Coastal Hazard Management

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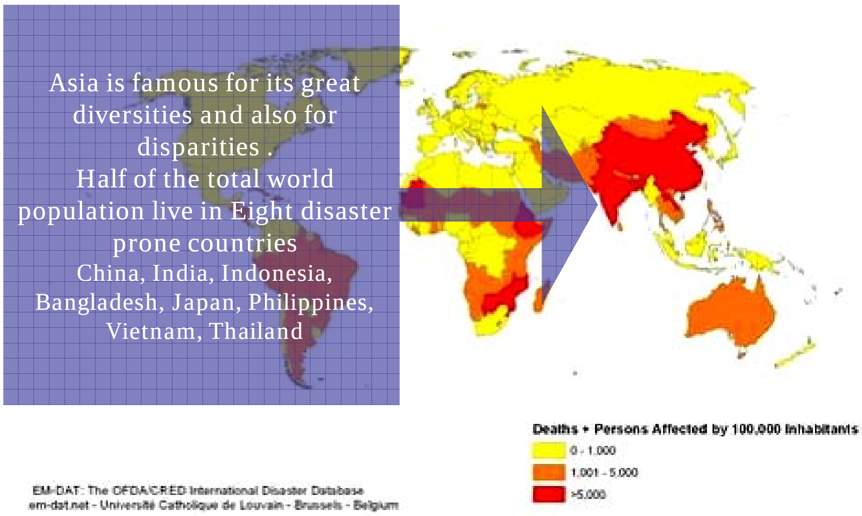
Vulnerability of the Asian Region

Asia is famous for its great diversities and also for disparities .
Half of the total world population live in Eight disaster prone countries
China, India, Indonesia, Bangladesh, Japan, Philippines, Vietnam, Thailand

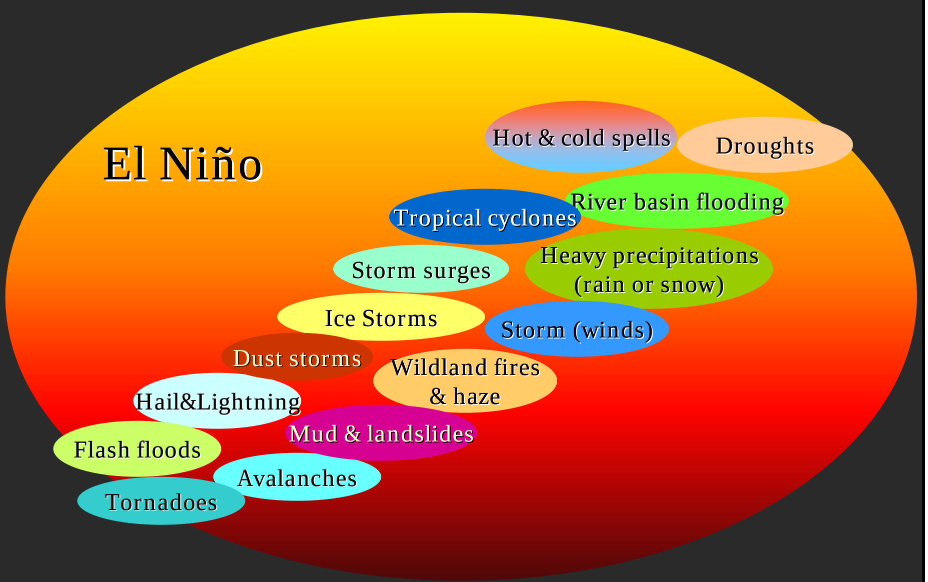


EM-DAT: The OFDA/CRED International Disaster Database
em-dat.net - Université Catholique de Louvain - Brussels - Belgium

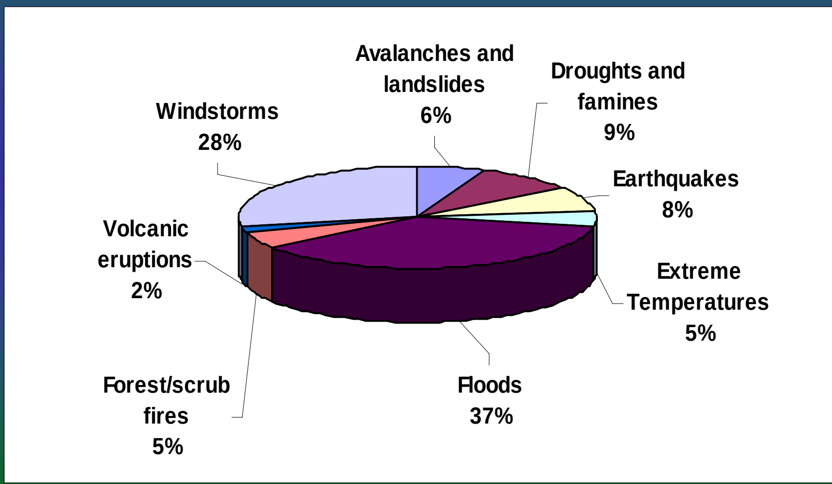
Cities are vulnerable to disaster risk because of-

- Rapid Urbanization
- Rural - Urban migration
- Growing population - already stretched resources
- Poor living standards - build without consideration of safety (time pressures) + in hazard prone areas
- Lack of public awareness to hazards/risks
- Building codes are poorly enforced or non-existent
- Environmental degradation - resource depletion - lowers resilience

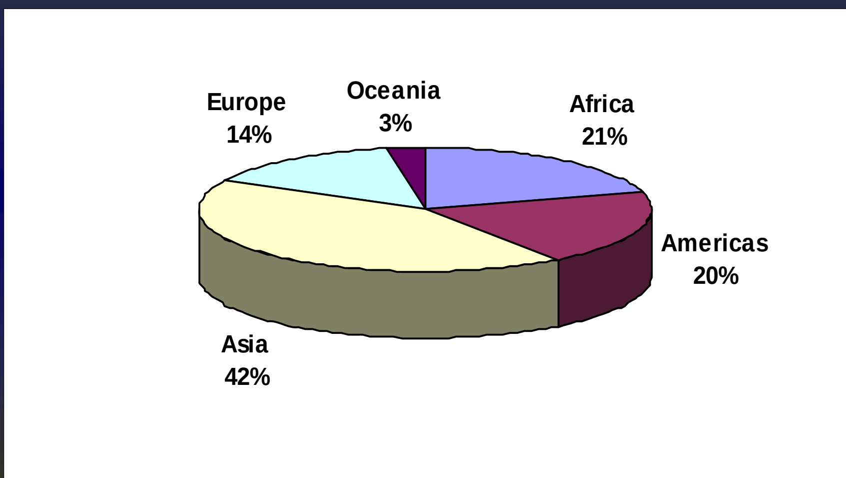
Weather, water and climate-related hazards



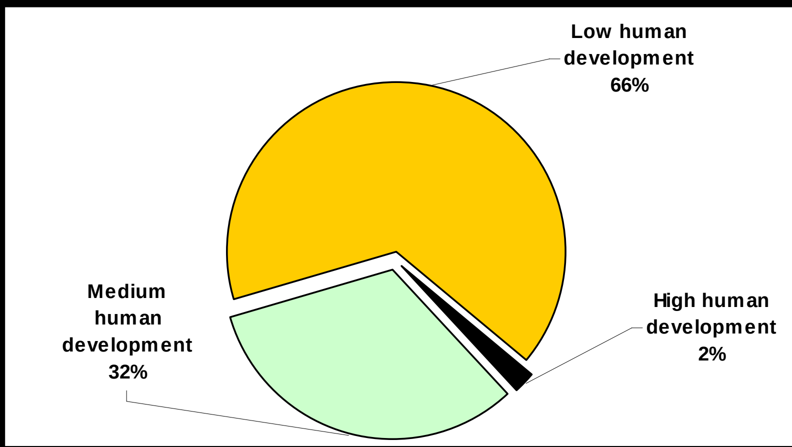
Global distribution of natural hazards (1993-2002)



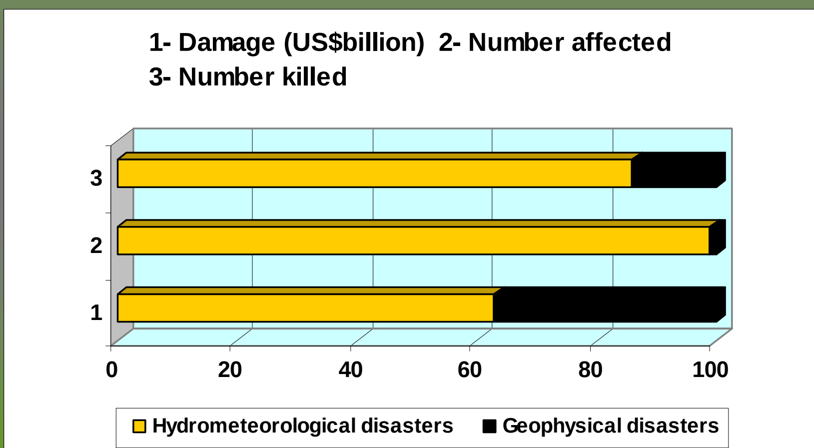
Regional distribution of natural disasters (1993-2002)



Distribution of people killed (1993-2002)

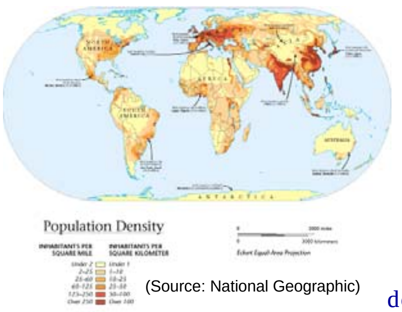


Hydro-meteorological and geophysical disasters (1993-2002)



Humans in the Coastal Zone

The coastal areas of the world are very densely populated and center around a large amount of economic activity.



(Source: National Geographic)

A satellite view of lights at night displays the dominance of world population along the coastline

(Source: NASA)

How Many People Live in the Coastal Zone?

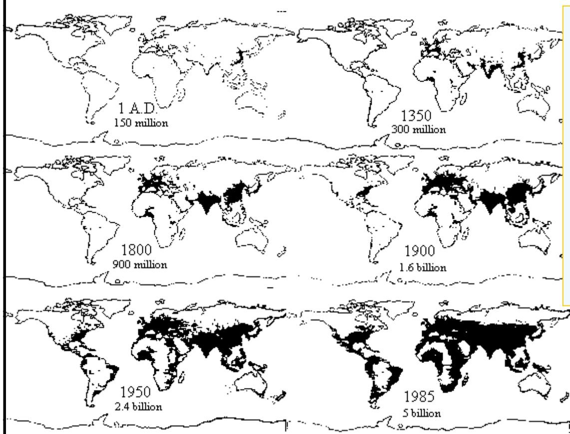
- India has a coastline of 7516 km of which the mainland accounts for 5422 km, Lakshadweep coast extends 132 km and Andaman and Nicobar islands have a coastline of 1962 km
- Nearly 250 million people live within a distance of 20 km from the coast
- Multiple coastal issues both physical and social occur along the coastline
- Solution to coastal problems have always been implemented with an engineering perspective
- Social conflicts on the rise along the coast
- Human and environmental vulnerabilities need to be addressed on same levels

Who Lives in the Coastal Zone?

Multi-unit dwellings are more common and is constantly expanding




Where do People Live in the Coastal Zone?



Settlement patterns by the coastline

(Source: http://desip.igc.org/populationmaps.html)

Top Ten Largest Cities:

Tokyo, Japan - Coastal
Mexico City, Mexico - Inland
Mumbai, India - Coastal
Sáo Paulo, Brazil - Inland
New York City, USA - Coastal
Shanghai, China - Coastal
Lagos, Nigeria - Coastal
Los Angeles, USA - Coastal
Calcutta, India - Coastal
Buenos Aires, Argentina - Coastal

(Source:http://www.globalchange.umich.edu/globalchange2/current/lectures/coastalenv/coastal.html)

Why do People Live in the Coastal Zone?

Economic Opportunities

Communication

Recreation

Favorable Climate

Transportation

What do People do in the Coastal Zone?

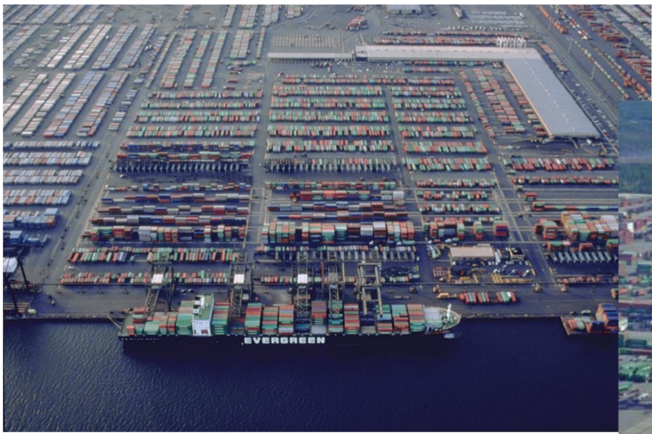
Recreation and Tourism

(Source: http://www.weddings-in-keywest.com/2-scuba-divers.jpg)

Coastal states together earn 85% tourist revenues in many countries

What do People do in the Coastal Zone?

Trade & Commerce



(Source: http://www.aapa-ports.org/industryinfo/gallery.htm)

What do People do in the Coastal Zone?

Oil and Gas Production

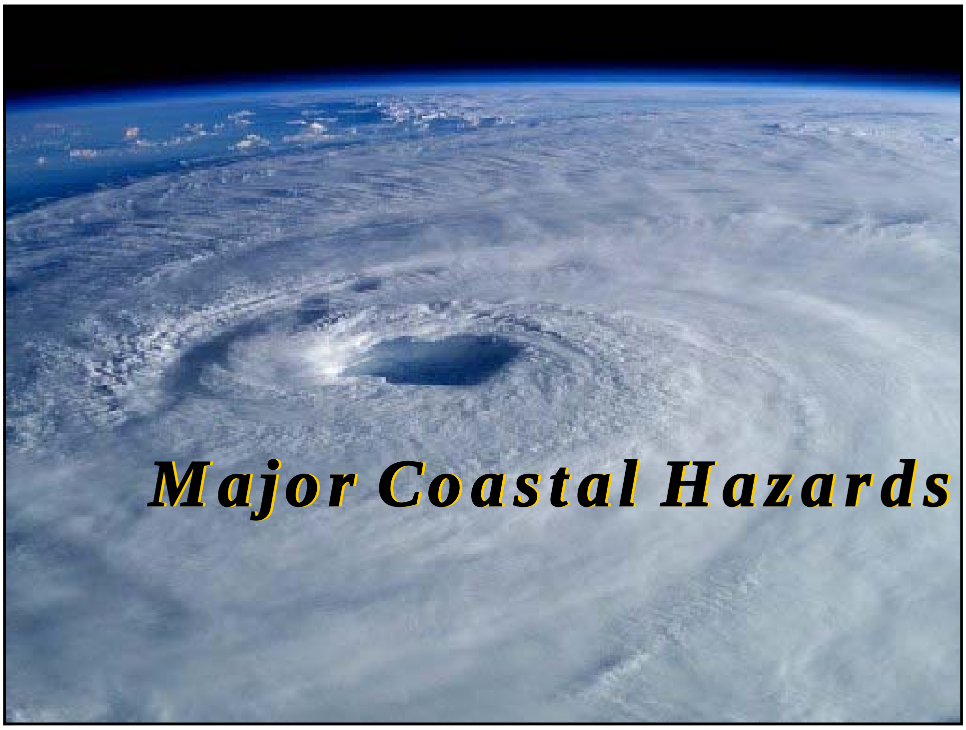
(Source: www.rfdbase.com/login/index.cfm)

What do People do in the Coastal Zone?

Fisheries & Aquaculture

Aquaculture represents a large source of seafood consumption globally

(Source:http://webinstituteforteachers.org/2000/teams/downeast/letters/Cutler.html)



Disaster versus Hazard

- Hazards pose a threat to a community
- Disasters cause destruction
- Understanding Hazards and taking preventive measures form the basis of Disaster Management

Classification of Disasters

Natural
Man-made &
Human-induced

- Disasters occur in varied forms
  - Some are predictable in advance
  - Some are annual or seasonal
  - Some are sudden and unpredictable
- Factors leading to a Disaster
  - Meteorological, Geological, Ecological or Environmental, Technological....

Natural Disasters

- Floods
- Earthquakes
- Cyclones
- Droughts
- Landslides, Pest Attacks, Forest Fires, Avalanches etc

Time duration of Natural Disasters

- Earthquakes – Seconds/minutes
- Cyclones – Days
- Floods – Days
- Droughts – Months

Disasters in India can be categorised into four types

- Group I (SI = 10) - Floods & Earthquakes
- Group II (8<SI<10) - Cyclones, Drought, Crop pests and diseases
- Group III (6<SI<8) - Forest fires, Epidemics, Thunderstorm, Hailstorm Lightning, Tornado, Landslides etc.
- Group IV (SI<6) - Dust Storms, Heat & Cold Waves

Severity Indices (SI) for Disasters in India

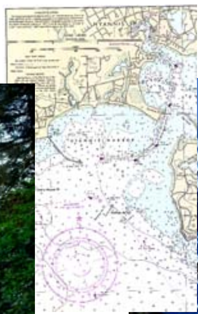
- About 3% of the country's area and 7% of the population are in such high vulnerable zones
- Andhra Pradesh, Maharashtra, Rajasthan and West Bengal are most severely affected

What is a Coastal Hazard?

Coastal Hazards can be defined as natural hazards that occur within the coastal zone.

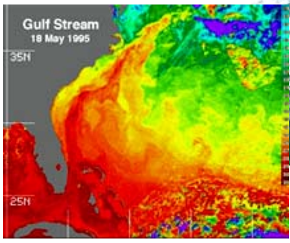
The following are major coastal hazards

- Hurricanes
- Coastal Erosion
- Tsunami
- Flooding



(Courtesy: http://www.library.yale.edu/MapColl/hyannis.htm)

(Courtesy: www.electrofin.com)



(Courtesy: www.missouri.edu/~geoscmbu/ ocean2003.html)

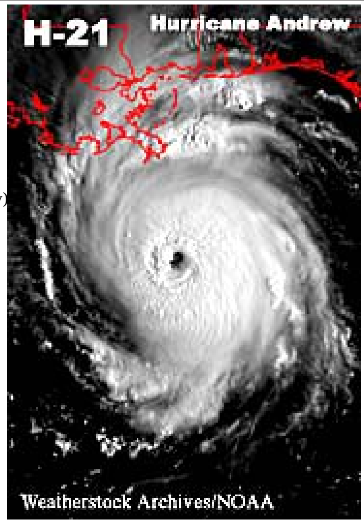
Hurricane

(Courtesy: http://www.mthurricane.com/hurricanes.htm)

(Courtesy: NOAA Photo Library)

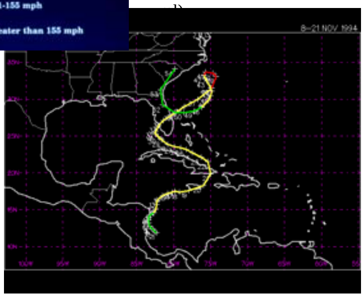
Saffir/Simpson Hurricane Scale

Category	Definition
ONE	Winds 74-95 mph
TWO	Winds 96-110 mph
THREE	Winds 111-130 mph
FOUR	Winds 131-155 mph
FIVE	Winds greater than 155 mph



(Courtesy:http://www.weatherstock.com/hurricanecat-science2.html)

(Courtesy: http://hpccsun.unl.edu/nebraska/Gtrack.ht



Hurricanes can take very variable tracks

Floods

There are two types of floods

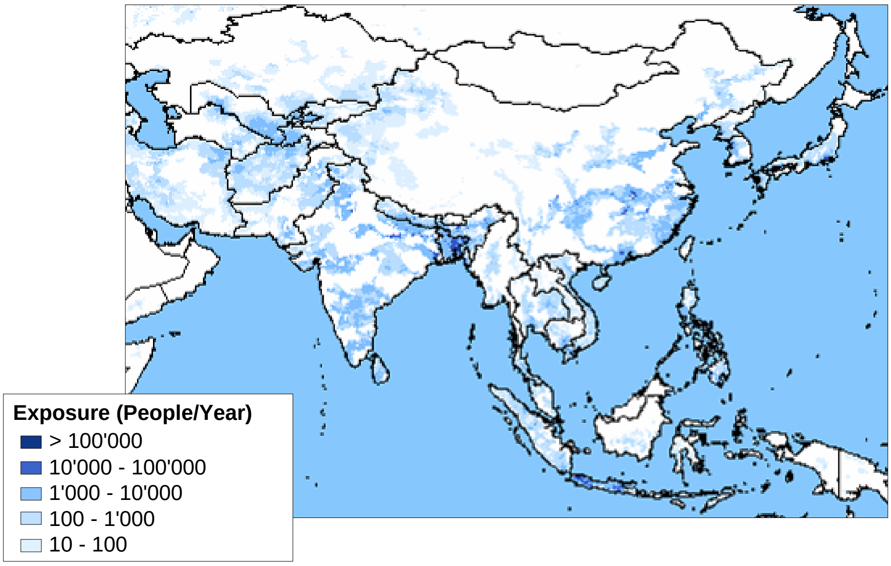
- Flash Floods
- Riverine Floods

(Courtesy: www.utahweather.org)

(Courtesy: http://www.sci.muni.cz/botany/gallery/lf109.jpg)

Riverine floods are common in low lying, sandy coastal areas, whereas flash floods are more common along rocky coasts

Flood Vulnerability in Asia



Flooding in Asia

- The year 2000 saw the worst flooding in 60 years for Vietnams' Mekong Delta region, 40 years for Cambodia, 35 years for Laos, and in a century for western Bangladesh and West Bengal, India.
- Year 2007 August Floods in India, Nepal and Bangladesh caused significant economic losses
- Recent events in 2007 show major threat is from flash floods which is evident from Nepal, Bhutan, Thailand, Philippines

Top Two Worst Disasters in Asia 2004

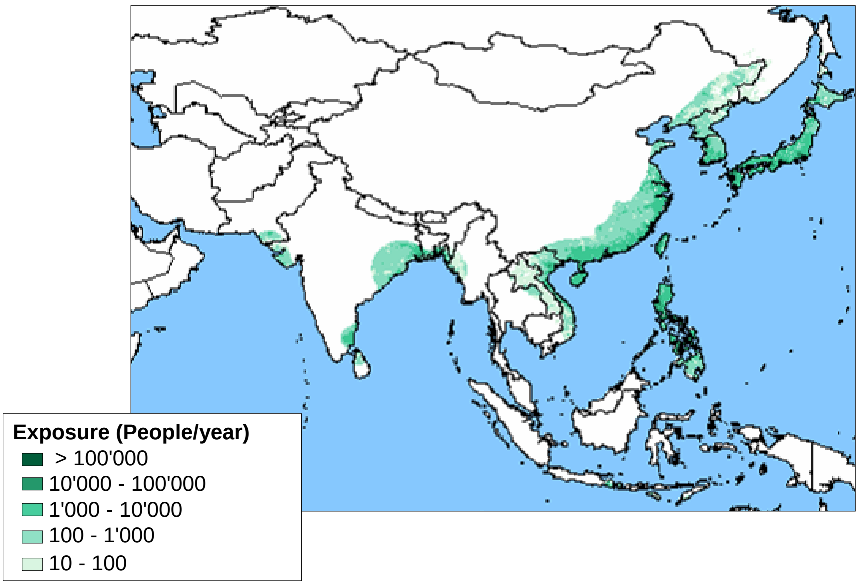
- Typhoon Nanmadol, Philippines (November) winds of 220 km/hr - at least 412 deaths
- Indian Ocean Tsunami and EQ (December) - Affecting: Indonesia, Sri Lanka, India, Bangladesh, Malaysia, Thailand, Maldives - death toll at least 212,000

Top Two Worst Disasters in Asia in 2006

The 2 deadliest disasters of 2006 were both in Asia

- Indonesian EQ (May) killing 5,778
- Typhoon Durian (Philippines, Dec) killing 1399

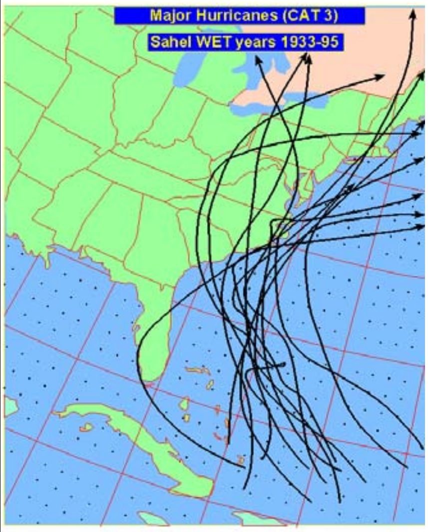
Cyclones/Typhoon Exposure in Asia

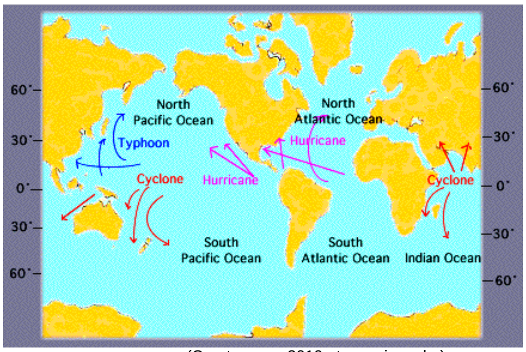


Cyclones/Typhoons in Asia

- There were 95 major storms in SE Asia and the Pacific regions between 1980-2000
- Since 1970, cyclones have killed an estimated 1.5 million in Bangladesh
- The October 1999 storm surge in Orissa, India, affected 15 million people, killed 9,500 people, destroyed 3 million homes, and left seven million people homeless
- Recent major events were in Karachci Pakistan in 2007, Vietnam and Philippines in 2006

Distribution of Hurricanes





(Courtesy: ww2010.atmos.uiuc.edu)

- Hurricanes can take many different tracks, but are limited to the Western Hemisphere
- Cyclones and typhoons are found elsewhere in the world.

Coastal Erosion

1890

1970

1920

1990

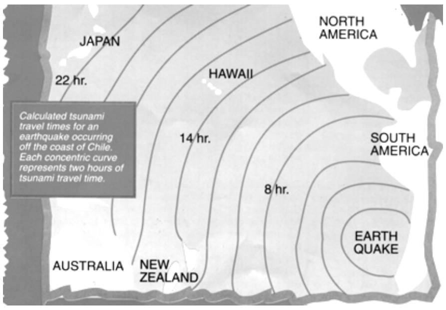
(Black-and-white photographs courtesy of Pacific Studios, Newport, Oregon.
Color photographs taken by Parke D. Snavely, Jr. of the USGS.)

Distribution of Coastal Erosion

- Coastal Erosion is very localized
- Some sections of sandy beaches will erode, while close by another section will accrete sand

Tsunami

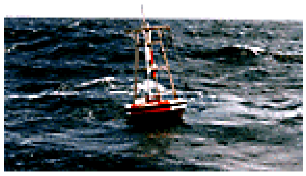
Tsunamis can be triggered by earthquakes, volcanoes or landslides



(Courtesy: National Weather Service)

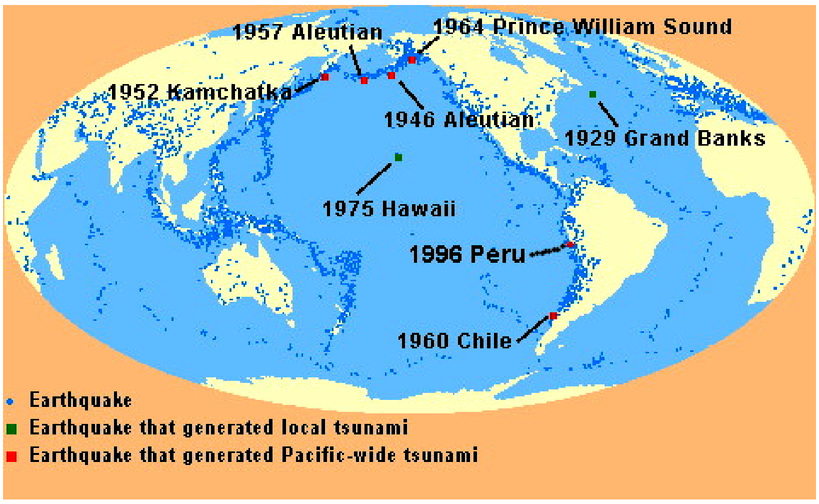
(Courtesy: users.belgacom.net)

Monitoring takes place on buoys



(Courtesy: FEMA)

Distribution of Tsunamis

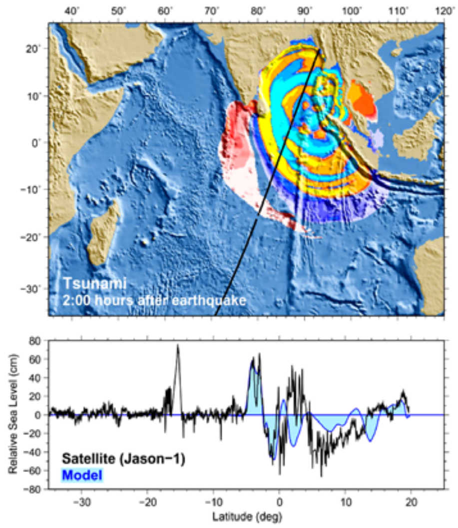


(Courtesy: http://www.geophys.washington.edu/tsunami/general/historic/historic.html)

A map of large tsunamis of recent history that were generated by earthquakes

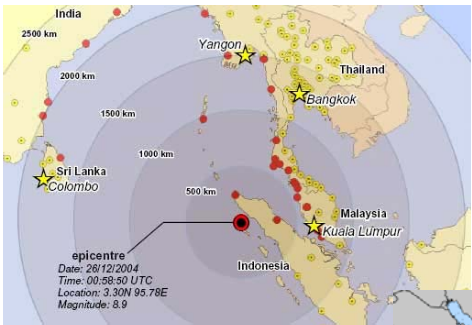
The Natural Hazard – How it Happened

The tsunami of December 26, 2004 is believed to have been caused by a 9.0-9.3 magnitude earthquake, have a wave height of up to 10 meters, and inundated land up to 2 kilometers from the shoreline in some areas.



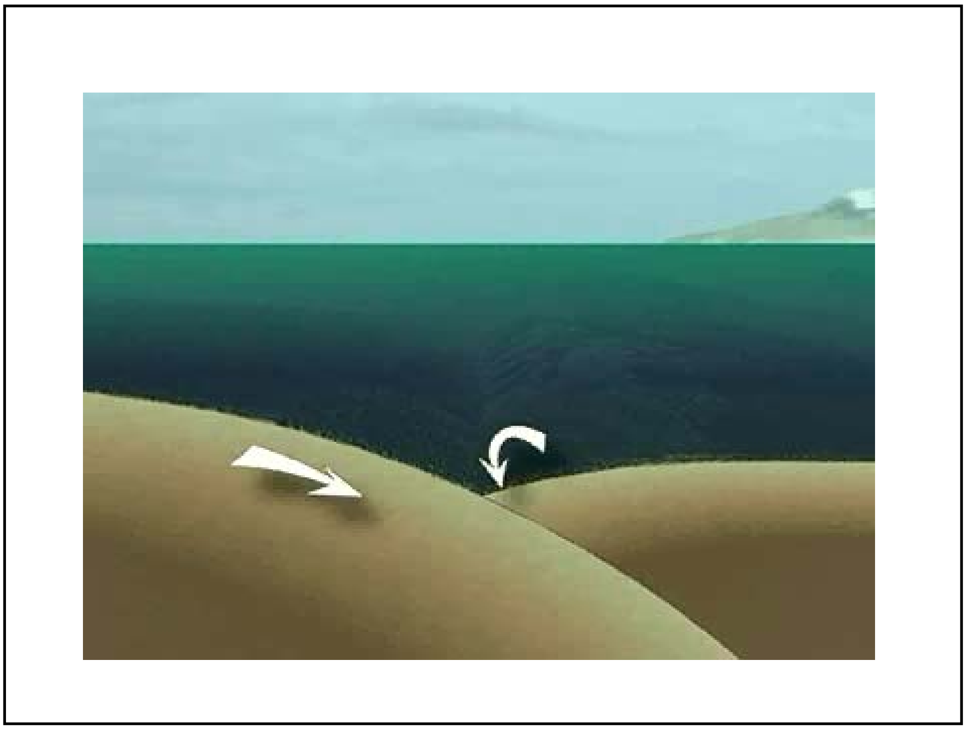
(Source: NOAA)

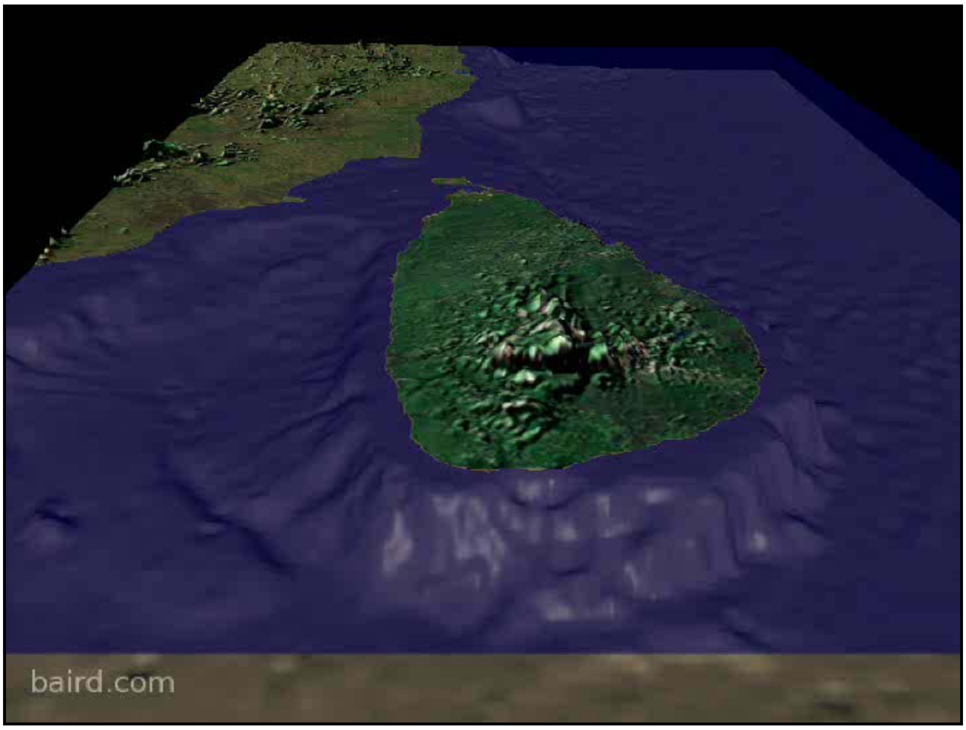
The Disaster – Where it Happened



(Source: www.reliefweb.int)

The tsunami struck a number of countries and took from 15 minutes to seven hours to reach the different coastlines.




baird.com

The Disaster – Human Loss

(Source: CNN; http://edition.cnn.com/SPECIALS/2004/tsunami.disaster/)

The Disaster – Property Loss

Before and after satellite images of the damage

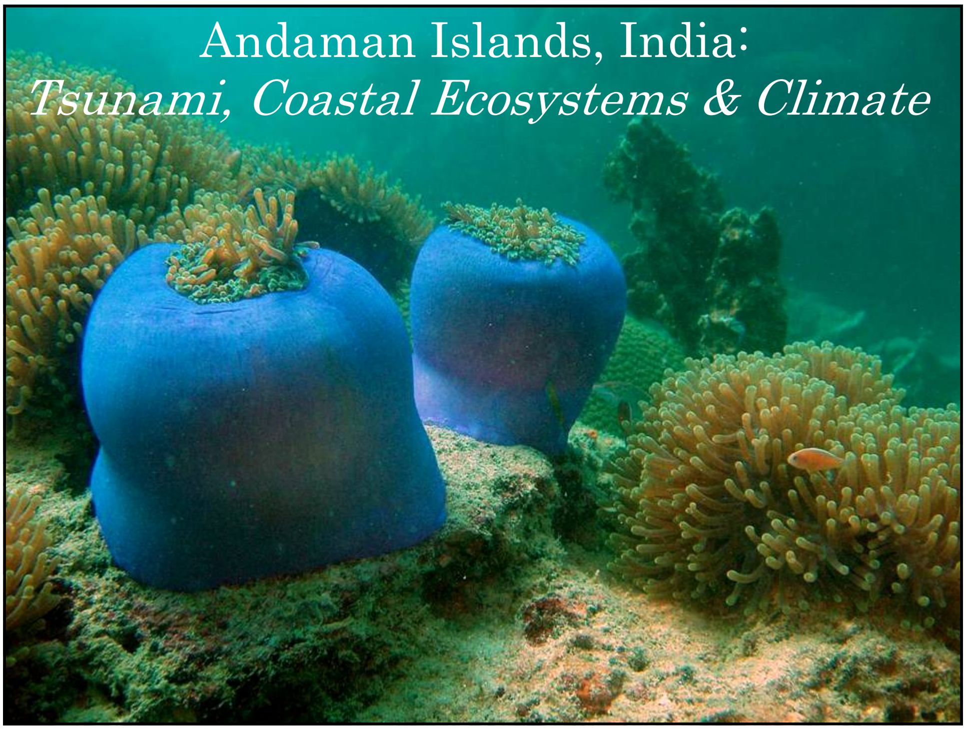
(Source: NASA Earth Observatory)

The Disaster – Economic Loss

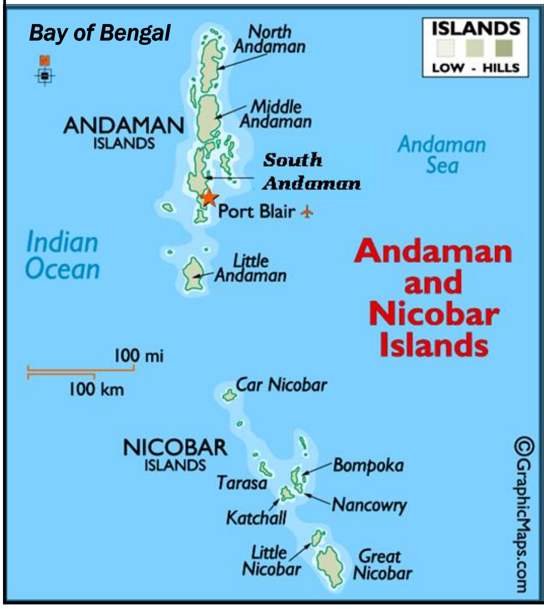
The impact on coastal fishing communities and fishermen has been devastating with high losses of income earners as well as boats and fishing gear

(Source:http://edition.cnn.com/SPECIALS/2004/tsunami.disaster/)

Andaman Islands, India:
Tsunami, Coastal Ecosystems & Climate

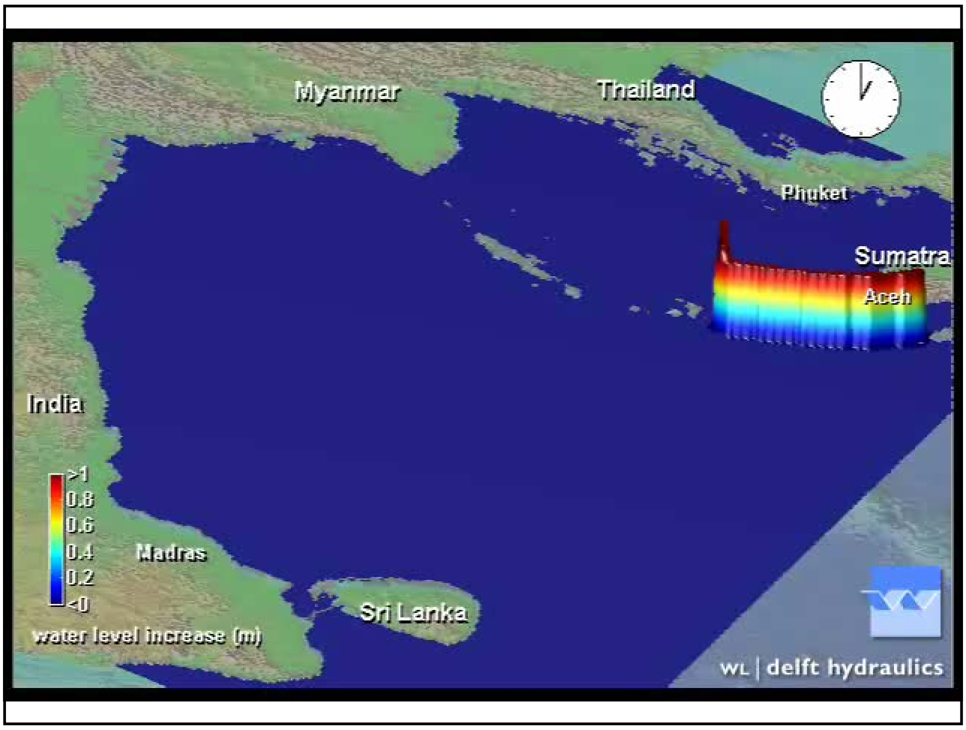


General features of the Andaman & Nicobar Group of Islands

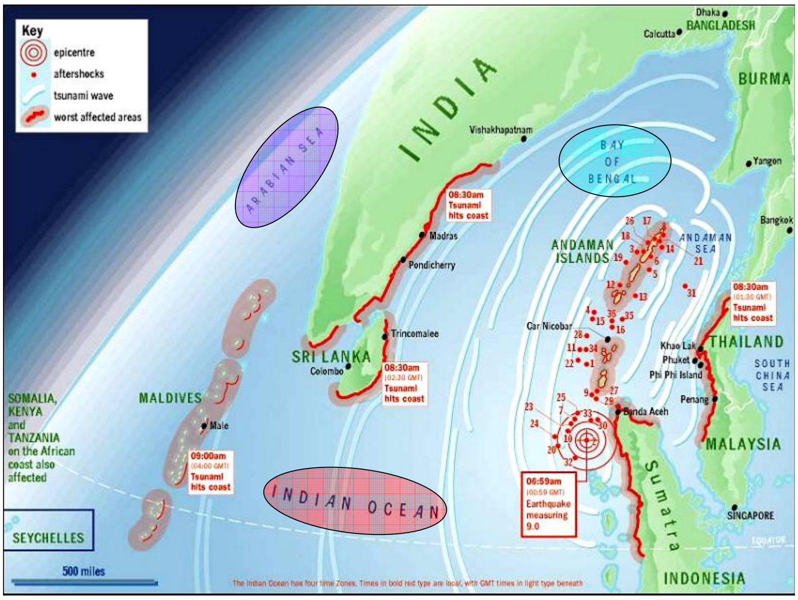


- Andaman Island group: 324 islands - 24 are inhabited
- Nicobar Island group: 28 islands - 12 are inhabited
- _Area_: Andaman group of islands 6408 km^2 and Nicobar group, 1841 km^2
- _Climate_: tropical monsoon climate with an annual average rainfall of 3180 mm
- _Flora & Fauna_: Evergreen, semi evergreen, moist deciduous and littoral forests including mangroves, coral reefs, sea grass and sea weeds
- The coast is very irregular and deeply indented by innumerable creeks, bays, inlets, estuaries and lagoons - rich biodiversity and high productivity
- BIODIVERSITY →


Indian Ocean Mega Tsunami
December 26, 2004


Myanmar
Thailand
Phuket
Sumatra
Aceh
India
>1
0.8
0.6
0.4
0.2
<0
Madras
Sri Lanka
water level increase (m)
WL | delft hydraulics

Basic Facts



History of Earthquakes in the Indian Ocean

Year	Date	Source/ Location	Magnitude	Maximum wave ht (m)
1762	02-Apr	Myanmar		
1797	10-11 Feb	West Sumatra	8.4	
1818	18-Mar	South Sumatra		
1819	16 Jun	Near Cutch	7.7	
1833	24-Nov	West Sumatra	8.7 - 9.2	
1843	5-6 Jan	North Sumatra	7.2	
1681	16-Feb	North Sumatra	8.3 - 8.5	7
1881	31-Dec	Nicobar Islands	7.9	1
1883	27-Aug	Sunda Strait (Krakatoa)		35
1907	04-Jan	West Sumatra	7.6	
1921	11-Sep	Java	7.5	
1941	26-Jun	Andaman Islands	7.7	
1945	27-Nov	Makran	8.1	15
1977	19-Aug	Java	8.3	30
1994	02-Jun	Java	7.6	13
2004	26-Dec	West Sumatra-Andaman Islands	9.3	48

Details of Coastline Affected

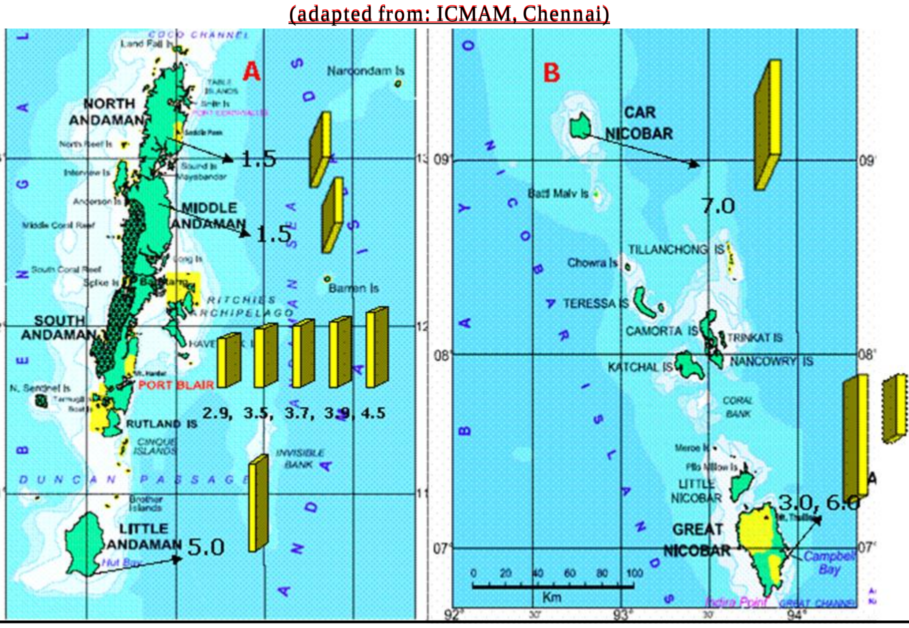
Details	Tamil Nadu	A&N Islands	Pondicherry	Kerala	Andhra Pradesh	Total
Coastal length affected in km	1000	Almost entire	25	250	985	2260
Penetration of water into mainland in km	1-1.5	1.5 – 7.0	0.3-3.0	1-2	0.5-2.0	
Average height of tidal wave in meters	7-10	>15	10	3-5	5	
Number of villages affected	376	30 Islands	33	187	301	927
Cropped Area (hectares)	10245	NR	506	NR	790	11827
Boats damaged	45920	NR	6678	10065	1362	64025

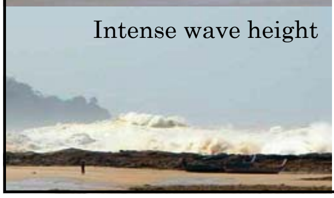
<u>*Note*</u>: The Tsunamis have caused extensive damage in the Nicobar Islands, which will require more or less rebuilding/ reconstruction

NR: Not Recorded

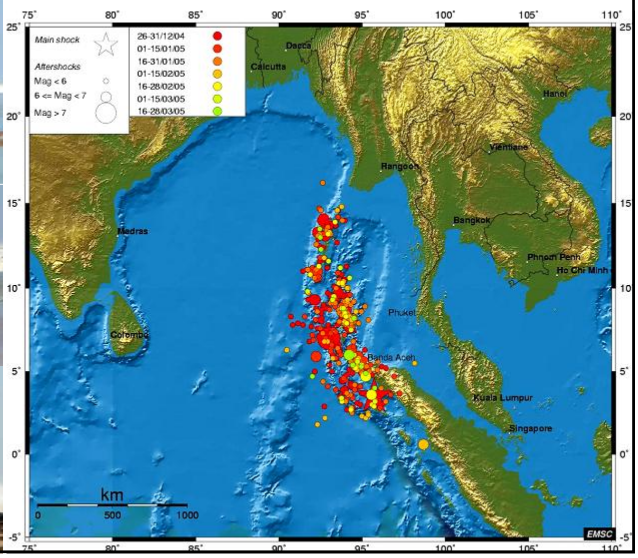
Maximum Wave Runup Level (m) in the Andaman and Nicobar Islands during Tsunami

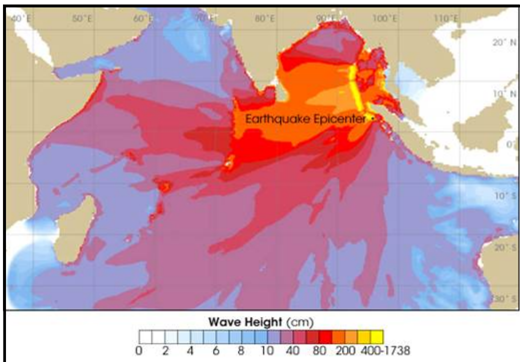
(adapted from: ICMAM, Chennai)





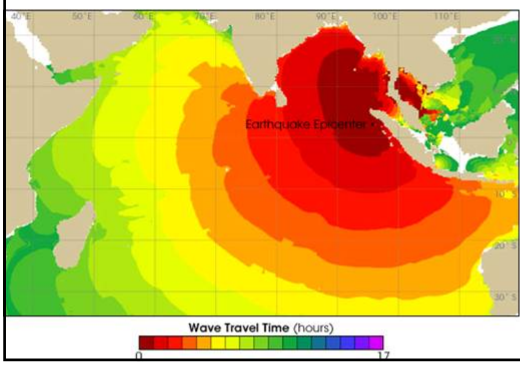
Sequence of events during tsunami and aftershocks





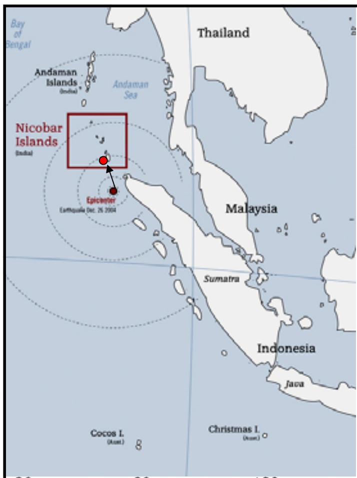
NOAA Tsunami Wave Similations

wave height (cm)

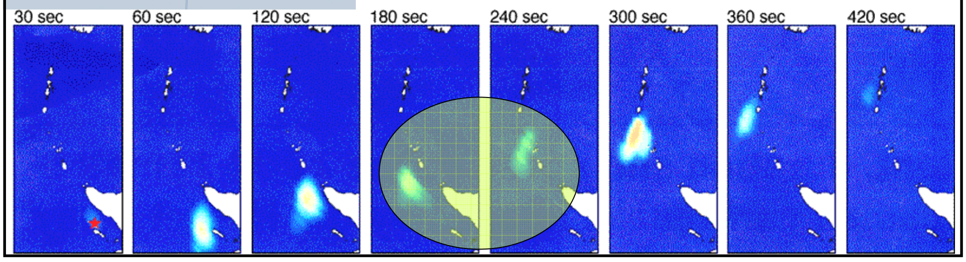


tsunami wave travel time

Travel time of tsunami waves

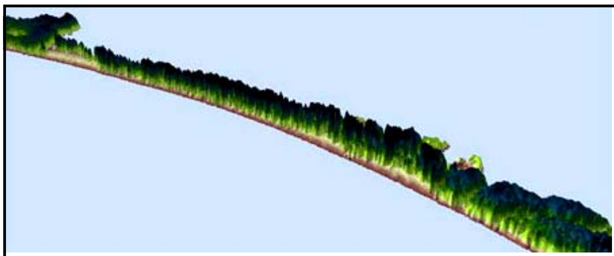


- Distance of Nicobar Islands from Epicenter: 124 km
- Time taken by the wave to reach Nicobar from Sumatra = 2 to 3 minutes (180 to 240 sec)
- Average speed of the wave: 600 - 800 km h^{-1} (open ocean)

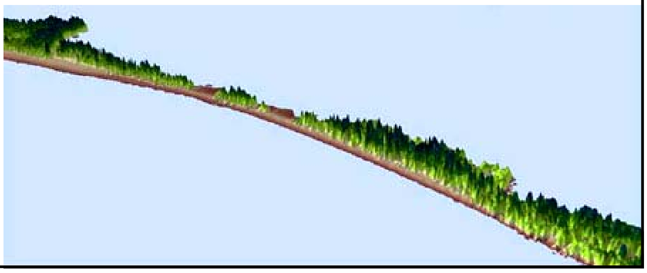


Current Scientific Investigations

- Physical disturbances/ changes
- Land emergence and submergence & Mapping
- Tsunami evidences/ proxies that are considered
  - Trenches
  - Coastal and wetland sediments
  - Coral reefs
- Mangrove Sediments
- Corals as proxies for climate and tsunami (??)

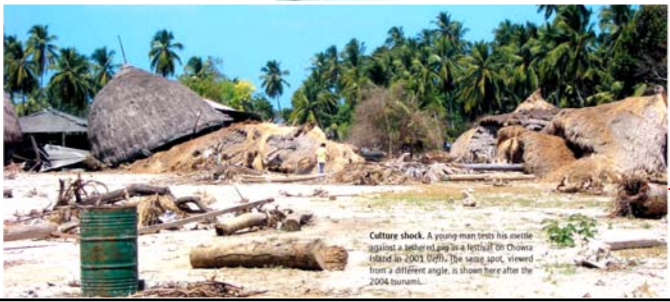


Physical Changes to the Coast



Villages in Nicobar Destroyed

Before

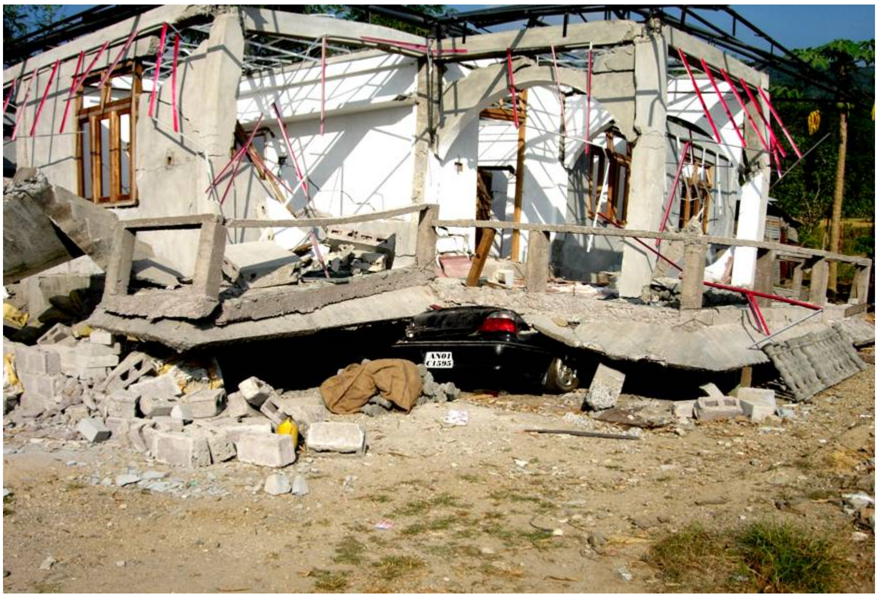


After

Ferry Terminals and Ports Destroyed

Ferry Terminal in Bamboo Flat near Port Blair

Buildings Collapsed due to Earthquake

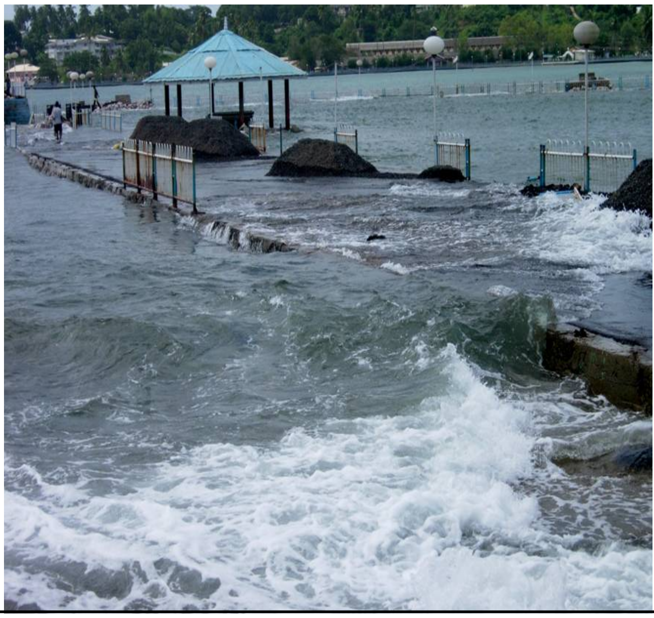


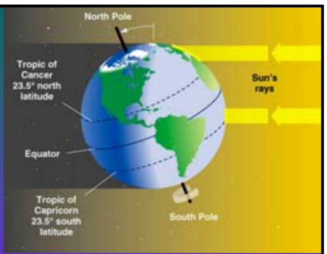
Wave Height during Tsunami

Access Roads Cut off

Destruction of several Fishing Boats, Harbors & Bridges

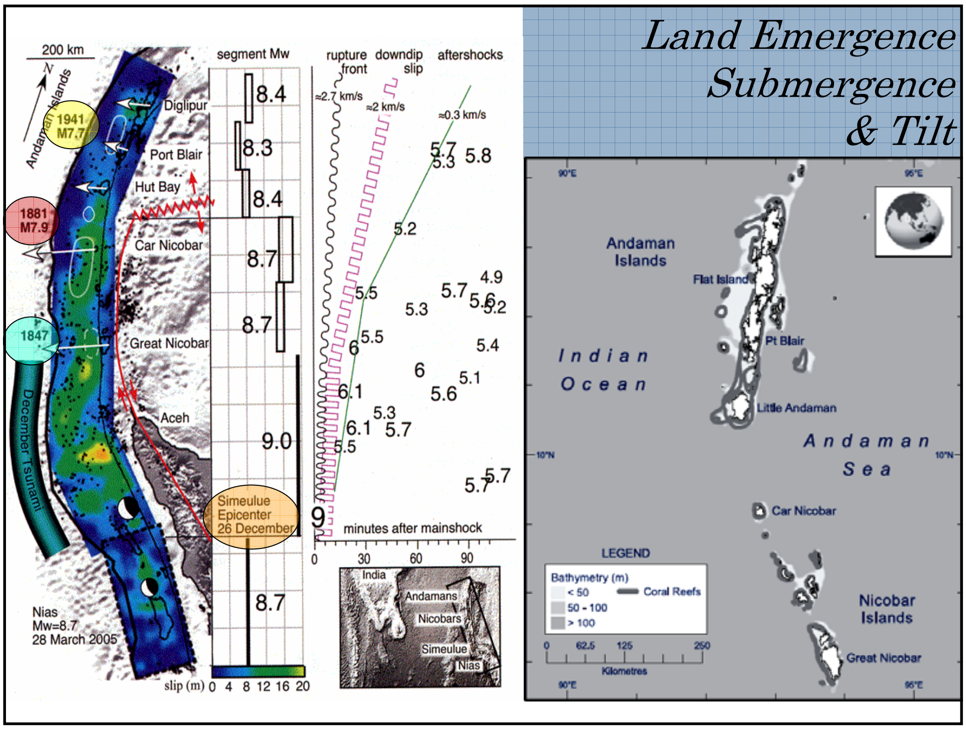
Continuous inundation of water into Cities (Port Blair, South Andaman) during high tide: June 2005



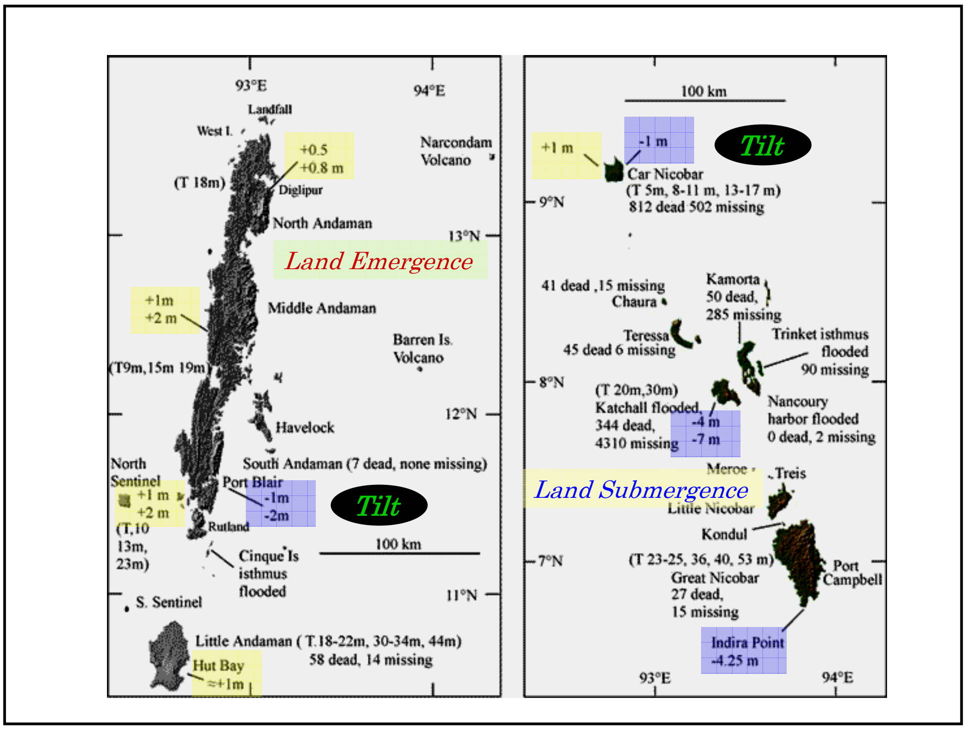


Andaman Islands

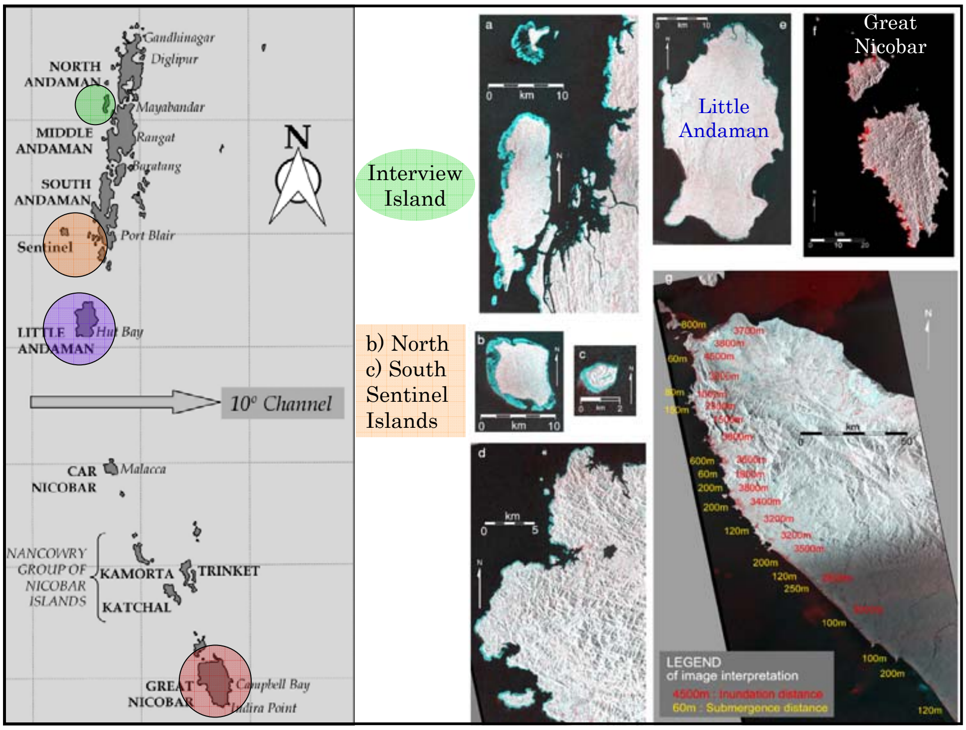
Titled??



Land Emergence
Submergence
& Tilt
200 km
N
Andaman Islands
1941 M7.7
1881 M7.9
1847
Diglipur
Port Blair
Hut Bay
Car Nicobar
Great Nicobar
Aceh
December Tsunami
Nias
Mw=8.7
28 March 2005
segment Mw
8.4
8.3
8.4
8.7
8.7
9.0
8.7
Simeulue
Epicenter
26 December
slip (m) 0 4 8 12 16 20
rupture front
downdip slip
aftershocks
≈2.7 km/s
≈2 km/s
≈0.3 km/s
minutes after mainshock
0 30 60 90
India
Andamans
Nicobars
Simeulue
Nias
Andaman Islands
Flat Island
Pt Blair
Little Andaman
Indian Ocean
Andaman Sea
Car Nicobar
Nicobar Islands
Great Nicobar
LEGEND
Bathymetry (m)
< 50
50 - 100
> 100
Coral Reefs
0 62.5 125 250
Kilometres



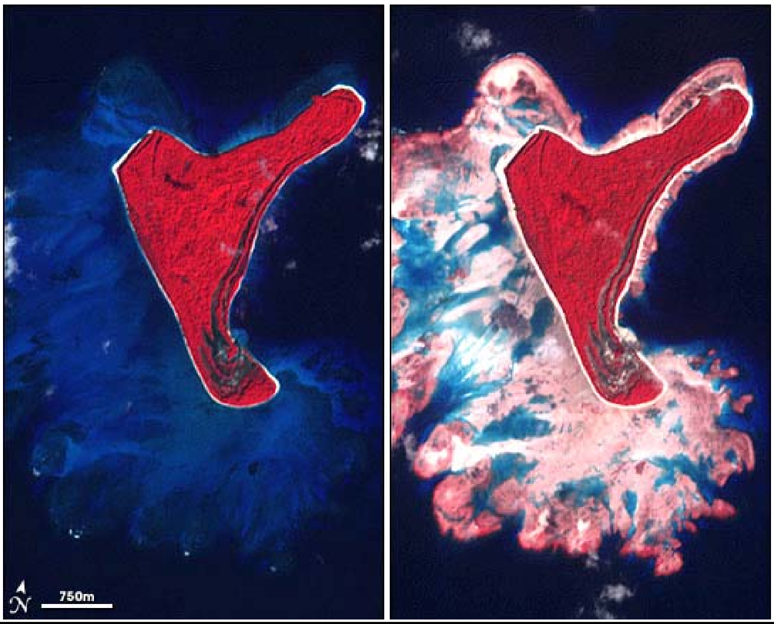
93°E
94°E
Landfall
West I.
+0.5
+0.8 m
Narcondam Volcano
(T 18m)
Diglipur
North Andaman
13°N
Land Emergence
+1m
+2 m
Middle Andaman
Barren Is. Volcano
(T9m,15m 19m)
Havelock
12°N
North Sentinel
+1 m
+2 m
(T,10 13m, 23m)
South Andaman (7 dead, none missing)
Port Blair
-1m
-2m
Tilt
Rutland
100 km
Cinque Is isthmus flooded
11°N
S. Sentinel
Little Andaman (T.18-22m, 30-34m, 44m)
58 dead, 14 missing
Hut Bay
≈+1m
100 km
+1 m
-1 m
Tilt
Car Nicobar
(T 5m, 8-11 m, 13-17 m)
812 dead 502 missing
9°N
41 dead ,15 missing
Chaura
Kamorta
50 dead,
285 missing
Teressa
45 dead 6 missing
Trinket isthmus flooded
90 missing
8°N
(T 20m,30m)
Katchall flooded,
344 dead,
4310 missing
-4 m
-7 m
Nancoury harbor flooded
0 dead, 2 missing
Meroe
Treis
Land Submergence
Little Nicobar
Kondul
7°N
(T 23-25, 36, 40, 53 m)
Great Nicobar
27 dead,
15 missing
Port Campbell
Indira Point
-4.25 m
93°E
94°E



Land Emergence/ Uplift

Luxuriant North Reef Coral Islands of North Andaman

a) December 2, 2004 b) February 4, 2005

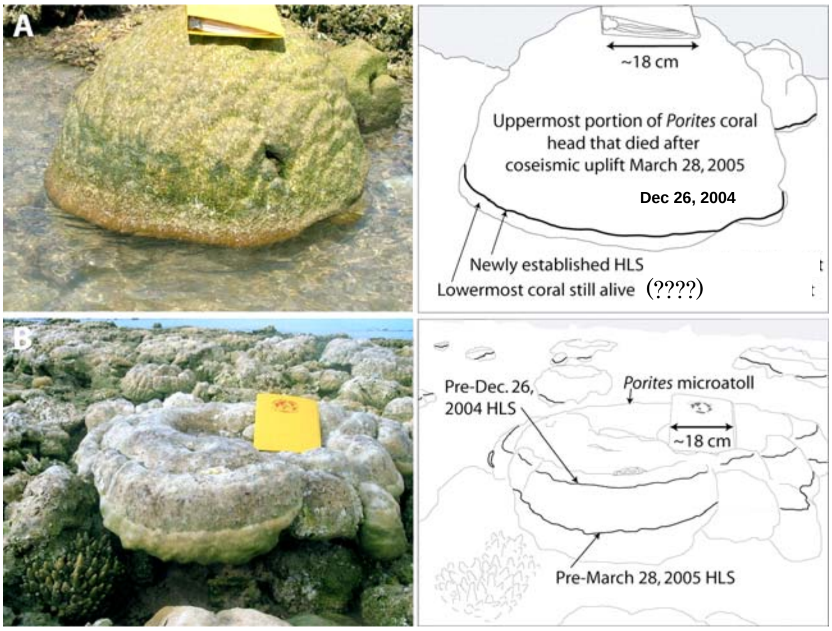


Coral Reef uplift in Flat Island Middle Andaman

Uplift of Flat Island along the western coast of Middle Andaman

Upthrow of Coral bed and rock starta in the same place

Coral Reefs of North Reef after Land Uplift



Coral Reefs after Land Uplift in the Andaman Seas

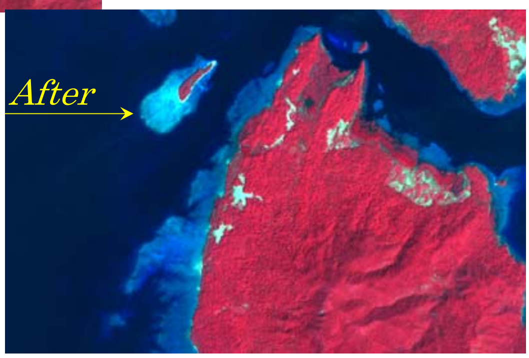

MANGROVE FORESTS IN NORTH ANDAMAN
Exposed mangrove roots at high tide in the Kalighat Creek, North Andaman


Previous High Tide Line
1 – 1.25 m
Present High Tide Line

Coral Reefs of Rutland Islands South Andaman

Brighter Blue: Healthy Reefs: light penetration high

Dull Blue: Reefs submerged and therefore decreased light penetration



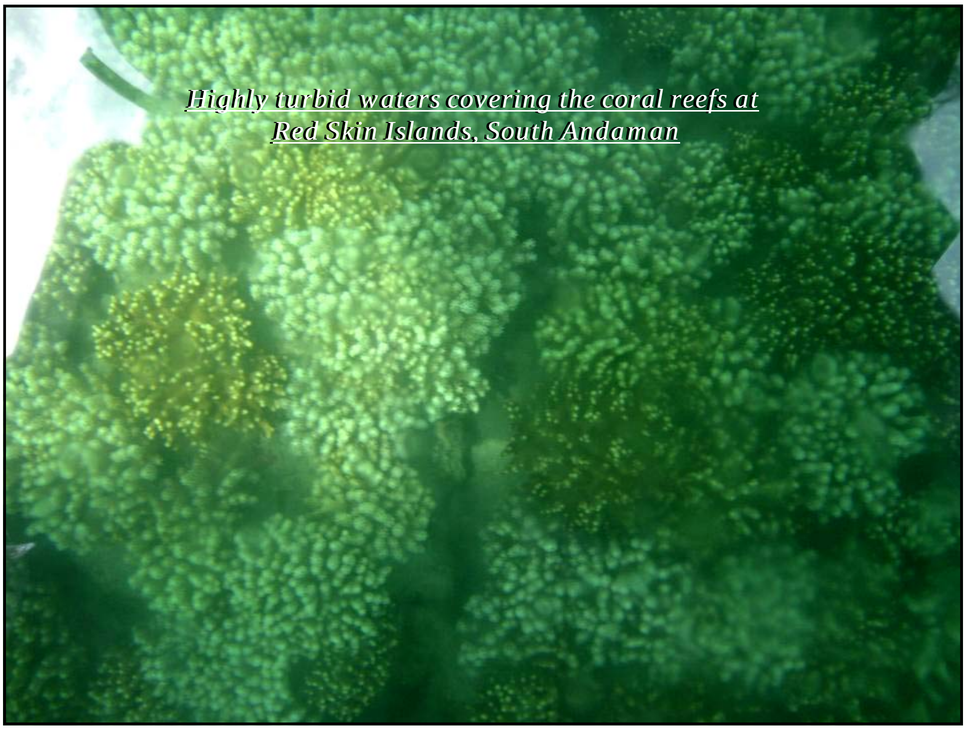
(a)

(b)

The lighthouse tower at Indira Point in Great Nicobar Island before the 26 December earthquake.

The tower is surrounded by lush green grass, residences are at the base and a sandy beach is in the foreground.

b Flooding of the lighthouse base because of land subsidence. The submergence of 3 m was caused by the 26 December earthquake



Mangroves ???

Complete degradation of mangroves due to submergence at Sipighat, South Andaman

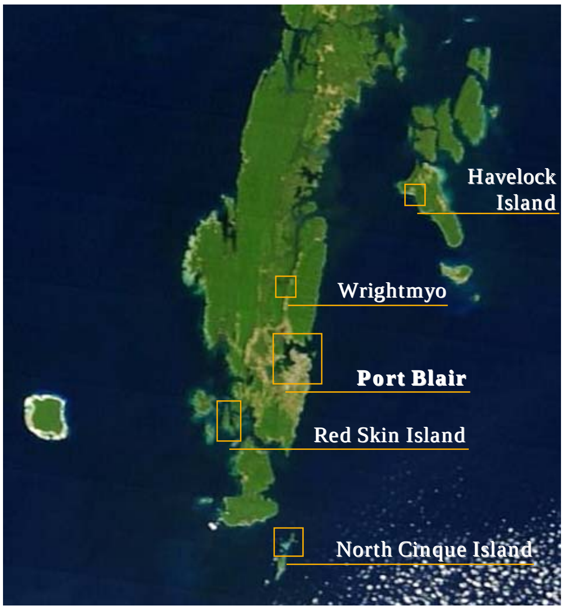
Sea water inundation in coconut plantations at South Andaman

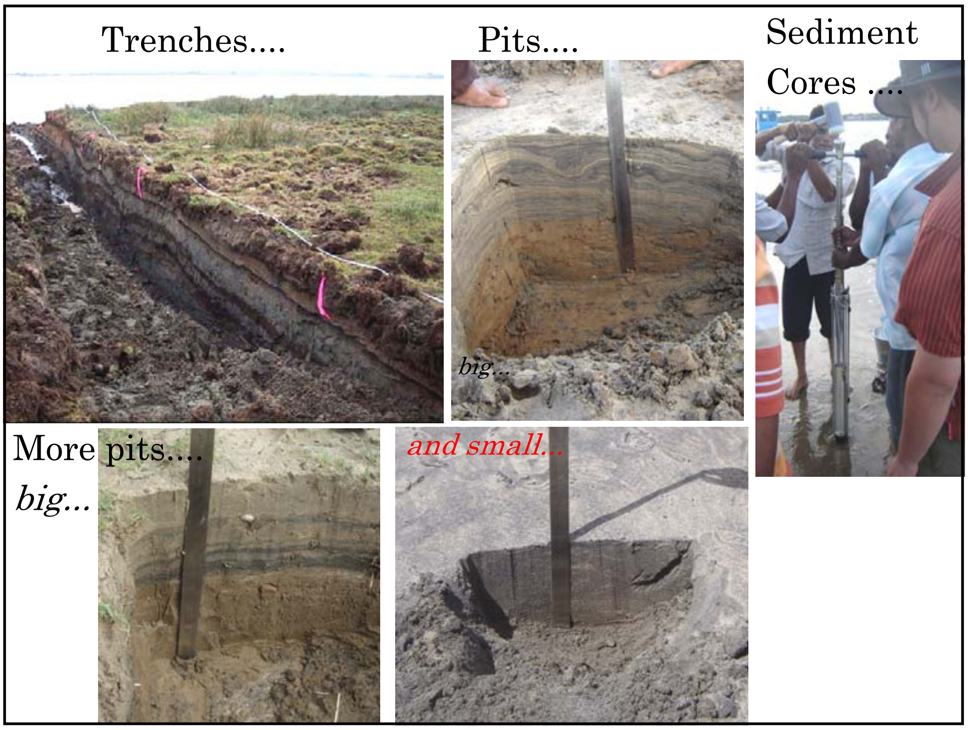
Uprooted Evergreen Forest Trees at North Cinque Island

Salinization of Agriculture Lands

Field Observations

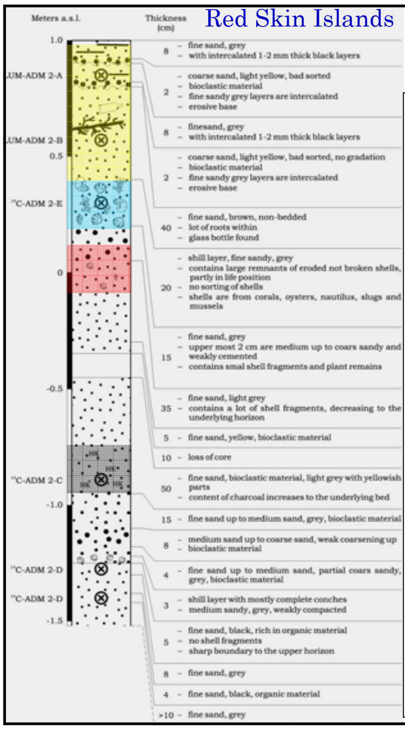
Sampling Sites…





Sampling Coastal Sediments...

- sampling for geochronological work
- focus on dating with the Optically Stimulated Luminescence method (OSL)
  - 7 samples for OSL
  - 11 samples for radiocarbon
  - 5 cores for Pb-210
- further analyses resulted from new question during the work
  - sieve analysis
  - Cs-137
  - x-ray fluoresence analyses
  - GIS-based geological map of the Andaman-Islands

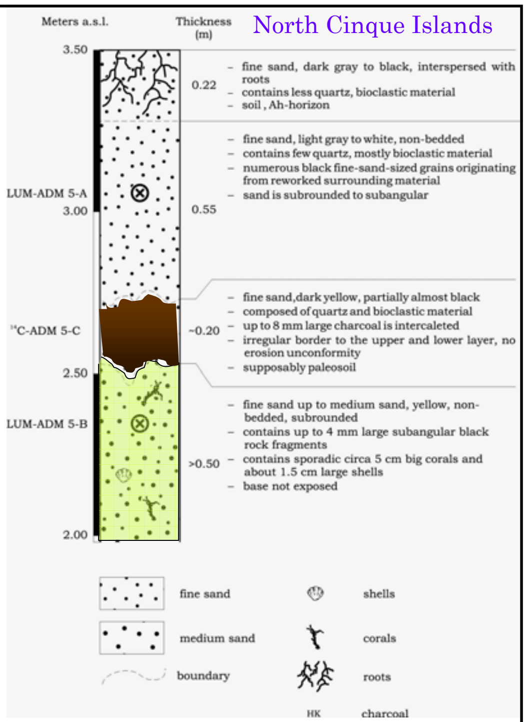


What does the OSL dating of these sediment sections tell us?

- The first 20 cm of the section – reliable OSL age could NOT be determined
- Activity of caesium-137 in this horizon is lower than the activity in the horizon below
- Therefore the first 20 cm should be older than the sediment below it
- This reversal of age results possibly from ***'re-deposition'*** during storm events
- Older sediment from the foreshore was deposited over younger material at the beach
- Sedimentological structure of the first 20 cm suggests these could be *two storm events*
- These deposits are NOT laid down by the tsunami of 2004
- At 40cm depth – glass bottle- supports age between 1940 and 1950
- Presence of eroded shells at 80cm depth – probably age between 190 and 200 years
- Charcoal at 2m depth and thick shell bank at 800 cm depth indicate that there must be times of fast subsidence interrupted by times with no movement
- AVERAGE RATE OF SUBSIDENCE: 1 mm yr^{-1}

Radiocarbon dating of these sediment sections

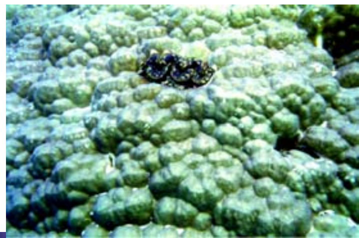
- Preliminary radiocarbon dating analysis indicates - deposits are definitely older than 60 years
- *Possibly deposits from former tsunami events*
- The first calculations of the radiocarbon ages indicate - horizon below the dark horizon could be deposited before the year 1530 A.D.
- Coarse grain size and bad sorting indicate deposit from a high energy event
- Fragments of corals of 5cm size probably confirms this
- *Could be a tsunami-laid deposit(!!)*
- Sediments are not laid down homogeneously by a tsunami - an effect called *"fining inland"*



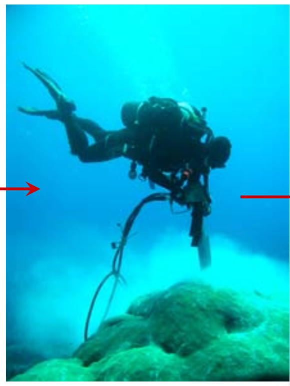
Sediment Section from
Wright Myo Mangroves, South Andaman

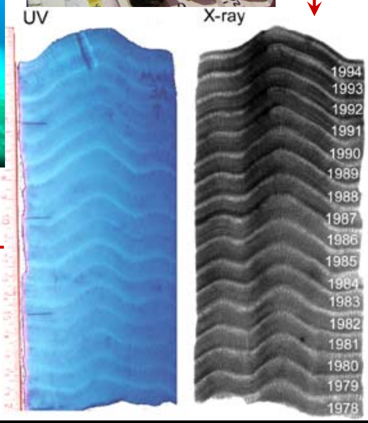
- Mangroves – largely unaffected - BUT -
- Tidal amplitude has become larger: from 2.0 to 4.0 m
- Sediment core section – shows interesting light layer at 20 cm depth
- Identified to be a PALEOTSUNAMI deposit
- More work is being done to confirm this!!!

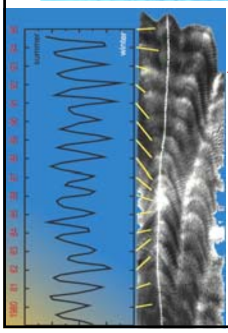
Sampling Corals....



Coral Sampling Protocol.....



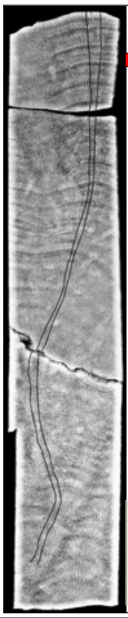


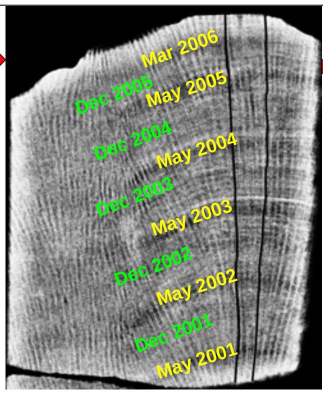


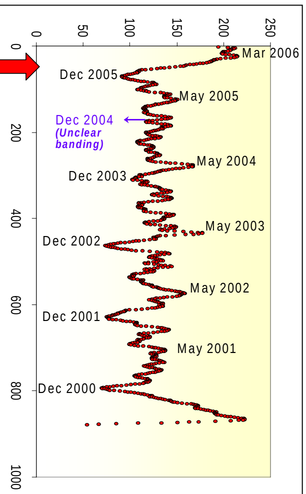
- Age determination
- Stable isotope ($\delta^{18}O$ and $\delta^{13}C$) and elemental (Sr/Ca and Mg/Ca) analysis of coral skeletal material
- Conduct growth rate analysis

What do the coral cores tell us??

Some results for the start...







December 2004:- Distinct dark banding is not observed like in other monsoon years

Peaks pointing right: Summer season (light penetration more; higher SST)

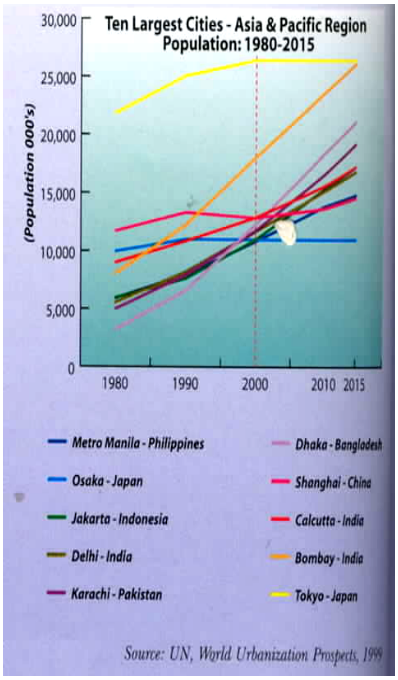
Peaks pointing left: Monsoon season (light penertation less; lower SST)

What more would we know...... ??

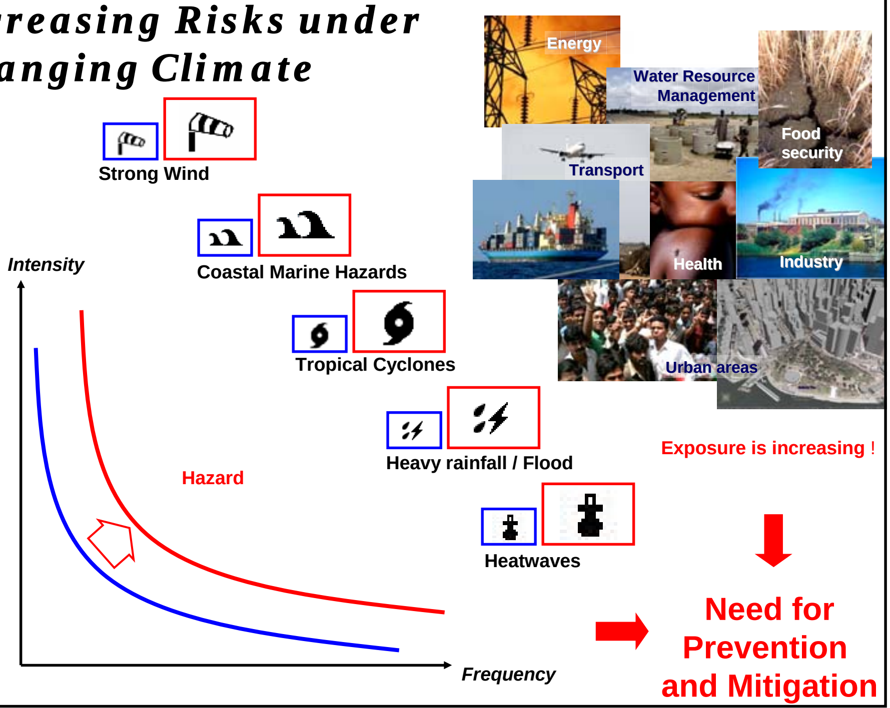
- Coral microatolls of Andaman Islands retain – stratigraphic and morphologic record of relative sea-level change
- This is because of a vertical tectonic deformation above the Sumatran subduction zone
- Seawater levels and their fluctuation produce measurable changes in coral morphology – limit upward growth of the corals
- **Annual rings – derived from seasonal variations in coral density – serve as an *internal chronometer* of coral growth**
- Microatolls act as natural long-term tide gauges – recording sea-level variations on time scales of decades (including El Niño events)
- We will examine the recent displacement history at the Sumatran subduction zone using living corals as a "coral tide gauge"
- Possible to determine uplift and submergence of land

Asian Cities at Risk

- 37% of Asia's population lived in cities by 2000; this will rise to 60% by 2025
- More than 50 cities in Asia with a population greater than 1,000,000 are at significant risk from an earthquake
- Rural to urban migration accounts for 64% of city growth in Asia
- Of the 10 largest Asian cities; 7 are prone to multi hazard risks and are awaiting a catastrophic event



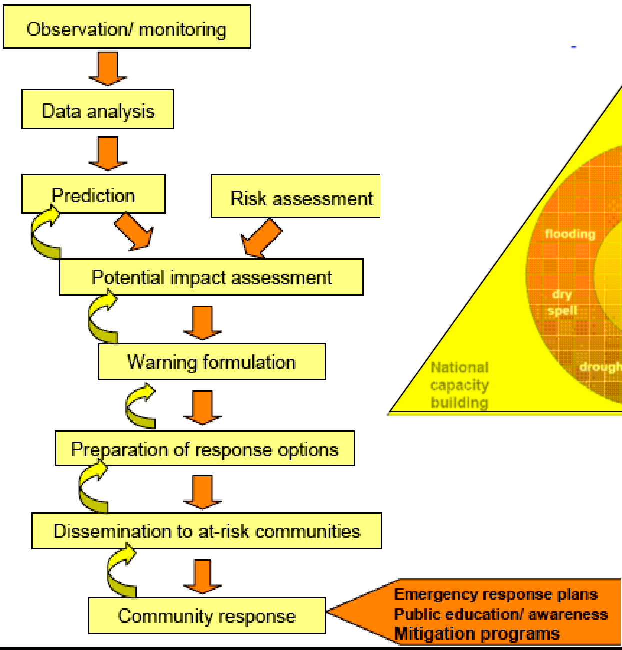
Increasing Risks under Changing Climate

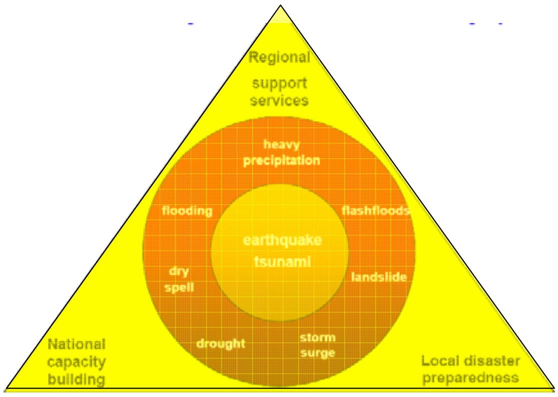


Hydro-meteorological Hazards Warning Systems:
PRIORITY ACTIVITIES

- Capacity building in early warning and risk reduction through training programmes
- Technology Transfer
- Regional Partnership for assessment of existing observational networks, identification of gaps and addressing these gaps

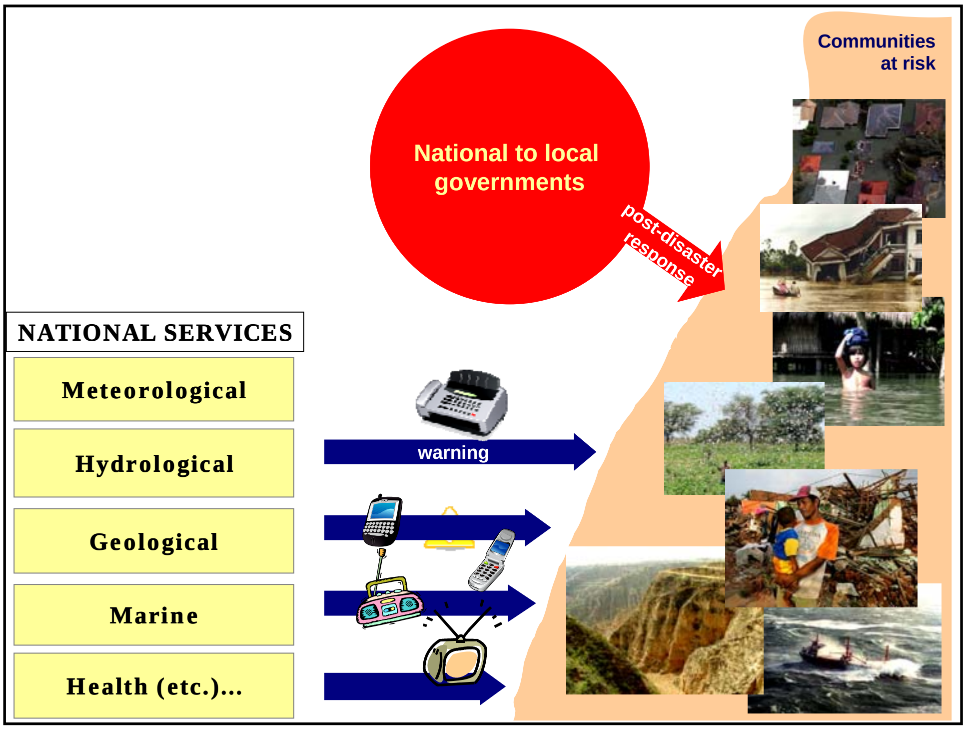
Gaps

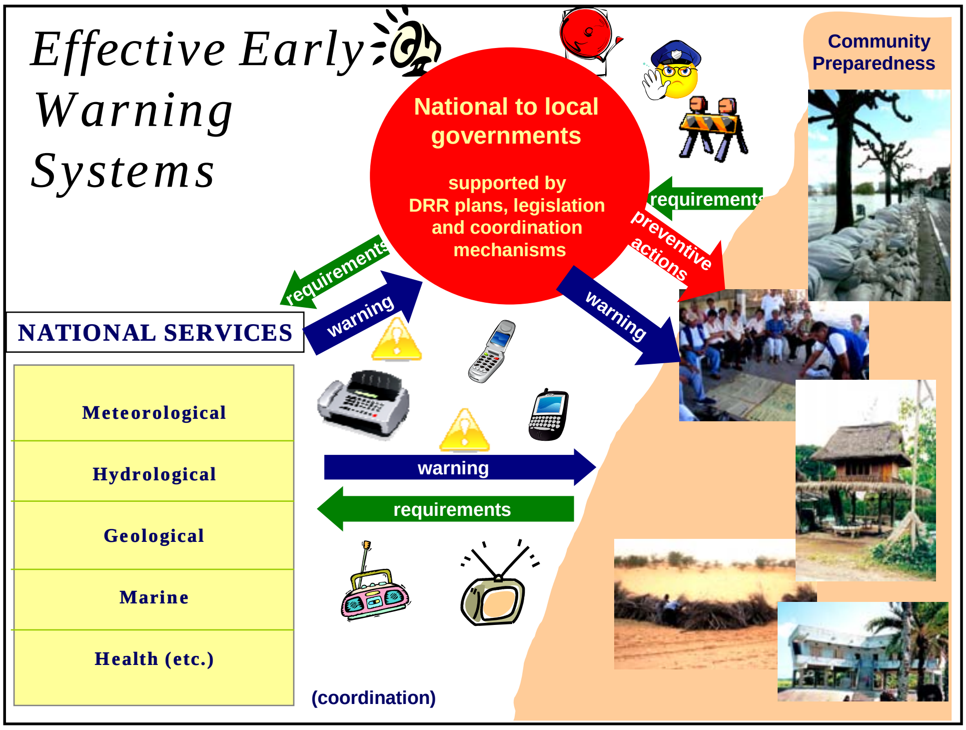


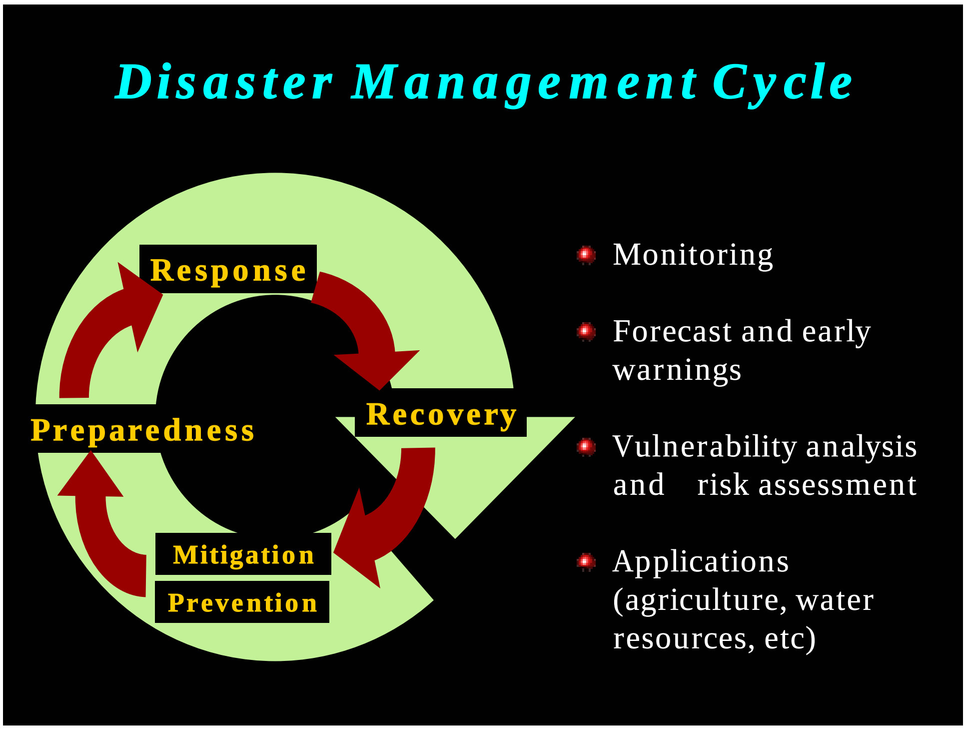


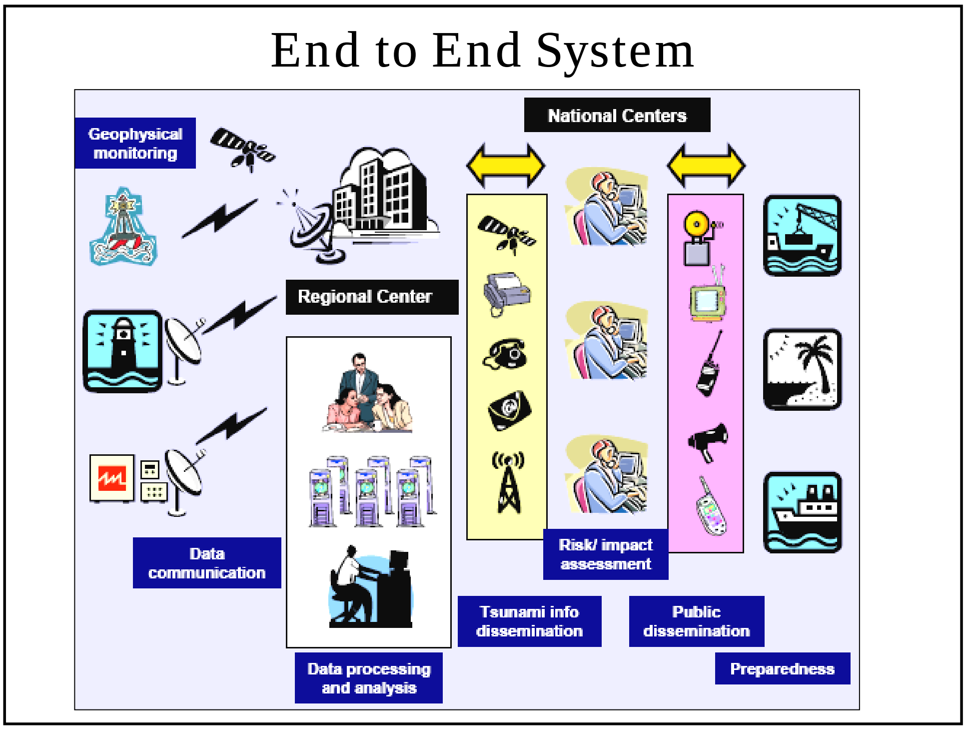
Early Warning Systems

National to local disaster risk reduction plans and legislation

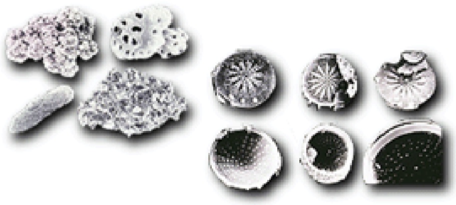

National to local governments
Communities at risk
post-disaster response
NATIONAL SERVICES
Meteorological
Hydrological
Geological
Marine
Health (etc.)...
warning


Effective Early Warning Systems
National to local governments
supported by DRR plans, legislation and coordination mechanisms
Community Preparedness
requirements
preventive actions
requirements
warning
warning
NATIONAL SERVICES
Meteorological
Hydrological
Geological
Marine
Health (etc.)
warning
requirements
(coordination)


Disaster Management Cycle
Response
Recovery
Preparedness
Mitigation
Prevention
Monitoring
Forecast and early warnings
Vulnerability analysis and risk assessment
Applications (agriculture, water resources, etc)


End to End System
National Centers
Geophysical monitoring
Regional Center
Data communication
Data processing and analysis
Risk/ impact assessment
Tsunami info dissemination
Public dissemination
Preparedness

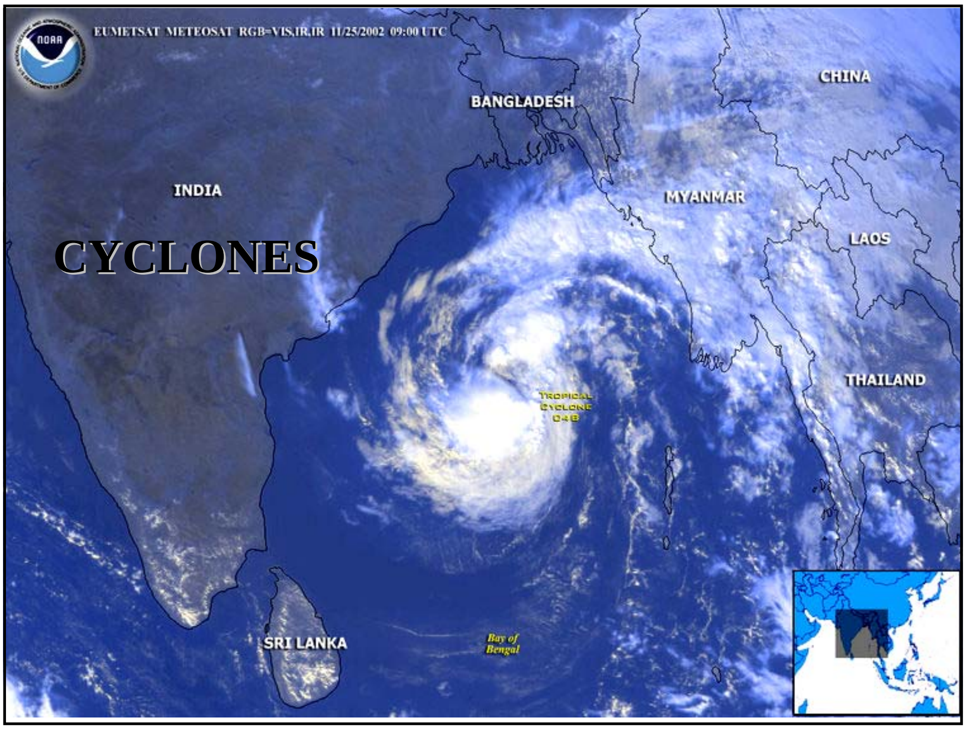
Summary Remarks



In Summary…

- Natural Hazards occur in the natural environment; they are a part of the world around us; the world we live in.
- Disasters occur only when a hazard intersects with human activity; with people, their property and possessions…
- Natural Hazards cannot be managed.
- Human activity can be managed.
- Mitigating the impacts of natural hazards involves managing human activity


Thank you for
your attention...



Cyclone forecasting

- Monitoring
  - Location
  - Intensity
- Prediction
  - Future intensity
  - Movement
  - Landfall

Type of Warnings

- Maritime interests
- Port warnings
- Four Stage warnings
  - Pre-Cyclone watch
  - Cyclone Alert
  - Cyclone Warning
  - Post Landfall outlook
- Warnings for designated officials
- Warnings for Aviation

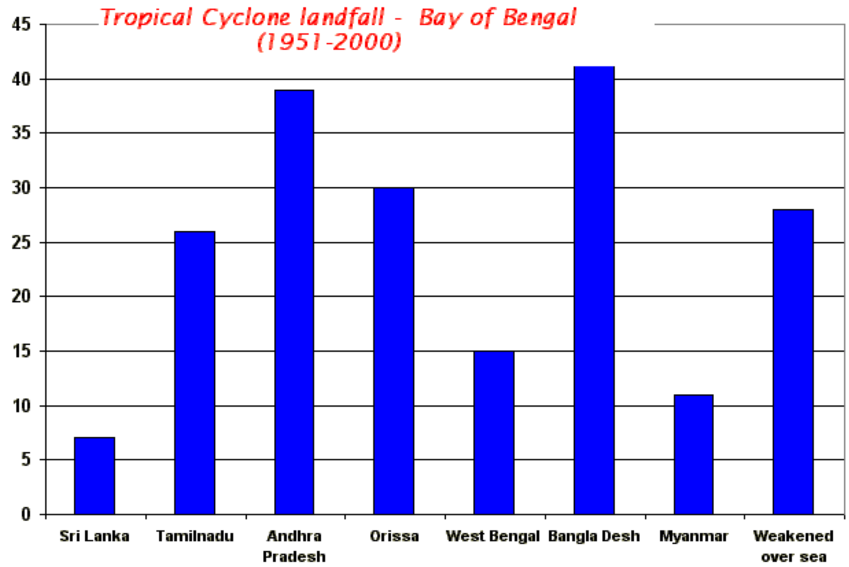
Dissemination of Cyclone Warnings

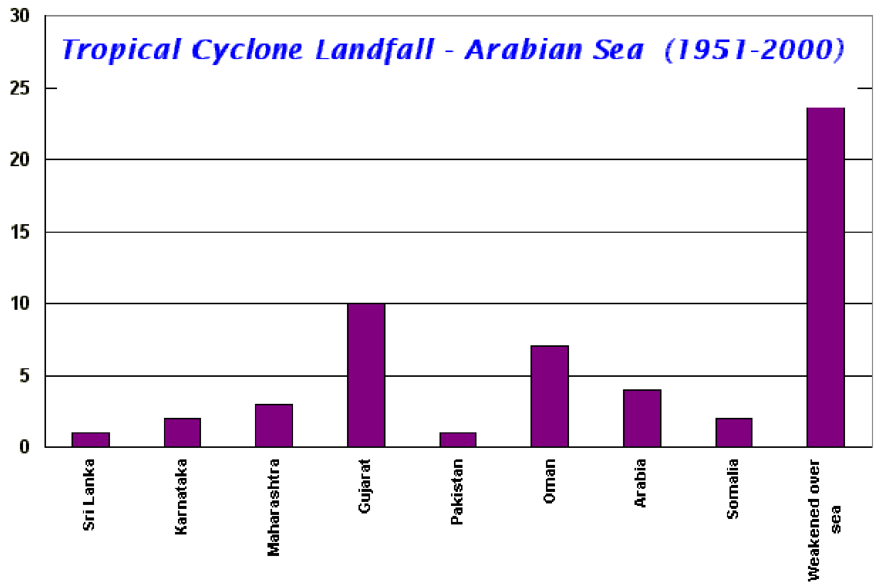
- Landline
- T/P
- Telex
- Telephone
- Telefax
- VSAT
- VHF/HFRT
- CWDS

- Police Wireless
- AFTN
- Internet (e-mail)
- Websites
- Radio/TV network

Tropical Cyclone - A Few Facts

- Tropical cyclones are macro-scale systems with meso-scale impact
- Probability of correct forecast decreases with increasing forecast validity period
- Mean forecast errors for validity periods of 12, 24, 48 and 72 hours are 104, 205, 415 and 633 km respectively





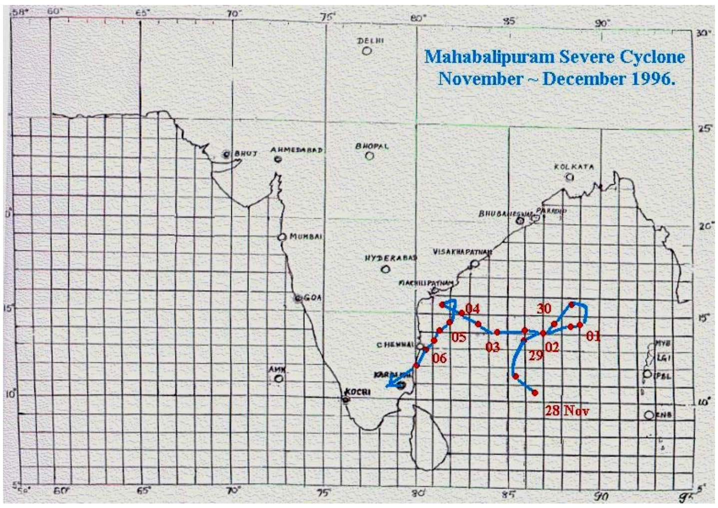
Effectiveness of Cyclone Warnings

- When decisions are delayed till the accuracy of prediction becomes high, only limited lead-time is available which may result in "under-warning" and possible chaos
- In case of low accuracy of landfall prediction, unnecessary large sector of the coastline have to be placed in full warning phase resulting in "over-warning"

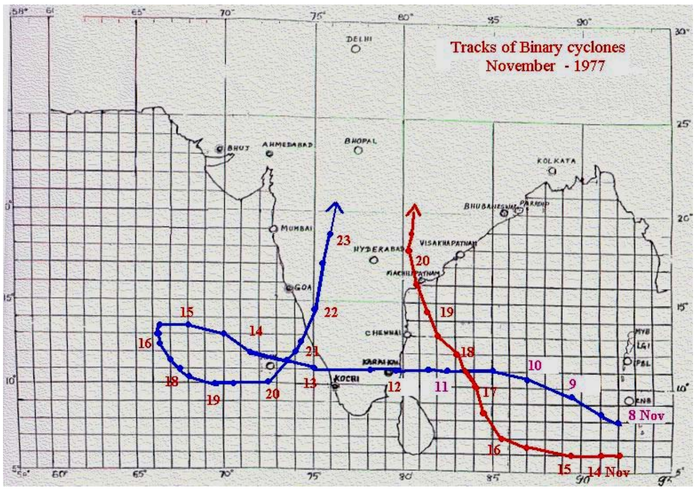
Expect the Unusual - It Is Normal

- Displaying changing trends in motion
- Rapid changes in intensity specially close to a populated coastline
- Remaining quasi-stationary close to landfall.
- Displaying erratic tracks such as looping, sudden acceleration/deceleration, interaction with other systems etc.

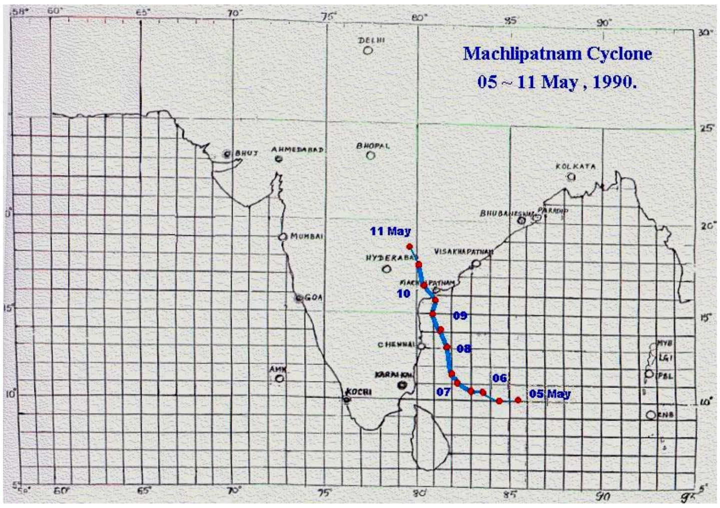
Double looping - Mahabalipuram Cyclone December , 1996



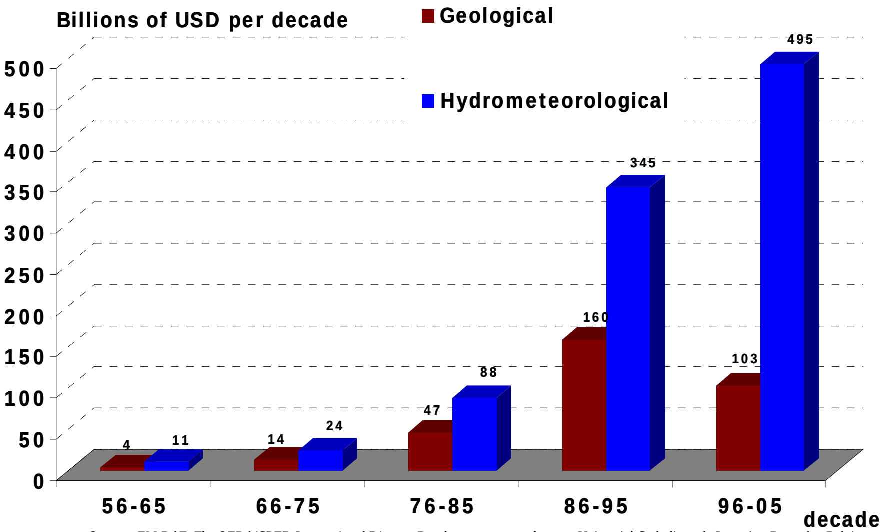
Interactive binary cyclones Nagapattinam & Chirala cyclones - November, 1977



Cyclone moving parallel to the coast
Machlipatnam cyclone - May ,1990

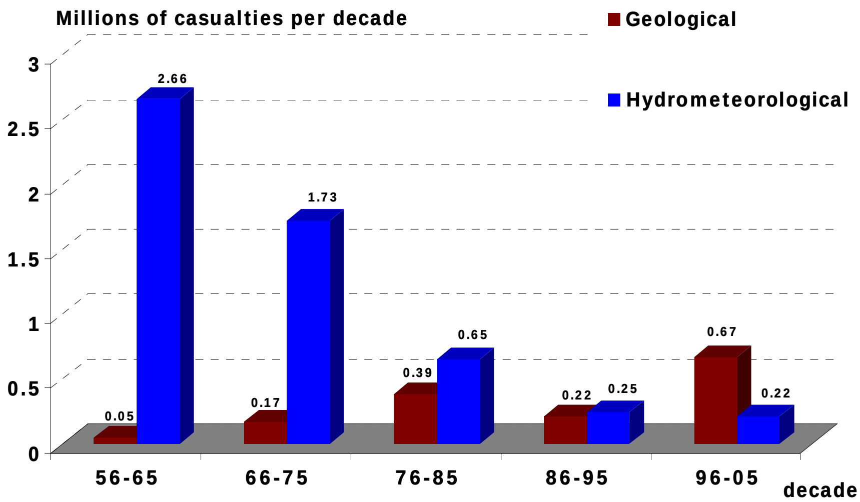


Economic Losses Related to Disasters are increasing



Source: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels - Belgium

While Casualties related to Hydro-Meteorological Disasters are Decreasing



Source: EM-DAT: The OFDA/CRED International Disaster Database - www.em-dat.net - Université Catholique de Louvain - Brussels - Belgium

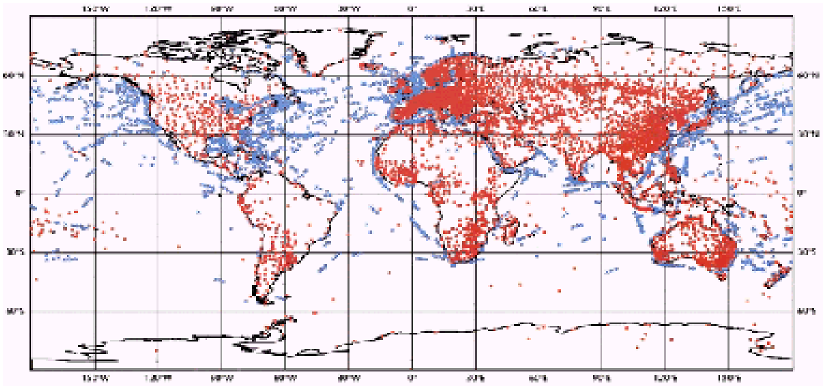
Making Cities Safer

- Promote household vulnerability reduction measures
- Build capacity of local government + emergency services
- Decentralization of resources + decision making
- Democratic means of DRR planning
- Build capacity of community/social groups
- Create institutional framework for action
- Enforce appropriate building codes + urban planning guidelines
- Hazard assessments - physical/social/economic
- Environmental management

Risk Identification

- Monitoring
- Early warnings for weather water or climate related disasters
- Adaptation measures
- Vulnerability assessment and Hazard analysis

Risk Identification: Monitoring (1)

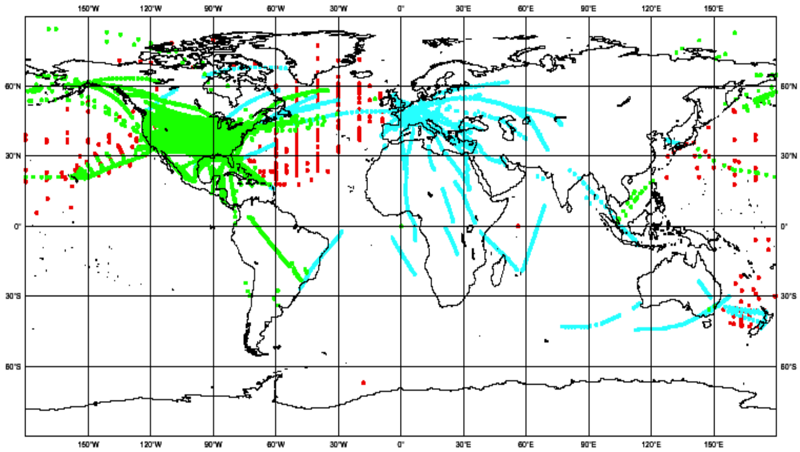


Typical daily coverage of surface observations made at meteorological stations (red) and from ships (blue)

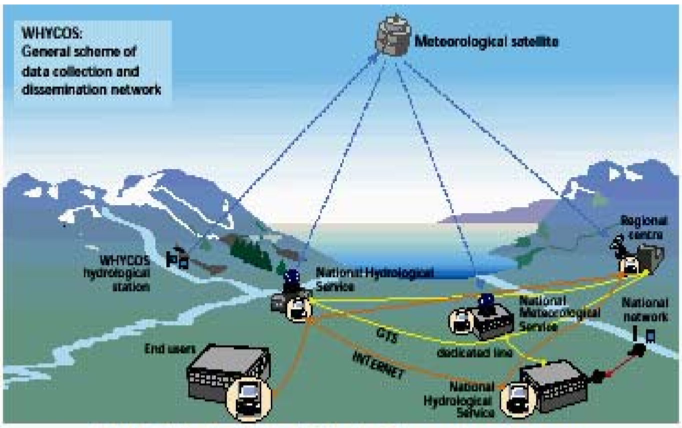
GOS includes 10 000 surface and 1 000 upper air stations; 700 buoys, weather radars, 7 300 ships and 3 000 aircraft.

Risk Identification: Monitoring (2)

ECMWF Data Coverage (All obs) - AIRCRAFT
06/JAN/2003; 00 UTC
Total number of obs = 37249



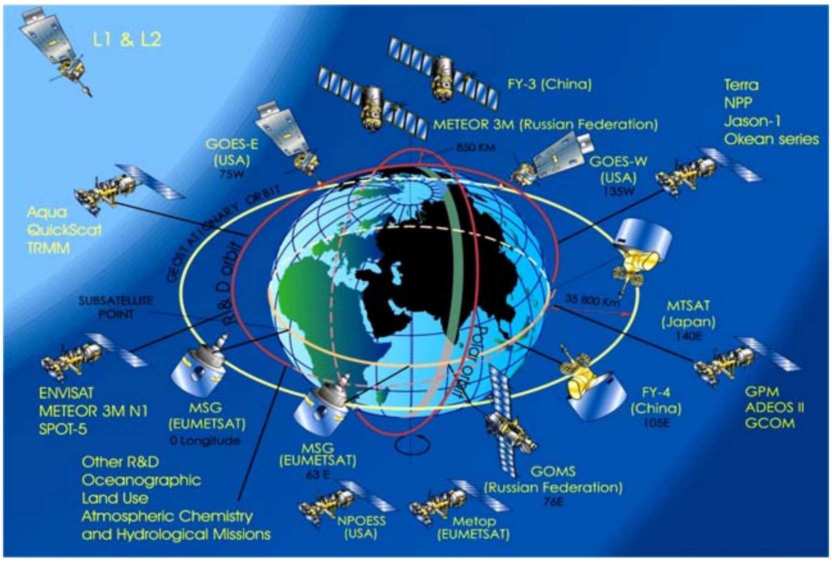
Risk Identification: Monitoring (3)



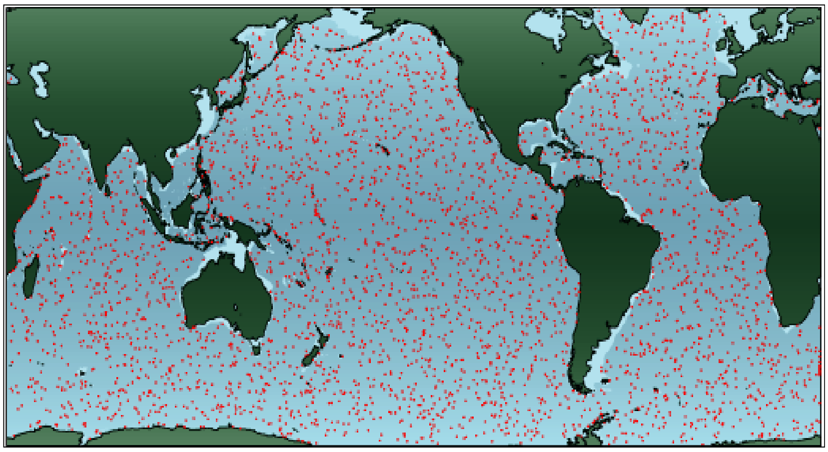
World Hydrological Cycle Observing System

- Hydrological data (river basin runoff, evaporation, ground water, etc.) may provide early warning signal of climate change.
- WHYCOS (MED-HYCOS, etc.) — increased exchange of hydrological data for climate studies.

Risk Identification: Monitoring (4)

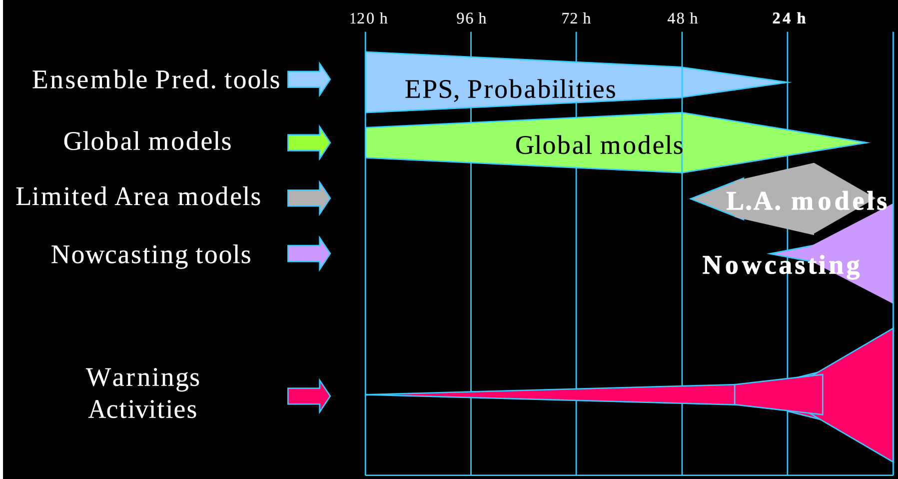


Risk Identification: monitoring (5)



900 Argo floats in operation by mid-2003
By 2005, some 3 000 floats are planned

Risk Identification: Early Warnings (1)



Time dependency of forecast methods used for the preparation and maintenance of warnings at DWD (From Thomas Shuman –DWD)

Risk Identification: Hazard analysis

- Improved hazard analysis and hazard mapping are needed to be extended to all countries as a tool for risk communication among policy makers and communities
- Hazard maps are essential to prepare evacuation efficiently and to allow authorities to adjust land use and city planning

Mitigation Defined

Hazard

....a possible source of danger

The American Heritage Dictionary 1985

Mitigation Defined

Natural Hazard

an extreme natural event that poses a threat to people, their property and possessions.....

Mitigation Defined

Disaster

An occurrence causing widespread destruction and distress

The American Heritage Dictionary
1985

Mitigation Defined

The Four Phases of Emergency Management:

1. Mitigation
2. Preparedness
3. Response
4. Recovery

Mitigation Defined

Approaches to Mitigation

1. Structural and Non-Structural Mitigation
2. Existing Development and Potential Development

Mitigation Defined

Types of Mitigation Strategies

- Prevention
- Property Protection
- Natural Resource Protection
- Structural Projects
- Public Information

Mitigation Defined

Examples of Mitigation Activities:

- Purchase of warning systems
- Stockpiling of food, water and supplies
- Evacuation of an area
- Zoning Ordinances
- Storm Water Management System