Sentinel Asia Flood WG

- Report on Recent Activities -

2nd Joint Project Team Meeting for Sentinel Asia STEP3 (JPTM2014)

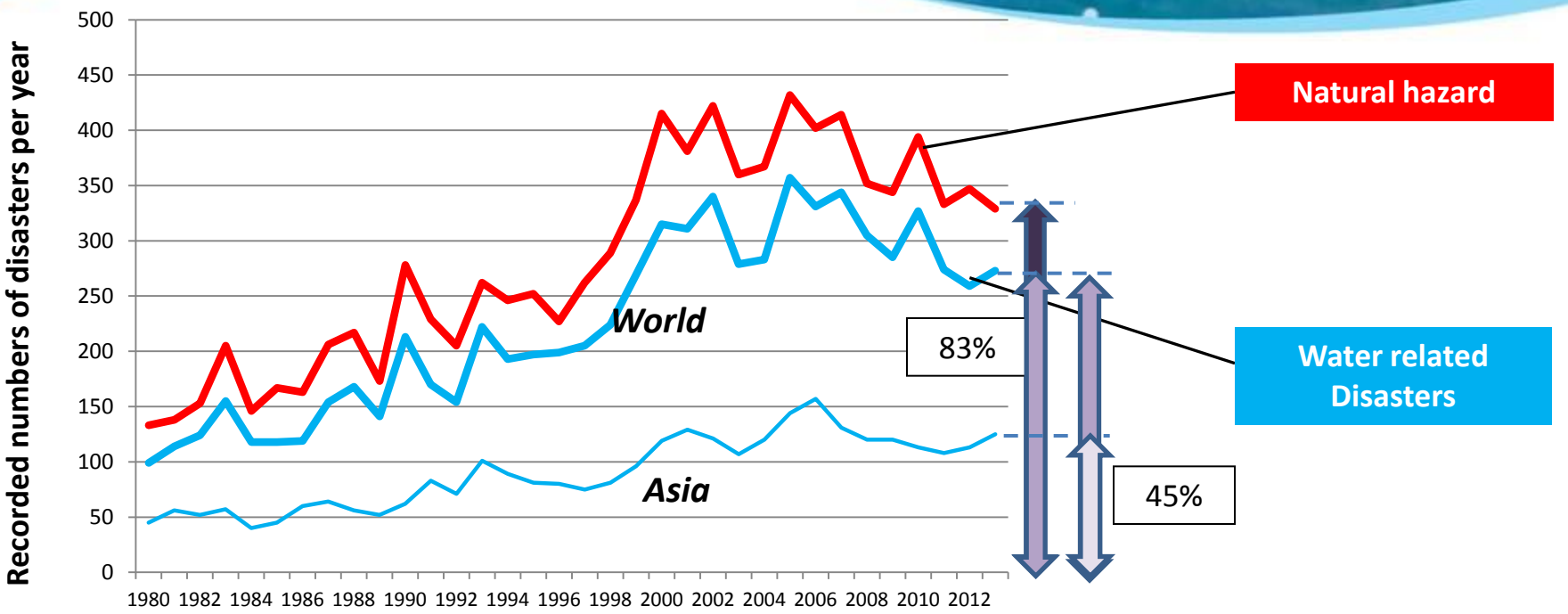
at Asia Plaza Hotel, November 19-21, 2014, Yangon, Myanmar

Yoichi IWAMI

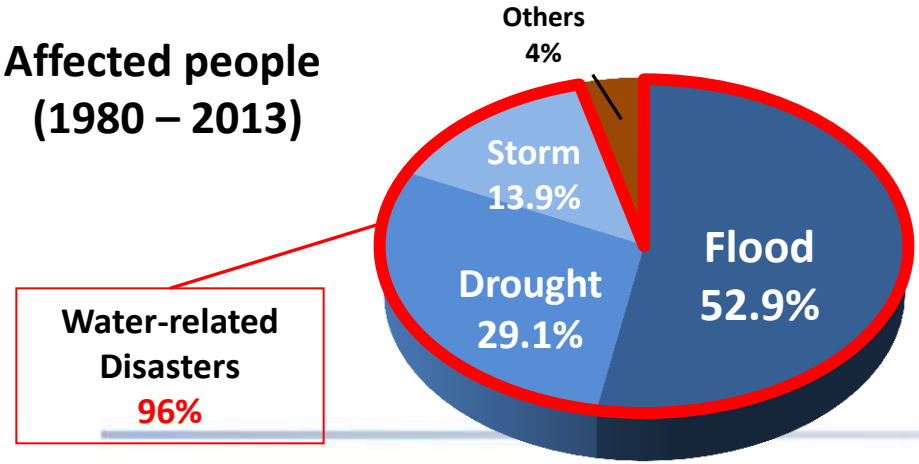
International Centre for Water Hazard and Risk Management (ICHARM)
under the auspices of UNESCO

Increase in water-related disasters

Increasing and evolving disasters (1980 – 2013)



Affected people (1980 – 2013)



Source: EM-DAT (The OFDA/CRED International Disaster Database, Université Catholique de Louvain, Belgium)
Reproduction by ICHARM, 2014

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Objective of Flood WG in Sentinel Asia

(Step 1 2006- & Step 2 2008-)

- To contribute to the mitigation of flood disasters in Asia through:
  - utilizing satellite, GIS and information network technologies, combined with in-situ data,
  - enhancing the development of the basis for sharing information on flood risks and disasters among national and international organization in relation to flood management,
  - and realizing the above development and information sharing on the basis of Sentinel Asia network system

Outcome of Flood WG (STEP 1, FY2006-2007)

- *Emergency ALOS-image delivery for flood disaster monitoring through the ADRC gateway* - supported by JAXA-ADRC
- *Global cloud cover image and its overlay on Digital Asia*
  - Provided by Japan Meteorological Agency (JMA)
- *Global satellite-based Daily rainfall map & heavy rainfall identification and its overlay on Digital Asia*
  - Provided by IFNet (International Flood Network)
    = "GFAS" (Global Flood Alert System) based on NASA-3B42RT
- *Global flood identification using AMSR-E*
  - Linked with Dartmouth Flood Observatory
    = "Satellite Water Watch" on the basis of AMSR-E
- *Mini-projects for flood disaster management using satellitte and GIS databases*
  - Conducted by JAXA and AIT

Those are most fundamental data for flood management.

Outcome of Flood WG (STEP 2, FY2008-2012)

1. Enhancement of rainfall information

1) Global satellite-based hourly/10km-grid rainfall mapping based on microwave radiometers = GSMaP_nRT (by JAXA)

2. Enhancement of flood / inundation forecasting system

1) **IFAS (Integrated Flood Analysis System)** applications with satellite - based rainfall and global GIS (by ICHARM)

- APRSAF-IFAS Seminars = 1st: Myanmar (2010), 2nd: India (2011)
- MAHASRI-IFAS Seminar = Vietnam (2011)
- UNESCO-IFAS Seminar = 1st: Vietnam (2012), 2nd: Indonesia (plan)

- IFAS-based flood warning system : Bengawan Solo River (Indonesia / ADB), Indus River (Pakistan / UNESCO), Cagayan (on going, Philippines / ADB), Kelantan & Dungun Rivers (on going, Malaysia / JICA-JST),

849 trainees from 45 countries have had IFAS training 2007 - 2013

2) **RRI (Rainfall-Runoff-Inundation)** model applications with satellite-based DEM and global GIS (by ICHARM)

- Chao Phraya River Flood in 2011 Mapping and Forecasting
- RRI-based flooding simulation system : Thailand etc.

Objective of Flood WG in Sentinel Asia for STEP3 (2013 ～)

- To contribute to the mitigation of flood disasters in Asia through:
  - Developing necessary scientific & engineering information for understanding flood hazards / risks with full utilization of satellite, GIS and information network technologies, combined with in-situ data
  - Enhancing the provision and usage of such innovative information for sound decision-making in all the stages of "flood risk management cycle"
  - Sharing such experiences and achievements in Asia on the basis of Sentinel Asia network system

The Combined Use of Remote Sensing / GIS with Hydrologic / Hydraulic Simulation Technology contributes to All the Stages of Flood Risk Management Cycle

Proactive measure

Mitigation

Flood Hazard Map
Flood Forecasting and warning
Flood insurance
Levee protection (flood drill)
Water-resistant house

Post measure

Disaster Response Operations

Levee protection
Information transmission and share
Flood warning and evacuation order
Rescue and relief
Provision of shelter

Integrated Flood Management

Disaster Prevention and preparedness

River improvement, Levee construction
Construction of flood control structures
Designation of flood prone / allowed areas
Urban plan with land use zoning / spatial management
Raise the height of housing lot

Disaster Recovery and Reconstruction

Disaster rehabilitation
Epidemic prevention
Rebuilding homes
Investigation into the cause of disaster
Record the lessons

Concept of Flood Monitoring in Sentinel Asia

Observation | **Processing** | **Integration**

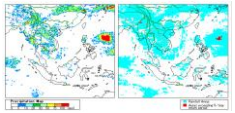
Rainfall Monitoring & Flood Forecasting

Rainfall Measurement from Satellites

TRMM, GPM, AMSR-E...

・Rainfall Data

Areal Rainfall Estimation Runoff and Inundation Analysis



GSMaP*1, GFAS*2, IFAS*3, RRI*4

・Precipitation Map
・Heavy Rainfall Estimation

・Flood Forecasting and Warning
・Probable Rainfall Map

Coupling with Global / In-situ Data

- Social Economic Data
- Land-use/cover Data

- Heavy Rainfall Alert
- Real-time Flood Inundation Monitoring
- Precipitation and Flood Inundation on Web GIS
- Flood Alert for Specific River Basins
- Flood Risk Map
- Flood disaster damage map
- Evacuation map

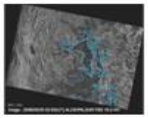
Flood Detection & Situation Analysis

Land Observation from Satellites

ALOS, MODIS, AMSR-E....

・Land Image

Fine DEM Generation Flooding Area Detection



JAXA, ICHARM, Dartmouth University...

・Identification of Flood-prone Area and Flooding Frequency

• Flood Hazard Map

Creating and Sharing Information for Flood Management In all Stages of Flood Disaster

Users

Residents in Flood-prone Area

・Planning
・Warning

・Evacuation
・Rescue
・Remediation

Disaster Management Organizations

*1 GSMaP = GSMaP_nRT
= Near Real-time Global Satellite-based Map of Precipitation (by JAXA)
*2 GFAS = GFAS-Rainfall
= Global Flood Alert System – Heavy Rainfall Alert (by IFNet)
*3 IFAS = Integrated Flood Analysis System
for the implementation of the concept of GFAS-Streamflow (by ICHARM)
*4 RRI = Rainfall-Runoff-Inundation model (by ICHARM)

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Activities for Rainfall monitoring and flood forecasting

- Flood WG of Sentinel Asia -

GFAS (Global Flood Alert System) - Rainfall

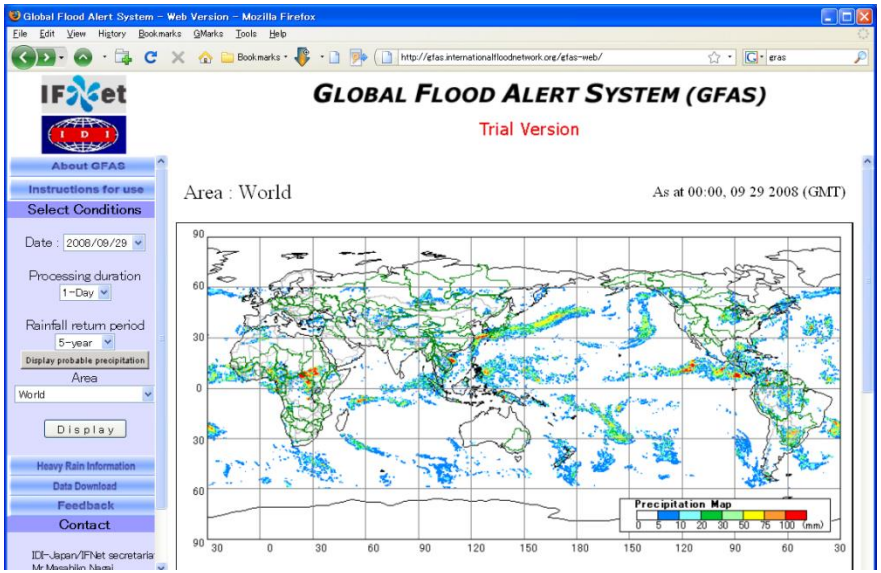
http://gfas.internationalfloodnetwork.org/gfas-web/

Rainfall information
from observation satellites

Data Obtainment
Data Processing
Data Dissemination

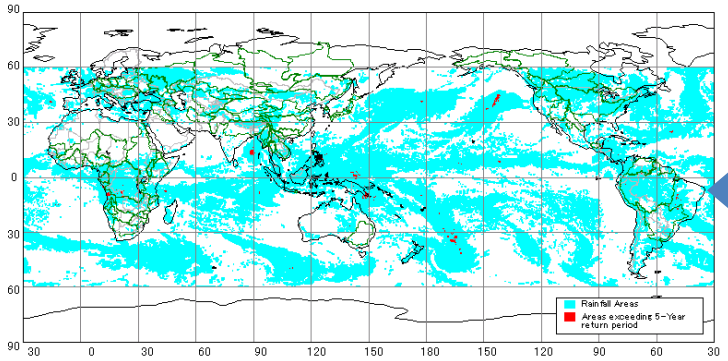
Website: Maps, Data
E-mail delivery:
Heavy Rain Notice

Flood Forecasting and Warning
by using GFAS information



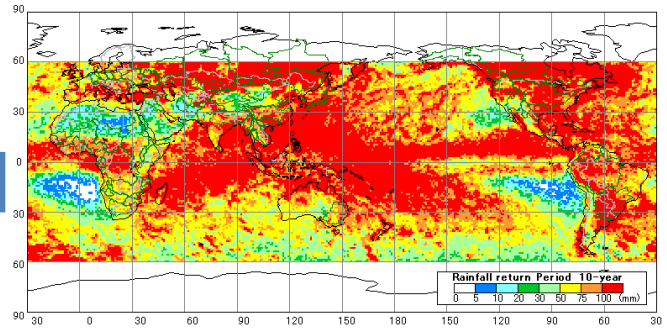
Real-time Rainfall Map (every 3 hour)

Heavy rainfall identification → alert



Real-time estimation of rainfall areas

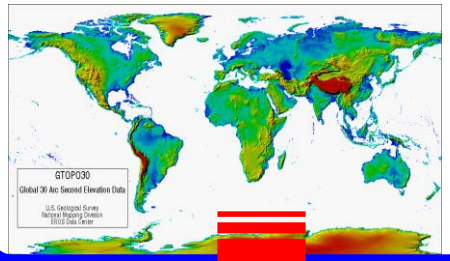
Exceeding 10- (or 5-) Year Return Period

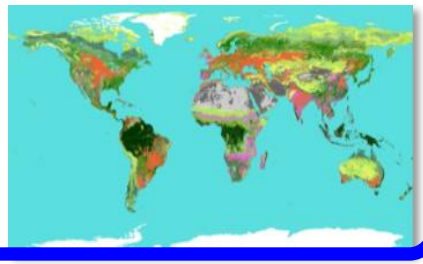


Pre-analyzed rainfall distribution exceeding 5 or 10-year return period

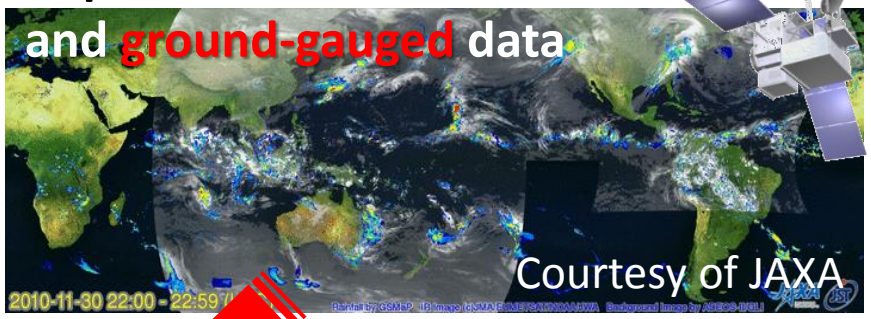
Integrated Flood Analysis System (IFAS) for insufficient observed basin GIS based Free system

Global data: topography, land use, etc.





Import satellite rainfall and ground-gauged data



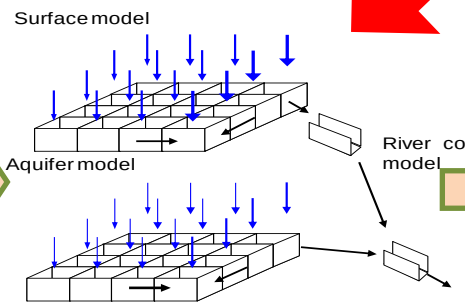
input

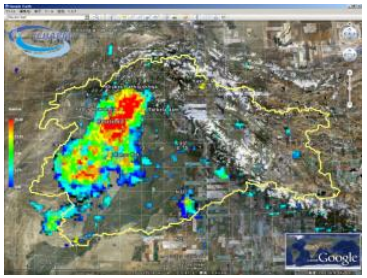
input

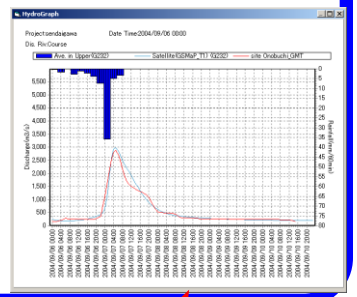
Run-off analysis by PWRI distributed tank model

Output: Rainfall distribution, River discharge, Water level hydrograph

Model creation







Judge by River management authorities

Alert message by E-mail and on the display for river management authorities

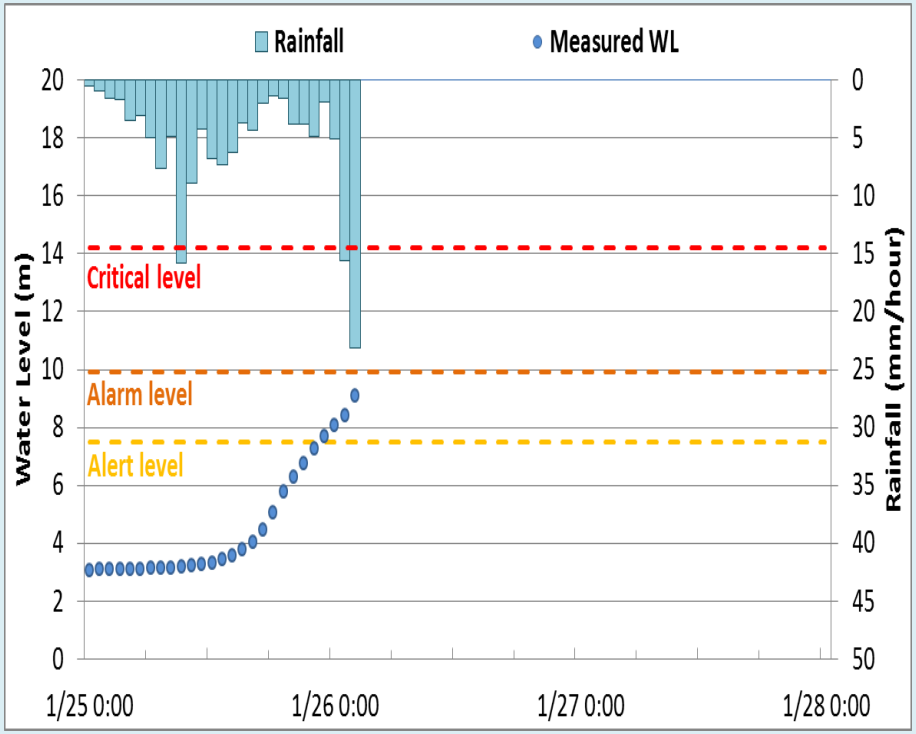
Discharge reaches warning level

Evacuate from dangerous areas

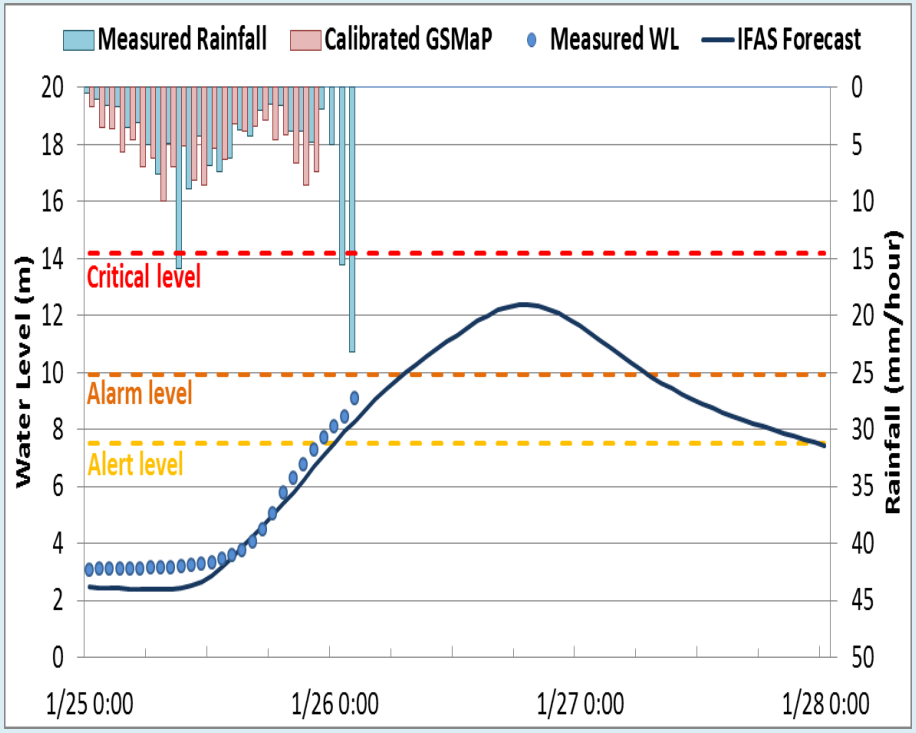
Available Information during flood (Cagayan river)

At Gamu (as of 3:00AM 26th Jan. 2006)

Existing data

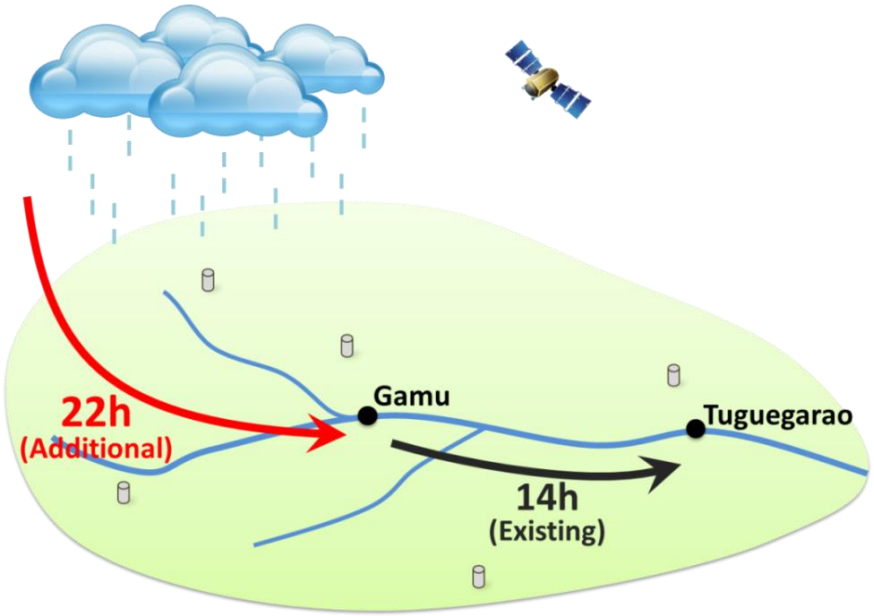


Forecasted info with a model

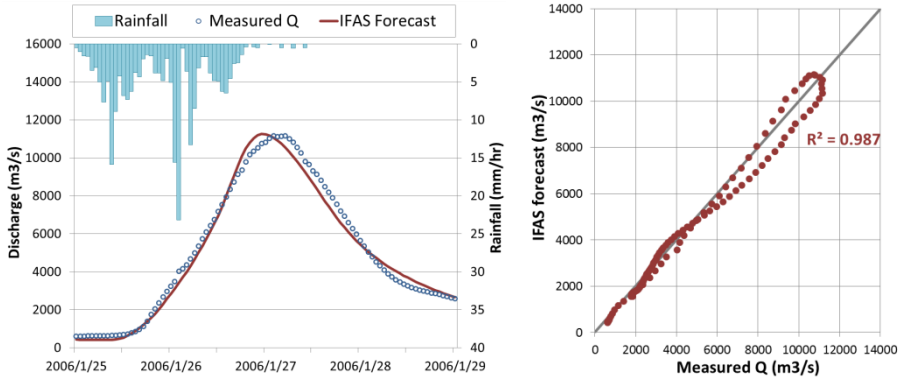


Benefits of IFAS

- **Lead-time**

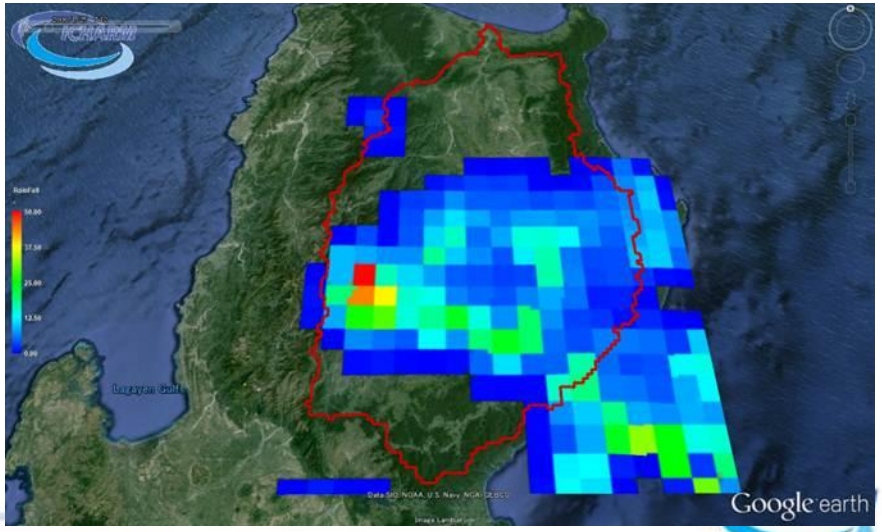


- **Reliability (Parameter tuning)**



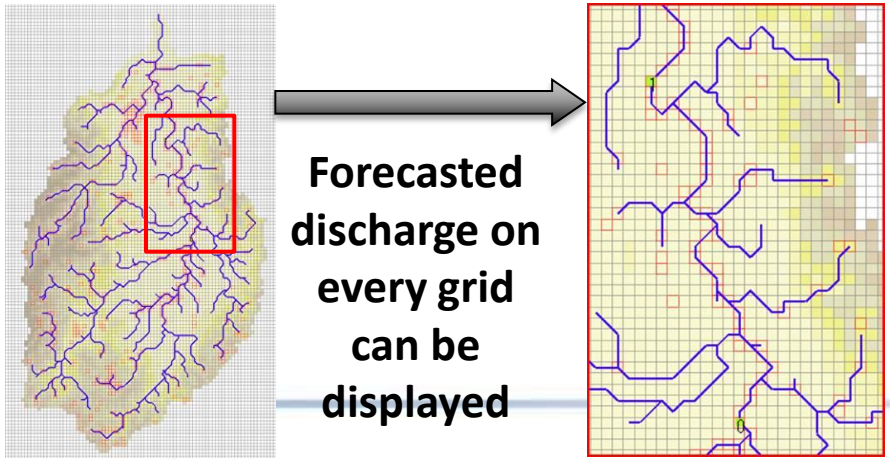
Example of simulation result

- **Visual display (Panoramic view)**



Example of calibrated GSMaP

- **Basin-wide Forecasting**



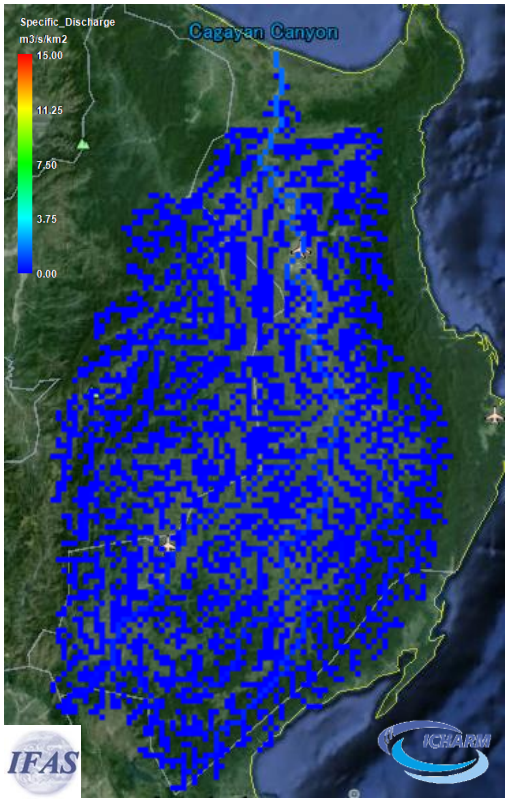
Forecasted discharge on every grid can be displayed

IFAS Dynamic Map

Specific discharge, discharge and rainfall can be displayed as a basin-wide animation.
Users can easily realize the situation of whole basin and risk area.

Rainfall

discharge



Specific discharge

Specific discharge ($m^3/s/km^2$) means the value of discharge divided by catchment area.

Specific discharge at Gamu (12,200km^2)
Critical level: 0.76
Alarm level: 0.39
Alert level: 0.23

Global Precipitation Measurement (GPM)

Current Observation System:

TRMM **and** other orbital Satellites**, and** 5 Geostationary Satellites

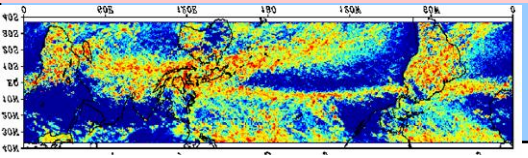
Core Satellite

Dual Frequency Radar
Multi Frequency Radiometer

✧Observation of rainfall with more accurate and higher resolution

✧Adjustment of data from constellation satellites

JAXA (Japan)
Dual frequency Radar, Rocket
NASA(US)
Satellite Bus, Micro-wave gauging measurement

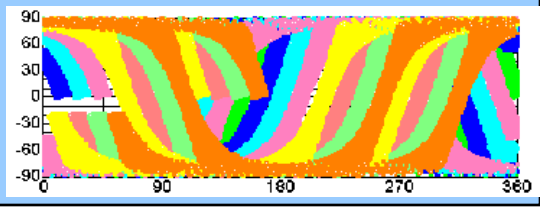


8 Constellation Satellites

Satellites with Micro-wave Radiometers

✧More frequent Observation

Cooperation：
NOAA(US),NASA(US),ESA(EU), China, Korea and others



–**Earth heating Phenomena**

–**Study of Climate Change**

–**Improvement of forecasting system**

Global Observation every 3 hours

- **IWRM**
- **Flood Forecasting**
- **Forecasting of crop productivity**

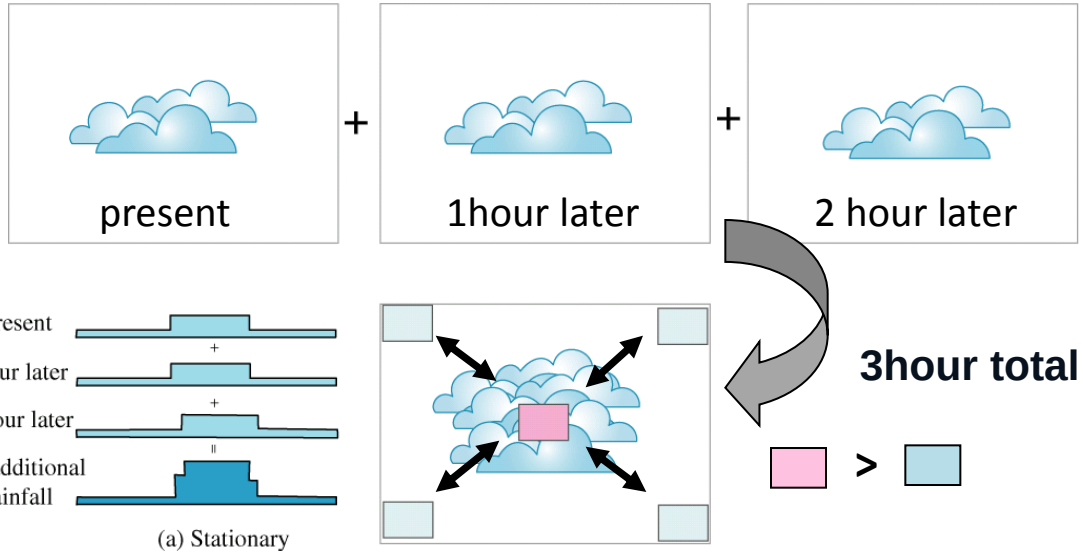
IFAS – Satellite rainfall data

- Several datasets have global coverage.
- Resolution (time and space) and observation accuracy are low compared with ground observation rainfall.

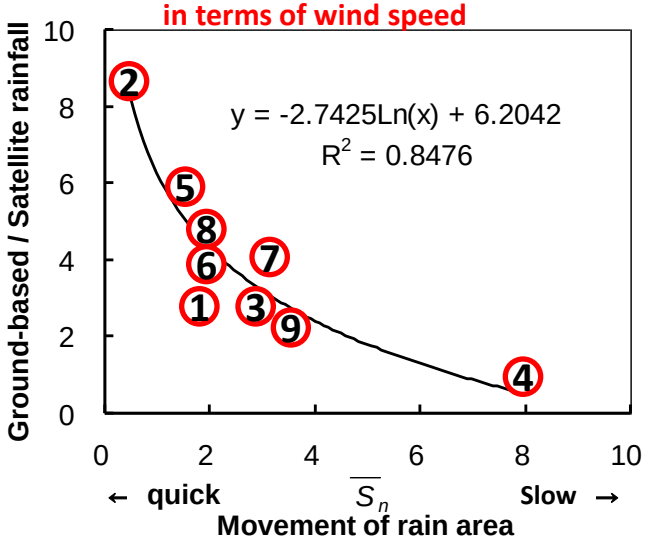
Product name	3B42RT	CMORPH	QMORPH	GSMaP_NRT
Builder	NASA/GSFC	NOAA/CPC	NOAA/CPC	JAXA/EORC
Coverage	50N～50S	60N～60S	60N～60S	60N～60S
Spatial resolution	0.25˚	0.073˚	0.073˚	0.1˚
Time resolution	3 hours	30 minutes	30 minutes	1 hour
Delay of delivery	6 hours	18 hours	3 hours	4 hours
Coordinate system	WGS			
Data archive	Dec. 1997～	Recent 1week	Recent 1week	Dec.2007～
Data source (sensor)	Aqua/AMSR-E, AMSU-B, DMSP/SSM/I and TRMM/TMI and IR	TRMM/TMI, Aqua/AMSR-E, AMSU-B, DMSP/SSM/I and IR		TRMM/TMI, Aqua/AMSR-E, DMSP-F13-15/SSM/I, DMSP-F16-17/SSMIS, IR data

Algorithm for self-correction of satellite-based rainfall data by ICHARM

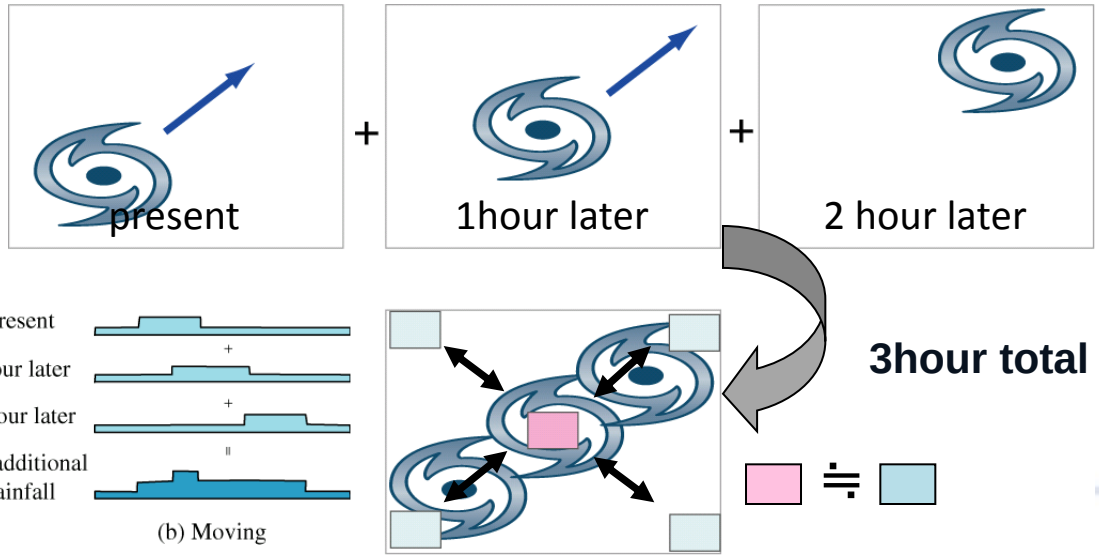
Rain event with slow movement of a rainy area

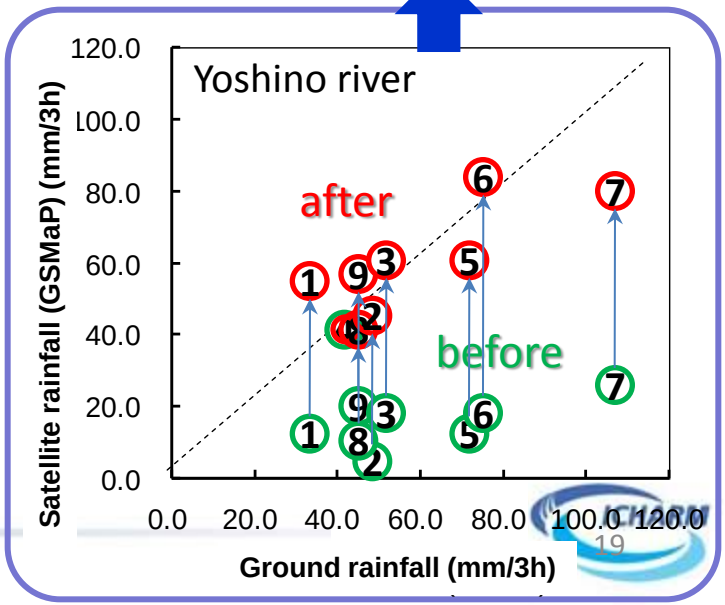


correction method
to describe the difference of rainfall events
in terms of wind speed



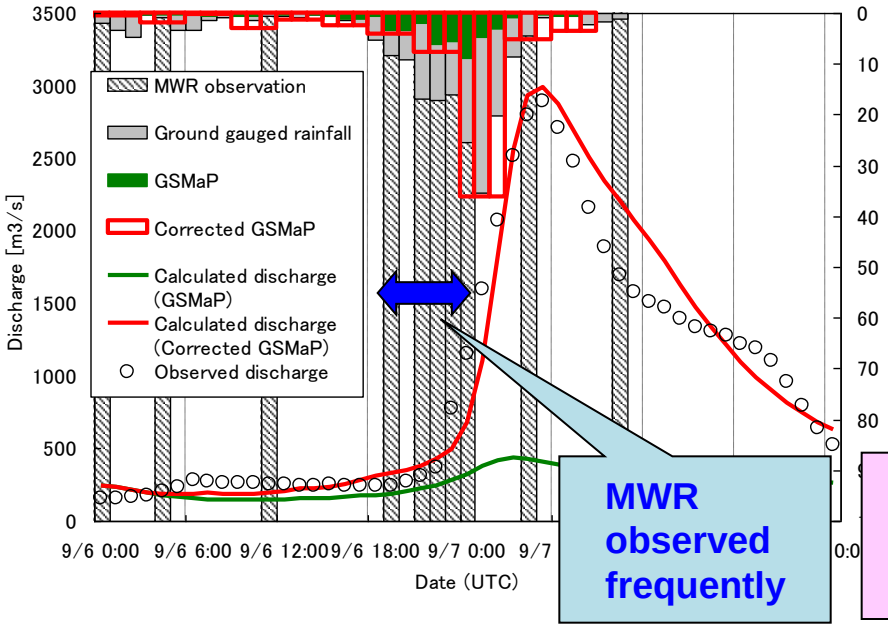
Rain event with quick movement of a rainy area



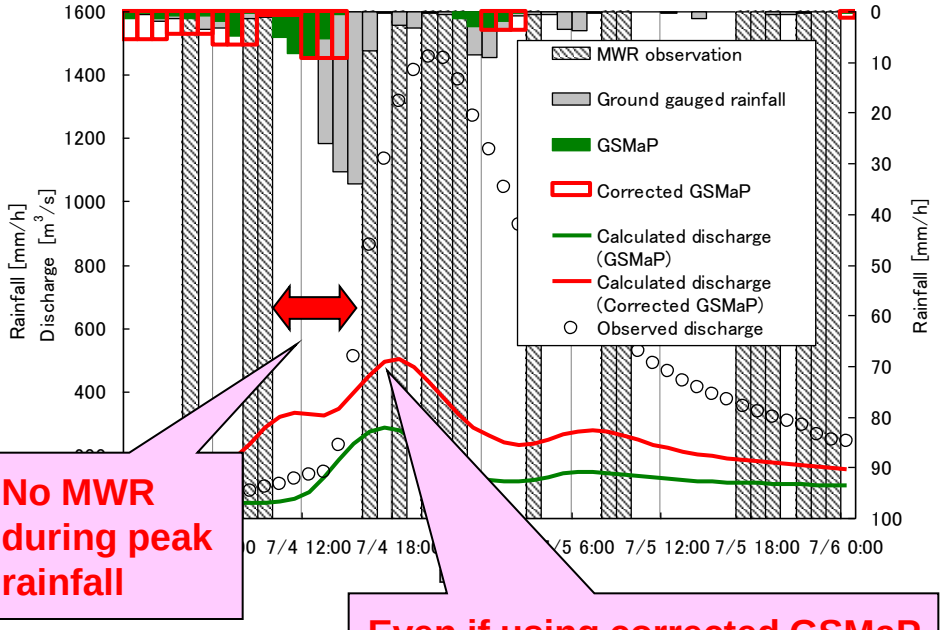


Difference of Frequency of Microwave radiometer Observation between the two river basins

Successful case : Sendai river



Unsuccessful case : Kikuchi river



Ozawa et al. (2010)

Even if using corrected GSMaP by rain area movement speed, the accuracy is not good.

Accuracy of rainfall area distribution depends on frequency of MWR observation (& accuracy of IR motion vectors)

We are expecting new GPM - GSMaP with real time correction by ground gauges

IFAS Training for ASEAN countries by JICA/AHA center

"Capacity Development for Immediate Access and Effective Utilization of Satellite Information for Disaster Management"

on October 6-10, 2014 at Sari Pan Pacific hotel in Jakarta

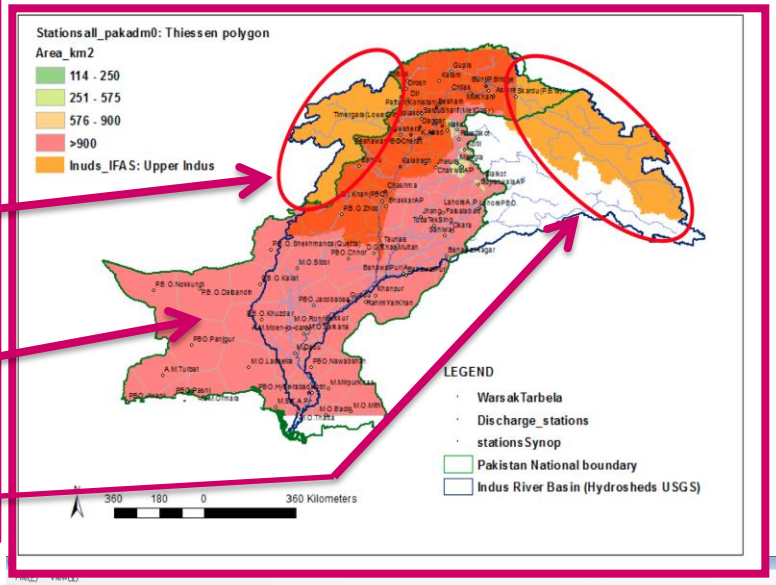
19 participants from 10 countries /organization (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Vietnam and AHA center)

IFAS result in Dungun river basin in Malaysia
Test run by UNITEN and DID in December 2013

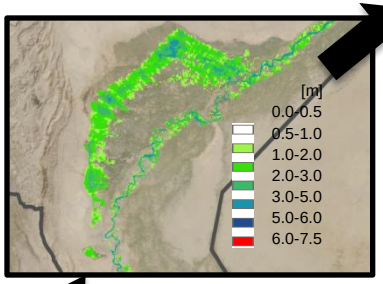
Indus-IFAS: flood forecasting system based on IFAS / RRI (UNESCO-Pakistan project 2012-14)

INPUT DATA CHALLENGES:

- *Lack of trans-boundary data*
- *Null-Low rain gauges network density*
- *Uncertainty on snowmelt*



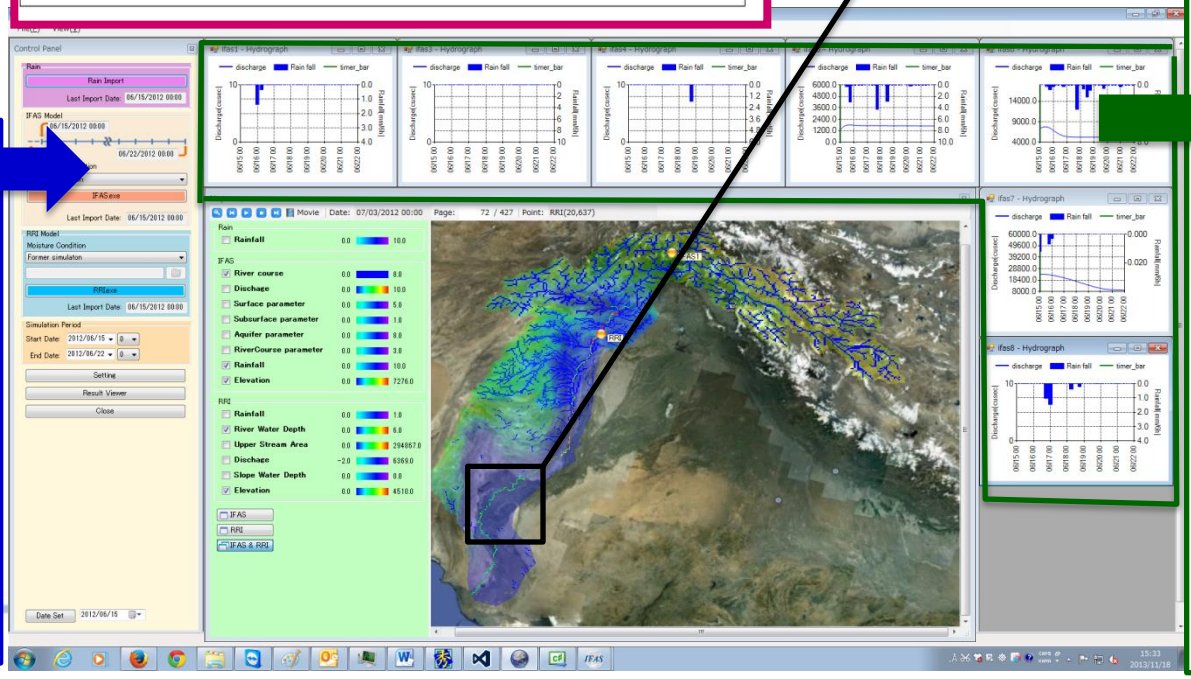
Inundation area by RRI



FLOOD HAZARD MAPPING

INPUT DATA :

- Rainfall data (PMD ground-gauges, GSMaP and forecasted)
- **Real-time observed discharges**



OUTPUT DATA:

- Rainfall distribu-tion maps
- Hydro-graphs at specified locations
- Inundation extents in mid-low Indus

Capacity Building for Pakistan (2012-13)

6 Pakistani officers (PMD, SPARCO & IPD) graduating from ICHARM/GRIPS MSc

Short- training in Japan of 11 Senior Managers from Pakistan

Indus-IFAS training at FFD Lahore

ICHARM participation to international Workshop and Training in Pakistan

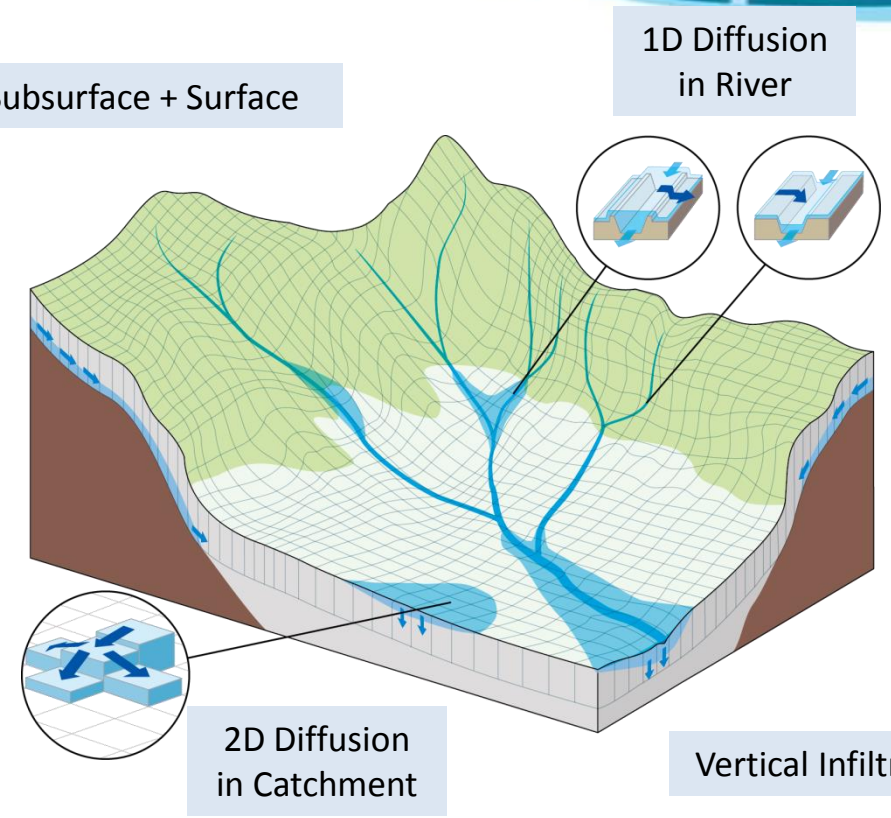
Indus-IFAS Flood forecasting on the web

by Pakistan Metrological Department, Flood forecasting Div. (http://www.pmd.gov.pk/FFD/index_files/ifashyd.htm) from 2013

RRI (Rainfall-Runoff-Inundation) Model Structure

Input

- Rainfall
- DEM
- Land Cover
- Cross Sec.



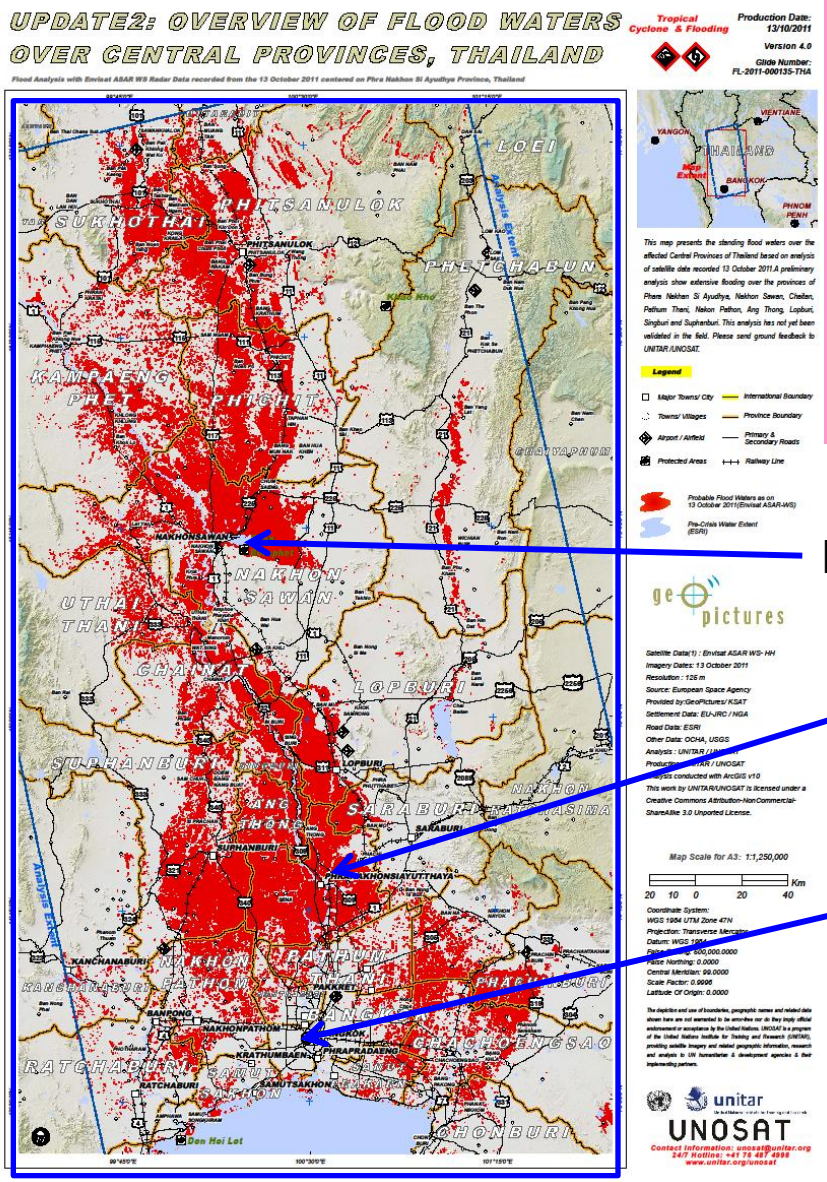
Output

- Discharge
- W. Level
- Inundation

- Two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously
- The model deals with slopes and river channels separately
- At a grid cell in which a river channel is located, the model assumes that both slope and river are positioned within the same grid cell

Sayama, T. et al.: Rainfall-Runoff-Inundation Analysis of Pakistan Flood 2010 at the Kabul River Basin, *Hydrological Sciences Journal*, 57(2), pp. 298-312, 2012.

13 Oct, 2011 by MODIS



Emergency inundation Simulation in Chao Phraya river basin in Thailand as of Oct.14, 2011

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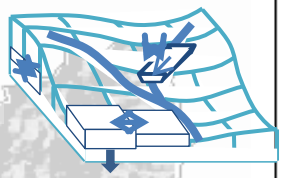
Simulation on Oct 18, 2011 by ICHARM

5m

Two dimensional diffusion wave model



RRI (Rainfall - Runoff - Inundation) model by using satellite data (3B42RT)

(Sayama 2011)

Nakhon Sawan

Ayutthaya

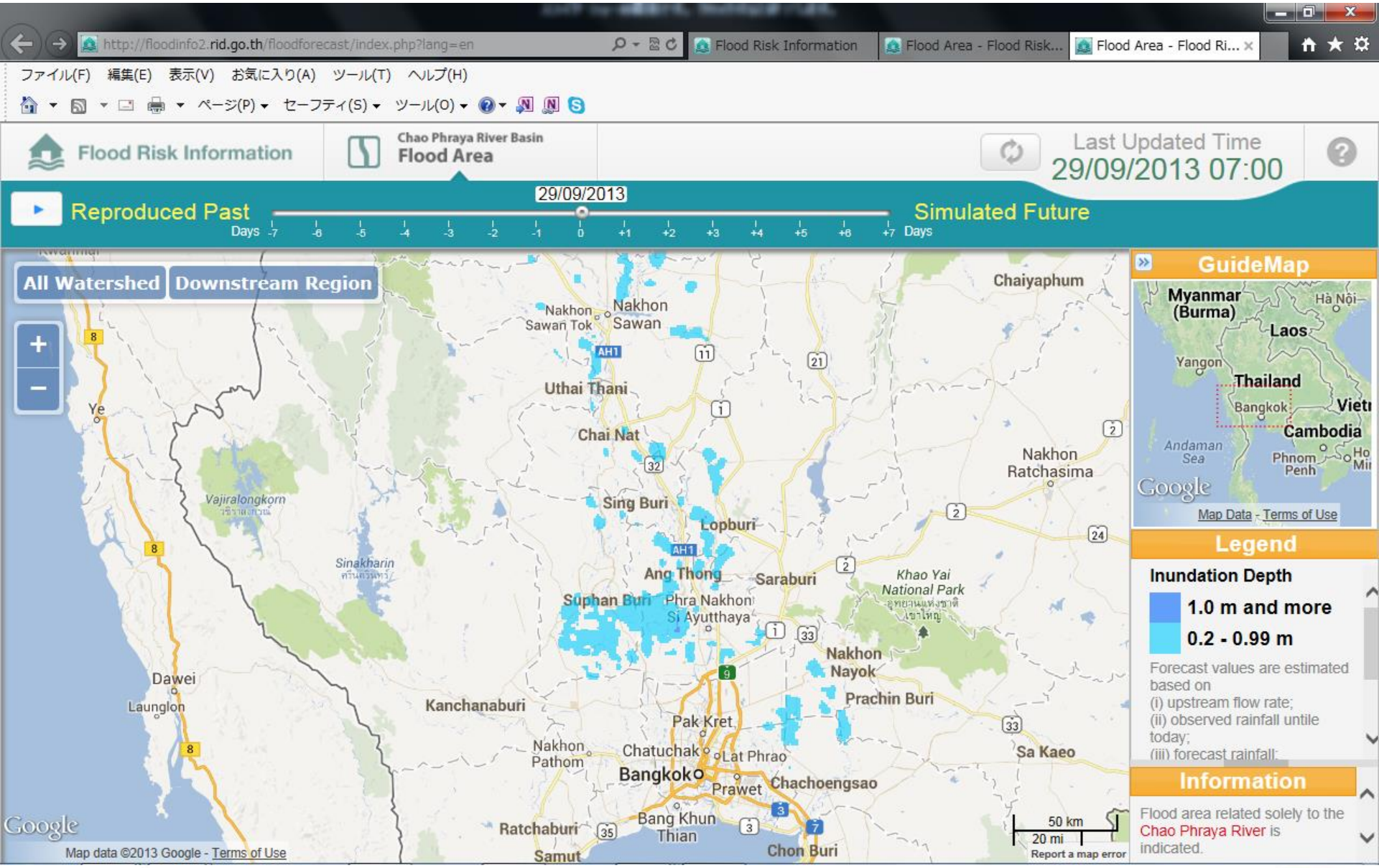
Bangkok

1 : July 2
31 : Aug 1
62 : Sep 1
92 : Oct 1
123 : Nov 1
152 : Nov 30

0m

Flood forecasting web site for Chao Phraya river basin using RRI model

(http://floodinfo2.rid.go.th/floodforecast/index.php?lang=en) from 2013



IFAS to enhance local ownership of flood forecasts and in-situ hydrological observation network on the ground

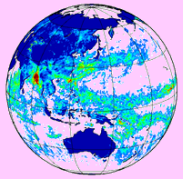
System

(Default)

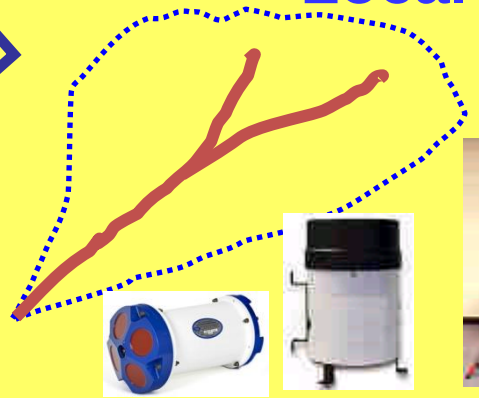
Training

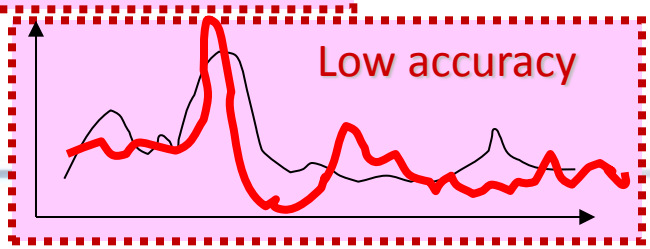
Better tuning

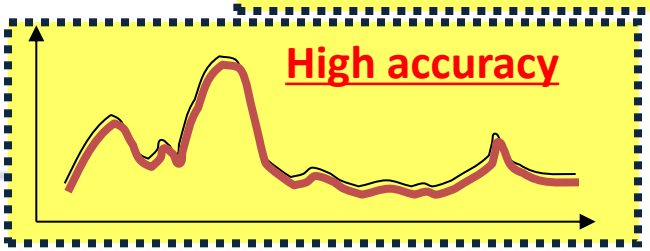
Global Data



Local Data







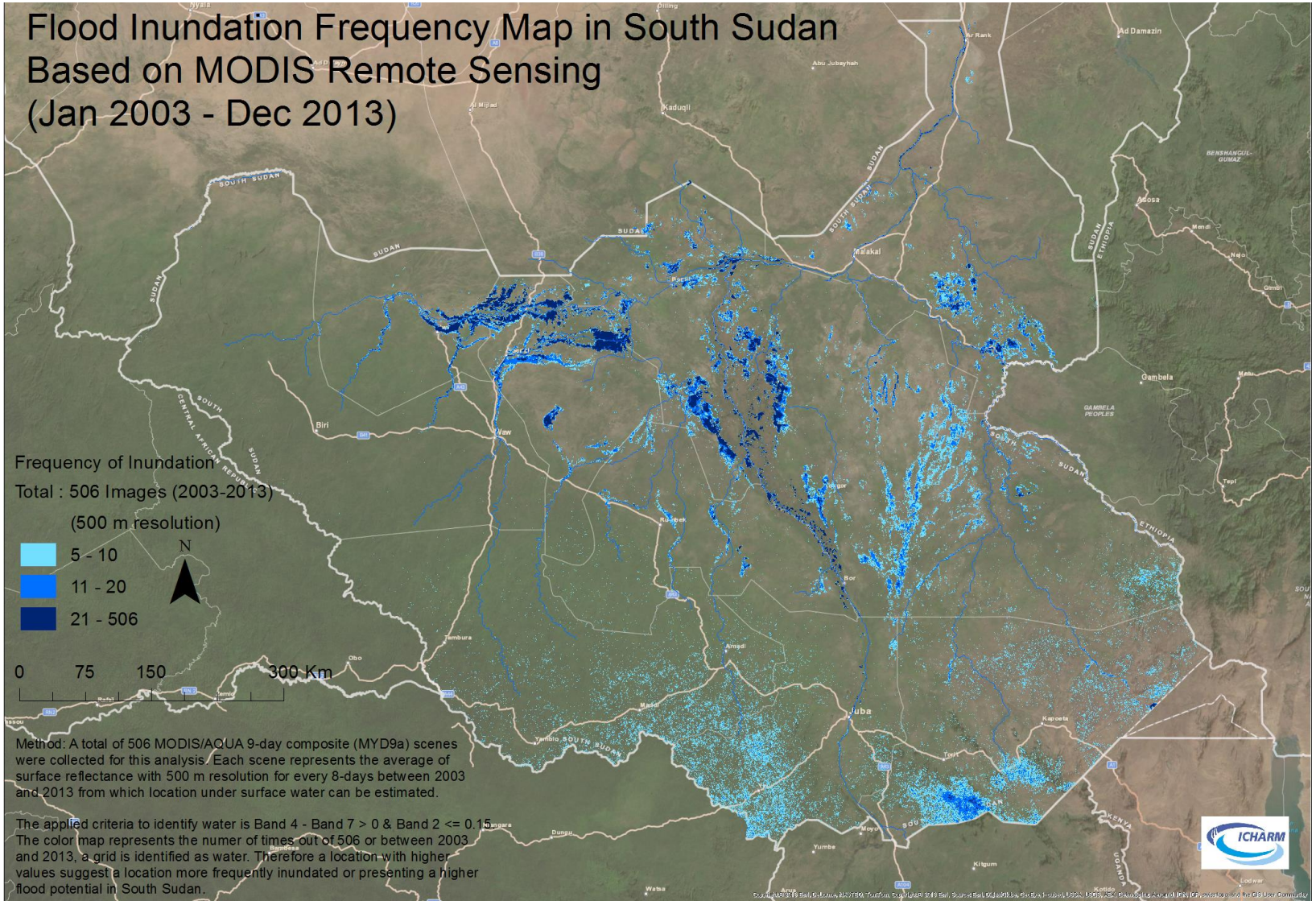
Activities for Flood detection and Situation analysis

- Flood WG of Sentinel Asia -

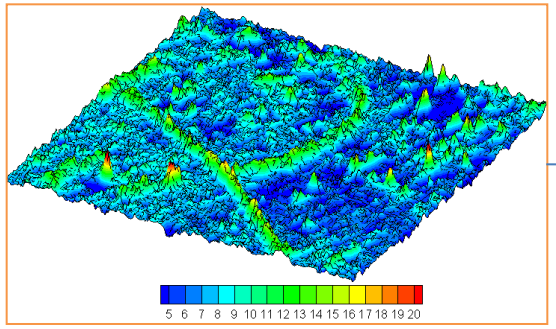
Flood Inundation Frequency Map in South Sudan (MODIS Analysis)

(Published in ICHARM Web site http://www.icharm.pwri.go.jp/ in April 3, 2014)

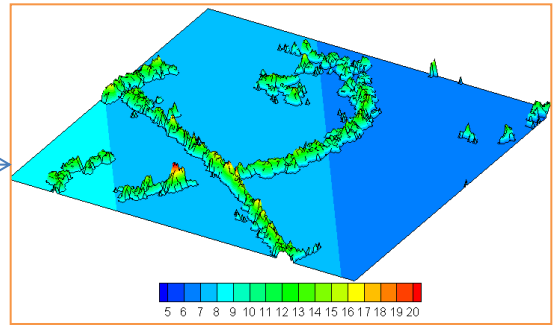
A number of IDPs (Internally Displaced Persons) may currently live in high flood potential areas in South Sudan.
As humanitarian and emergency aid to mitigate flood damages, a country wide flood hazard map is desired for effective evacuations. ICHARM rapidly analyzed a series of MODIS remote sensing images (a total of 506 images) obtained from January 2003 to December 2013.



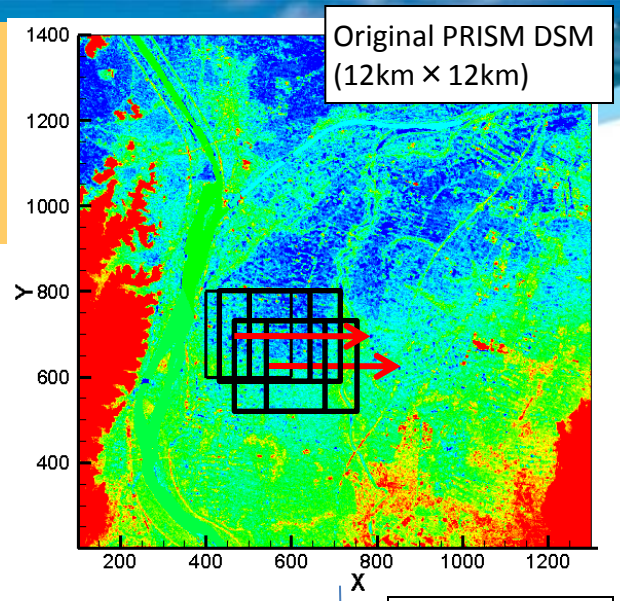
Modification method to get more accurate elevation data using satellite observation product (PRISM DSM)

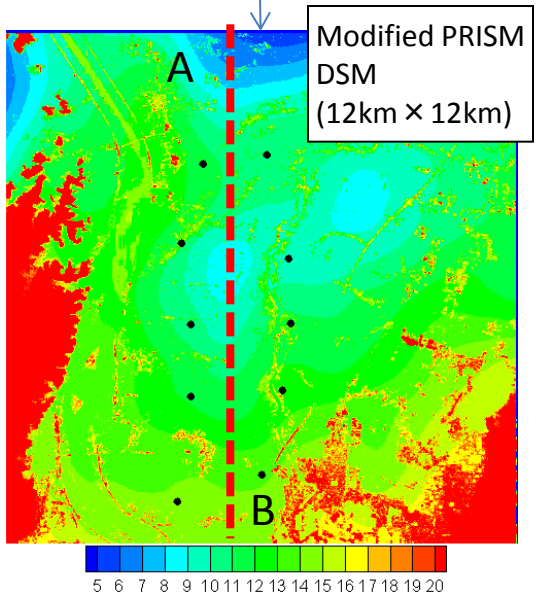


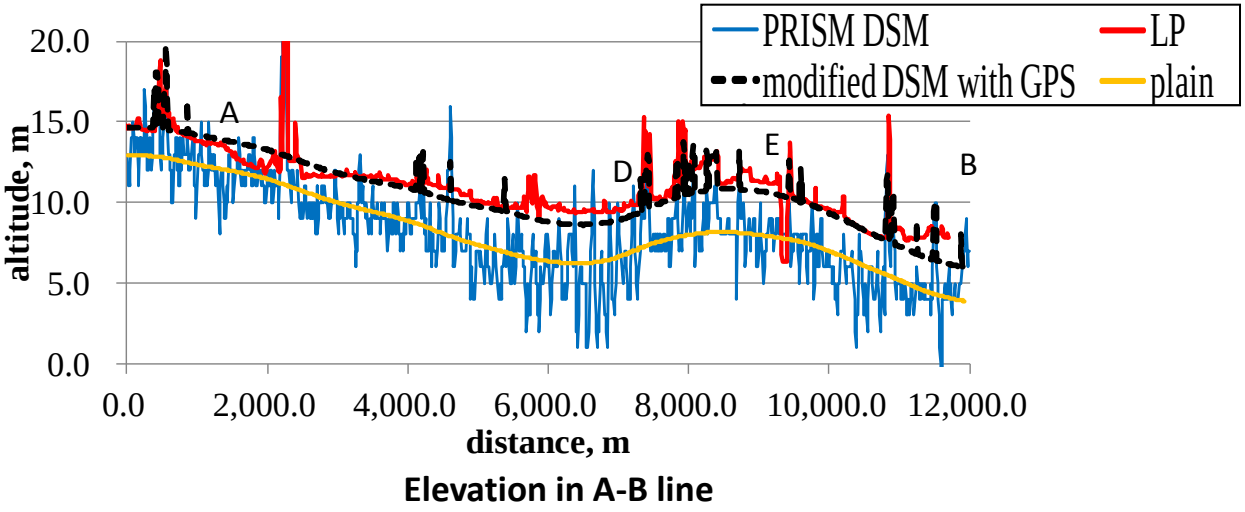
Original PRISM DEM(2km × 2km)
Including noise



Modified PRISM DEM(2km × 2km)
Only structures are remained.







Elevation in A-B line

After removing structures, making moving average of DEM in plain area and compound the modified DEM with GPS and structures

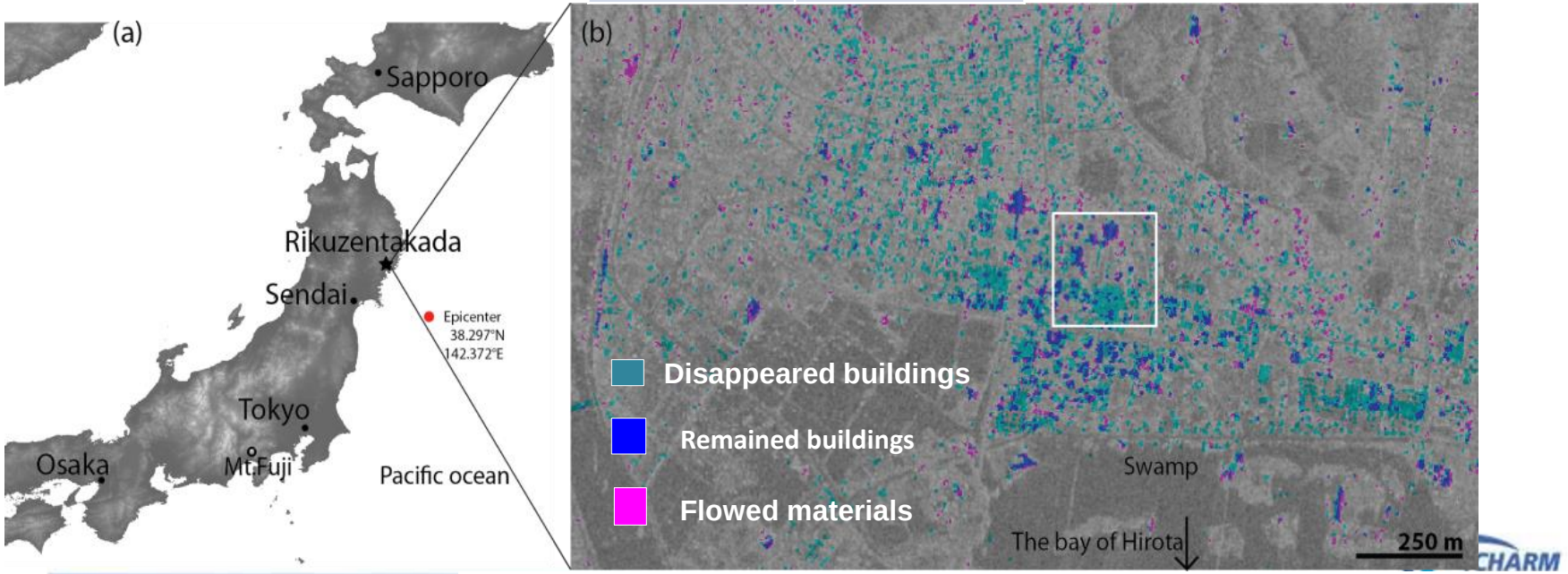
Estimation of numbers and location of buildings and their changes after the Tsunami using satellite (SAR)

- Developed an algorithm for estimation of buildings using SAR image from satellites

→ Validation of estimated number of buildings with optical satellite and study for possibility of application in the case of flood damages

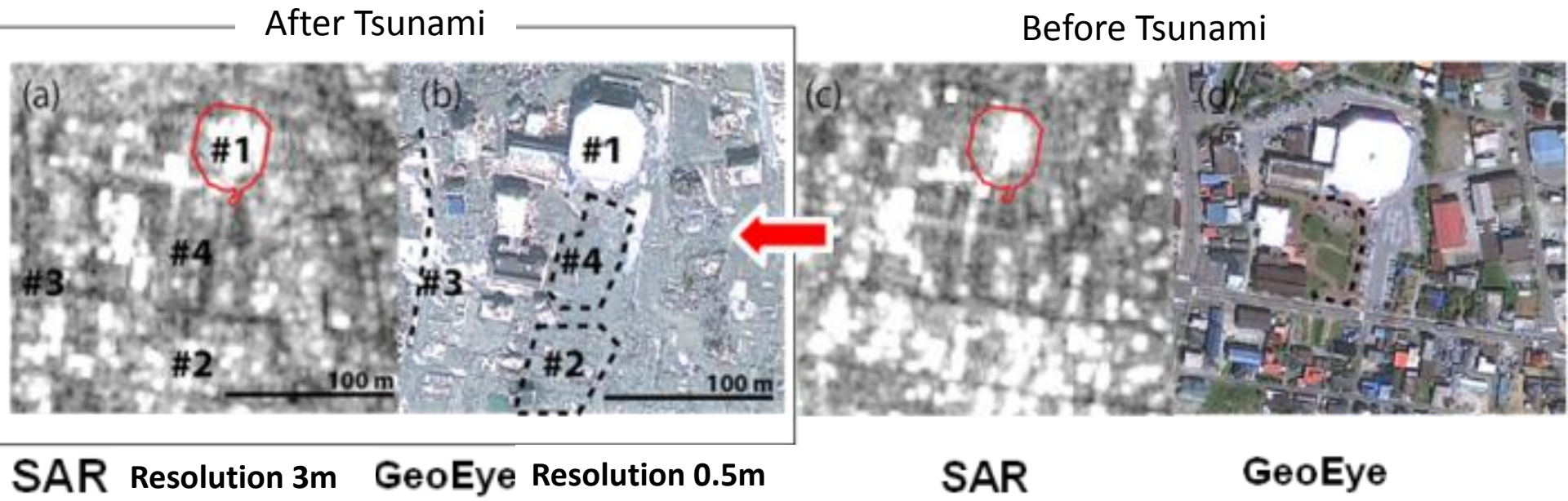
● Number of buildings by SAR

After Tsunami	Before Tsunami
2300	5468



Estimation of buildings (Rikuzen-takada city)

Estimation of numbers and location of buildings and their changes after the Tsunami using satellite (SAR)



Comparison of SAR image (Sky Med, Iraly) and optical image（GeoEye, the US）

Climate change

- Flood WG of Sentinel Asia -

Impact of the future climate in Chao Phraya river basin

1 Methodology

1) Projection in the future inputting MRI-AGCM results into RRI

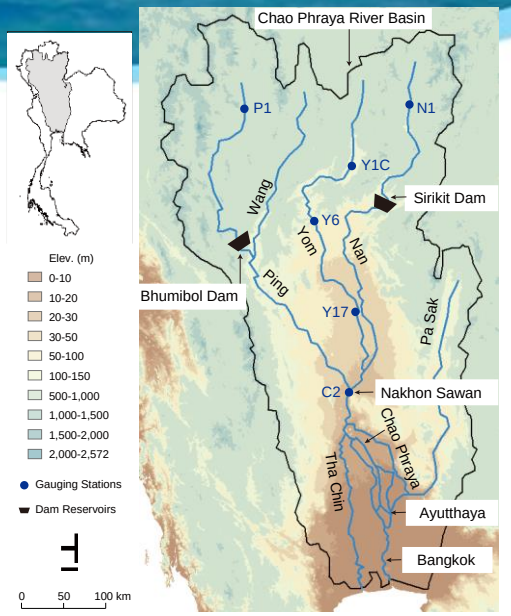
MRI-AGCM3.2S (20 km), AGCM3.2H (60 km) –Scenario SRES A1B

Present climate (1979-2003) : 4 cases (3.2S : 1 case + 3.2H : 3 cases)

Future climate (2075-2099) : 13 cases (3.2S : 1 case + 3.2H : 12 cases)

2) **RRI** model was applied for the whole Chao Phraya river basin

- Spacial resolution: 2km, long term simulation by using 52 years (1960–2011) ground gauged rainfall
- Analysis on relation between rainfall and inundation volume



Chao Phraya river basin (160,000 km²)

2 Analysis of relation between rainfall and inundation volume (mm/km²)

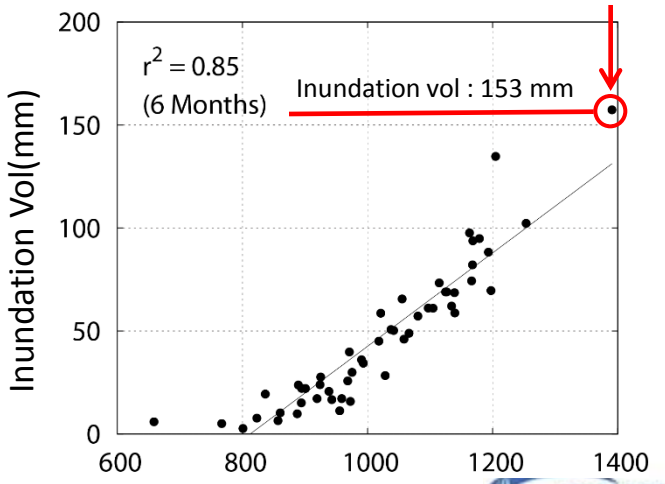
1) 2011 flood

6 months rainfall : 1400 mm

Inundation volume : 150 mm

2) If rainfall increase to 200mm more in 6 months, inundation volume will increase to 9.8 billion m^3 more.

It corresponds to Sirikit dam.



3 Assessment of the impact of climate change

1) 6 months average rainfall in the basin

Present (994 mm) → Future (1078 mm)
+ 84 mm

Return period of the 2011 flood event (1400mm)
Present (**33** years) → Future (**10** years)

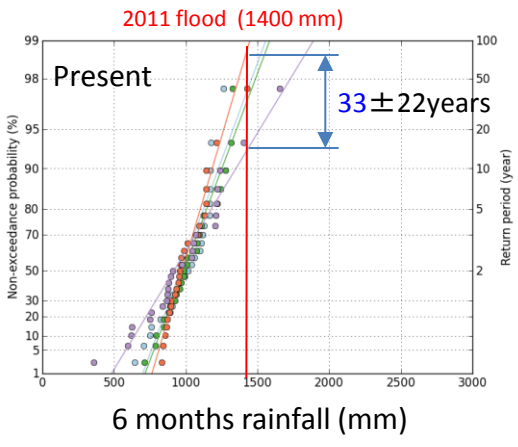
2) Average inundation volume

Present (42 mm) → Future (60mm)
+18 mm / km^2

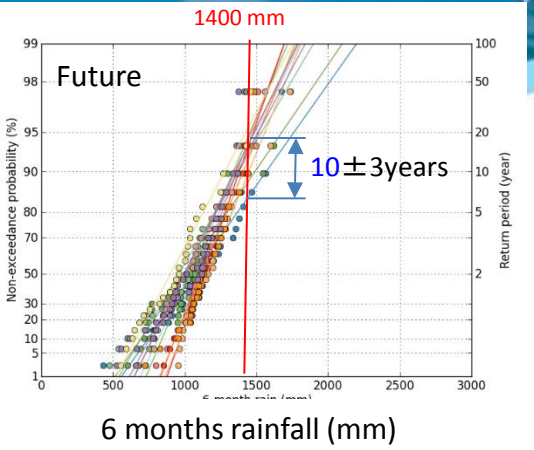
Return period of 2011 flood event (150mm)
Present (**33** years) → Future (**15** years)

3) Change of inundation frequency and area

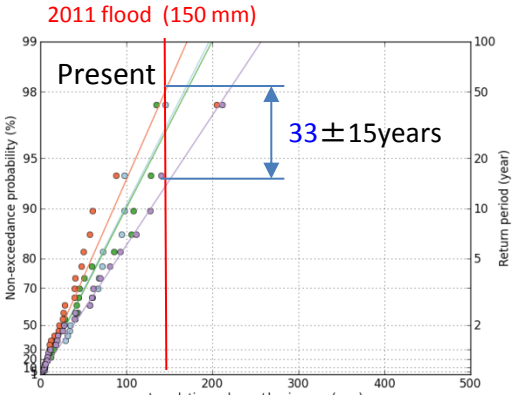
Frequency of inundation will increase.
（Ex. 3-5 events will increase within 25 years in the northwest area of Bangkok）
There is not so change in inundation area in the future.



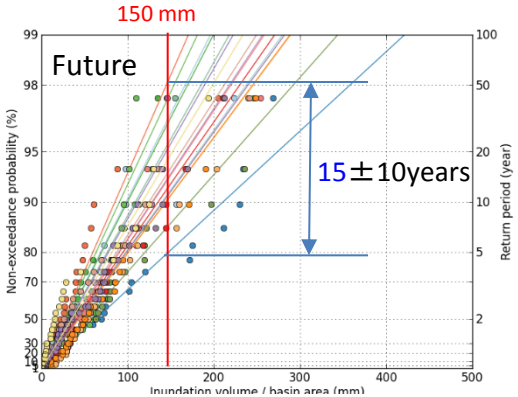
6 months rainfall (mm)



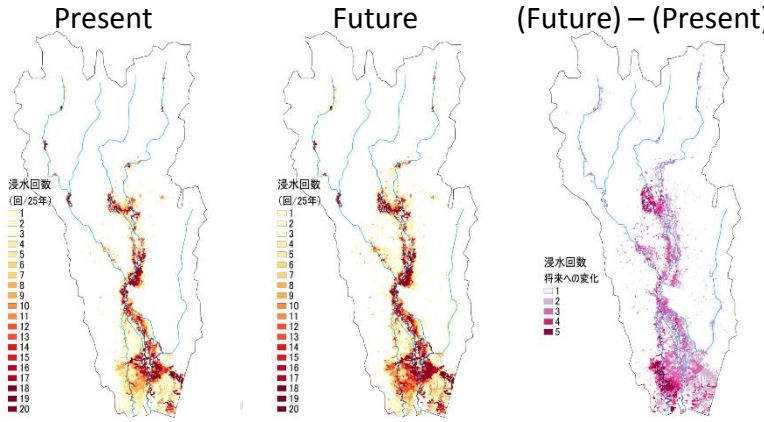
6 months rainfall (mm)



Inundation volume (mm)



Inundation volume (mm)



Inundation area and frequency(events/25 years)

Suggestion

Using satellite observation also contributes to global monitoring for climate change

Discussion

- Your active trials & studies to manage flood risk and to mitigate flood disasters using opportunities available through Sentinel Asia are expected.
- Your proposals to improve activities of Flood WG are welcome.


Thank you for your kind attention