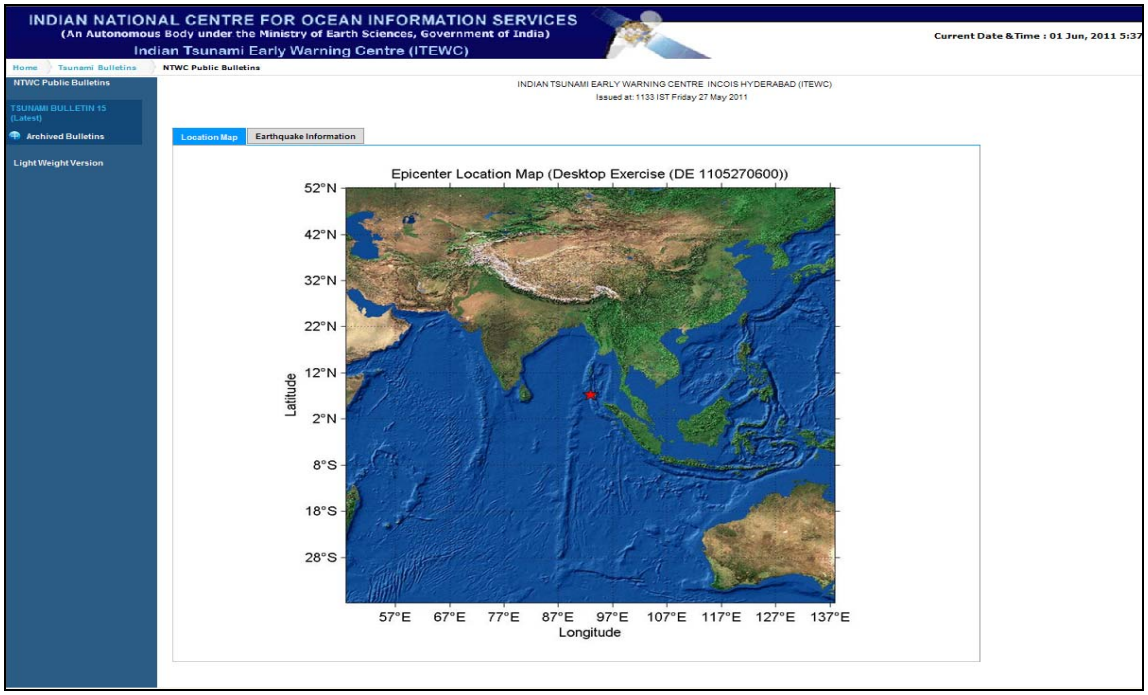
UPDATES

Additional bulletins will be issued by ITEWC INCOIS for this event as more information becomes available.

CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)
Indian National Centre for Ocean Information Services (INCOIS)
Address:"Ocean Valley", P.B.No.21,IDA Jeedimetla P.O,
Hyderabad - 500 055, India.
Tel: 91-40-23895011
Fax: 91-40-23895012
Email: tsunami@incois.gov.in
Website: www.incois.gov.in

Elapsed Time: This Earthquake happened 00 Hours, 02 Minutes, 43 Seconds ago



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Indian Tsunami Early Warning Centre (ITEWC)

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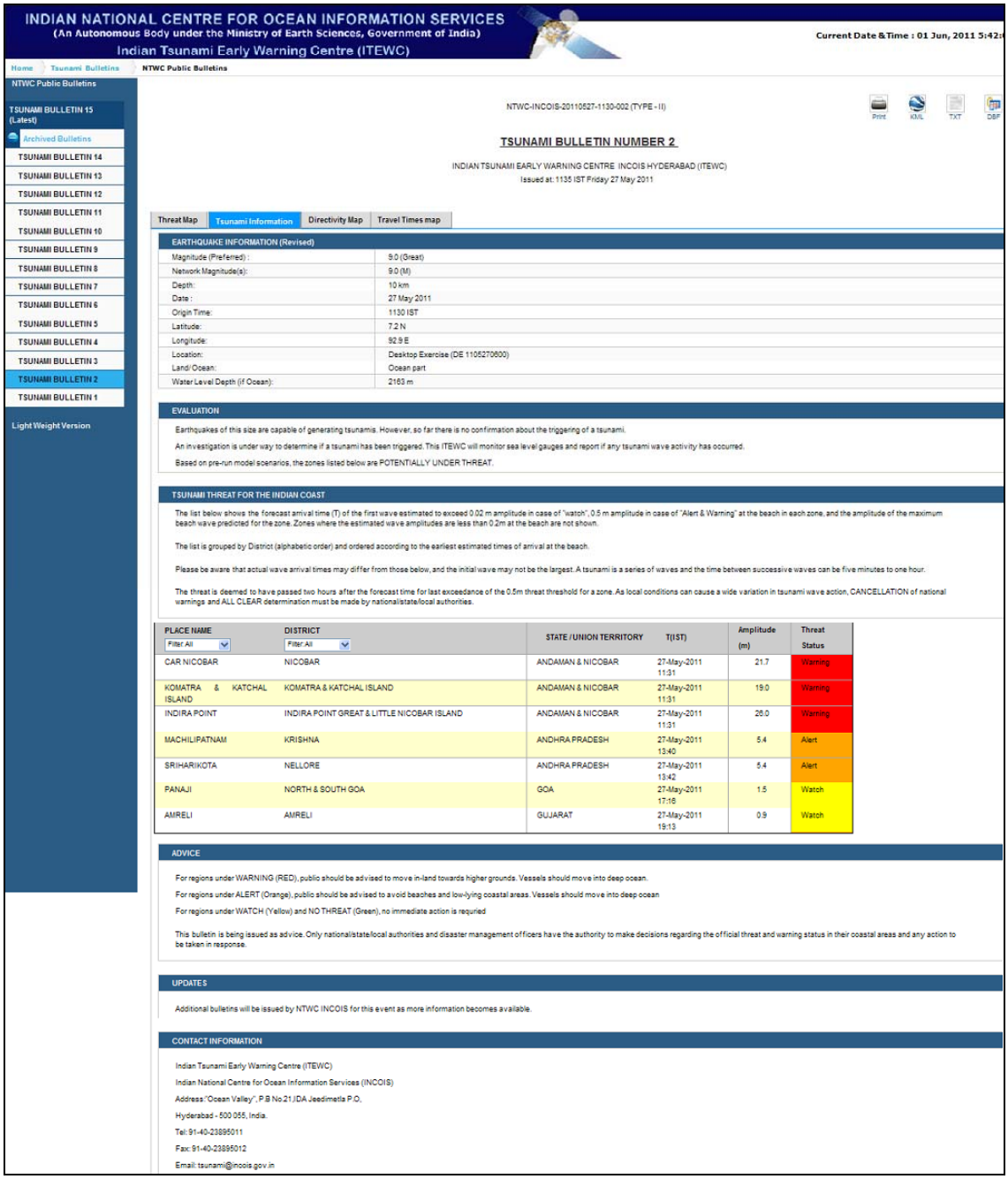
INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 1133 IST Friday 27 May 2011

Location Map | Earthquake Information

Bulletin-2 with Threat (WARNING/ALERT/WATCH) information based on Model Scenario Results



INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(An Autonomous Body under the Ministry of Earth Sciences, Government of India)
Indian Tsunami Early Warning Centre (ITEWC)

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NTWC-INCOIS-20110527-1130-002 (TYPE - II)

Print KML TXT DBF

TSUNAMI BULLETIN NUMBER 2

INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 1135 IST Friday 27 May 2011

Threat Map | Tsunami Information | Directivity Map | Travel Times map

EARTHQUAKE INFORMATION (Revised)

Magnitude (Preferred) :	9.0 (Great)
Network Magnitude(s):	9.0 (M)
Depth:	10 km
Date :	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Desktop Exercise (DE 1105270600)
Land/Ocean:	Ocean part
Water Level Depth (if Ocean):	2163 m

EVALUATION

Earthquakes of this size are capable of generating tsunamis. However, so far there is no confirmation about the triggering of a tsunami.

An investigation is under way to determine if a tsunami has been triggered. This ITEWC will monitor sea level gauges and report if any tsunami wave activity has occurred.

Based on pre-run model scenarios, the zones listed below are POTENTIALLY UNDER THREAT.

TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time (T) of the first wave estimated to exceed 0.02 m amplitude in case of "watch", 0.5 m amplitude in case of "Alert & Warning" at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.2m at the beach are not shown.

The list is grouped by District (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

PLACE NAME (Filter: All)	DISTRICT (Filter: All)	STATE / UNION TERRITORY	T(IST)	Amplitude (m)	Threat Status
CAR NICOBAR	NICOBAR	ANDAMAN & NICOBAR	27-May-2011 11:31	21.7	Warning
KOMATRA & KATCHAL ISLAND	KOMATRA & KATCHAL ISLAND	ANDAMAN & NICOBAR	27-May-2011 11:31	19.0	Warning
INDIRA POINT	INDIRA POINT GREAT & LITTLE NICOBAR ISLAND	ANDAMAN & NICOBAR	27-May-2011 11:31	26.0	Warning
MACHILIPATNAM	KRISHNA	ANDHRA PRADESH	27-May-2011 13:40	5.4	Alert
SRIHARIKOTA	NELLORE	ANDHRA PRADESH	27-May-2011 13:42	5.4	Alert
PANAJI	NORTH & SOUTH GOA	GOA	27-May-2011 17:16	1.5	Watch
AMRELI	AMRELI	GUJARAT	27-May-2011 19:13	0.9	Watch

ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into deep ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into deep ocean

For regions under WATCH (Yellow) and NO THREAT (Green), no immediate action is required

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

UPDATES

Additional bulletins will be issued by NTWC INCOIS for this event as more information becomes available.

CONTACT INFORMATION

Indian Tsunami Early Warning Centre (ITEWC)
Indian National Centre for Ocean Information Services (INCOIS)
Address:"Ocean Valley", P.B No.21,IDA Jeedimetla P.O,
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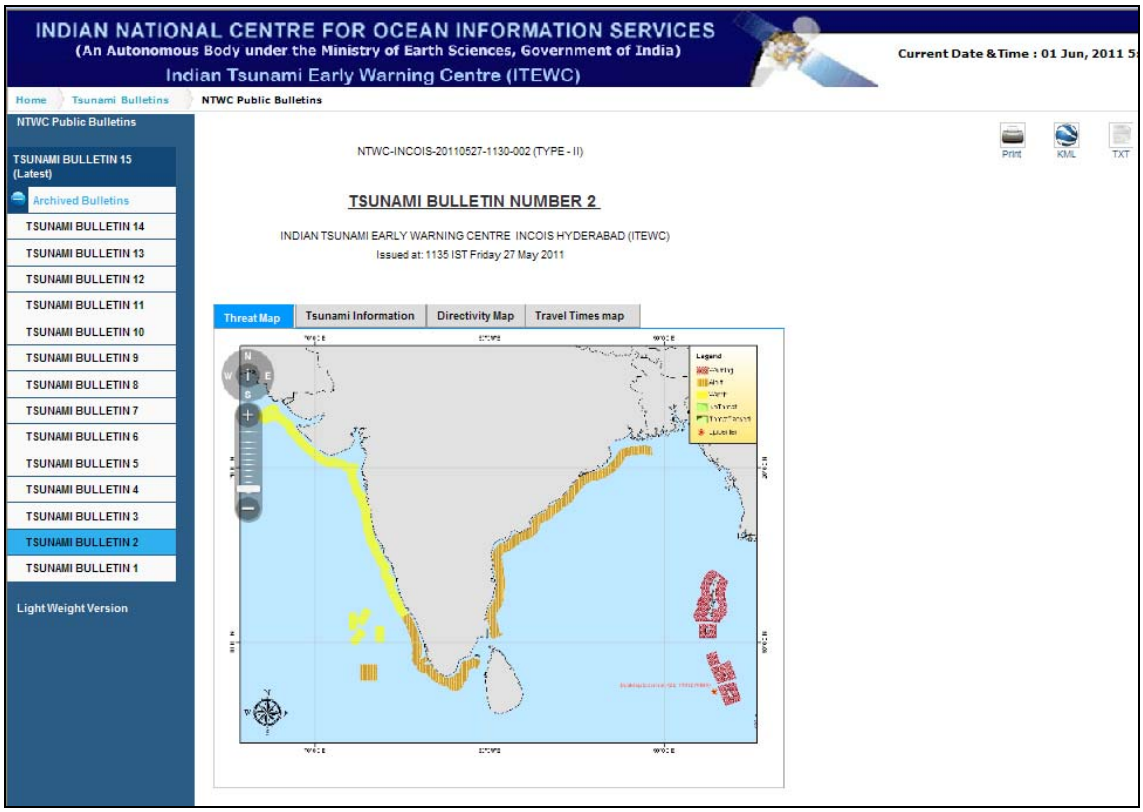
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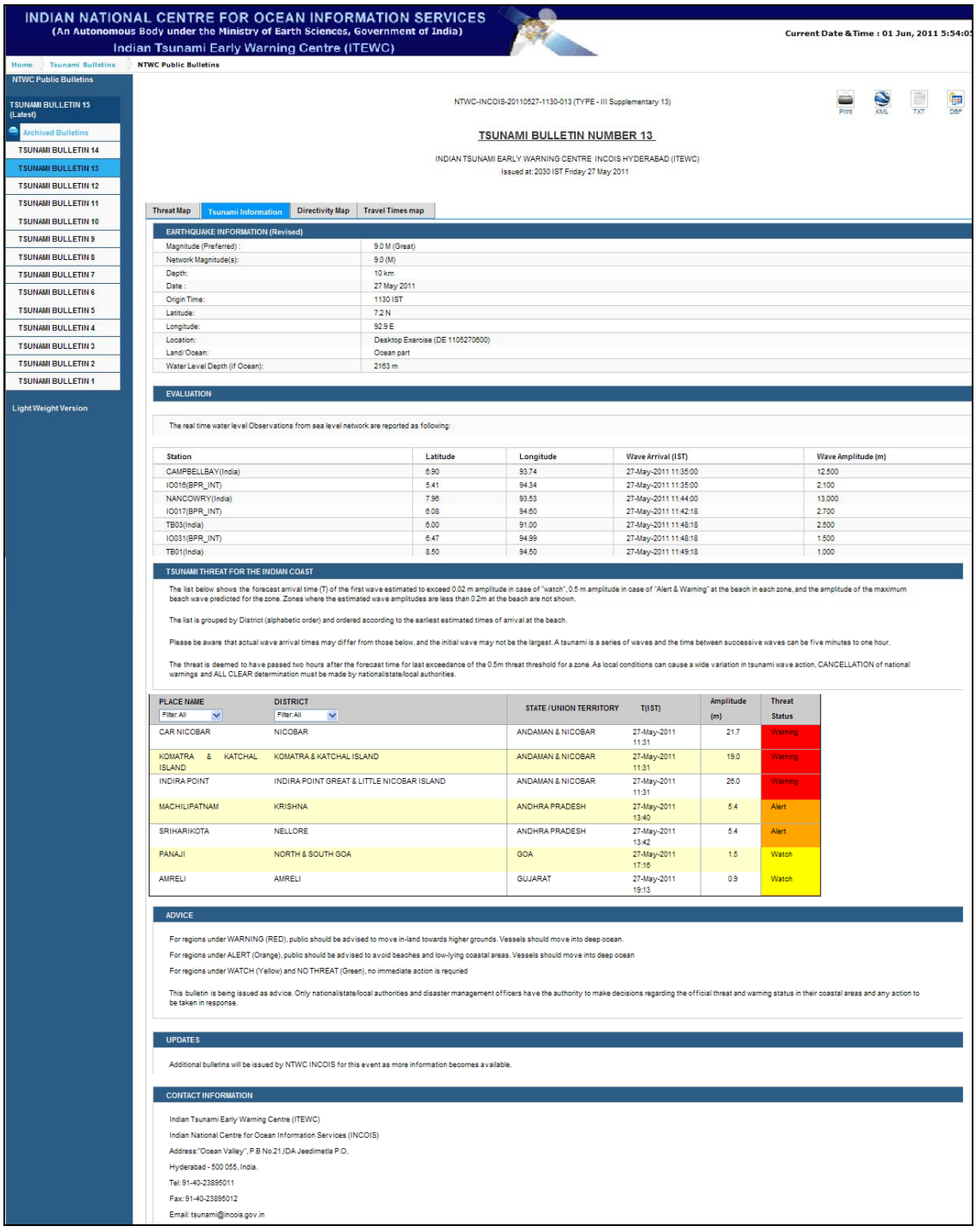
INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 1135 IST Friday 27 May 2011
Threat Map
Tsunami Information
Directivity Map
Travel Times map
Legend

Bulletin-3 with Real-time Water level Observations and Threat Passed information



INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
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Indian Tsunami Early Warning Centre (ITEWC)

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NTWC-INCOIS-20110527-1130-013 (TYPE - III Supplementary 13)

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TSUNAMI BULLETIN NUMBER 13

INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 2030 IST Friday 27 May 2011

Threat Map | Tsunami Information | Directivity Map | Travel Times map

EARTHQUAKE INFORMATION (Revised)

Magnitude (Preferred) :	9.0 M (Great)
Network Magnitude(s):	9.0 (M)
Depth:	10 km
Date :	27 May 2011
Origin Time:	1130 IST
Latitude:	7.2 N
Longitude:	92.9 E
Location:	Desktop Exercise (DE 1105270600)
Land/Ocean:	Ocean part
Water Level Depth (if Ocean):	2163 m

EVALUATION

The real time water level Observations from sea level network are reported as following:

Station	Latitude	Longitude	Wave Arrival (IST)	Wave Amplitude (m)
CAMPBELLBAY(India)	6.90	93.74	27-May-2011 11:35:00	12.500
IO016(BPR_INT)	5.41	94.34	27-May-2011 11:35:00	2.100
NANCOWRY(India)	7.96	93.53	27-May-2011 11:44:00	13.000
IO017(BPR_INT)	6.08	94.60	27-May-2011 11:42:18	2.700
TB03(India)	6.00	91.00	27-May-2011 11:48:18	2.500
IO031(BPR_INT)	6.47	94.99	27-May-2011 11:48:18	1.500
TB01(India)	8.50	94.50	27-May-2011 11:49:18	1.000

TSUNAMI THREAT FOR THE INDIAN COAST

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The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

PLACE NAME (Filter All)	DISTRICT (Filter All)	STATE / UNION TERRITORY	T(IST)	Amplitude (m)	Threat Status
CAR NICOBAR	NICOBAR	ANDAMAN & NICOBAR	27-May-2011 11:31	21.7	Warning
KOMATRA & KATCHAL ISLAND	KOMATRA & KATCHAL ISLAND	ANDAMAN & NICOBAR	27-May-2011 11:31	19.0	Warning
INDIRA POINT	INDIRA POINT GREAT & LITTLE NICOBAR ISLAND	ANDAMAN & NICOBAR	27-May-2011 11:31	26.0	Warning
MACHILIPATNAM	KRISHNA	ANDHRA PRADESH	27-May-2011 13:40	5.4	Alert
SRIHARIKOTA	NELLORE	ANDHRA PRADESH	27-May-2011 13:42	5.4	Alert
PANAJI	NORTH & SOUTH GOA	GOA	27-May-2011 17:16	1.5	Watch
AMRELI	AMRELI	GUJARAT	27-May-2011 19:13	0.9	Watch

ADVICE

For regions under WARNING (RED), public should be advised to move in-land towards higher grounds. Vessels should move into deep ocean.

For regions under ALERT (Orange), public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into deep ocean

For regions under WATCH (Yellow) and NO THREAT (Green), no immediate action is requried

This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

UPDATES

Additional bulletins will be issued by NTWC INCOIS for this event as more information becomes available.

CONTACT INFORMATION

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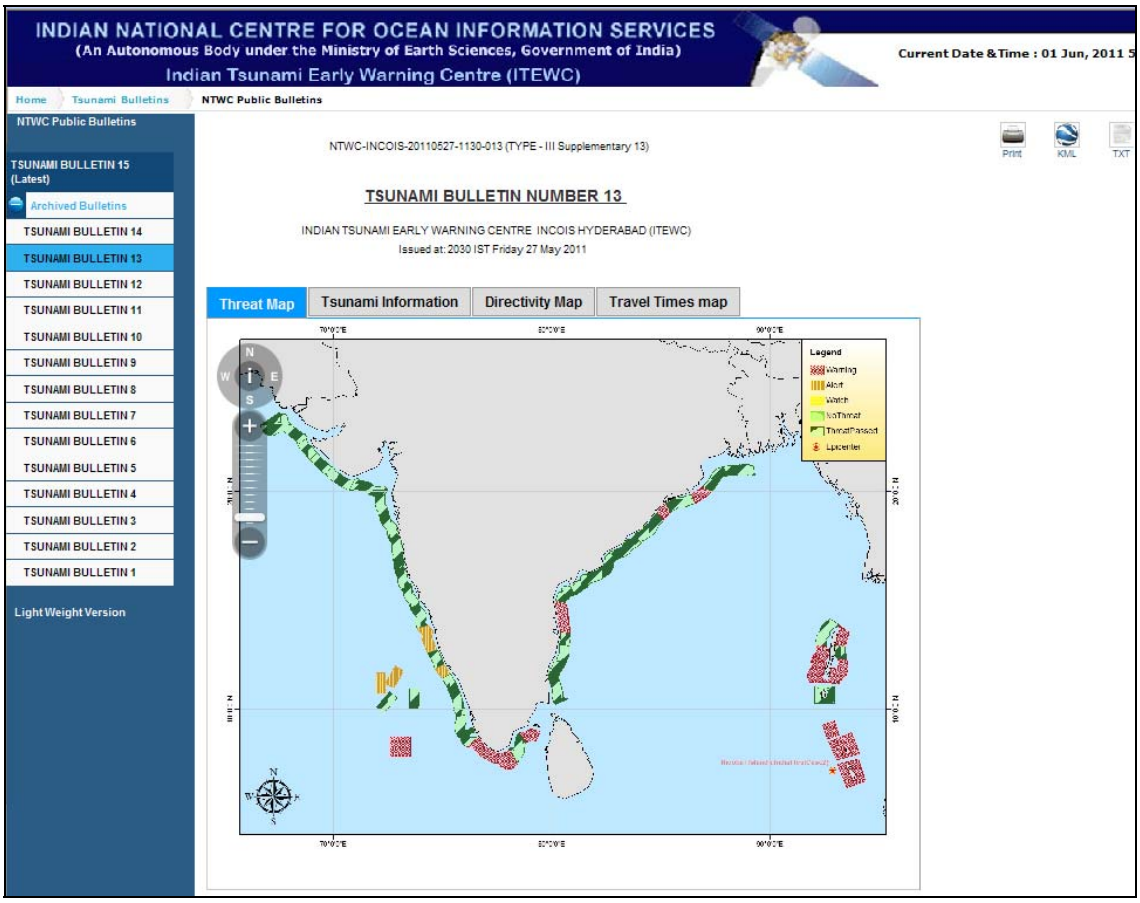
Fax: 91-40-23895012
Email: tsunami@incois.gov.in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(An Autonomous Body under the Ministry of Earth Sciences, Government of India)
Indian Tsunami Early Warning Centre (ITEWC)
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INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 2030 IST Friday 27 May 2011
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Tsunami Information
Directivity Map
Travel Times map
Legend
Warning
Alert
Watch
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ThreatPassed
Epicenter

FINAL Bulletin with Threat Passed information

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Light Weight Version

FINAL BULLETIN

Indian Tsunami Early Warning Centre (ITEWC)
Indian National Centre for Ocean Information Services (INCOIS), Hyderabad
PHONE: 91-40-23895011 FAX: 91-40-23895012 E-MAIL: tsunami@incois.gov.in
Date and Time of Bulletin Issue: 27-May-2011 17:36:47 UTC

Earthquake Parameters (Revised)	
Preferred Magnitude	9.0 M (Great)
Network Magnitude(s):	9.0 (M)
Earthquake Origin Date & Time:	27-May-2011 06:00:00 (UTC)
Latitude:	7.2 N
Longitude:	92.9 E
Focal Depth:	10 km
Land/ Ocean:	Ocean part
Water Level Depth (if Ocean):	2163 m
Region:	Desktop Exercise (DE 1105270600)

Tsunami Information

Real time sea-level observations indicated that a tsunami was generated. Wave activity now indicates that the threat has diminished or passed away. For any affected areas - when no major waves have occurred for at least two hours after the estimated arrival time or damaging waves have not occurred for at least two hours then local authorities can assume the threat is passed.

As local conditions can cause a wide variation in tsunami wave action the ALL CLEAR determination must be made by local authorities.

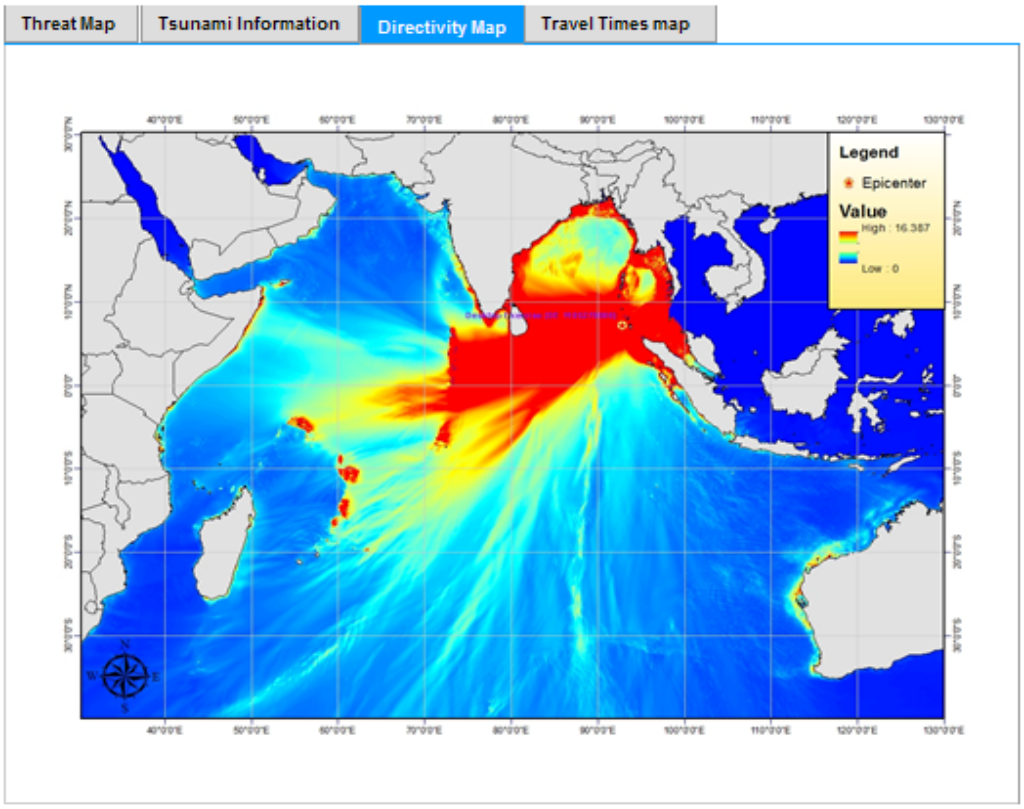
Advice:

This Bulletin is being issued as an advice. Only national/state/local administration and disaster management offices have the authority to make decisions regarding the official threat status in their coastal area and any action to be taken in response.

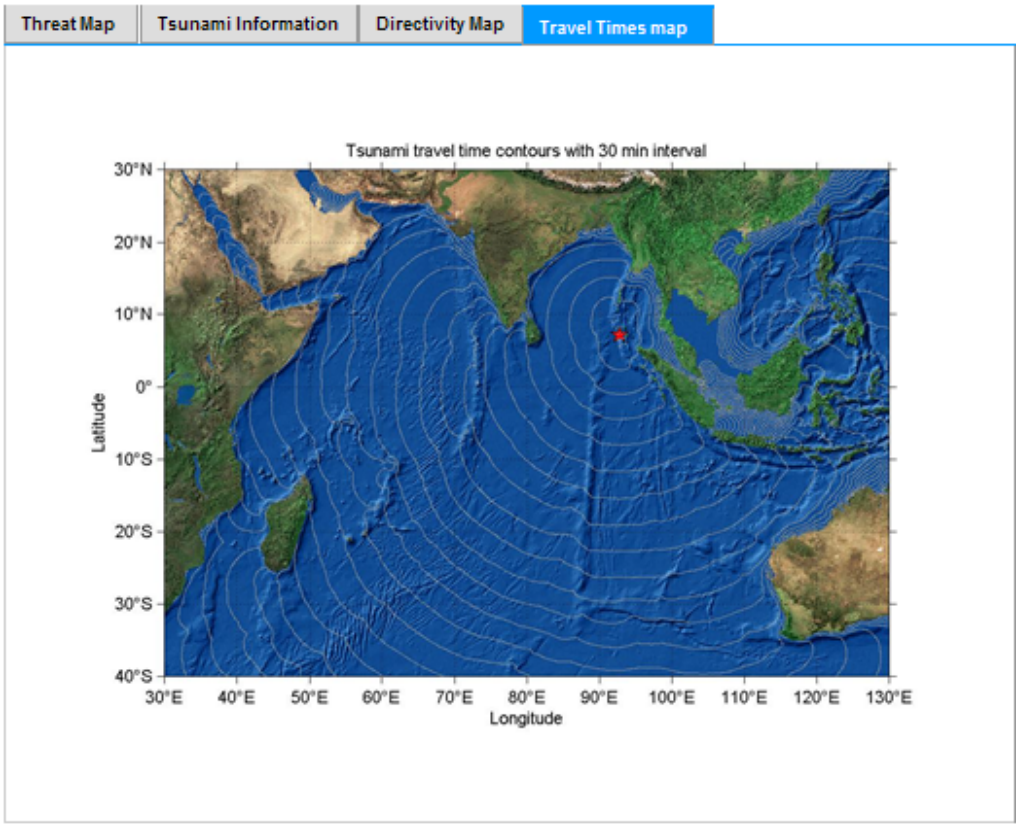
This will be final bulletin unless additional information regarding this event becomes available.

Additional Earthquake Parameters	
Event ID:	dss110527060000
Event Solution:	Type A (Automatic)
No of Stations Used:	25
No of Phases Used:	25
RMS Residual:	1.1s
Azimuthal Gap:	89 degress

This report supersedes any earlier reports about this event.
This earthquake is reviewed by a seismologist.
Elapsed Time: This Earthquake happened 11 Hours, 32 Minutes, 00 Seconds ago



Sample Directivity Map



Sample Tsunami Travel Time Map