Use of Space based Information in Early Warning Systems

Expert Meeting organised by UN-SPIDER

24-25 June , 2013, Bonn

Early Warning Systems/Risk Knowledge/ Case study-IOTWS

Early Warning in the context Risk Management

Sam Hettiarachchi

Chair, Working Group on Risk Assessment and Reduction
UNESCO/IOC/ICG/IOTWS

Before and after- destructive power of natural hazards

Banda Aceh (2004)

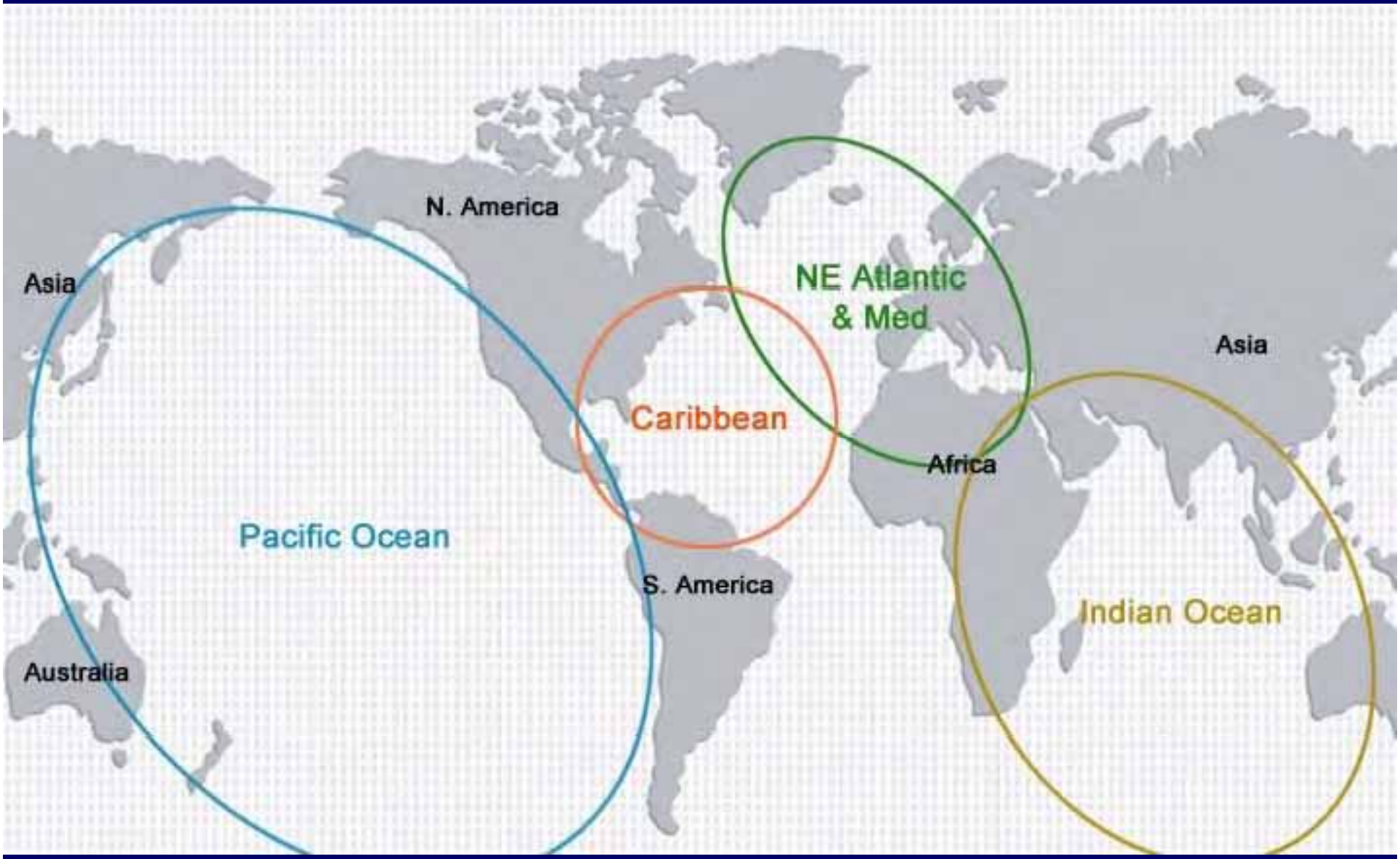
Louisianna (2005)

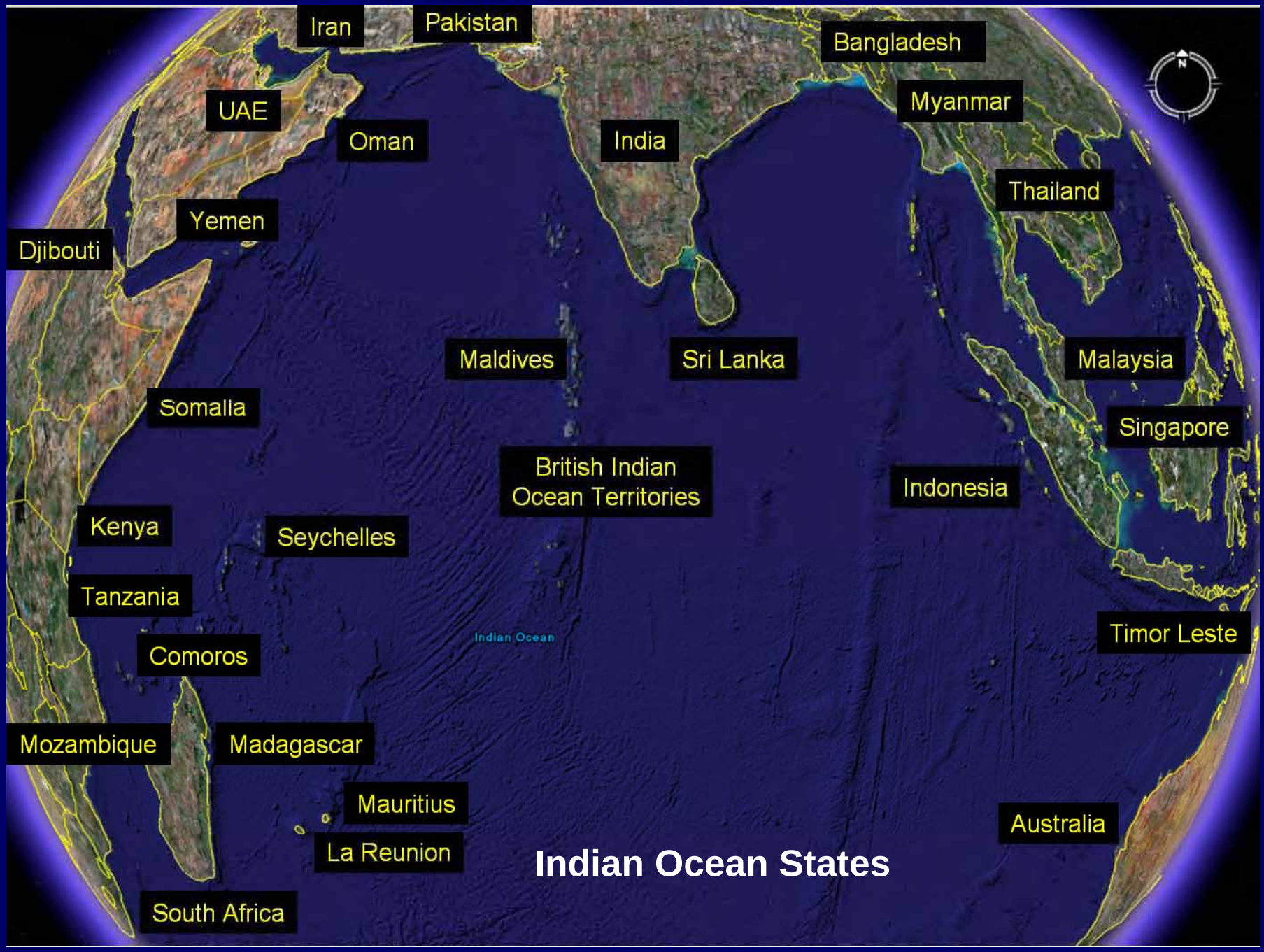
Approach to the Development of the Indian Ocean Tsunami Warning System

Tsunami Warning Systems

Tsunami Warning Systems are governed UNESCO/IOC, Paris

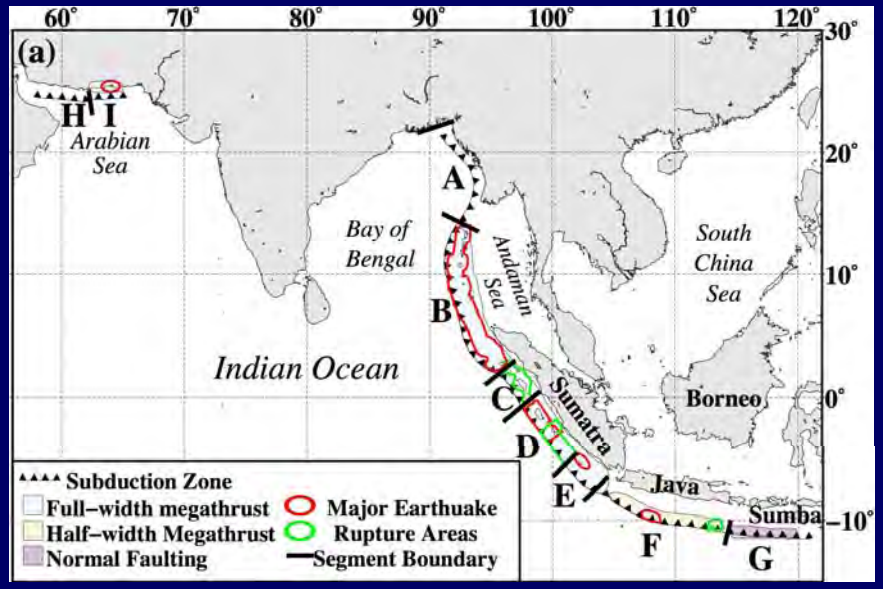
Tsunami Warning Systems under UNESCO /IOC




Iran
Pakistan
Bangladesh
UAE
Oman
India
Myanmar
Thailand
Yemen
Djibouti
Maldives
Sri Lanka
Malaysia
Somalia
Singapore
British Indian
Ocean Territories
Indonesia
Kenya
Seychelles
Tanzania
Indian Ocean
Timor Leste
Comoros
Mozambique
Madagascar
Mauritius
Australia
La Reunion
South Africa
Indian Ocean States

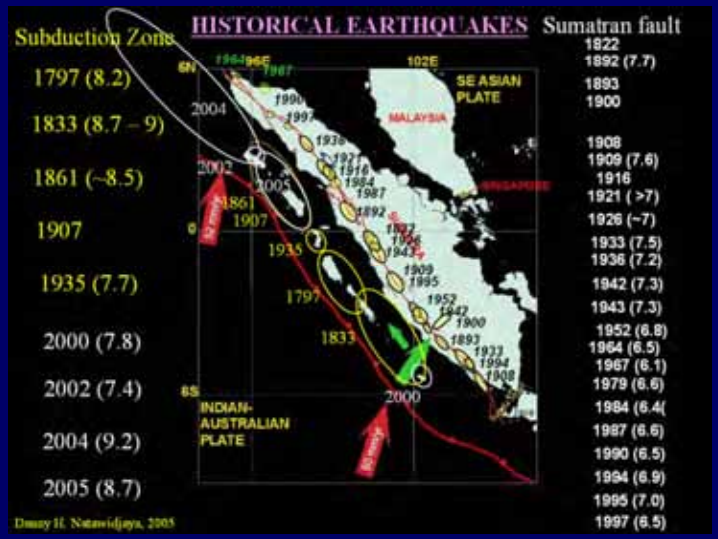
Tsunami Hazard Sources

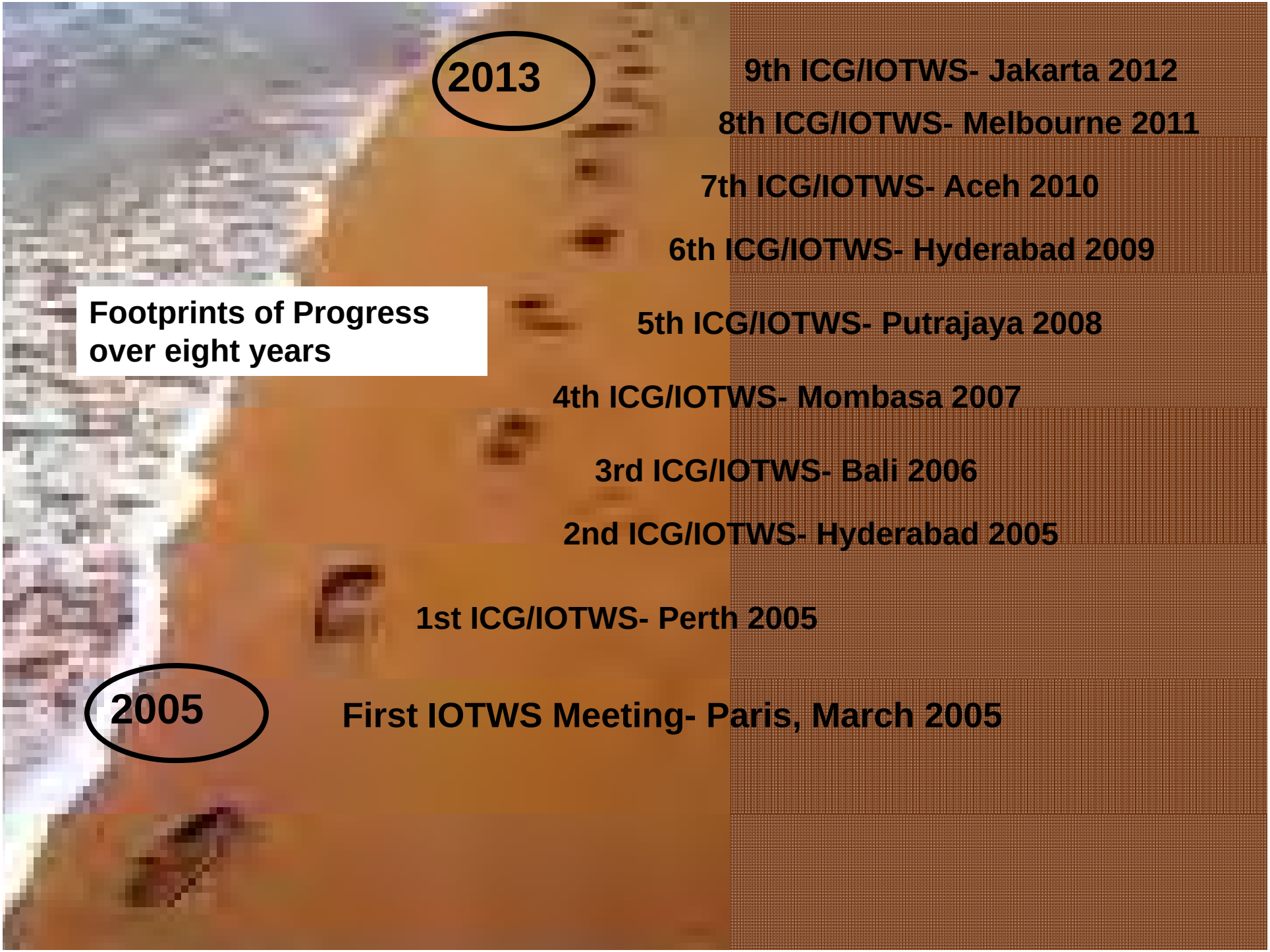
Makran

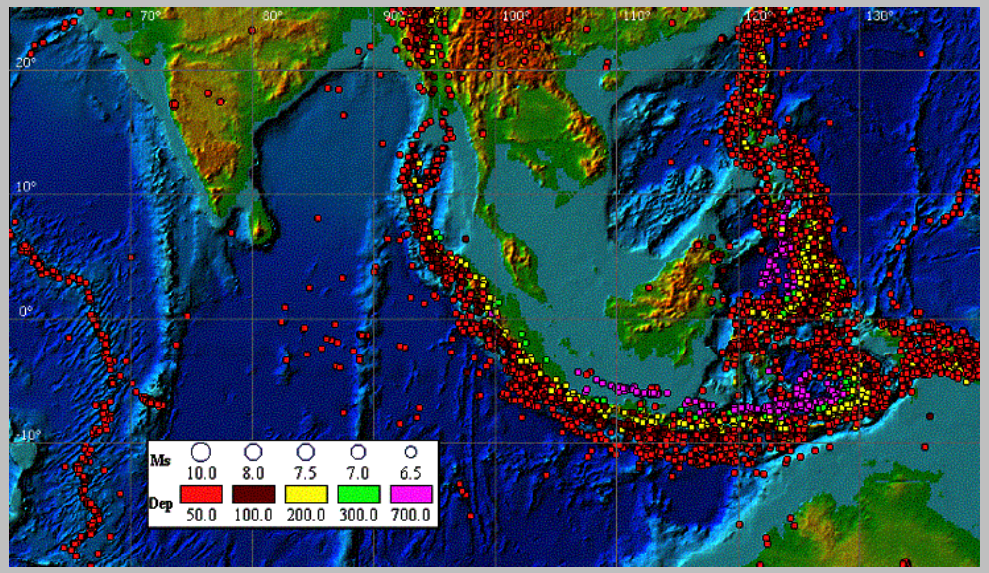


Sunda Arc

800 km across the North Arabian sea
Occurrence of Mw 8.1 earthquake in 1945 near Pasni




2013
9th ICG/IOTWS- Jakarta 2012
8th ICG/IOTWS- Melbourne 2011
7th ICG/IOTWS- Aceh 2010
6th ICG/IOTWS- Hyderabad 2009
Footprints of Progress over eight years
5th ICG/IOTWS- Putrajaya 2008
4th ICG/IOTWS- Mombasa 2007
3rd ICG/IOTWS- Bali 2006
2nd ICG/IOTWS- Hyderabad 2005
1st ICG/IOTWS- Perth 2005
2005
First IOTWS Meeting- Paris, March 2005



IOTWS is developed as a coordinated network of country systems in which each country has the responsibility of identifying the hazard, assessing the risk and issuing the warning.

The countries will be assisted by Regional Tsunami Service Providers (RTSP).

The establishment of the IOTWS is supported by several Working Groups including one on Risk Assessment and Reduction, operating since the inception of the IOTWS initiative in 2005.

Working Groups of IOTWS

Tsunami Risk Assessment and Reduction — WG 1

Modelling, Scenario Development

Tsunami Detection Warning and Dissemination — WG 2

Seismic Measurement, Data Collection and Exchange

Sea Level Data Collection and Exchange

Modelling, Forecasting

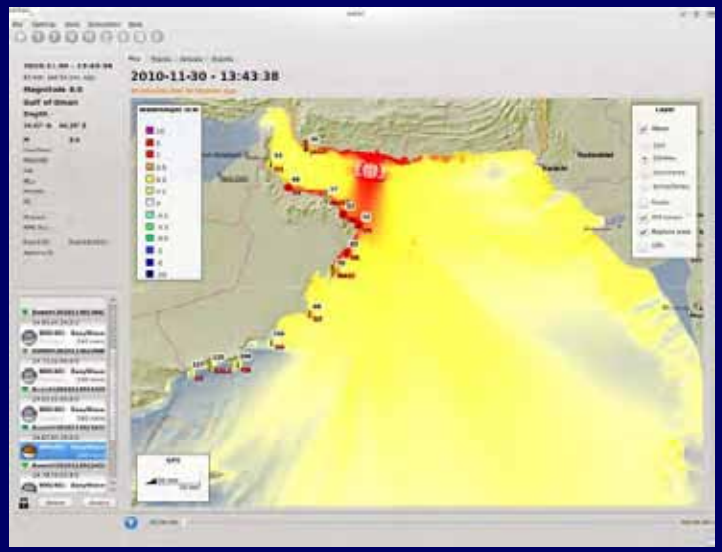
A System for Interoperable Advisory and Warning Centres

Tsunami Awareness and Response — WG 3

Awareness, Preparedness and Response- 'the last mile'

Investigating the Makran Source

UNESCO IOC and the Government of Oman are working in collaboration to assess the tsunami risk



Project will cover

- Hazard Source Identification and Assessment
- Scenario Modelling
- Vulnerability
- Risk Assessment and Management

The Risk Assessment and Management studies will comprise

-Overall risk assessment along the coast of Oman

-Detailed risk assessment of selected coastal cities

The assessment will cover the city boundaries and a minimum distance of 15-20 km on either side along the coast.

Early Warning Systems and Risk Management

Approach towards Risk Assessment and Management

Multi Hazard Coastal Risk Assessment Framework

Risk = *f* (Hazard , Vulnerability)

Risk = *f* (Hazard , Vulnerability , Capacity)

Risk= f (Hazard , Vulnerability , Preparedness)




Risk = f (Hazard , Vulnerability , Deficiencies in Preparedness)

after Juan Carlos Villagran

The separation between
Vulnerability and
Deficiencies in Preparedness
is done to highlight the existing
vulnerabilities and those deficiencies which
could enhance the loss of life during disaster.

-Awareness

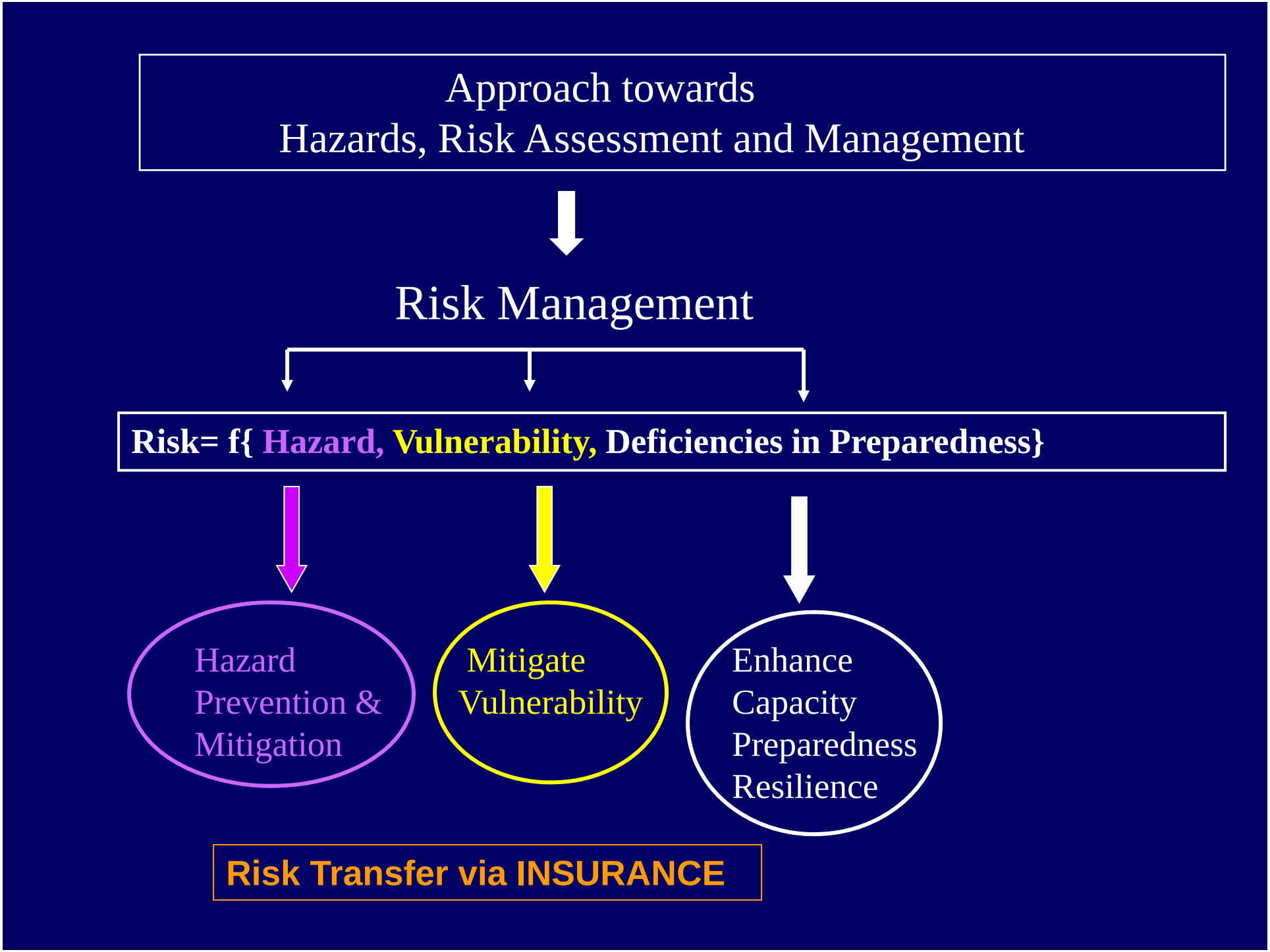
-Preparedness

-Early Warning

-Response

-Evacuation / Safe Places

-Evacuation Structures/
Tsunami Resilient Infrastructure


Approach towards
Hazards, Risk Assessment and Management
Risk Management
Risk= f{ Hazard, Vulnerability, Deficiencies in Preparedness}
Hazard Prevention & Mitigation
Mitigate Vulnerability
Enhance Capacity Preparedness Resilience
Risk Transfer via INSURANCE

Risk Management

Hazard Prevention & Mitigation

-Physical Interventions

(Artificial Methods, Natural Methods and Hybrid Methods)

Mitigate Vulnerability

-Land Use Planning

-Regulatory interventions such as set back of defense line

-Hazard resilient buildings and infrastructure

Enhance Capacity Preparedness Resilience

-Early Warning System (Local and Regional)

-Public Warning System

-Evacuation Routes & Structures

-Community Education, Maps for their benefit and Preparedness

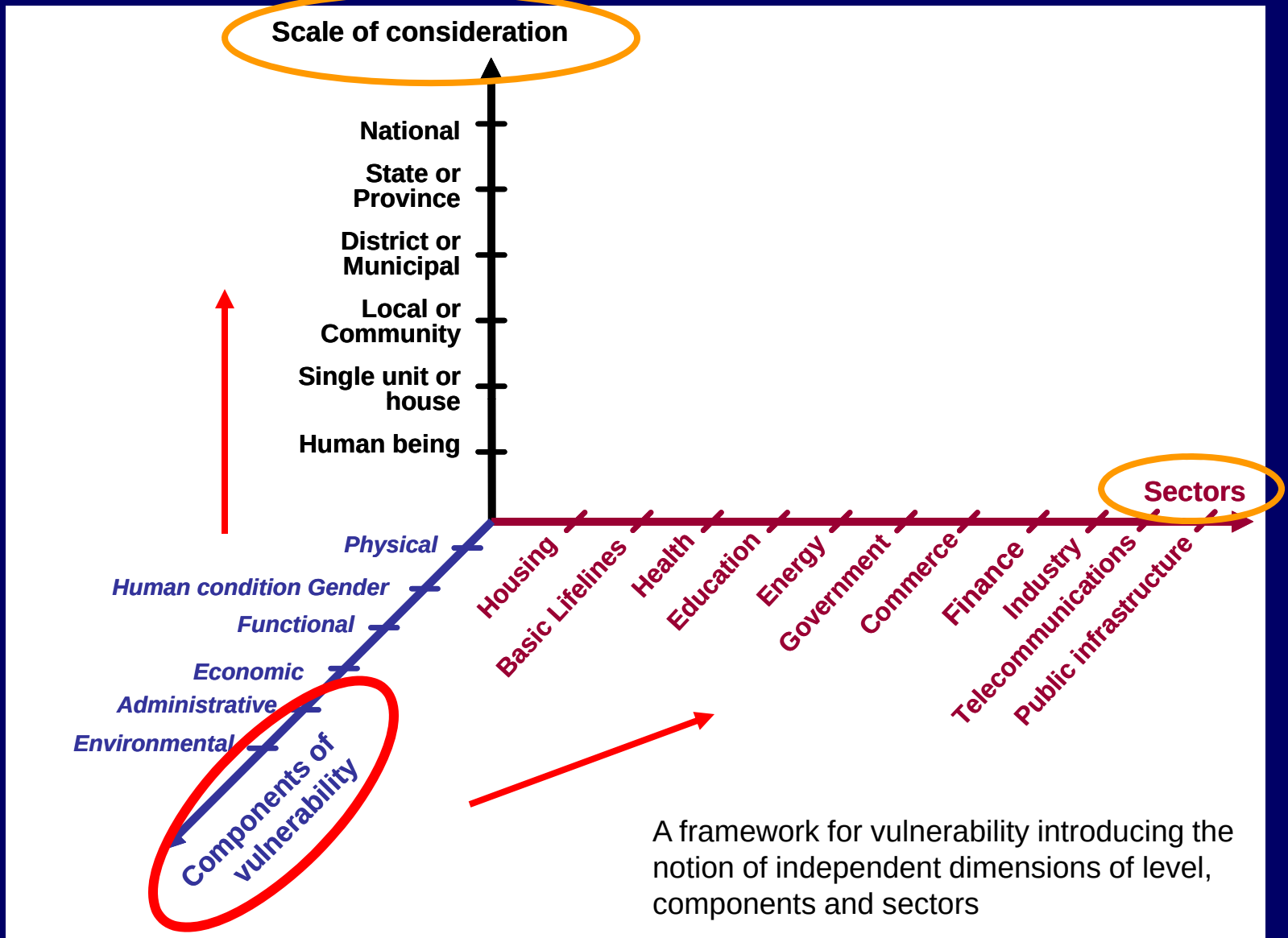
Vulnerable Communities

Vulnerability represents the proneness of society and its full structure to be affected by the hazard.

Components of Vulnerability (1D approach)

1--Human, Cultural and Psychological
2--Physical/Structural
3--Socio-Economic
4--Environmental
5--Functional
6--Administrative

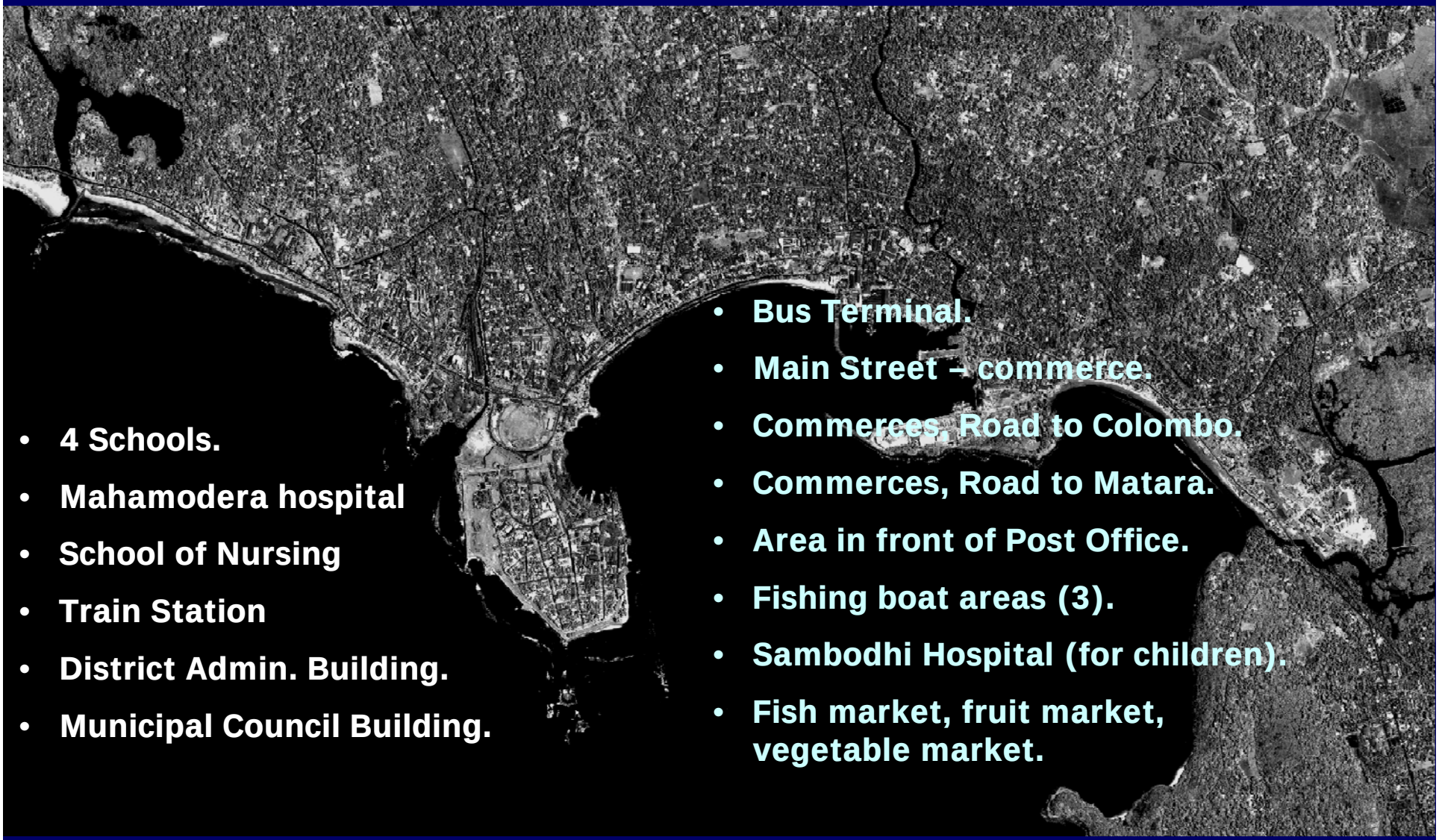
The Sector Approach (3D approach)



A framework for vulnerability introducing the notion of independent dimensions of level, components and sectors

after Juan Carlos Villagran

Examples of Vulnerable Public Infrastructure and Sectors within the City of Galle



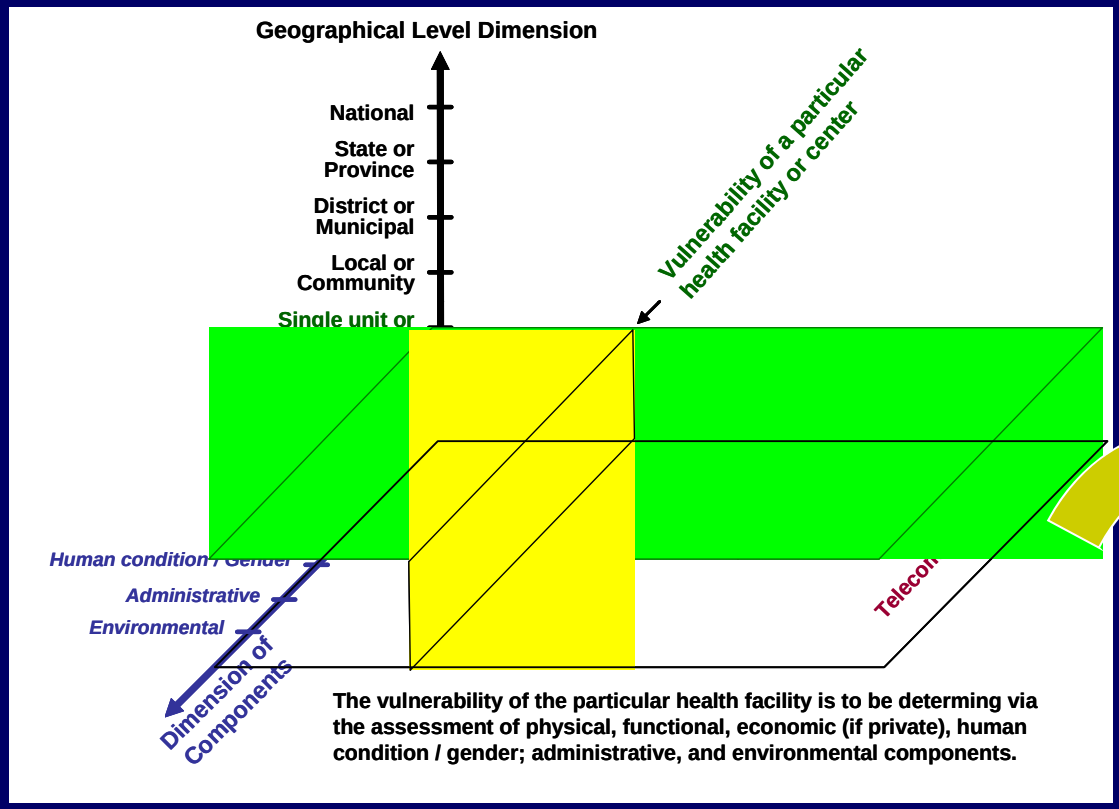
- 4 Schools.
- Mahamodera hospital
- School of Nursing
- Train Station
- District Admin. Building.
- Municipal Council Building.

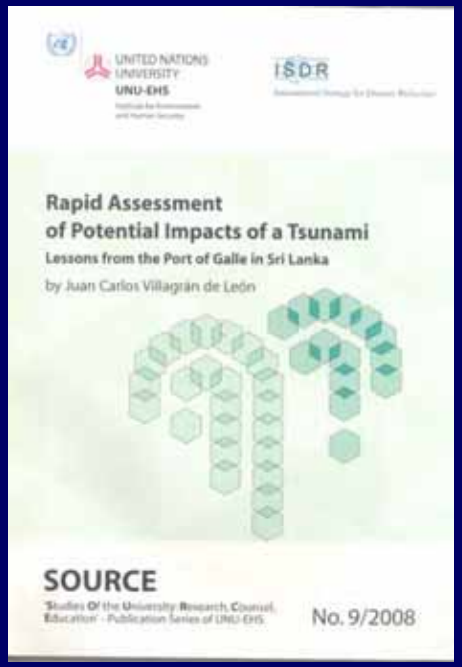
- Bus Terminal.
- Main Street – commerce.
- Commerces, Road to Colombo.
- Commerces, Road to Matara.
- Area in front of Post Office.
- Fishing boat areas (3).
- Sambodhi Hospital (for children).
- Fish market, fruit market, vegetable market.

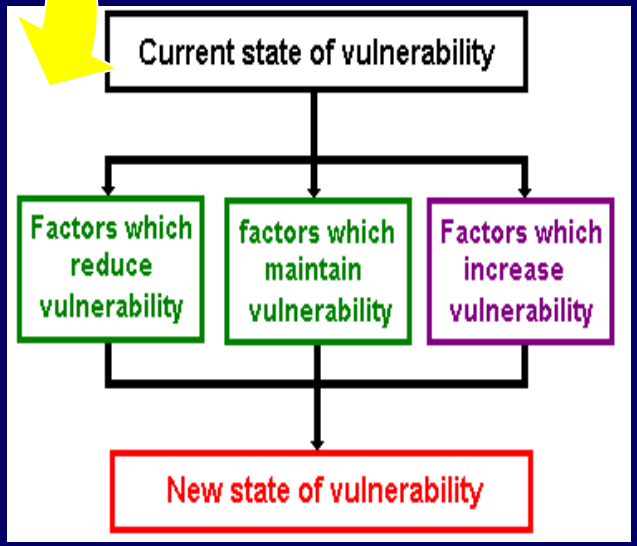
after Juan Carlos Villagran

Vulnerability - The Sector Approach

Detailed Approach towards Vulnerability Analysis







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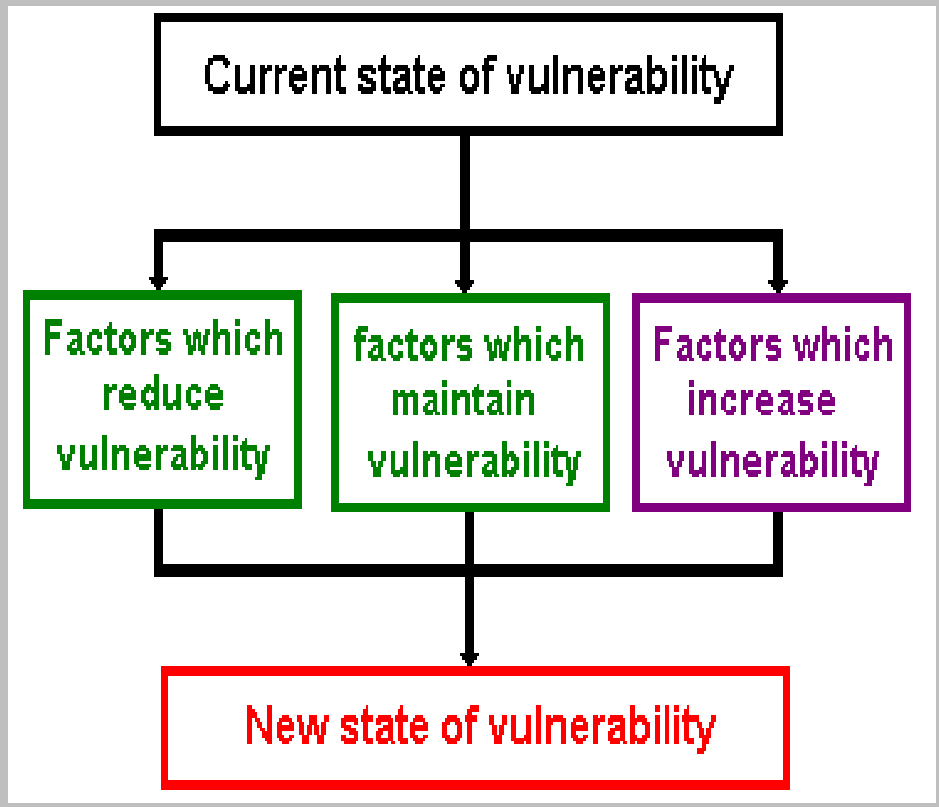
Risk Management

(before disaster)

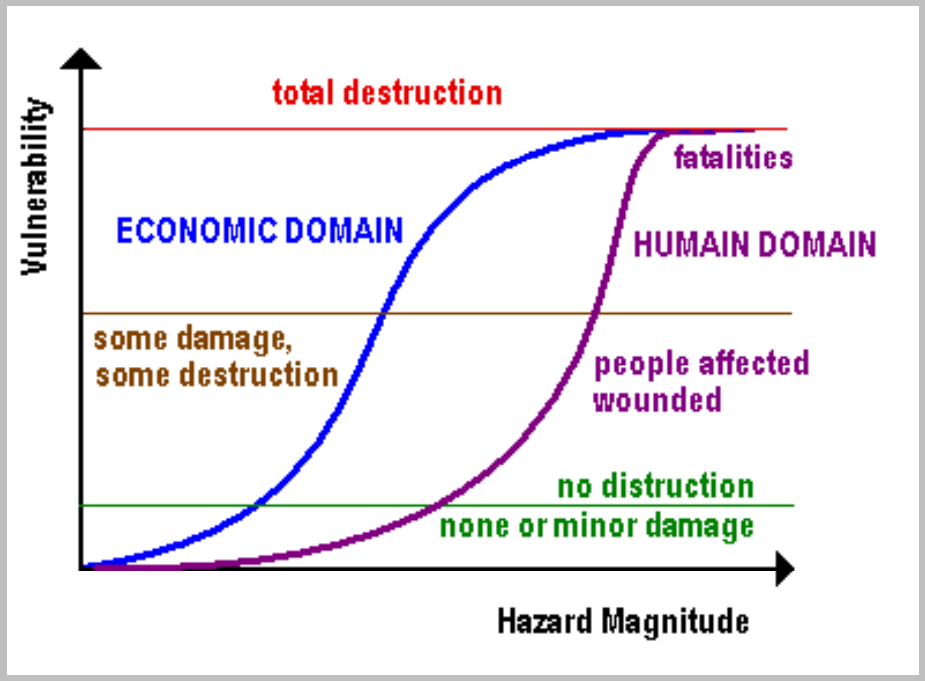
Vulnerability check



Disaster Management

(after disaster)

Post Disaster
Vulnerability Assessment



Capacity, Resilience and Preparedness of communities

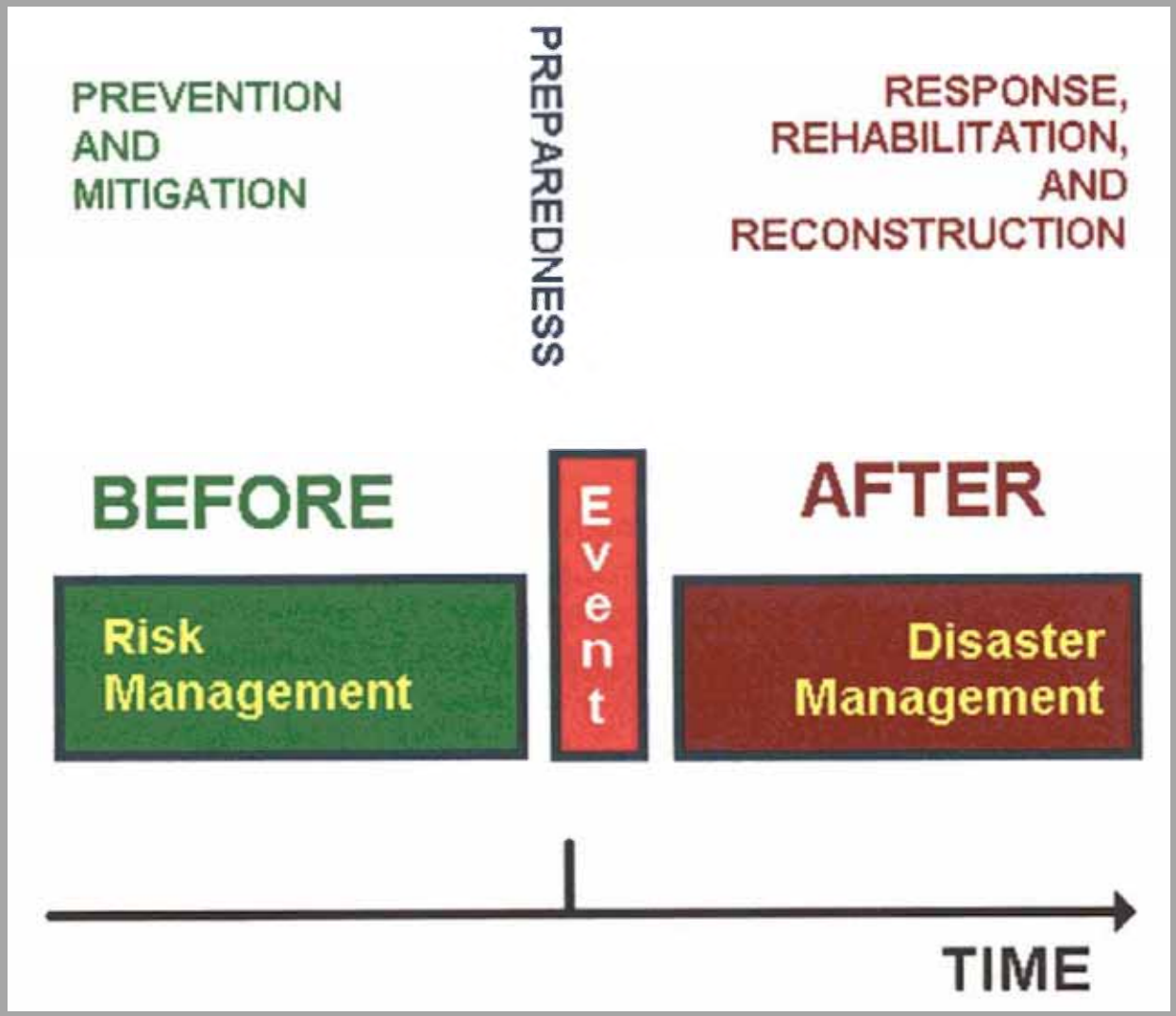
Key Areas

-Awareness and Education
-Preparedness
-Early Warning
-Response
-Evacuation / Safe Places
-Evacuation Structures
-Tsunami Resilient Infrastructure

↓

Building a Tsunami Resilient Community

28th March 2005-
Successful evacuation



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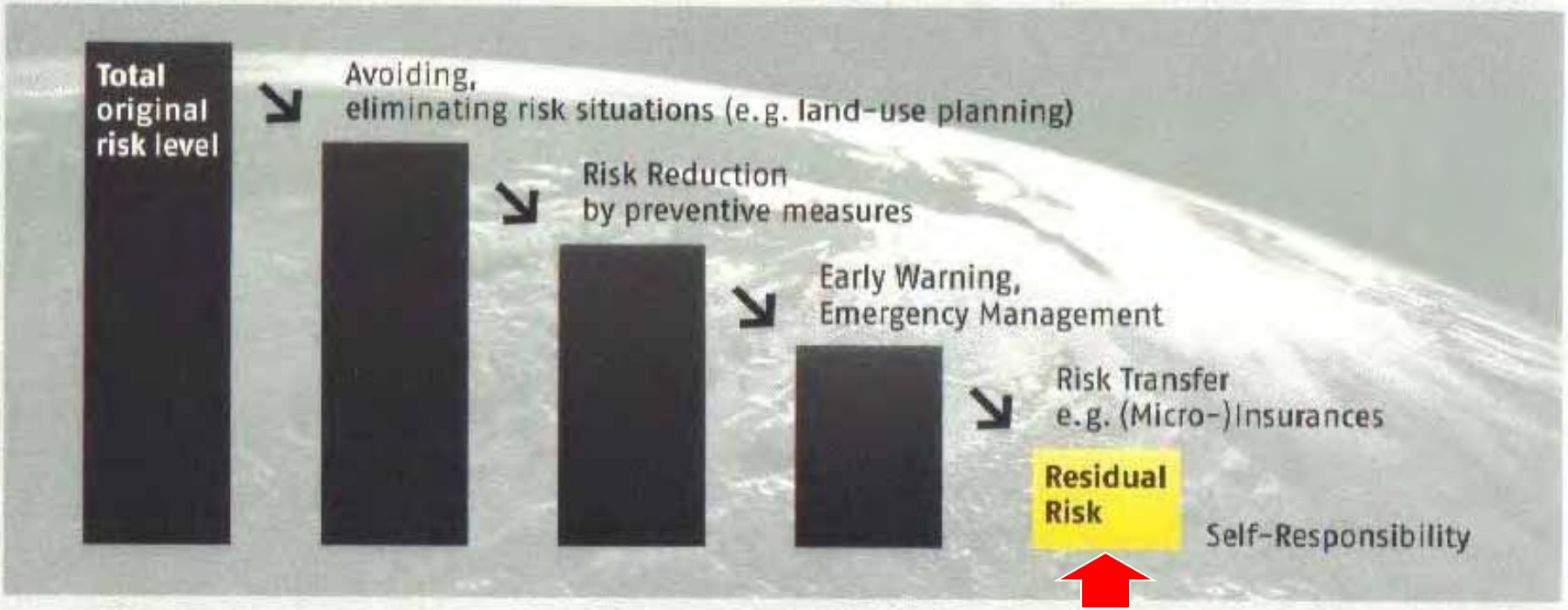
Vulnerability Mitigation

Hazard Mitigation

Improve Preparedness

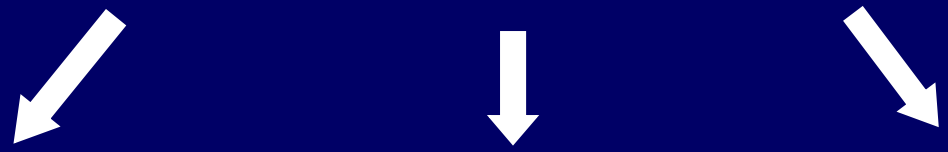
Risk Transfer

Risk Cascade Approach in Integral Risk Management



DRR is everyone's business

Risk Management



Hazard Prevention & Mitigation	Mitigate Vulnerability	Enhance Capacity Preparedness Resilience
-Physical Interventions (Artificial Methods, Natural Methods and Hybrid Methods)	-Land Use Planning -Regulatory interventions such as set back of defense line -Hazard resilient buildings and infrastructure	-Early Warning System (Local and Regional) -Public Warning System -Evacuation Routes & Structures -Community Education, Maps for their benefit and Preparedness

Enhance the application of Remotely-Sensed Data

Birds Eye Impacts of Major Tsunamis

Sanriku, Japan 1933 –
before the Tsunami

after the Tsunami – **28.2 m**

Indian Ocean
Tsunami 2004

Macro view of damage

Banda Aceh

Indian Ocean
Tsunami 2004

Macro view of damage

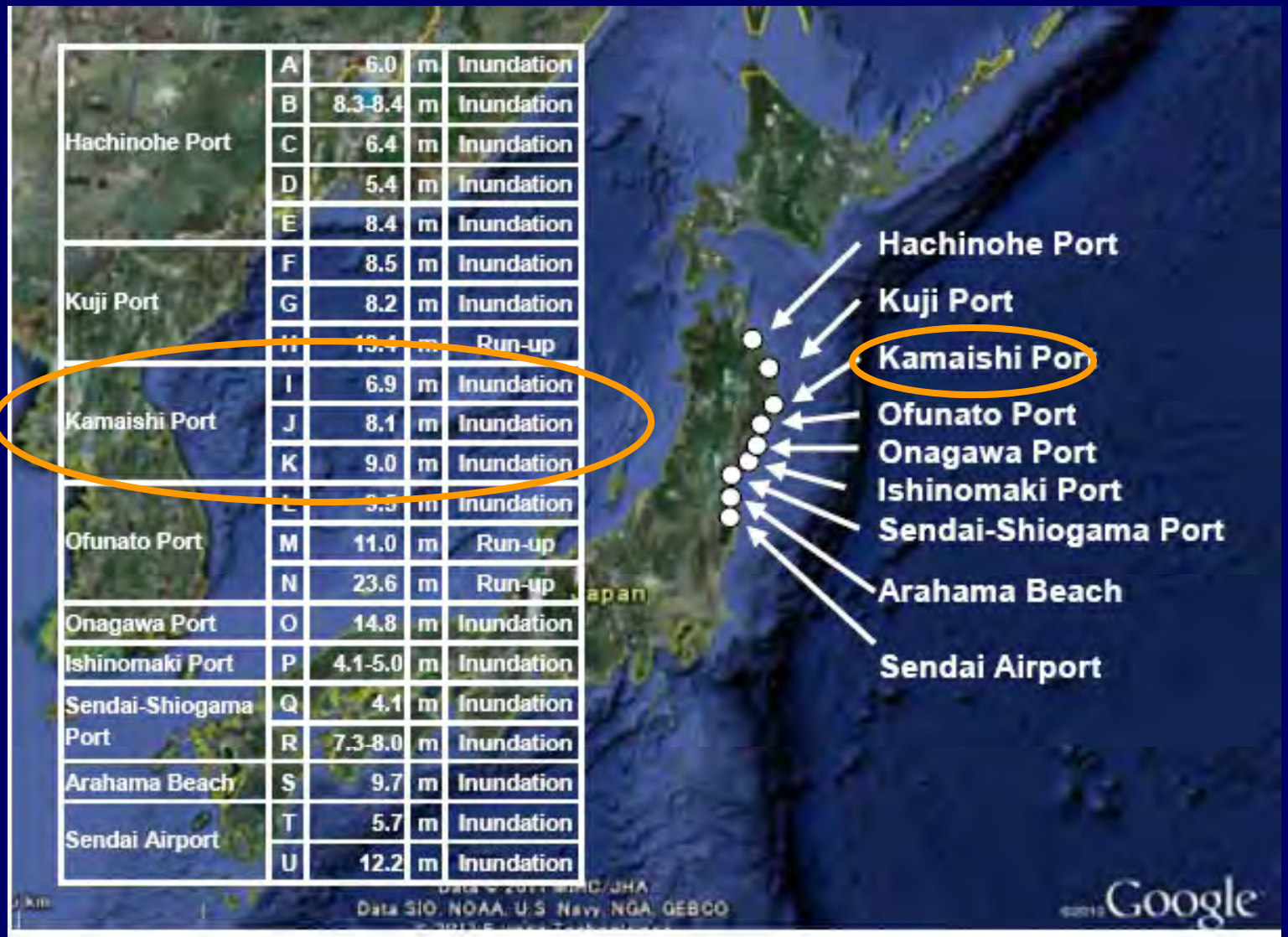
Kamaishi City

Japanese Tsunami March 2010

Kamaishi City

Japanese Tsunami March 2010

Japanese Tsunami March 2011-Surveys by PARI Japan

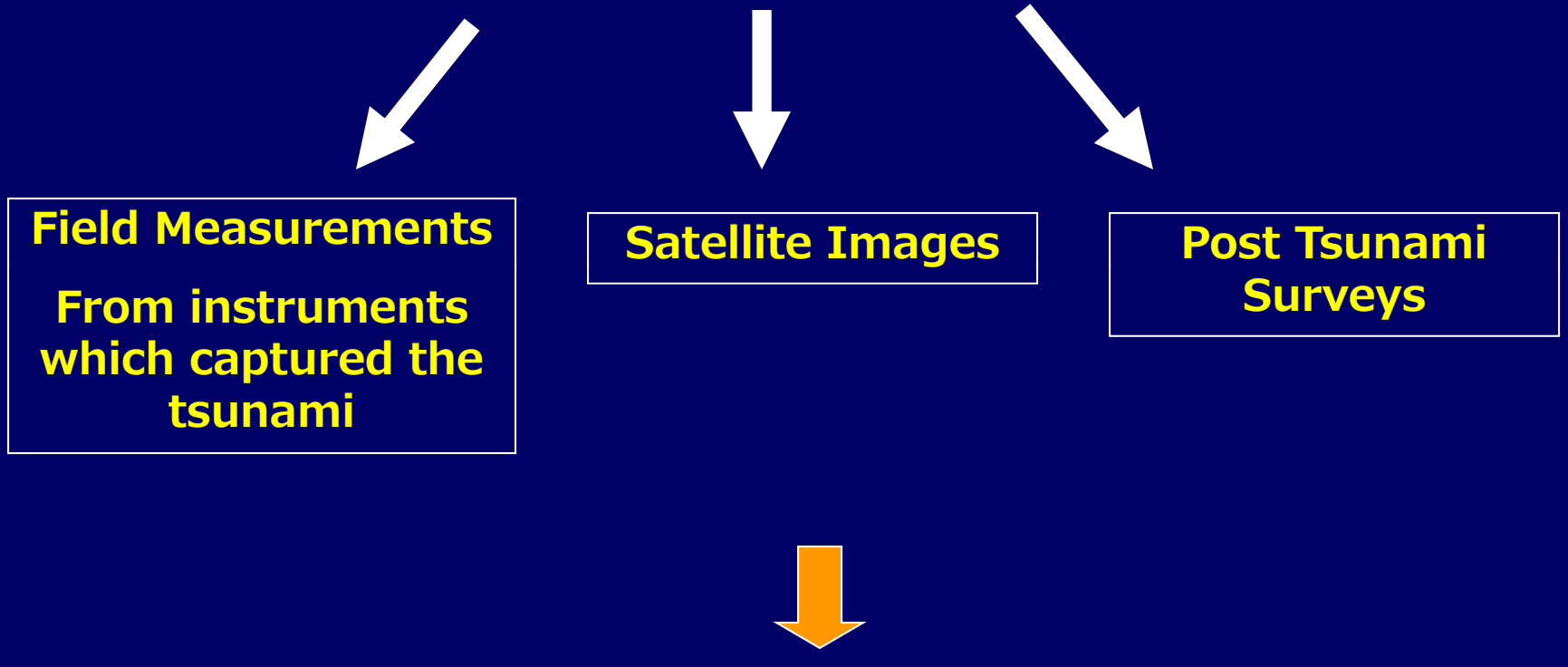


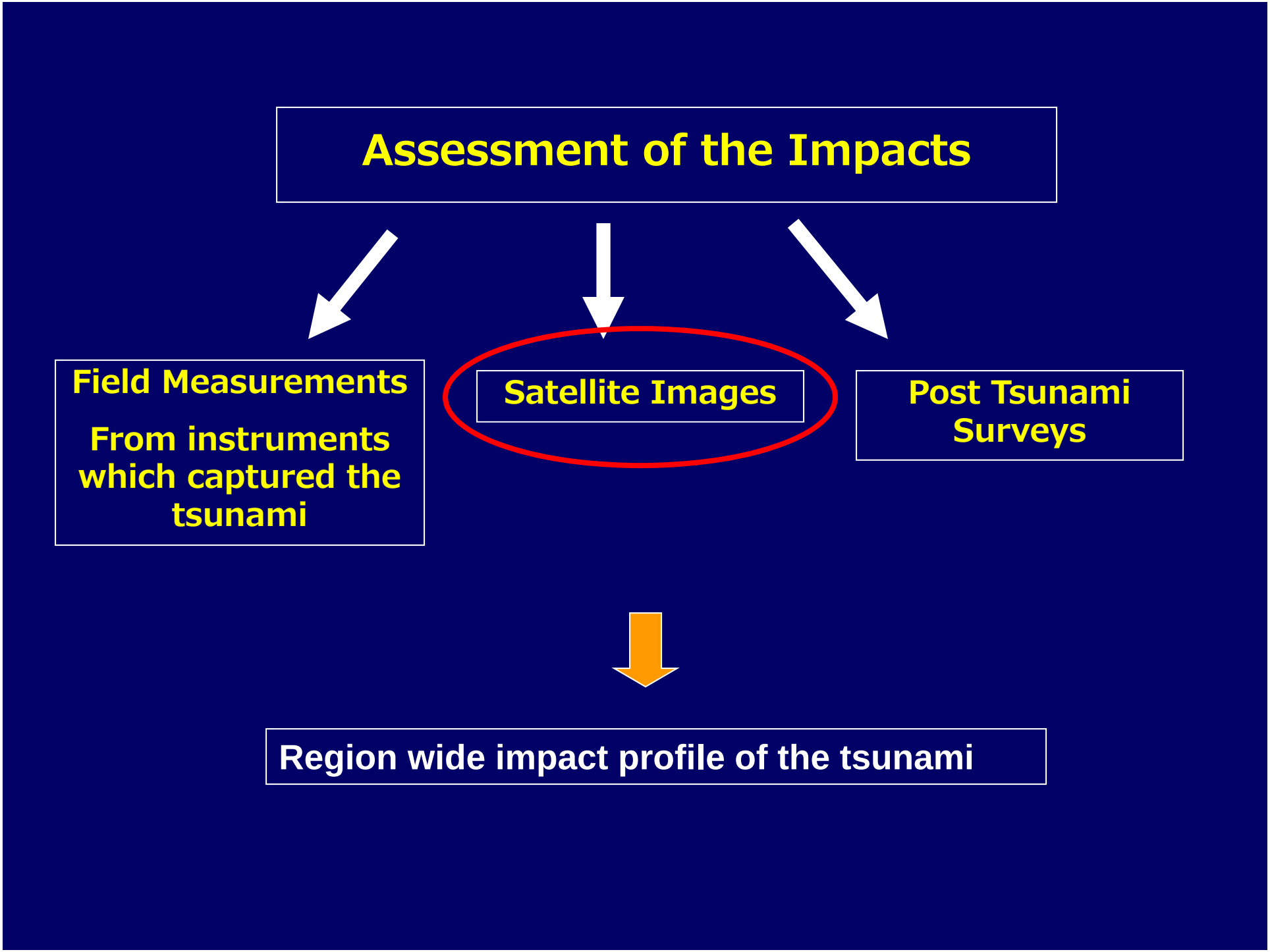
Hachinohe Port	A	6.0	m	Inundation
	B	8.3-8.4	m	Inundation
	C	6.4	m	Inundation
	D	5.4	m	Inundation
	E	8.4	m	Inundation
Kuji Port	F	8.5	m	Inundation
	G	8.2	m	Inundation
	H	13.4	m	Run-up
Kamaishi Port	I	6.9	m	Inundation
	J	8.1	m	Inundation
	K	9.0	m	Inundation
Ofunato Port	L	3.5	m	Inundation
	M	11.0	m	Run-up
	N	23.6	m	Run-up
Onagawa Port	O	14.8	m	Inundation
Ishinomaki Port	P	4.1-5.0	m	Inundation
Sendai-Shiogama Port	Q	4.1	m	Inundation
	R	7.3-8.0	m	Inundation
Arahama Beach	S	9.7	m	Inundation
Sendai Airport	T	5.7	m	Inundation
	U	12.2	m	Inundation

Map 1: Location of Surveyed Ports

Understanding the Propagation and Impacts of Tsunamis

Assessment of the Impacts



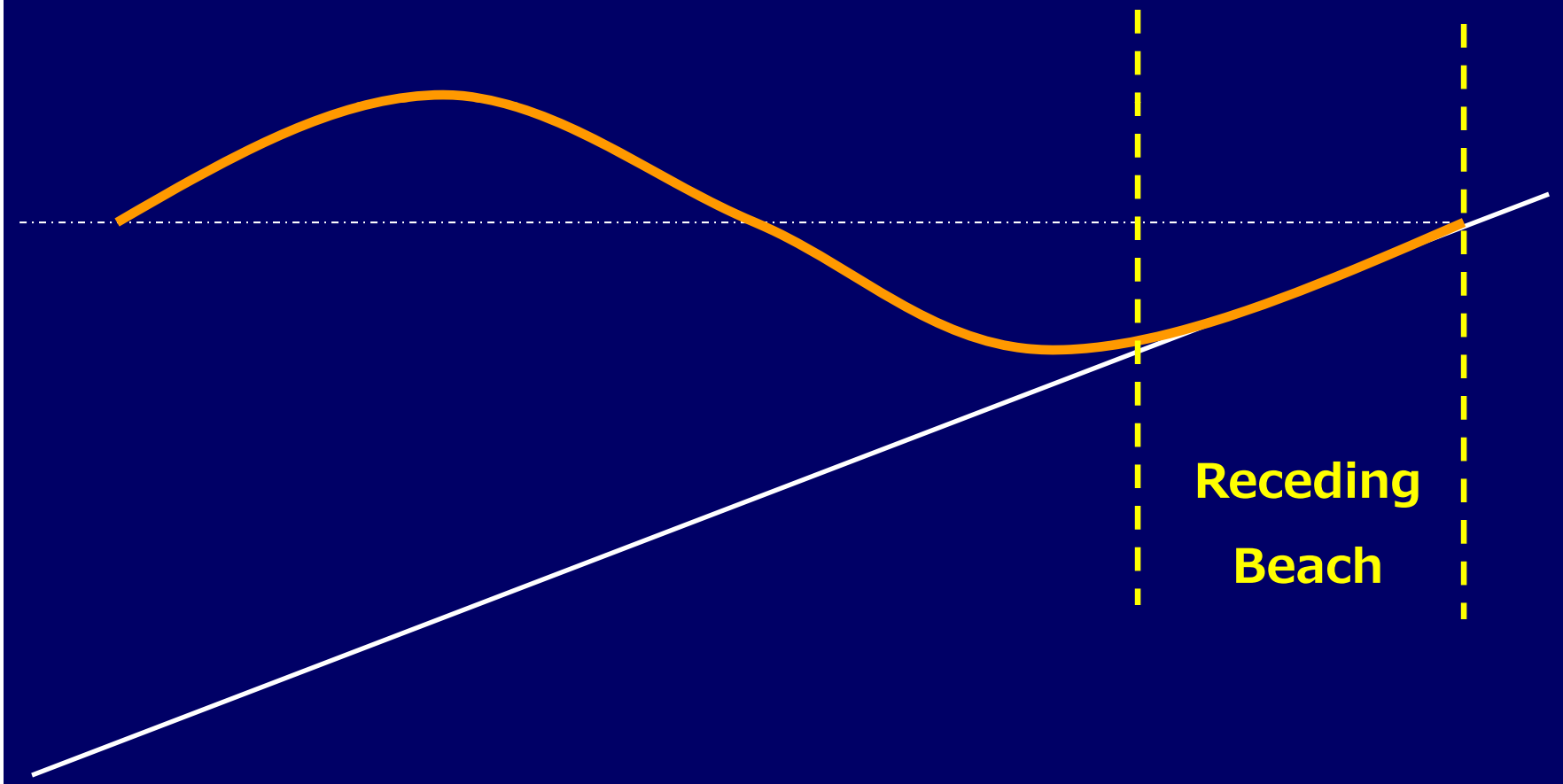

Assessment of the Impacts
Field Measurements
From instruments which captured the tsunami
Satellite Images
Post Tsunami Surveys
Region wide impact profile of the tsunami

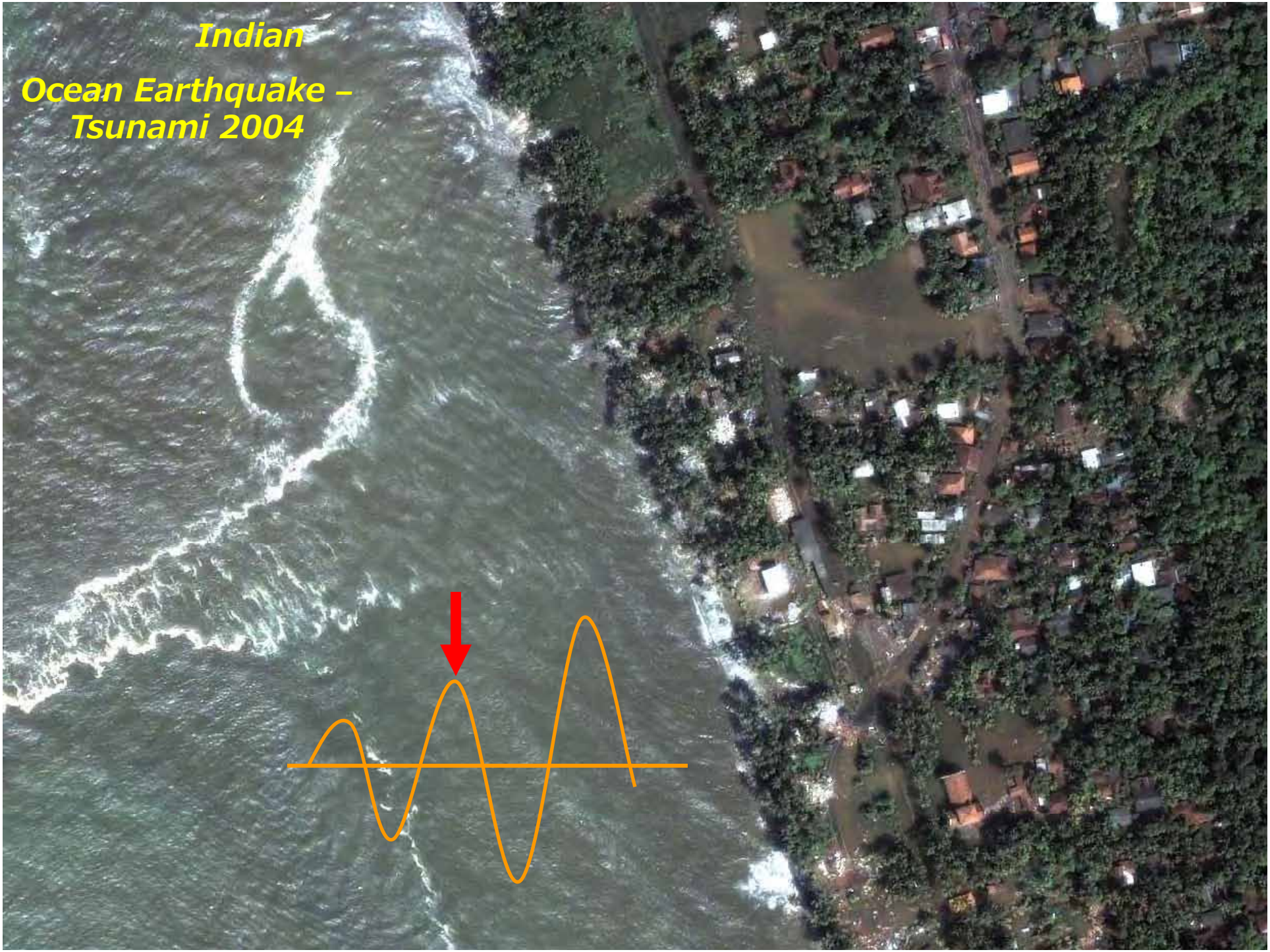
Indian Ocean

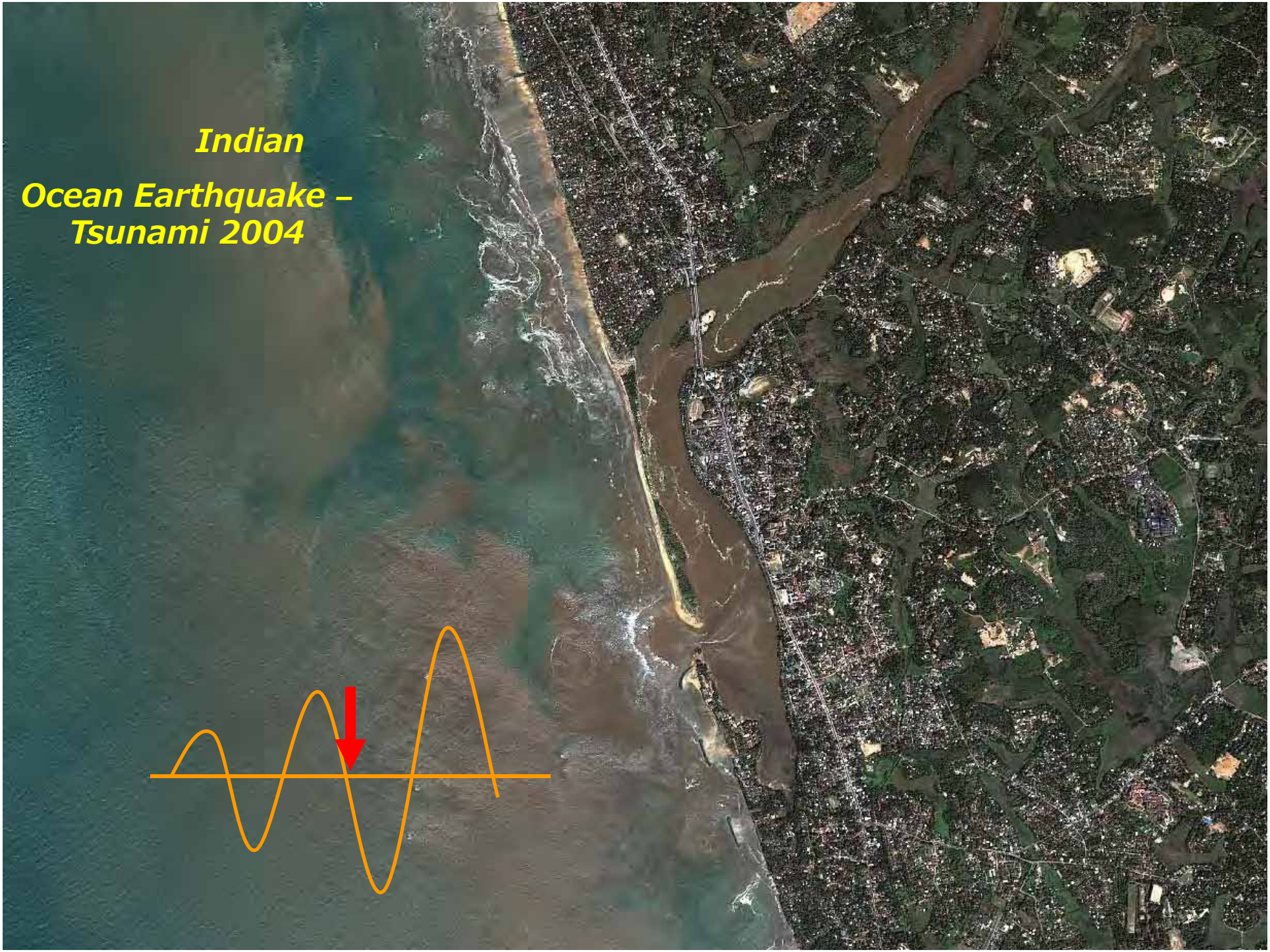
Earthquake – Tsunami 2004

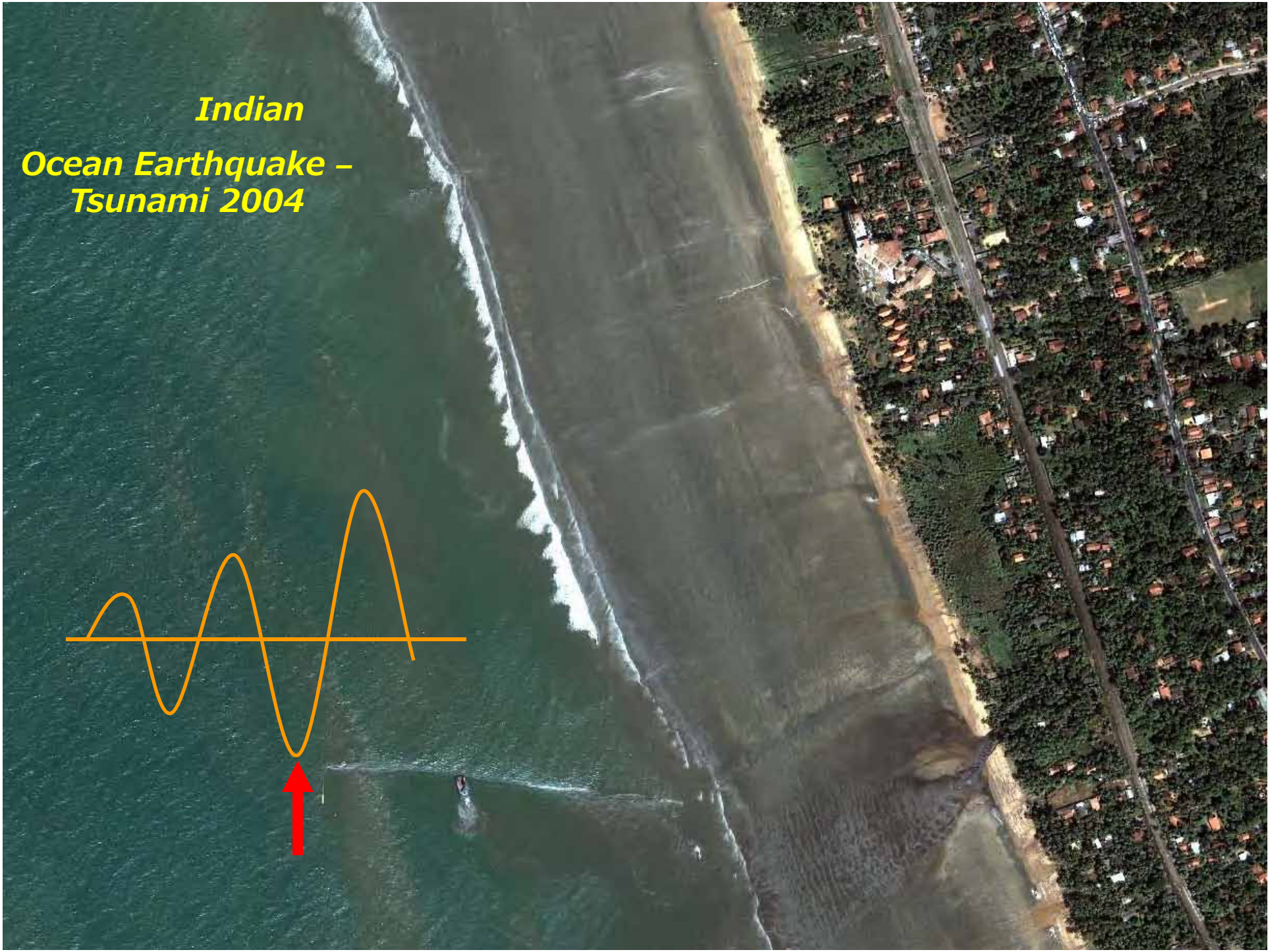

Indian
Ocean Earthquake –
Tsunami 2004

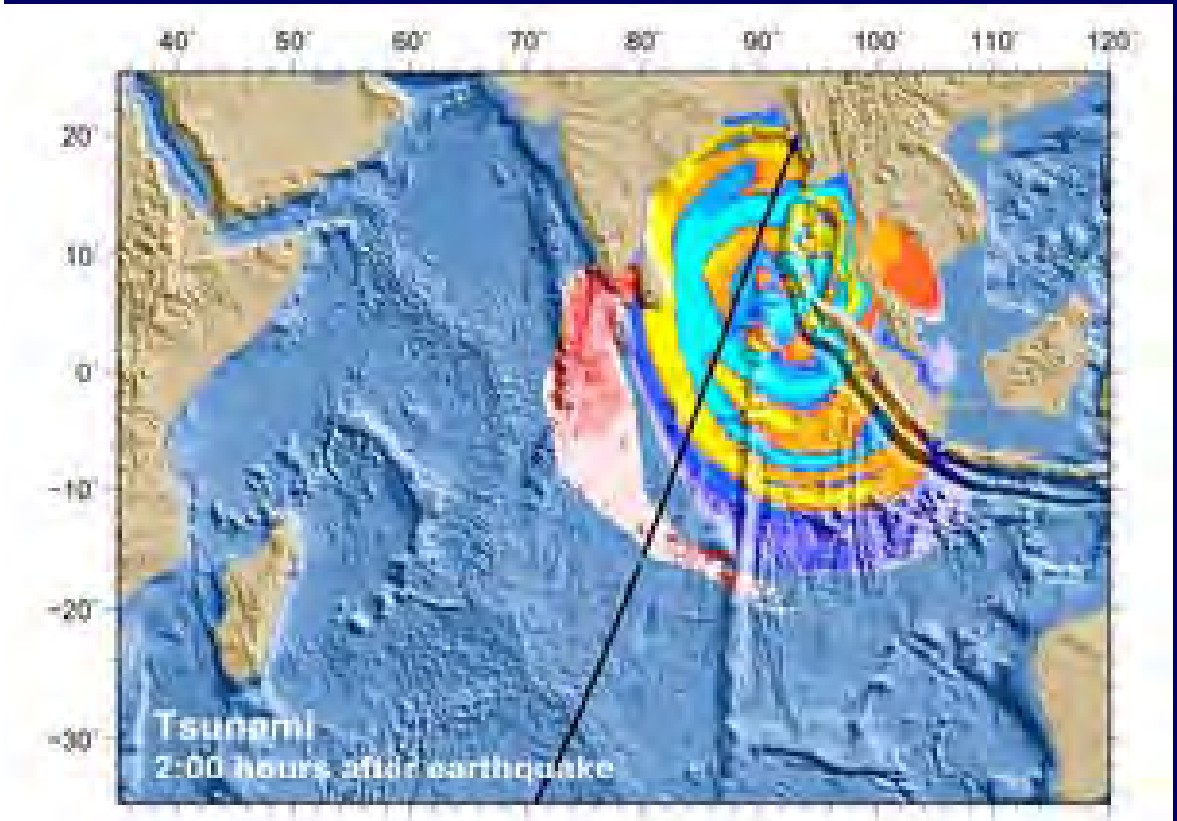
Receding Beach

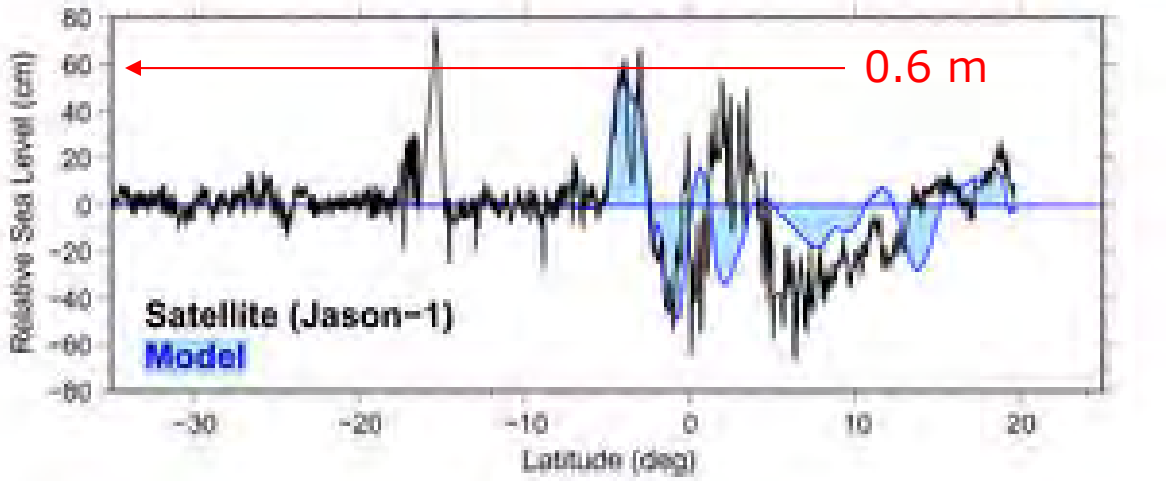



Indian
Ocean Earthquake –
Tsunami 2004


Indian
Ocean Earthquake –
Tsunami 2004


Indian
Ocean Earthquake –
Tsunami 2004

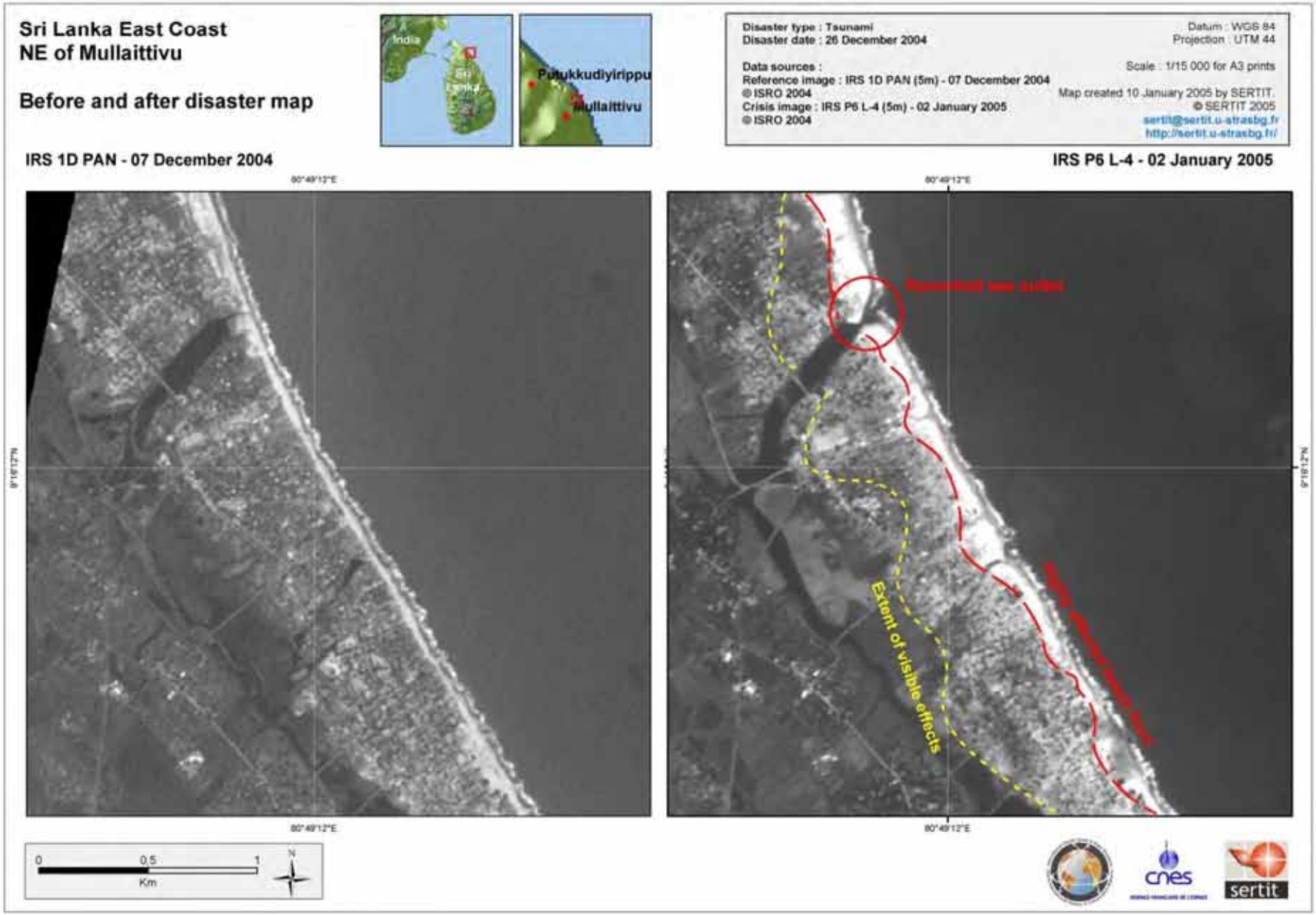


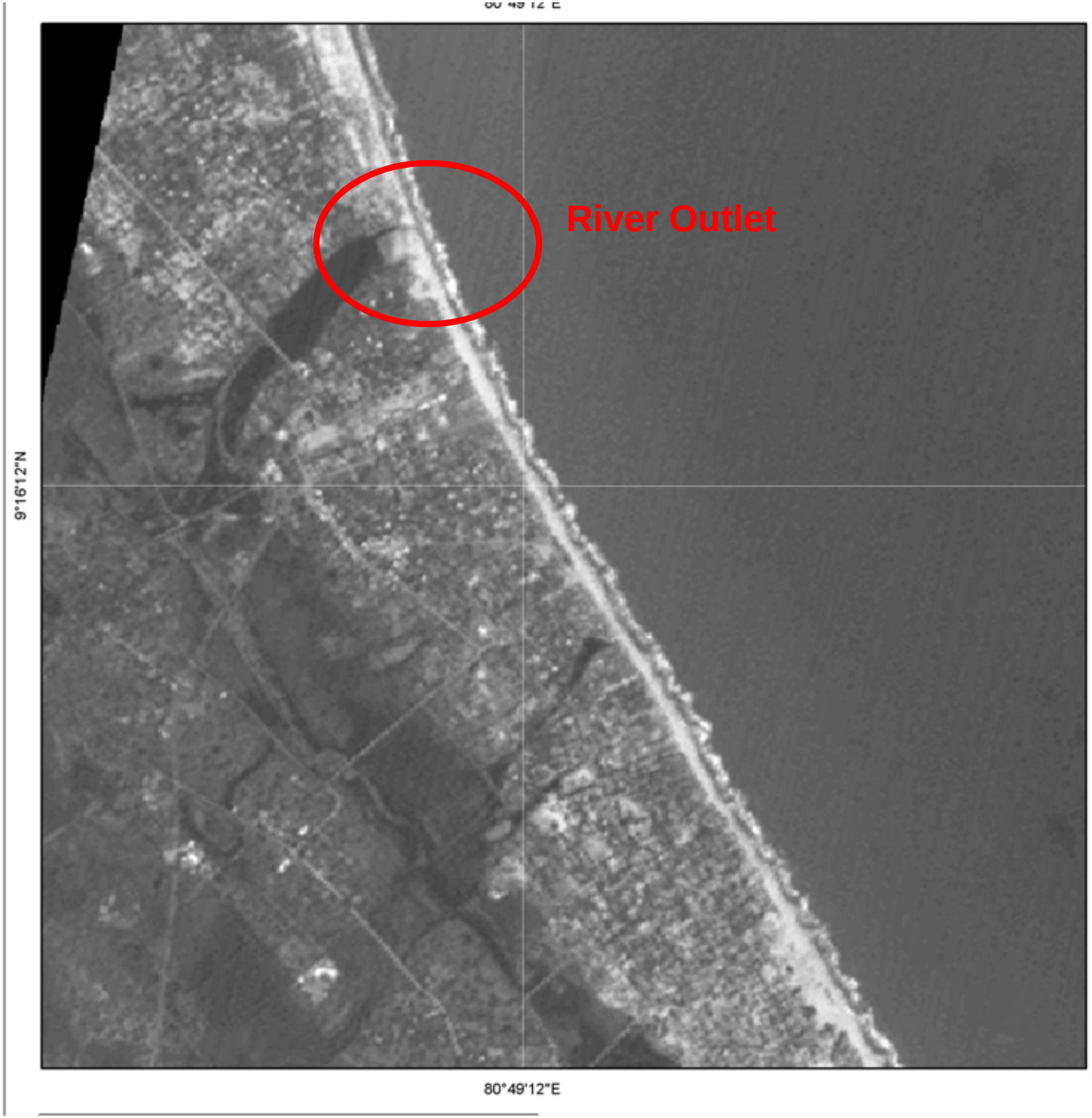


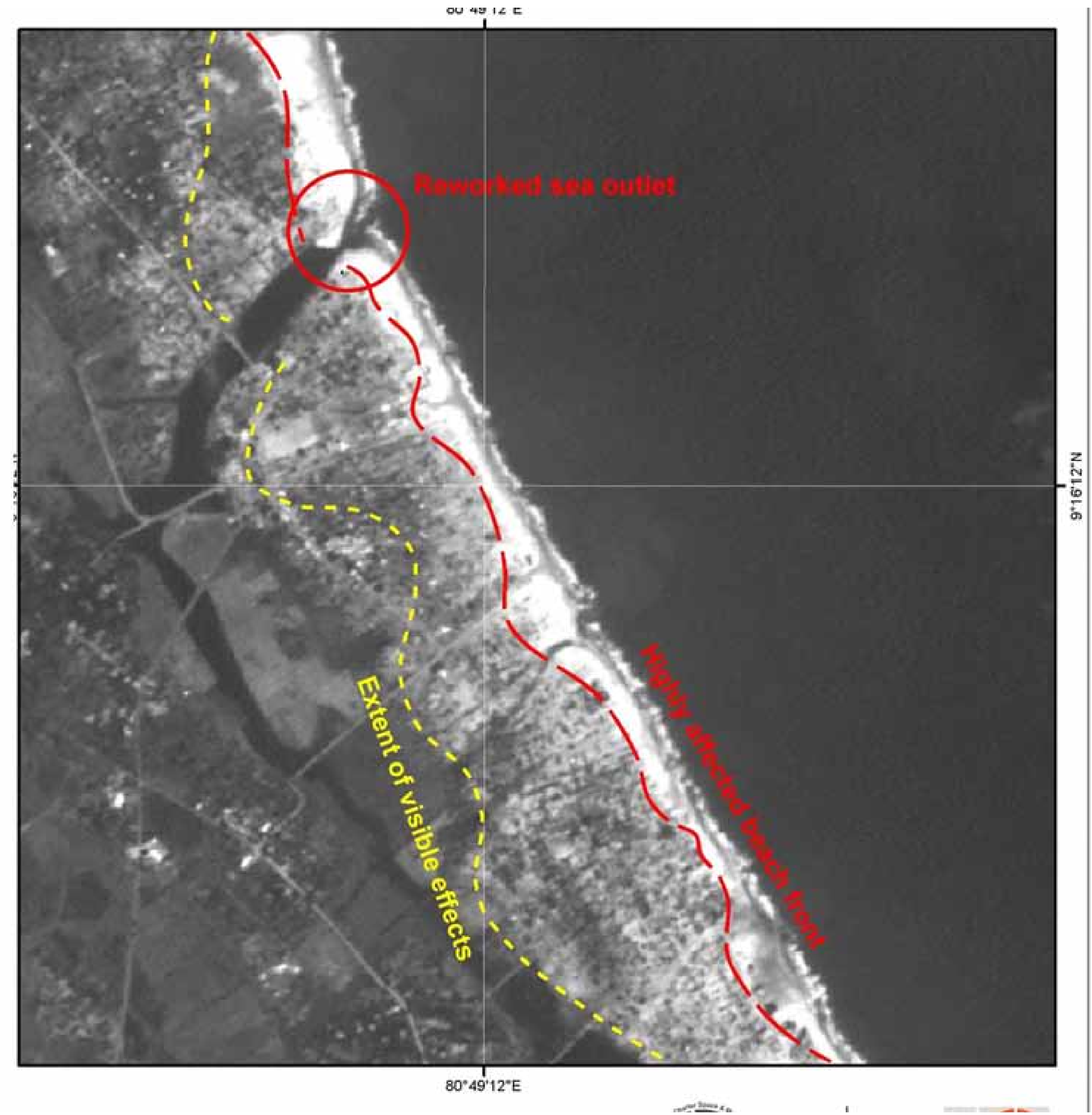
Radar Satellite record of wave heights - Two hours after the EQ

Maximum deep water wave height = 0.6 m

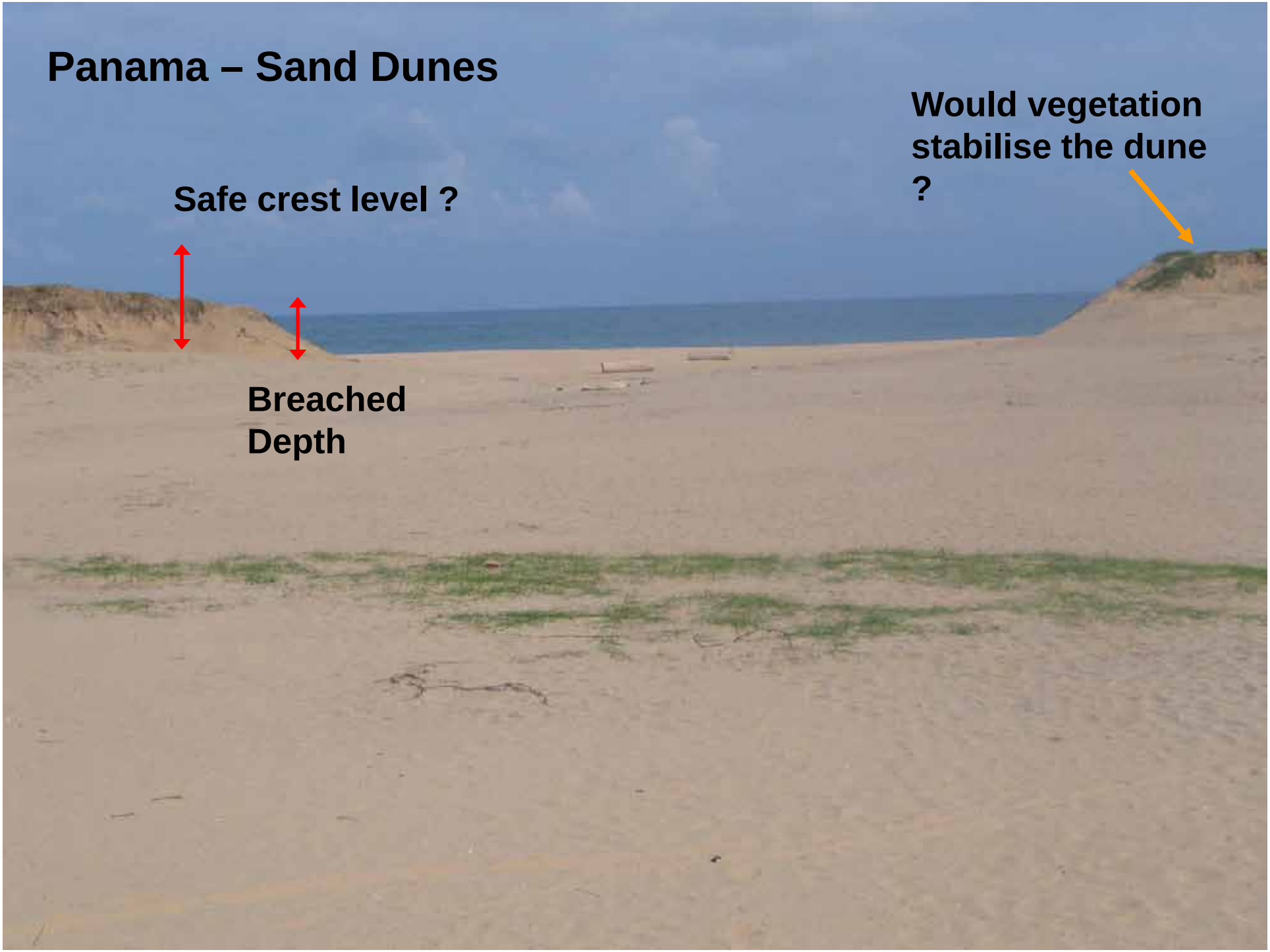
Coastal Inundation Maps

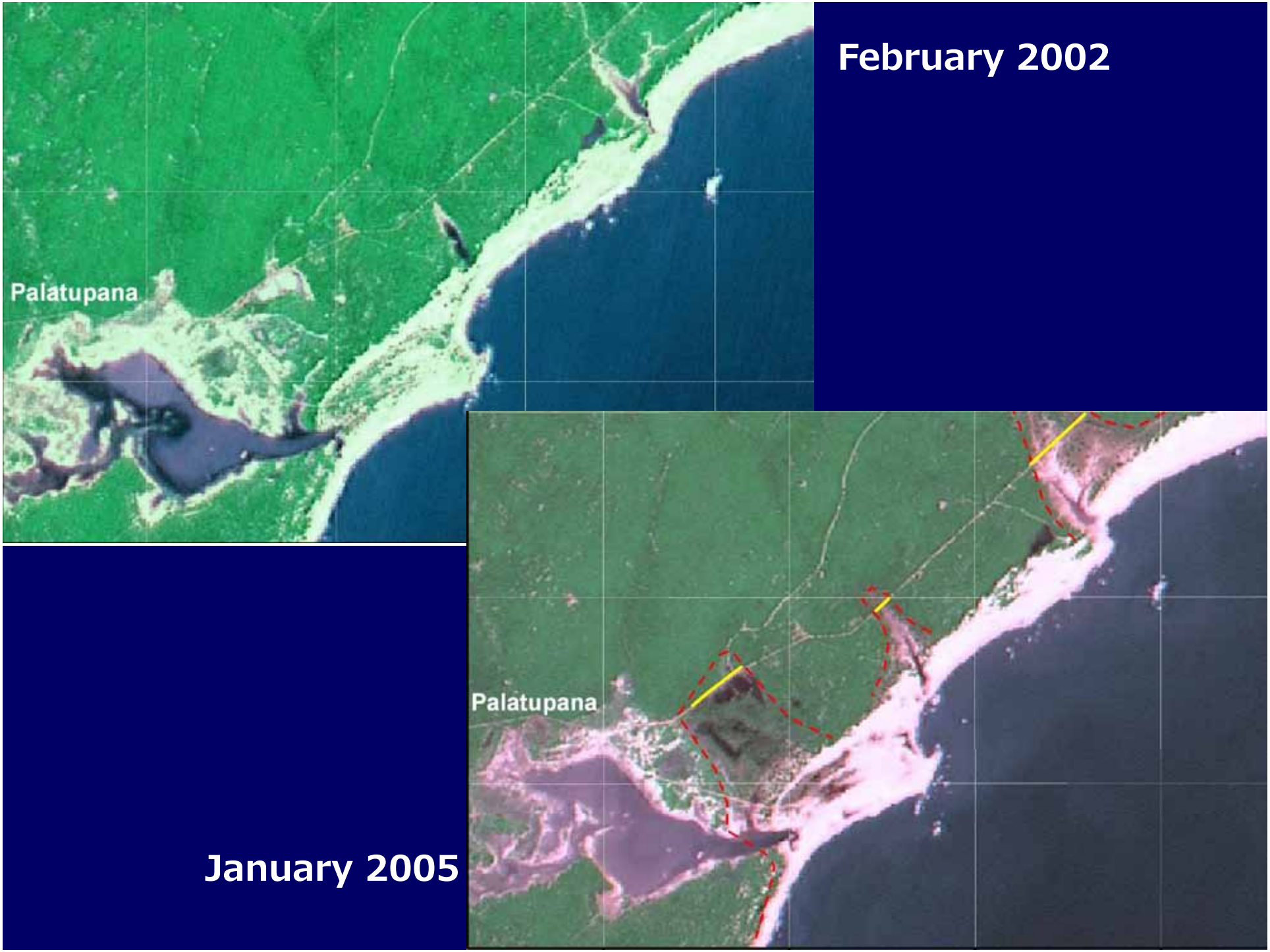



River Outlet
9°16'12"N
80°49'12"E

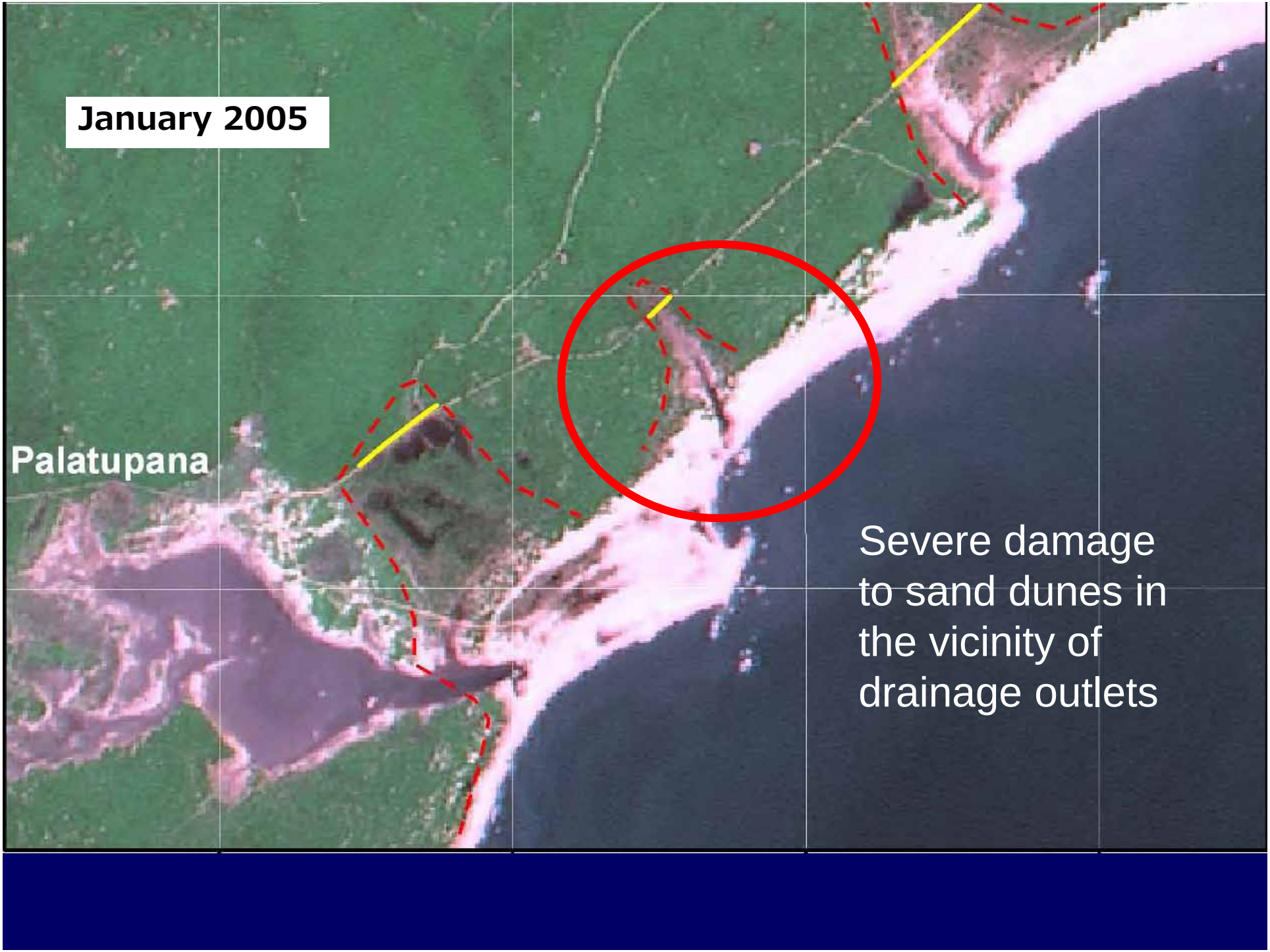

80°49'12"E
Reworked sea outlet
9°16'12"N
Highly affected beach front
Extent of visible effects
80°49'12"E

Sand Dunes (Mitigation by High Crest Natural Dikes-full barrie

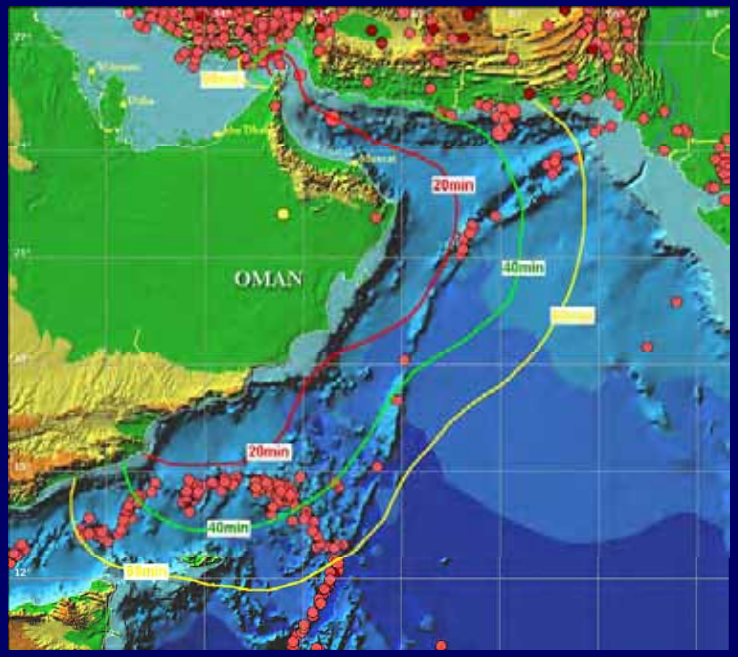

Panama – Sand Dunes
Would vegetation stabilise the dune ?
Safe crest level ?
Breached Depth

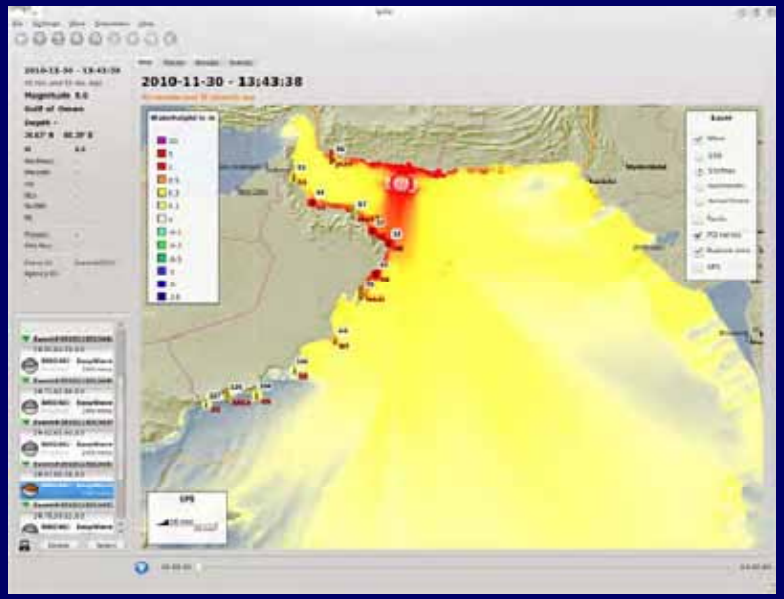

February 2002
Palatupana
Palatupana
January 2005


February 2002
Palatupana


January 2005
Palatupana
Severe damage to sand dunes in the vicinity of drainage outlets

MAKRAN SOURCE





Makran Source

Muscat, Oman

Muscat, Oman

Important components of the IOTWS

Requirements of a Early Warning System

A Warning System must alert all persons on every vulnerable coast of imminent danger, covered by the system

Response must be ‘RARE’:

- Rapid (as soon as possible)
- Accurate (minimize false warning)
- Reliable (continuous operation)
- Effective (to save lives)

IOT - Banda Aceh

Early Warning Systems

UN-ISDR Framework for effective EWS encompass 4 critical linked elements,

- Awareness of the Risk
- Technical Monitoring and Warning Service
- Dissemination of meaningful warnings to Persons and Communities at Risk
- Public Awareness and Preparedness to Respond

Key Components of an Early Warning System

1. Earth Data Observations
2. Data and Information Collection
3. Hazard Event Detection
4. Hazard Warning System Decision Support
5. Warning and other Products
6. Dissemination and Notification and
7. Anticipated Response to the warning and potential disasters

Key Components of an EWS

1. Earth Data Observations
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5. Warning and other Products
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7. Anticipated Response to the warning and potential disasters

Archival Data

Risk Knowledge

Detection,

Monitoring and

Technical Warning

Public Warning

Dissemination

Response

Categories of Tsunami Warning Systems

(1) Minimal

Earthquake Detection

Dissemination System

Educated Population

Stage 1

Categories of Tsunami Warning Systems

(1) Minimal

Earthquake Detection

Dissemination System

Educated Population

(2) Standard

Earthquake Detection

Tsunami Detection

Dissemination System

Educated Population

Stage 1 → Stage 2

Categories of Tsunami Warning Systems

(1) Minimal	(2) Standard	(3) Advanced
Earthquake Detection	Earthquake Detection	Earthquake Detection
	Tsunami Detection	Tsunami Detection
		Tsunami Forecast
Dissemination System	Dissemination System	Dissemination System
Educated Population	Educated Population	Educated Population

Stage 1 → Stage 2 → Stage 3

Developments in Tsunami Forecasting -Experience from the Pacific Ocean

Relevance of Forecasting

Impact of **8** Experimental Forecasts since November 2003

0 False Alarms

3 Evacuations of Hawaii avoided saving approximately $200M in lost productivity

5 Early cancellations of warnings reducing time of disruption

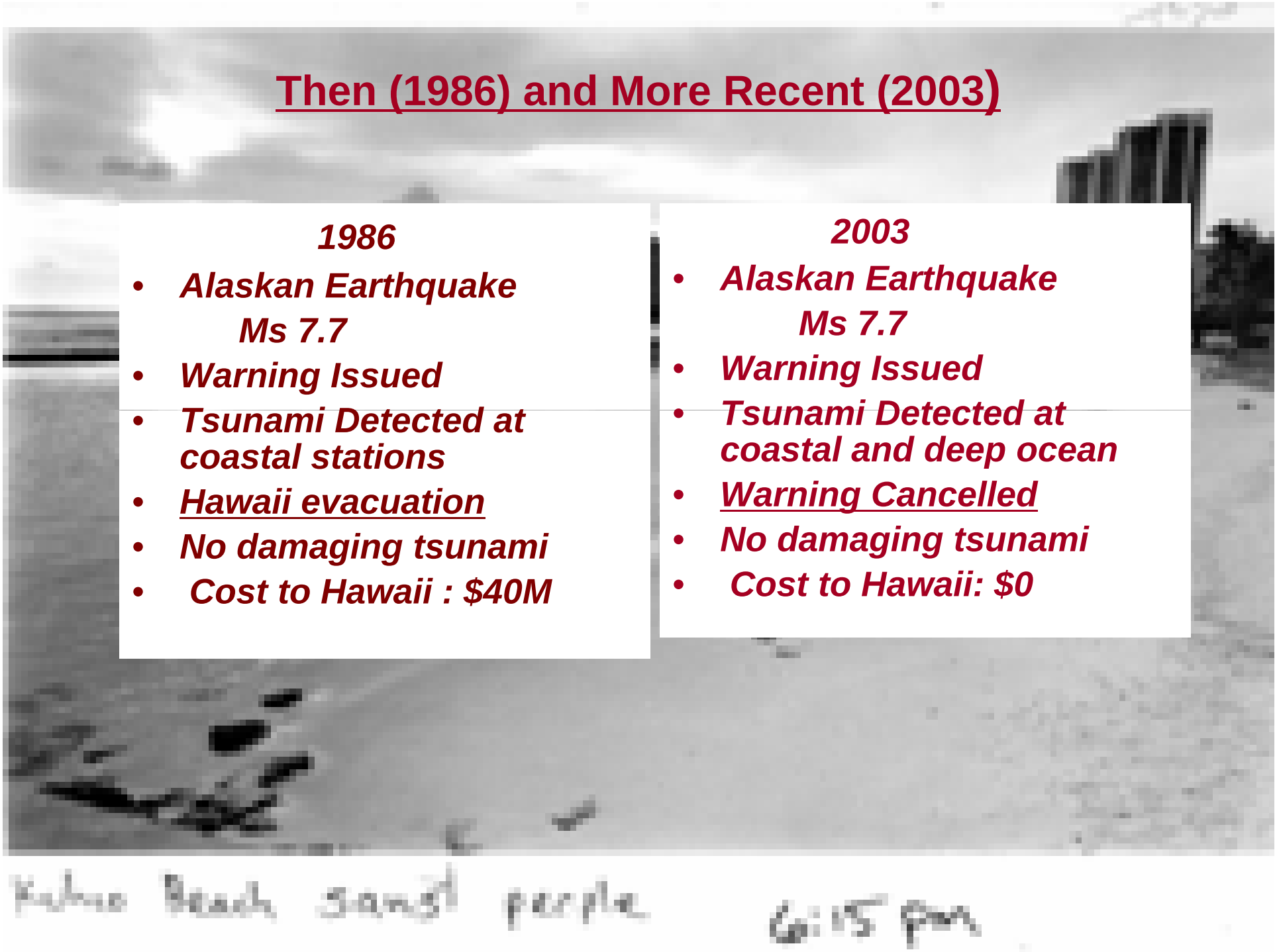
Then (1986) and More Recent (2003)

1986

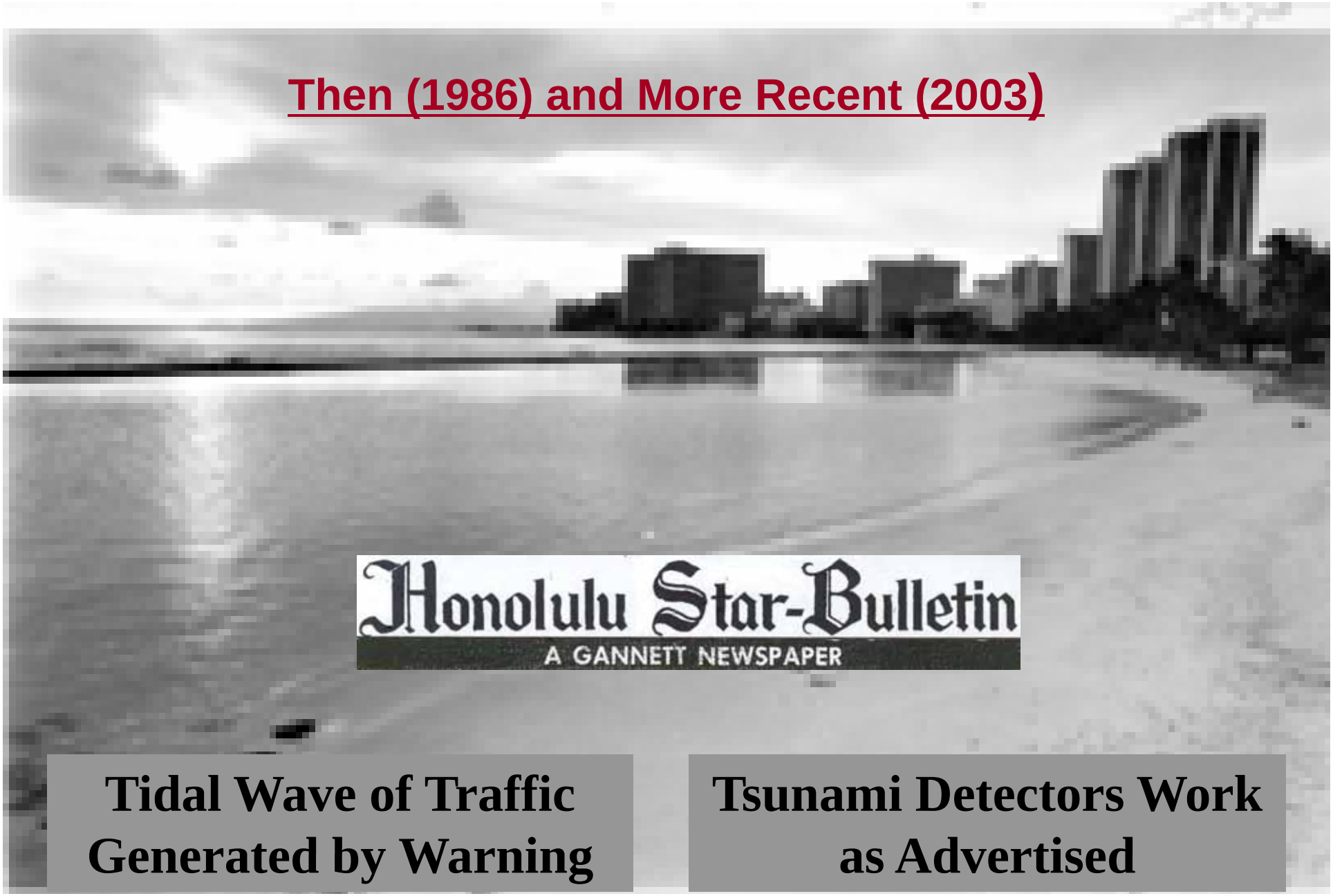
- ***Alaskan Earthquake Ms 7.7***
- ***Warning Issued***
- ***Tsunami Detected at coastal stations***
- ***Hawaii evacuation***
- ***No damaging tsunami***
- ***Cost to Hawaii : $40M***

2003

- ***Alaskan Earthquake Ms 7.7***
- ***Warning Issued***
- ***Tsunami Detected at coastal and deep ocean***
- ***Warning Cancelled***
- ***No damaging tsunami***
- ***Cost to Hawaii: $0***



Then (1986) and More Recent (2003)



Honolulu Star-Bulletin

A GANNETT NEWSPAPER

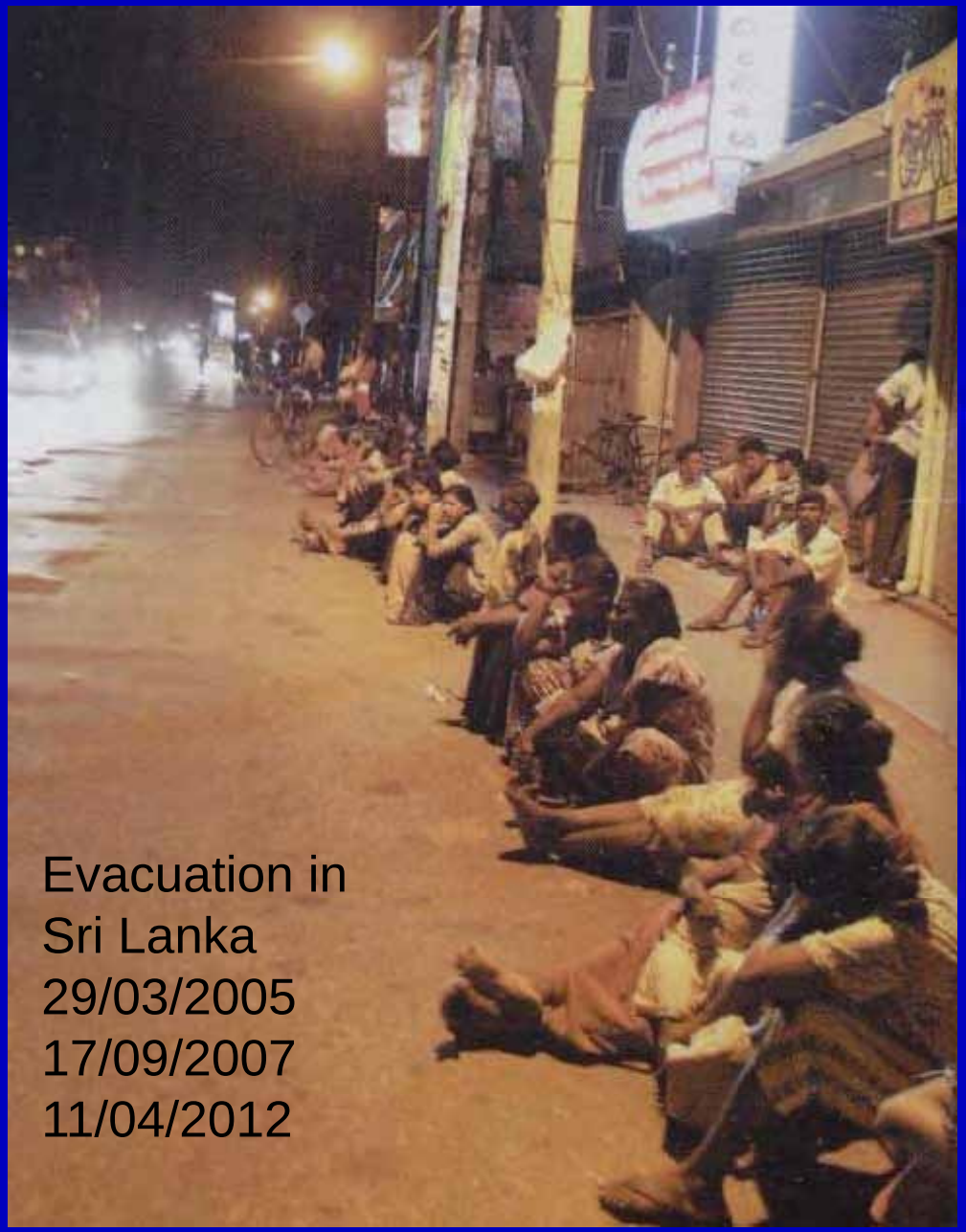
Tidal Wave of Traffic Generated by Warning

Tsunami Detectors Work as Advertised

Kahuku Beach Sand purple

6:15 pm

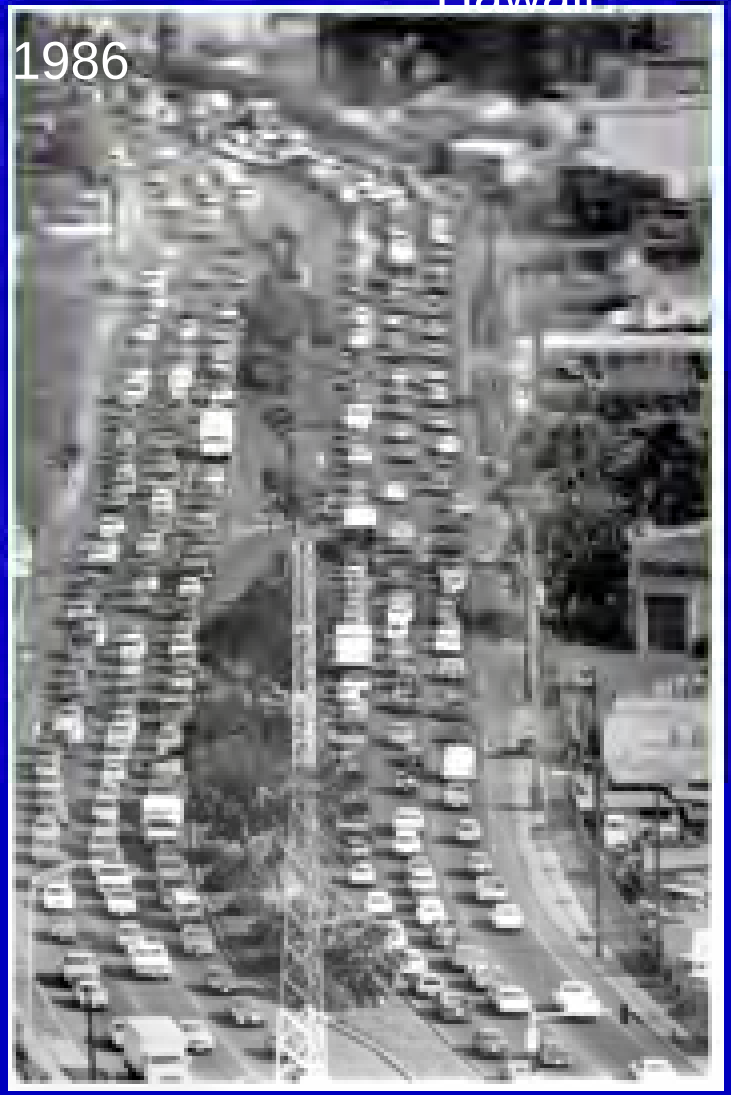
Evacuation Planning



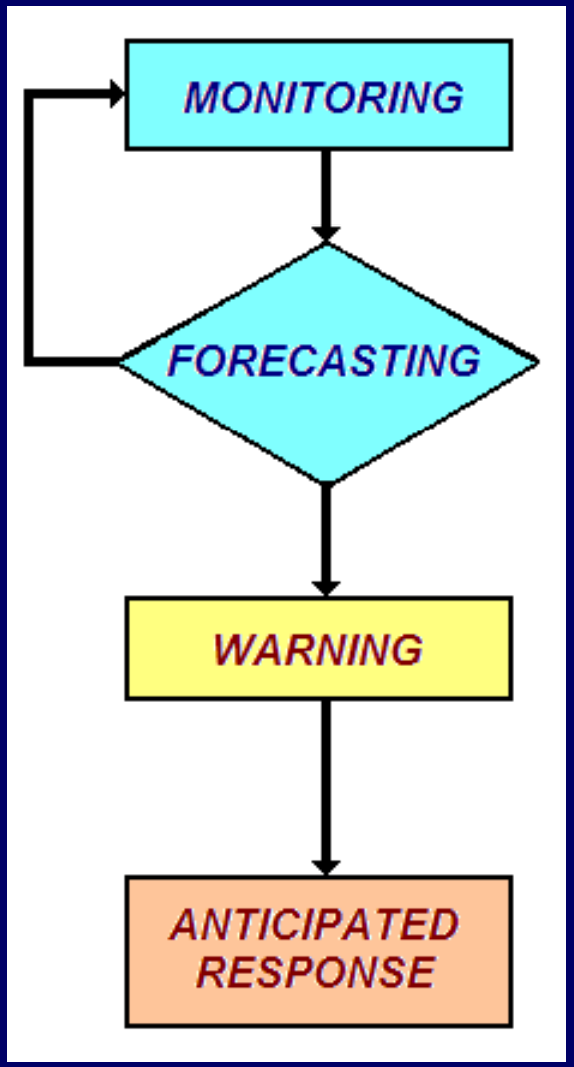
Evacuation in
Sri Lanka
29/03/2005
17/09/2007
11/04/2012

Sri Lanka 2005

Hawaii
1986



Basic Framework for Early Warning Systems



National level	International efforts + National efforts
National level	Technical Advisory Committee on Early Warning
National level	Distaster Management Centre Ministry of Law & Order and Public Safety
Municipal level Local level	Police stations + media
National level	Mobilization of resources
Provincial level	Coordination of event at this level
Municipal level Local level	Evacuation of people to safe areas Cofirmation of event (or lack of event), magnitude and intensity

Port City of Galle Sri Lanka-after Juan Carlos Villagran

HyperDEM

The precise 3-D model of the coastal areas of Sri Lanka

COOPERAZIONE ITALIANA

UNIVERSITÀ DELLA CALABRIA
CAMPUS DI ARCAVACATA

OGS

POLITECNICO DI MILANO

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

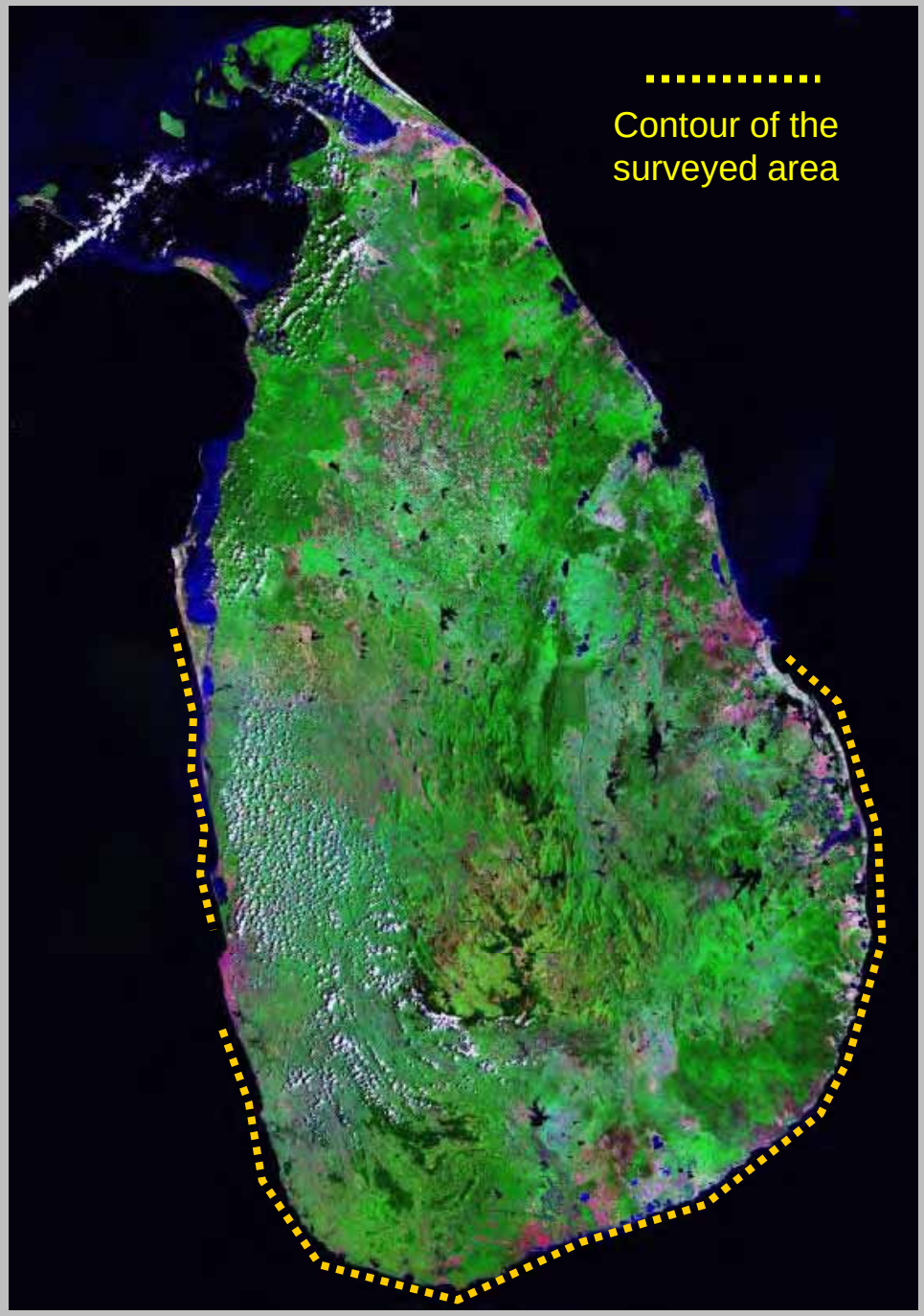
“HyperDEM” Tasks

Università della Calabria
(Co-ordinator; Spaceborne Multispectral & Airborne Hyperspectral Pre-/Post-Processing)

Istituto Nazionale di Oceanografia e Geofisica Sperimentale-OGS
(Airborne Campaign, Laser Scan, Color Orthoimages)

Politecnico di Milano
(Spaceborne Synthetic Aperture Radar and Permanent Scatterers-InSAR)

Università di Bologna
(*Tsunami* Wave Modelling)



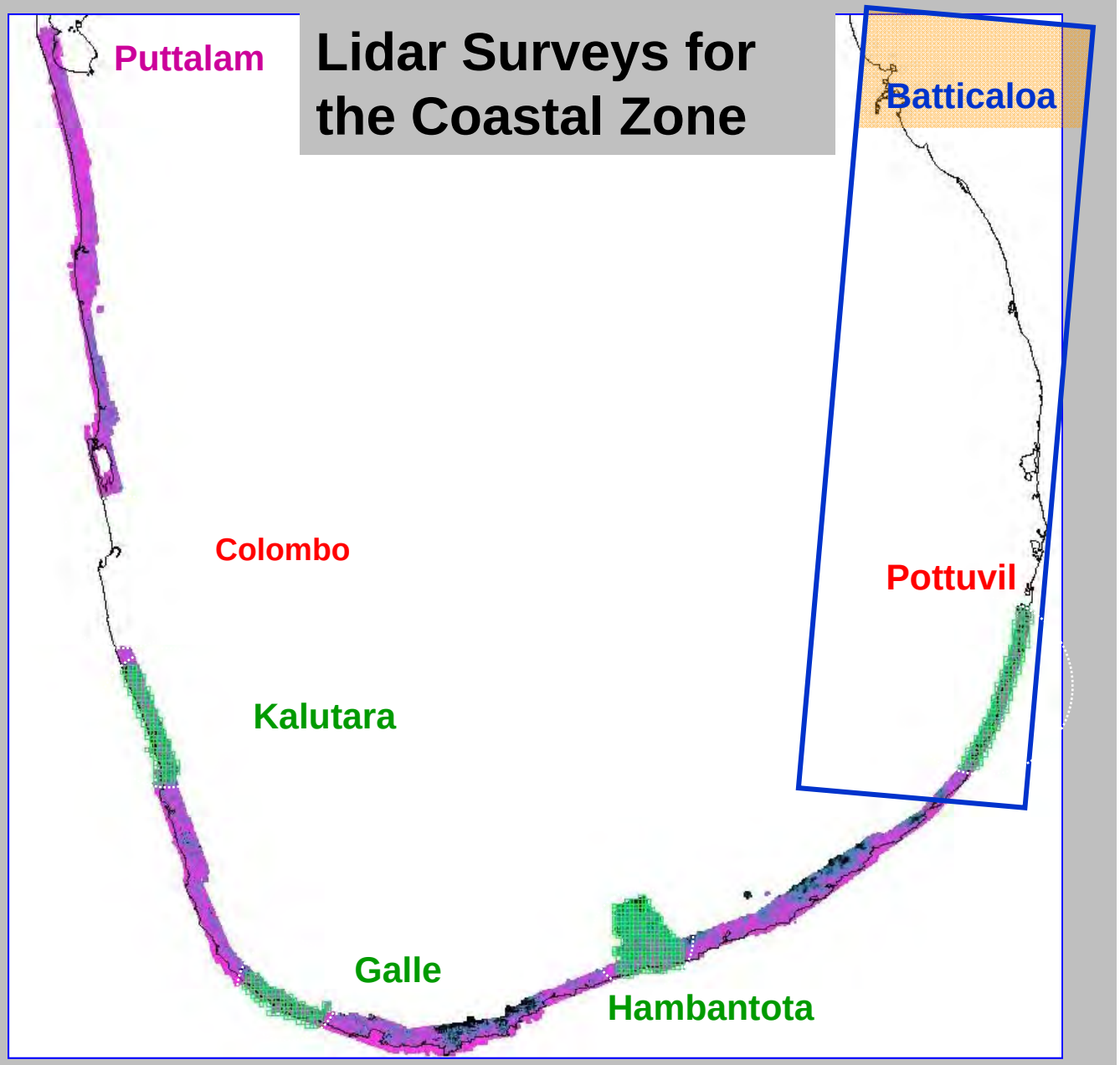
HyperDEM”

Funded by the Italian Government

Airborne acquisition (Stage 1)

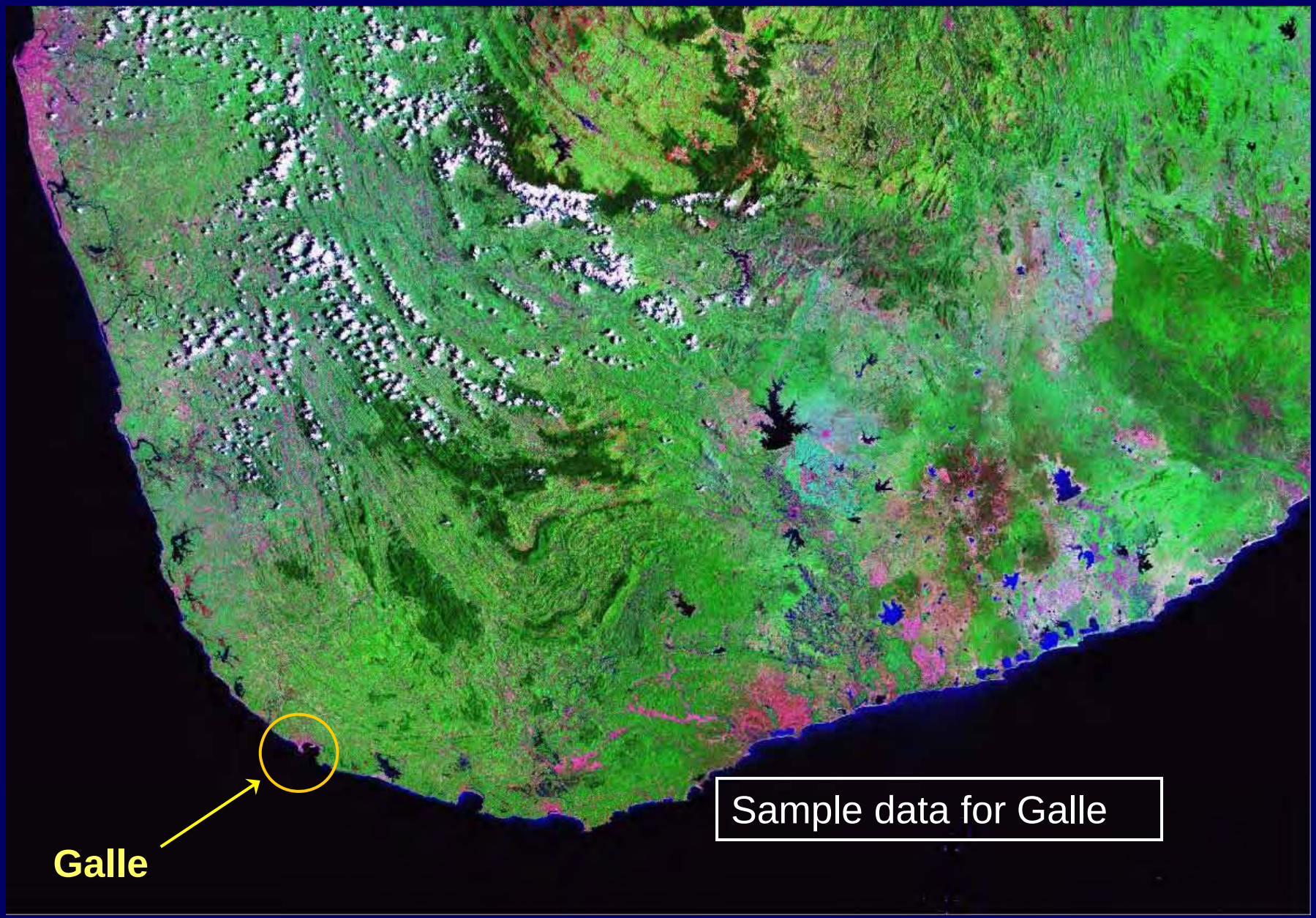
Airborne acquisition (Stage 2)

Satellite acquisitions (Stage 2)



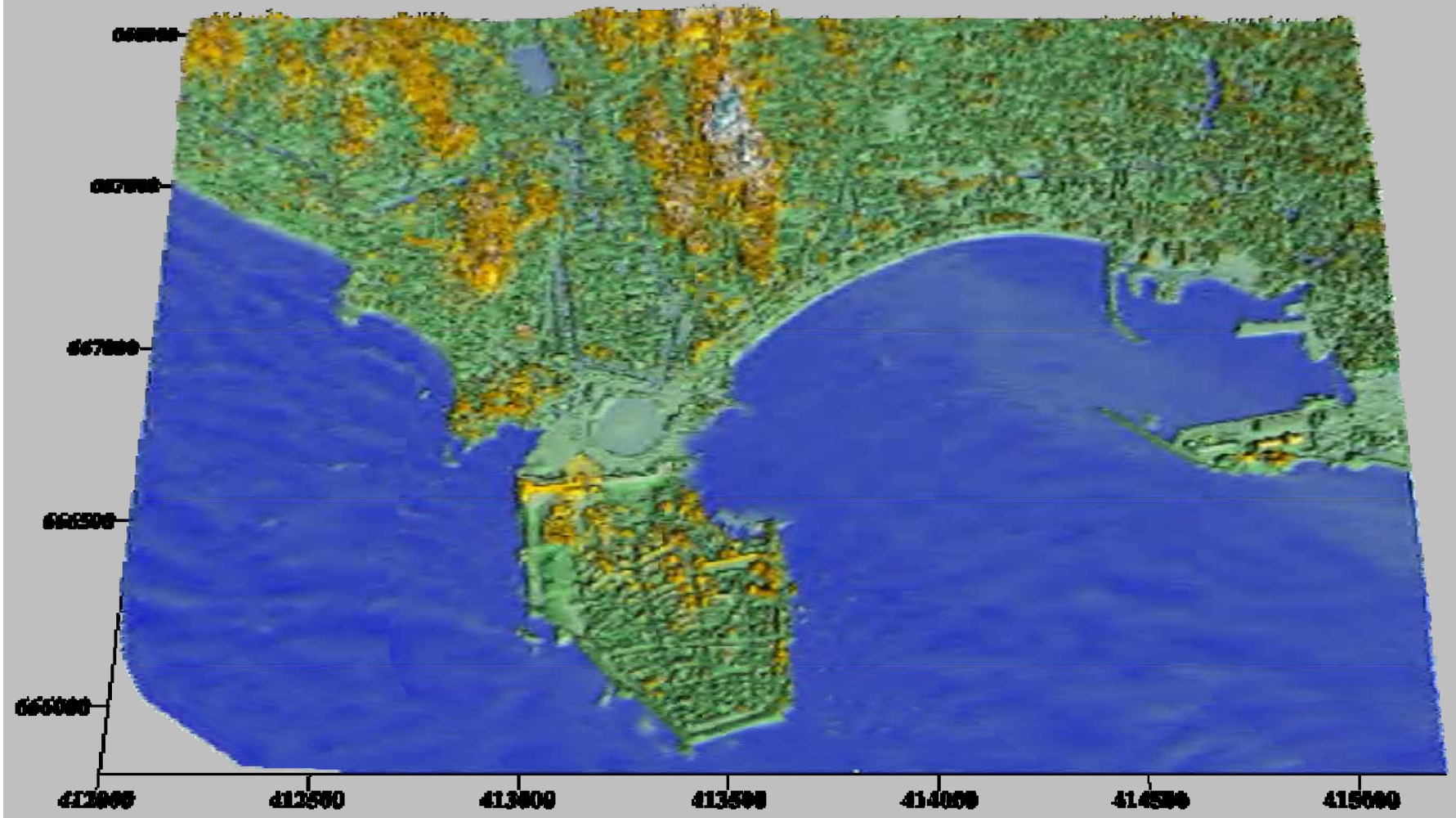
Project “HyperDEM” , South-eastern Sri Lanka

Vegetal Landuse by Landsat-7, Landsat-5 and Terra Spacecrafts)



Application of Lidar Surveys

Project “HyperDEM” Galle (Sri Lanka)-

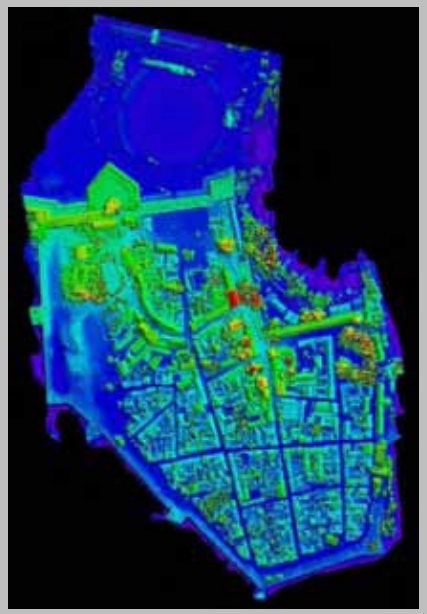


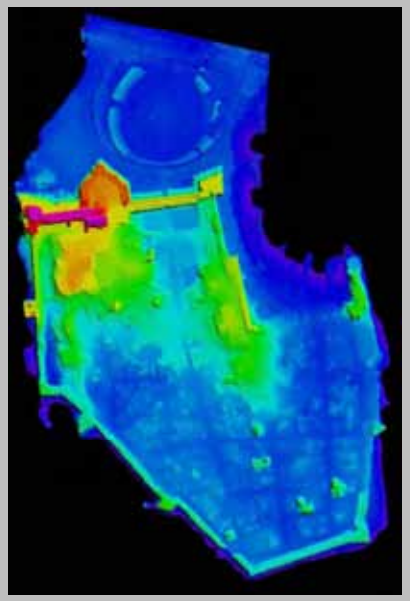
Full 3-D reconstruction of the urban area of Galle. In foreview, the Dutch Fort

Project “HyperDEM”

3-D PERSPECTIVE VIEW OF THE DUTCH FORT IN GALLE

DIGITAL
SURFACE MODEL



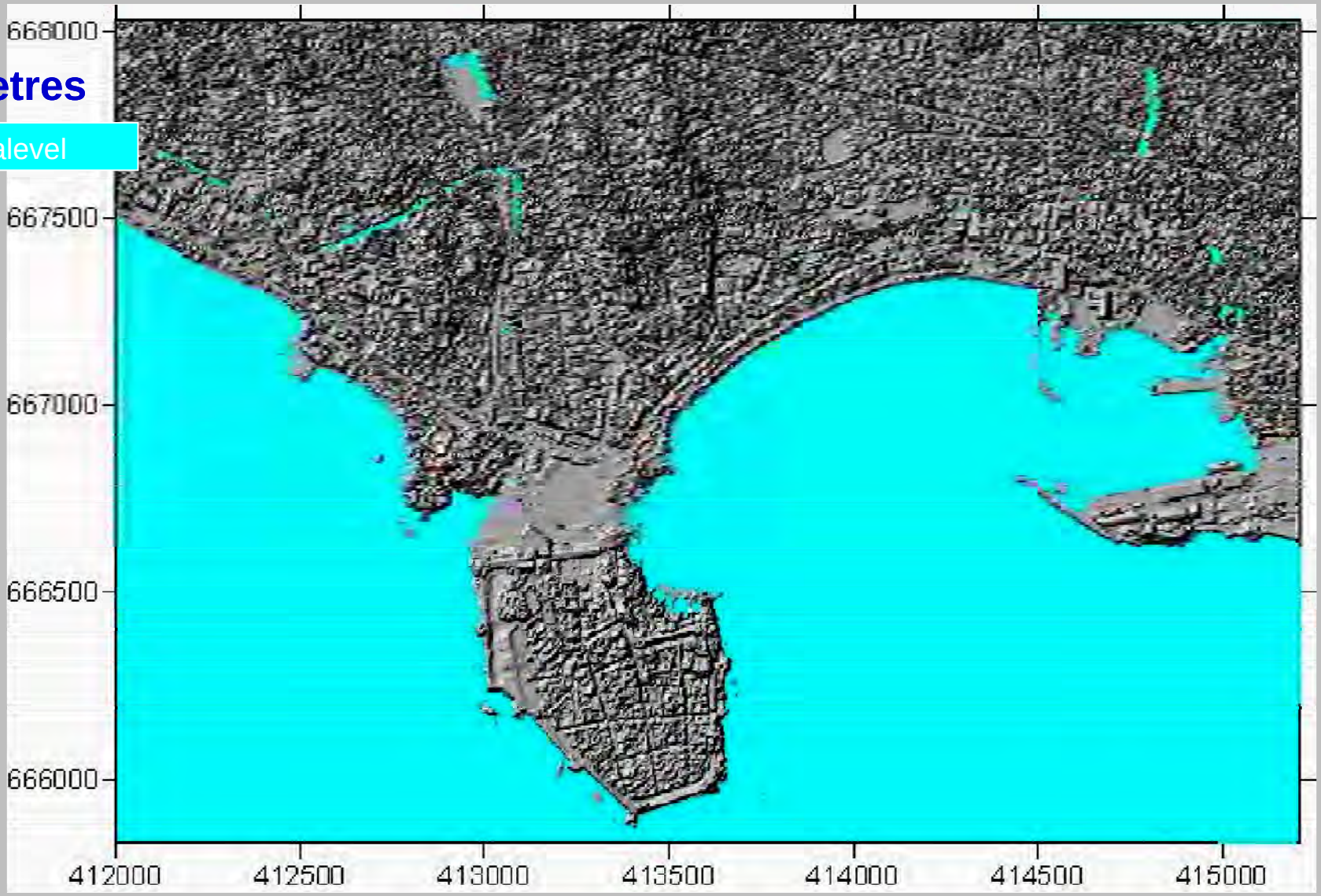


DIGITAL
TERRAIN MODEL

Galle – Surge Simulation (I)

0 metres

sealevel

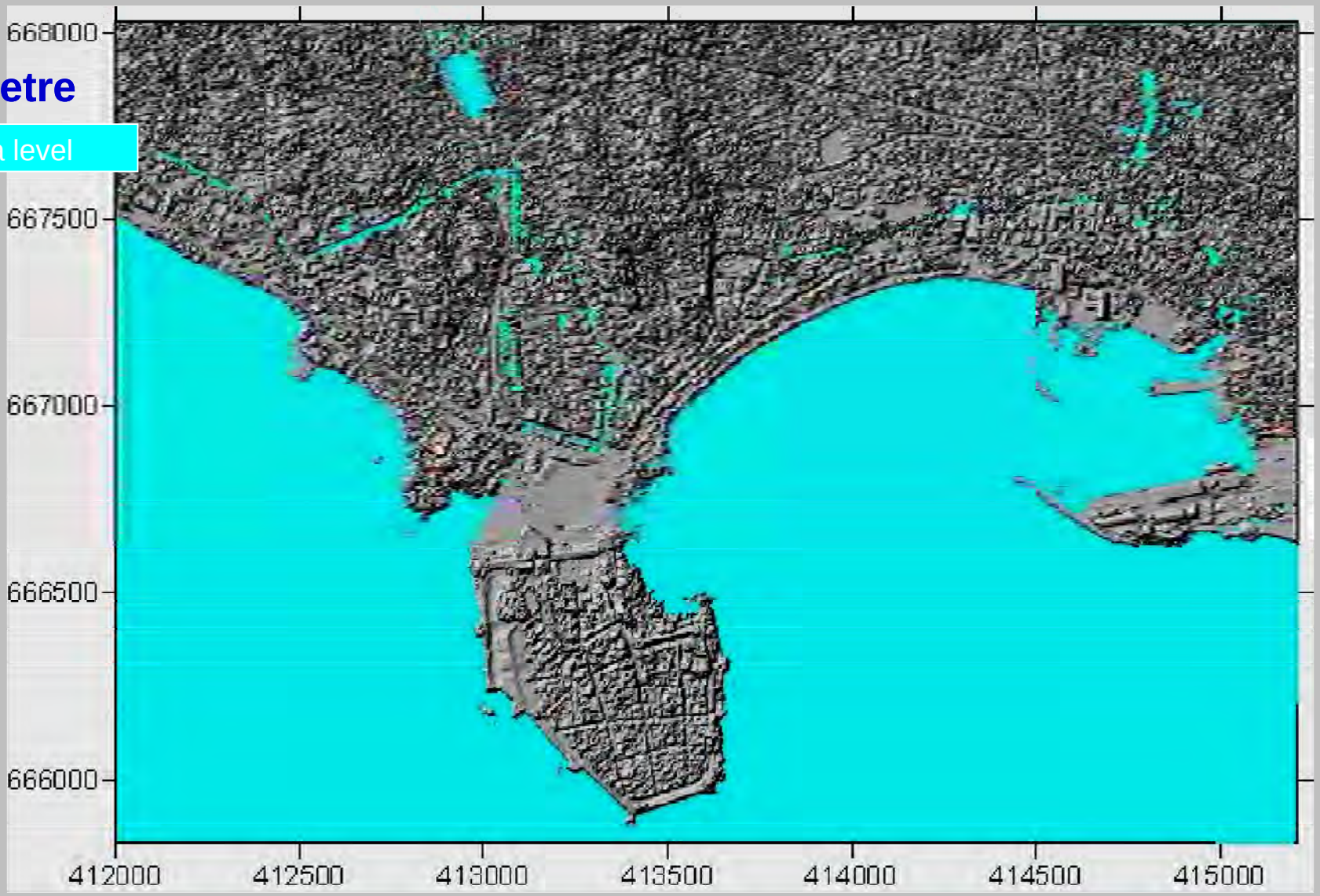


HyperDEM

Galle – Surge Simulation (II)

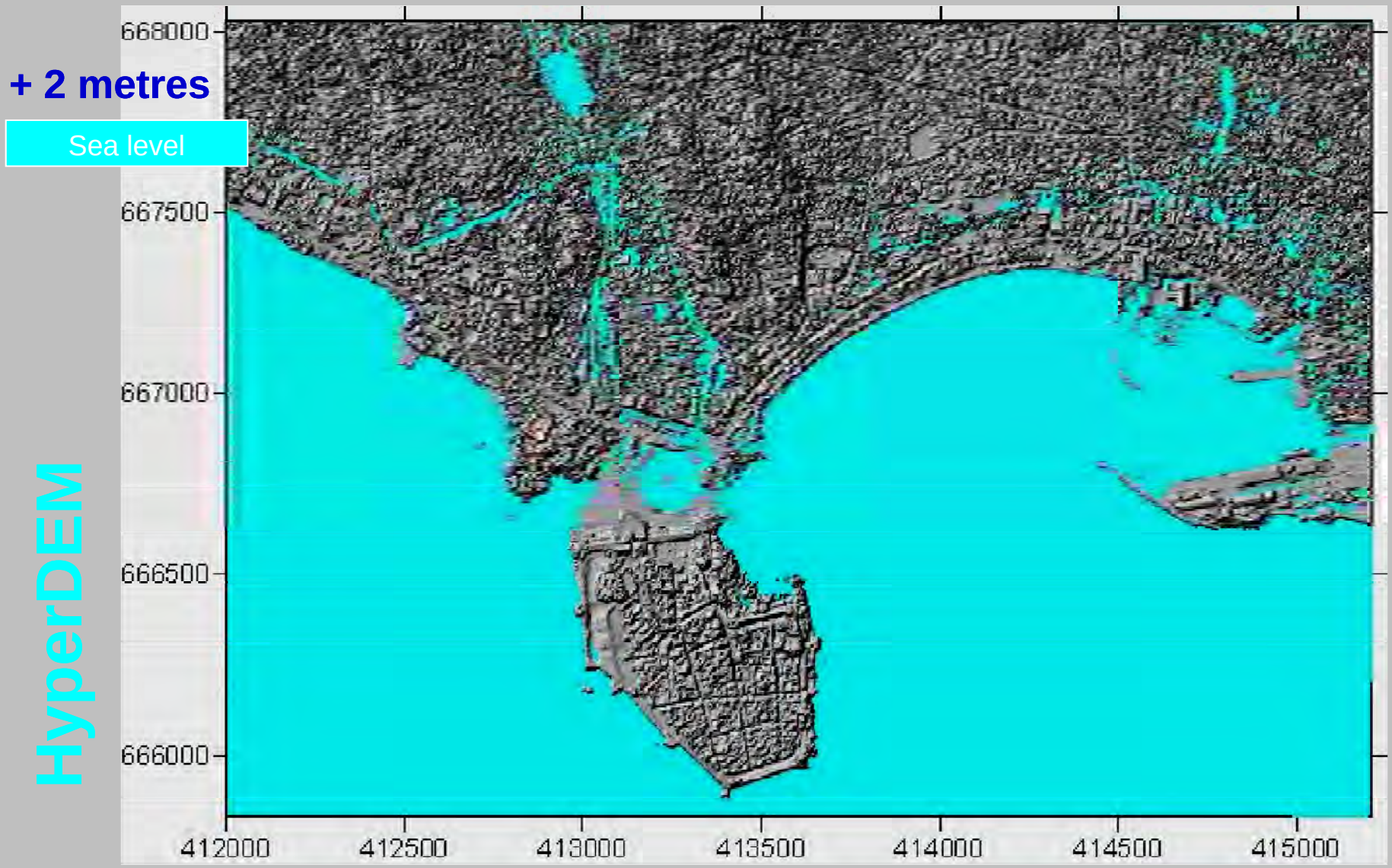
+ 1 metre

Sea level



HyperDEM

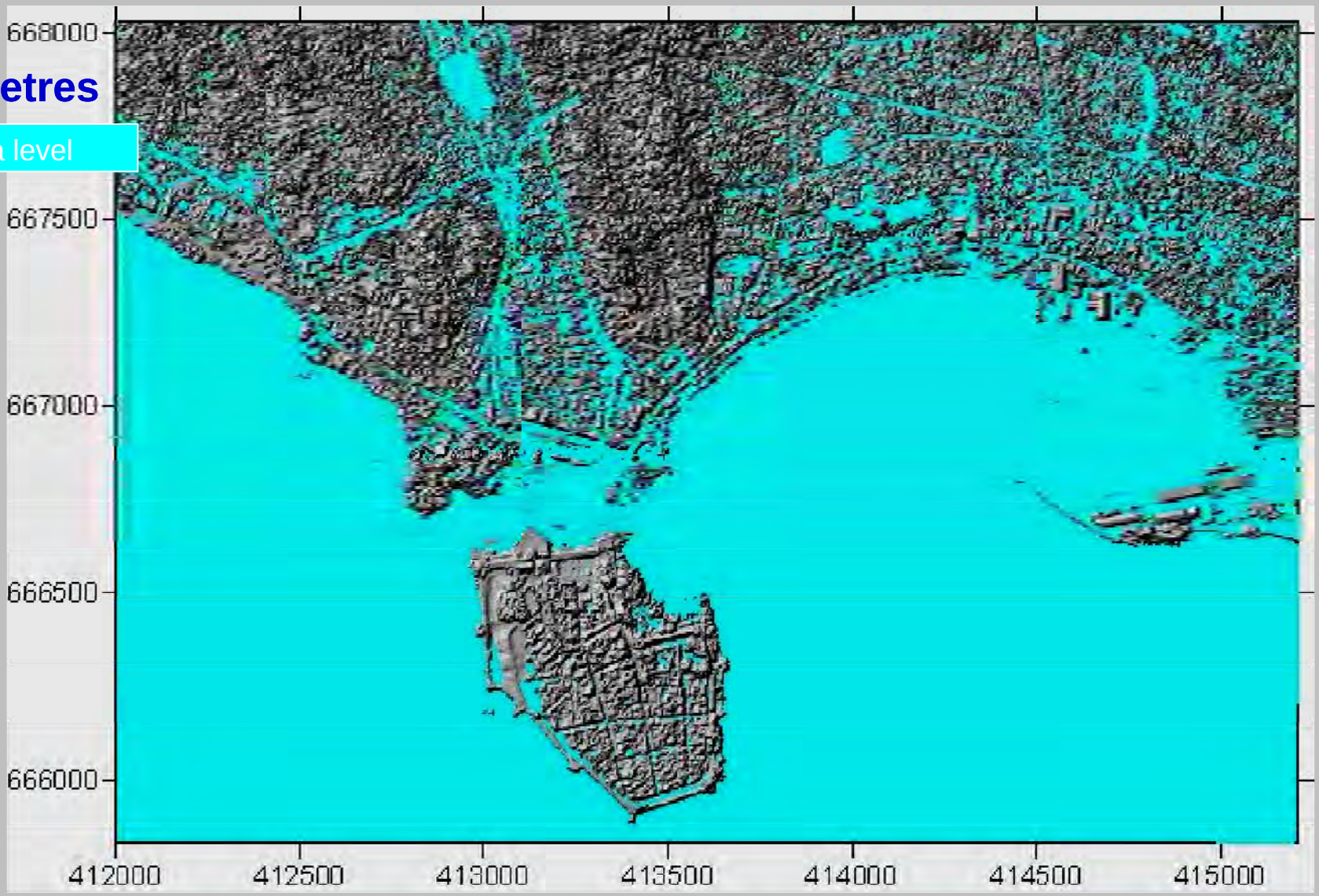
Galle – Surge Simulation (III)



Galle – Surge Simulation (IV)

+ 3 metres

Sea level

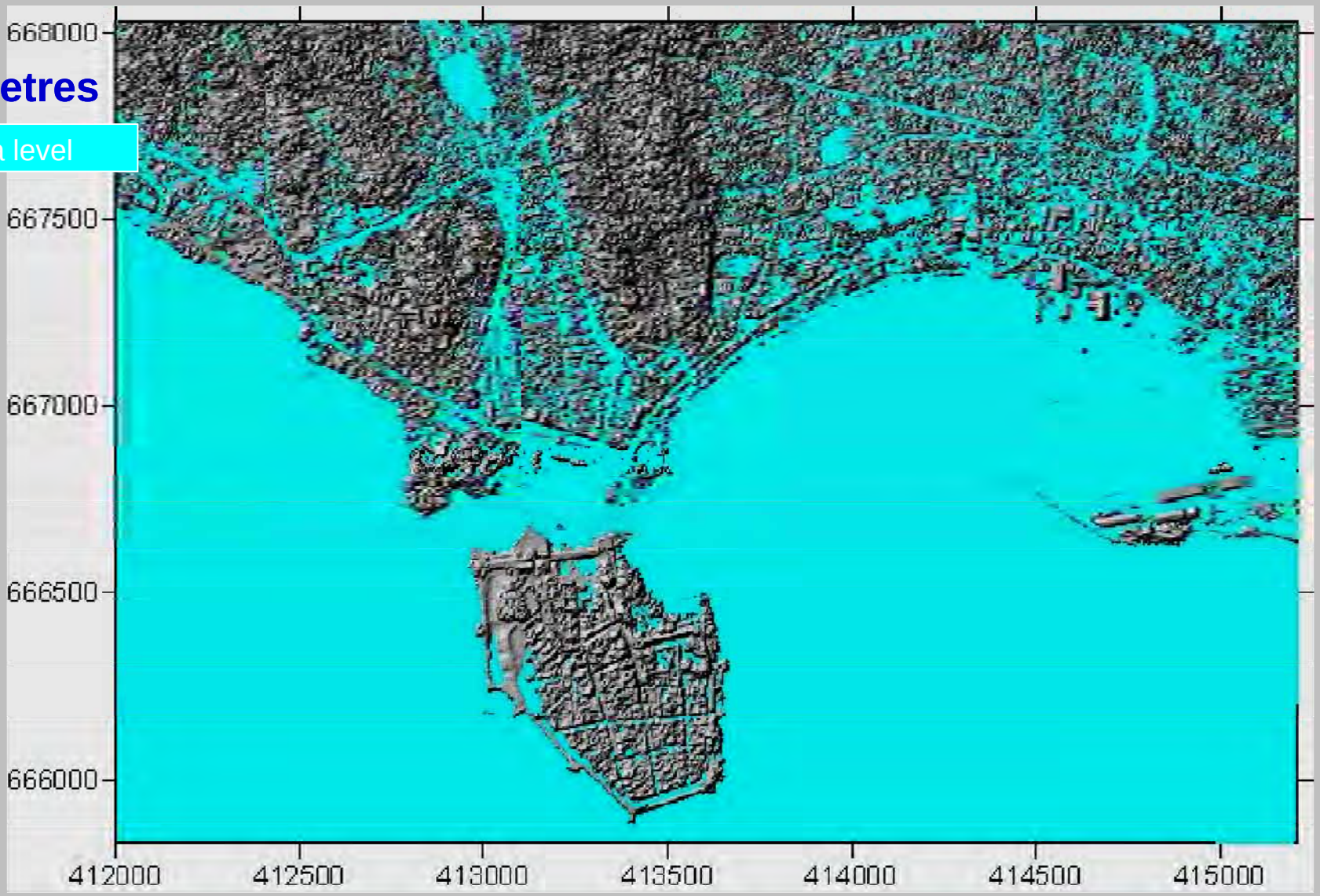


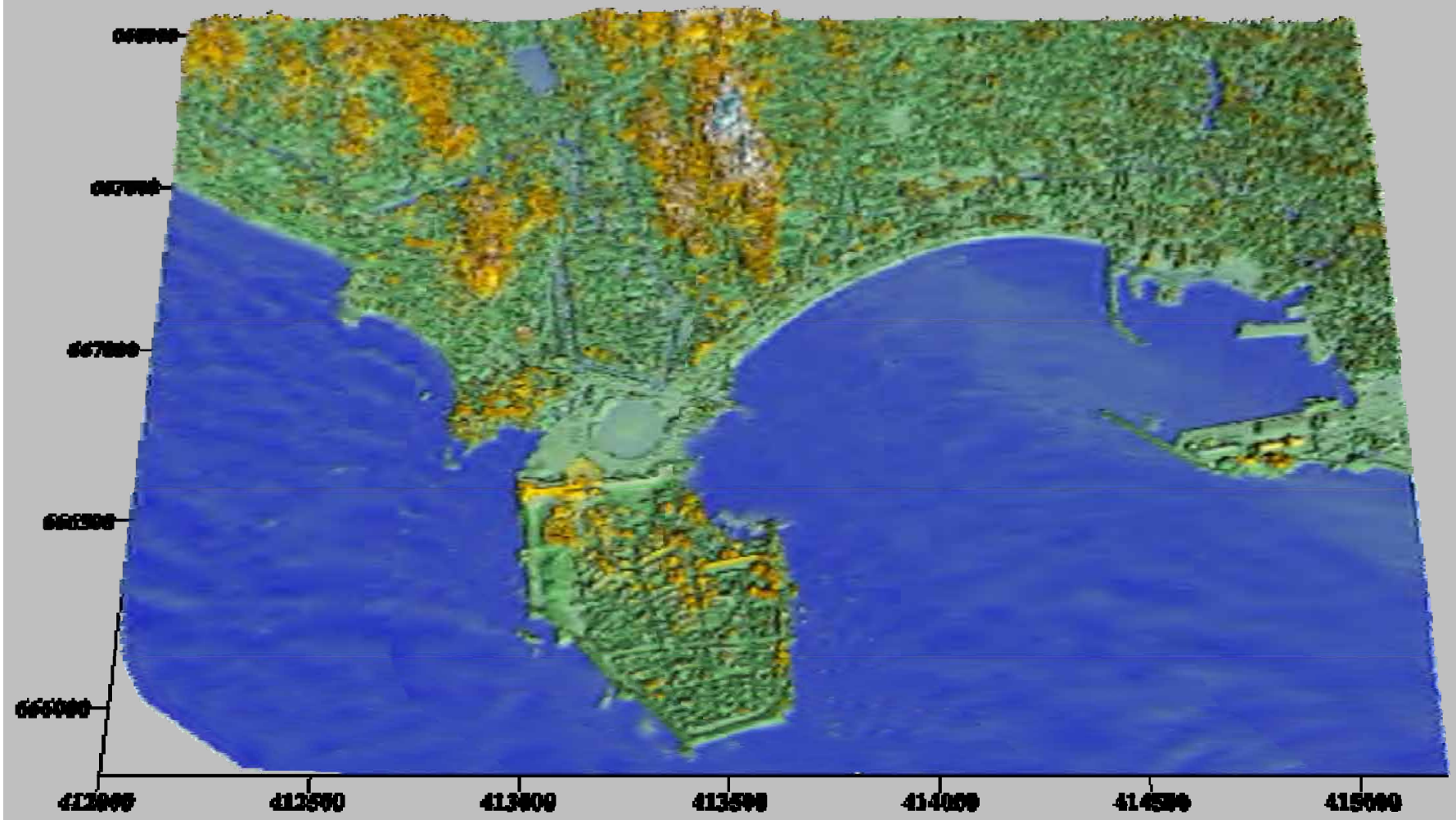
HyperDEM

Galle – Surge Simulation (V)

+ 4 metres

Sea level





Dynamic Hazard Modelling of Tsunami Propagation

M

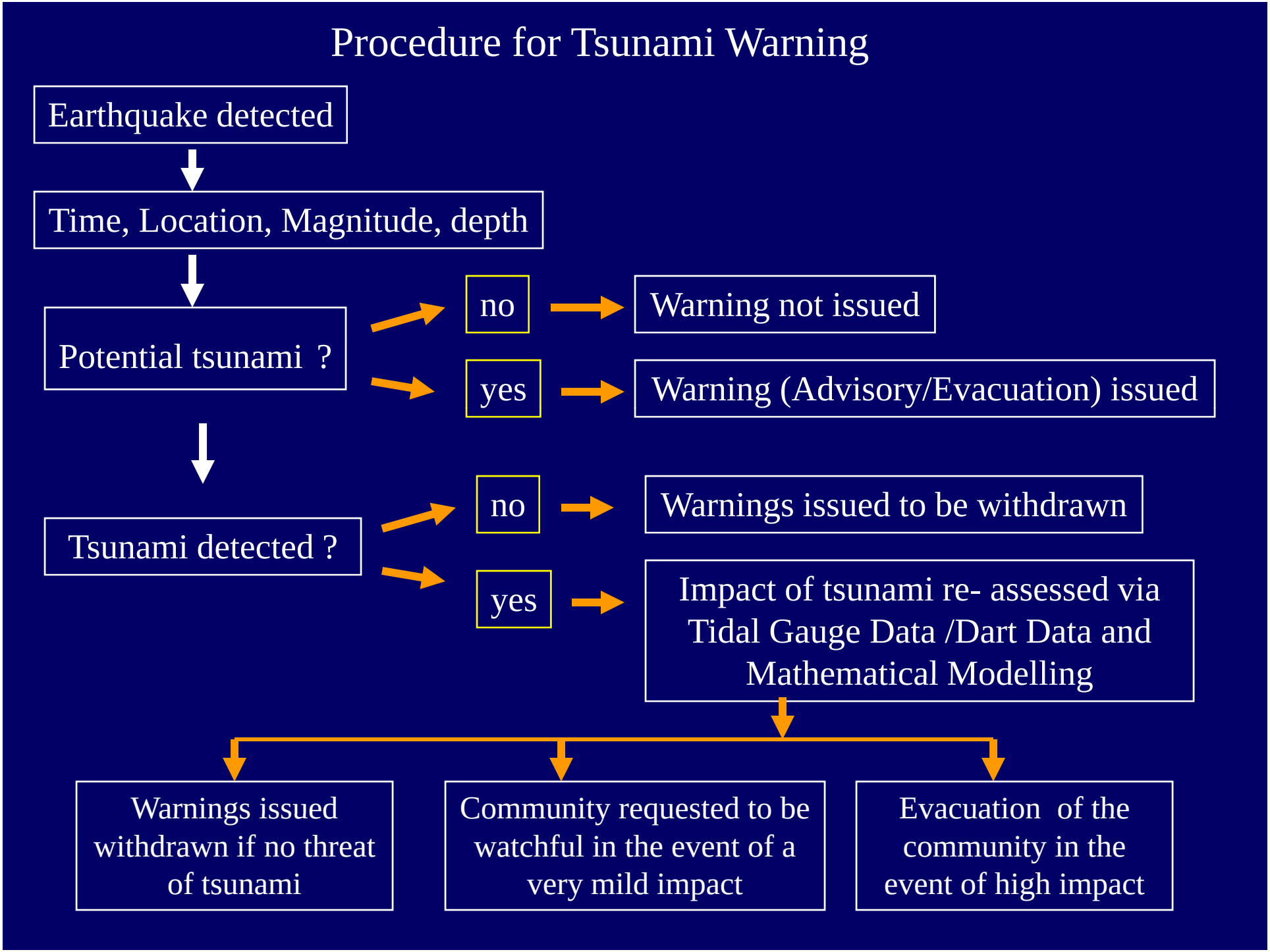
Dynamic Hazard Map of Inundation of IOT for Galle- PARI, Japan

based on Deterministic Tsunami Hazard Modelling

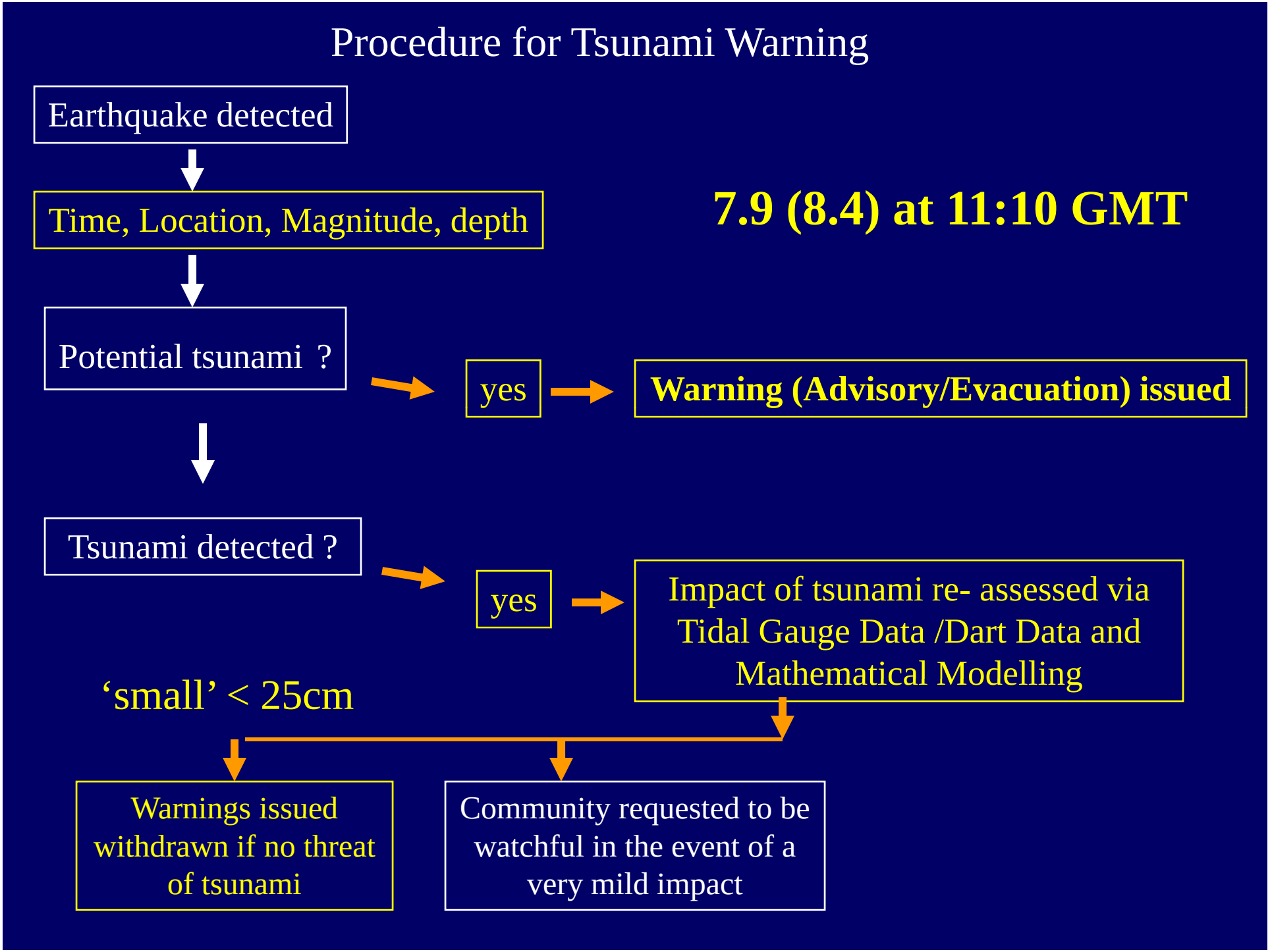
Tsunami and the Issue of Warnings- associated RISKS

Earthquake 	**Tsunami not generated**	**Tsunami generated**
Warning not issued	Safe by default ★	Possible Disastrous Consequences ★
Warning issued	False Warning ★	Safe ★

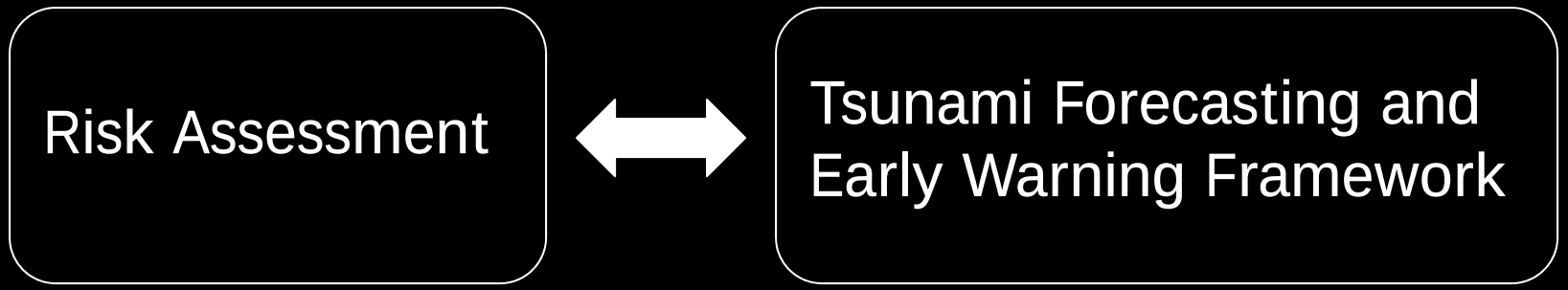
Procedure for Tsunami Warning



Procedure for Tsunami Warning



Risk Assessment within a Tsunami Forecasting and Early Warning Framework established by IOTWS



Risk Assessment within a Tsunami Forecasting and Early Warning Framework

Risk Assessment within a Tsunami Forecasting and Early Warning Framework

Operating within a Tsunami Forecasting Framework,
a capability can be developed to serve

1. Real-time operational needs
2. Hazard/Risk Assessment needs
3. Research and Development opportunities

through the use of a standardized tsunami forecast system that includes

- tsunami source characterization,
- tsunami measurements, and
- tsunami forecast models.

Risk Assessment within a Tsunami Forecasting and Early Warning Framework

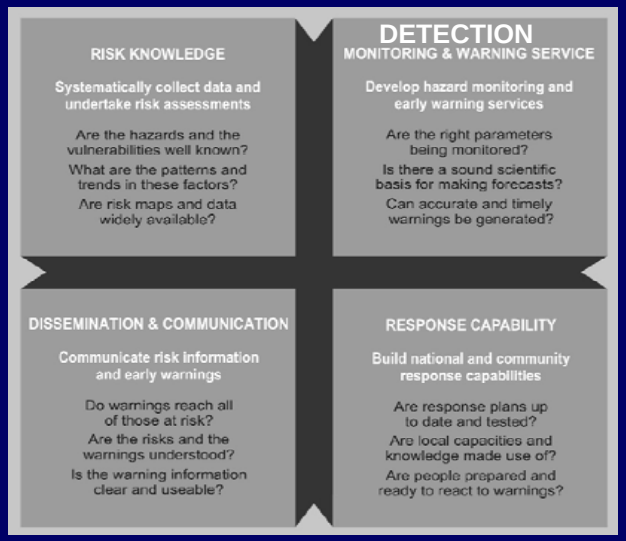
Tsunami Forecasting System would have two immediate applications

1. Real time operational forecasts of tsunami arrival time, tsunami amplitude, maximum height and inundation areas etc

2. Long term assessments of hypothetical tsunamis based on plausible tsunami sources for a particular areas to be used for Risk assessment and for the production of tools such as disaster management maps.

UN-ISDR Framework for effective Early Warning systems encompass 4 critical linked elements,

EWS

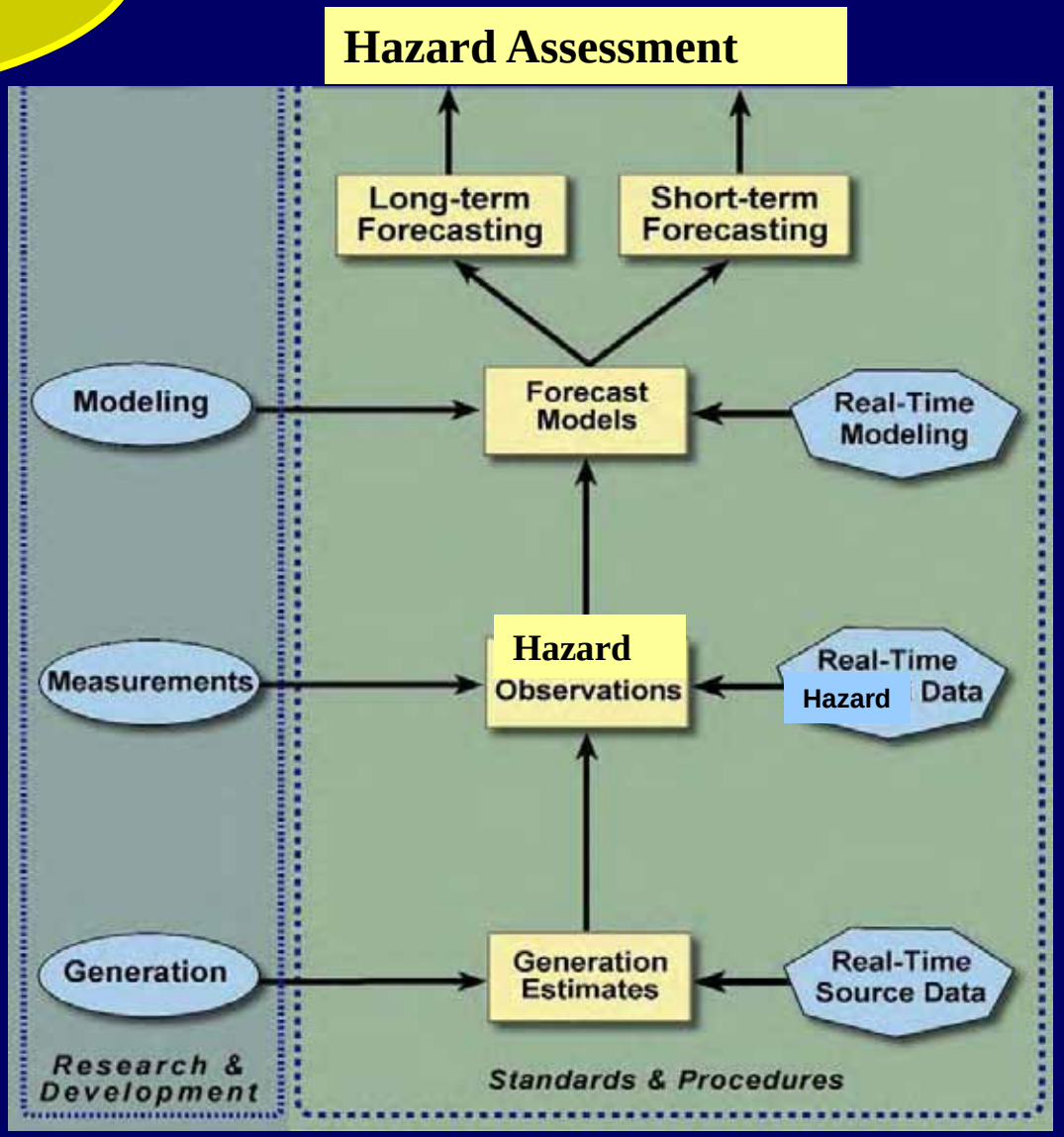


Early Warning Systems

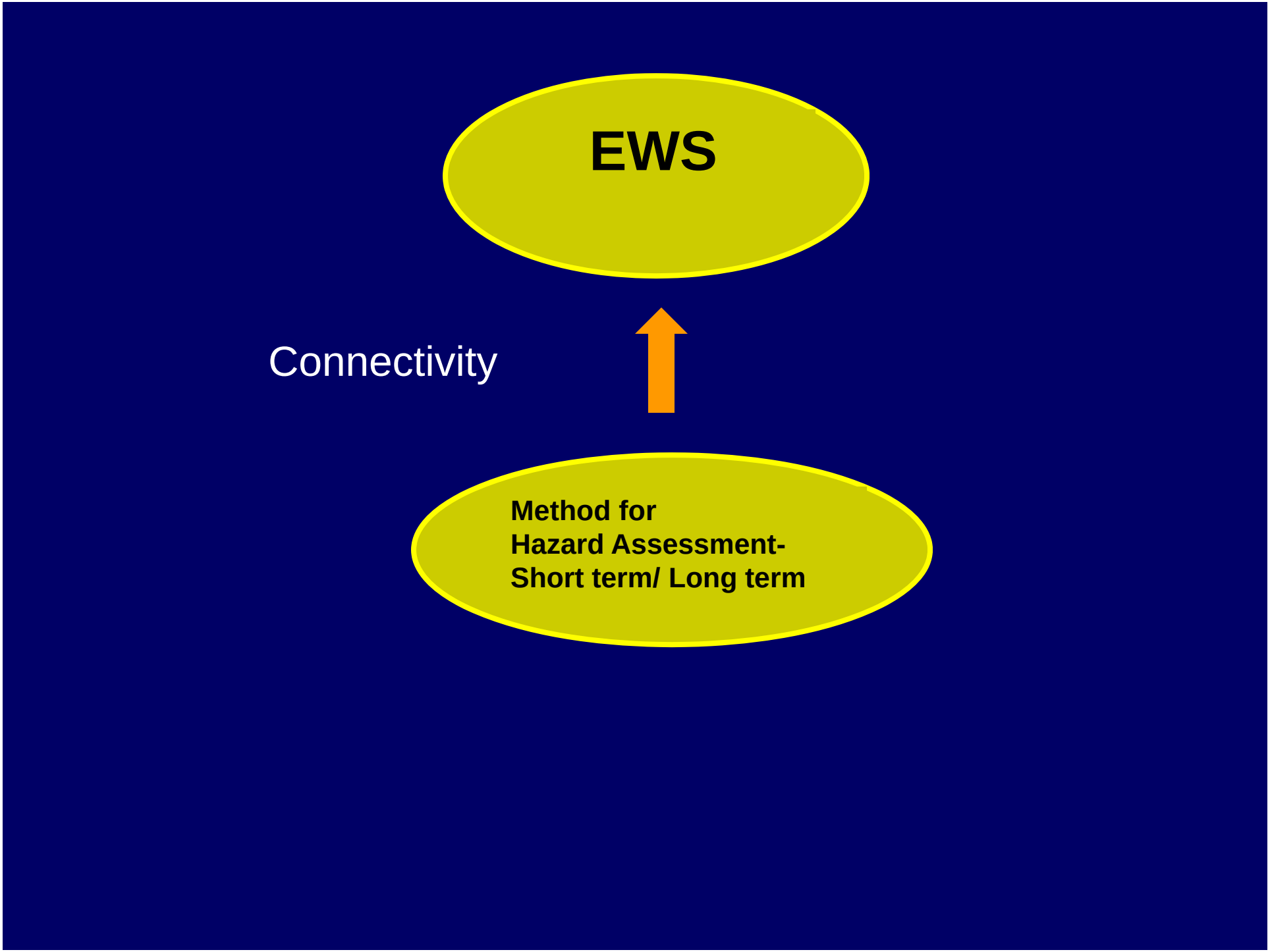
Response Capability	**Dissemination and Communication**
Risk Knowledge	**Detection, Monitoring and Warning Service**

Method for Hazard Assessment- Short term/ Long term

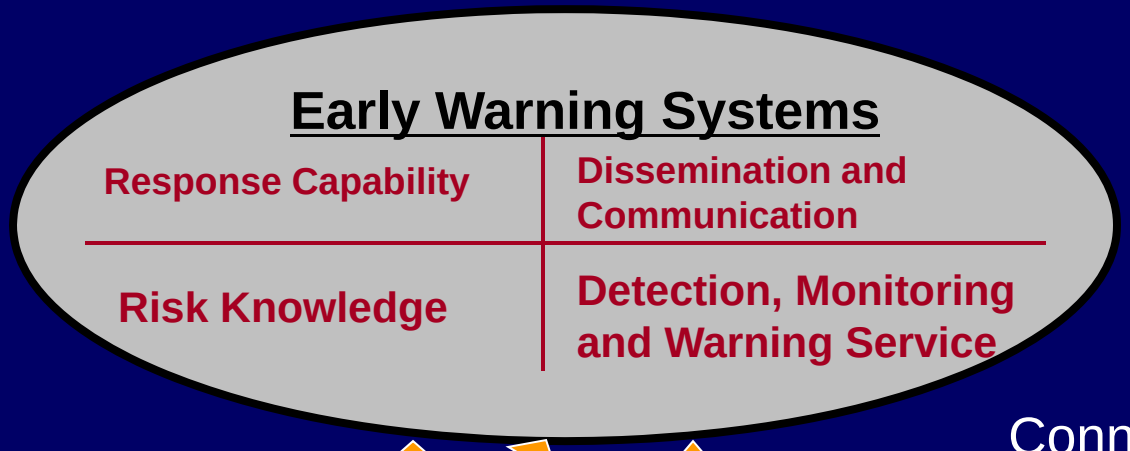
Method for Hazard Assessment



after Eddie Bernard

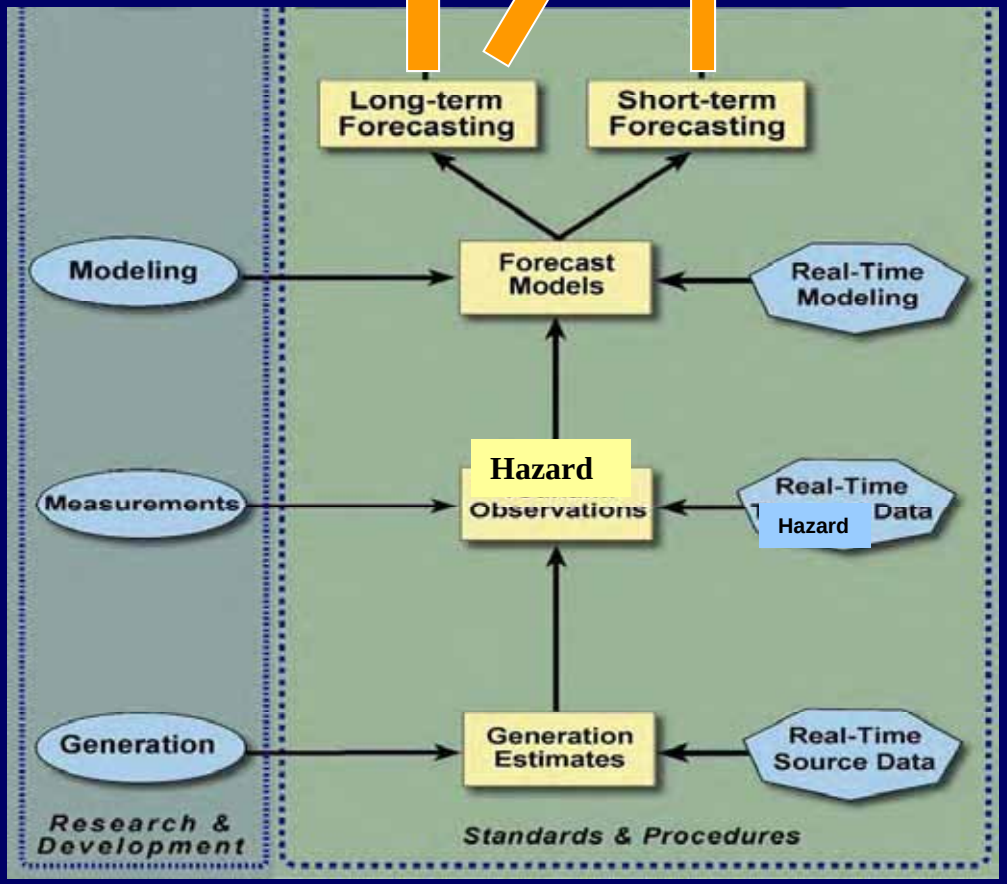

EWS
Connectivity
Method for
Hazard Assessment-
Short term/ Long term

EWS



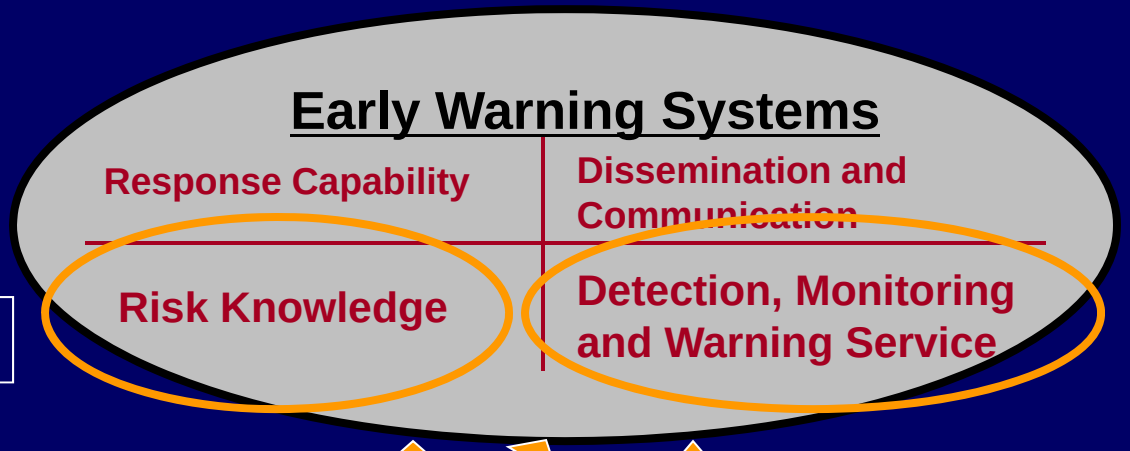
Connectivity to EWS

Hazard Assessment



after Eddie Bernard

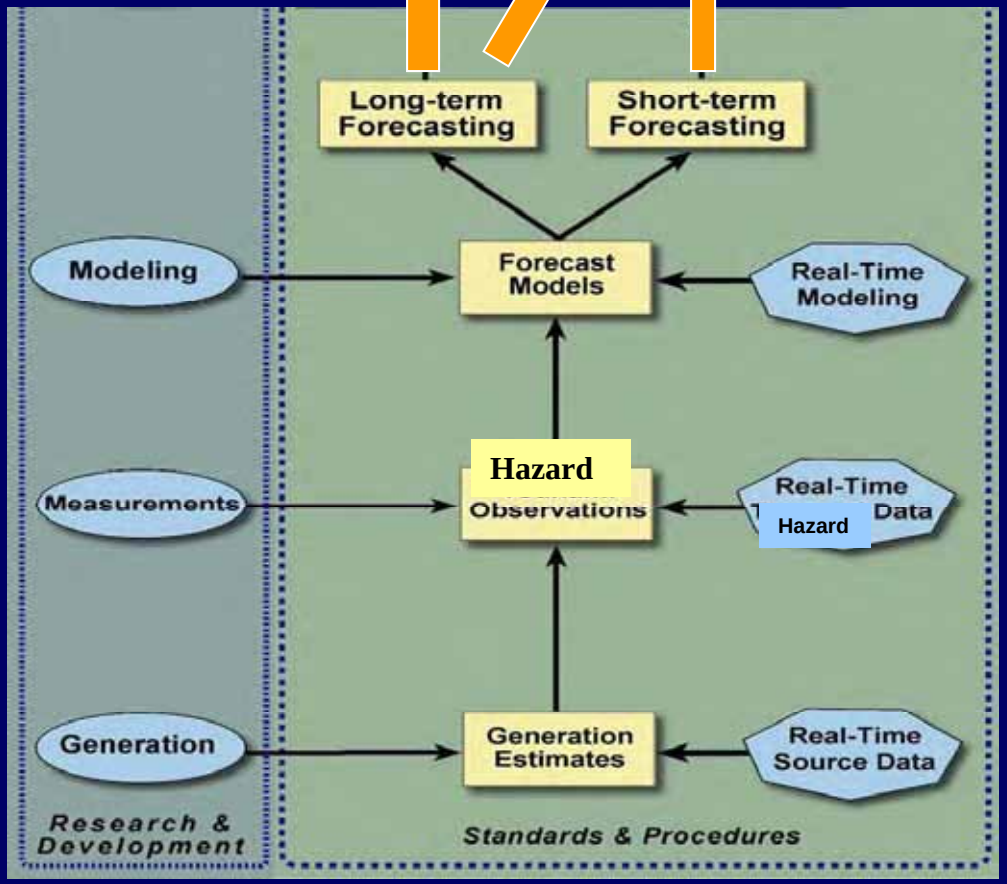
EWS



Strategic

Event

Hazard Assessment



after Eddie Bernard

EWS

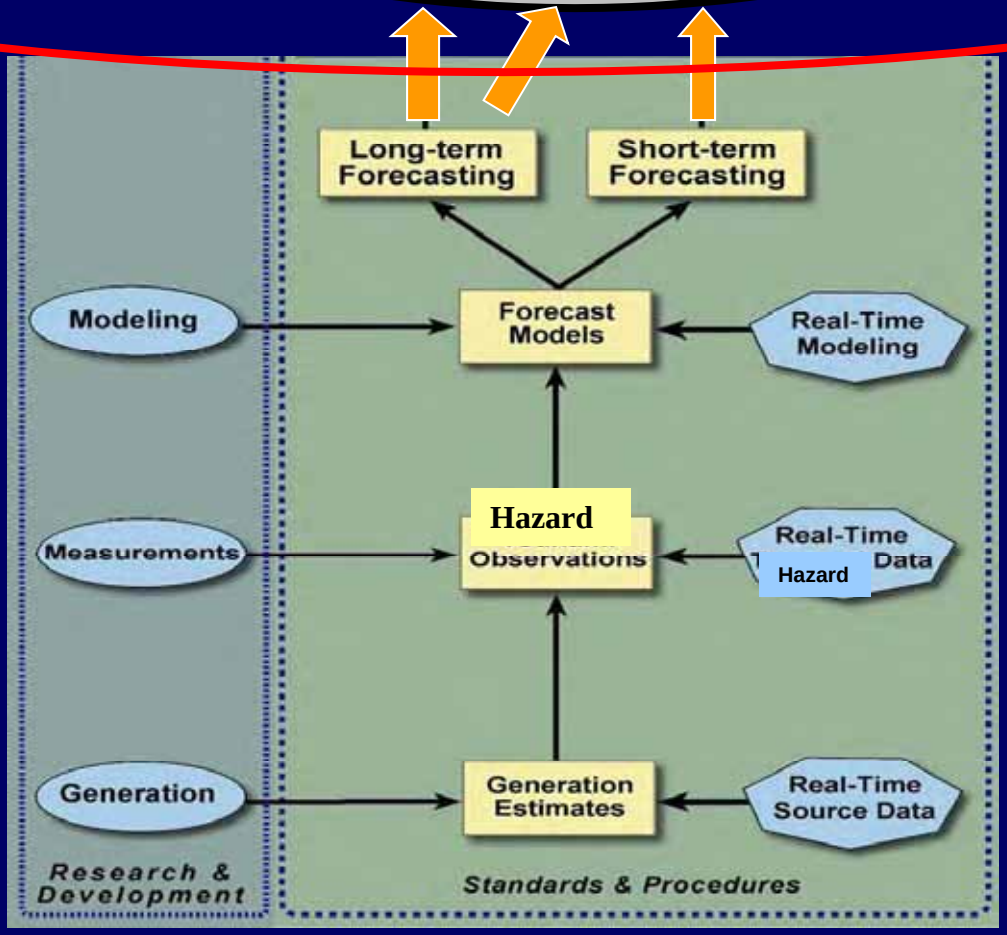
Early Warning Systems

Response Capability	Dissemination and Communication
Risk Knowledge	Detection, Monitoring and Warning Service

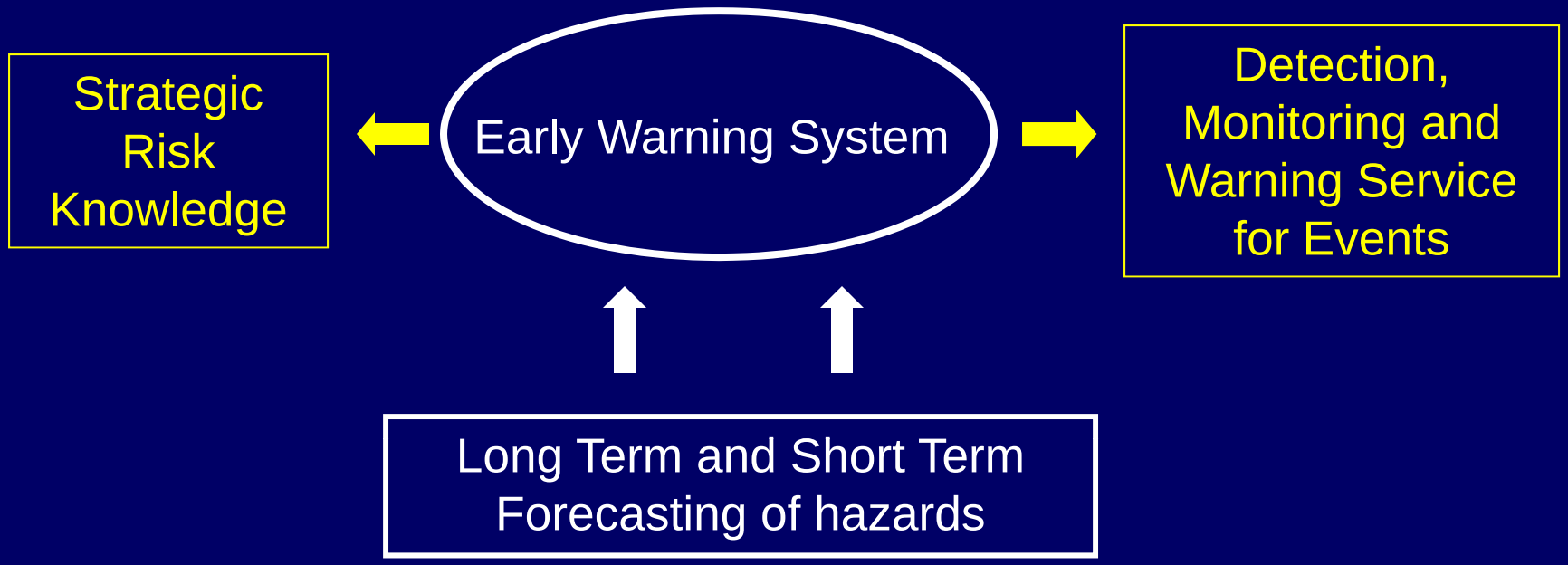
Strategic

Event

Hazard Assessment



after Eddie Bernard



Long term assessments of hypothetical tsunamis based on plausible tsunami sources for a particular area could be used for Risk Assessment and for the production of tools such as disaster management maps.

For multi hazard early warning systems it is necessary
to establish an effective framework
--to accommodate multi hazard analysis and
--for ‘collaborative operation’ among different agencies dealing with the multi hazards

Understanding the diversity of and connectivity among
coastal hazards

Multi Hazard Warning Systems

Early Warning System

Response Capability	**Dissemination and Communication**
Risk Knowledge	**Detection, Monitoring and Warning Service**

Hazard Analysis-
Short term/ Long term

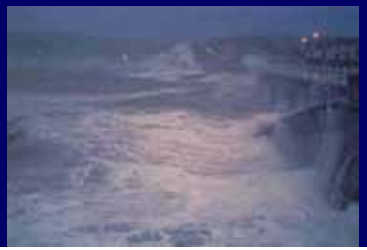
Hazard Analysis-
Short term/ Long term

Hazard Analysis-
Short term/ Long term

Hazard Analysis-
Short term/ Long term

Hazard Analysis-
Short term/ Long term






Critical Issues on Establishing new or Maintaining and Enhancing existing end-to-end multi hazard EWSs include:

1. Identifying and reviewing risk scenarios

2. Agreement on specific responsibilities within the EWS

3. Coordination among those managing EWSs

4. Investigation of past events and implementation of improvements

5. Development of procedures and manuals and assessing their effectiveness

6. Consultation with communities and dissemination of information

7. Regular practice and testing of Operational Procedures including dissemination of warnings and evacuation.

The Japanese Earthquake and Tsunami March 2011

The main lessons

Hazard Detection

-Early detection of the rapid onset of extreme tsunami events generated closer to shoreline.

Vulnerability

-**Human life**; Response to early warning (sense of security from hazard protection structures which may fail), Evacuation , Safe places.

-**Design of hazard resilient infrastructure**; Review based on damage profiles

-**Hazard protection structures**; They become vulnerable to extreme hazard conditions and may fail. On failure they become hazardous elements.

-**Review of vulnerability;** *'Vulnerability Checks' as part of Risk Management*

Thank you