Water-related Disasters in Asia-Oceanic Region

Kaoru TAKARA
Disaster Prevention Research Institute
Kyoto University

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Today's Talk

- To show hydro-meteorological characteristics of Asia-Oceanic region in terms of water-related disasters
- To consider how to cope with the disasters
- Giving some ideas for collaboration of Water Cycle group with Climate Change and Disaster groupes

A natural disaster strikes when people lose their memory of the previous one.

By Dr. Torahiko Terada
(1878-1935)

天災は忘れた頃にやってくる

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We know the phenomena.

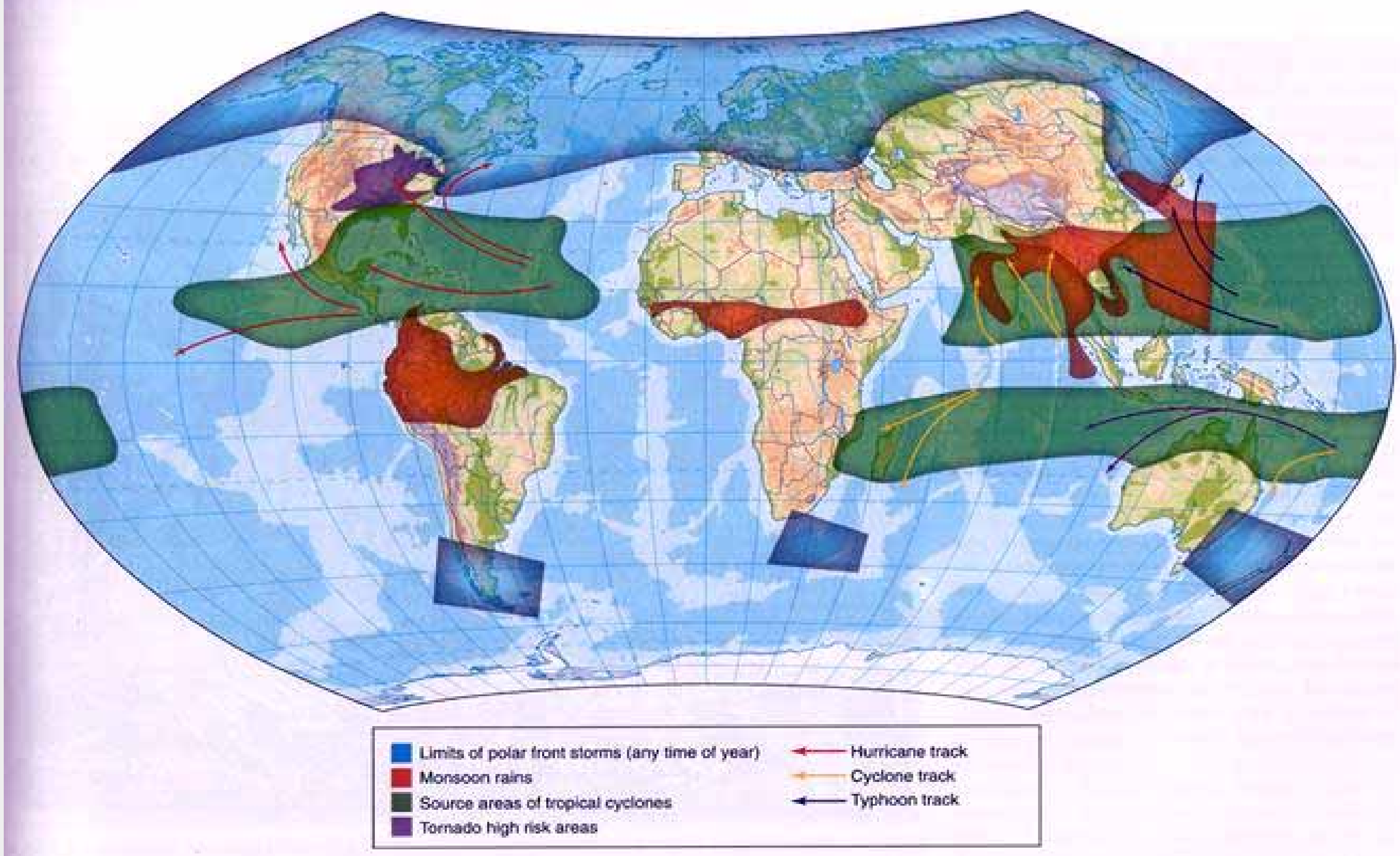

Figure 1.7 Floods and windstorms can occur anywhere on the planet. Monsoon and storm track disposition, however, provides a guide to those regions that are worst and repeatedly affected by meteorological hazards. Modified from Maslin (2002).

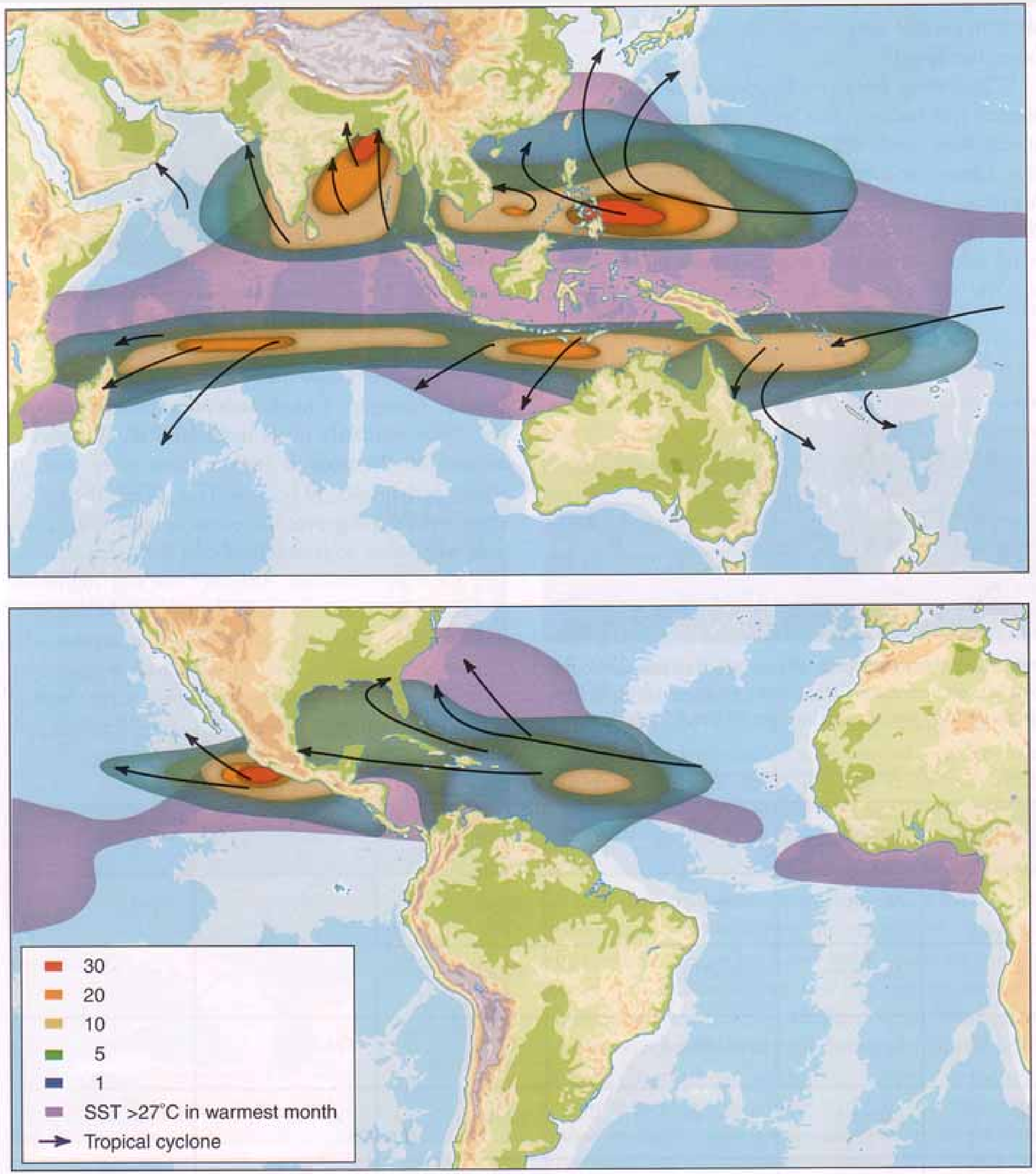

Figure 1.40 Contours of tropical cyclone genesis frequency (in a 20-year period), showing the main source regions. Principal tropical cyclone tracks and areas warmer than 27°C in their warmest month are also shown. Source: Modified from McGuire et al. (2002).

We know the mechanism.

Natural disasters strike our region every year !

Asia-Oceania: Prone to water-related disasters

Geoscientific Characteristics -

- Rainfall: large seasonal fluctuation
- Mountain areas: fragile geology
- Alluvial plains: highly populated, human activities concentrated
- Small islands: vulnerable to sea level rise

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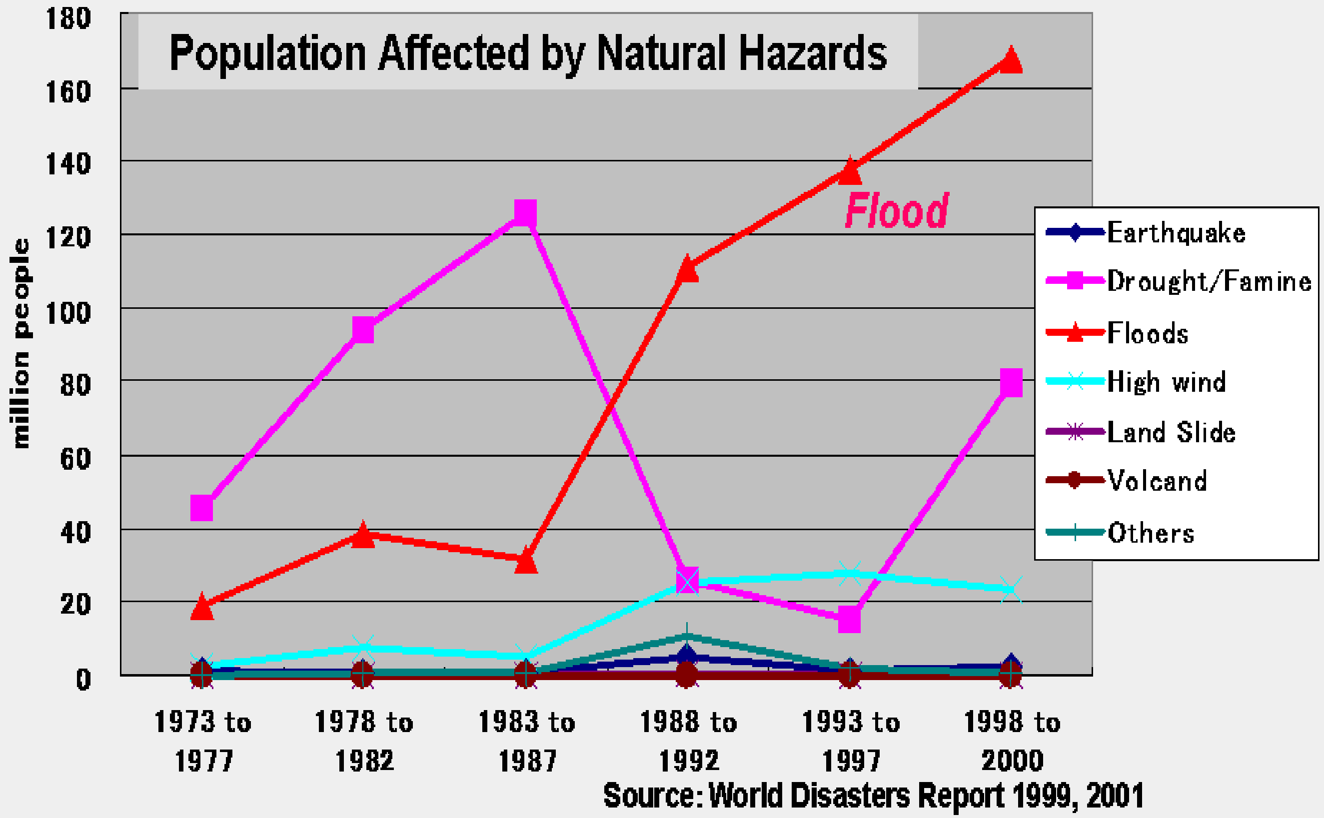
Natural Disasters in the World



Among the causes of natural disasters, **flood disaster** is remarkably increasing in these two decades in the world. Especially in humid Asia, flood problems are crucial in their seriousness and frequency.

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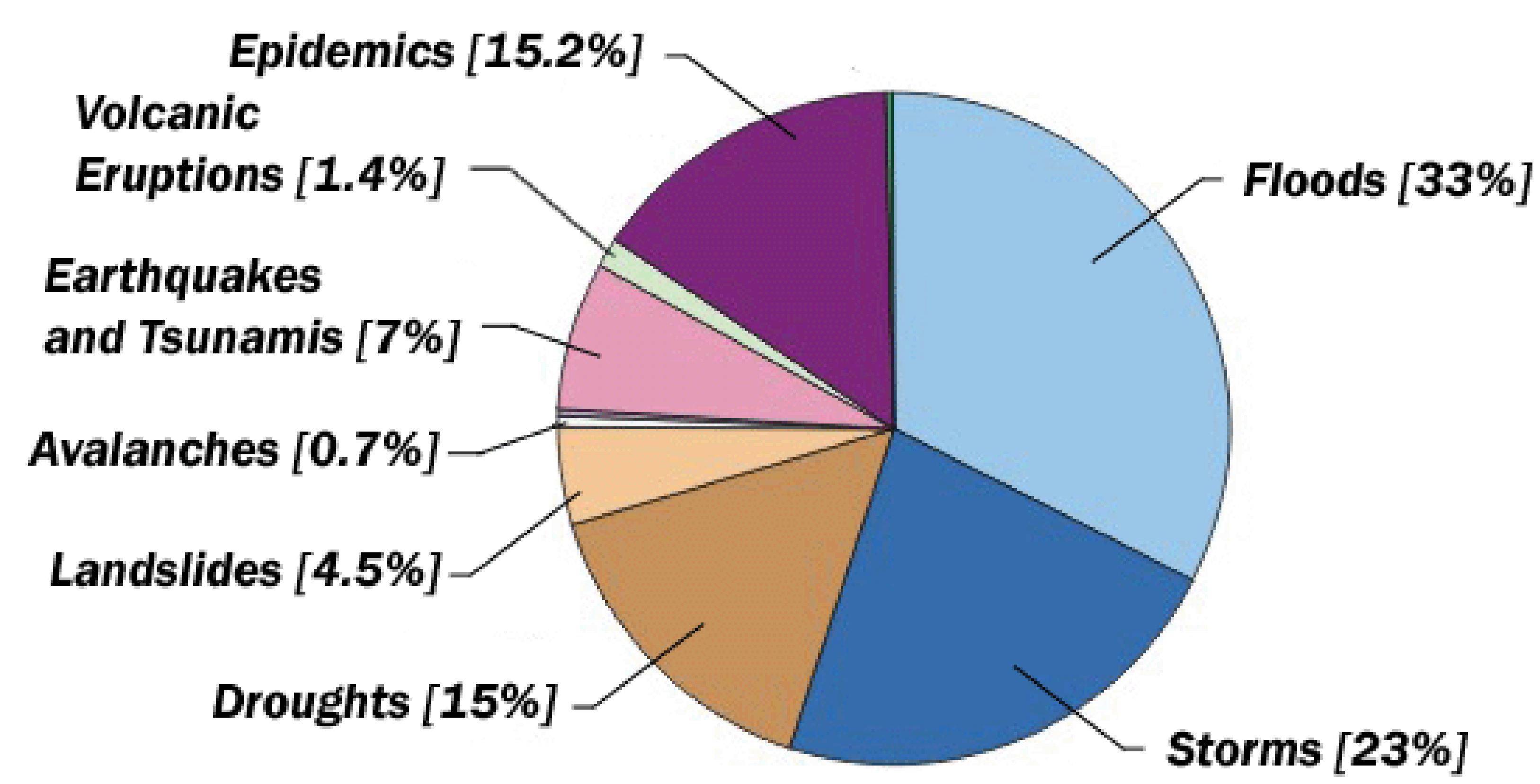
Water-related disasters: major issue

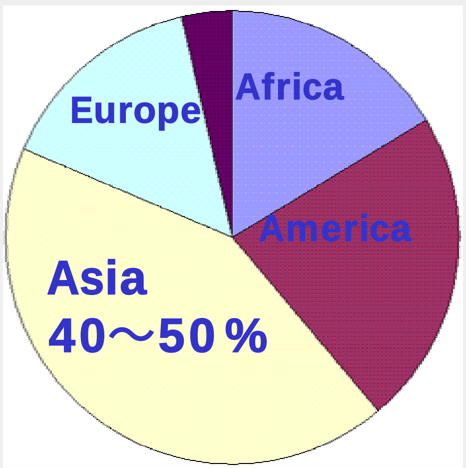


Huge Natural Disasters

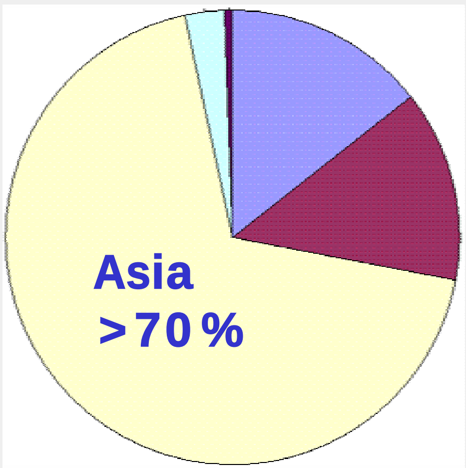
Tremendous human damages
Indian Ocean Tsunami
Myanmar Cyclone

Economic loss
Hurricane Catherine
Great Kobe Earthquake

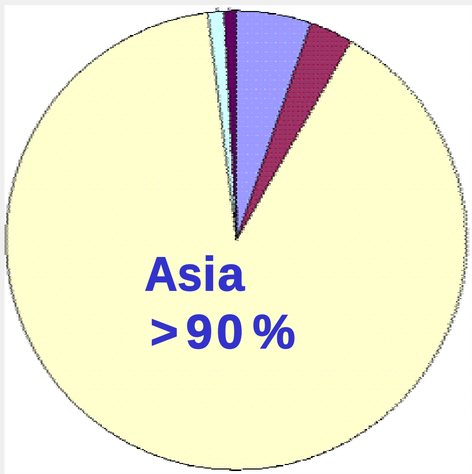
Damages are mainly in Asia



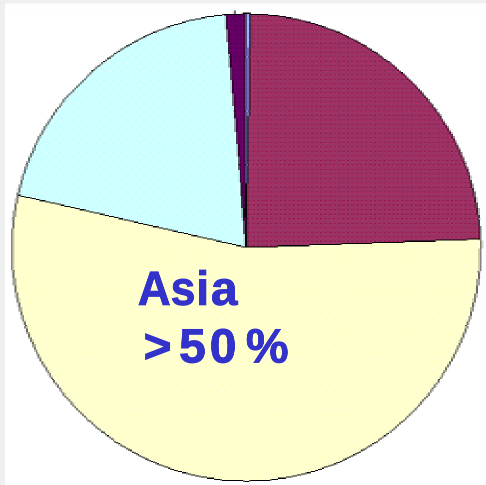
No. of events



Dearthtoll

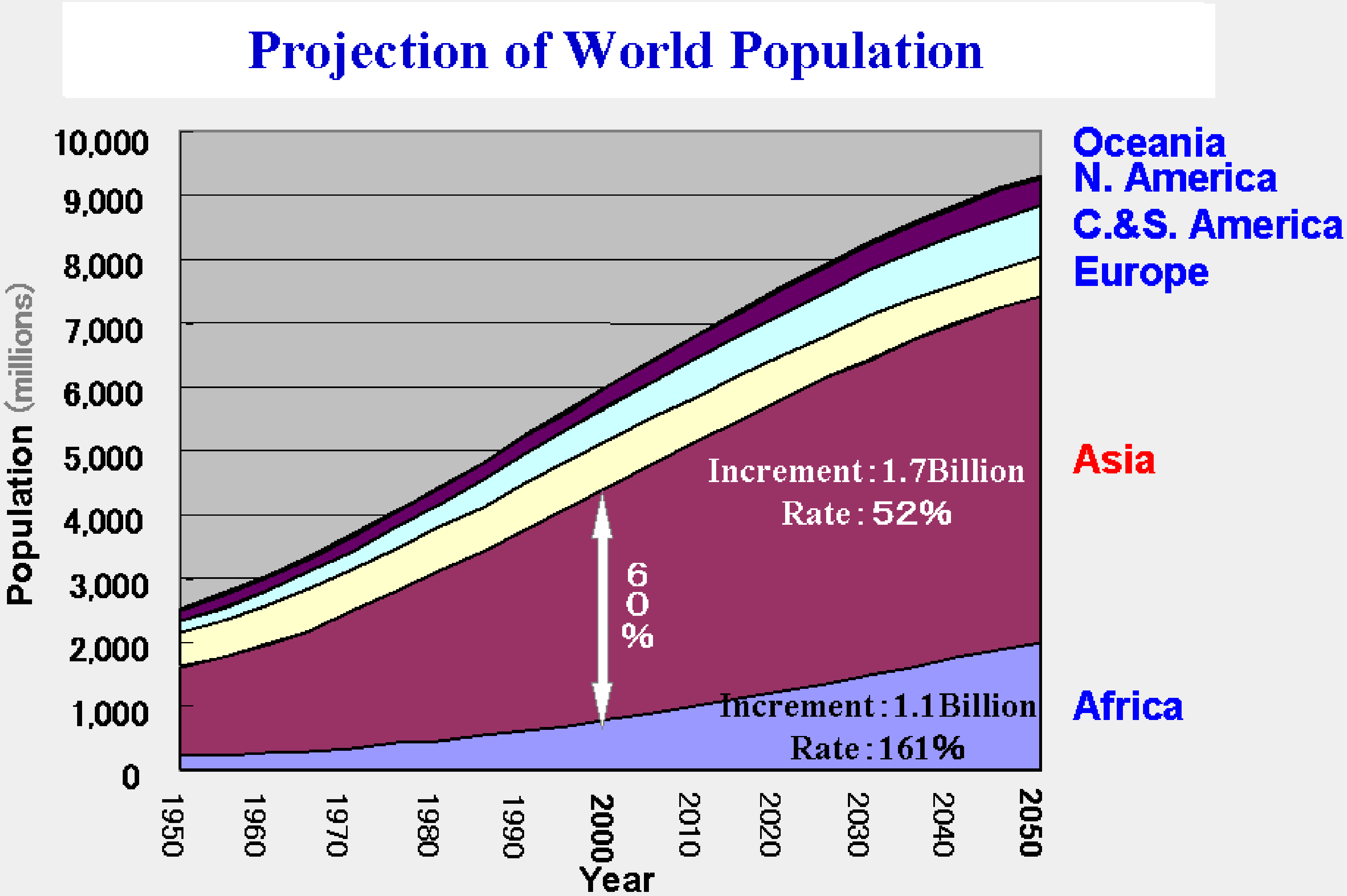


Affected people



Econimic loss

Continuing Population Growth in Asia



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What Characterizes Hydrology and Water Issues in Monsoon Asia, Especially in Humid Asia?

- Two important factors which characterize regional features of hydrology and water issues:
  - Climatic factor, and
  - Geomorphologic factor
- As for the climatic factor characterizing the Asia, the Asian monsoon climate is very important.
- As for the geomorphologic factor characterizing the Asia, land conditions formed by the plate tectonic motion, called "tectonic zone or orogenic belt", are very important.

(Musiake, 2007)

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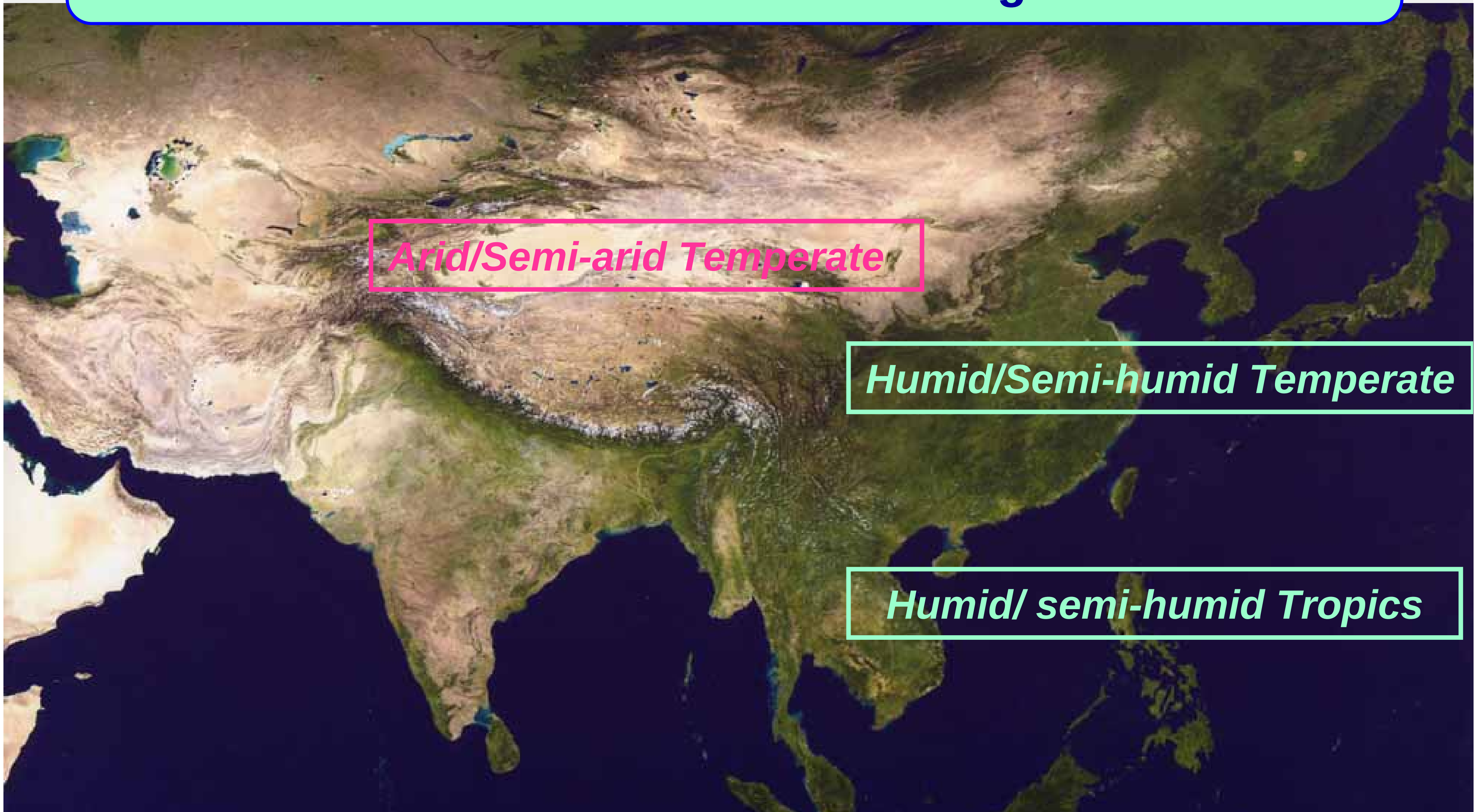
Asian Monsoon Climate
- includes various climatic regions-



- The AMC covers from sub-arctic to tropical in terms of a latitudinal climatic classification, and from arid/semi-arid to humid.

Water Issues to be Considered in Monsoon Asia

Mountain slope cultivation

- Fragile mountain lands formed up due to mountain making activities, such as slopes of volcanoes, fractured zones, Tertiary formation and weathered granite areas, can be cultivated, if they have necessary temperature and water. ⇨ mountain slope cultivation in Asian tectonic zones
- On the other hand, they are disaster-risk areas vulnerable to slope failure, landslide, debris/mud flow, etc..
- "Land productivity" and "Disaster risk" are both sides of coin.

(Musiake, 2007)

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Heavy Sediment Yield and Water-related Disasters in Mountain Areas

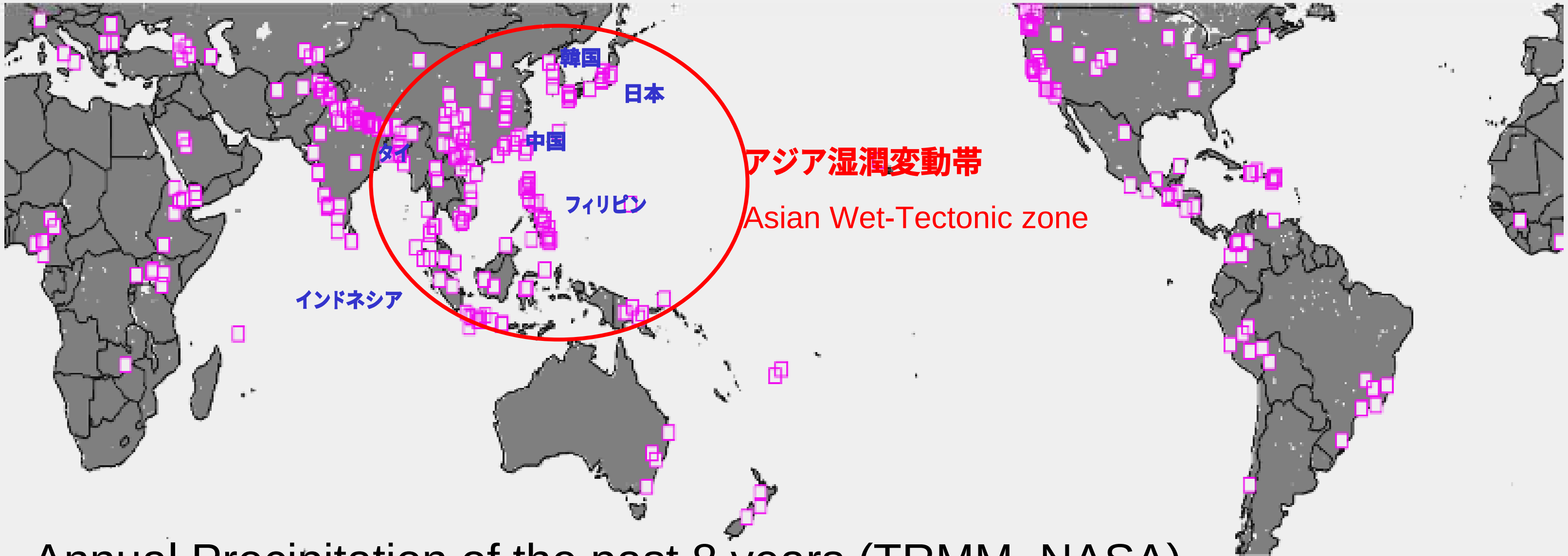
- The steep slope and fragile geology bring about high sediment yield, slope failure, landslide, volcanic eruption and debris/mud flow in mountainous areas.

- Sabo engineering works (debris control, landslide and slope failure prevention works) are applied to prevent or mitigate damages caused by them.

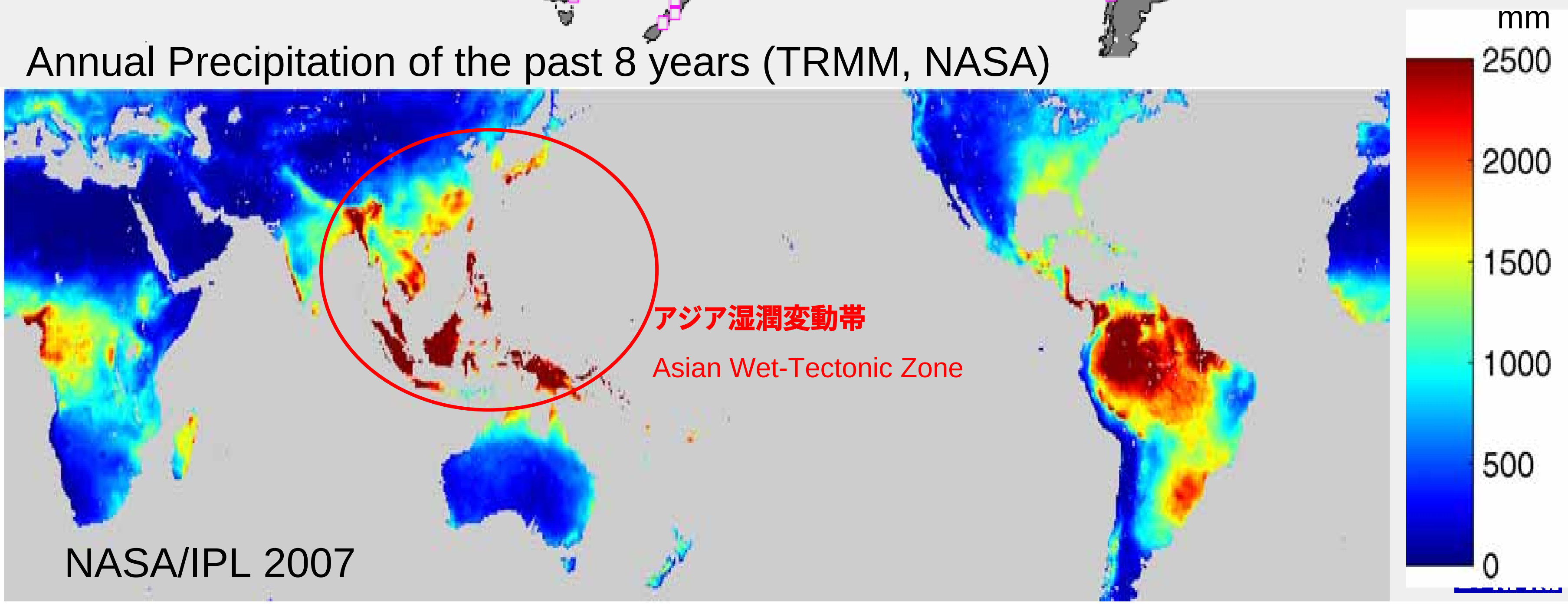
Sabo dam constructed in the upper reaches of Brantas river basin, Indonesia

Landslide prone areas with heavy rains and tectonic activities such as earthquakes, volcanoes, faulting and ground deformation (Asian Wet-Tectonic zone)

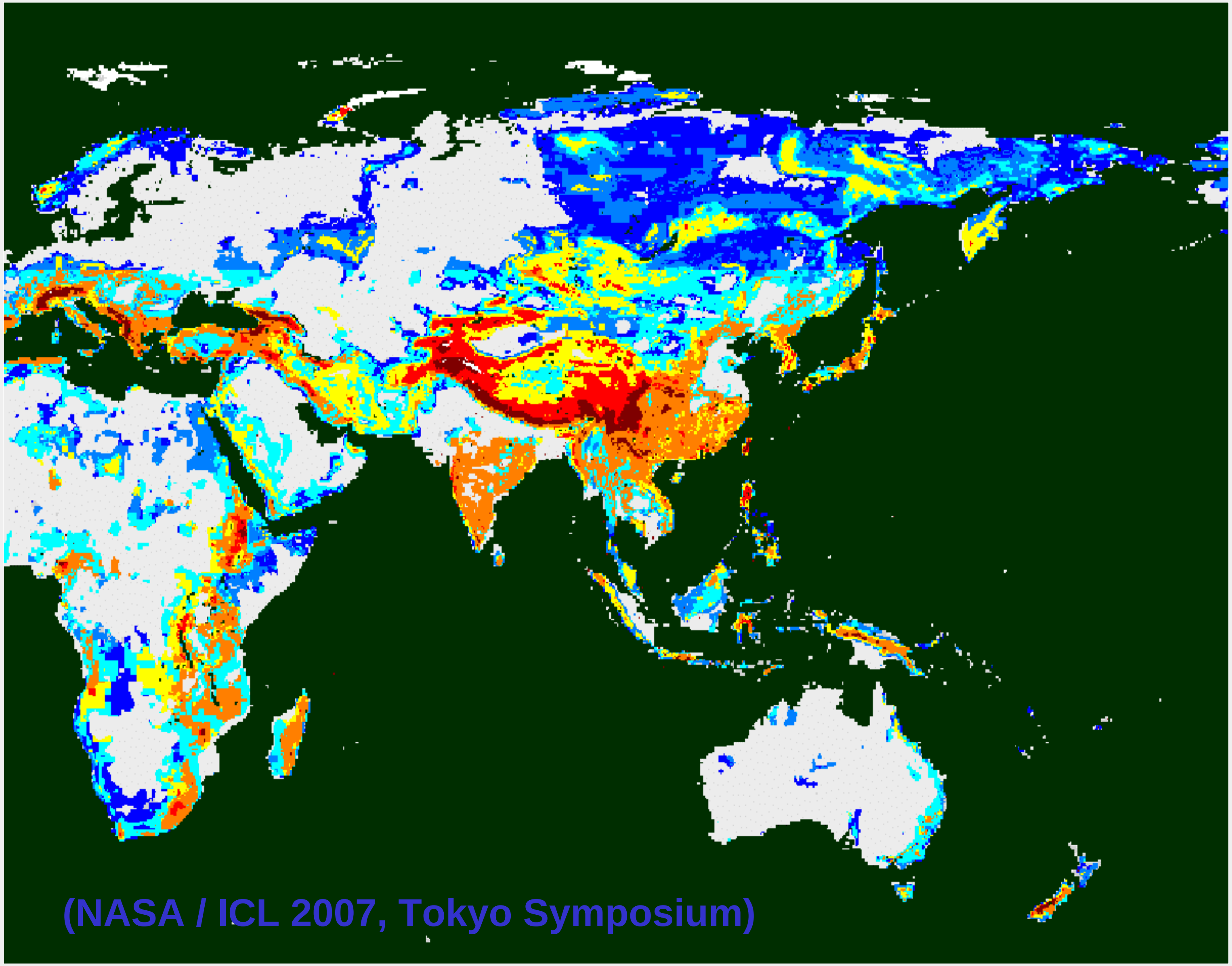
Major Landslide Events (2003-2006, NASA)

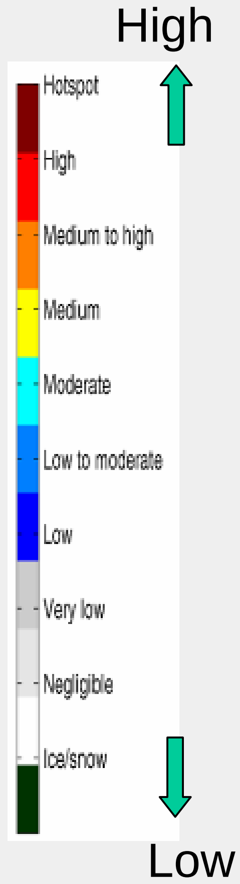


Annual Precipitation of the past 8 years (TRMM, NASA)



Landslide Susceptibility Mapping





Sediment yield and runoff

- **The source of sediment yield in stable regions is mainly soil erosion. We have other major sources of sediment in humid Asia, such as landslide, slope failure, volcanic eruption, debris/mud flow, etc.**
- **Estimation and prediction of these kinds of sediment yield/runoff are very difficult due to their discontinuous nature, but we have to carry out systematic studies on them.**

Eruption of Mt. Pinatubo, PHILLIPINES, in July 1991

Landslide due to earthquake. The Abe River Basin, JAPAN

Debris/mud flow with drifting fallen trees in Ban Nam Kor, Petchaboon, THAILAND, in 11 August 2001.

Seasonal land cover change

Oct 2002

Feb 2003

Oct 2003

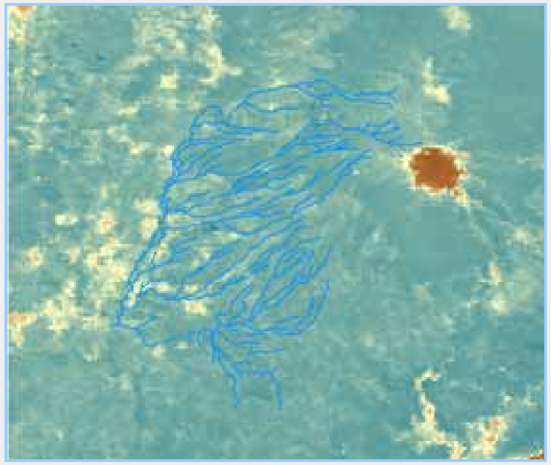
Lesti River basin, East Java, Indonesia
(Sayama, Tachikawa and Takara, 2005)

Seasonal variability of vegetation index

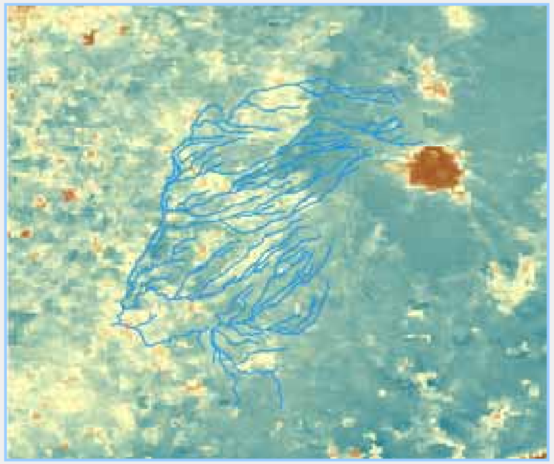
MODIS is a optical sensor installed in the satellite “TERRA”

NDVI=(IR-R)/(IR+R)

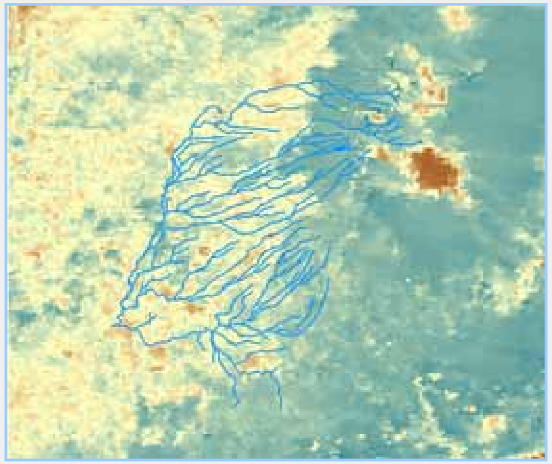
Dry season : May.- Aug.
Rainy season: Oct. – Mar.



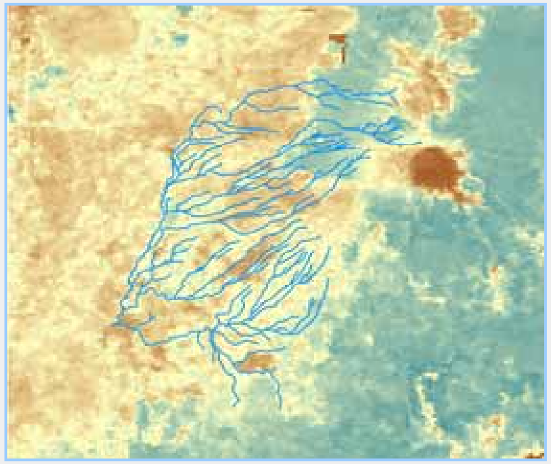
May, 2002



July, 2002



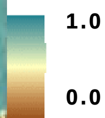
August, 2002



October, 2002

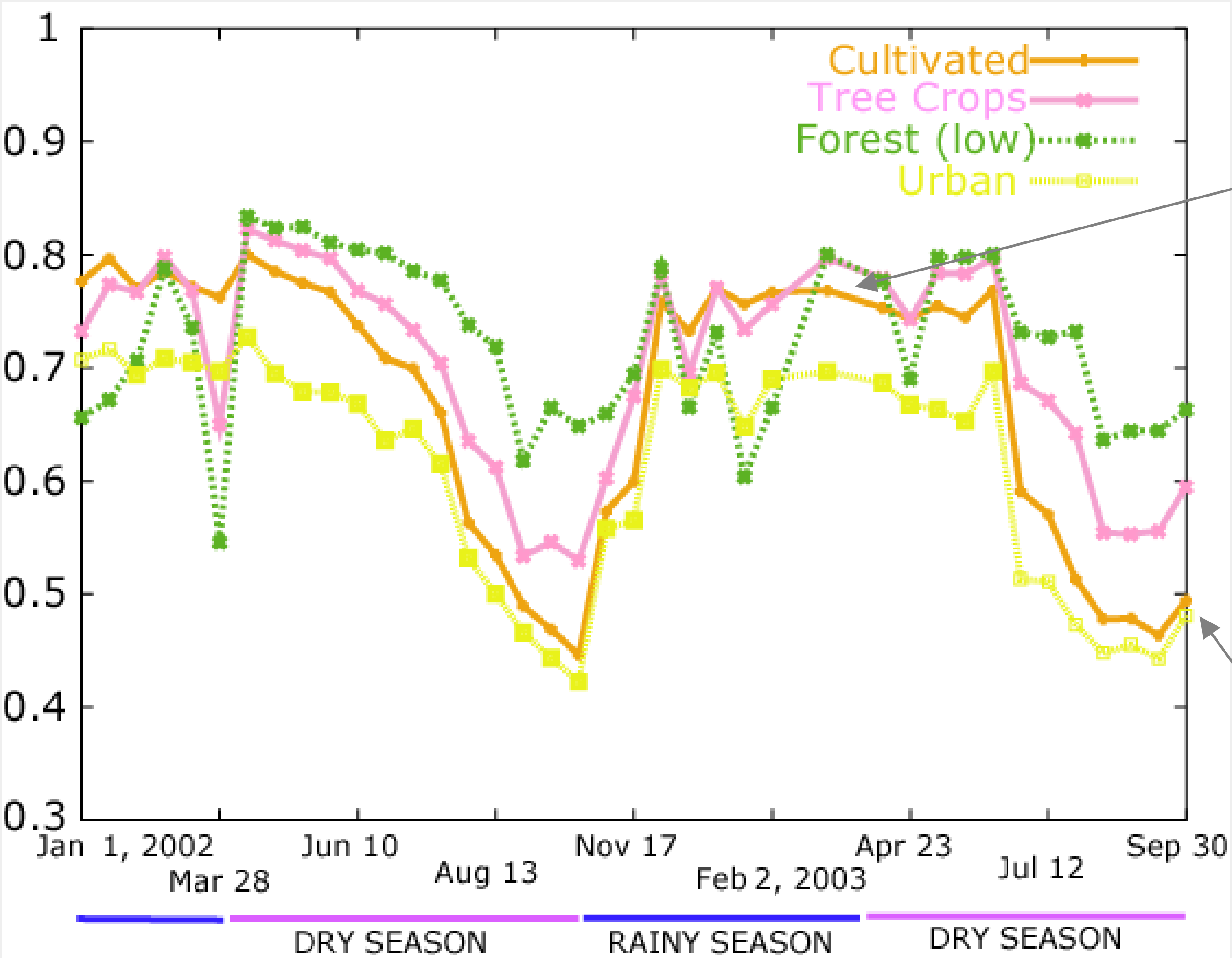
December, 2002

March, 2003



Lesti River basin, East Java, Indonesia (Sayama, Tachikawa and Takara, 2005)

NDVI time series in different landuse



Lesti River basin, East Java, Indonesia
(Sayama Tachikawa and Takara, 2005)

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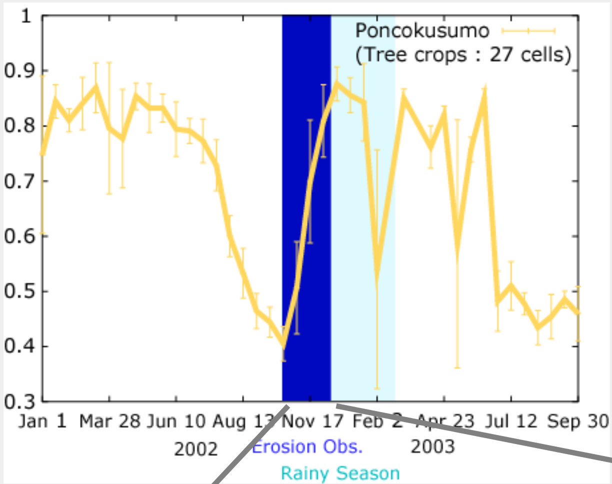
MODIS/NDVI to monitor land cover change

Lesti River basin, East Java, Indonesia (Sayama Tachikawa and Takara, 2005)

NDVI by MODIS



Dec 19, 2003

Oct 12

Nov 1

Nov 6

Nov 17

Nov 29

PHYSICALLY BASED DISTRIBUTED RAINFALL-SEDIMENT-RUNOFF MODEL

Hydrological Submodel

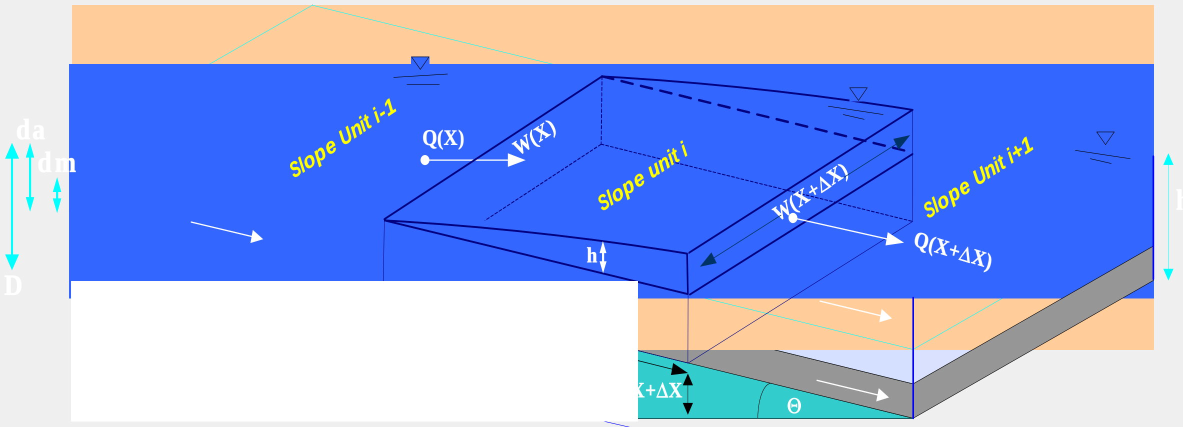
(Apip and Takara, 2007)

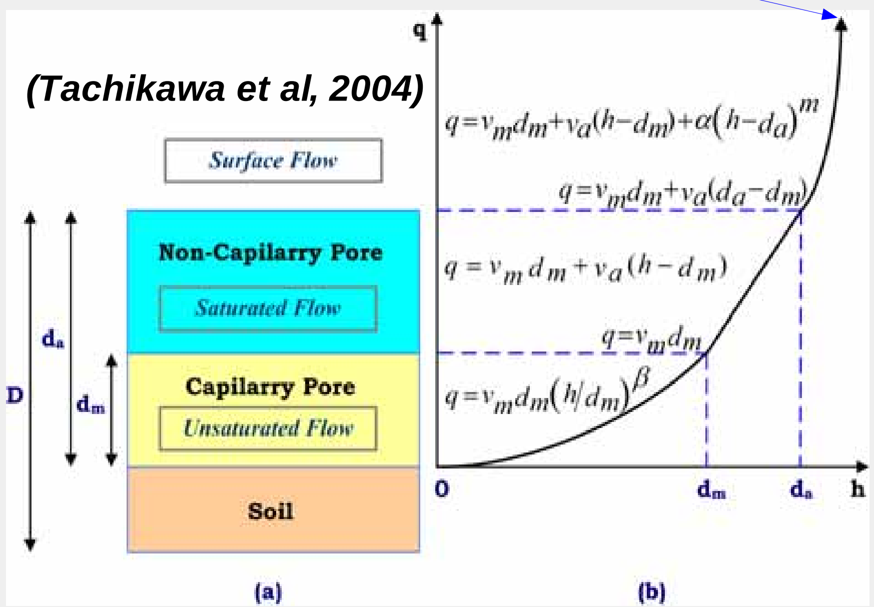
A Physically based Cell Distributed Rainfall-Runoff Model (Kojima and Takara, 2003) was applied for Simulate Hydrological Response.

Continuous Eq. of Water

$$\frac{\partial h}{\partial t} + \frac{\partial q}{\partial x} = r(x,t)$$

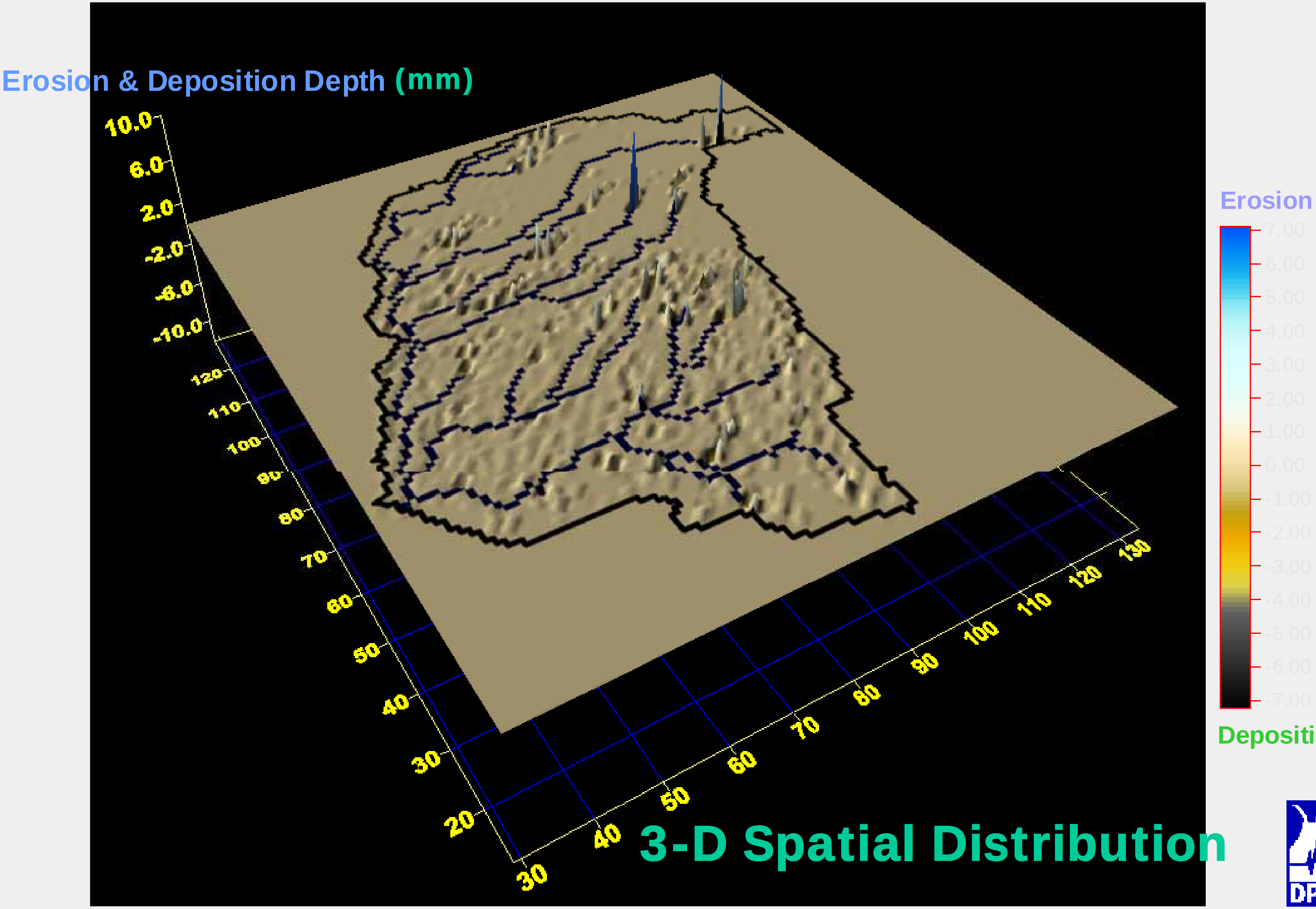
The Model Soil Structure and Stage Discharge Relationship CDRM V.3 Model





Runoff and Sediment Yield Simulation by a Distributed Model

(Apip and Takara, 2007)



3-D Spatial Distribution

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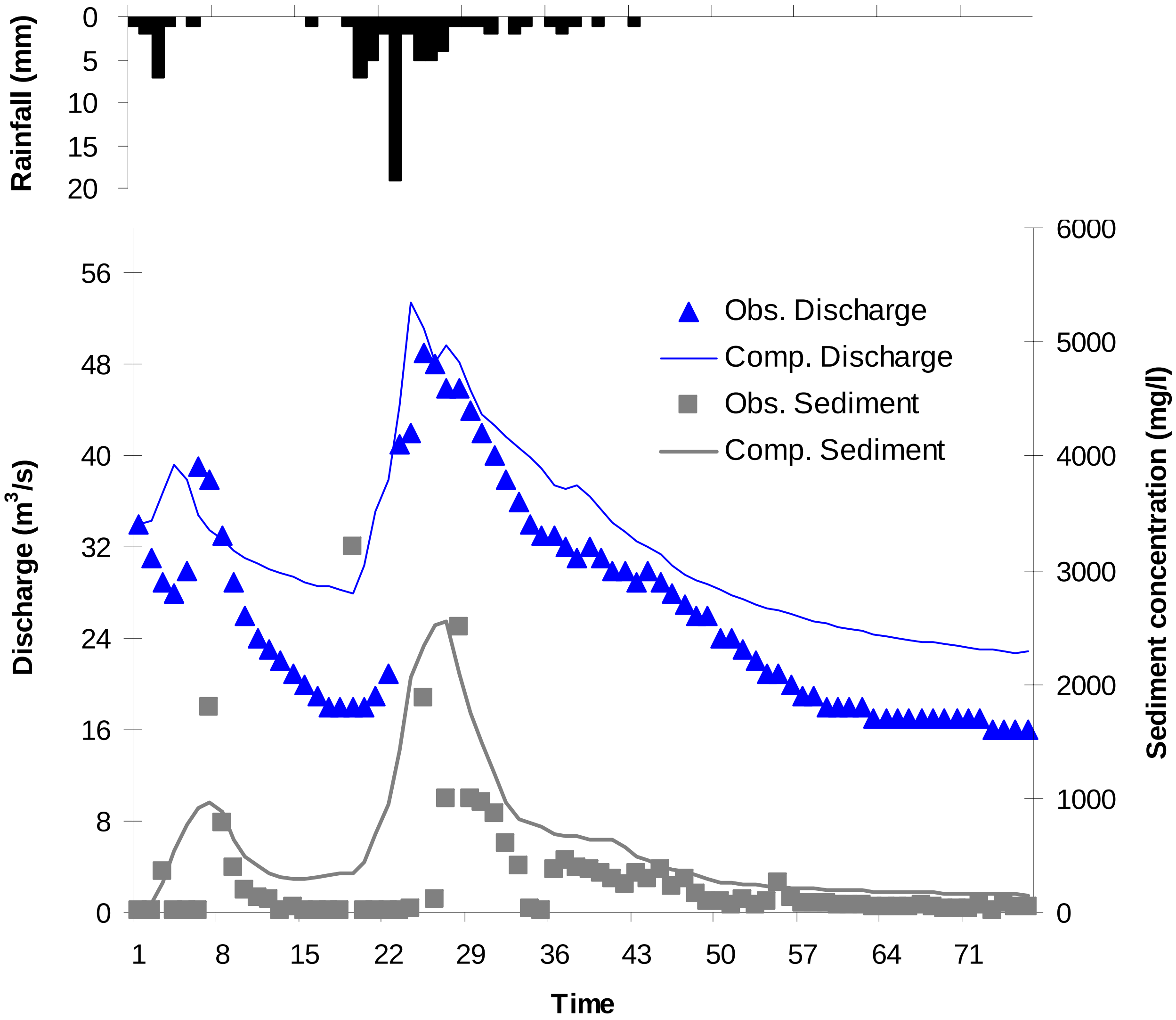
Runoff and Sediment Yield Simulation by a Distributed Model

(Apip and Takara, 2007)

Rainfall event based (Flood Event)

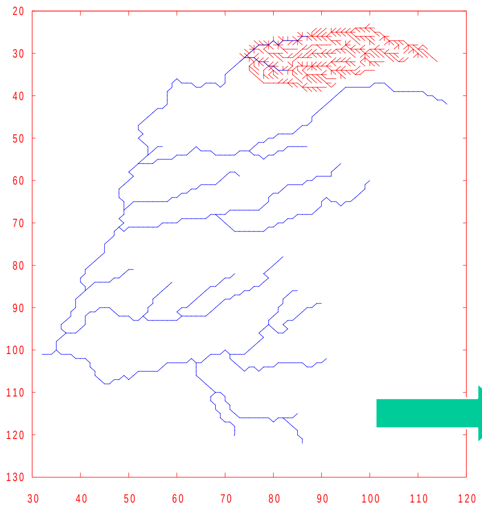
Hydrograph and Sedimentgraph

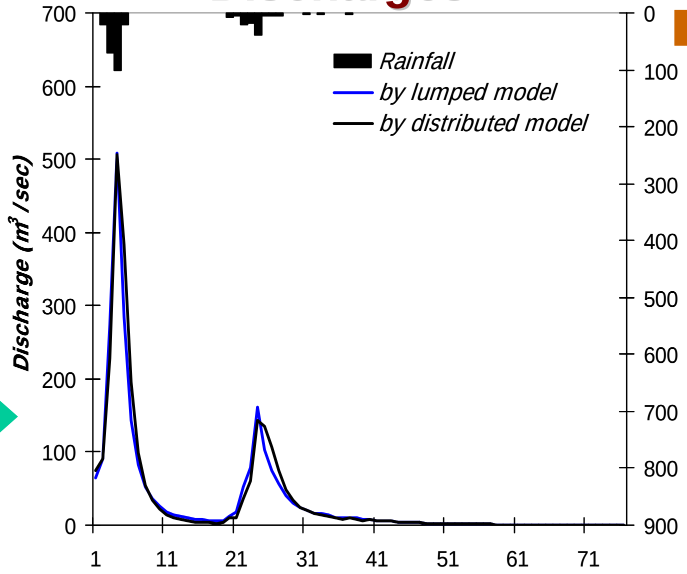


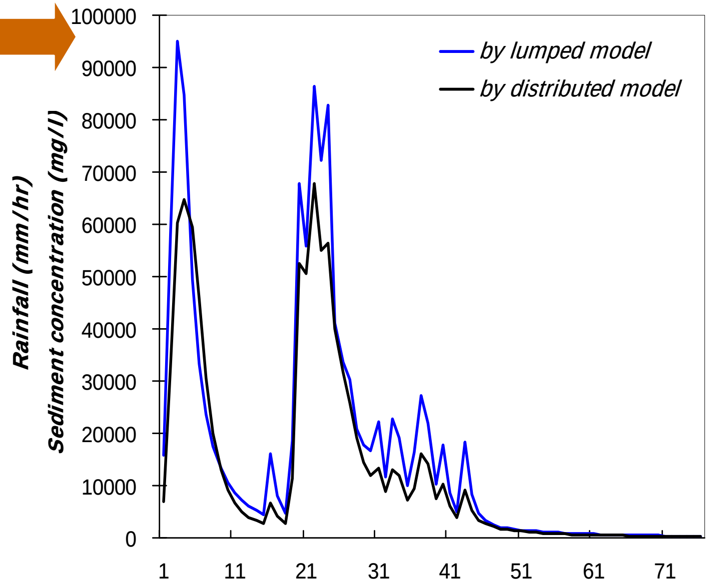
SIMULATION RESULTS → <u>*Case 1 (total rainfall 333 mm)*</u>

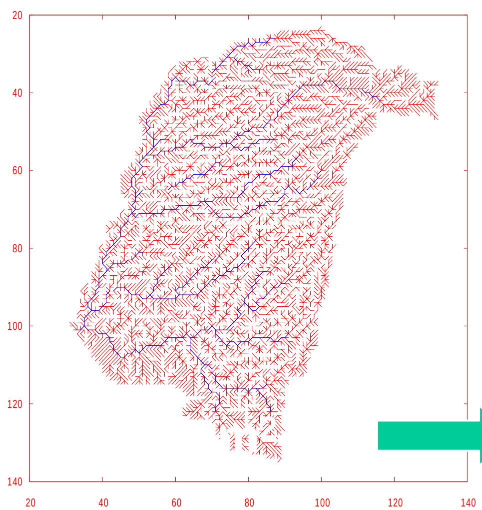
Discharges

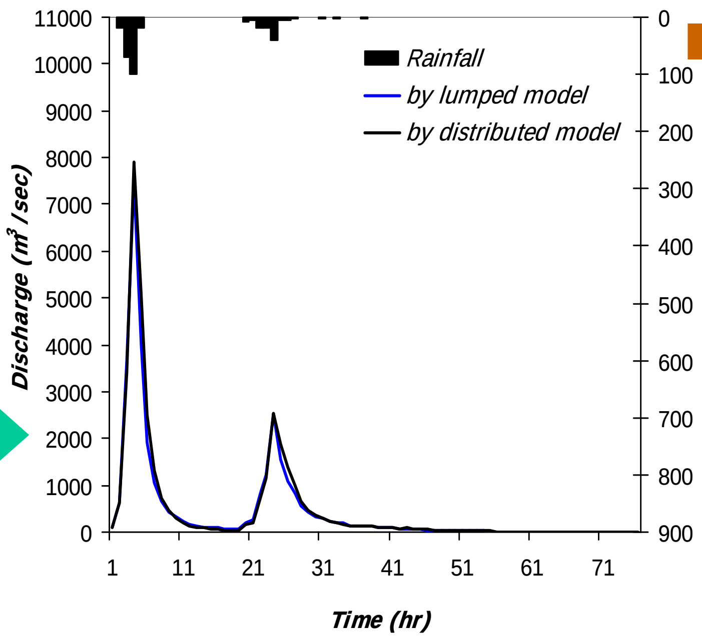
Sediment Concentrations

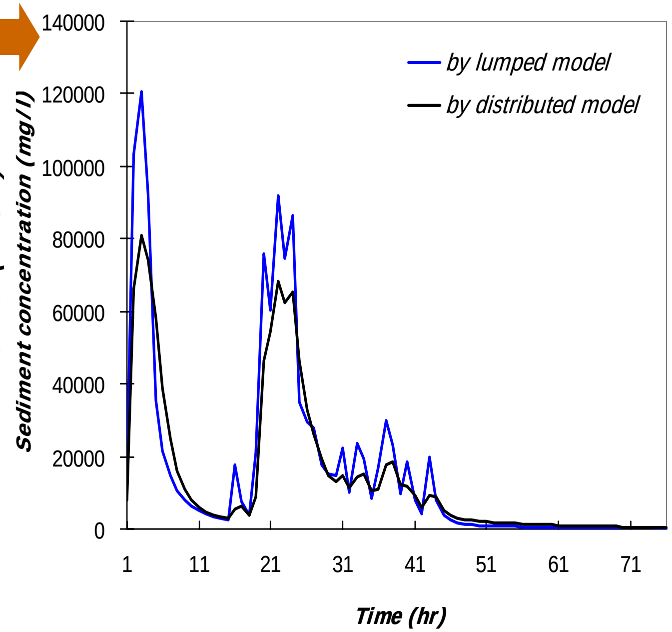












Paddy cultivation in the alluvial plain

- Since the alluvial plain is low-lying and wet land, it is used for paddy cultivation if the high temperature and sufficient water can be obtained.

- The paddy cultivation is the most suitable agriculture for the low-lying wet alluvial plain.

- It has a special water management with irrigation/drainage technologies different from dry crop cultivations in stable region.

Urban areas located in the alluvial plain

- **The alluvial plain is the most densely populated area in tectonic zones ; big cities, town and villages are located in the alluvial plain.**

- **Alluvial plains, formed up by flooding of rivers, have a nature vulnerable to be flooded. Therefore, flood control and flood disaster mitigation measures are much more important in tectonic zones than in stable regions.**

Jakarta, INDONESIA

Flooding in Jakarta city

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Floods in Johor, Malaysia

Flooding is the most frequent and disastrous weather phenomena for Malaysia in the recent years. In December 2006, the southern Peninsular Malaysia was devastated by a 100-year-return-period major flood which had almost paralysed the whole state of Johor. Alarmingly, the state was devastated again in less than a month in January 2007 when a second wave of massive flood hit.

(TAHIR and BAKAR, 2007)

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Flash Flood in February 2006 at Shah Alam

Few months before the Johor flood, Shah Alam in Klang River Basin was inflicted with severe flash flood which had caused property damages of approximately RM100 million. The recorded 104 mm rain within three hours had caused water rise to about 1.6 m depth in some residential and commercial area, hence damaging around 4000 homes and properties.

Residents complaint of no flood warning

(TAHIR and BAKAR, 2007)

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Countermeasures against urban floods

Over the years, flash floods have caused countless grievances to the urban folks of Malaysia; from trapped in long hours of traffic jam, damage of cars at parking, to the destruction of homes and business properties. Comprehensive flood mitigation measures have been implemented by the authority including enforcing storage pond for construction sites, improving river channel sections and building the SMART tunnel in the midst of the capital city of Malaysia. In addition to the structural measures, a significant non-structural measure is the operation of flood forecasting and warning system (FFWS).

SMART tunnel

(TAHIR and BAKAR, 2007)

Flood Strike


EARLY WARNING WOULD ALLOW ENOUGH TIME TO SAVE PROPERTIES


(TAHIR and BAKAR, 2007)

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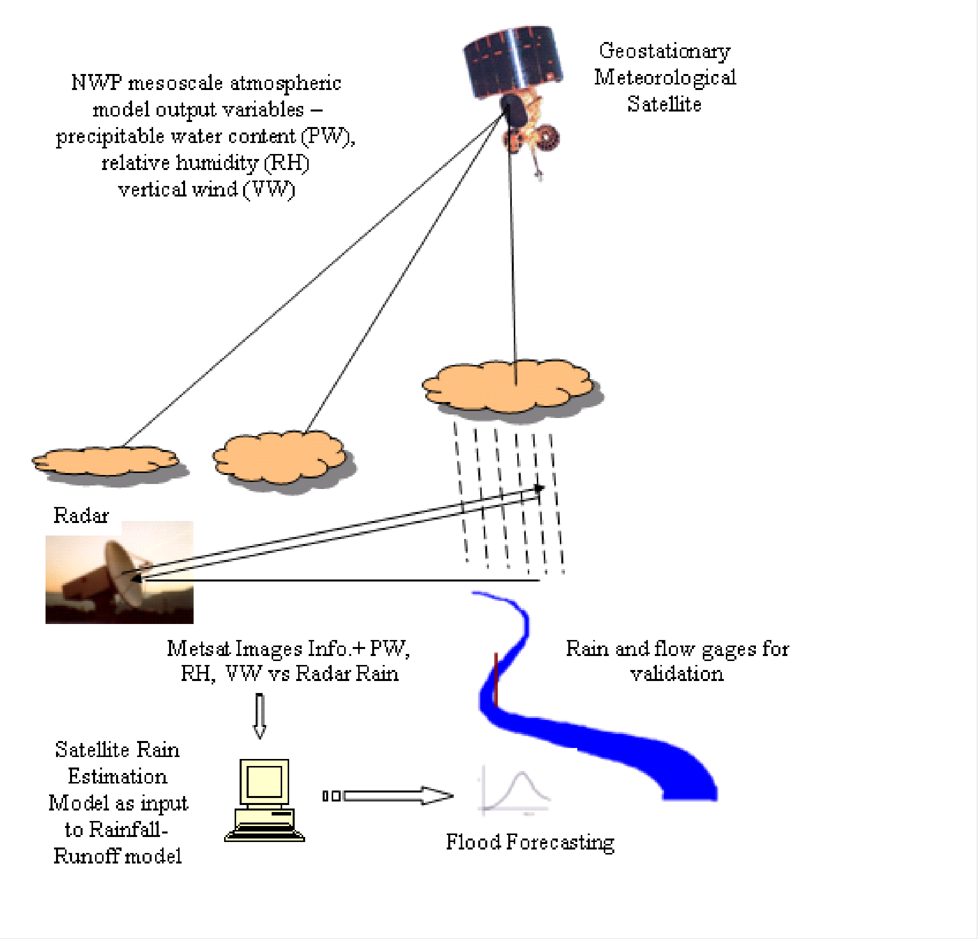
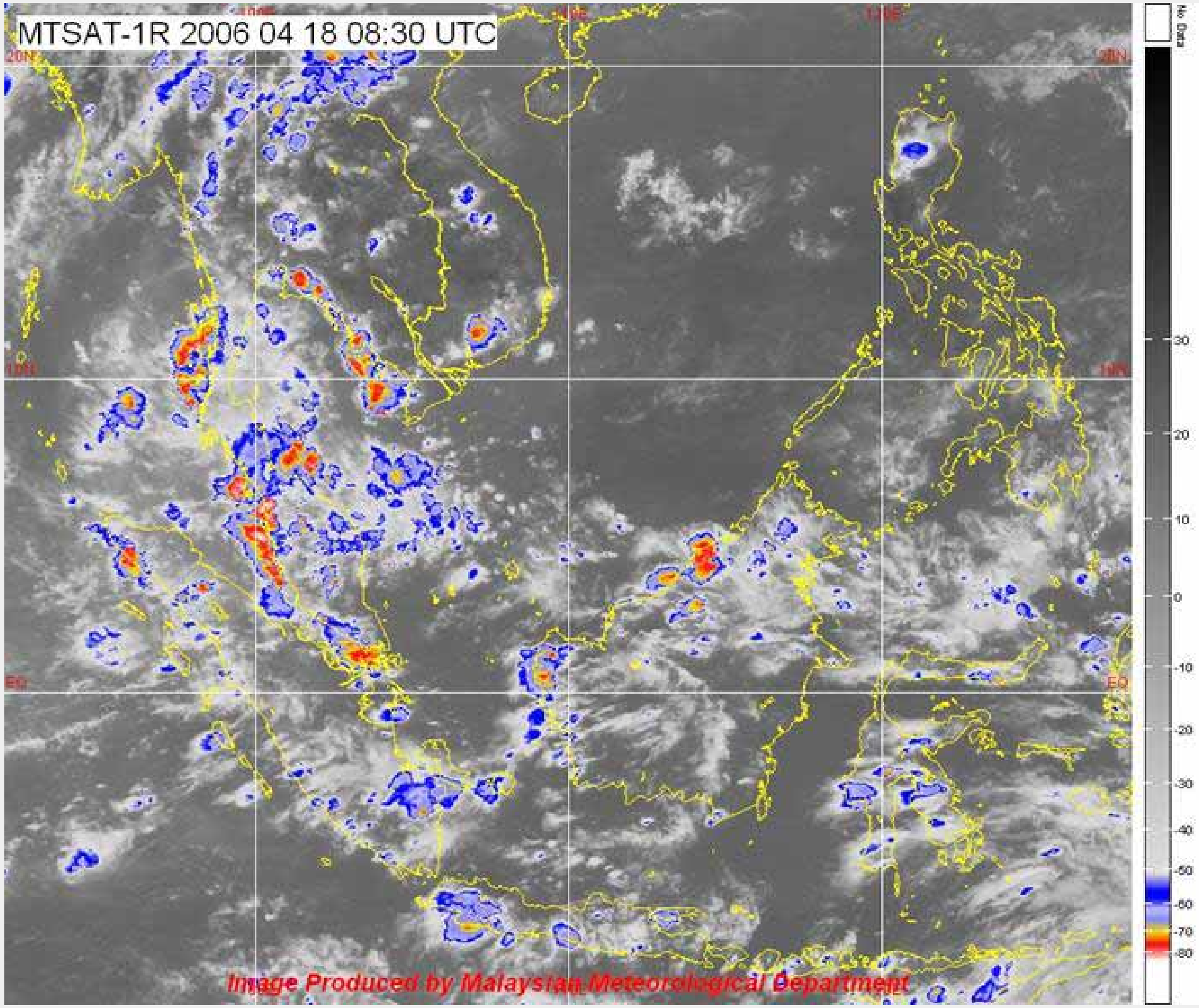
Attempts to develop an advanced and improved flood forecasting system with a better lead time by coupling a Quantitative Precipitation Forecast (QPF) model with a rainfall-runoff model using multi-sensor data inputs especially the **geostationary meteorological satellite images**. Many studies have been done on satellite-based rainfall estimation as published among others by Porcù et al. (1999), Sorooshian et al. (2000), Todd et al.(2001) Anagnostou et al. (1999), Arkin and Janowiak (1991), Barrett and Martin (1981) Bellon et al.(1980), Griffith et al.(1979) Lovejoy and Austin (1979).

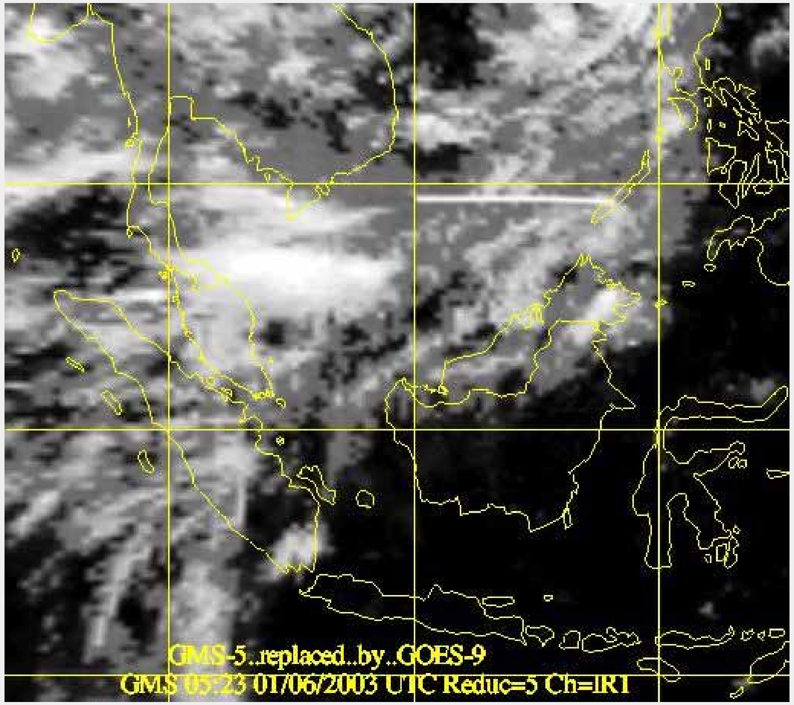


Coupled Hydro-Meteorological Flood Forecasting Components

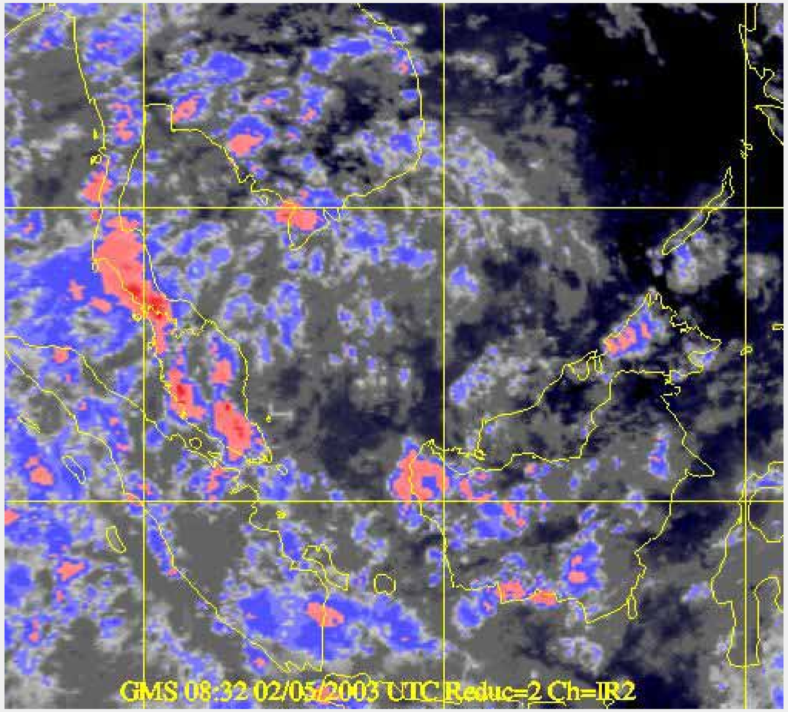
FLASH FLOOD AND SATELLITE OBSERVATION



DATA



Grayscale image



Enhanced color image

Geostationary Meteorological Satellite Infrared Images

Meteorological satellite images were acquired from the Malaysian Meteorological Department which receives the images from the Japanese National Space Development Agency (NASDA) and Japan Meteorological Agency (JMA). The GMS-5 is positioned at 140^{o} east and has a spin scan radiometer that returns visible and infrared images. The images utilised for this study is hourly infrared GMS-5 IR images channel 10.3-11.3 µm with spatial resolution of 5 km. Images were collected for year 2003 and wet months (March, April, October and November) of 2004 and 2005. Validation data used are MTSAT (latest GMS generation) IR images for rainy days for year 2006.

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135° E
150° E
165° E
180°
165° W
150° W
135° W
120° W
Northern Mariana Islands (U.S.)
Philippine Sea
Pacific Ocean
Hawaii
N
15° N
Philippines
Guam (U.S.)
Marshall Islands
1000 mi
1000 km
Palau
Micronesia
ASIA
Papua New Guinea
Gilbert Islands
Phoenix Islands
EQUATOR
0°
Solomon Islands
Nauru
Tokelau (N.Z.)
Kiribati
Line Islands
Indonesia
Tuvalu
Arfura Sea
Wallie & Futuna (France)
American Samoa (U.S.)
Timor Sea
Great Barrier Reef
Bora Bora
Tuamotu Archipelago
Cook Islands
Coral Sea
Vanuatu
Fiji
Samoa
Tahiti
15° S
MELANESIA
Niue (N.Z.)
POLYNESIA
French Polynesia (France)
Tonga
Society Islands
TROPIC OF CAPRICORN
New Caledonia (France)
INTERNATIONAL --DATE LINE--
Austral Islands
Australia
MONDAY
SUNDAY
Pitcairn Islands (U.K.)
30° S
Norfolk Island (Australia)
North Island
OCEANIA
New Zealand
Kangaroo Island
Tasman Sea
Indian Ocean
Pacific Ocean
Tasmania
45° S
Auckland Islands (N.Z.)
South Island
Chatham Island (N.Z.)
Stewart Island
©GraphicMaps.com
105° E
120° E
135° E
150° E
165° E
180°
165° W
150° W
135° W
120° W

PIC's are Vulnerable to Natural Disasters such as

- Tropical Storms or Typhoons
- Extended Droughts
- Land Slides
- Floods on the bigger islands such as Pohnpei
- Coastal Erosion
- Surge or Tidal Waves
- Climate Change & Sea Level Rise

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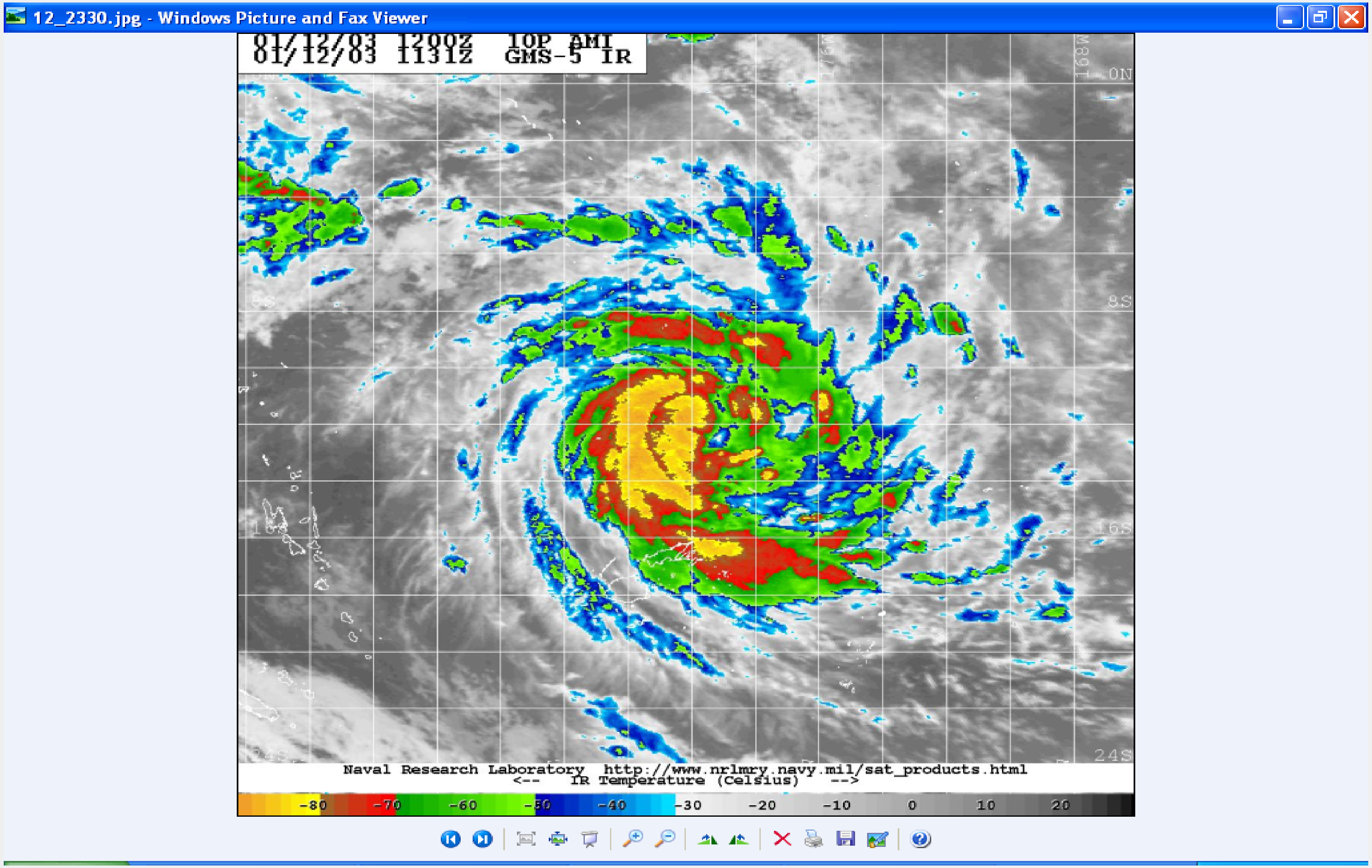
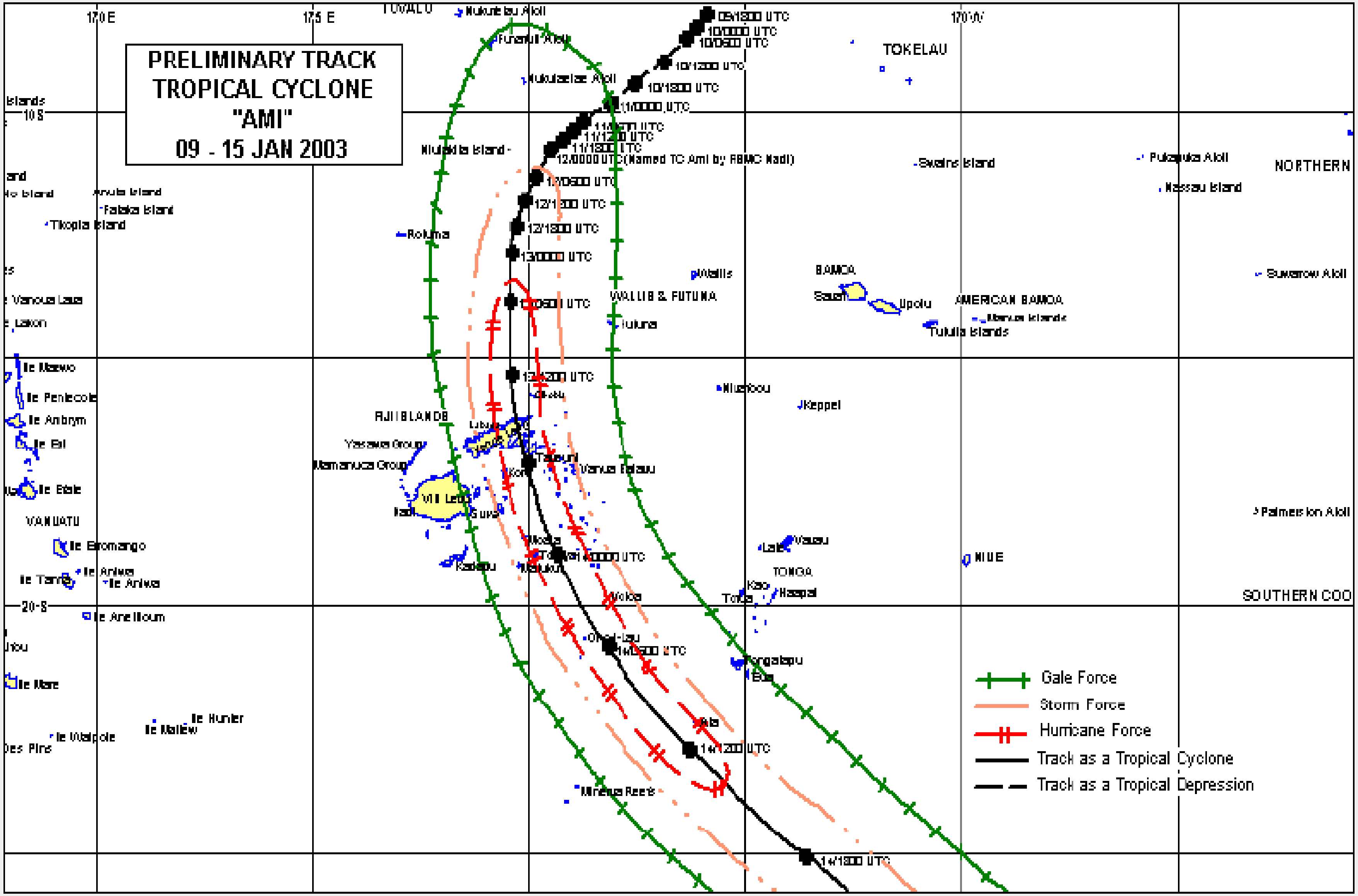
Tropical Cyclone



(McGree and Terry, 2003)



(McGree and Terry, 2003)

Tropical Cyclones

- Major climatic hazard in the South Pacific costing the Pacific Islands millions of dollars each year in damage (>$300M in Fiji) and recovery costs
  - Violent winds cause much damage to vegetation and buildings, loss of life due to flying debris or collapsed buildings
  - Large waves driven onto the shore damage coral reefs, and coastal infrastructure
  - Storm surge can lead to sea flooding of low lying coastal areas
  - Intense and large amounts of rainfall
  - Landslides on steep slopes (triggered by heavy rain)
  - Extreme river discharges, causing river flooding

- For these reasons, it is important people living on Pacific Islands understand TC formation and behaviour

(McGree and Terry, 2003)

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Tropical Cyclone Facts and Statistics

- The mean number of cyclones in a season in the South West Pacific from 1969/70 to present is 9.4.

  Max. numbers: 1997/98 – 17 , 1982/83 – 16, 1996/97 – 15

- Most off season cyclones occur during an El Niño Event.

- The season with the highest number of cyclones attaining hurricane intensity was 1971/72 (11) (Weak La Nina/Neutral??) followed by 1982/83 (10).

- The least number of cyclones in a season is four - 1990/91 and 1994/95 (Weak El Nino/Moderate El Nino) .

  Month with the highest frequency and highest numbers of cyclones attaining hurricane intensity is February followed by January then March.

(McGree and Terry, 2003)

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Storm surge and sea flooding

- Storm surge is a temporary rise in the level of the sea, caused by a very low atm. pressure close to the cyclone centre. This rise is sometimes more than half a metre.
- The surge can result in flooding of deltas and coastal lowlands, especially if it co-insides with the time of high tide.
- Will cause the local submergence of coral reefs which normally protect the coasts from waves. Huge cyclone wind generated waves have a much better chance to sweep ashore and cause damage to much greater heights reached by the surge alone.
- Violent winds also drive the waves on shore exacerbating the above effect.

(McGree and Terry, 2003)

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Coastal Zone Disasters in Asia-Oceania

- High tides, tidal waves
- Tsunami
- Coastal environmental problems
- Sea level rise

Figure 4.7 Area of Bangladesh subject to flooding to depths in excess of 90 cm in a normal year. In addition to the possibility of enhanced monsoon flooding, a combination of rising sea level and sinking of the land surface are forecast to produce a 1.5m rise in the next 50 years, leading to the loss of 16 per cent of the land area and the displacement of 17 million people. Source: Smith (2001).

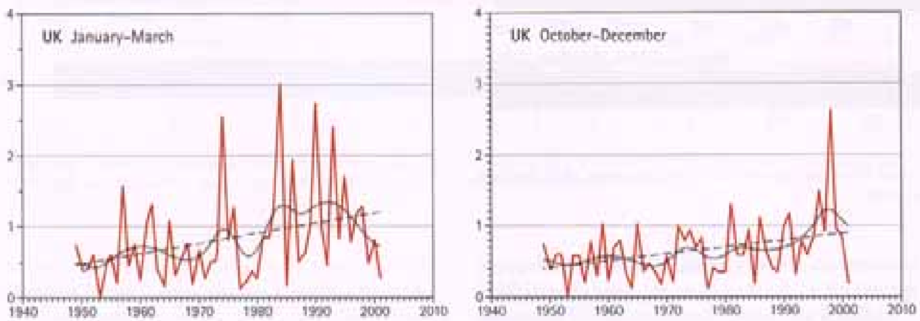

Figure 4.8 The last 50 years has seen a significant rise in the number of severe winter storms affecting the UK. It is not clear, however, if this trend is a consequence of climate change or part of a natural trend. Source: Hadley Centre for Climate Prediction and Research (2003).

Flood-prone Area of Bangladesh: 16 % land would be lost, 17 mil. people displaced in 50 years

Winter storms in UK: Climate change or Natural trend?

Storm surges in Japan

Past Typhoons which much affected Japan

Name of typhoon	Places	Anomaly (cm)	Death toll	Inundated houses
Taishou 6th (1917)	Tokyo Bay	230	1,127	302,917
Muroto (1934)	Osaka Bay	310	2,703	401,157
Sou-Nada (1942)	Sou-Nada	160	891	132,204
Makurazaki (1945)	Kagoshima Bay	>200	2,076	217,326
Jane (1950)	Osaka Bay	240	398	301,919
Ise-Wan (1959)	Ise Bay	345	4,697	363,611
2nd Muroto (1961)	Osaka Bay	241	194	384,120
Typhoon 10 (1970)	Tosa Bay	235	12	40,293
Typhoon 18 (1999)	Suo-Nada & Yatsushiro Sea	211	30	18,001
Typhoon 16 (2004)	Seto Inland Sea (Uno &Takamatsu)	160	16	44,935
Typhoon 18 (2004)	Seto Inland Sea (Hiroshima)	180	22	–

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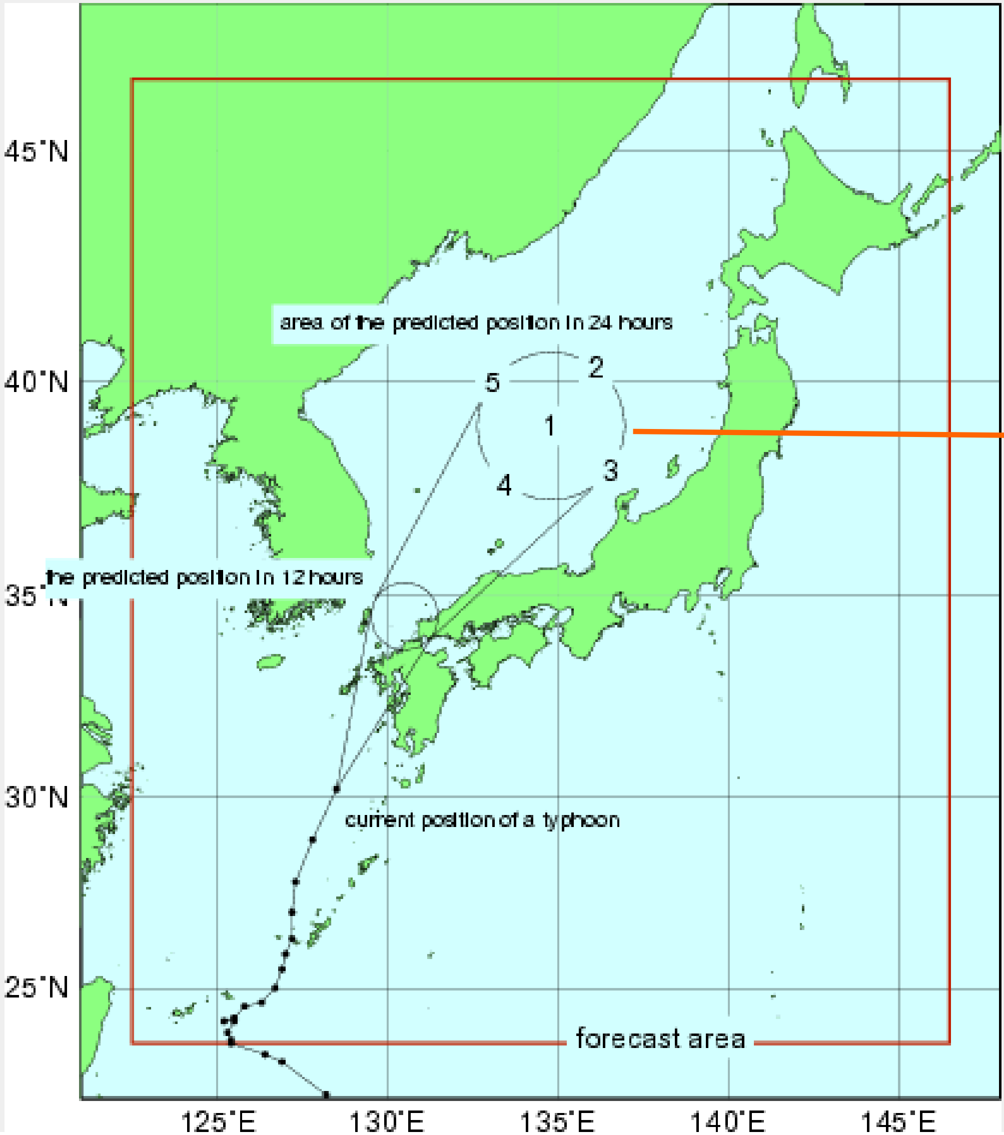
5 model runs for 5 possible typhoon tracks



- The model provides 5 storm surge forecasts for 5 possible typhoon tracks.

1 Center track
2 Fastest track
3 Right-hand side track
4 Slowest track
5 Left-hand side track

Quantitative Estimation of Tsunami

Initial Tsunami Wave Estimation by Fault Model (100,000 different cases)

+

Tsunami Propagation by Numerical Simulation with 2-4km grid size

↓

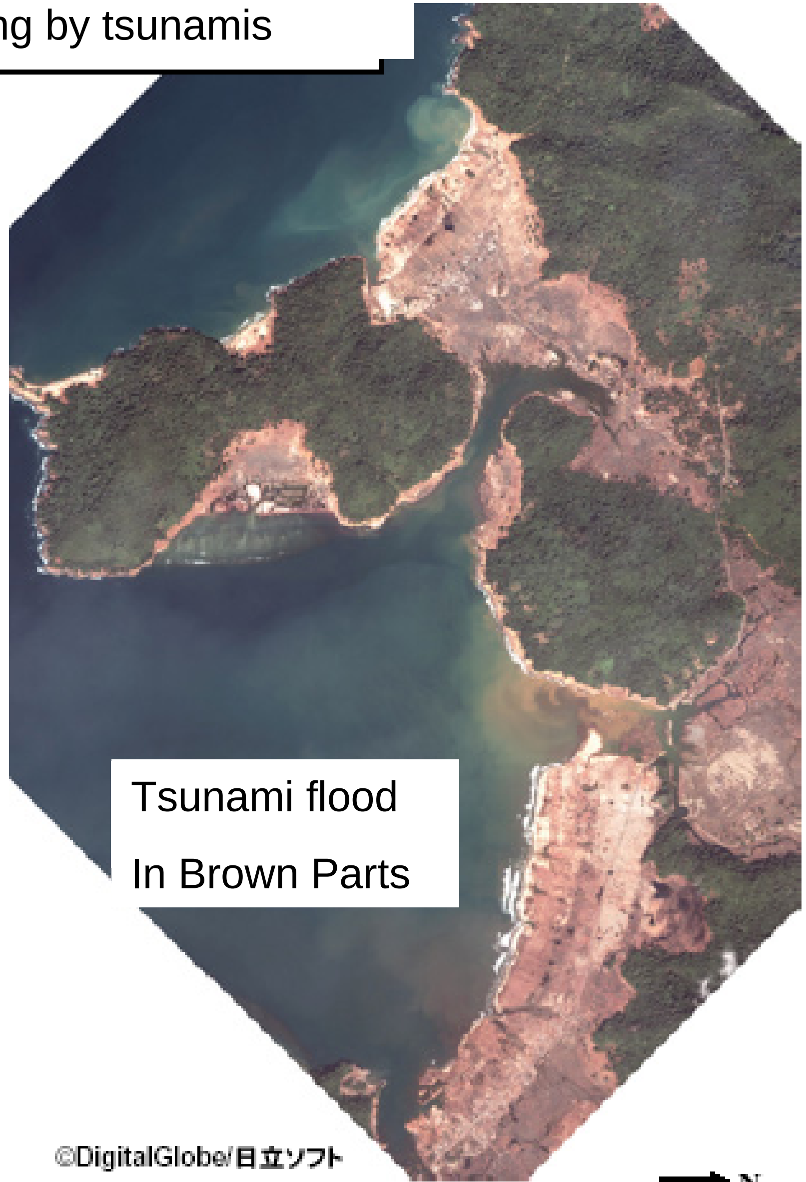
Database of Tsunami Heights and Arrival Times as a Result of the Simulation

Breaking tsunami on Kao Lak Beach

SW part of Banda Ache ／ Tsunami Disaster in Glee Bruk District

Wash away of everything by tsunamis

Before 2004.4.12



After : 2005.1.2

Taro-Chou in Japan in 1933

Before tsunami

After tsunami

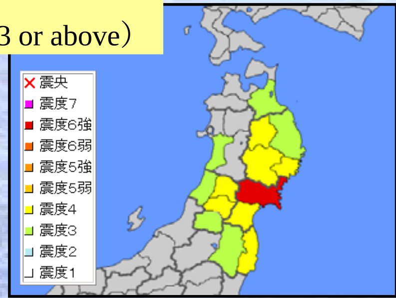
Tsunami Forecast		Value of Tsunami Height to be issued
Tsunami Warning	Major tsunami	“3m”,“4m”,“6m”, “8m”,“over 10m”
	Tsunami	“1m”,“2m”
Tsunami Advisory	Tsunami attention	“0.5m”

Procedure of issuance of tsunami forecast and earthquake information

Earthquake

2min.

Seismic Intensity Information
（areas which observed 3 or above）



3min.

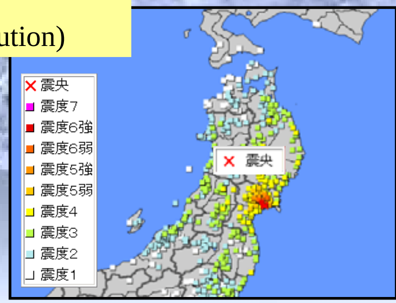
Tsunami Forecast
(warning and advisory)

Tsunami Information
(estimated heights and estimated times of initial wave arrival)

Earthquake Information
(hypocenter, M and "No tsunami is generated")
*This information is issued in case of the earthquake does not generate a tsunami.

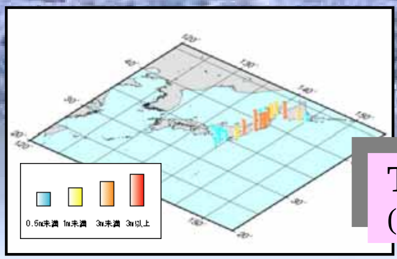
5min.

Earthquake and Seismic Intensity Information
(hypocenter, M and seismic intensity distribution)



Tsunami Information
(estimated times of initial wave arrival and highest tide times)

Tsunami Information
(tsunami observations)



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Information

Rapid information

Structural Barriers

Aerial photograph of present Taro-Cho

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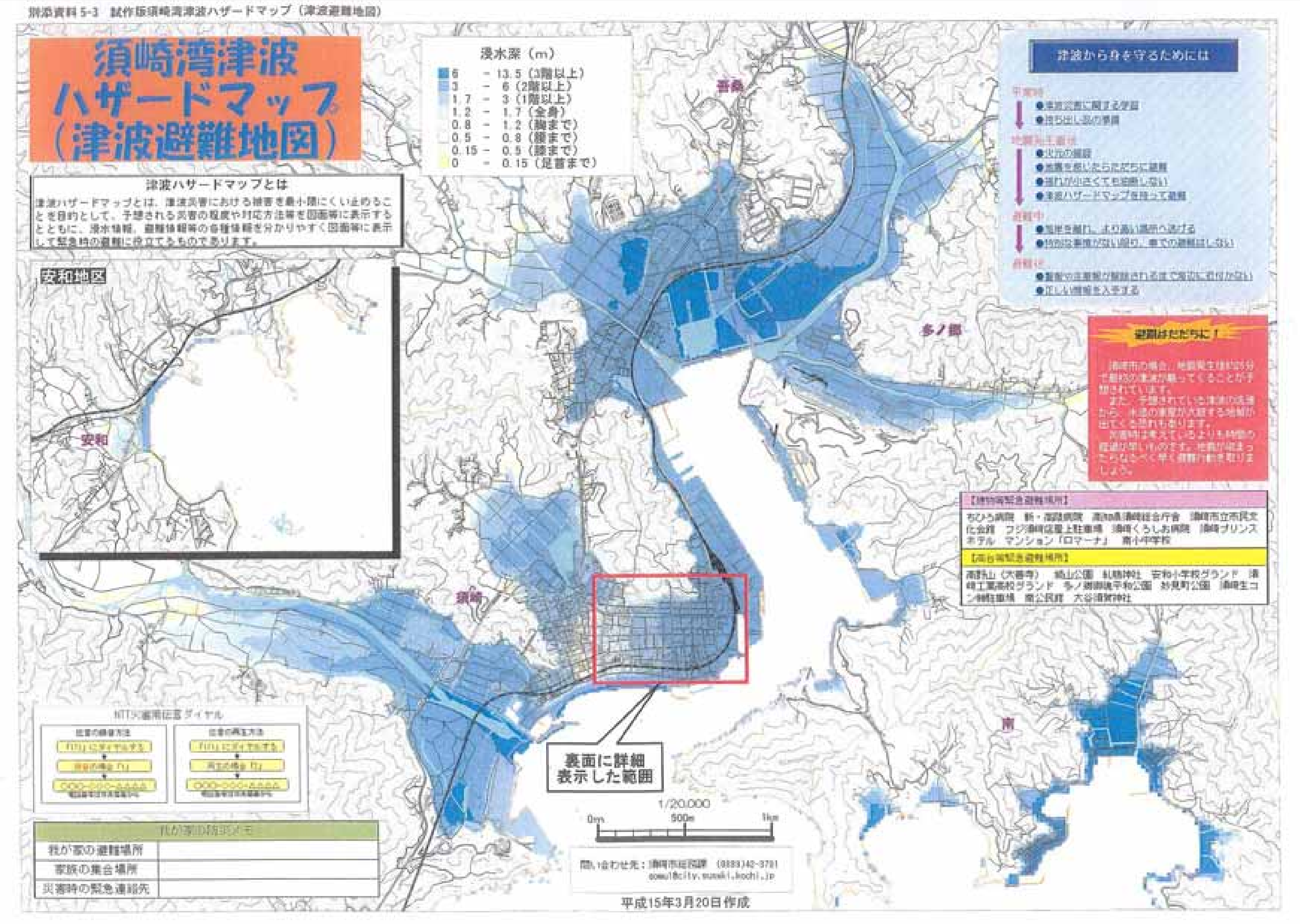
Storm surge protection line in Tokyo

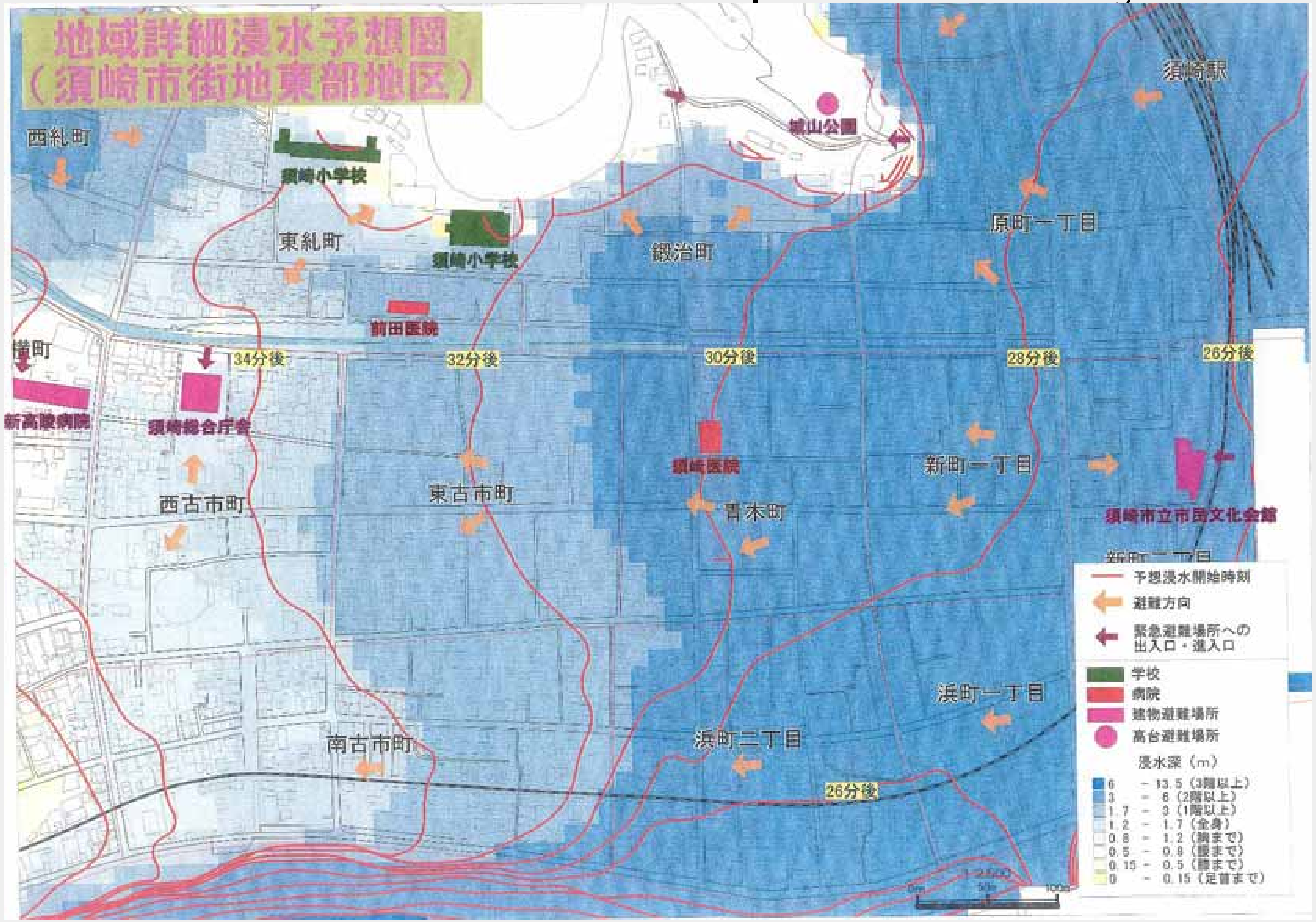
Water gate

Shelter for tsunami events

Tsunami hazard map for Suzaki-City



Tsunami hazard map of Suzaki City



Disaster Reduction Hyperbase (DRH)

- Database management system of knowledge and technology for various disaster prevention/reduction, which includes:

- Implementation oriented technologies
- Transferable indigenous knowledge
- Process technologies

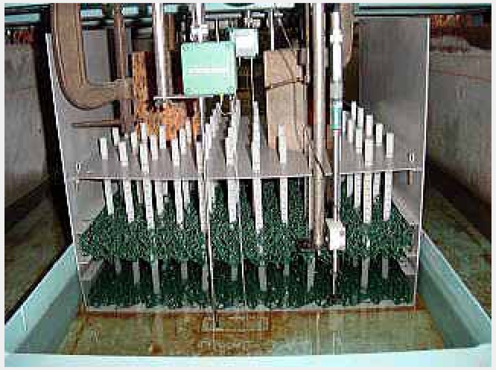
Oriented Technology

Reduction of tsunami flow pressure in greenbelt- (mangrove, waru, etc.)

(EqTAP Project: PARI, Japan and CDRC, Indonesia)

Project in Sulawesi Island, Indonesia

- *Can not stop tsunamis but can reduce their effects.
- *Inexpensive, no "high-tech" required
- **<u>*Design guideline*</u>** developed through lab tests and numerical simulation
- *Being implemented in Sulawesi Island, and other 14 sites in Indonesia.



Laboratory test

Criteria for Transferable Indigenous Knowledge (TIK)

ver. 070702(FM1)
070917(Stresa)

- Originated within communities, based on local needs, and specific to culture and context (environment and economy)
- Provides core knowledge with flexibility for local adaptation for implementation
- Uses local knowledge and skills, and materials based on local ecology
- Has been proven to be useful in disasters
- Is applied or applicable in other communities or generations

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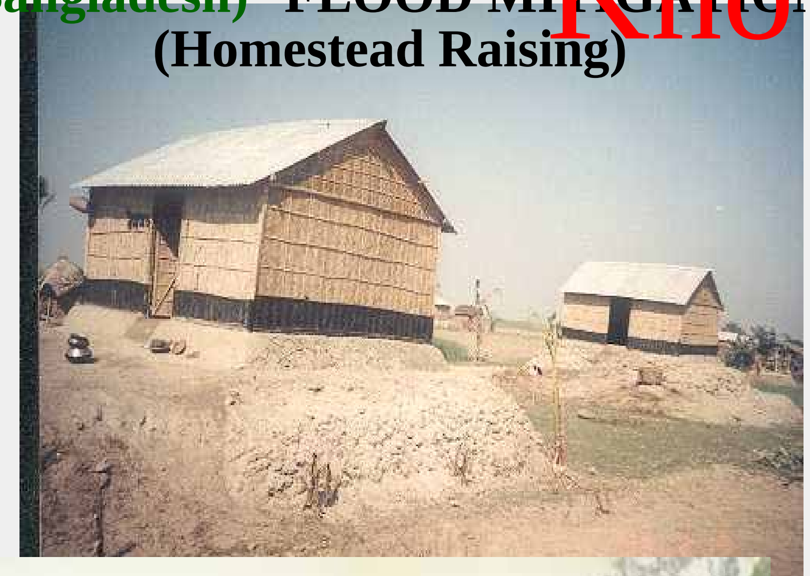
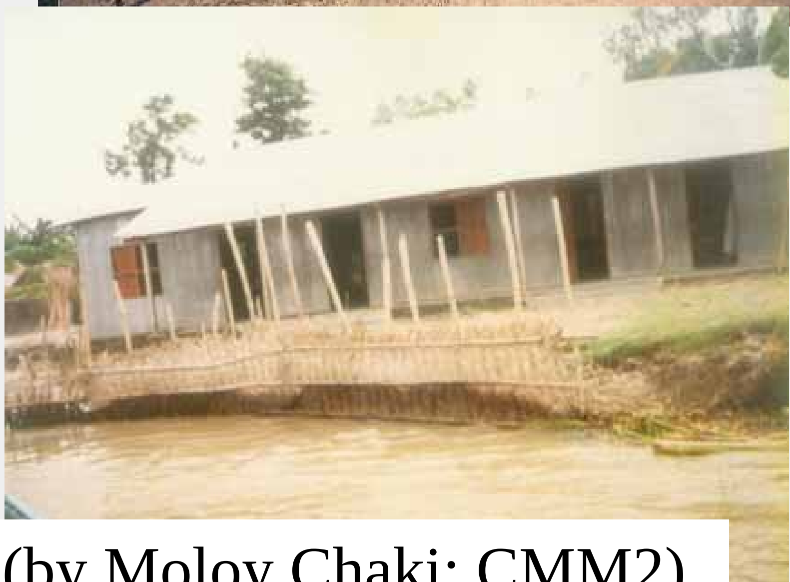
Indigenous Knowledge

(Bangladesh) FLOOD MITIGATION (Homestead Raising)





(by Moloy Chaki: CMM2)

(Japan) "Mizuya" (Flood house)

(NIED-KU survey team)

Disaster management cycle

Water management : to apply structural and non-structural measures to modify natural and man-made water systems for the enhancement of human welfare as well as the conservation of natural environment.

- water supply
- wastewater treatment
- water quality improvement
- flood disaster mitigation
- debris/sediments control
- hydropower generation
- navigation
- recreation
- conservation/restoration of eco-system

Water has diverse functions, and the water management includes various subjects.

Lessons learned from recent water-related disasters

- Awareness of
  - disaster risks,
  - vulnerability by social change,
  - possible climate change impacts
- Insufficient preparedness due to
  - lack of proper information,
  - overconfidence or ignorance,
  - limited budget
- Needs for
  - capacity building, education
  - integrated disaster management,
  - fundings

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Vulnerable people are always hit by disasters.

災害弱者がいつもやられる。

災害は脆弱な人と場所を襲う。

An ounce of prevention is worth a pound of cure.

1オンスの予防薬は
1ポンドの治療薬に値する。
(備えあれば憂いなし)