Indian Tsunami Early Warning System

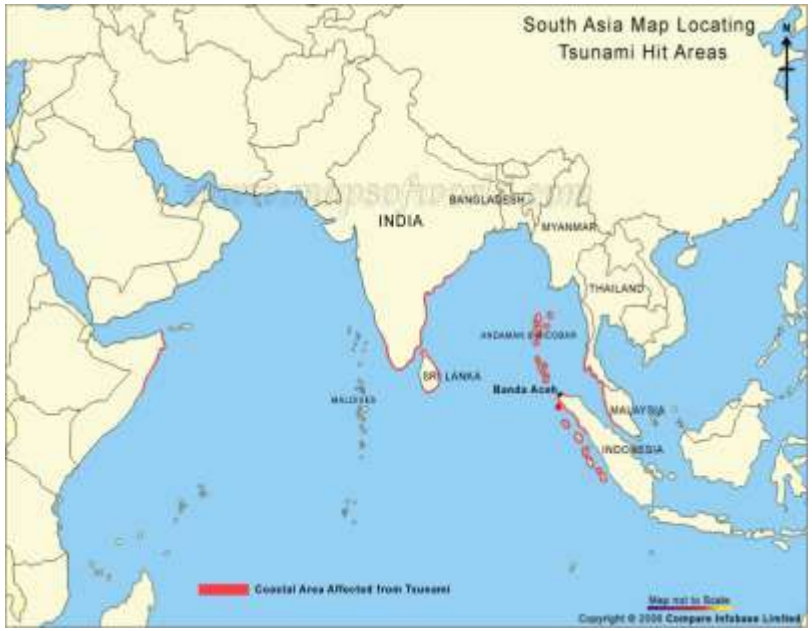
Dr. Satheesh C. Shenoi

Indian National Centre for Ocean Information Services (INCOIS)

Hyderabad, India

Indo-US Workshop on Small Satellite and Sensor Technology for Disaster Management
IISc., Bangalore March 31-April 2 2014.

Indian Ocean Tsunami of December 26, 2004

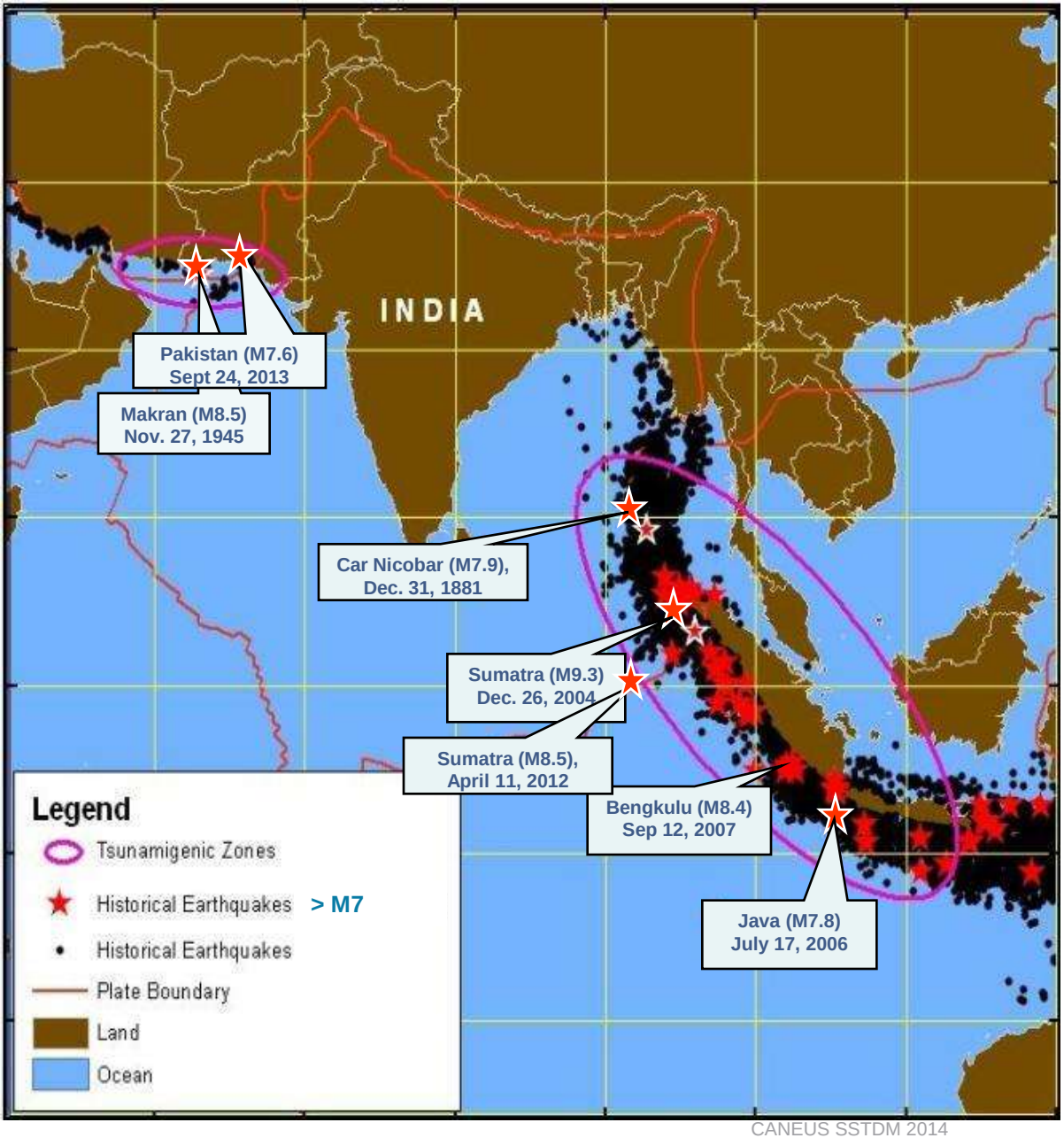


- **The worst tsunami in the recorded history - on December 26, 2004**
- **Magnitude 9.3 (second strongest earthquake ever recorded on a seismograph)**
- **Lasted ~ 10 minutes (longest lasting earthquake in the history)**
- **229,866 confirmed deaths, that include 42,883 missing**
- **Material damage - more than $7 billion USD**

Reasons for huge loss were

- Many nations in the Indian Ocean did not even recognize the word "tsunami"
- None had tsunami preparedness programs in place
- Absence of Tsunami Early Warning System in the Indian Ocean
- Ignorance of the natural signs of tsunami led to inappropriate actions

Historical Tsunamis in the Indian Ocean



- 326 BC
- Bt. 1 Apr – 9 May, 1008
- 12 Apr, 1762 (BoB EQ) – 1.8 m
- 31 Dec, 1881 (Car Nicobar EQ)
- 27 Aug, 1883 (Krakatoa) – 2.0 m
- 26 Jun, 1941 (Andaman EQ)
- 27 Nov, 1945 (Makran EQ) – 12.0 m
- 19 Aug, 1977 (Sunda EQ) – 5.0 m

- 26 Dec, 2004 (Sumatra EQ) – 10 m
- 28 Mar, 2005 (Sumatra EQ) – 4.0 m
- 12 Sept, 2007 (Sumatra EQ) – 0.6 m
- 11 Apr, 2012 (Sumatra EQ) – 1.0 m

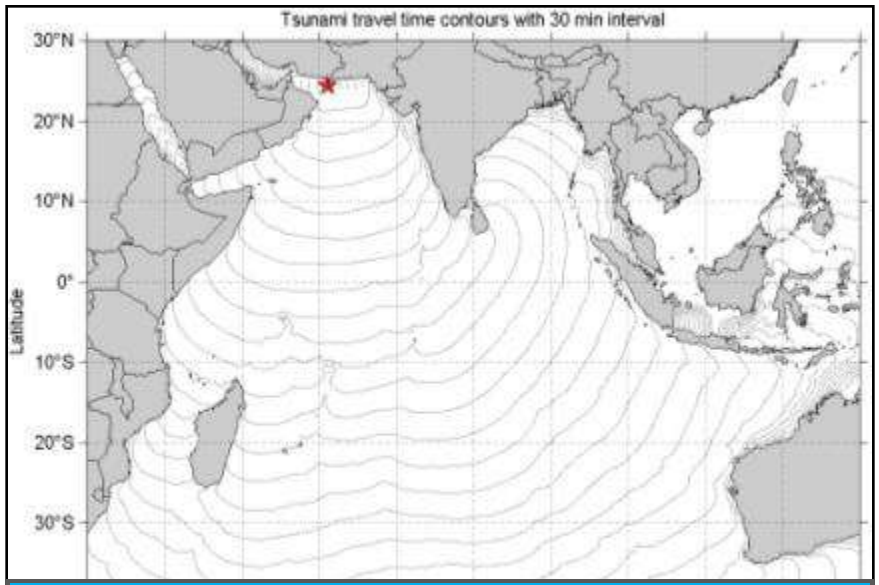
Tsunamigenic potential EQs in the Indian Ocean

- Andaman-Sumatra & Makran subdution zones
- EQ Mag > 6.5
- Earthquakes under or near ocean
- Depth < 100 km
- Vertical movement of the sea-floor

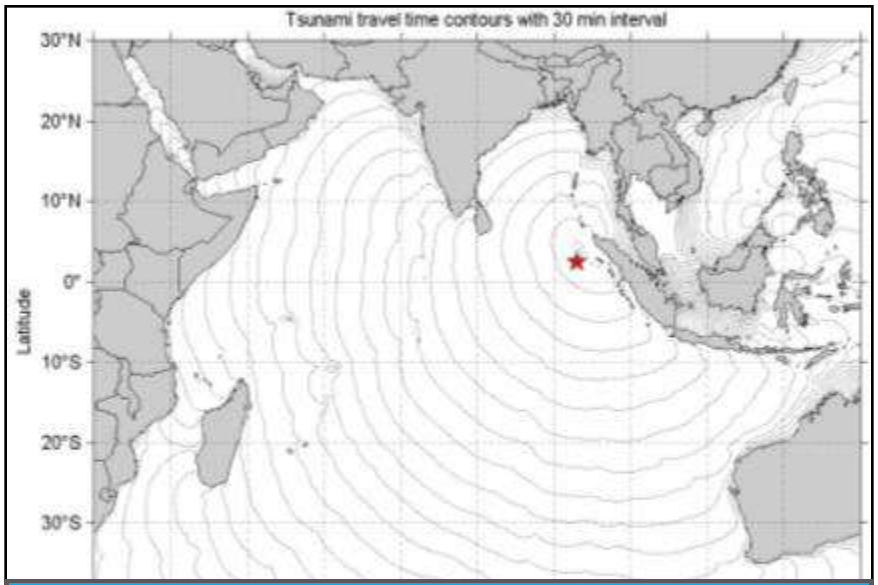
Tsunami Travel Times & Response time

- **Depending upon the location of Earthquake (Makran/Andaman-Sumatra Subduction Zone) the response time for evacuation of coastal population ranges between 10 min to few hours.**

- **As Andaman & Nicobar Islands are situated right on the subduction zone, the available response time is too short**



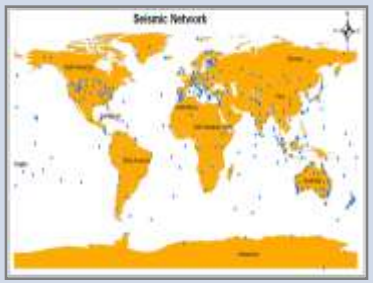
- **If the earthquake occurs at Makran subduction zone, travel time to nearest Indian Coast (Gujarat) are 2 to 3 hrs**



- **If the earthquake occurs off Sumatra, travel times to nearest coast (A&N Islands) are 20 to 30 minlyn o**
- **For Indian main land travel times are 2 to 3 hrs**

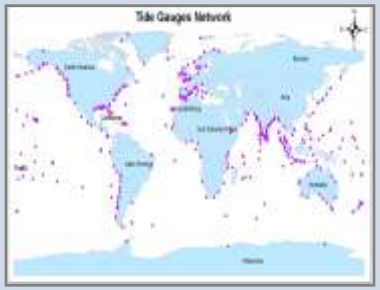
Components of a tsunami warning system

Detection → **Warnings** → **Dissemination**



Seismic Network

BPR Network



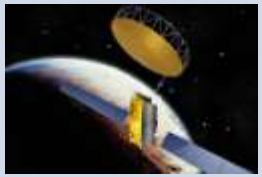
Tide gauge Network

Observation Networks

VSAT

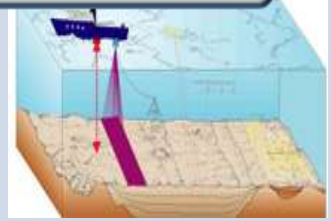
INSAT

GPRS

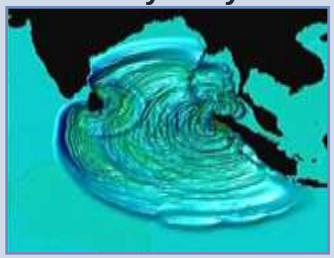


INMARSAT

Communication



Bathymetry



Tsunami Modelling

Topography

Costal Vulnerability

Simulations

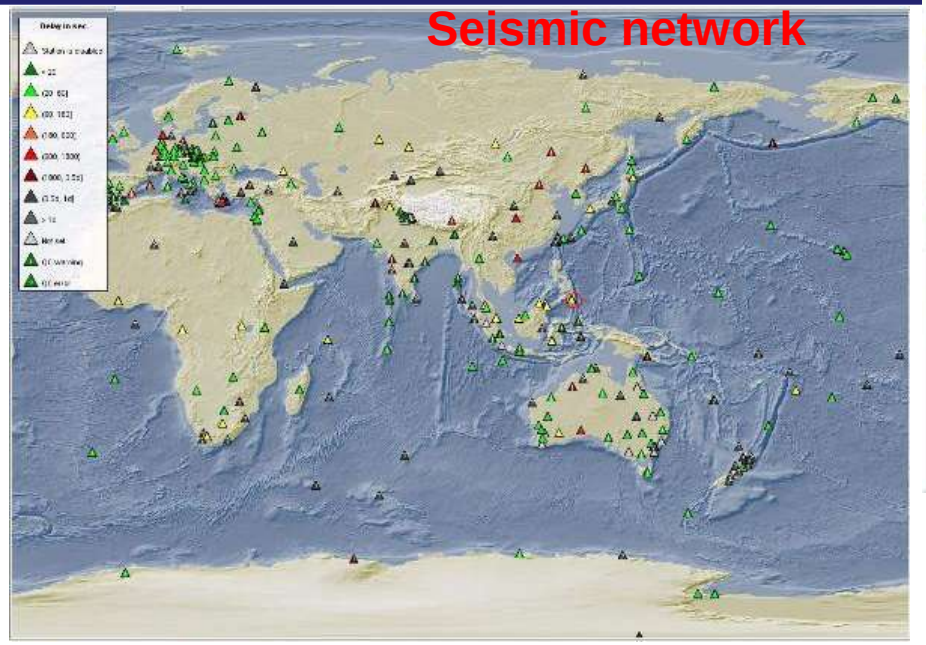
Capacity Building

R & D

Last mile connectivity

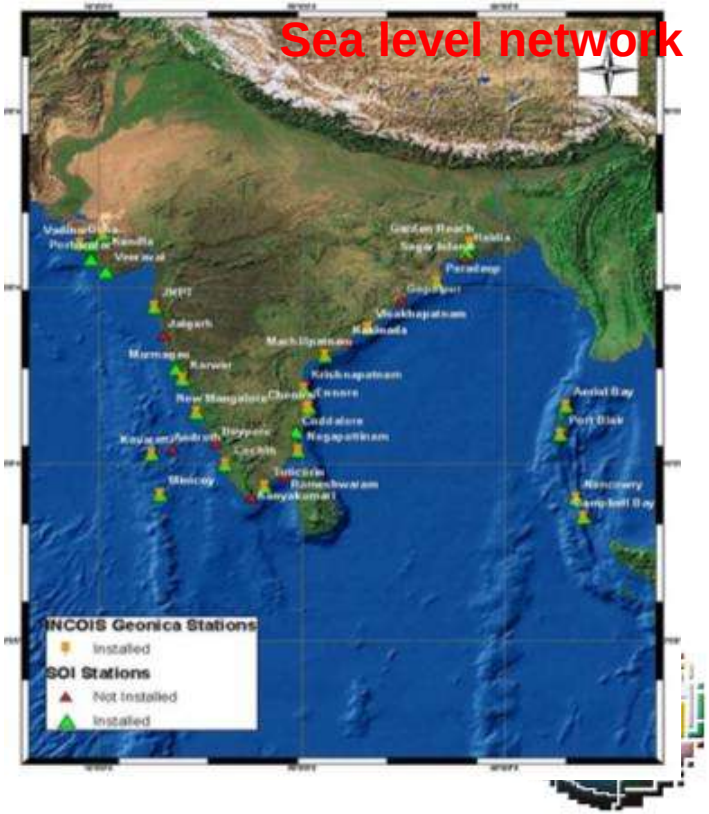
Tsunami Early Warnings – observing systems

Seismic network

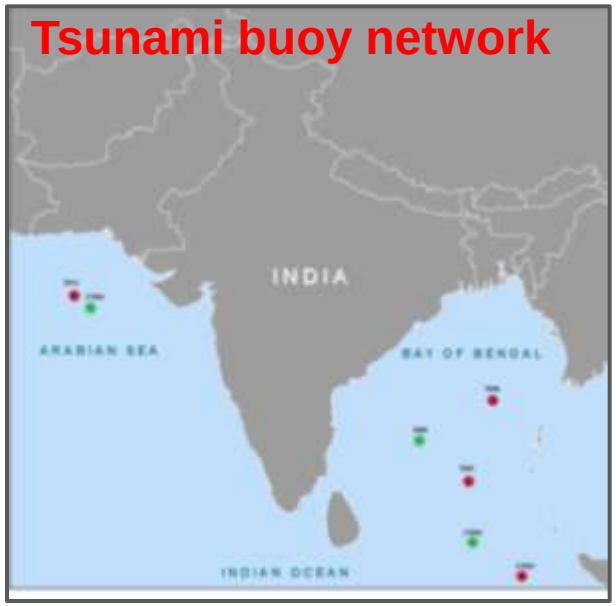


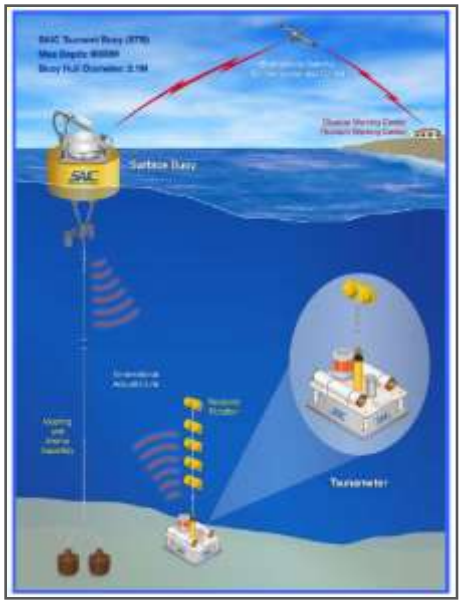
Sea level network

Sea level network



Tsunami buoy network





24x7 tsunami warning centre at INCOIS




24 x 7 operations

Heterogeneous Real-Time Data from a variety of Sensors

Data Acquisition, Display, Processing, Archival

Numerical Modeling and Decision Support

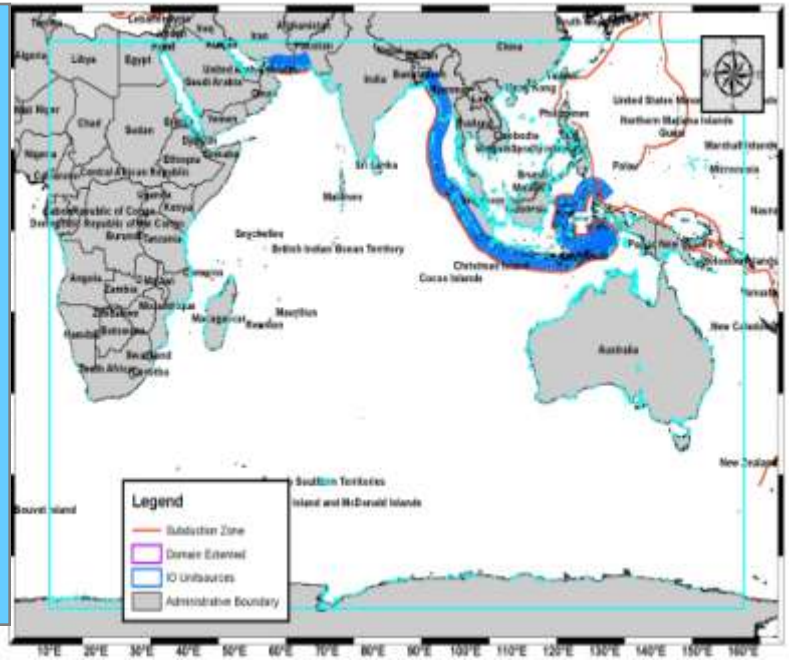
Generation of Advisories and Dissemination

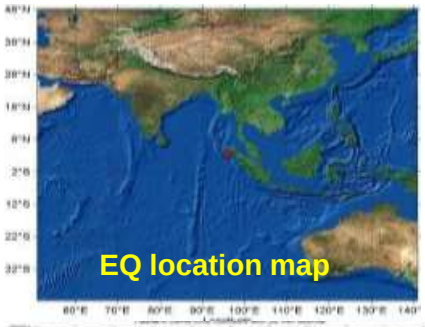
Mission Critical - Infrastructure to be highly available

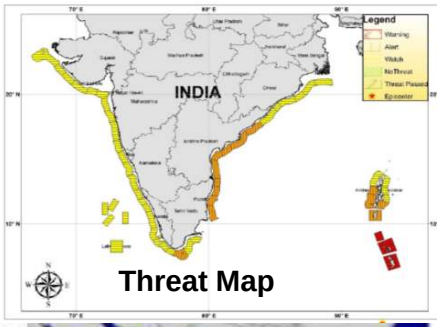
Tsunami Modelling and Threat Maps

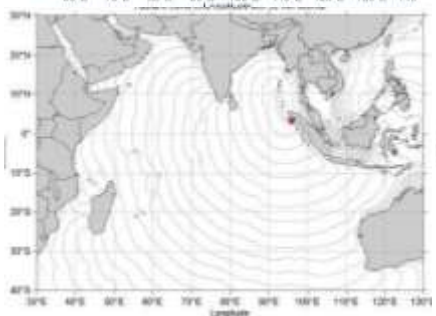
➢ Open Ocean Modelling

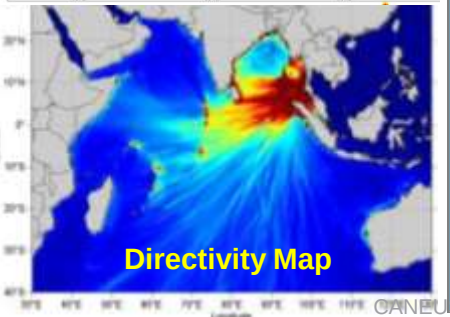
- Database of Scenarios covering both Makran and Sunda Tsunamigenic Zones
- Each unit source is of 100 X 50 km area representing rupture caused by EQ of M 7.5 with slip as 1m
- Spatial resolution: 2.5 km
- Depending on EQ's location and magnitude basic unit source open ocean propagation scenarios are either scaled up or down
- Expected Wave Arrival & Amplitude forecasts at 1800 Costal Forecast Points (CFPs) in the Indian Ocean Coast
- CFPs are then rendered to create threat profile for Coastal Forecast Zones (CFZs)







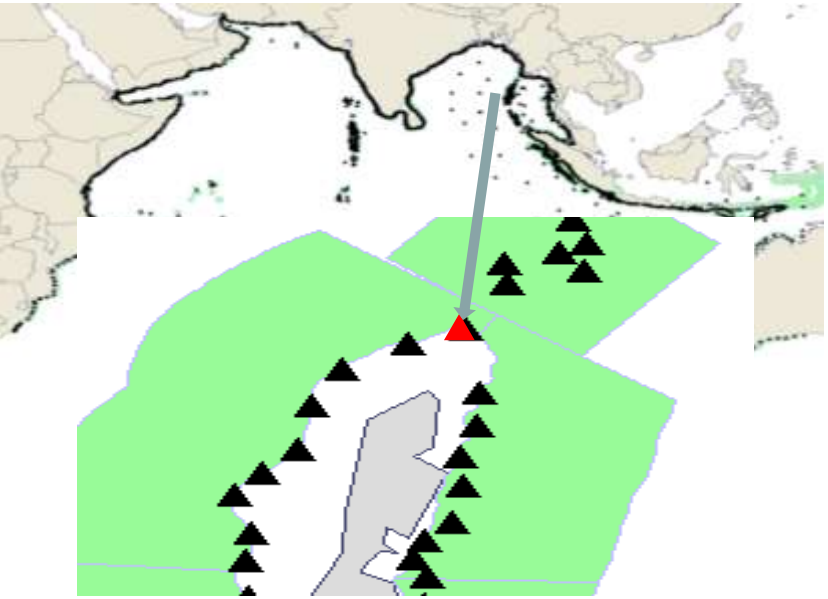




➢ Model Output Parameters

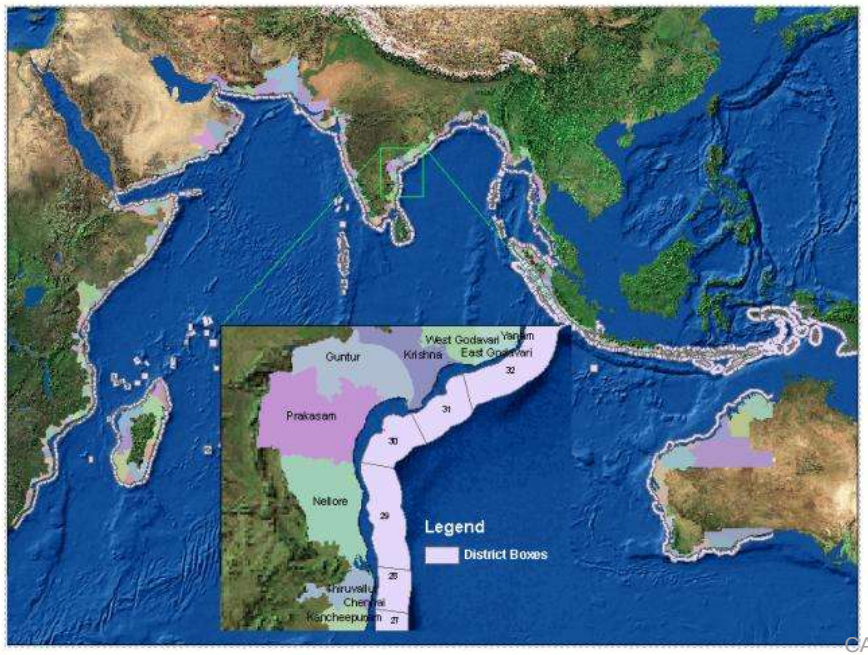
- T1 (Time of arrival of the minimum detectable positive amplitude wave)
- T2 (Time of first exceedance of the Threat Threshold)
- T3 (Time of arrival of max_beach)
- T4 (Time when the last exceedance of the Threat Threshold is forecast)
- max_beach (Maximum Positive wave amplitude at the shore line)
- max_deep (Maximum positive wave amplitude in deep water in each coastal zone)
- Depth (Depth of the water where the max_deep occurs)
- Threat Category (Threat / No Threat based on 0.5 m Wave Amplitude at Coast i.e. 1 m water Depth)

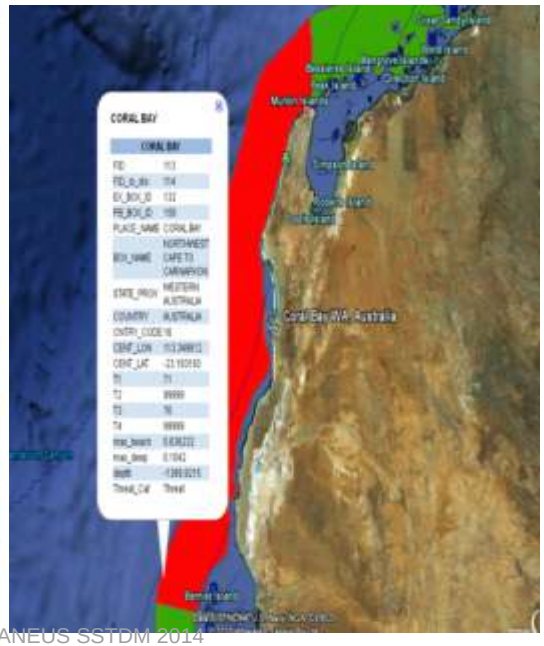
Tsunami Modelling and Coastal Forecast Zones



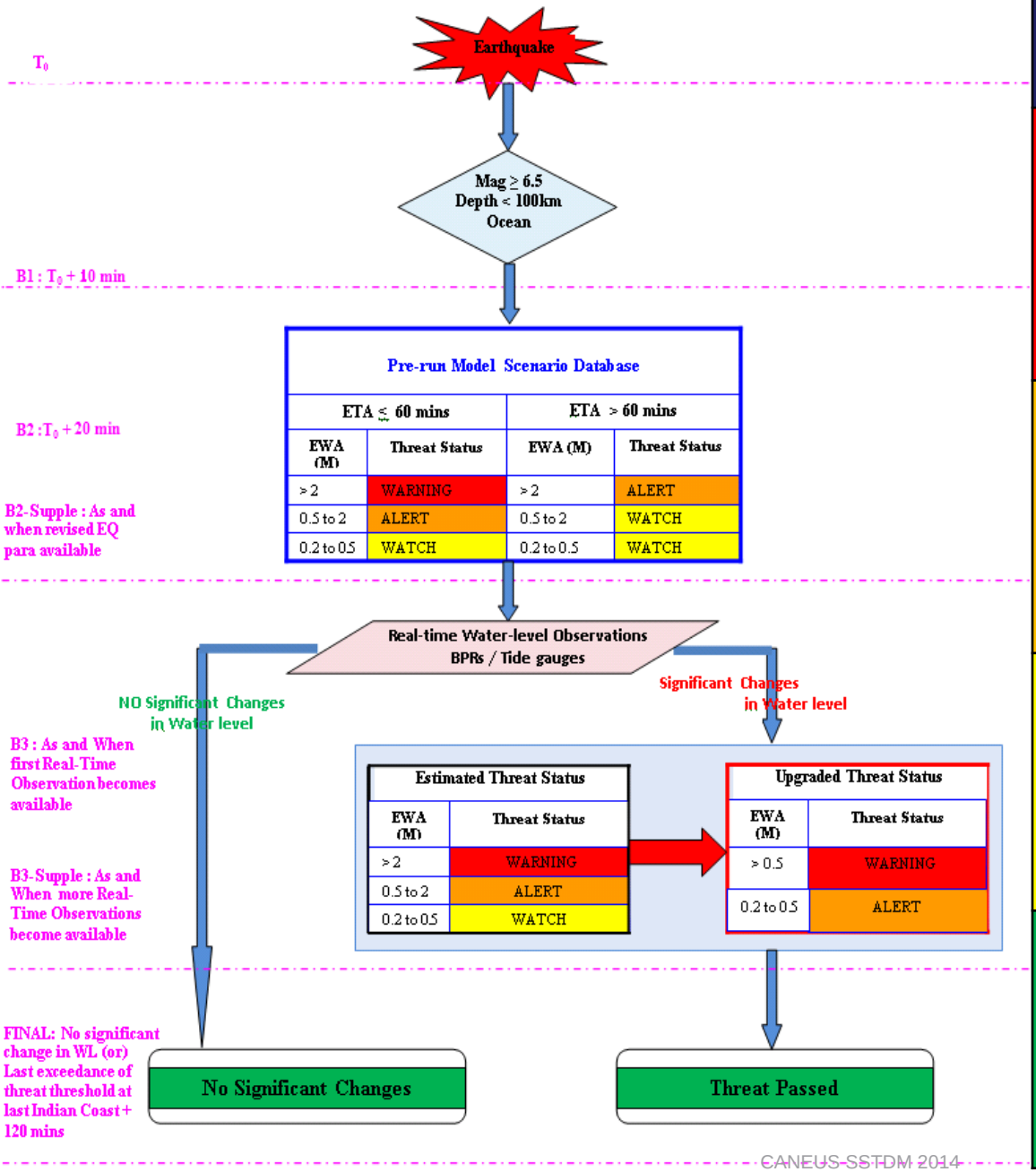
➢ Coastal Forecast Zones

- Common and agreed formats for information exchange
- 50 km buffer drawn for the 30 m bathymetry towards offshore
- Buffer zone is further divided into 100 Km segments along the coast
- Graphical presentation of tsunami bulletins into geospatial information (Threat/no threat) and first wave arrival times for each Coastal Forecast Zone
- Each element represents a specific point/region along the coast which would be well known to Emergency managers and populace





Standard Operating Procedures and Threat Levels



Threat Status	Action to be taken	Dissemination to
WARNING	Public should be advised to move inland 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, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media
WATCH	No immediate action is required	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Media
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media

Sample Bulletins

Bulletin Formats

- Notification Messages are issued in text format
- Bulletins are issued in both text and html formats
- Graphics are made available in jpg or png format on the website
- Spatial data is made available in dbf format through the ftp site

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NOTIFICATION MESSAGE 1
INDIAN TSUNAMI EARLY WARNING CENTER (ITEWC)
ISSUED AT: 0635 IST Wednesday 20 November 2013

TO: NATIONAL NTWC BULLETIN RECIPIENTS
FROM: ITEWC

NOTIFICATION:
ITEWC INCOIS HAS JUST ISSUED TEST BULLETIN 1 (PRELIMINARY EARTHQUAKE INFORMATION)
FOR THE INDIA, BASED ON THE FOLLOWING TEST EARTHQUAKE EVENT:

MAGNITUDE:          8.8 M
DEPTH:              10  km
DATE:               20 Nov 2013
ORIGIN TIME:        0630 IST
LATITUDE:           3.35 N
LONGITUDE:          95.96 E
LOCATION:           Northern Sumatra

TO VIEW THE TEST BULLETIN GO TO ITEWC INCOIS WEBSITE AT:
 www.incois.gov.in/Incois/tsunami/COMM_ntwclogin.jsp

NTWC IS A SERVICE OF ITEWC, INCOIS FOR PROVIDING TSUNAMI ADVISORIES FOR INDIA.

GENERAL PUBLIC INFORMATION FOR THIS TEST EVENT IS AVAILABLE FROM:

INDIAN TSUNAMI EARLY WARNING CENTER (ITEWC)
INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES (INCOIS)
ADDRESS:"OCEAN VALLEY", PRAGATHI NAGAR (BO), NIZAMPET (SO),
HYDERABAD - 500 090, INDIA.
PHONE:  91-40-23895011
FAX:    91-40-23895012
EMAIL:  TSUNAMI@INCOIS.GOV.IN
WEB:    WWW.INCOIS.GOV.IN

YOU ARE RECEIVING THIS "NOTIFICATION MESSAGE" VIA DSS_1_0 (MANUAL (INTERACTIVE))
CONFIGURED TO SEND MAIL FROM  tsunami@incois.gov.in

END OF NOTIFICATION MESSAGE
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Sample Notification Message

Sample Bulletins

BULLETIN 3

INDIAN TSUNAMI EARLY WARNING CENTRE INCOIS HYDERABAD (ITEWC)
Issued at: 0745 IST Wednesday 20 November 2013
*** THIS IS A COMMUNICATIONS TEST OF THE INDIAN TSUNAMI EARLY WARNING SYSTEM ***
*** THIS IS NOT A REAL TSUNAMI EVENT ***

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

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 :	20 Nov 2013
Origin Time:	0630 IST
Latitude:	3.35 N
Longitude:	95.96 E
Location:	Northern Sumatra
Land/ Ocean:	Ocean part
Water Level Depth (if Ocean):	1251 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)
Meulaboh (Indonesia)	4.3N	96.2E	20-Nov-2013 06:50:00	3.6
Sabang (Indonesia)	5.8N	95.3E	20-Nov-2013 06:55:00	4.0

Real-time measurements of wave activity have indicated that a tsunami was generated.

The following is the threat assessment based on revised earthquake information and pre-run model scenarios.

TSUNAMI THREAT FOR THE INDIAN COAST

The list below shows the forecast arrival time (T) of the first wave estimated to exceed 0.2 m amplitude 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 (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

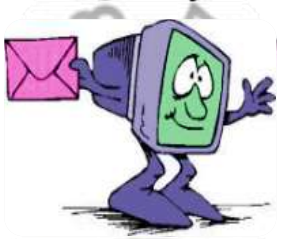
Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

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
DIGLIPUR	DIGLIPUR	ANDAMAN & NICOBAR	20-Nov-2013 08:20	2.1	Warning
RANGATH BAY	RANGATH BAY	ANDAMAN & NICOBAR	20-Nov-2013 08:22	5.0	Warning

Bulletins are sent to …….

Fax



Email

SMS

Web

GTS

International Level

23 countries on Indian Ocean rim

National Level

MHA, NDMA, MoES, NDRF Head quarters, IMD & CWC

State Level

Principal Secretaries (Revenue) of Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamilnadu, West Bengal, Lakshadweep and Puducherry

District Level

DROs of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasham, and S.P.S Nellore

Institutional

1-10 NDRF Battalions, ALL control rooms of A&N Islands, HQWNC, HQENC, HQANC, HQSNC, NOIC Tamilnadu, Gujarat, West Bengal, NPCIL, Mumbai, Madras Atomic Power Station, Tarapur Atomic Power Station (1&2, 3&4), Kudankulam Atomic Power Unit, SHAR, MRCC, Coast Guards, Port Officers, Coastal Industries (Reliance) Media & Public subscriptions

8.5 M EQ off northwest coast of Sumatra on 11 April 2012

Time line

14:08 Earthquake

8.5 M

14:16 Bulletin - 1

14:20 Bulletin - 2

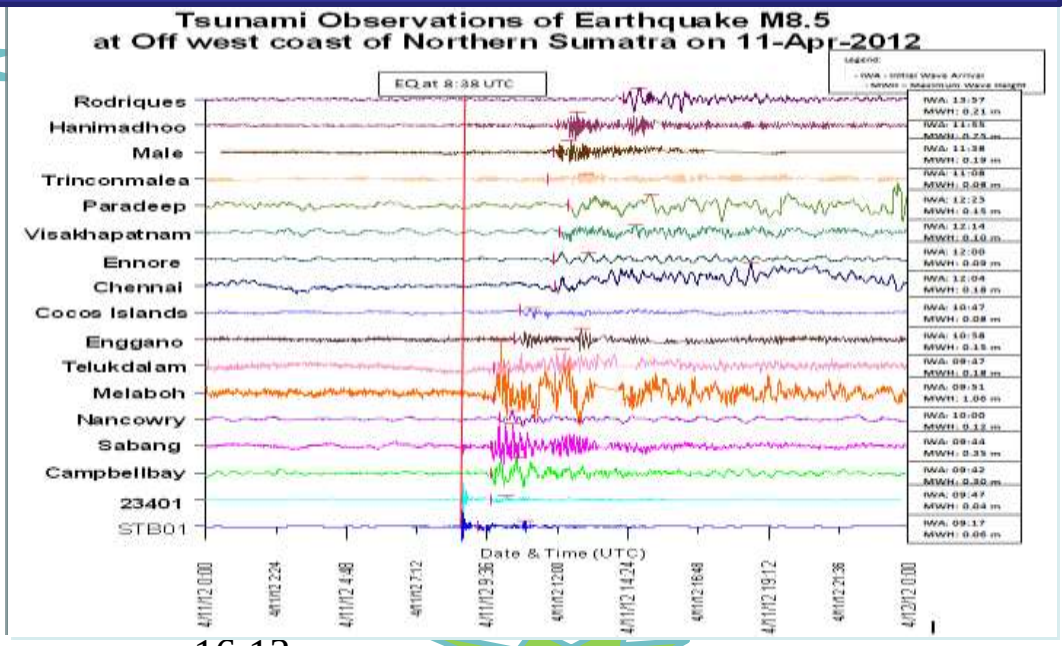
15:21 Bulletin - 3

15:48 Bulletin - 4

17:02 Bulletin - 5

18:08 Bulletin - 6

ALL CLEAR



16:13 Earthquake

8.2 M

16:19 Bulletin - 1

16:46 Bulletin - 2

17:08 Bulletin - 3

17:33 Bulletin - 4

18:29 Bulletin - 5

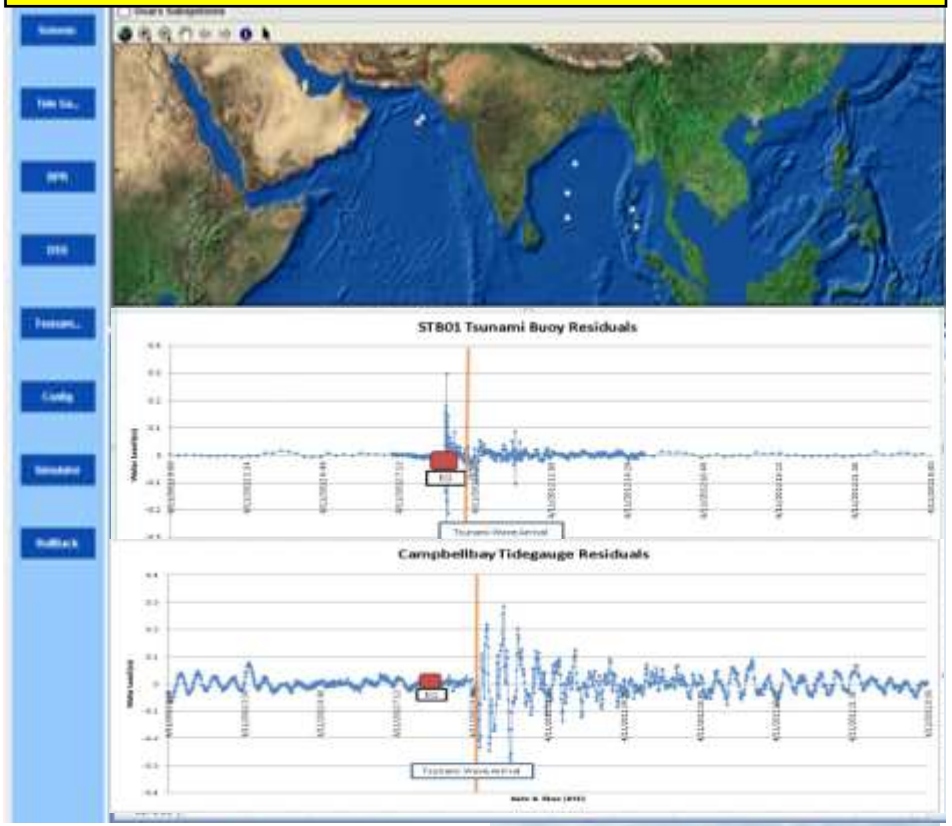
ALL CLEAR

Alert for Indira Point, Komatra & Katchal Island and Car Nicobar

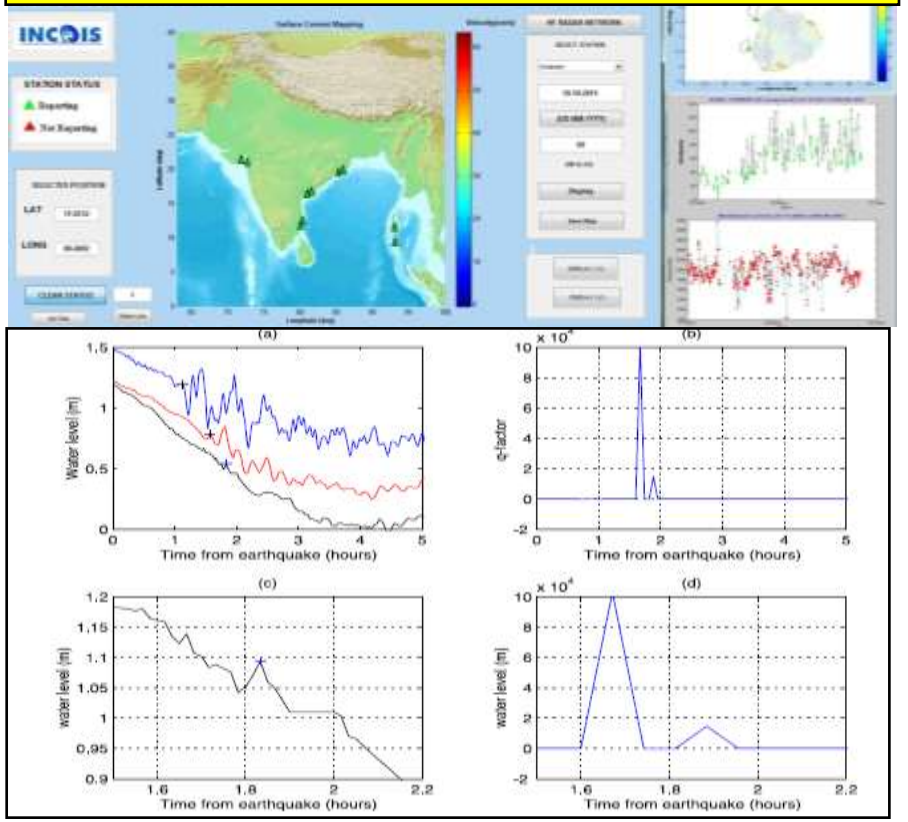
Observed water level 0.2m change at Meulaboh

Tsunami observations during the 8.5 M EQ off northwest of Sumatra on 11 April 2012

Tsunami Buoy & Tide gauge data during EQ on April 11, 2012



HF Radar data during EQ on April 11, 2012



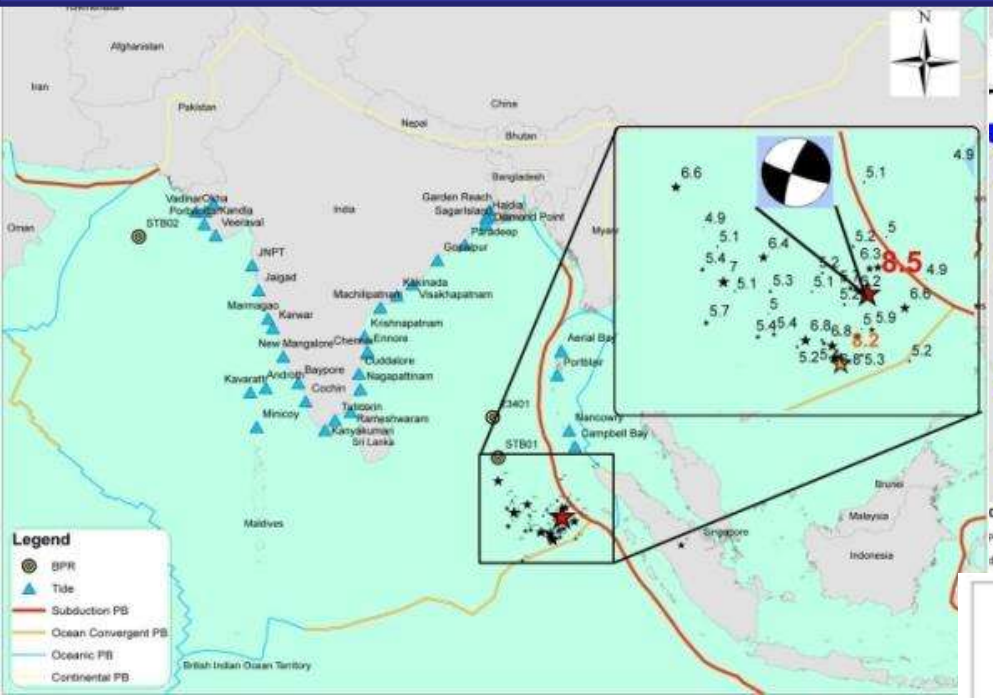
Tsunami Buoy

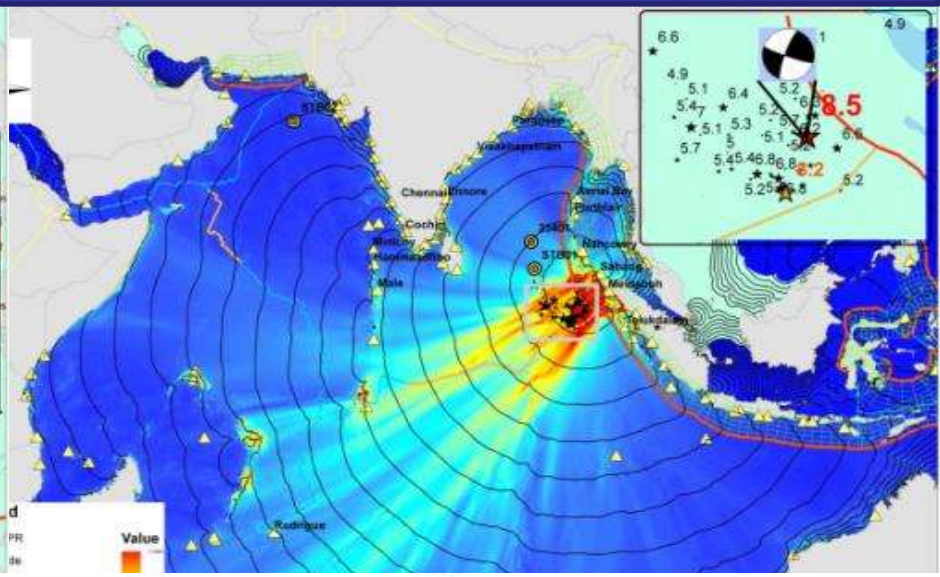
Tide gauge sensor

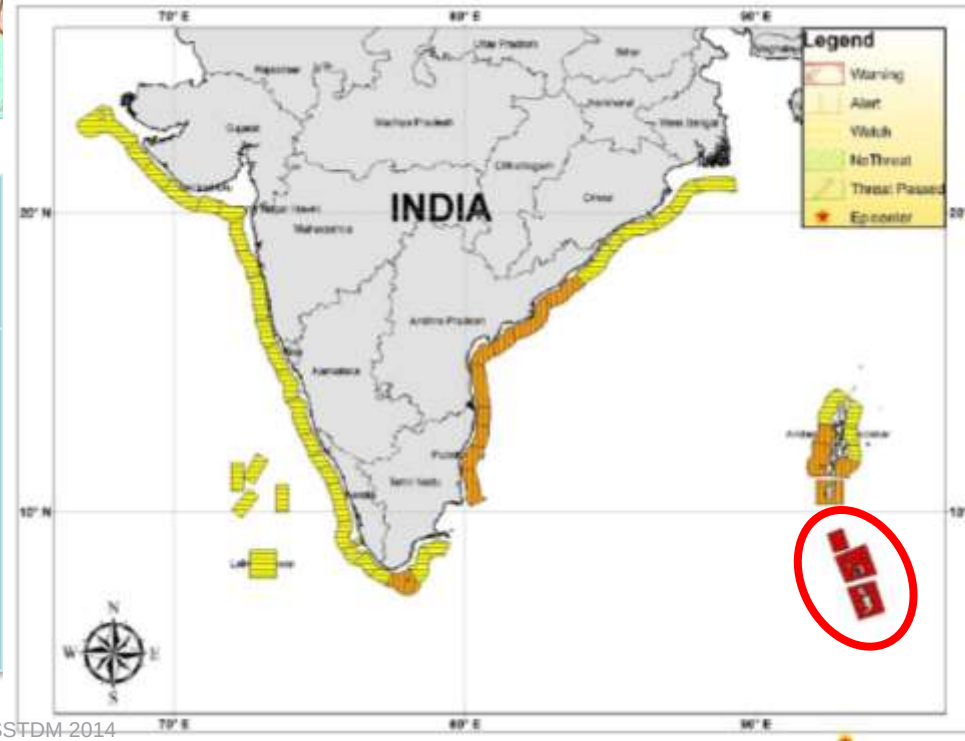
HF Radar Receiver

HF Radar Transmitter

Quantitative evaluation by ITEWC avoided unnecessary evacuation and panic

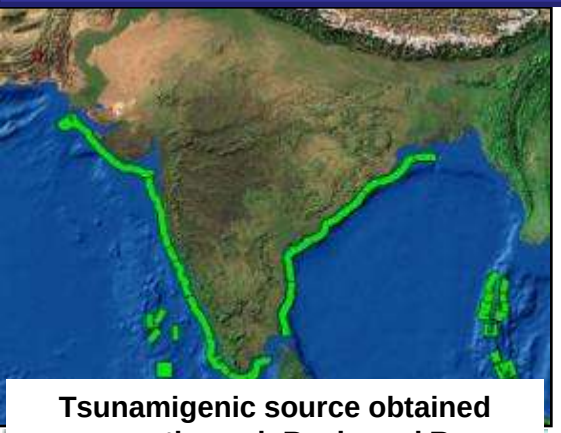




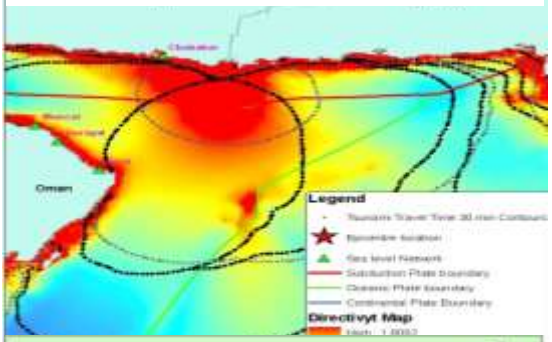


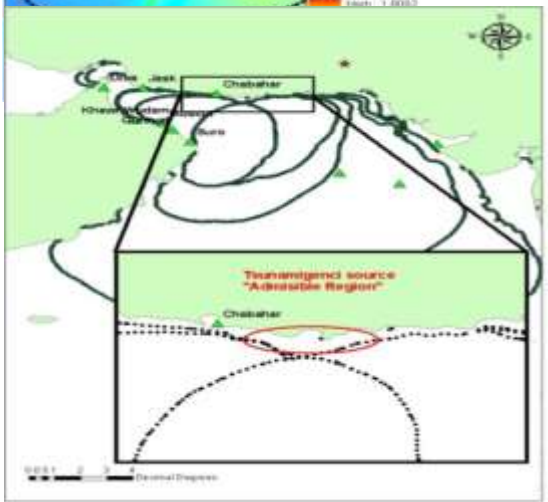
Quantitative evaluation by ITEWC	Qualitative Evaluation would have lead to…
Tsunami Evaluation: Based on PRE-RUN model Simulations, TSUNAMI WARNING is issued for only THREE regions in Nicobar Islands. Later cancelled.	**Tsunami Evaluation:** Indian Ocean wide Watch

7.6 EQ in Pakistan (land) generated a micro tsunami on 24 September 2013



Tsunamigenic source obtained through Backward Ray tracing Method





Pakistan earthquake of Magnitude 7.6 (Mw(mB))

On 24-September-2013 11:29 UTC; 24-September-2013 16:59 IST

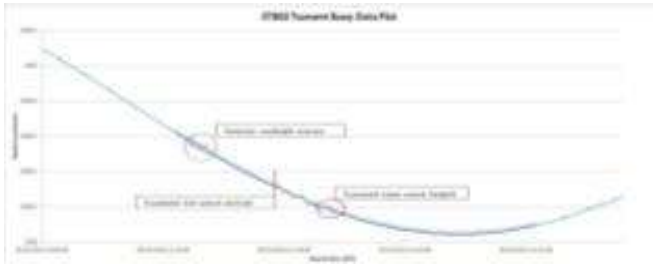
Minor water level changes are observed at different sea-level stations which could be due to submarine land slides due to this near coast major earthquake .

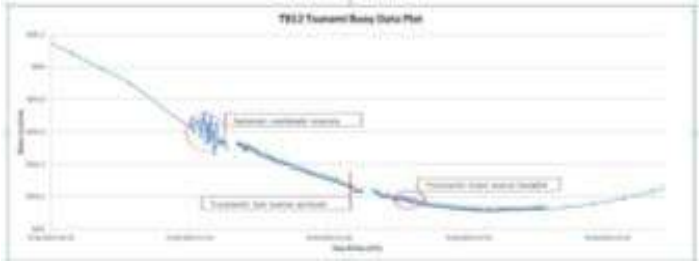
ITEWC Issued Bulletins

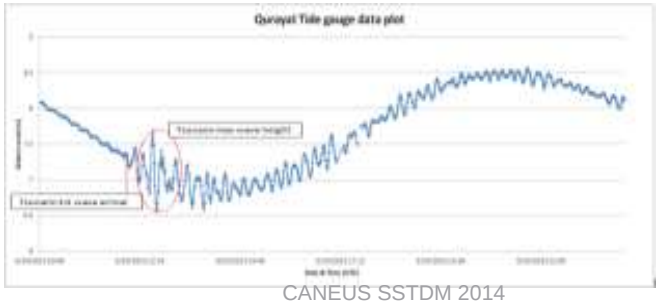
Bulletin No 1: Earthquake Information M7.6

Bulletin No 2: *No Tsunami threat* for India and Indian Ocean region

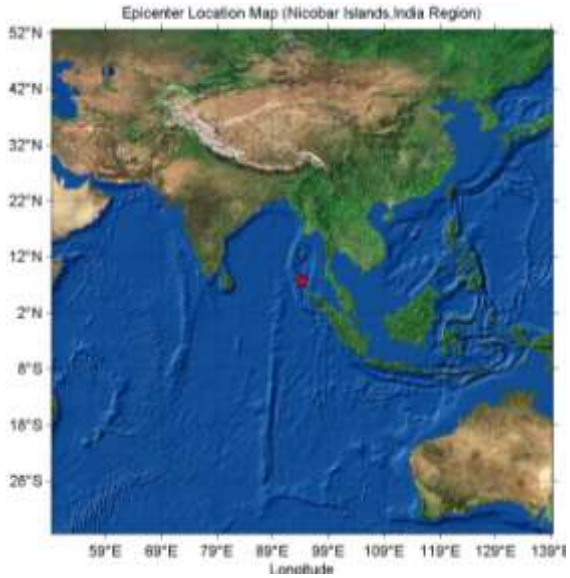
S.NO.	Station Name (Country)	Lat (° N)	Long (° E)	Expected Time of 1st Arrival (UTC)	Observed Time of 1st Arrival (UTC)	Observed Max. Wave Height (cm)
1	STB02 (India)	20.80	65.34	12:28	12:25	0.9
2	Chabahar (Iran)	25.295	60.603	12:39	12:40	11
3	TB12 (India)	20.18	67.65	12:45	12:55	1.1
4	Suro (Oman)	22.57	59.59	12:46	12:08	18
5	Qurayat (Oman)	23.26	58.92	12:49	12:06	55
6	Muscut (Oman)	23.633	58.566	12:53	12:05	24
7	Jask (Iran)	25.63	57.77	13:25	14:12	06
8	Khawr Wudam (Oman)	23.82	57.52	13:27	13:14	10
9	Diba (Oman)	25.649	56.269	14:01	13:45	08
10	Okha (India)	22.467	69.083	14:38	17:12	02







6.5 M EQ in Andaman & Nicobar on 21 March 2014



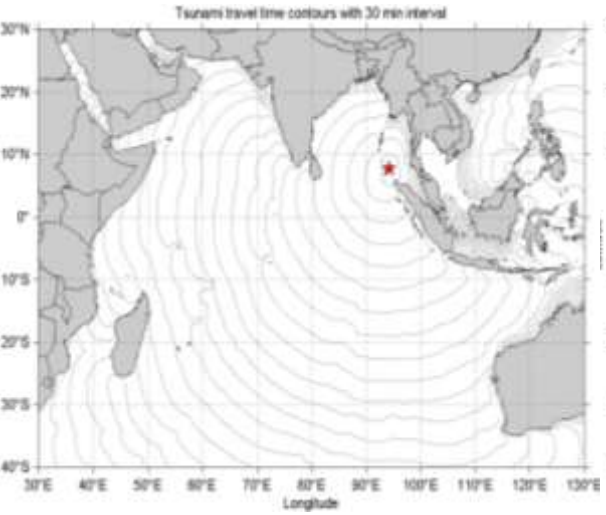
Nicobar Islands earthquake of Magnitude 6.5 (Mw(mB))
On 21-March-2014 13:41 UTC
No significant water level changes are observed

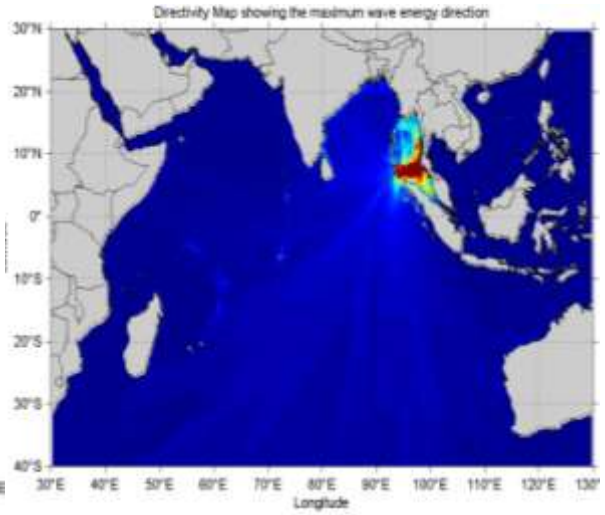
ITEWC Issued Bulletins

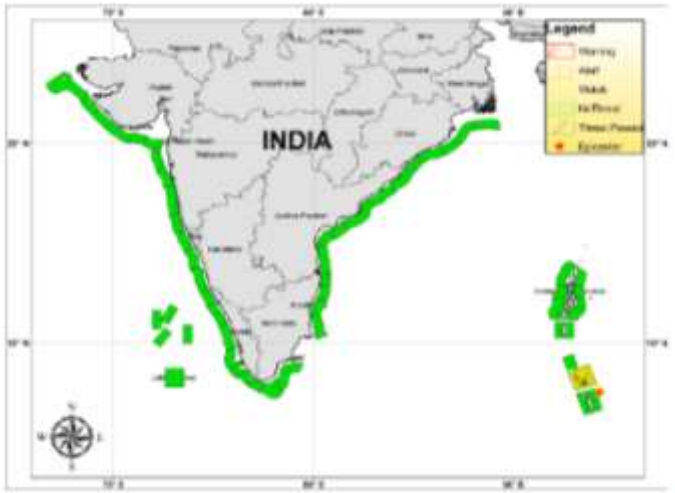
Bulletin No. 1: Earthquake Information M6.5

Bulletin No. 2: WATCH for Komatra & Katchal Island

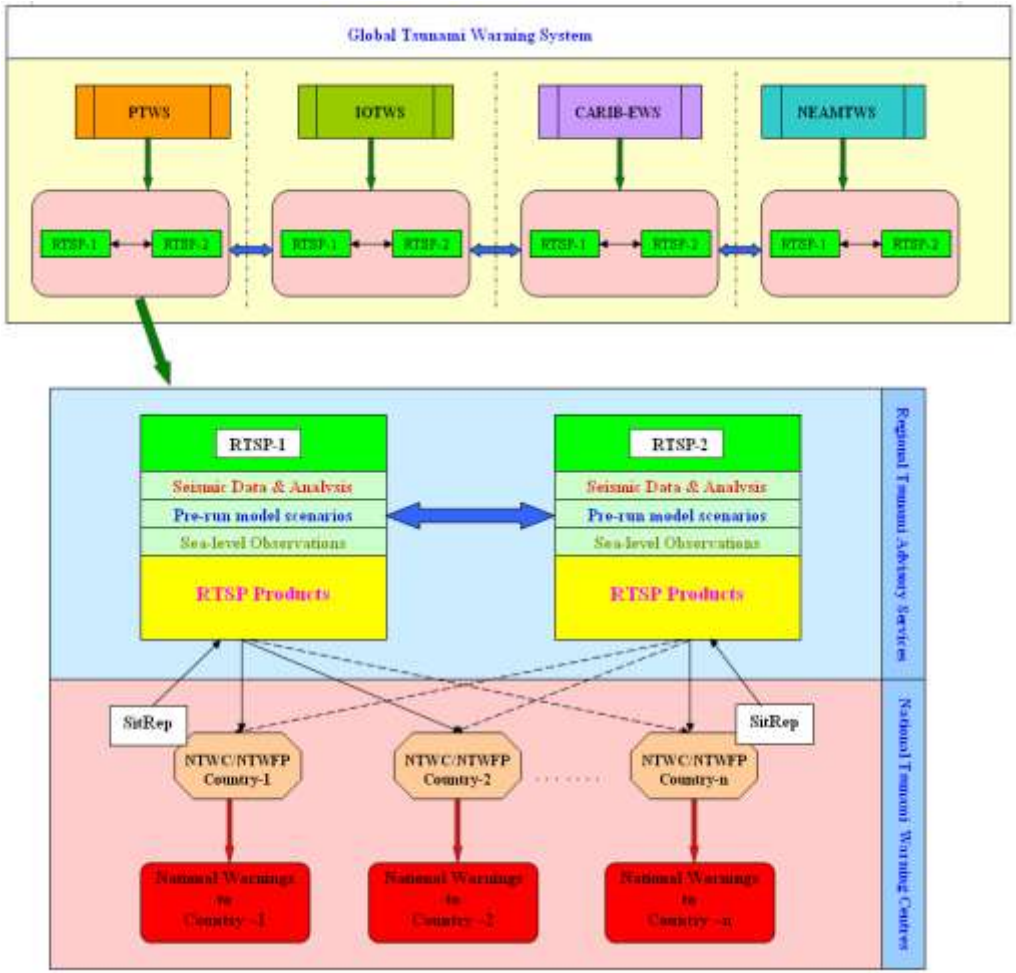
Bulletin No. 3: Cancellation







Role of India in building tsunami warning services



India is playing major role in UNESCO's

- **Intergovernmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS)**
  - As a Regional Tsunami Advisory Service Provider (RTSP) providing bulletins to all Indian Ocean rim countries
  - Standardisation of Bulletin formats & content
  - Concept of Coastal Forecast Zones
  - Public Bulletins
  - Performance Indicators
  - NTWC Trainings / Workshops
  - Communication Tests & Tsunami Drills
- **Tsunamis and Other Hazards Related to Sea-Level Warning and Mitigation Systems (TOWS-WG)**
  - Global Harmonization

Regular communication tests

Communication Tests

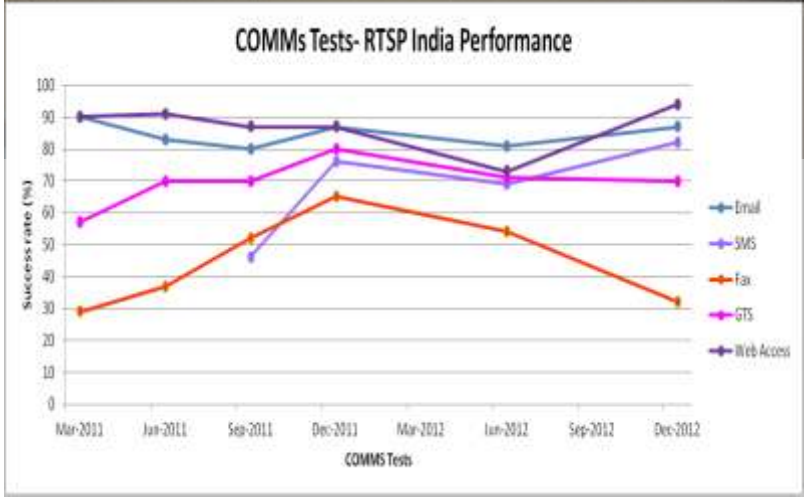
1. March 16, 2011 (NTWCs)
2. June 15, 2011 (NTWCs & National DMOs)
3. September 14, 2011 (NTWCs & National DMOs)
4. December 14, 2011 (NTWCs)
5. June 13, 2012 (NTWCs)
6. December 12, 2012 (NTWCs)
7. June 13, 2013 (NTWCs & National DMOs)
8. December 11, 2013 (NTWCs)

Modes of Communication

- International: Email, Fax, GTS, SMS, Web
- National: Email, Fax, SMS, Web

Performance till now:

- Compared 6 COMMs test results
- Significant improvement over SMS, Email & Web



	16 Mar 2011		15 Jun 2011		14 Sep 2011		14 Dec 2011		13 Jun 2012		12 Dec 2012	
Mode	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)	No. of NTWCs Received	Time Delay (Mins)
Email	19/23	0 – 11	20/22	0 – 48	22/23	0 – 15	17/19	0 – 9	18/21	0 – 2	15/17	0 – 4
Fax	7/23	0 – 61	10/22	0 – 91	12/23	0 – 93	13/19	0 – 35	12/21	0 – 35	6/17	0 – 32
GTS	12/23	0 – 5	17/22	0 – 17	17/23	0 – 26	16/19	0 – 25	15/21	0 – 7	12/17	0 – 14
SMS	--	--	--	--	13/23	0 – 13	15/19	0 – 23	15/21	0 – 1	14/17	0 – 3

IOWave09 & IOWave11

ITEWC Participated in two Tsunami mock drills
(i) IOWave09 on October 14, 2009 and ii) IOWave11 on October 12, 2011

➢ Lessons Learnt

✓ Warning Centre dissemination process

- Warning Centre disseminated 15 bulletins in total, through Email, Fax, SMS, GTS and Web to all national and international contacts available at ITEWC
- State/District/Mandal/Block level DMO contact list to be prepared

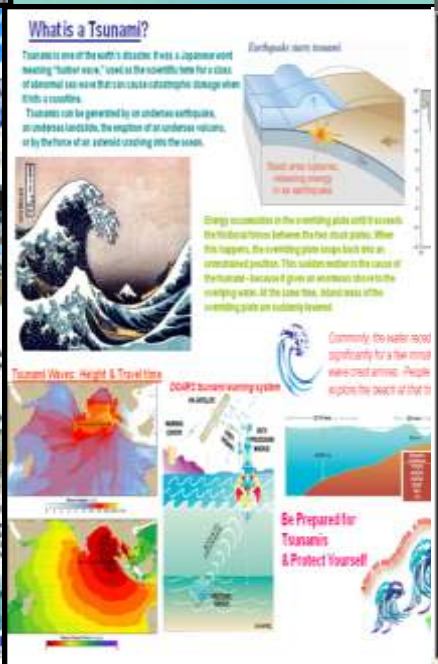
✓ Stakeholders reception process

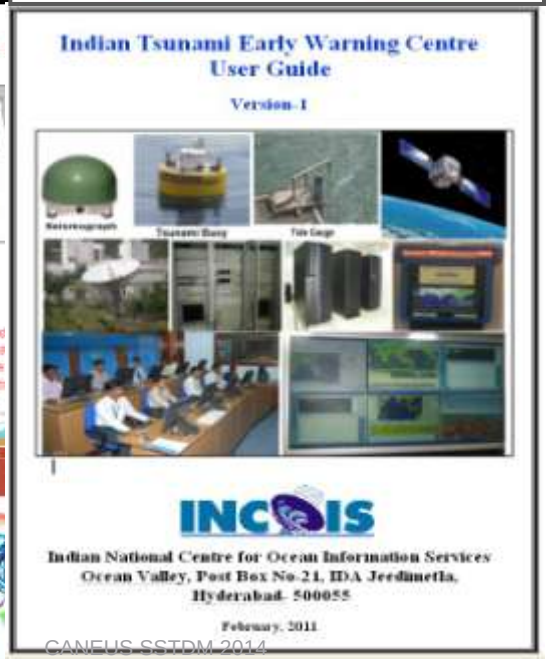
Communication mode	Elapsed time	No. of Stakeholders who received all 15 bulletins
Email	0 - 94 mins	21
Fax	0 - 111 mins	6
SMS	0 - 20 mins	18

✓ Time taken to notify public

State	Making a decision on public warning (from time of receipt of warning)	Formulation of public notification (from time of decision)	Activation of public notification systems (from time of notification formulated	Total Elapsed time
Maharashtra	20	40	25	1 hr 20 mins
Puducherry	10	5	5	20 mins
Orissa	5	5	10	20 mins

Public awareness and preparedness





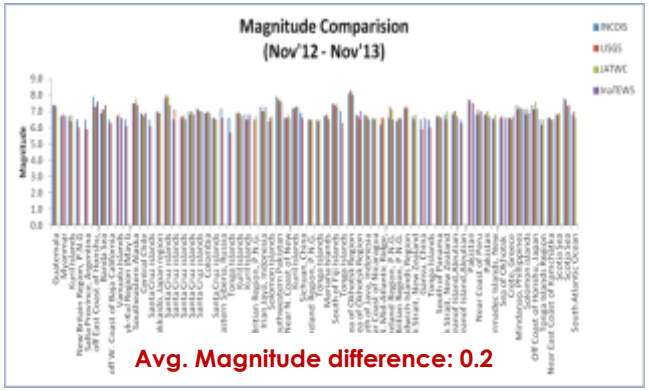
Tsunami Preparedness Material

- Tsunami Warning Centre operations Handbook & User guide
- Tsunami awareness films for Administrators, General public and Children
- Tsunami awareness & preparedness posters
- Leaflets in mutliple local languages

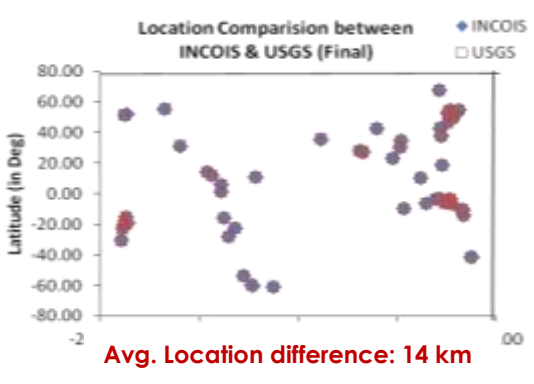
Performance of ITEWC

Summary of Performance Indicators

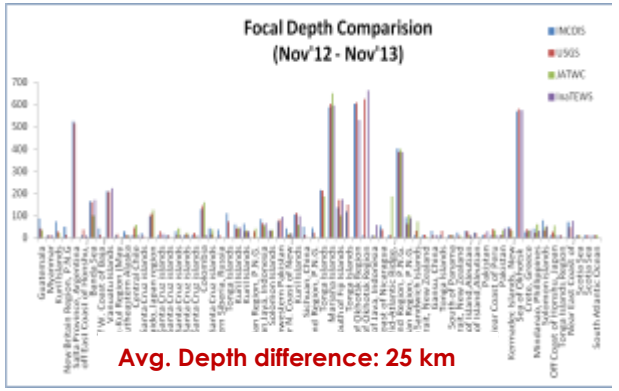
Reporting Period: November 2012 to December 2013	
Total Number of Global Earthquakes M≥6.5	79
Total Number of Indian Ocean Earthquakes M≥6.5	3
Number of Events for which **"THREAT"** Bulletin issued	0



Avg. Magnitude difference: 0.2



Avg. Location difference: 14 km



Avg. Depth difference: 25 km

S. No	Performance Indicator	Target	RTSP India Performance
PI 1	Elapsed time of issuing first earthquake bulletin after earthquake	10 min	11 Min
PI 2	Accuracy of Earthquake Parameters, in comparison with final estimates from USGS		
a	Magnitude	0.3	0.2
b	Depth	25 km	25 km
c	Location	30 km	14 km
PI 3	Probability of Detection of IO EQ with Mw >= 6.5	100 %	100%
PI 4	Elapsed time of issuing first tsunami threat assessment bulletin after earthquake	20 min	20 min
PI 5	Probability of detection tsunamis above threat threshold	100%	--
PI 6	Accuracy of tsunami wave height predictions	Factor of 2	--
PI 7	RTSP Participation in communication tests	100%	100%

Challenges in Tsunami Warning and ITEWC's Steps Forward

- **Under-estimation of Magnitude and Tsunami wave heights**
  - Ex: Tohoku-Oki Earthquake on March 11, 2011
  - underestimated magnitude 7.9 and Initial Tsunami amplitude "3m"

ITEWC Step: Establishment of GNSS & SMA Network at Andaman & Nicobar Islands, and Indian Seismic & GNSS Network (ISGN) for Tsunami Early Warning for estimating Mw (Moment Magnitude), Rupture area, Vertical displacement on sea floor

- **Over-estimation of Tsunami wave heights**
  - Ex: Northern Sumatra Earthquake on April 11, 2012
  - Tsunami amplitude estimate " > 2m" at Andaman & Nicobar Islands, but observed 30 cm as the actual displacement was in horizontal direction

ITEWC Step: Real-time water level inversion

- **Estimation of only wave heights not the inundation stretch**

ITEWC Step: Standby Inundation Model & Real-time Inundation Model and Visualization and Analysis System for 2D and 3D Geospatial data (3DVAS)

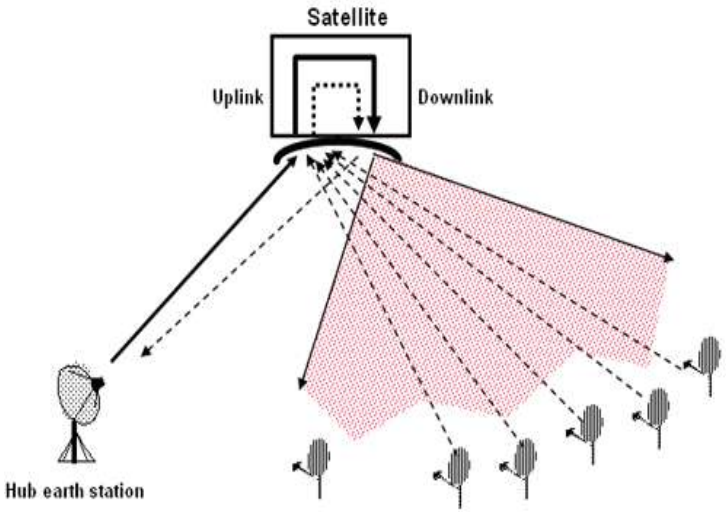
- **Emergency Communication**
  - Ex: Northern Sumatra Earthquake on October 25, 2010
  - Tsunami that killed over 400 people as most coastal villages in the Pagais/ Sipura there is no electricity or telephone communications, so residents couldn't receive alert

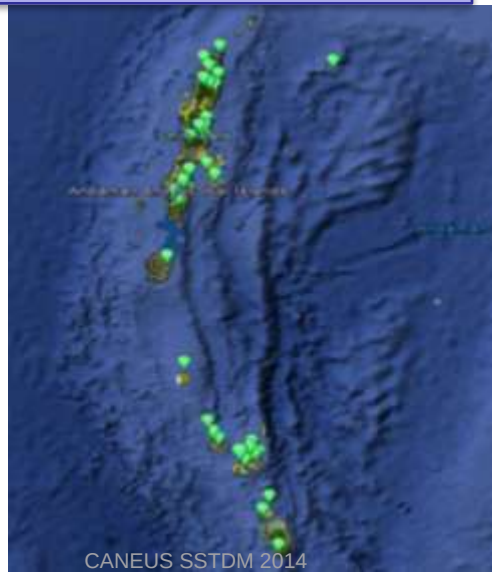
ITEWC Step: VSAT based Emergency Communication System at all Emergency Operations Centres

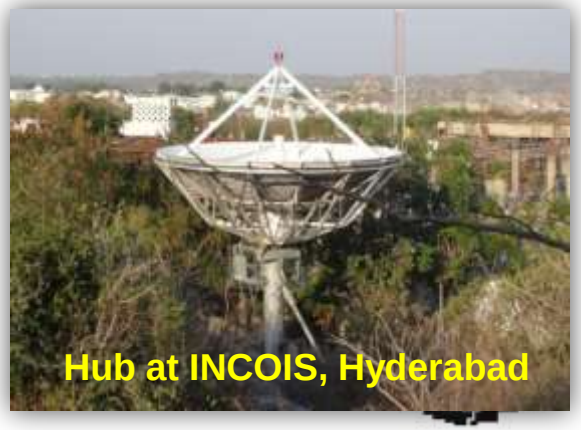
Indian Seismic & GNSS network

Origin Time (UTC)	Magnitude	Latitude	Longitude	Depth (KM)	Region Name
2014-03-19 00:34:14	6.1	5.28	153.883E	10	New Ireland Region, P.N.G.
2014-03-18 21:28:48	6.1	20.005S	70.759W	10	Near Coast of Northern Chile
2014-03-17 05:11:36	6.4	20.044S	70.888W	10	Near Coast of Northern Chile
2014-03-16 21:16:38	6.8	19.688S	70.689W	10	Near Coast of Northern Chile
2014-03-15 23:51:31	6.3	5.572S	81.07W	10	Near Coast of Northern Peru
2014-03-15 08:59:21	6.1	14.109S	76.302W	10	Near Coast of Peru

GNSS and Strong motion sensor network in A & N

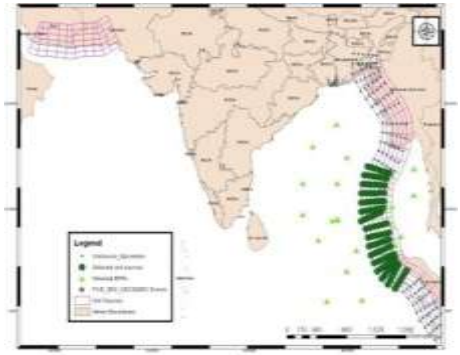


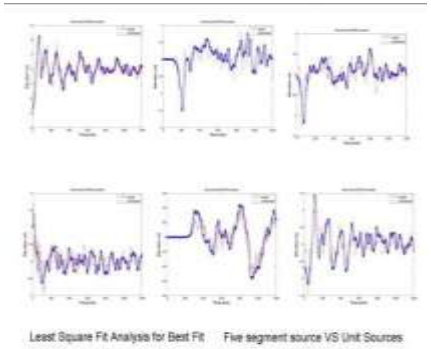


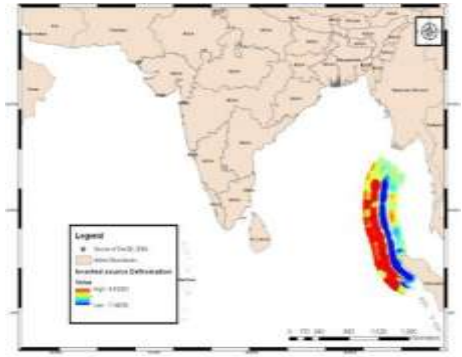


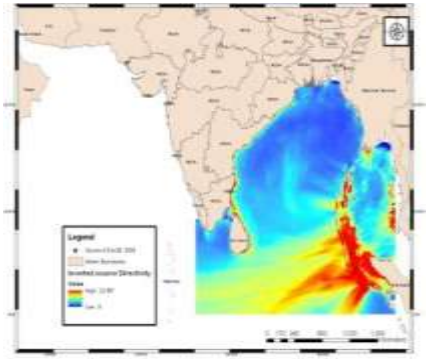
Real-time water level inversions & inundation modelling

Real-time Water level inversion





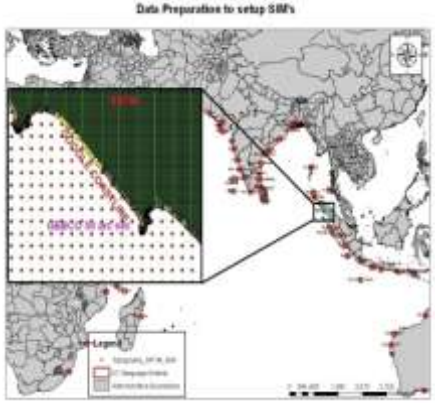


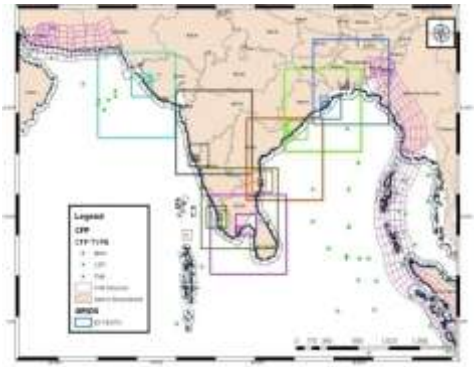


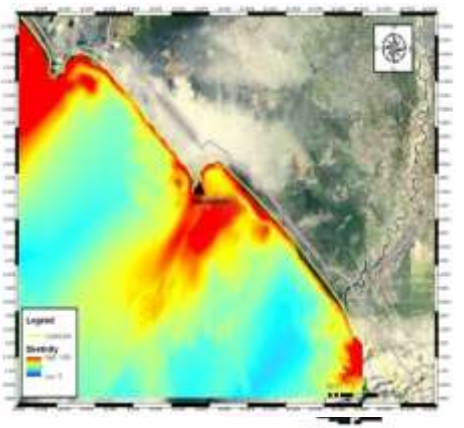
- Integration of Inversion module into DSS under progress
- Inversion for slip distribution at unit sources
- Least square fit analysis of green functions and residuals at BPRs
- The Planned BPR network will cover the sources at Andaman & Nicobar Islands

Real-time Inundation Model

- Total no of Indian Ocean Tsunamigenic sources: 2(Andaman &Sumatra, Makran)+7 (includes South China sea, Banda sea, Java sea, Celeb sea)
- Total no of Indian Ocean Unit sources: 1320
- New IO Domain Extent: 10E-160E
- Spatial Resolution: 2.5Km
- No Of Output Files For Each Scenario:1500 (25 hr)

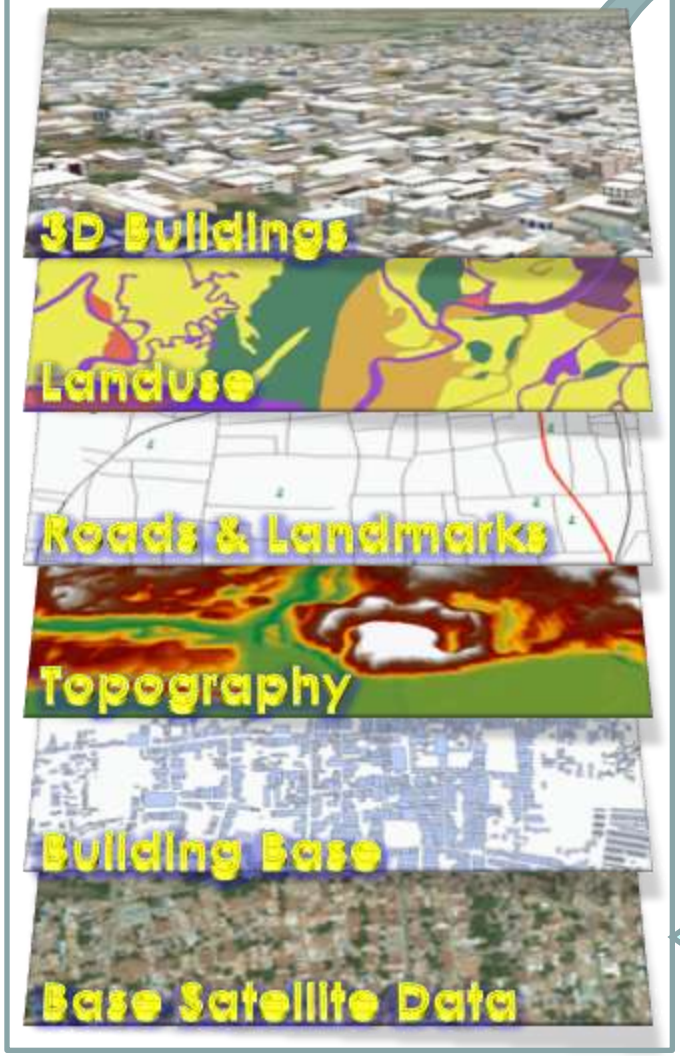


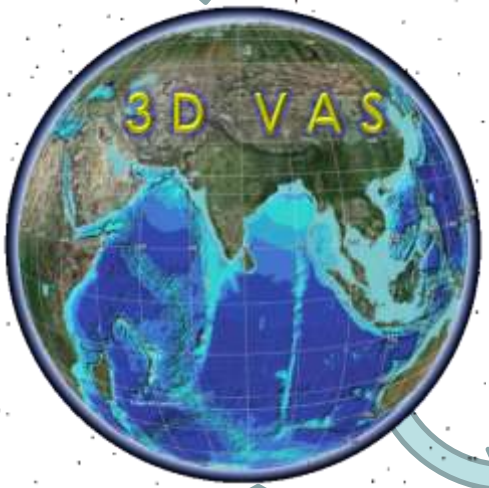




Hazard maps and risk analysis

Generation of 3D GIS Maps





Base Maps, Hazard Maps, vulnerability maps, database of tsunami and storm surge inundation modeling results, event data, etc.

Ground Survey: GCP, Leveling, Field Photos, Socio-economic census, etc

Risk analysis and advisory

Vulnerability maps integrated with 3D GIS database will aid in making the effective disaster management plans

Manipulation with realistic 3D models and textures of real buildings. Provides the possibility for including of real object images (peoples, items, signs) in a 3D model. The building brief (address, telephone, owner) appears in the pop-up information box. (This example is Nagapattinam India).


Thank You!